

# African biodiversity genomics in the era of the Kunming-Montreal Global Biodiversity Framework: Ethical, Legal, and Social Perspectives

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## Abstract

The African BioGenome Project (AfricaBP) is a Pan-African initiative which aims to improve food systems and conservation through genomics, and ensure data sharing and benefits. The Kunming-Montreal Global Biodiversity Framework (KMGBF) is one of the frameworks of the Convention on Biological Diversity which seeks to reduce threats to biodiversity, ensure sustainable use of biodiversity as well as equitable sharing of benefits. AfricaBP's objectives and activities are closely aligned with the goals of the KMGBF. However, implementing genomic research in the African context presents unique ethical, legal and social challenges and benefits. Here, we explore the alignment between the AfricaBP and the KMGBF, focusing on the potentials for genomics to drive biodiversity conservation and food security across Africa. We critically examine the ethical, legal, and social implications (ELSI) and related challenges associated with implementing the KMGBF. In response to these challenges, and to strengthen AfricaBP's capacity to implement the KMGBF goals, we make specific recommendations such as, amongst others, the creation of clear policy and legal frameworks, implement transparent monitoring and reporting mechanisms, and ensure interoperability of key regulatory instruments in biodiversity conservation. We also discuss how AfricaBP integrates the theory of change in its activities to enhance the implementation of the KMGBF by strengthening biodiversity data infrastructure, creating awareness via communication and capacity-building whilst empowering local communities, promoting gender diversity in the African biodiversity genomics landscape, facilitating research and innovation by advancing ethical and legal frameworks, and understanding access and benefit-sharing and KMGBF through roundtable meetings, survey development and analysis.

## Background

Africa is rich with a diverse range of biological organisms that are found across various ecological hotspots including mountain peaks, savannahs, wetlands, and deciduous forests (Chapman, *et al.*, 2022, IPBES, 2018, O'Connell, *et al.*, 2019, Archer, *et al.*, 2021). Despite this richness, Africa is currently facing huge biodiversity losses of both plants and animals, many of which are endemic to the continent. These losses are mainly driven by climate change and adverse human activities, such as overexploitation and environmental degradation (UNEP-WCMC, 2016). 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, data sharing and benefits (Ebenezer, *et al.*, 2022).

The Convention on Biological Diversity (CBD) is a multilateral treaty that seeks to promote biodiversity conservation, the sustainable use of its components, and the fair and equitable sharing of benefits arising from the use of genetic resources (Chandra and Idrisova, 2011, UNEP Convention on Biological Diversity, 2011a, Tsioumani, *et al.*, 2024). The CBD sets the stage for more specific protocols and agreements, including: The Cartagena Protocol which supports the CBD's objective of biodiversity conservation by managing the risks associated with living modified organisms resulting from modern biotechnology that may have adverse effects on biodiversity (Convention on Biological Diversity, 2000), the Nagoya Protocol which enhances the CBD by operationalizing its objectives on access and benefit-sharing (UNEP Convention on Biological Diversity, 2011b), and finally, the Kunming-Montreal Global Biodiversity Framework (KMGBF) which builds on the foundational principles and objectives of the CBD, integrating and reinforcing the regulatory frameworks established by the Cartagena and Nagoya Protocols (UNEP Convention on Biological Diversity, 2022).

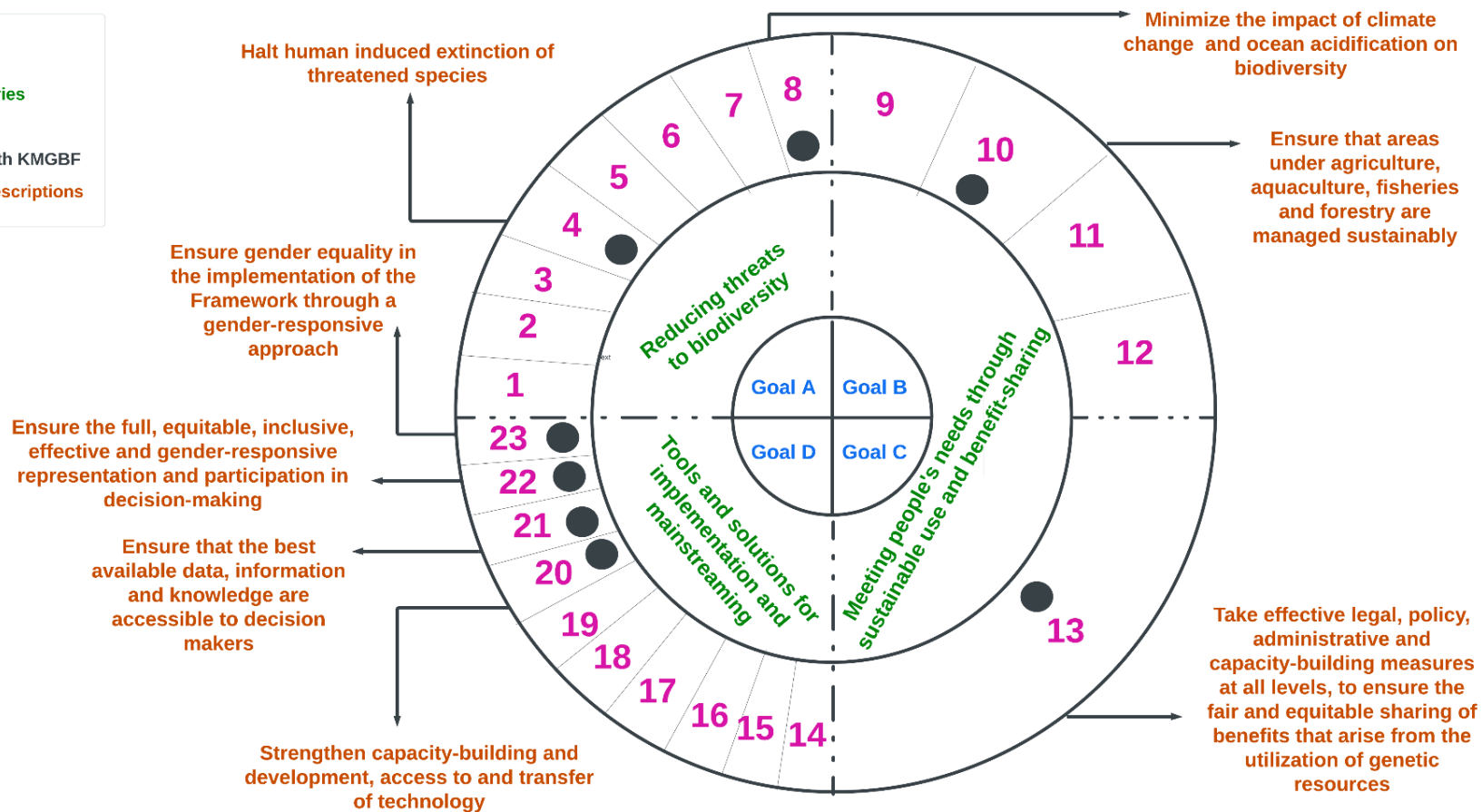
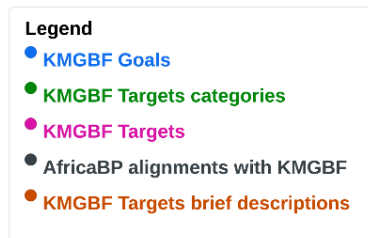
The KMGBF is one of the outcomes of the 2022 United Nations (UN) Biodiversity Conference of the Parties (COP15) to the UN CBD to establish a multilateral mechanism for benefit-sharing from the use of Digital Sequence Information (DSI) on genetic resources, including a global fund, as part of the GBF; a fair, transparent, inclusive, participatory, and time-bound process to further develop and operationalize the mechanism to be finalized at COP 16 in Cali, Colombia in October 2024 (UNEP Convention on Biological Diversity, 2022, Tsioumani, *et al.*, 2024). Here, DSI refers to digitally recorded DNA, RNA, proteins, metabolites, and associated products (Smith, *et al.*, 2023).

AfricaBP's objectives and activities are closely aligned with the four goals of the KMGBF - Goal A: The genetic diversity within populations of wild and domesticated species are safeguarded, Goal B: Biodiversity is sustainably used and managed, Goal C: Monetary and non-monetary benefits from the utilization of genetic resources and digital sequence information on genetic resources are shared fairly and equitably, and, Goal D: Adequate financial resources, capacity-building, technical and scientific cooperation, and access to and transfer of technology to fully implement the KMGBF are secured and equitably accessible to all Parties, especially developing country Parties (Figure 1) (Ebenezer, *et al.*, 2022, UNEP Convention on Biological Diversity, 2022). However, meeting these objectives require addressing the ethical, legal, and social implications (ELSI) of genetics and genomics science which are crucial in overcoming Africa's specific challenges such as robust regulatory frameworks and implementation

instruments (Burke, *et al.*, 2015, Bledsoe, 2017, Ozdemir & Hekim, 2018, Argudo-Portal & Domenech, 2020, Sherkow, *et al.*, 2022, Trump, *et al.*, 2023, Conley, *et al.*, 2020, Tzortzatou-Nanopoulou, *et al.*, 2023).

To address these challenges, AfricaBP established a dedicated sub-group in 2021 called the ELSI subcommittee. This sub-group ensures that research and science conducted in AfricaBP adheres to legal and ethical frameworks, particularly in the context of benefit-sharing and protecting Africa's traditional knowledge systems and indigenous communities. This subcommittee also provides support in AfricaBP such as access to resources including legal expertise, capacity-building, and mainstreaming of ELSI in AfricaBP's activities.

Here, we describe the alignment between the AfricaBP and KMGBF goals, potential challenges in implementing the KMGBF in the African context, and provide recommendations for achieving these goals across Africa. We highlight the critical role of the ELSI subcommittee in guiding AfricaBP's mission through integration of ethical dimensions and considerations. Finally, we explore how the AfricaBP can be leveraged by African organizations and policymakers for continent-wide implementation of the KMGBF.



**Figure 1: The African BioGenome Project (AfricaBP) is key to enabling implementation of the Kunming-Montreal Global Biodiversity Framework (KMGBF) goals and targets at the genetic level across Africa.** AfricaBP objectives (Ebenezer, *et al.*, 2022, Sharaf, *et al.*, 2023, 2024) are aligned with the KMGBF goals (A - D) and Targets (4, 8, 10, 13, 20, 21, 22, and 23) respectively. The KMGBF goals are to be achieved through 23 targets categorized into three main areas: Reducing biodiversity threats (Targets 1 - 8), meeting people's needs through sustainable use and benefit-sharing (Targets 8 - 13), and tools and solutions for implementations and mainstreaming (Targets 14 - 23). Goal A focuses on reducing biodiversity threats. Goals B and C address meeting people's needs through sustainable use and benefit-sharing. The Targets associated with Goals B and C include Targets 9, 10, 11 and 12 which focus on sustainable use of biodiversity (Goal B), and Target 13, which addresses access and benefit-sharing (Goal C). Goal D emphasizes the need for adequate means of implementation, including capacity-building and technology transfer. Broken lines indicate the interconnectedness and cross-cutting relationships and priorities amongst all the Targets. Brief descriptions of KMGBF Targets are highlighted in amber (see UNEP Convention on Biological Diversity, 2022, for extensive details on the KMGBF goals and targets).

## Challenges with implementation of the KMGBF in Africa

Next-generation sequencing methods have transformed the field of population and functional genomics over the past decade, by enabling the screening of whole-genome variation within and between species relevant for biodiversity conservation through genetics (Stange, *et al.*, 2020). For example, genome-wide studies of responses to new environmental conditions through changes in gene expression and epigenetic modifications can be investigated using molecular approaches to infer or predict biodiversity loss or gain resulting from climate change (Bernatchez, *et al.*, 2023, Theissinger, *et al.*, 2023). The application of genomics in biodiversity conservation (Harris, *et al.*, 2021) and sustainable use is an innovative avenue (see Target 20 in Figure 1) that provides opportunities to facilitate benefit-sharing from DSI (see Target 13 in Figure 1) (UNEP Convention on Biological Diversity, 2022). Here, we describe potential challenges, in the African context, when navigating ELSI associated with biodiversity conservation and its DSI:

1. *Inadequate legal and administrative frameworks and clarity*: Foremost among the hurdles facing some African nations in biodiversity conservation are inadequate and comprehensive legal frameworks (Ogunniyi & Azeta, 2024), the clarity as well as limited availability of tools for implementation of these frameworks (Stephenson, *et al.*, 2020). This is evident with the implementation of Nagoya Protocol where some countries have established legal and administrative frameworks, access and benefit sharing (ABS) guidelines, through digital avenues and physical locations, while other countries are still lagging behind in developing these frameworks (see Text Box 1). In addition, not all countries in the African region are responsive to communications and awareness and/or capacity building activities (see Figure S1 - S3 and Text Box 1) (Laird, *et al.*, 2020a). Factors such as unclear land tenure, insufficient resource rights, and the regulation of activities impacting biodiversity act as impediments to effective conservation efforts (Rands, *et al.*, 2010). This challenge is compounded by the insufficient allocation of financial and human resources, proving to be a significant obstacle to implementing robust biodiversity conservation measures (Martínez-Alier, 2023). Scarce resources often hinder the monitoring and enforcement of regulations, conducting essential research, and adopting sustainable management practices in some African countries (Ohuruogu & Okoye-Asoh, 2014).
2. *Absence of federated African infrastructure for generating, studying and using DSI*: The success of implementing KMGBF in Africa lies heavily in addressing the triangular imbalance of the capacity to generate, study, and use genomic data

(Stephenson, *et al.*, 2017) that is supported through legislative instruments. Three sub-challenges exist here: a) Limited capacity to generate DSI at scale. For instance, while there are 10 PacBio Revio sequencers at the Broad Institute in Cambridge, United States, (PacBio, 2023) yet only one exists across the African continent. Given that a PacBio Revio has a sequencing capacity of 1300 human genomes per year (PacBio, 2024), the Broad Institute can sequence 13000 human genomes per year, while Africa can only sequence 1300, b) Maximizing use of existing capacity to generate and use DSI is one of the biggest problems in Africa. As an example, while 206 sequencers were identified in Africa in 2021, this number did not translate to increased usage of these local infrastructures to generate sequence data from African plants and animal species (Ebenezer, *et al.*, 2022), and c) Absence of a federated DSI storage (database), analysis, visualization, and sharing platforms, to maximize capacity to use and share anchored through national frameworks across Africa (Sharaf, *et al.*, 2023, 2024). To illustrate, Africa is underrepresented in biodiversity data governance, and the African Group, Africa's negotiating body at the KMGBF, proposed establishing a centralized database for DSI under the Clearing-house Mechanism (CHM), but some countries prefer to use existing public databases mechanism (Tsioumani, *et al.*, 2024). While the framework that established existing public databases is anchored in national or regional institutions and ratified through legislative instruments in Japan, Europe or the USA; however, no African nation is a signatory of the agreements that established these public databases (Sharaf, *et al.*, 2024).

3. *Separating access to genetic resources and DSI from benefit-sharing*: The KMGBF goals and targets recognise the interconnectedness between reducing current threats to biodiversity, sustainable use of biodiversity and benefit-sharing, given there is no clear separation between Goal B and C in the Targets delivery mechanism (Figure 1). For example, while the KMGBF recognises that benefit-sharing is coupled to use of genetic resources and DSI (UNEP Convention on Biological Diversity, 2022), a multilateral mechanism where access to DSI is decoupled from benefit-sharing (Scholz, *et al.*, 2022) will be incompatible with the objectives of the KMGBF (see Figure 1, Goal C & Target 13 in UNEP Convention on Biological Diversity, 2022) and domestic DSI provisions of some African countries such as Malawi where collection, export and utilization of genetic resources or DSI triggers benefit-sharing obligations (UNEP Convention on Biological Diversity, 2020).

4. *Variations in gender balance in African DSI researchers across geographical regions:* Women are predominantly underrepresented in research across Africa. For example, in 2021, around 35% of scientific researchers were females (UNESCO, 2024). This underrepresentation also differs from one African region to another (UNESCO, 2024). In particular, during the 2023 regional workshops of the AfricaBP Open Institute, the knowledge exchange programme of the AfricaBP (Sharaf, *et al.*, 2024), 38% of registered applicants from Southern Africa were female while 53% were from Northern Africa (Sharaf, *et al.*, 2024pp), suggesting any framework for mainstreaming gender balance in fulfilling Targets 22 and 23 will differ across African regions.
5. *Conflict between biodiversity conservation and poverty alleviation programmes:* The intricate challenge of balancing biodiversity conservation with poverty alleviation and sustainable development is underscored by the direct dependence of many communities on natural resources for their livelihoods (Wei, *et al.*, 2018). Finding a sustainable equilibrium that benefits both biodiversity and local populations remains a significant challenge (Sintayehu, 2018). By way of illustration, sequencing 100,000 endemic and indigenous African species will cost \$100 million per year over 10 years, but some might argue that \$100 million per year would be better spent on combating malnutrition and disease in impoverished communities across Africa (Ebenezer, *et al.*, 2022). Yet, consider the Human Genome Project, which cost around \$3 billion in 2003. By 2019, the human genetics and genomics sector alone was contributing \$265 billion annually to the US economy (Tripp & Grueber, 2021).
6. *Establishing transparent and inclusive mechanisms for ABS and aligning this with national strategies:* The successful implementation of the KMGBF (especially through DSI) requires responsibility and transparency supported by effective mechanisms for planning, monitoring, reporting and review, including alignment with national biodiversity strategies and action plans (Renard, 2023). However, several countries proposed to approach this in different ways (Waneyombo-Brachka and Abada, 2016, Tsioumani, *et al.*, 2024). To cite an instance, the African Group proposed establishing a centralized database for DSI to monitor access to and utilization of DSI, ensuring benefits are shared fairly and equitably; support the capacity of all parties; facilitate information exchange; and assist in monitoring compliance (Tsioumani, *et al.*, 2024). Some countries prefer to monitor access and utilisation of DSI, some prefer not to (Tsioumani, *et al.*, 2024, Adebola & Manzella, 2022). It is challenging to ensure accountability, transparency and responsibility in achieving the objectives of KMGBF without

monitoring access and use of DSI, however, this will require implementation infrastructure (Adebola & Manzella, 2022).

7. *Visualizing capacity-building as a one-way process*: The KMGBF recognises the importance of respecting Indigenous People, traditional knowledge, scientific approaches, and capacity-building in biodiversity conservation. However, while meaningful and equitable capacity-building effort is a two-way process (Crisp, *et al.*, 2000, Li, *et al.*, 2017, Jacob, *et al.*, 2024), the adopted KMGBF captures this as a one-way process, from developed to developing countries (Target 20, UNEP Convention on Biological Diversity, 2022). Indigenous People in Africa possess traditional knowledge that can be mainstreamed to conservation education (Selemani, 2020). For example, analysis of the management and sustainability of natural resources in Ghana reveals that indigenous knowledge systems such as taboos and totems have played major roles in conserving biological resources (Kosoe, *et al.*, 2020, Sinthumule, 2023).
8. *Lack of clarity on the emerging fields of synthetic and generative DSI*: It is important to ensure that AI and synthetic DSI applications are ethically and legally sound, particularly in the context of benefit-sharing from DSI (Hao, *et al.*, 2024). Currently, in the KMGBF, there is lack of clarity on mechanisms to navigate issues related to artificial DSI, artificial intelligence (AI) and benefit-sharing, especially in the emerging fields of synthetic and AI-generated DSI (Tsioumanis, *et al.*, 2024b, Vindman, *et al.*, 2024). Clarity on synthetic and AI-generated DSI must be made in the final KMGBF agreements to adapt to these fast-evolving fields. As of 2020, six African countries (Kenya, Malawi, Mozambique, Namibia, South Africa and Uganda) have established domestic measures addressing DSI (UNEP Convention on Biological Diversity, 2020, Adebola and Manzella, 2022). For example, Namibia's ABS legislation requires users who intend to access biological and genetic resources and their intangible components, which include genetic information or gene sequences, found in in situ or ex situ conditions, to apply for an access permit for research leading to commercialization, scientific research with a commercial purpose, commercialization, or export (Convention on Biological Diversity, 2020, Namibia, 2021, Adebola and Manzella, 2022).
9. *Mainstreaming ABS in KMGBF using existing ABS mechanisms*: National Biodiversity and Strategies Action Plans (NBSAPs) are the main national planning instrument for implementing the CBD at the national level, and thus the principal means by which to address the drivers of biodiversity loss by mainstreaming biodiversity across government and society (UNEP Convention

on Biological Diversity, 2011a, Cardona Santos, *et al.*, 2023). Incorporating NBSAPs signifies a commitment to responsible and ethical biodiversity management. However, the effective implementation of the Nagoya Protocol through the NBSAPs for each country is influenced by the unique national conditions, including the political landscape, economic resources, social issues, technological and administrative infrastructure, policies and political will (Whitehorn, *et al.*, 2019). Countries with federated social security schemes and strong footprints in DSI generation and use, but with less biodiversity, are more likely to promote open-access with unrestricted DSI access and use in their NBSAPs and ABS regimes (Whitehorn, *et al.*, 2019, Sara, *et al.*, 2022, Maney, *et al.*, 2024, Tsioumani, *et al.*, 2024). On the other hand, countries with less footprints in DSI generation and use, without federated social security schemes, and where such social securities are anchored onto their biodiversity, are more likely to capture monitoring and reporting of DSI access and use in their NBSAPs and ABS regimes (Whitehorn, *et al.*, 2019, Cartney, *et al.*, 2022, Maney, *et al.*, 2024).

## **Recommendations on the implementation of the KMGBF in Africa**

Here, we provide a set of recommendations that African scientists, non-scientists, policymakers, and the CBD, must consider for effective implementation of the goals of the KMGBF across Africa:

1. *Maximize awareness creation, equitable co-operations, clear policy and legal frameworks:* African countries need to implement, and enforce regulations and laws that are robust and that align with international agreements like the Nagoya Protocol to ensure the fair and equitable sharing of benefits arising from genetic resources (Wynberg and Laird, 2022). Creating policy awareness, educating the public about the importance of biodiversity, DSI, and the roles they can play in conservation is vital (Akindele, *et al.*, 2021, ABS Capacity Development Initiative, 2024). Awareness campaigns can be conducted through schools, print and digital media, and community workshops to foster a culture of conservation (Foyet and Louis, 2023). Engaging Indigenous Peoples and local communities as key parties in biodiversity conservation is crucial. The African community, and its Indigenous People, need to make informed decisions on the significance of coupled access, sustainable use and benefit-sharing of DSI, to achieve the KMGBF goals (Coolsaet & Pitseys, 2015).

2. *Maximize capacity to generate, study and use DSI*: AfricaBP goal aims to increase the capacity to generate through promotion of on-the-ground sequencing efforts (Ebenezer, *et al.*, 2022). AfricaBP has focused on sequencing African species locally and organizing regional training workshops that maximize the usage of local sequencing capabilities (Sharaf, *et al.*, 2024). However, more still needs to be done in scaling up capacity-generation efforts through distributed technology acquisition and use across Africa, and AfricaBP is enabling this so far (Ebenezer, *et al.*, 2022, Sharaf, *et al.*, 2023, 2024). The AfricaBP ecosystem has catalyzed the acquisition of the only PacBio Revio sequencer in Africa which was purchased through a public-private partnership (PPP) between two AfricaBP partners: Inqaba Biotechnical Industries and the University of South Africa (African BioGenome Project, 2024, Inqaba Biotec, 2024, University of South Africa, 2024). PPPs such as this need to be encouraged, supported and maximized across Africa.

Absence of a DSI federated database for storage, analysis, visualization and sharing platforms to mainstream capacity to generate and use, is one of the weak points of Africa (O'Connell, *et al.*, 2019). Additionally, to help address the issues around capacity to use DSI, the AfricaBP has recently initiated proposals for the creation of the African Digital Sequencing Information Data Bank for Biodiversity and Agriculture (Sharaf, *et al.*, 2024), through a hub-and-spoke model, to grant agency to participating African institutions and organizations to develop and advance data storage, analysis, visualization and sharing platforms. Large-scale, targeted, and people-oriented investments on this DSI data bank platforms across Africa will create dynamic and cross-domain thinkers (Sharaf, *et al.*, 2023, Parker-Allie, *et al.*, 2023) with deep knowledge in a wide range of DSI types, applications and mainstreaming of the KMGBF across Africa (Renard, 2023). This proposal could be supported, anchored, or absorbed, by the African Union, or its specialized scientific agencies such as the African Union – Inter-Africa Bureau for Animal Resources, Inter-African Phytosanitary Council (Dosso, *et al.*, 2023), as a permanent structure for DSI to ease regulatory hurdles (Sharaf, *et al.*, 2024)

If a multilateral mechanism of benefit-sharing is agreed upon and finalized (Laird, *et al.*, 2020b), the first tranche of funds received by African governments could go into setting up national, regional databases or used to support the federated coordination and delivery of these data banks. Such data banks could also benefit from international partnerships (Levine, 2002) which could be counted towards benefit-sharing credits for participating international partners, including

public databases (Abebe, *et al.*, 2021, see Target 23 for further details on tools and capacity-building for mainstreaming of KMGBF). Expertise and information generated from the data bank could be used to build DSI curriculum and research programmes across Africa (Sharaf, *et al.*, 2023), hence meeting KMGBF Targets 20, 21, and 22 (Figure 1).

3. *Maximize participation of Indigenous Peoples and local communities in decision making and capacity-building initiatives:* Traditional knowledge often does not fit into conventional intellectual property frameworks, necessitating the development of *sui generis* systems to safeguard these rights (Dutfield, 2010). Apart from the formal regulatory aspects, conservation initiatives must also be culturally sensitive and inclusive, adopting human rights approach in biodiversity conservation through free and pre-informed consent, ensure that Indigenous Peoples and local communities retain ownership and control over their knowledge with mechanisms for negotiating and enforcing benefit-sharing agreements, and recognize the diverse values and worldviews of Indigenous Peoples and local communities (Boyd & Keene, 2021, Tauli, 2022.). Social justice and ethics considerations include addressing historical injustices and ensuring that Indigenous Peoples and local communities have a meaningful role in conservation governance as equal partners (Tobin, 2013, Morgera, 2014). Integrating science with Indigenous Peoples and local communities' traditional ecological knowledge is vital for the conservation process. For example, by combining remote sensing and climate modeling digital tools with Indigenous Peoples and local communities' deep local ecosystem knowledge, genomics projects such as the AfricaBP can enhance biodiversity conservation while grounding efforts in the communities' cultural and ecological realities (Garnett, *et al.*, 2018)
4. *Promote national and societal co-operations:* National and societal cooperation is crucial for achieving the goals set forth in the KMGBF (Mair, *et al.*, 2024) and the practical implementation of projects like the AfricaBP. Challenges like political instability, limited resources, and conflicts between national policies and local practices can hinder the KMGBF (Wilson, 2009); however, collaborative efforts at multiple levels can address ethical, legal, and social challenges, integrate traditional knowledge, and promote sustainable biodiversity conservation (Mabele, *et al.*, 2022). Effective national cooperation involves harmonizing biodiversity policies across different sectors to ensure cohesive action plans. Integrating biodiversity considerations into national development plans, agricultural policies, and climate strategies is essential (Arthur, 2019). A

community-based natural resource management program in Namibia is one evidence of successful national and societal cooperation in biodiversity conservation. By involving local communities in wildlife and resource management, this initiative has improved both biodiversity and community livelihoods (Naidoo, *et al.*, 2010). Societal cooperation should also involve respecting and integrating traditional knowledge, providing platforms for Indigenous Peoples and local communities to share their insights, and ensuring their participation in decision-making processes (Sinthumule & Mashau, 2020).

5. *Allocate adequate resources to develop and implement NBSAPs:* African countries should allocate adequate resources to develop and implement NBSAPs, and these plans should be backed by sufficient funding to support conservation initiatives and community engagements (Whitehorn, *et al.*, 2019). Providing financial incentives for sustainable practices, such as tax breaks for conservation activities or subsidies for sustainable agriculture, can encourage broader participation in biodiversity conservation (De Roeck, 2020). Encouraging businesses to adopt sustainable practices and contribute to biodiversity conservation through corporate social responsibility initiatives can have a significant impact (Rampersad & Skinner, 2014). Partnerships between public institutions and private companies can lead to innovative conservation projects and sustainable resource management (Muller, 2010).
6. *Promote equitable collaborations in genetic resources and DSI:* Research between national universities, research institutions, and international organizations can drive innovation and share knowledge (Dine, *et al.*, 2024). Joint research projects can focus on biodiversity monitoring, ecosystem restoration, and the sustainable use of genetic resources (Mc Culloch-Jones, *et al.*, 2021). These collaborations should have ELSI at its forefront. Developing collaborative projects that involve government agencies, non-governmental organizations, private sector, and local communities can pool resources and expertise for more effective biodiversity conservation (Obiero, *et al.*, 2020). These projects can focus on habitat restoration, species protection, and sustainable livelihoods.
7. *Foster inclusive governance:* Establishing multi-stakeholder platforms that include representatives from government, Indigenous Peoples and local communities, civil society, and the private sector can ensure inclusive governance (Kusters, *et al.*, 2018). These platforms can facilitate dialogue, coordinate actions, and monitor progress towards biodiversity goals (Ratner, *et al.*, 2022). Integrating biodiversity policies with broader socio-economic policies

can ensure that biodiversity conservation is considered in all aspects of national development (Akindele, 2024). This holistic approach can address the root causes of biodiversity loss and promote sustainable development (Knight, 2024).

8. *Implement transparent monitoring and reporting mechanisms:* A successful implementation of the objectives of KMGBF will require monitoring access and use of DSI. Implementing transparent monitoring and reporting mechanisms to track progress towards the framework's Targets (UNEP Convention on Biological Diversity, 2022), including DSI, is essential. Regular reporting and independent assessments can ensure accountability and inform necessary adjustments to strategies (Angeles & Catap, 2023). To enable effective implementation of the KMGBF Targets, monitoring DSI access and use will maximize responsible and equitable open science (Figure 1) (Tsioumani, *et al.*, 2024), especially where this is in line with the respective national frameworks. A simplistic analogy is through the lens of research mobility. While research mobility across national borders enables scientific advancements (Liu & Hu, 2022), researchers still require minimum travel documentations such as passports or other forms of identification - even for countries with free movement of people and services, for example, the Economic Community of West African States or the European Union (Omotuyi, *et al.*, 2024, Mouthaan, 2022).
9. *Interoperability of key regulatory instruments in biodiversity conservation:* The Convention on Biological Diversity (CBD), the Cartagena Protocol on Biosafety, the Nagoya Protocol on Access and Benefit-sharing, and the KMGBF are key regulatory instruments designed to address various aspects of biodiversity conservation (Ring & Barton, 2015). Understanding these regulatory instruments, and their interoperability ensures a comprehensive and cohesive approach to managing biodiversity, biosafety, genetic resources, and equitable benefit-sharing (Avilés-Polanco, *et al.*, 2019, Ekardt, *et al.*, 2023).

African policies should integrate the principles and requirements of the CBD, Cartagena Protocol, Nagoya Protocol, and the KMGBF. This will not only ensure synergy between these instruments but also ensure that biosafety, access and benefit-sharing, and biodiversity conservation, are addressed cohesively. This can be achieved by establishing unified monitoring and reporting mechanisms (Lachenmeier & Montagnon, 2024) which can also help track progress towards the goals and targets set by these regulatory instruments, ensuring transparency, accountability, consistency and effective implementations across Africa (Maney, *et al.*, 2024).

## **AfricaBP's framework to implementing the KMGBF goals and targets**

As the world navigates the challenges of biodiversity loss and climate change, Africa's role in safeguarding global biodiversity has never been more critical (Scheren, *et al.*, 2021; Bakarr, 2023). AfricaBP is at the forefront of efforts to harness genomic data and technological innovation to preserve the continent's rich biodiversity (Ebenezer, *et al.*, 2022). The AfricaBP Theory of Change integrates ELSI considerations, as previously discussed above, into the broader implementation of the KMGBF goals. Our framework, informed by insights gained from AfricaBP Open Institute initiatives (Sharaf, *et al.*, 2023, 2024), roundtable meetings, research, and the recently conducted ABS survey across the continent (see Text Box 1), focuses on the following key areas:

1. *Strengthening biodiversity data infrastructure:* A central focus for AfricaBP is the development and expansion of a robust digital sequence information (DSI) data bank dedicated to African biodiversity for storage, analysis, visualization and sharing in line with national regulatory framework (Sharaf, *et al.*, 2024). This data bank will serve as a critical resource, providing researchers, policymakers, and local communities with access to genetic data essential for crop and animal improvement, conservation, and sustainable use. By ensuring ethical and secure management of this data, AfricaBP aims to safeguard Africa's biodiversity. This approach will promote the implementation of the KMGBF while maximizing its potential for scientific and economic advancement. In parallel, AfricaBP is prioritizing the generation and collection of genomic data across the continent, driven by African institutions. This includes sequencing and documenting underrepresented species, from staple crops and livestock, to wild species and microorganisms crucial for ecosystem health and resilience (Ebenezer, *et al.*, 2022). This effort will fill significant gaps in global biodiversity data, enabling more effective conservation strategies and sustainable development initiatives.
2. *Communication, awareness creation and capacity-building, and empowering local communities:* For AfricaBP, the empowerment of local communities and the development of a skilled workforce are essential components of its strategy. The AfricaBP Open Institute focuses on awareness and capacity-building for scientists, data managers, and policymakers in bioinformatics, genomics, and ELSI research practices (Sharaf, *et al.*, 2023, 2024) to maximize assimilation and uptake of biodiversity projects (UNEP Convention on Biological Diversity, 2022). Since 2022, AfricaBP has trained over 450 African scientists providing them with hands-on genomics and bioinformatics training and has built awareness for close to 5000 Africans through its Open Institute workshops. These have included

practical sessions that focus on ELSI related to acquiring and using genetic resources (Sharaf, *et al.*, 2023, 2024). AfricaBP is building and empowering local communities, and helping to achieve Goal D of the KMGBF by strengthening governance and management through grassroots involvements while also equipping individuals with the skills needed to manage and utilize genomic and biodiversity data (Sharaf, *et al.*, 2024). Similarly, AfricaBP ensures geographical diversity and co-developments in its activities. This includes the AfricaBP Open Institute regional workshops which, in 2023, attracted 21 African organizations that hosted 28 workshops in 10 African countries, across all five African geographical areas, including in Cameroon and Algeria that are not traditional destinations for biodiversity genomics and bioinformatics capacity-building efforts (Sharaf, *et al.*, 2024).

3. *Promoting gender diversity in the African biodiversity genomics landscape:* AfricaBP is intentional about gender, geographical and career stage diversities as its cornerstone, especially through the AfricaBP Open Institute. Out of the 14 research fellowship awards made by the AfricaBP Open Institute in 2024, eight (8) were awarded to females while seven (7) were awarded to males. Similarly, of the 3783 registered attendees during the AfricaBP Open Institute regional workshops in 2023, 41% were females while 59% were males (Sharaf, *et al.*, 2024). Finally, the current Chair of AfricaBP and the Chair of the AfricaBP Pilot Committee are all females. Additionally, the AfricaBP regional nodes are coordinated by two (2) females (Southern and Eastern Africa) and three (3) males (Northern, Western, and Central Africa). The leaders of the subcommittees of the AfricaBP Pilot Project are balanced between 63% females and 46% males. This is helping to address Target 23 of the KMGBF, enabling gender-responsive representation and participation in decision-making in biodiversity genomics, since the scientists now trained will go on to become leaders in their various subfields within biodiversity and policy making.
4. *Facilitating research and innovation by advancing ethical and legal frameworks:* AfricaBP advocates for the harmonization of biodiversity legal frameworks across Africa (Ebenezer, *et al.*, 2022) as African countries will benefit from a unified position on genetic resources and DSI (Adebola & Manzella, 2022). By fostering international and regional collaborations, AfricaBP brings together African researchers and global partners to advance biodiversity science. These collaborations will leverage AfricaBP's data and resources, driving innovation in the sustainable use of biodiversity for economic development. AfricaBP provides ELSI support to its members, partners, and participating African institutions and

scientists through designing and developing template material and data transfer agreements. Additionally, AfricaBP aims to ensure that all publications arising from its genomics research are accompanied by a section describing ELSI implementations, including compliance with (or advancement of) relevant regulations and provisions under the guidance of the AfricaBP ELSI subcommittee.

5. *Promoting sustainable use of biodiversity, advocating for policy integration and global representation:* Sustainable use of biodiversity is at the heart of AfricaBP's mission (Ebenezer, *et al.*, 2022). By leveraging genomic data, AfricaBP aims to drive innovation in agriculture, focusing on developing resilient crop varieties, improving livestock breeds, and supporting sustainable agricultural practices (Mmbando, 2024). These efforts will enhance food security, improve livelihoods, and help communities adapt to the impacts of climate change. In addition to agricultural innovation, AfricaBP is committed to supporting conservation and restoration initiatives across the continent. These efforts will contribute to the broader goals of the KMGBF, ensuring that Africa's biodiversity is preserved for future generations.

Additionally, AfricaBP works to integrate biodiversity and genomic data considerations into national and regional policies across Africa, ensuring alignment with the objectives of the KMGBF and Nagoya Protocol (Figure 1 and Text box 1). This includes advocating for Africa's interests and perspectives in global biodiversity discussions, particularly in the implementation and review processes of the KMGBF. By ensuring that Africa's unique challenges and opportunities are addressed in global biodiversity policy, AfricaBP aims to secure the resources and support needed to achieve its vision of a sustainable and biodiverse Africa.

6. *Engaging African policymakers through roundtable meetings on ABS and DSI:* AfricaBP initiated a community of practice monthly roundtable meetings and this was held between late 2021 and November 2022 to better understand, and support African countries' requirements under the Nagoya Protocol on Access and Benefit Sharing (ABS) (see Text Box 1). These meetings hosted African ABS National Focal Points from Zimbabwe, Malawi, Nigeria, and Liberia, as well as ABS specialists from the Wellcome Sanger Institute in Hinxton, UK, and the UNEP CBD in Montreal, Canada. The fundamental objectives were to help AfricaBP understand and comply with ABS by assessing the diverse needs across the continent, promote regional co-operations among African nations, and tackle common challenges related to biodiversity conservation, climate change,

and food security, identify areas where capacity-building is needed for effective implementation of the CBD and its protocols, including technical and financial support, and ensuring alignment of national policies with regional and global biodiversity goals. AfricaBP ensured these meetings were well-publicized, attracting participants from both within and outside Africa. However, challenges included unreachable contacts for some invited speakers, time zone differences, language barriers (mitigated by translators), obstructed internet access, and electricity fluctuations, which limited effective communication and participation.

7. *Understanding access and benefit-sharing and KMGBF through survey developments and analysis:* AfricaBP carries out open surveys to gain deeper understanding of the implementation of the Nagoya Protocol on Access and Benefit-Sharing procedures as well as the KMGBF landscape in various African countries (See text box 1, Figure S1 - S3 for additional details).

### **Text Box 1**

The survey dataset (Figure S1 - S3) provides a comprehensive overview of institutional participation across various countries, revealing an apparent overrepresentation of Nigeria (19 institutions), Kenya (11 institutions), and Ethiopia (10 institutions) (Figure S1). This suggests that these nations may exhibit a heightened interest in genetic resources, likely due to the significant agricultural and biodiversity stakes within their borders. The role that state owned or federally governed institutions play should not be underestimated. The data indicated that the majority of these institutions are state-owned (34.5 %) or federally governed (25.3 %), underscoring the pivotal role of the public sector in genetic resource management. The governance landscape is further diversified by the presence of public-private partnerships and private not-for-profit organizations, reflecting a multifaceted approach to resource management. Moreover, the data reveal that a substantial proportion of these institutions (88.5%) engage in activities related to both plant and animal genetic resources, indicating the critical importance of these resources in the surveyed regions and likely reflecting a strong focus on agriculture, conservation, and biodiversity preservation.

Data on legal frameworks indicate that 75.5% of the countries have established laws on the protection of the rights of local and Indigenous people, but there is a considerable variation regarding policies on genetic sequencing or on the management of certain plant and animal species. These differences show that the levels of development with respect to regulation are not the same, and there could be different priorities at a

national level as previously reported in Ivey, *et al.*, 2021, 2023. Furthermore, the adoption of ABS policies tailored to Digital Sequence Information (DSI) remains limited, with 27.3% of respondents reporting the presence of such regulations. This suggests a critical area for policy enhancement, especially in light of recent decisions at the UNEP Convention on Biological Diversity COP15.

The integration of Word Cloud and sentiment analysis (Figure S2 and S3) provides a comprehensive understanding of the current state of genetic resources management and the implementation of ABS mechanisms across various countries. Through Word Cloud analysis, it becomes evident that academic and research institutions play a central role in the discourse surrounding genetic resources. This is highlighted by the frequent appearance of terms such as "University," "Research," and "Institute," which point to the significant contributions of academia in advancing both scientific knowledge and practical conservation efforts.

Sentiment analysis reveals that respondents generally have a positive view of their countries' alignment with the Nagoya Protocol and ongoing improvements in legislative and policy frameworks. This optimism reflects a broader commitment to strengthening governance structures for genetic resources, with many countries actively enhancing their legal provisions. The analysis reveals significant variations in sentiment, particularly regarding existing policies and legal frameworks. While some respondents are optimistic about their countries' progress, citing robust law development, others express concerns about challenges like low awareness, insufficient capacity, and lack of resources. These issues contribute to negative sentiment in certain regions, highlighting uneven progress in policy development and implementation across different African countries.

This analysis revealed major obstacles in implementing ABS mechanisms, highlighting barriers in establishing effective legal frameworks. Respondents identified insufficient financial resources, inadequate capacity, and poor infrastructure as critical issues needing urgent attention. These challenges hinder ABS implementation and widen regional disparities, emphasizing the need for greater policy harmonization, especially given the global importance of biodiversity conservation.

The analysis reveals mixed sentiments about the recent CBD-COP15 decision (Figure S3). Some respondents express uncertainty about the effectiveness of current mechanisms, while others acknowledge ongoing efforts by technical committees to address these challenges. This blend of optimism and concern underscores the issue's complexity and the need for further engagement with African stakeholders on these topics. The frequent mention of related terms in the word cloud ('strategy', 'convention',

etc) suggests respondents are keenly aware of the importance of adapting to new international agreements, particularly for implementing novel ABS mechanisms. Despite the challenges identified, there is a prevailing sense of hope and optimism for the future. Respondents generally expressed satisfaction with the thoroughness of the survey and appreciation for the ongoing initiatives aimed at improving the management of genetic resources, and advocating on how AfricaBP can play a more critical role in ABS regulations at the continent level.

The ongoing development of policies, along with the recognized need for continued support and resources, demonstrates a commitment to overcoming barriers and effectively implementing ABS mechanisms. This progress, highlighted by the current survey, emphasizes the critical issues, institutional roles, and policy stages shaping the global discourse on genetic resources. In this context, AfricaBP is playing a crucial role in establishing and harmonizing laws across the continent, paving the way for more effective and equitable management of genetic resources and ensuring biodiversity conservation efforts are globally coordinated and locally implemented.

## **Conclusion**

Africa supports current approaches in the conservation of biological diversity, and especially, implementation of ABS (African Union Commission, 2015). However, there is a need to address the multifaceted challenges of ELSI in Africa within the context of biodiversity and the 2030 Agenda for Sustainable Development (Katee, 2023) demands a comprehensive and collaborative approach. African nations must actively work towards fortifying legal frameworks, allocating sufficient resources, fostering community engagement, and integrating global commitments into their national strategies to achieve sustainable biodiversity conservation. The AfricaBP has demonstrated progress in creating awareness, facilitating research and innovation by advancing ethical and legal frameworks, and understanding access and benefit-sharing and KMGBF through roundtable meetings, survey development and analysis.

The KMGBF presents an opportunity for further action, with its successful implementation dependent on concerted efforts at local, national, and international levels. African policymakers can leverage the AfricaBP in order to make informed policy and implementation decisions for the KMGBF, especially through biodiversity genomics. This includes establishing permanent biodiversity genomics structures within the African Union and creating federated data storage, analysis, visualization, and sharing platforms. Achieving the goals of KMGBF will require more intentional investments in

DSI research and innovations across Africa. Such investments could involve African governments, research institutes, or funding agencies, and supported by international partners and funders, to help Africa meet its KMGBF goals.

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### **Competing interests**

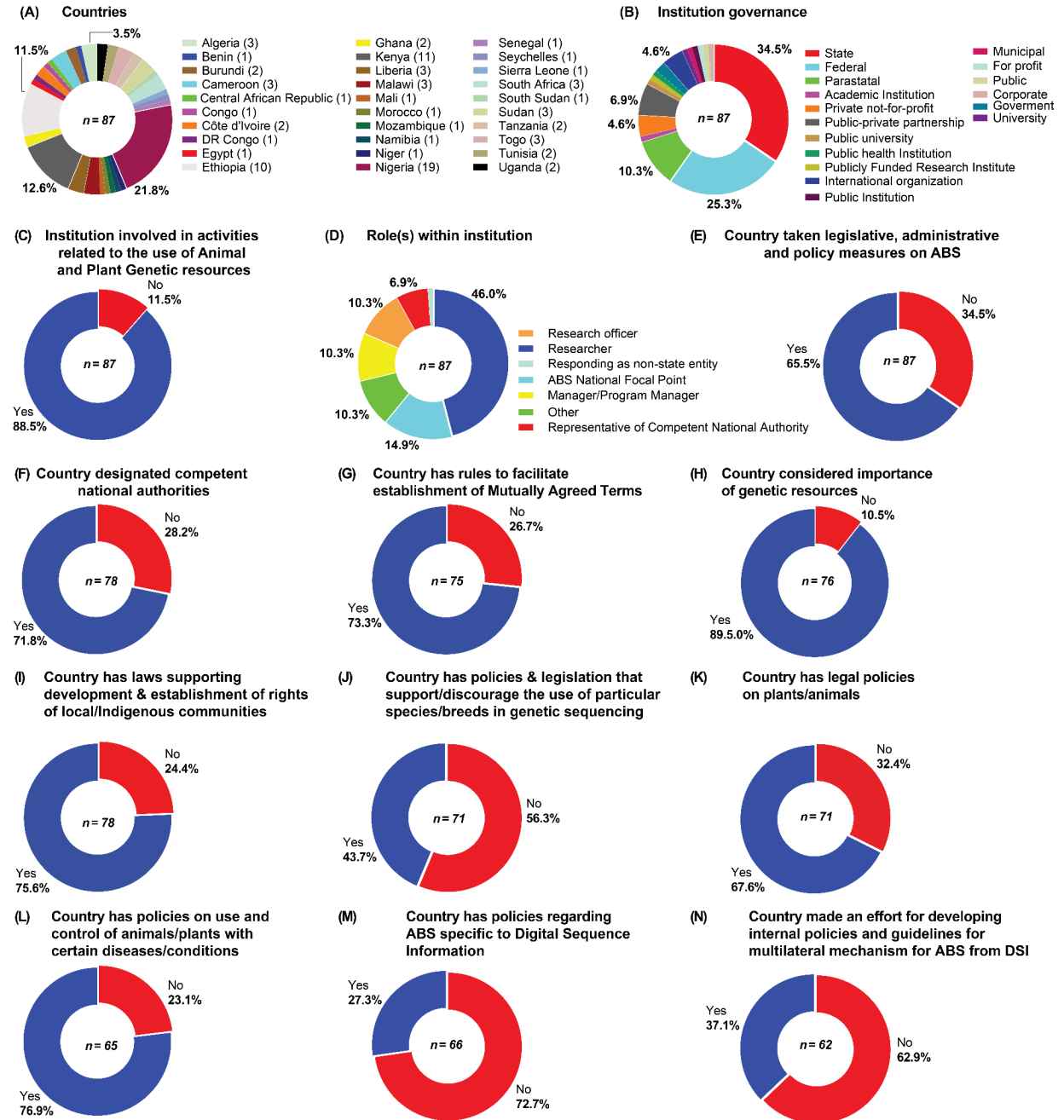
JEI is Principal Investigator at MyAfroDNA

## Authors contributions

S/N	Author name	Conceived idea	Literature review	Survey development and collection	Survey analysis	Production of manuscript diagram	Manuscript drafting	Manuscript revision	Supervision - oversight and leadership responsibilities	Journal correspondence	Manuscript review
1	Sally Katee Mueni	✓	✓				✓	✓			✓
2	Marietjie Botes	✓	✓				✓	✓			✓
3	Justin E. Ideozu			✓				✓			✓
4	ThankGod Echezona Ebenezer	✓	✓		✓	✓		✓	✓	✓	✓
5	Bouabid Badaoui		✓		✓			✓			✓
6	Varsha Shetty			✓			✓				✓
7	Sadye Paez		✓					✓			✓
8	Anne WT Muigai		✓					✓			✓
9	Girish Beedessee				✓	✓					✓
10	Sizwe Innocent Ndlovu		✓					✓			✓
11	Emmanual Hala						✓				✓

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# Supplementary

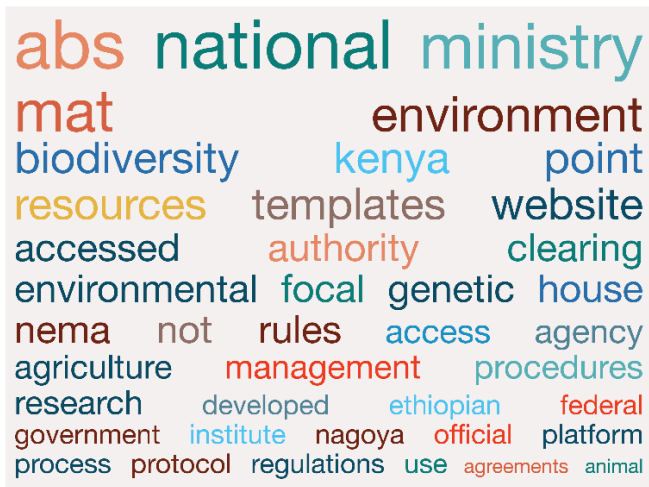


**Figure S1: Diagram showing participants' responses to surveys on the Nagoya Protocol on Access and Benefit Sharing (ABS) as well as the multilateral mechanism for ABS from DSI.** A-D: Distribution of participating countries (number of participants = 87), their institutional governance, and role of participants within their institution. E-H: Majority of countries (> 65%) have legislative, administrative and policy measures on ABS, designated competent authorities, established Mutually Agreed Terms (MAT) and understood the importance of genetic resources. Notably, 28% of countries do not have a dedicated competent authority to administer ABS. I-L: Majority of countries (75%) have laws that support development of rights of local communities while this trend is reversed (with 56%) of countries not having policies and legislation for use of species in genetic sequencing. At least 67% of countries have policies on plants/animals, their use and control. M-N: Importantly, a high proportion of countries have no ABS policies specific to Digital Sequence Information (DSI) nor made any effort to develop a multilateral mechanism for ABS from DSI. Figures were generated using GraphPad Prism version 10 for Mac. (GraphPad Software, Inc. [www.graphpad.com](http://www.graphpad.com)).

(a) Participant's response to type of activities that they are engage in.



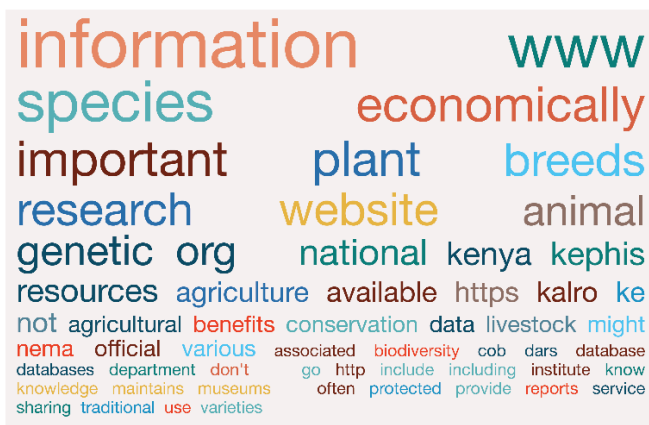
(b) Participant's reponse as to where rules, procedures or templates to facilitate the establishment of Mutually Agreed Terms (MAT) can be accessed.



(c) Has participant's country considered the importance of genetic resources for food and agriculture and their special role for food security and what measures taken in light of this consideration?



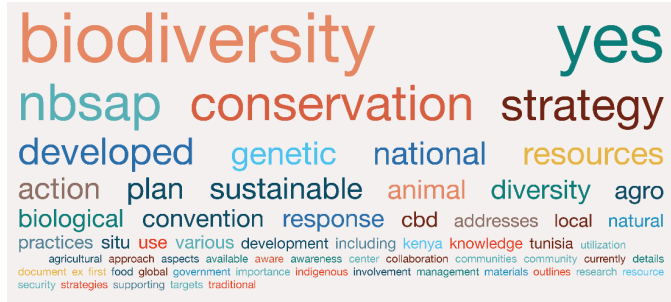
(d) What information do participants maintain on the economically important animal or plant species and breeds in their country?



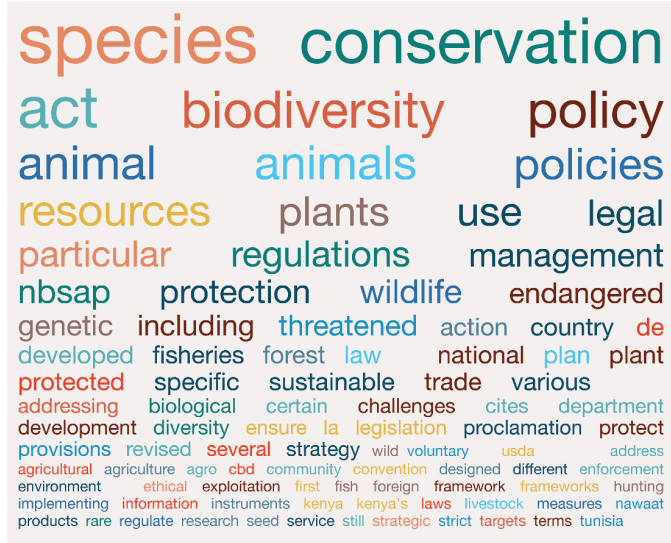
(e) Does participants' country have policies and legislation that support or discourage the use of particular species or breeds in genetic sequencing?



(f) Has participant's country developed, in response to the Convention on Biological Diversity, a National Biodiversity Strategy that addresses agro-biodiversity and animal genetic resources conservation and sustainable use?



(g) Does participant's country have any legal policies on particular plants and animals?



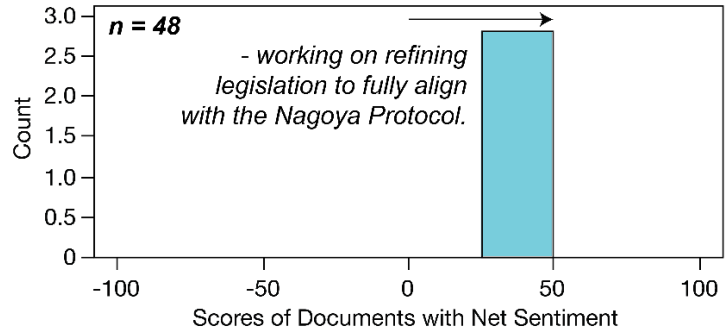
(h) Does participant's country have policies on use and control of animals or plants with certain diseases or conditions?



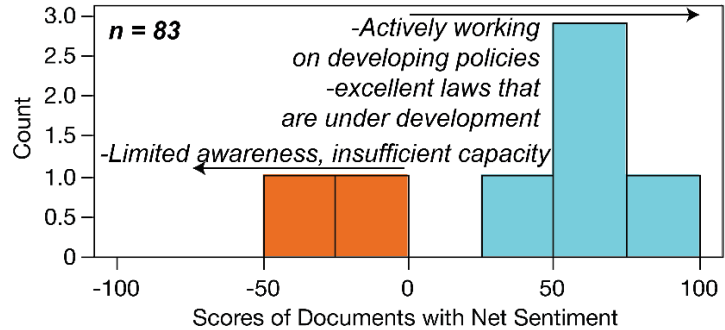
**Figure S2: Word cloud analysis from 87 responses to free text questions in the survey.** Most of the words highlighted are not surprising. A-B: Most of the participants were involved in “research” and “ABS”, “national ministry” suggested where rules for establishment of Mutually Agreed Terms (MAT) can be accessed. C-D: “Resources”, “genetic”, “food”, “conservation”, “agriculture” were the most prominent terms on measures taken and how the information was maintained. E-H: It was not surprising to see that majority of the respondents responded positively “yes” to having a developed strategy that address agro-biodiversity and animal genetic conservation and use with legal policies pertaining to “species conservation” and that countries have policies for

use and control of animal/plants with “diseases”. Analysis was carried out using the Text Explorer platform in JMP (Version 17.0. SAS Institute Inc., Cary, NC, 1989-2023).

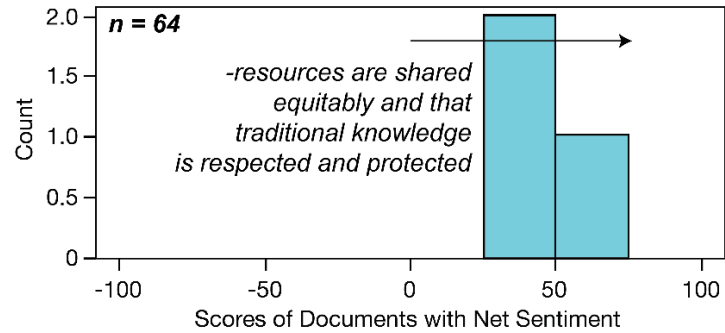
(a) Participant's response to their country taking legislative, administrative and policy measures on Access and benefit Sharing (ABS)



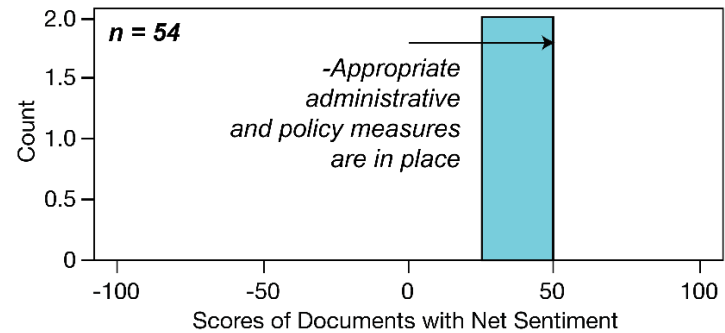
(b) Participant's response to the state of knowledge on policies and legal framework within their country's plant and animal genetic resources



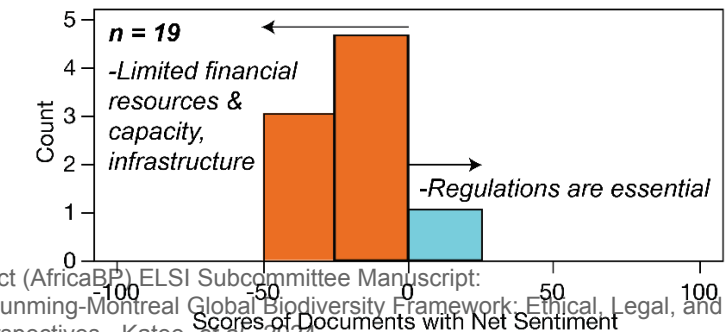
(c) Participant's knowledge on policies governing access to genetic resources in their country and if it is subject to Prior Informed Consent (PIC)



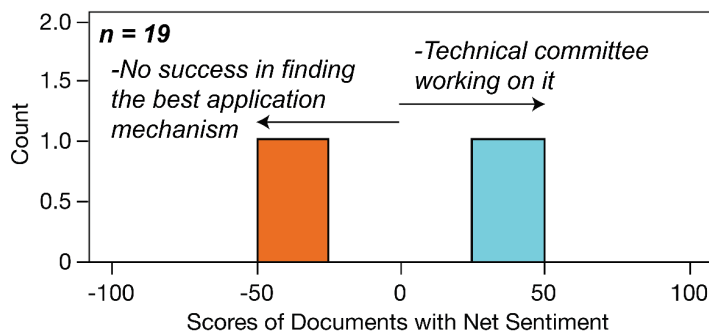
(d) Has participant's country considered the importance of genetic resources for food and agriculture and their special role for food security and what measures taken in light of this consideration?



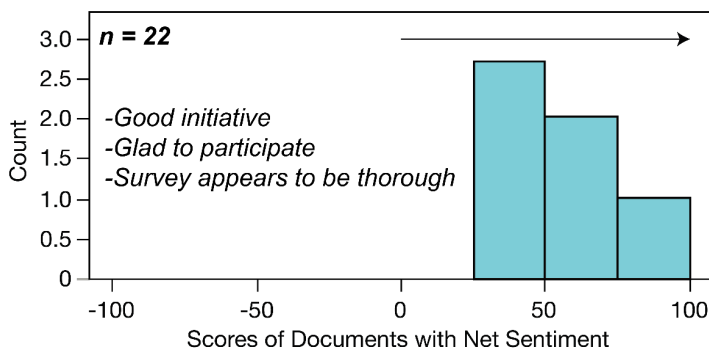
(e) What challenges does the participant's country had with implementing ABS arising from the equitable use of genetic resources?



(f) The CBD-COP15 decided to adopt a multilateral mechanism for ABS from the use of Digital Sequence Information (DSI) on genetic resources, including a global fund. Has the participant's country made any efforts towards developing internal policies and guidelines regarding the same?



(g) Participant's opinion on the survey



**Figure S3: Sentiment analysis reveals positive sentiments about policies implemented by their country with negative sentiments and challenges associated with lack of financial resources and infrastructure.** A-D: Diagram shows the result of the sentiment analysis performed in at least 54 textual responses to questions regarding their country taking legislative, administrative and policy measures on Access and Benefit Sharing (ABS) and if the country has considered the importance of genetic resources. In general, responses were positive with many countries found to be working on refining legislation and there are appropriate administrative measures in place (as shown by blue bars with high overall positive scores). However, there were challenges such as limited awareness and insufficient capacity were identified with respect to the country's state of knowledge on policies and legal framework for animal/plant genetic resources. E-F: Other challenges such as limited financial resources, capacity, infrastructure, and lack of an ideal mechanism were identified from countries implementing ABS sharing of genetic resources and how to develop internal policies and guidelines. G: Participants (n =22) found that this survey was a good initiative and were glad to participate in it. **XXX**. Sentiment analysis was carried out using the Text Explorer platform in JMP (Version 17.0. SAS Institute Inc., Cary, NC, 1989-2023).

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