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Establishing African genomics and bioinformatics programs through annual regional workshops

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Abstract

The African BioGenome Project (AfricaBP) Open Institute for Genomics and Bioinformatics aims to overcome barriers to capacity building through its distributed African regional workshops and prioritises the exchange of grassroot knowledge and innovation in biodiversity genomics and bioinformatics. In 2023, we implemented 28 workshops on biodiversity genomics and bioinformatics, covering 11 African countries across 5 African geographical regions. These regional workshops trained 408 African scientists in hands-on molecular biology, genomics and bioinformatics techniques as well as the ethical, legal, and social issues associated with acquiring genetic resources. Here, we discuss the implementation of transformative strategies, such as expanding the regional workshop model of the AfricaBP to involve multiple countries, institutions and partners, including the proposed creation of an African digital database with sequence information relating to both biodiversity and agriculture. This will ultimately help to create a critical mass of skilled genomics and bioinformatics scientists across Africa.

Keywords: Genomics, bioinformatics, workshops, trainings, sequencing, Africa, policy, biodiversity, and agriculture

Main

The African BioGenome Project (AfricaBP) (<https://africanbiogenome.org>) is a coordinated Pan-African effort established in 2021 to sequence the genomes of 105,000 endemic biological species (plants, animals, fungi, protists and other eukaryotes) to improve food systems, conservation, and data sharing and benefits¹. The Open Institute for genomics and bioinformatics is the knowledge exchange program for the AfricaBP, which aims to overcome barriers to capacity-building such as curriculum development using local languages and biological species, support African research and academic institutions that have fewer resources for their research needs, and enable scientific entrepreneurial opportunities to support Africa's bioeconomy through its distributed African regional workshops on biodiversity genomics and bioinformatics². Here, biodiversity genomics is defined as the application of genomics in the assessment, conservation, and improvement of biological diversity^{3,4,5}.

One of the priorities of the AfricaBP Open Institute is the exchange of knowledge at the grassroot level, as well as lowering visa and travel barriers that limit participation in scientific engagements^{2,6,7}. For example, despite the fact that bioinformatics in Africa has already been established in 1996 with the South African National Bioinformatics Institute, and subsequently, there have been more extensive capacity-building efforts by the bioinformatics network for H3Africa (H3ABioNet) and the Alliance for Accelerated Crop Improvements in Africa^{8,9,10}, there is still much work to be done in scaling bioinformatics capacity-building at the grassroot level in biodiversity genomics and bioinformatics area. In 2023, the AfricaBP Open Institute implemented 28 awareness and hands-on practical workshops on biodiversity genomics and bioinformatics in 11 African countries across five African geographical regions (Fig. 1). The fundamental objectives were to bring relevant technologies closer to African researchers by integrating awareness-building with hands-on practical workshops, as well as to exemplify the principles of public-private partnerships (PPP) in delivering genomics and bioinformatics workshops in low-resource settings. These regional workshops had 3,788 registered participants with 408 African scientists trained hands-on.

Here, we discuss the implementation of transformative strategies aimed at genomic innovations and knowledge exchange at the grassroot level by deploying the AfricaBP Open Institute regional workshops through PPP. We also propose measures to strengthen the impact of the AfricaBP Open Institute, including the creation of fellowships dedicated to biodiversity genomics and bioinformatics, the establishment of group leader positions for early-career and established researchers, and the creation of an African digital database containing sequence information relating to biodiversity and agriculture. In addition, we also make recommendations on how this workshop model could be adopted by other scientific communities across Africa such as, for instance, the African

microbiome community¹¹, hopefully enabling African researchers to be reached more effectively.

Workshop structure and key outcomes

The 2023 series (inaugural edition) of the AfricaBP Open Institute regional workshops were held across five regions of Africa (Fig. 1) at different times of the year through a ‘hub and spoke’ model (Fig. 2): (i) Western Africa, coordinated and hosted by the University of Port Harcourt (UniPort), Nigeria from 15th - 16th February 2023, (ii) Southern Africa, coordinated and hosted by the University of South Africa (UNISA), South Africa from 21st - 25th August 2023, (iii) Northern Africa, coordinated and hosted by Mohammed V University in Rabat (UM5R), Morocco from 9th - 13th October 2023, and (iv) Eastern and Central Africa, coordinated and hosted by the International Livestock Research Institute (ILRI), Kenya from 4th - 8th December 2023 (Fig. 1, 2).

Each regional workshop lasted 5 days, and together, they attracted 3,788 African scientists, students, and researchers and were sponsored through a PPP between AfricaBP, African institutions and industry sponsors. The first two days included presentations on diverse aspects, such as biodiversity genomics and bioinformatics, sample collection, as well as ethics and policy issues, by Africa- and non-Africa- based speakers and were selected to focus on understanding the current landscape of biodiversity across each region. The last three days involved hands-on practical sessions on genomics and bioinformatics processes; these were hosted in parallel across different locations in each of the regions. For each of the workshops, participants for the hands-on practical sessions were selected through a competitive shortlisting process, whereas attendance to the lectures was open to anyone interested. Below, we highlight five key outcomes of the workshops.

Launch of comprehensive Fellowships to drive significant change

One outcome of the workshop series was the launch of a comprehensive Fellowship program, as well as proposed Group Leaders and Professorial Chairs positions in biodiversity genomics and bioinformatics across Africa by the AfricaBP Open Institute (Fig. S2). Here, the regional workshops paved the way for initial investments in short-term and residential training ‘Fellowships in Biodiversity Genomics’, which was launched through a partnership between the AfricaBP Open Institute and the African Genome Center (AGC), University Mohammed VI Polytechnic (UM6P) in Morocco. For the short-term fellowship, in May 2024, ten selected African scientists will spend 2 weeks at the AGC laboratory in Morocco to generate a publishable sequenced genome of *Vachellia gummifera*, a species native to Morocco. This plant plays a critical role in soil conservation and has the ability to thrive in harsh deserts environments¹².

Similarly, AfricaBP Open Institute partnered with Carl R. Woese Institute for Genome Biology (IGB), University of Illinois, USA, to launch the ‘African Biodiversity Fellowship for

Emerging Genomics Leaders 2024', which aims to empower five African researchers to develop curricula, research programmes and leadership in biodiversity genomics and bioinformatics². The eligibility for this program focuses on African scientists with permanent positions in African institutions and whose institutions organised workshops, to ensure the availability of trained personnel to continue delivering the annual practical workshops, as well as address the brain-drain challenges experienced by the H3ABioNet¹.

Bringing local genomics and bioinformatics to the mainstream

The regional workshops delivered by the AfricaBP Open Institute utilised entirely local infrastructure and personnel across the 28 locations and 11 African countries and were organised in African regions with initiatives that encourage free movement of people without visa requirements for African researchers¹³. For example, the East African regional workshop in Kenya hosted researchers from the Eastern African states of Burundi, Ethiopia, Rwanda, Tanzania, Uganda, and Kenya, who did not require visas to travel to Kenya; this would not have been the case if they had to travel to other African regions (Fig. 1).

Furthermore, the workshops demonstrated that African countries with comparably limited genomics and bioinformatics capacities can benefit from other African countries that have more advanced genomics and bioinformatics capabilities. Specifically, during the Central/Eastern, and Northern Africa workshops, the AfricaBP Open Institute workshops reached African institutions and scientists from DR Congo, Cameroon, and Algeria, respectively, which do not constitute the primary destinations for most African genomics and bioinformatics capacity-building efforts (Fig. 2 and suppl. Fig. 2)^{1,2,14}.

Integrating PPP is beneficial to workshop delivery

AfricaBP Open Institute successfully integrated PPP into the delivery of the regional workshops (Fig. 2) involving 9 industry sponsors and 24 African institutions; this benefited both the Open Institute and public African institutions, for instance the University of Yaounde 1 in Cameroon, which did not need to apply for grant funding to host the workshops, the industry sponsors, as well as the African researchers trained, who were able to participate at no cost to them. The PPP arrangements involved establishing five levels of sponsorship (see Table S1), depending on the activities sponsored during the first two days, such as catering, videography, IT and/or Media, or during the practical workshop, such as organising and hosting these, provision of laboratory consumables, reagents, computing resources, and/or laboratory spaces.

Here, the PPP was significant for the success of the workshop as it allowed AfricaBP Open Institute to quickly mobilise resources (see Table S1) to host regional workshops

without applying for grant funding to funding agencies, which not only takes considerable time but also has a low success rate^{15,16}. Among the benefits for the industry sponsors are establishing third-party partnerships and increasing awareness for their technologies, products and services; not only to the registered participants (Fig. S3 and S4) across 80 countries (Fig. S1), but also to the additional followers across AfricaBP's social media platforms.

Engaging participants by lowering language barriers

One barrier to delivering effective training in Africa is the language used, which some participants may not fully understand². Therefore, the presentations during the first two days of the East and Central Africa regional workshop were primarily delivered in English in Nairobi, Kenya, and translated into French for the participants in Kinshasa, Democratic Republic (DR) of the Congo - a French-speaking country, while the last three days of the hands-on practical workshops were delivered in English in Kenya, Ethiopia, Uganda and Cameroon, and in French in Kinshasa, DR Congo (Box 1). In the future, delivering such training in Kikongo, one of the Bantu languages in Congo DRC, is expected to further increase training success, as has been previously proposed².

Establishing an African Digital Sequence Information Databank for Biodiversity and Agriculture

The current realities of digital sequence information and the Global Biodiversity Framework^{17,18,19} call for a more federated database configuration that maximises data ownership at national levels across Africa in line with national biodiversity regulatory frameworks^{2,20,21}. AfricaBP Open Institute initiated proposals for the creation of the African Digital Sequence Information Databank for Biodiversity and Agriculture (Fig. S2) in the form of federated repositories for storage, computing, processing, and visualisation of African biodiversity and agricultural genomic data. Such federated repositories could involve databases from national storage centres, being supplied from those, or could mirror the original data sets in the countries of sample origin. In this way, the countries where these samples originated would retain ownership of the data, whilst promoting open science. An example for such a set up is the Korean BioData Station (K-BDS), a repository for biological data generated from research projects funded by the Korean government with multiple databases for individual data types²².

Summary of course contents of the regional workshops

Here, we provide a brief summary of the hands-on practical sessions (Fig. 2), which were classified into five categories: (i) genome sequencing and bioinformatics analysis, (ii) bioinformatics analysis only, (iii) basic molecular biology, (iv) ethical, legal and social (ELS) issues, and (v) sample collection and biobanking, as outlined below.

Genome sequencing and bioinformatics analysis

Illumina technology genome sequencing

Illumina and its Africa-based partners (Separations, Megaflex and FNS Scientific) conducted hands-on training in South Africa, Morocco, and Kenya, respectively. Practical training on Day 1 began with an introduction to the basic principles of Illumina Next Generation Sequencing (NGS) technology, covering various experimental approaches and a practical session focusing on library preparation utilizing Illumina DNA Prep workflows²³ for downstream whole genome sequencing on Illumina NGS platforms. Experiments to optimise, quantify and quality control libraries were also performed hands-on by the trainees. The second day consisted of highlighting best practices to pool libraries, as well as troubleshooting common issues, which was followed by practical guidance for sequencing on the Illumina platform. The final day was purely dedicated to data analysis and bioinformatic tools that are vital to genome assembly, annotation, and analysing genetic variation using Illumina BaseSpace sequencing hub²⁴.

Inqaba Biotec genome sequencing

Inqaba Biotec gave practical sessions held at Inqaba Biotec in Pretoria, South Africa, and International Livestock Research Institute in Nairobi, Kenya. Day 1 started with a theoretical introduction of the PacBio SMRT technology and an overview of the protocol. Participants were either given a bacterial genomic DNA sample (in South Africa) or fish tissue (in Kenya) for processing. Sample quantification, DNA extraction and quality control were performed using PacBio Nanobind tissue kit and Qubit HS DNA Assay kit. Day 2 started with SMRTbell library prep using the PacBio SMRTBell Prep Kit 3.0^{25,26}, following which participants were introduced to PacBio SMRTLink software for sample setup and run design. Finally, on Day 3, participants were introduced to PacBio SMRTLink analysis software for performing data quality control and genome assemblies.

MGI-Tech genome sequencing

The MGI-Tech workshop focused on their single tube Long Fragment Read (stLFR) technology, which entailed library preparation and sequencing of two plant species using the MGI DNBSEQ-G400 medium-high throughput sequencer²⁷ located at the Agricultural

Research Council (ARC) in Pretoria, South Africa. Day 1 began with an introductory lecture to MGI's DNBSEQ and stLFR technologies, before participants commenced wet laboratory work with sample quality control, followed by library preparation, which was completed on Day 2. The final day started with sequencing of constructed libraries on the DNBSEQ-G400, followed by a presentation on primary bioinformatics analyses, such as nucleotide signal detection, base calling, FASTQ writing, interpretation of preliminary and final sequencing reports.

Oxford Nanopore Technology genome sequencing

DIPLOMICS, Oxford Nanopore Technologies (ONT) and the University of Pretoria Genomics Laboratory hosted the workshop in Pretoria, South Africa. Day 1 focused on introducing the principles of the ONT sequencing platform and library preparation. Participants completed library preparations, these were loaded onto MinION flow cells and sequenced using both MinION Mk1B and Mk1C instruments²⁸. Day 2 focused on project design, quality control, planning ONT sequencing run experiments, including the DNA isolation methods, and selection of the most relevant kits. The final day focused on in-depth analyses of all the sequencing run reports, data quality, and yield. Analysis software was introduced, followed by extended practical metagenomic and SARS-Cov-2 data analysis sessions as well as exposure to the various Oxford Nanopore community resources and applications, including metagenomics solutions^{29,30,31}.

Bioinformatics analysis only

The Institut Pasteur de Tunis (IPT), Tunisia, organised a 'Data Carpentry Genomics' workshop focused on managing and analysing genomics data using cloud computing during the North Africa regional workshop. The workshop leveraged a pre-configured Amazon Machine Image (AMI) for Amazon Web Services (AWS), and equipped participants with essential skills through four key modules: cloud computing for genomics navigation and data transfer, project organisation and data management such as accessing data on the NCBI Sequence Read Archive, command line fundamentals for file system navigation and automation, and data wrangling, quality control, read alignment, and visualisation of genetic variation. The workshop utilized data from Tempo and mode of genome evolution experiment³².

Basic molecular biology

This workshop was organised and sponsored by Inqaba Biotec Central Africa Ltd (IBCA) in collaboration with the Biotechnology Center (BTC), University of Yaounde 1, Cameroon, during the East and Central Africa workshops. Primer sequences were obtained from BTC, synthesised, and used to detect the presence of malaria parasites and drug resistant biomarkers in blood samples. Day 1 focused on a presentation on

sample collection, nucleic acid extraction and sequencing technologies, and a hands-on session on DNA extraction from blood samples using the Quick-DNA Miniprep Plus Kit from Zymo Research. Day 2 focused on DNA quantification, quality assessment, PCR amplification and subsequent quality controls using the OneTaq® Quick-Load® 2X Master Mix from New England Biolabs. On Day 3, agarose gel electrophoresis was performed on the PCR products and lectures held on sample conditioning for sequencing, Sanger DNA sequencing, and an introduction to bioinformatics analysis.

Ethical, legal and social (ELS) issues

Navigating South Africa's Access and Benefit Sharing (ABS) and ELS issues

The main objective of this workshop held at the University of South Africa (UNISA) was to provide participants with a general overview of the ethical and legal requirements of research projects that involve the collection of genetic samples of African fauna and flora to ensure protecting Africa's biodiversity and its stakeholders, by following a typical research project from conception through to dissemination. On Day 1, initial stages of a project were discussed, including conception and initiation, definition, and planning, by using the San-Hoodia case³³ as a case study. The knowledge of the San people about the appetite-suppressant properties of Hoodia, a succulent plant used as a substitute for food and water during hunting expeditions, led to agreements with Council for Scientific and Industrial Research, a South African research institution, to share any benefits arising from the use of this knowledge as well as the challenges in developing and implementing these agreements³³. Participants explored how lack of proper research planning, failed attempts to obtain informed consent, and the lack of any benefit sharing negatively influenced the project, and learned how to effectively engage with stakeholders, including indigenous people, informed consent, data collections tools, and permits. Day 2 explored regulatory instruments, such as Material Transfer Agreements (MTA), Data Transfer Agreements (DTA), ABS of the Nagoya Protocol, Cartagena Protocol on Biosafety, Convention on Biological Diversity, South African Biodiversity Act^{34,35,36}, and how these complement and support one another. The final day addressed benefit sharing, research dissemination, and commercialisation of genetic materials and how this can be resolved within MTAs and DTAs.

Navigating Uganda's ABS policy during sample acquisition

The National Animal Genetic Resources Centre and Data Bank (NAGRC & DB) organized a practical workshop in Entebbe, Uganda, tailored at building capacity in ethical, legal, and social issues associated with acquiring and/or moving genetic resources. Day 1 focused on an overview of national, international, and global regulatory frameworks related to conservation of genetic resources, including an in-depth account of the

Convention on Biological Diversity (CBD), ABS of the Nagoya Protocol, Global Plan of Action on Animal Genetic Resources and the Interlaken Declaration^{35,36,37}, and how they were to be localised by countries. Day 2 focused on completion of ethical compliance documents, in particular, templates relating to research ethics such as justification of using animals in research following the 3Rs (replacement, reduction, and refinement), as well as drafting an MTA and data sharing agreement. The final day focused on training on obtaining blood samples from cattle for different purposes, including biobanking, diagnosis, DNA extraction, serum, or plasma extraction, according to the sample requirements of respective projects.

Sample collection and biobanking

This hands-on workshop at the South African National Biodiversity Institute (SANBI) provided an opportunity for participants to learn about sample collection and processing. Day 1 focused on the value of biodiversity biobanks and collections, as well as additional topics, including ethics, permits and other considerations, such as ABS of the Nagoya Protocol and Convention on International Trade in Endangered Species of Wild Fauna and Flora import and export permits^{38,39}. In addition, an overview of the Biodiversity Biobank South Africa project, the SANBI Plant Biobank and the Millennium Seed Bank were also provided. Day 2 focused on taxon sampling, endo- and ecto- parasite sampling and e-vouchering. Sampling for genetic analysis was discussed, such as suitability for high quality extractions required for whole genome sequencing, as well as forensic sampling and the use of chain-of-custody methods. Day 3 focused on plant sampling for DNA and herbarium collections, introduction to biodiversity data, minimum data standards, and barcode of life data system.

Participants feedback

As noted above, the workshops attracted over 3,700 scientists, students, and researchers, and, notably, around 90 % of attendees were not affiliated with AfricaBP (Fig. S4), suggesting that this workshop was successful in attracting participants that are not already involved in AfricaBP. More than 40 % of all attendees across the four regional workshops were female, achieving a commendable gender balance in a field where female representation is traditionally low (Box 1). Interestingly, participants noted ethical compliance for sample collection, data and biomaterial specimen sharing and a lack of clear policy, as significant factors slowing down their genomics research work. Machine-learning analyses of the post-workshop survey (Fig. S5) pointed to an overwhelmingly positive assessment of the workshops, with 97 % of the 1,030 survey respondents expressing a desire for the return of the regional workshops in 2024.

Future directions

Based on the outcome of the inaugural workshop and feedback received, we developed four strategic directions for future regional workshops as outlined below.

Increase locations for practical sessions to build critical mass

To enable a wider reach of the regional workshops, we aim to add further locations for the practical sessions in various African countries. For example, in 2024, we plan to organise at least 33 workshops and reach researchers in island states, such as Cabo Verde, Sao Tome and Principe, and Seychelles, which did not participate in 2023 (Fig. S1), as well as maximise the use of infrastructures covering infectious diseases such as the African Center of Excellence for Genomics of Infectious Diseases⁴⁰. Similarly, we encourage the institutions hosting regional workshops to schedule these during graduate (PhD and MSc) research showcase week in 2024 and beyond to ensure their schedules align strongly with the academic calendars and research activities of host institutions.

Create further Fellowship opportunities and progression to Group Leader and Professorial Chairs

The 2023 regional workshops paved the way for the award of 15 Fellowships to African scientists in 2024. We aim to ensure that the 2024 regional workshops will create an additional 35 Fellowship opportunities in 2025 and enable sustained progression from Fellowship recipients to early career Group Leader and Professorial Chair positions (Fig. S2) to firmly root the disciplines of biodiversity genomics and bioinformatics across Africa. AfricaBP will increase Fellowships and create group leader and professorial chairs positions by strengthening its role as a negotiator of opportunities that overlaps between genomics funding agencies, industry partners, and African institutions and scientists.

Realising the African Digital Sequence Information Databank for Biodiversity and Agriculture

AfricaBP Open Institute will work with African governments and policymakers to secure government agreements through existing (or new) national or regional regulations that govern the scientific parastatals of the African Union, African economic area or national institutions for the African digital sequence information databank for biodiversity and agriculture - compared to the member databases of the International Nucleotide Sequence Database Collaboration (INSDC), this has better chances of easing regulatory hurdles with regard to sharing of sequence information data, their access and ownership across Africa³⁸. For example, the framework that established the member databases of

the INSDC is anchored in national or regional institutions and ratified through legislative instruments in Japan, Europe or the US respectively^{41,42,43,44}; however, no African nation is a signatory of the agreements that established these member databases.

Engaging with genomics funders to target African scientists

The AfricaBP Open Institute will encourage genomics funding organisations to target African scientists by promoting on-the-ground genome sequencing, and efforts to raise awareness and build capacities (Box 1). For example, the Illumina Agricultural Greater Good Initiative (GGI), which started in 2010 and offers reagents and consumables to researchers totalling \$350,000 for up to 1000 genomes in 2023^{45,46}, could help African scientists more by facilitating sequencing on the continent and establishment of Professorial Chairs positions to advance the GGI. Similarly, future iterations of the 2024 Wellcome Trust scoping and workshop exercise, which aims to further integrate international genomics research and practices focusing on ELS contexts of genomics⁴⁷, could benefit from distributed workshops across five African regions to maximum engagement with Wellcome's initiatives. For instance, 81 % of the 1374 participants who attended the AfricaBP Open Institute regional workshops in East and Central Africa in 2023 did not attend the regional workshops in Southern Africa (Fig. S3)

Box 1. Lessons learned

- Persistent inclusion of local funding sources are key to enable uptake and assimilation of genomics and bioinformatics

One of Africa's problems is its over-dependence on international grants to fund science^{48,49}. For example, the African Union established a target of 1 % of GDP to be committed to research and development; however, most of the African countries commit only around 0.38 % (United Nations Conference on Trade and Development, 2021). In 2023, the AfricaBP Open Institute brokered opportunities for all participating African institutions to co-sponsor and host the regional workshops, either through in-kind contributions, institutional part-funding or institutional self-funding to minimise financial burden on the scientists or institutions (Fig. 2 and Table S1).

- Strategic planning is key to workshop success

It is crucial to acknowledge that the inaugural West African Regional Workshop was considered a pilot run. It had fewer participants than the subsequent workshops and encountered challenges such as a low number of industry sponsors and hands-on practical sessions, limited publicity for the workshop, its scheduling during the electoral

period in Nigeria, as well as a short planning time. This served as valuable learning experiences for subsequent regional workshops in 2023.

- Lack of travel and accommodation funding did not limit participation drastically

The AfricaBP Open Institute did not fund travel and accommodation associated with workshop attendance, instead, we prioritised sponsoring additional practical sessions for genome sequencing and holding these in African countries, where there are no such courses currently. Hopefully, this will encourage commercial sponsorship of satellite sites that might reflect new markets within Africa.

- Maximise impact through increased virtual engagement

Given the limited places for in-person practical sessions, leveraging virtual participation can significantly extend the reach and impact of regional workshops. Hosting workshops in various African regions and offering online bioinformatics training sessions can help to ensure that all participants, regardless of location or financial constraints, have access to valuable learning opportunities (Fig. S5). Additionally, exploring virtual labs or demonstrations, especially using emerging technologies, such as imaging and AI, might enhance engagement and knowledge dissemination, ultimately maximising the workshops' impact.

- Customised curriculum development

A crucial lesson learned is the importance of tailoring the workshop curriculum, including language and available resources, to the specific needs and context of African biodiversity researchers. For instance, while some participants were trained in PacBio HiFi genome sequencing at Inqaba Biotec facility in Pretoria, South Africa, participants at the University of Yaounde 1 in Yaounde, Cameroon, were trained in basic molecular biology techniques as there is no PacBio HiFi technology in Cameroon. This tailored approach ensured that the workshops are relevant (Fig. S2) and directly address the challenges faced by participants, such as limited access to resources and expertise. By focusing on practical skills and tools relevant to the research interests of participants, the impact of the workshops can be maximised by empowering participants.

- Fostering inclusivity and diversity

Creating an inclusive environment by actively including researchers from diverse backgrounds, including women, early-career researchers, and those from underrepresented regions (Fig. S2), enriches the learning experience for all participants. This inclusivity not only enhances the immediate impact of the workshop, but also contributes to the long-term sustainability of the format and the broader impact within the research community.

- Continuous evaluation and adaptation

It is essential to continuously evaluate workshops and adapt them based on feedback and evolving needs. Such an approach ensures that the workshops remain responsive to the changing needs and priorities of African biodiversity researchers, thus helping to maintain their effectiveness and relevance over time.

Conclusions

The current model of regional workshops organised by the AfricaBP Open Institute addresses issues facing African scientists, such as visa requirements, costs, travel, time, and language barrier, by delivering training using local resources and creating opportunities for both the researchers and industry partners. A multi-partner and multi-country framework exemplified by this initiative is a cost-effective and viable strategy in boosting the current capacity-building strategies across Africa. In the future, the regional workshops will contain practical workshops to address specific bioinformatics problems, such as modular and internet agnostic analytical techniques, through hackathons.

The regional workshops held in 2023 allowed AfricaBP Open Institute to identify several grassroots scientists who are well positioned to have a local impact in genomics and bioinformatics. To build on these successes, the regional workshops will need to be held annually to widen the pool of trained researchers throughout Africa. However, this will require core funding and sustained investments. The AfricaBP Open Institute welcomes investments from both industry partners and science funding agencies at different levels, from sponsoring one or more practical sessions, long-term funding of Fellowships, group leader and professorial chair positions, to seed funding for the establishment of an *African Digital Sequence Information Data Bank for Biodiversity and Agriculture*, or by providing secretarial and administrative funding for the AfricaBP Open Institute to continuously coordinate these efforts. We will continuously implement new ways, and optimise capacity-building and development approaches, that fuel in-continent genome sequencing, analysis, and impacts.

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Author contributions

- *Conceived and initiated regional workshops:* TEE and JOO
- *Designed regional workshop model:* TEE and JOO
- *Discussed designed model, implemented and executed regional workshops:* TEE, JOO, NM, BB, AM, LTN, IH, JOK, SM, TCO, BAO, AB, AMM, AEH, AB, AB, AE, AH, ALM, AMA, AKE, BA, CW, CCN, CE, DI, EEF, EA, FO, FZB, FZT, FR, FZ, GLM, HG, MH, HN, HC, IB, IM, IH, IMK, JFM, JBKDE, JBR, JO, JBD, KE, KL, KKK, LBT, LH, MR, MC, MWB, MK, MK, MM, MC, MK, MA, MPM, MH, MRM, MAH, MP, MM, MM, MM, NAO, OA, OA, OS, PFD, RM, RDZ, RBT, RM, SPK, SS, SE, SBSG, SRAR, SF, SK, SA, TM, TS, OUU, VE, XD, YG, YHT, ZC, CZ, and AD
- *Drafted manuscript:* TEE, AS, KL, JO, MWB, AB, MC, XD, AMM, NAO, MPM, RBT, and VR
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- *Approved manuscript:* all authors

Competing interest statement

Acclaim Moila and Hamilton Ganesan are employees of Inqaba Biotechnical Industries. Zhiliang Chen, Michael Abdo, Sean Edwards, Lydia Hadjeras, Tulsi Sahil, and Xavier David are employees of Illumina, Inc. Mariëtte Kilian, Marija Kvas, and Charles Wairuri are employees of Separations (Pty) Ltd. Mossaab Maaloum and Fatimzohra Tmimi are employees of Megaflex. Mmatshapho Phasha-Muchemenye is an employee of MGI-Tech. Rolland Bantar Tata is an employee of Inqaba Biotec Central Africa. ThankGod Echezona Ebenezer is an Independent Contractor for the Wellcome Trust. All other authors declare no competing interests.

Figure legends

Fig. 1: Locations of the AfricaBP Open Institute 2023 regional workshops. A: Illustration of the countries of origins of registered participants for A. Southern Africa regional workshop, B. Eastern and Central Africa regional workshop. C. Northern Africa regional workshop and D, Western Africa regional workshop. This map was generated with AfricaBP registration information using QGIS software (QGIS, 2024), courtesy of ArcWorld Supplement. Sections of the map coloured in dark grey represent African geographical regions with overlapping common travel areas.

Fig. 2: Local resources utilized in the 2023 regional workshop. Illustrated here are 'hub and spoke' models for delivery of the different AfricaBP Open Institute 2023 workshops. A. Southern Africa regional workshop. B: Northern Africa regional workshop. C: East and Central Africa regional workshop. D: West Africa regional workshop. The diagrams also highlight interactions between genomic technology and service providers, genomics technology distribution partners, regional representatives or country representatives and academic and research institutions, providing mutual knowledge exchange.

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