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Bird monitoring in Africa: present state and future prospects

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Summary

Biodiversity monitoring is essential to inform the state of wildlife populations, and the impacts of environmental change, conservation intervention, and sustainable development policies and actions. We review the current state of bird monitoring across Africa using public questionnaires and semi-structured interviews. We received 87 questionnaire responses from 46 (of 54) countries and, additionally, 24 in-depth interviews were carried out. Multiple data collection methods were reported with total counts of individuals being most frequent, but all-species surveys, essential for quantifying ecosystem health, were restricted to bird atlases and Common Bird Monitoring (CBM) projects in Kenya, Uganda, and Botswana. Data collection relied largely on volunteers, but their motivation, recruitment, training, and retention is a continuing challenge. The most sustainable programmes were driven by clear policy objectives (e.g. waterbird monitoring under the Ramsar Convention or the Convention on the Conservation of Migratory Species), monitoring of individual groups (e.g. raptors, vultures, bustards), specific threatened species, and where clear national priorities had been set within government agencies. Use of monitoring data by governments in country biodiversity reports or National Biodiversity Species Action Plans (NBSAPs) varied widely and, for many countries, simply did not exist. A lack of skilled analysts and a comprehensive approach to data curation and ownership were identified as major limitations. A more strategic approach to funding and monitoring is needed, whereby smaller funders collaborate to reduce costs associated with applying for small amounts of money, and bird (and biodiversity) monitoring is explicitly integrated with sustainable development goals to exploit broader funding streams.

Review Article

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Resumen

La surveillance de la biodiversité est essentielle pour informer sur l'état des populations sauvages et ainsi que sur les impacts des changements environnementaux, des mesures de conservation et des politiques et actions de développement durable. Nous avons examiné l'état actuel de la surveillance des oiseaux en 'Afrique à l'aide de questionnaires publics et d'entretiens semi-structurés. Nous avons reçu 87 réponses provenant de 46 pays (sur 54) et, en complément, 24 entretiens approfondis ont été menés. Plusieurs méthodes de collecte de données ont été rapportées, les dénombrements totaux d'individus étant les plus fréquents, cependant les inventaires couvrant toutes les espèces, essentielles pour quantifier la santé des écosystèmes étaient limités aux atlas ornithologiques et aux programmes de Suivi des Oiseaux Communs (CBM) au Kenya, en Ouganda et au Botswana. La collecte des données reposait largement sur des bénévoles, mais leur motivation, leur recrutement, leur formation et leur fidélisation restent des défis permanents. Les programmes les plus durables étaient ceux motivés par des objectifs politiques clairs (par exemple le suivi des oiseaux d'eau dans le cadre de la Convention de Ramsar ou de la Convention sur la Conservation des Espèces Migratrices), le suivi de groupes particuliers (par exemple les rapaces, vautours, outardes), des espèces menacées spécifiques, ainsi que ceux où des priorités nationales clairement définies avaient été établies au sein des agences gouvernementales. L'utilisation de données librement accessibles par les gouvernements dans les rapports nationaux sur la biodiversité ou les Plans d'Action Nationaux pour la Biodiversité (NBSAPs) variait considérablement et, pour de nombreux pays, était inexistante. Le manque d'analystes qualifiés et l'absence d'approche cohérente en matière de gestion et de propriété des données ont été identifiés comme des obstacles majeurs. Une approche plus stratégique du financement et du suivi est nécessaire, dans laquelle les petits bailleurs collaborent pour réduire les coûts liés aux demandes de financements de faible montant, et où le suivi des oiseaux (et de la biodiversité) est explicitement intégré aux objectifs de développement durable afin d'exploiter des sources de financement plus larges.

Introduction

Globally, biodiversity is in crisis, and the situation is particularly acute in Africa, where conservation and development goals are often in conflict and the pressures resulting from human population growth can be intense (Chapman et al. 2022). Healthy ecosystems maintain viable populations of native species and the ecological processes they engender, alongside human use and occupancy (Grumbine 1994), and are essential for human well-being due to the goods and services they provide (IPBES 2019; Mace et al. 2012). Implementing positive change, at local, national or regional scales, requires robust data to inform the decision-making process. Effective monitoring of biodiversity, of which avifaunas are an important component, provides a critical information base on the impacts of environmental and ecosystem change on species' populations (e.g. Nagy et al. 2022; Stephenson et al. 2022), and helps identify where to target scarce conservation funds most effectively. However, the strength of biodiversity monitoring in a country is strongly positively correlated with its per capita gross domestic product (Moussy et al. 2022), so countries in the Global South, including many in Africa where some of the highest levels of biodiversity and the greatest developmental challenges occur, disproportionately lack the data and tools to make informed decisions around land use and sustainable development (Stephenson et al. 2017).

Owing to their ubiquity, position near the top of the food chain, and relative ease of recording, birds are useful indicators of biodiversity, especially at larger scales and in terrestrial environments (Brooks et al. 2001; Howard et al. 1998). However, to be effective, avian monitoring schemes need to be carefully designed, from initial conception and planning through to data use and reporting (see Box 1). Examples of such schemes include: site assessments, e.g. Important Bird and Biodiversity Areas (IBAs) or Ramsar Sites, which require estimation of abundance; species assessments, e.g. International Union for Conservation of Nature (IUCN) Red List evaluation, where some measure of range occupancy may be sufficient; abundance indices in the wider countryside, e.g. Common Bird Monitoring (CBM); Wotton et al. 2020); impact reviews of land management or urban planning; evaluation of conservation interventions; environmental impact assessment, e.g. Performance Standard 6 of the International Finance Corporation (IFC PS6); reviews of sustainable business practices. A well-developed bird monitoring network (e.g. Gregory et al. 2008; Hudson et al. 2017; Lee et al. 2017; Underhill 2016) is likely to combine scientists designing and analysing studies with citizen scientist data collection (Greenwood 2007; Pocock et al. 2018). This can require hundreds, or even thousands, of experienced volunteers, something which is not currently possible in most African countries, and different approaches may be needed to those currently used in, for example, the USA and Europe. The application of conservation science methods to monitoring has seen many recent developments (e.g. Lahoz-Montfort and Magrath 2021; Nichols and Williams 2006; Stem et al. 2005) and these should be incorporated where possible when devising monitoring schemes, even where apparent barriers may operate. One example where this has been achieved is the Southern African Bird Atlas Project (SABAP2), which is the continent's flagship citizen science project (Lee et al. 2017; Underhill 2016), which has now extended, with varying degrees of take-up, across 14 African countries under the banner of the African Bird Atlas Project (Brooks et al. 2022).

In this study we assess the current state and potential of bird monitoring in Africa, seek options for its development while recognising the very significant limitations in capacity and financing, and provide a conceptual basis for greater integration of such work across the continent. We undertook this study through a questionnaire as well as semi-structured interviews with individuals or organisations considered to be key players in bird monitoring in Africa. These interviews provided snapshots of present activities and opinion which will have been influenced by past activities and data sets, as many of the interviewees were generally long-standing members of the research and conservation communities. For this study, we defined monitoring as periodic surveys of abundance or distribution (in terms of presence/absence) using standardised methods, to measure trends (preferably with associated measures of uncertainty) relevant to conservation targets (Greenwood 2003). There are many other past published and unpublished studies which were not necessarily designed to be on-going monitoring studies, but which can be repeated to give one-off measures of change, e.g. raptors (Thiollay 2006, 2007), vultures (Ogada et al. 2016), and Nubian Bustard *Nubotis nuba* (Collar and Wacher

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Box 1. A general framework for designing robust monitoring projects. For each stage of the design process key questions to be considered are indicated, along with some brief commentary on their importance and relevance

1. Aims and objectives	
What is being monitored?	Biodiversity monitoring can be established to detect change in range, abundance, density or presence at some scale, be that for a Red List assessment, an IBA, an ecoregion or a country. Surveys might focus on single species, particular groups, or all species present in an area.
What are the targets for action?	Monitoring implies that some action will follow a particular level of change in specific species or their habitats, such as listing species as threatened or implementing particular conservation measures.
How much precision is required?	A first consideration in a designed study is to decide what size of change (effect) in the study needs to be detectable; this will determine the size of the spatial or temporal sampling. For example, consideration for red-listing may only be appropriate if large changes are detected, habitat management will require smaller changes to be monitored. Sampling at random locations (possibly stratified by accessibility or habitat) enables inference to be extended to similar areas that are not sampled.
2. Study design	
What sampling protocol will be used?	Where possible sampling should be structured (in terms of collecting data over a predefined area for a predefined time). This usually leads to more robust results than simply collecting ad hoc lists (Boersch-Supan et al. 2019), such lists should always be 'complete' (i.e. all target species recorded) allowing absences to be inferred. Where possible repeat visits (or multiple independent observers) allow error/certainty in estimates to be quantified.
Who is doing the recording?	Using professionals often allows a greater degree of direction, but typically significantly limits the spatial or temporal scale that can be covered. Citizen scientists (volunteers) allow the opportunity to survey many more sites and undertake surveys over much larger areas and over longer time periods. Deployment of passive recording devices (triggered or continuous) may greatly improve sample density in some habitats/areas, such as forest.
How is detectability accounted for?	Even large and vocal species will vary in their detectability, e.g. between habitats or with time of day/season. All studies should consider using either distance-based sampling (Thomas et al. 2010) or repeat measures using occupancy models (Altwegg and Nichols 2019). Having highly consistent effort at the same sampling locations across seasons can reduce issues caused by differential detectability.
3. Data collection	
Are participants suitably trained?	Particularly important for multi-species surveys, consider both visual and sound identification.
Are field protocols clear (and safe)?	People are more likely to participate if they are confident that they can achieve what is asked.
How will data be recorded?	Recording on paper is generally 'safe', though consider taking photographs of data sheets at the end of each recording period. Apps on mobile devices allow recording directly to a computer and can incorporate validation on entry, reducing chance for error, but beware risk of batteries running out!
4. Data curation	
How are data stored?	For single species surveys a well-designed spreadsheet may suffice, but for surveys of any complexity, (relational) databases are to be preferred – these allow each piece of information to be stored only once, which maximises efficiency and minimises risk of error (e.g. multiple species records may be stored against a single site record, rather than having that site information repeated many times for each species).
Where are they backed-up?	All data should exist in at least two independent places. Use of commercial cloud storage minimises risk of long-term data loss. Once it is lost it cannot be replaced.
5. Data analysis	
Which methods are appropriate?	Robust analysis of structured data with consistent, repeated effort is almost always much easier than for ad hoc collected data, although these can be used given sufficient care (Johnston et al. 2021).
Are analysis methods repeatable?	Use of an open-source scripting language, such as R (www.r-project.org), rather than 'point-and-click' menu-driven software enables analyses to be repeated and shared in a transparent way – enhancing confidence in their correctness.
6. Reporting and use	
Are data regularly summarised?	Regular use and analysis of data increase the likelihood that errors will be corrected in a timely fashion and provides evidence for the value of their continued collection.
Are data available to those who need it?	Data should be FAIR (www.go-fair.org/fair-principles/), that is: Findable (metadata stored in a place where it can be easily searched for); Accessible (it is clear where to get the data from, note this is not the same as 'open' – especially where rare/vulnerable species are concerned); Interoperable (well described and formatted so they can be integrated easily with other data); Reusable (data ownership and conditions around subsequent use are clear).

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2023). While these and data from the many research studies in Africa (e.g. Dendi et al. 2018) are extremely valuable sources of information, this paper focuses on regularly repeated monitoring schemes.

Methods

Most respondents were asked to complete a questionnaire in February and March 2021 (see Appendix S1 in Supplementary material) concerning current monitoring activities and barriers to implementing these, but those who had several projects to report or whom we identified as key players in an area were offered an online structured interview lasting approximately one hour based on the same questions but allowing for greater flexibility in responses. These included individuals from NGOs, national biodiversity institutes, academic organisations, international and global conservation organisations, and representatives of multilateral agencies.

A mix of formal and informal approaches was used to elicit responses from the questionnaire. We contacted known networks (e.g. the BirdLife International and Wetlands International African networks), key organisations inside and outside Africa, as well as individuals known to be expert or active in a particular country or taxonomic group. The most recent five-year summary of the International (African) Waterbird Census (IWC) was obtained from Wetlands International, and all the national coordinators who had sent in data during that period were contacted. Requests to fill out the questionnaire were made to all African BirdLife International partners and, where different, African Bird Club country representatives. More informally, a targeted call for information was put out on social media using Twitter (now X) hashtags (#ornithology and #monitoring) and via Facebook. Our aim was to elicit responses from all 54 African countries, as recognised by the United Nations.

Results

A total of 87 completed forms were received from 47 of 54 African countries; these often included details of multiple projects within the countries. Eleven were classed as multi-country projects, including four that covered the entirety of the continent: the IWC and three citizen science recording schemes (see below). Completed forms were received from Francophone ($n = 36$ forms), Anglophone ($n = 37$), and Lusophone countries ($n = 7$) (Figure 1). No responses were received from Equatorial Guinea, the only Hispanophone country in Africa. The Twitter campaign reached more people (English version: 30,725 impressions, 304 likes, 61 clicks to questionnaire; French: 20,596 impressions, 189 likes, 14 clicks to questionnaire) compared with Facebook (English: 4,235 impressions, 180 likes, 9 clicks to questionnaire; French: 2,563 impressions, 46 likes, 2 clicks to questionnaire).

Types of bird monitoring data collected

Details of a total of 170 different monitoring projects were submitted, approximately a third of which were total counts of individual birds observed at a site (Table 1), reflecting the widespread uptake

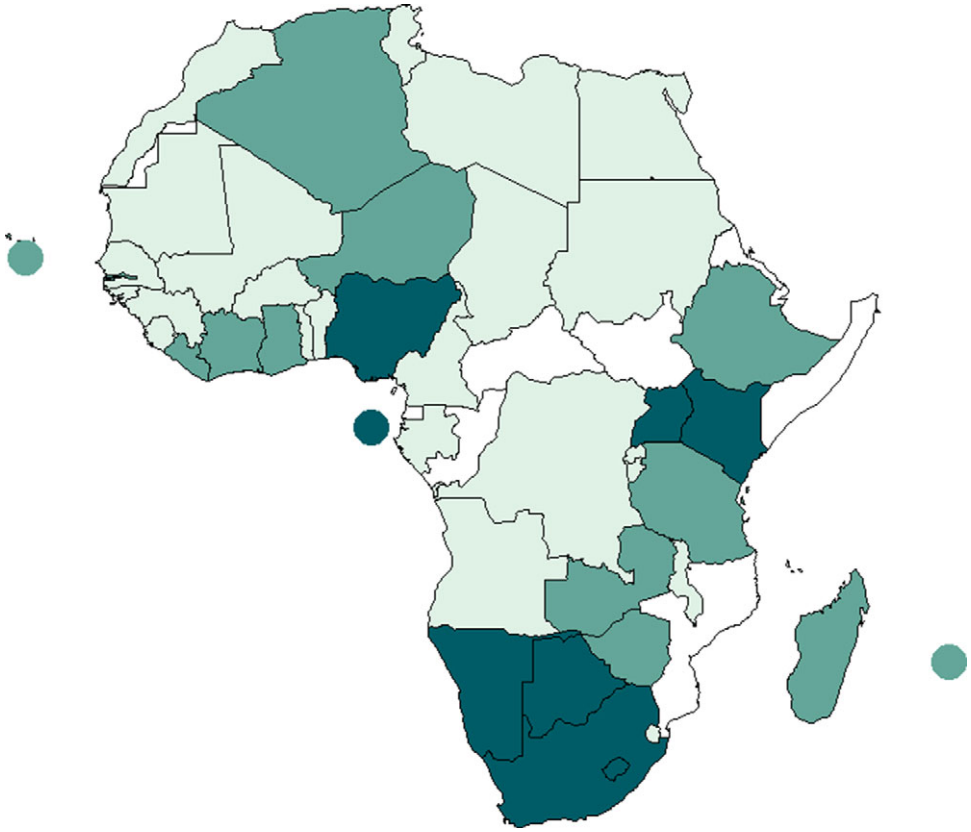

Figure 1. Map of Africa depicting the relative number of bird species groups that are regularly monitored at one or more sites in each country. No colour – incidental records only; pale green – one species group (e.g. waterbirds or vultures) or all species monitored in <5 sites; mid green – more than one species group monitored or 5–50 individual sites monitored nationally; dark green – national bird monitoring scheme using >50 sites. The island nations of Cabo Verde, São Tomé and Príncipe, and Mauritius are shown as coloured dots due to the scale of the map.

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Table 1. Response from the questionnaires (n = 87) in relation to the methods used in each monitoring project reported. Some questionnaires reported more than one monitoring project, yielding a total of 170 projects

Data collection method	*n*	Proportion
Total counts of birds observed	57	0.34
Presence/absence	25	0.15
Demographic parameters (survival, breeding success etc.)	23	0.14
Transects (with distance bands)	18	0.11
Transects (without distance bands)	18	0.11
Point-counts (with distance bands)	11	0.06
Atlas	9	0.05
Point-counts (without distance bands)	6	0.04
Bird ringing and marking	2	0.01
Nest recording	1	0.01

of the IWC, but also visual counts of raptors and vultures. Total counts were often assumed to be a census (i.e. complete counts with no error), where issues of detectability were not accounted for. Presence/absence type surveys were the next most common, followed by studies where total counts were undertaken, and breeding success was monitored. These tended to be species-specific and involved studies of breeding waterbirds (9 responses), vultures (7), cranes (2), bustards, ibises, seabirds, and Osprey *Pandion haliaetus* (all 1 mention).

Multi-species nest record schemes exist in Zimbabwe and Namibia and provide a valuable historical resource for looking at causes behind population change and the impacts of longer-term environmental change (e.g. climate change). However, the amount of new data being added to these is very limited. While many initiatives were country-specific, the four below span the continent and provide a strong basis for future development.

International Waterbird Census (IWC)

The IWC collates coordinated counts of waterbirds and is the most widespread scheme on the continent. It focuses primarily on "January counts" and, although some counts have taken place in July, more consistent monitoring in other months is needed to better understand the movements of intra-African migrants (Dodman 1997). In the 10 years prior to 2021, 50% of African countries participated and counts from over 4,000 sites were received, requiring continual financing, training, and motivation of volunteers. Sites were selected by participants, and it is not always clear exactly what proportions of the different types of wetlands were being surveyed, leading to statistical challenges such as how to address detectability and zero-inflation (this occurs when counts contain an excess of zero counts). Furthermore, substantial numbers of several waterbird species also occur in terrestrial habitats (e.g. some lapwing and stork species) and so are not covered. The Sahel, in particular, has a large number of ephemeral wetlands whose size and location vary with climatic conditions on annual and longer timescales. This makes population estimates based on traditional site-based counts less reliable, and techniques such as using aerial surveys and remote-sensed data to identify the number and size of ephemeral wetlands have the potential to provide more reliable population estimates (Suet et al. 2021). Aerial surveys can be effective in certain situations, such as for monitoring cranes in South Africa (Galloway-Griesel et al. 2023), but they can be financially and logistically challenging to organise (finding suitable aircraft and pilots and requiring specialist training for counters). There are increasing amounts of free remotely sensed data and open-source tools (e.g. QGIS, R, Google Earth Engine) for processing them, facilitating their use to augment and stratify large-scale surveys.

Common Bird Monitoring (CBM)

CBM, i.e. the standardised recording of multiple species on delineated plots, includes repeatedly monitoring a number of sites (both protected and non-protected) using point-counts or transects, with or without recording sightings in distance bands. While recording distance to observations (either precisely or in bands) can improve estimation of abundance (Buckland et al. 2008), it is more challenging for inexperienced observers, and around half of schemes (55%) did not incorporate it. Used over large areas of Kenya, Uganda, and Botswana, CBM provides trends in the presence and abundance of commoner species (Wotton et al. 2020). Sampling approaches vary. Botswana's scheme took a randomised stratified approach to select survey sites, whereas in Kenya and Uganda considerations such as where volunteers were based or loyalty to historically monitored areas determined which sites were covered.

Vulture and raptor monitoring

Vulture and raptor monitoring takes place in many countries in three main forms: at colonies (where counts often include measures of breeding success), at feeding hotspots such as carcasses, rubbish dumps, and abattoirs, and along roads. The African Raptor Databank provided a platform and brought together a range of current and historical data of African raptors between 2012 and 2020 before it was expanded to the Global Raptor Impact Network (GRIN) (McClure et al. 2021a).

Road counts have been widely used (e.g. Daboné et al. 2024; Ogada et al. 2016), the largest of them to date being the Coordinated Avifaunal Road (CAR) counts (e.g. Young and Harrison 2020), in South Africa, but the method is popular elsewhere, including repeat counts (e.g. Ogada et al. 2016; Pomeroy et al. 2015). There are opportunities for better coordination, standardisation of road count methods, and training in raptor and vulture identification (e.g. McClure et al. 2021b). The range of species counted in different schemes can be expanded. For example, the CAR counts were originally set up to monitor cranes and bustards, but not raptors, largely because raptors were considered difficult to identify in flight by volunteers, highlighting the continent-wide need for volunteers with reliable identification skills. This has changed and six raptor species are now included in the suite of species that are monitored during CAR counts.

Bird atlases

Bird atlases can provide either repeatable snapshots of distribution and relative abundance, between two or more years (typically as a printed book) or, with the advent of online publishing, as a more or less continuous presentation of the state of current knowledge. Of the 54 African countries, 23 have a completed bird atlas project, albeit 18 of them before the year 2000 (Oschadleus 2020). The grid scales vary from 1' × 1′ to 1° × 1° although most are 15' × 15′ or 30' × 30′ (Oschadleus 2020). Uganda was one of the first to use modelled species distribution maps to infer presence/absence outside areas where surveys have taken place (Carswell et al. 2005) and the Tanzania Bird Atlas project (http://tanzaniabirdatlas.net/) provides an example of a continuous presentation of results. African–Eurasian

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migrants have had their own atlas since 2022 (https://migrationatlas.org; Spina et al. 2022) and the IWC counts have provided atlases of, for example, waders (Delany et al. 2009). The SABAP is the longest-running project and has continuously collected data over some 20 years. Data were gathered within defined grid squares (and in the case of SABAP2 also with GPS accuracy from the linked smartphone app) and both the duration of observations and sequence of first observation of each species were recorded. This allows analyses (e.g. Lee and Nel 2020), based on presence/absence and attributes of the grid or GPS coordinates of the observations, such as land use and human population density. SABAP methods have extended into the African Bird Atlas Project (ABAP) (Brooks et al. 2022), active with varying intensities in Botswana, eSwatini, Ghana, Kenya, Lesotho, Liberia, Malawi, Mozambique, Namibia, Nigeria, Sierra Leone, Uganda, Zambia, and Zimbabwe. SABAP is actively used for the estimation of species distribution and its change, habitat associations, and the overlap of development proposals and habitats likely to support species of conservation concern.

Participation in monitoring

The number of people contributing to each monitoring project was generally low, with 40% (n = 35 responses) of projects indicating fewer than 10 contributors. Just over a third (37%, n = 32 responses) reported tens of participants, and only 13% (n = 11) reported hundreds. The latter were atlas or CBM projects where most or all participants are volunteers, with the occasional exception of projects which involve government staff only. The importance of volunteers on projects, at least equal in abundance to paid staff on 76% of projects, was clear. The pattern of professional and voluntary participation in surveys was similar across Francophone and Anglophone countries.

Data collation, storage, and management

For most projects, data collection was on paper, with data only later entered into a spreadsheet or database. Worryingly, almost half (45%) of projects had no data back-up. Only a few key projects such as SABAP, ABAP, African Raptor Databank, and GRIN have a smartphone app through which data are collected and formally stored in a database. We suspect that the number of records of data storage in databases and back-up on servers is an overestimate, as some organisations, known not to have either, have responded 'yes' to both, probably referring to spreadsheets or individual computers. Geographical Information Systems (GIS) were used in 24% of projects and cloud storage in only 14%. Only South Africa and Kenya reported having a national biodiversity database organisation to curate data storage as a core activity.

Cloud data storage is, in principle, usually accessible to all but could be made more affordable with joint initiatives sharing costs between countries or organisations. Storage in the Global Biodiversity Information Facility (GBIF) is a cost-effective way of archiving and securing data and is used by global birding projects, such as eBird and SABAP2. As internet access can be a limiting factor, local storage, preferably in a backed-up structured database to more easily accommodate metadata on associated metrics, such as survey effort, may often be a necessity, but the practice of ensuring that regular back-up copies are made should be universal. Regularly scheduled synchronisation over the internet mitigates the risk of mishaps stemming from different versions; manual back-ups provide a bare minimum to address widespread inadequacies in data storage identified by the questionnaire.

Analysis, reporting use, and data availability

Detailed analysis, including statistical modelling, of the bird data was rare. Routine analysis generally involved the use of spreadsheets to plot simple change graphs. Basic use of data in National Biodiversity Species Action Plans (NBSAPs) was widely reported as occurring, but use of more sophisticated analyses (e.g. statistical modelling in relation to environmental change, species distribution modelling etc.) was rare outside CBM or atlas projects and, as far as we are aware, only routinely undertaken in South Africa, Nigeria, and Kenya. Improved accessibility to continent-wide databases, such as GRIN, would provide a valuable large-scale resource for species distribution modelling (e.g. Sutton et al. 2022, 2023) or the production of species actions plans (e.g. Botha et al. 2017), so such coordination should be considered at the outset where resources are likely to permit this. It can also be noted that sharing of resources in large projects can also result in a larger funding pool.

Government and policymakers typically require derived data products that contain high-level but rapidly comprehensible summaries from such analyses to feed into biodiversity reports, and planning and site management plans. In general, the necessary analyses tended to be undertaken by NGOs or university staff and not those in government institutions, often resulting in problems of a lack of long-term funding and, in some cases, capability issues, as analytical expertise lies within the NGOs and not governmental institutions. Indeed, a lack of trained analysts was frequently cited as a major issue, and institutes undertaking analysis require long-term investment in training around analytical methods, which increasingly includes integration of remote-sensed environmental data. Given the vast scale of Africa, the use and appropriate processing of remote-sensed data sets will be essential for producing the derived outputs that policymakers, planners, and conservation organisations require.

Most of the questionnaires returned (76 of 87) reported that the dissemination of information from individual projects was important and is, in principle, available to the public, whether as reports to government, scientific publications in peer-reviewed literature, or in other ways. The majority of questionnaires that reported no dissemination noted their intention to do so in future, often stating that the paper/report had yet to go through peer review. Almost all (83 of 87 questionnaires) stated that their monitoring results were put to use, including in response to international obligations such as the Convention on Biological Diversity Aichi targets (25) or the Ramsar Convention (23). Domestically, 33 questionnaires reported that data from individual projects contributed to national biodiversity reports, and 32 to site management reports.

The questionnaire did not consider the extent of open access to data explicitly. In common with biodiversity databases globally, there are potential conflicts between free access to an open data repository and ownership of data by government or civil organisations (Pearce-Higgins et al. 2018), but making data findable with clear routes for access should only increase their value and utility. Thus, SABAP, and its evolution into ABAP, have made its data available for anyone to download, but this may not be desirable in all cases. The principle of 'informed consent' should underlie all data sharing and access activities, particularly when indigenous knowledge is central to its gathering (Oguamanam 2020; Reyes-García et al. 2022).

Information on delayed data release was not collected, but, while some data sets will be stipulated as free access after an embargo period, for example EU-funded projects, the vast majority will not. A first step would be for organisations with a common interest in

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data use to agree a set of principles (e.g. following FAIR principles, that is, being Findable, Accessible, Inter-operable, and Reusable, www.go-fair.org) to determine the type of licence under which data could be shared (e.g. the Creative Commons licences used by GBIF) and when it would be appropriate for data to be shared and when not. This and the data type would determine the storage system. For example, many data sets where sharing is desirable may be most efficiently stored within existing databases, notably GBIF.

Project financing

Most projects received relatively limited amounts of money, with approximately half receiving between $4,000 and $10,000 annually (Table 2). Two projects with annual budget estimates over $100,000 were both in East Africa with USA funding, one from a private zoo and one from United States Agency for International Development (USAID). Most projects were funded from outside the country in which they were implemented, and a very small minority of projects had domestic government support (Table 3). In addition to those responding to the questionnaire, interviewees from Kenya and Namibia reported being in receipt of government funding. Where the country of origin of the funding was mentioned, the most frequent was the USA, followed by Germany (German Nature and Biodiversity Conservation Union – NABU– being the most frequently mentioned BirdLife partner), and the UK.

In terms of financing, there was a great deal of confidence in the continuation of monitoring projects over the short term (1 year), with three-quarters of respondents being moderately sure or very sure of funding (Table 4). This level of certainty declined when considering longer time periods (to 60% over 5 years and 44% over 10 years). Money is important but, as one interviewee reported, "no African bird institution breaks even or makes a profit"; they also highlighted the need for innovative solutions, i.e. being able to implement cheap, sustainable, volunteer-driven monitoring schemes which can cover the basic costs of fuel, transport hire, and subsistence. Those projects reporting positively over longer-term (10-year) funding probably reflected the anticipation of funding from past experience, rather than it being contractually secure. Examples include the IWC supported by Wetlands International (including targeted IWC support for the East Atlantic Flyway by the Wadden Sea Flyway Initiative) and locally supported self-sustaining projects (e.g. Kartong Bird Observatory in The Gambia).

Table 2. Response from the questionnaire in relation to the size of the annual budget in US$ in each monitoring scheme reported

Budget range (US$)	*n*	Proportion
0–1,000	25	0.3
1,000–10,000	20	0.24
10,000–50,000	29	0.35
50,000–100,000	6	0.07
100,000–500,000	2	0.02

Table 3. Source of funds for each monitoring scheme reported via the questionnaire

	Funder	*n*	Proportion
Domestic	NGO	19	0.22
	Business	6	0.07
	Government	4	0.05
International	NGO	42	0.48
	Business	1	0.01
	Government	4	0.05
	Multilateral body	11	0.13

Table 4. Levels of confidence (percentage and number of forms in parentheses) in the availability of future funding for each monitoring project reported via the questionnaire (108 responses)

Confidence in future funding	1 year	5 years	10 years
Not at all sure	6.6 (7)	13.2 (14)	22.6 (24)
Slightly sure	17.9 (19)	27.4 (29)	34.9 (37)
Moderately sure	18.9 (20)	34 (36)	21.7 (23)
Very sure	56.6 (60)	25.5 (27)	20.8 (22)

Barriers to more effective monitoring

Many barriers in terms of logistics, capability, capacity, and finance were raised against the establishment and continuation of effective biodiversity monitoring (Table 5). Funding was clearly the top challenge, with 90 of the 106 responses reporting it as an issue. This was closely followed by logistical issues, some of which would be related to funding (e.g. lack of vehicles, fuel, and equipment), but may also be due to access to sites because of poor security situations.

Challenges can come from the top, i.e. for some governments there is a lack of ability to use monitoring data, desire to collect it, or a clear communication of what is needed, leaving civil society (NGOs, universities) to step in and take the lead. More commonly mentioned were basic capability issues, for which such things as bird identification books and binoculars are urgently needed to improve people's skills. On-going and long-term training investment in field identification skills is necessary due to high rates of volunteer turnover. Moreover, the lack of trained analysts was reported in just over a third of the questionnaires. Donor-funded projects generally have a strong capacity-building focus but tend to be short term in nature; moreover, (tangible) outputs such as training manuals and toolkits, while sometimes necessary outputs from grants, can divert resources away from actual monitoring activity. Without sustained resourcing, such projects are often not implemented sustainably and can quickly become obsolete or irrelevant. Long-term, secure funding would be required to significantly add to both the number of field surveyors and analysis that could be carried out.

Recruitment, management, and retention of volunteers was a consistent issue in the interviews and existing ones were often characterised as "too busy, too tired and too old" as one respondent noted. Security concerns were a particular issue in the Sahel and Horn of Africa regions.

Discussion

Biodiversity in Africa is threatened by increasingly severe climate change and environmental conflicts, the latter resulting from a rapidly growing human population and higher standard of living expectations (Chapman et al. 2022), yet even basic information on the scale of the problem is largely lacking over much of the continent

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Table 5. Barriers to expanding monitoring schemes as reported by respondents to the questionnaire. Proportion = the proportion of answers that were in the Extremely Important or Very Important categories

Limitation	Extremely important	Very important	Moderately important	Slightly important	Not important	Proportion
Funding	67	23	7	7	2	0.85
Logistics for site access	43	24	17	13	9	0.63
Inadequate government support	30	19	20	21	16	0.46
Lack of trained analysts	16	25	24	19	22	0.39
Lack of trained fieldworkers	15	23	25	16	27	0.36
Inadequate institutional support	16	14	24	18	34	0.28
Site remoteness/ terrain	15	18	17	20	36	0.31
Lack of trained coordinators	8	20	19	24	35	0.26
Species focus is intentionally limited to specific species groups	9	13	9	13	62	0.21
Site safety restrictions	7	4	12	13	70	0.1

(Siddig 2019). Decisions around development and the conservation of biodiversity in Africa need to be well-informed, ensuring that African stakeholders have access to a strong evidence base which is vital to support such decision-making (MacFadyen et al. 2022; Stephenson et al. 2017). The monitoring of bird populations forms a key part of this evidence base in determining priorities for conservation action, both in terms of reversing species declines and highlighting the wider impacts of environmental degradation.

Setting monitoring objectives

The monitoring programmes described by our interviewees have largely been driven and funded by multilateral agreements, global organisations or NGOs outside Africa. Similarly, funding has predominantly been in response to priorities that were either global or external to the country in question. These may align with national priorities, where they exist. The questionnaire responses suggested that the most sustainable and long-term projects tend to be those that are driven by clear policy objectives, either international (e.g. IWC and monitoring of threatened migratory bird species), or in response to clear national priorities set within government agencies (e.g. bird monitoring schemes in Kenya, Uganda, and South Africa). Various models for developing monitoring schemes were suggested during the interviews: (1) a bottom-up approach focused on internal priorities, e.g. globally threatened species at key sites, internationally important assemblages, Key Biodiversity Areas or protected areas; (2) a top-down approach from international reporting obligations, e.g. Convention on Biological Diversity or Convention on the Conservation of Migratory Species, which can also support national objectives (e.g. national biodiversity/state of nature reports); (3) mainstreaming biodiversity data into landscape management (Huntley 2014) and sustainable development goals by, for example, explicitly connecting human health and well-being to biodiversity (the One Health approach; Behravesh et al. 2024); (4) requiring pre- and post-consent monitoring to be undertaken where major infrastructure projects are being undertaken following IFC PS6.

These latter approaches (3 and 4) are likely to attract longer-term funding opportunities and are already used to some extent, largely in the southern and eastern parts of Africa, to support development aims and identify priority regions and issues, although the transparency of these processes can often be improved. The monitoring required by IFC PS6 directly relates biodiversity conservation to sustainable development, with biological and environmental data being used to identify mitigation and biodiversity offsets, and management objectives should be assessed against concepts such as No Net Loss (zu Ermgassen et al. 2019) and Biodiversity Net Gain (Bull and Brownlie 2017). However, much of the data collected to assess the impact of individual development projects are currently confidential and there is an urgent need to make them available to national biodiversity recording systems. These Performance Standards are also not without their critics, however, as economic development needs often conflict with wider conservation goals. It is also essential that any mitigation and offsets proposed are explicitly separated from, and additional to, existing commitments to biodiversity conservation (Maron et al. 2016).

Are field data collection and analytical methods adequate?

This review has shown that many of the bird monitoring schemes operating in Africa are based around a species or groups of species (e.g. waterbirds, vultures), and most of the avifauna is not included. Similarly, in common bird monitoring or atlas schemes, there will be many gaps in terms of scarce, rare or hard to detect species and the spatial coverage may not include the range of all the species. This is a perennial problem but, given that most of the land area of Africa is covered by no, or only one, species-group-focused monitoring scheme (Figure 1), there are major gaps in the coverage of most species which would be impossible to fill. In terms of a global perspective, prioritisation therefore needs to be given to where scarce resources should be spent, e.g. focusing on particularly rare or globally threatened species or species for which a particular range state has significance, but local priorities may differ. In common bird monitoring schemes, a number of methods such as point-counts, transects, timed species counts, and various atlas methods are used. Standardising the methods used would help make common bird monitoring between countries comparable, and ideally a region or continent-wide minimum standard for monitoring would need to be drawn up and widely adopted, which could be achieved through existing fora such as the Pan-African Ornithological Congress.

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The primary aim of monitoring schemes should be to document patterns of change over years as a trigger for conservation action. However, in Africa, there is still much work to be done to establish even basic parameters, such as the (seasonal) range limits of many species. Mapping changes in the range of a species provides a relatively crude measure of impact, whereas estimating changes in relative abundance enables, in theory at least, changes to be detected sooner, facilitating identification of key environmental drivers and early conservation interventions. However, doing so requires robust estimates of change that account for imperfect detection (e.g. Edwards et al. 2023; Kéry and Schmid 2004), and larger-scale surveys also need to ensure that sampling is appropriately stratified, both spatially (e.g. by habitat, altitude, and climate region) and temporally (e.g. Nagy et al. 2022). Even counts of large species in open habitats are almost never absolute; acknowledging and quantifying the uncertainty around them (e.g. by making independent repeat counts) leads to more robust measures of change and more informed decision-making as a result.

Power to detect change can be substantially higher in more formal monitoring programmes, but establishing these requires a substantial and reliable volunteer base. In the meantime, the use of checklist apps as a source of records is increasing; these are not a replacement for more formal monitoring schemes, as using such data requires substantial verification effort and development of appropriate analysis (Johnston et al. 2021; Xie et al. 2023). However, they can supplement formal monitoring in certain circumstances and where coverage overlaps (Boersch-Supan et al. 2019). Currently, African bird data from app-based, open access databases, such as eBird and GBIF, are clustered around access points such as major cities and nature reserves or national parks (Freeman and Peterson 2019). Securing an affordable app-based system in the long term for the African Bird Atlas and ensuring it has wide appeal (e.g. adding French and Portuguese language support at least, but also support for Arabic and indigenous languages) should be a high priority. Encouraging the recording of easy-to-enter data along with very simple metadata (i.e. time, location, effort, and observer identity) facilitates the collection of multiple counts at the same location, allowing detection to be quantified and accounted for, thereby increasing the power of any analysis to detect change.

New methods and technologies are being developed that can be utilised in monitoring programmes (Lahoz-Montfort and Magrath 2021). For example, passive acoustic monitoring can be used in forests, where distance measurement is difficult or impossible, to improve occupancy estimates (Abrahams and Geary 2020; Rea et al. 2023), or in wetlands to detect globally threatened birds (Moskidi et al. 2023). Species occupancy and/or distance sampling can be undertaken with camera traps (Bitani et al. 2023; Bessone et al. 2020; Gumede et al. 2022), which are becoming increasingly affordable as the technology develops.

Capacity needs

Capacity has to be built at all levels, starting from the bottom up, such as with the provision of basic field equipment such as binoculars and field guides, and from the top down, e.g. governments leading on strategic policy requirements and implementation, academic institutions producing trained ecologists (e.g. Cresswell 2018), and NGOs having the mechanisms to collect and use those data effectively. However, in some countries these institutions may be non-existent or weak, leaving capacity building stalled. Moreover, several interviewees reported that foreign donors can compete for trained project staff, especially in West Africa and the East Atlantic Flyway, leading to under-funding in other areas (e.g. the Asian–East African flyway) where such staff are scarcer, a phenomenon which only highlights the need for urgent expansion of the workforce pool. An example of an excellent working relationship between academics, NGOs, and government is in southern Africa between the FitzPatrick Institute (academic institution), which runs the volunteer scheme, the South African National Biodiversity Institute (SANBI), a government institution, and BirdLife South Africa (an NGO). More support to not only help some governments develop national priorities and policy objectives, but also to value the importance of biodiversity and monitoring alongside areas such as human health, well-being, and development, would be a major achievement (Barnard et al. 2017).

Lack of available analytical expertise was identified as a critical gap, and even producing simple trends for reporting purposes may be a challenge in many countries. Moreover, monitoring data are often collected under difficult conditions and may be quite heterogeneous and thus need sophisticated methods requiring a high degree of statistical training to analyse effectively. It is generally cheaper and more effective to design a better survey than to try and rescue results where data collection was poorly designed, but survey design skills are also largely lacking. Thus, CBM data quality is generally higher, and usually improves over time as observers receive extra training, but this requires on-going training, mentoring, and the availability of relevant support materials (Kepler and Scott 1981).

Ensuring equitable access to data (and metadata, such as observer identity), recognising the rights of both the data generator and value that can be added through re-use, can also be a challenge, especially for those platforms developed in non-African contexts, where appropriate recognition of data ownership is critical (Reyes-García et al. 2022). The main African-based app, BirdLasser (www.birdlasser.com), used in the SABAP and ABAP projects, has revolutionised data collection in those countries which have a higher level of smartphone usage (Lee and Nel 2020). However, access to smartphones, power or internet may not be available, especially in rural areas in some countries, so paper forms for capturing data may still be required with additional resource needed to integrate these into a largely digital data pipeline.

There is no doubt that centres of excellence work, i.e. A. P. Leventis Ornithological Research Institute (APLORI) (Nigeria), the National Museums of Kenya, and the FitzPatrick Institute (South Africa), are long established and have transformed African ornithology. For example, in the 23 years since the start of the programme, APLORI has trained 146 young West Africans on its Master's degree course in Ornithology and Conservation Biology (APLORI 2025). Approximately a quarter of these graduates have gone ahead to complete PhDs, while another quarter are currently studying for PhDs. Approximately 90% of APLORI graduates remain active contributors to biodiversity conservation efforts as researchers, lecturers, teachers, government officials, and environmental NGO founders and workers. Since 2015, APLORI has also begun directing efforts towards increasing public awareness and engagement in biodiversity conservation through the Nigerian Bird Atlas Project (NiBAP), a citizen science project that recruits, trains, and organises young Nigerians into bird clubs and bird atlas teams. From just two, largely expatriate-dominated, bird clubs in Nigeria, the NiBAP had, by 2024, founded and established 20 bird clubs with over 1,000 mostly members. From three active bird atlasers in 2015, there are now over 250 in the country (APLORI 2025). All these citizen scientists have helped to survey close to 4,000 of the 11,080 pentads needed for a complete survey coverage of Nigeria.

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Programmes producing Master's-level courses have recently started at Gorongosa National Park, Mozambique (https://gorongosa.org/masters-program/) and Université Gaston Berger, Senegal. Bird monitoring expertise has previously tended to flow from the Global North to Global South but, as the number of Master's graduates has increased, many now hold positions in national and global institutions, with consequent opportunities for intra-African capacity building. This can be further expanded using online courses, the development of which has been spurred by the pandemic years, although access through the internet remains a key challenge for some, and courses still tend to be conducted in English, presenting a barrier for many. These would have the benefit of being able to be run across several countries and partner with universities or other educational institutions to provide a local hub for remote teaching. Examples include Wetlands International's Flyway Training Kit, the toolkit made by the Office Français de la Biodiversité (OFB) and the African–Eurasian Waterbird Agreement (AEWA) for trainers in waterbird identification and counting in Africa, and the Wadden Sea Flyway Initiative's field guide to the waterbirds of the East Atlantic Flyway.

Financing models

Funding is clearly an issue for all monitoring projects in Africa. Respondents noted that the amounts of money available for monitoring terrestrial biodiversity are tiny in comparison to other development and aid projects, even though the impacts of short-/long-term environmental change on human health and livelihoods are well documented. Interviewees reported that the models which tended to work best were those where there was an explicit government/NGO public–private partnership. Blended models, where funds were administered by a consortium on behalf of governments but outside national treasury control, were often appreciated by employees of government institutions as it gave them both a voice in the management of funds and in the co-design of solutions. A strong message (from the NGO sector) was that money directed through the NGO sector offered better value for money, although this perception may be less true for international NGOs, which can have higher institutional overheads. Local or regional NGOs can, in principle, also move more rapidly than government departments or agencies. For example, NatureUganda recognises that no institutions within Uganda, or external donors, have money for regular monitoring, so it essentially subsumes monitoring costs within institutional overheads.

To be genuinely sustainable, large-scale monitoring schemes ideally need to be inexpensive, simple, and highly accessible, but well designed. While collecting regional records of occurrence (such as https://www.wabdab.org/) can be useful to document species ranges, *ad hoc* records of presence are unlikely to provide a robust evidence base, unless data volumes are sufficiently large to overcome their inherent heterogeneity (Johnston et al. 2021). While large projects/donors can be important for implementing new monitoring projects, as they come to an end smaller grants are critical in keeping many monitoring schemes going in the long term. Organisations like the African Bird Club, Rufford Foundation, JRS Biodiversity Foundation, and Mohamed bin Zayed Species Conservation Fund, as well as local funding sources (e.g. large businesses, embassies), are vitally important. A more coordinated approach to funding would also be welcomed by NGOs whose limited capacity can often be eroded by chasing small individual grants. Approximately half of the monitoring projects mentioned in the questionnaires (44 in total, see Table 2) cost less than US$10,000 annually. If global funders were to combine and commit to provide long-term funding of, for example, US$10,000–15,000 to each of these monitoring projects over a sustained period (say 10 years), it would save both time and resources spent fund-raising, allowing NGOs to focus on developing the schemes by training more people and investing in, and undertaking, data analysis. Opportunities to contribute via existing structures and for co-financing are available, for example, the subsidiary agreements of the Convention on the Conservation of Migratory Species of Wild Animals (CMS), or international partnerships such as the Wadden Sea Flyway Initiative, which funds monitoring and capacity-building activities in countries along the East Atlantic Flyway. In global terms, the cost would be moderate (<U$1 million p.a.), but could provide a secure base for long-term monitoring.

Building long-term sustainability

Understanding and managing the impacts of environmental change on biodiversity will not be achieved just by monitoring in protected areas; the wider countryside must be included (e.g. Buechley et al. 2022; Evans 2023). Well-designed protocols, probably undertaken by volunteers and analysed by professional staff, are required. Internationally, the most successful monitoring projects tend to be those which support long-term data collection and analysis concurrently; continued use and interrogation of data to address specific, clear objectives often identify ways of collecting data more effectively. Feedback loops are essential, in terms of both providing results to promote a sense of investment and ownership in volunteers (reported from many countries) and showing how data are used. If data are seen to be valued by people in power, then volunteers are motivated to keep going. For instance, it was reported by one interviewee that visits by Kenyan Wildlife Service staff have given substantive encouragement to volunteer counters.

Building social capital is essential to ensure enough people support monitoring activities. People need to feel involved in their local environment which, in turn, empowers them to understand, and engage with, environmental change (Greenwood 2007). Engaging local volunteers can produce a large return on investment. An extreme example is found in South Africa where estimates suggest that the value of the in-kind contributions by citizen scientists to the SABAP2 project exceeded ZAR40 million per year – more than 25 times the cost of maintaining the core team which runs the project, highlighting the value for money using this approach (Lee et al. 2022). Even where people may be less affluent and have less free time, the setting up of bird clubs with relatively little investment and making recording a social activity have increased the number of observers in Nigeria from a few dozen to over 1,500, with 20% of the country being covered by atlas volunteers in five years (Ringim et al. 2022).

Networks, however, are only as robust as the organisations underpinning them. The recent closure of the Animal Demography Unit at the University of Cape Town was of huge concern as it ran a host of online citizen science projects, including the South African Bird Ringing Scheme (SAFRING), the SABAP atlas projects, and southern African waterbird counts (CWAC). The FitzPatrick Institute has taken on the avian schemes but financing them and securing staff to run/develop them are major issues. Costs, however, are relatively small, again highlighting the need for international donors to commit to longer-term funding, as this will give organisations undertaking biological monitoring in Africa the motivation and incentive to invest for the long term in the schemes and really

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develop the monitoring and analytical capability within their organisation.

Where next – a new paradigm for bird monitoring in Africa?

Each country is at a different stage of bird monitoring, ranging from none, or just waterbird counts, to well-structured projects that are integrated into policy and decision-making. Apart from waterbirds, vultures and a few other species groups (e.g. bustards and cranes), there are few schemes that monitor common birds in the wider countryside. Setting up sustainable common bird monitoring schemes across Africa will be challenging, requiring long-term investment, but experience in southern and eastern Africa shows they can provide a robust evidence base for the impacts of environmental change in areas where sufficient participation can be established. It will require continuous training and institutional capacity-building in both data collection and analysis, and a key step will be building monitoring goals into long-term planning, likely with governments and NGOs working in partnership (Kühl et al. 2020). Use of common standards will be important to tackle some regional or continent-wide issues, where data need to be compatible between countries. Supporting the use of ABAP in a wider range of countries, assisted by the development of the BirdLasser or another bespoke mobile app, has the potential to develop a broader evidence base relatively quickly, especially where this is coupled with building capacity in analytical expertise and stronger links to policy- and decision-makers as end-users of the data.

If the outputs of monitoring schemes are to be self-determined (i.e. owned, initiated, and analysed) and relevant to the needs and requirements of each country, the skills required to carry out these analyses must be available in the region. It is perhaps unrealistic to think that centres of excellence (e.g. biological records centres and databanks for long-term, safe storage of data) could be established in each country, but many of the key drivers of biodiversity change (e.g. climate change, desertification, invasive species, rainfall etc.) operate at regional scales. Consequently, regional centres of excellence that link biodiversity (e.g. bird monitoring) and remote-sensed environmental data sets, together with data from the planning, developmental, and aid sectors, would provide a very clear way of starting to mainstream the environment into the aid and development sectors, and could revolutionise the extent of biological recording undertaken in Africa.

Increased communication and coordination through the support of existing networks, and facilitation of new ones, was a clear recommendation from interviewees. Wetlands International coordinates the longest-running and most widespread bird monitoring network in Africa, and monitoring of other taxa would benefit from similar coordination across countries. For example, a large amount of road transect data (including for raptors and vultures) from across Africa is available, and even though different methods were used (McClure et al. 2021b), if it were collated, it would form a valuable historic data set as well as being a monitoring tool for many species that are of conservation concern. The West African Bird DataBase represents another attempt at regional coordination of records, but one which needs more funding to achieve its true potential.

It is probably naïve to think that bird monitoring will be commonly carried out across the continent just to inform the conservation of the birds themselves, but these data are relevant to many other areas of social and economic development. Monitoring projects could be scaled up in countries in relation to a range of policy areas, building on an increased requirement for monitoring of impacts of intervention and mitigation or adaptation measures in response to global drivers of change. Development of standardised continent-wide common monitoring indicators (e.g. Wotton et al. 2020) would allow not only novel and existing conservation interventions to be evaluated but would also provide a robust evidence base against which to assess mitigation of, and adaptation to, broad-scale drivers of environmental change.

The amounts of money involved in official development assistance (ODA) programmes and major infrastructure projects are orders of magnitude more than is currently spent on bird monitoring by NGOs and governmental agencies, and even a very small percentage would allow long-term investment by African institutions in monitoring, volunteer management, analysis, and reporting. Biodiversity assessment and monitoring for a single large infrastructure project (e.g. wind, solar or hydroelectric project) may exceed the total annual budget for all the monitoring schemes across the continent reported in this study (<US$1 million), especially if mitigation or compensation is required. The integration of wider environmental modelling products, derived from increasingly available remote-sensed data, has the potential to complement and extend the inference possible from bird monitoring programmes (e.g. Cervantes et al. 2023). By incorporating biodiversity and nature-based solutions into sustainable development programmes, the increasing negative impact of human development on the environment may be reduced. However, it is essential that the main reason for monitoring birds – the conservation of the birds themselves – is not lost (e.g. Ishong et al. 2022). Ultimately, ecosystems are composed of species, and it is often the fate of individual species that most resonates with people and motivates them to act for a better future.

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References

Abrahams C. and Geary M. (2020). Combining bioacoustics and occupancy modelling for improved monitoring of rare breeding bird populations. *Ecological Indicators* **112**, 106131.

A. P. Leventis Ornithological Research Institute (APLORI) (2025). 23 Years of Capacity Building for Ornithology and Conservation Science in West Africa. Available at https://aplori.org/capacity-building (accessed 24 October 2025).

Altwegg R. and Nichols J.D. (2019). Occupancy models for citizen-science data. *Methods in Ecology and Evolution* **10**, 8–21.

Barnard P., Altwegg R., Ebrahim I. and Underhill L.G. (2017). Early warning systems for biodiversity in southern Africa – How much can citizen science mitigate imperfect data? *Biological Conservation* **208**, 183–188.

Behravesh C.B., Charron D.F., Liew A., Becerra N.C., Machalaba C., Hayman D. T. et al. (2024). An integrated inventory of One Health tools: Mapping and analysis of globally available tools to advance One Health. *CABI One Health* **3**, 1–31.

Bessone M., Kühl H.S., Hohmann G., Herbinger I., N'Goran K.P., Asanzi P. et al. (2020). Drawn out of the shadows: Surveying secretive forest species with camera trap distance sampling. *Journal of Applied Ecology* **57**, 963–974.

Bitani N., Cordier C.P., Smith D.A.E., Smith Y.C.E. and Downs C.T. (2023). Microhabitat requirements and occupancy of understorey bird forest

specialists in Southern Mistbelt Forests of KwaZulu-Natal, South Africa. *Forest Ecology and Management* **549**, 121484.

Boersch-Supan P.H., Trask A.E. and Baillie S.G. (2019). Robustness of simple avian population trend models for semi-structured citizen science data is species-dependent. *Biological Conservation* **240**, 108286.

Botha A.J., Andevski J., Bowden C.G.R., Gudka M., Safford R. J., Tavares J. et al. (2017). *Multi-species Action Plan to Conserve African-Eurasian Vultures. CMS Raptors MOU Technical Publication No. 4.* CMS Technical Series No. 33. Abu Dhabi: Coordinating Unit of the CMS Raptors MOU.

Brooks M., Rose S., Altwegg R., Lee A.T.K., Nel H., Ottosson U. et al. (2022). The African Bird Atlas Project: a description of the project and BirdMap data-collection protocol. *Ostrich* **93**, 223–232.

Brooks T., Balmford A., Burgess N., Hansen L.A., Moore J., Rahbek C. et al. (2001). Conservation priorities for birds and biodiversity: do East African Important Bird Areas represent species diversity in other terrestrial vertebrate groups? *Ostrich* (Suppl.) **15**, 3–12.

Buckland S.T., Marsden S.J. and Green R.E. (2008). Estimating bird abundance: making methods work. *Bird Conservation International* **18**, S91–S108.

Buechley E.R., Girardello M., Santangeli A., Ruffo A.D., Ayalew G., Abebe Y. et al. (2022). Priority areas for vulture conservation in the Horn of Africa largely fall outside the protected area network. *Bird Conservation International* **32**, 188–205.

Bull J.W. and Brownlie S. (2017). The transition from no net loss to a net gain of biodiversity is far from trivial. *Oryx* **51**, 53–59.

Carswell M., Pomeroy D., Reynolds J. and Tushabe H. (2005). *The Bird Atlas of Uganda*. Oxford: British Ornithologists' Club/British Ornithologists' Union.

Cervantes F., Altwegg R., Strobbe F., Skowno A., Visser V., Brooks M. et al. (2023). BIRDIE: A data pipeline to inform wetland and waterbird conservation at multiple scales. *Frontiers in Ecology and Evolution* **11**, 1131120.

Chapman C.A., Abernathy K., Chapman L.J., Downs C., Effiom E.O., Gogarten J.F. et al. (2022). The future of sub-Saharan Africa's biodiversity in the face of climate and societal change. *Frontiers in Ecology and Evolution* **10**, 790552.

Collar N.J. and Wacher T. (2023). The conservation status of the Nubian Bustard *Nubotis nuba*: a review and prognosis. *Bird Conservation International* **33**, e76.

Cresswell W. (2018). The continuing lack of ornithological research capacity in almost all of West Africa. *Ostrich: Journal of African Ornithology* **89**, 123–129.

Daboné C., Ouédraogo I., Ouéda A., Thompson L.J. and Weesie P.D. (2024). Hooded Vultures *Necrosyrtes monachus* are still declining in West Africa: a nearly 50-year assessment study (1969–2019). *Ostrich: Journal of African Ornithology* **95**, 21–31.

Delany S., Scott D., Helmink A.T.F., Dodman T., Flink S., Stroud D. et al. (2009). *An Atlas of Wader Populations in Africa and Western Eurasia*. Wageningen: Wetlands International.

Dendi D., Luiselli L., Eniang E.A., Fakae B.B., Nioking A., Akani G.C. et al. (2018). Past trends, current research and future perspectives of West African ornithology. *Vie et Milieu – Life and Environment* **68**, 3–18.

Dodman T. (ed.) (1997). *A Preliminary Waterbird Monitoring Strategy for Africa: Incorporating the Proceedings of the African Waterfowl Census Review and Development Workshop, Djoudj, Senegal, 6–10 February 1996*. Wetlands International Publication 43. Wageningen: Wetlands International.

Edwards B.P., Smith A.C., Docherty T.D., Gahbauer M.A., Gillespie C.R., Grinde A.R. et al. (2023). Point count offsets for estimating population sizes of North American landbirds. *Ibis* **165**, 482–503.

Evans S.W. (2023). The effects of habitat loss and fragmentation on the relative abundance and conservation of Southern Black Korhaan *Afrotis afra*, a South African endemic. *Bird Conservation International* **33**, e71.

Freeman B. and Peterson A.T. (2019). Completeness of digital accessible knowledge of the birds of western Africa: Priorities for survey. *The Condor* **121**, duz035.

Galloway-Griesel T., Roxburgh L., Smith T., McCann K., Coverdale B., Craigie J. et al. (2023). Evidence of the effectiveness of conservation interventions from long-term aerial monitoring of three crane species in KwaZulu-Natal, South Africa. *Bird Conservation International* **33**, e7.

Greenwood J.J.D. (2003). The monitoring of British breeding birds: a success story for conservation science? *Science of the Total Environment* **310**, 221–230.

Greenwood J.J.D. (2007). Citizens, science and bird conservation. *Journal of Ornithology* **148**, S77–S124.

Gregory R., Vořišek P., Noble D., Van Strien A., Klvaňová A., Eaton M. et al. (2008). The generation and use of bird population indicators in Europe. *Bird Conservation International* **18**(S1), S223–S244.

Grumbine R.E. (1994). What is ecosystem management? *Conservation Biology* **8**, 27–38.

Gumede S.T., Smith D.A.E., Smith Y.C.E., Ngcobo S.P., Sosibo M.T., Maseko M. S. et al. (2022). Occupancy of two forest specialist birds in the Southern Mistbelt Forests of KwaZulu-Natal and Eastern Cape, South Africa. *Bird Conservation International* **32**, 27–42.

Howard P.C., Viskanic P., Davenport T.R.B., Kigenyi F.W., Baltzer M., Dickinson C.J. et al. (1998). Complementarity and the use of indicator groups for reserve selection in Uganda. *Nature* **394**, 472–475.

Hudson M-A.R., Francis C.M., Campbell K.J., Downes C.M., Smith A.C. and Pardieck K.L. (2017). The role of the North American Breeding Bird Survey in conservation. *The Condor* **119**, 526–545.

Huntley B.J. (2014). Good news from the South: Biodiversity mainstreaming – a paradigm shift in conservation? *South African Journal of Science* **110**, a0080.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (2019). Brondizio E.S., Settele J., Díaz S. and Ngo H.T. (eds), *Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Bonn: IPBES Secretariat.

Ishong J.A., Afrifa J.K., Iwajomo S.B., Deikumah J.P., Ivande S.T. and Cresswell W. (2022). Population trends of resident and migrant West African bird species monitored over an 18-year period in central Nigeria. *Ostrich: Journal of African Ornithology* **93**, 171–186.

Johnston A., Hochachka W.M., Strimas-Mackey M.E., Ruiz Gutierrez V., Robinson O.J., Miller E.T. et al. (2021). Analytical guidelines to increase the value of community science data: an example using eBird data to estimate species distributions. *Diversity and Distributions* **27**, 1265–1277.

Kepler C.B. and Scott J.M. (1981). Reducing bird count variability by training observers. *Studies in Avian Biology* **6**, 366–371.

Kéry M. and Schmidt B.R. (2004). Monitoring programs need to take into account imperfect species detectability. *Basic and Applied Ecology* **5**, 65–73.

Kühl H.S., Bowler D.E., Bösch L., Bruelheide H., Dauber J., Eichenberg D. et al. (2020). Effective biodiversity monitoring needs a culture of integration. *One Earth* **3**, 462–474.

Lahoz-Monfort J.J. and Magrath M.J. (2021). A comprehensive overview of technologies for species and habitat monitoring and conservation. *BioScience* **71**, 1038–1062.

Lee A.T.K., Altwegg R. and Barnard P. (2017). Estimating conservation metrics from atlas data: the case of southern African endemic birds. *Bird Conservation International* **27**, 323–336.

Lee A.T.K., Brooks M. and Underhill L.G. (2022). The SABAP2 legacy: a review of the history and use of data generated by a long-running citizen science project. *South African Journal of Science* **118**, 12030.

Lee A.T.K and Nel H. (2020). BirdLasser: The influence of a mobile app on a citizen science project. *African Zoology* **55**, 155–160.

Mace G.M., Norris K. and Fitter A.H. (2012). Biodiversity and ecosystem services: a multilayered relationship. *Trends in Ecology & Evolution* **27**, 19–26.

MacFadyen S., Allsopp N., Altwegg R., Archibald S., Botha J., Bradshaw K. et al. (2022). Drowning in data, thirsty for information and starved for understanding: A biodiversity information hub for cooperative environmental monitoring in South Africa. *Biological Conservation* **274**, 109736.

Maron M., Gordon A., Mackey B.G., Possingham H.P. and Watson J.E. (2016). Interactions between biodiversity offsets and protected area commitments: avoiding perverse outcomes. *Conservation Letters* **9**, 384–389.

McClure C.J., Anderson D.L., Buij R., Dunn L., Henderson M.T., McCabe J. et al. (2021a). Commentary: The past, present, and future of the Global Raptor Impact Network. *Journal of Raptor Research* **55**, 605–618.

McClure C.J., Carignan A. and Buij R. (2021b). Lack of standardization in the use of road counts for surveying raptors. *Ornithological Applications* **123**, duaa061.

Mosikidi T., Le Maitre N., Steenhuisen S.L., Clark V.R., Lloyd K.S. and Le Roux A. (2023). Passive acoustic monitoring detects new records of globally

https://doi.org/10.1017/S0959270925100397 Published online by Cambridge University Press

threatened birds in a high-elevation wetland (Free State, South Africa). *Bird Conservation International* **33**, e80.

Moussy C., Burfield I.J., Stephenson P.J., Newton A.F., Butchart S.H., Sutherland W.J. et al. (2022). A quantitative global review of species population monitoring. *Conservation Biology* **36**, e13721.

Nagy S., Breiner F.T., Anand M., Butchart S.H., Flörke M., Fluet-Chouinard E. et al. (2022). Climate change exposure of waterbird species in the African-Eurasian flyways. *Bird Conservation International* **32**, 1–26.

Nichols J.D. and Williams B.K. (2006). Monitoring for conservation. *Trends in Ecology & Evolution* **21**, 668–673.

Ogada D.L., Shaw P., Beyers R.L., Buij R., Murn C., Thiollay J.M. et al. (2016). Another continental vulture crisis: Africa's vultures collapsing toward extinction. *Conservation Letters* **9**, 89–97.

Oguamanam C. (2020). Indigenous peoples, data sovereignty, and self-determination: Current realities and imperatives. *The African Journal of Information and Communication* **26**, 1–20.

Oschadleus H-D. (2020). African bird atlasses. Available at https://birds4africa.org/2020/03/20/african-bird-atlasses/ (accessed 3 January 2024).

Pearce-Higgins J.W., Baillie S.R., Boughey K., Bourn N.A.D., Foppen R.P.B., Gillings S. et al. (2018). Overcoming the challenges of public data archiving for citizen science biodiversity recording and monitoring schemes. *Journal of Applied Ecology* **55**, 2544–2551.

Pocock M.J., Chandler M., Bonney R., Thornhill I., Albin A., August T. et al. (2018). A vision for global biodiversity monitoring with citizen science. *Advances in Ecological Research* **59**, 169–223.

Pomeroy D., Shaw P., Opige M., Kaphu G., Ogada D. and Virani M. (2015). Vulture populations in Uganda: using road survey data to measure both densities and encounter rates within protected and unprotected areas. *Bird Conservation International* **25**, 399–414.

Rea M., Elliot J., Carstens J.C., Leaver J., Carstens K., Wimberger K. et al. (2023). Using acoustic recording units to investigate the effects of logging of indigenous trees in the Amathole forests, South Africa on Cape Parrot *Poicephalus robustus* breeding and the presence of three primary cavity-excavating bird species. *Bird Conservation International* **33**, e59.

Reyes-García V., Tofighi-Niaki A., Austin B.J., Benyei P., Danielsen F., Fernández-Llamazares Á. et al. (2022). Data sovereignty in community-based environmental monitoring: toward equitable environmental data governance. *BioScience* **72**, 714–717.

Ringim A.S., Muhammad S.I., Bako L.A., Abubakar H.M., Isa S.M., Nelly D.J. et al. (2022). How citizen scientists are rapidly generating big distribution data: lessons from the Arewa Atlas Team, *Nigerian Bird Atlas Project*. Ostrich: Journal of African Ornithology **93**, 24–33.

Siddig A.A. (2019). Why is biodiversity data-deficiency an ongoing conservation dilemma in Africa? *Journal for Nature Conservation* **50**, 125719.

Spina F., Baillie S.R., Bairlein F., Fiedler W. and Thorup K. (eds) (2022). The Eurasian African Bird Migration Atlas. *European Union for Bird Ringing (EURING)/Convention on the Conservation of Migratory Species of Wild Animals (CMS)*. https://migrationatlas.org

Stem C., Margoluis R., Salafsky N. and Brown M. (2005). Monitoring and evaluation in conservation: a review of trends and approaches. *Conservation Biology* **19**, 295–309.

Stephenson P.J., Bowles-Newark N., Regan E., Stanwell-Smith D., Diagana M., Höft R. et al. (2017). Unblocking the flow of biodiversity data for decision-making in Africa. *Biological Conservation* **213**, 335–340.

Stephenson P.J., Londoño-Murcia M.C., Borges P.A., Claassens L., Frisch-Nwakanma H., Ling N. et al. (2022). Measuring the impact of conservation: the growing importance of monitoring fauna, flora and funga. *Diversity* **14**, 824.

Suet M., Lozano-Arango J.G., Defos Du Rau P., Deschamps C., Abdalgader Mohammed M.A., Elbashary Adam E. et al. (2021). Improving waterbird monitoring and conservation in the Sahel using remote sensing: a case study with the International Waterbird Census in Sudan. *Ibis* **163**, 607–622.

Sutton L.J., Benjara A., Rene de Roland L-A**.,** Thorstrom R. and McClure C.J.W. (2022). Distribution and habitat use of the Madagascar Peregrine Falcon: first estimates for area of habitat and population size. *Bird Conservation International* **32**, 624–640.

Sutton L.J., Benjara A., Rene de Roland L-A**.,** Thorstrom R. and McClure C.J.W. (2023). Extensive protected area coverage and an updated global population estimate for the Endangered Madagascar Serpent-eagle *Eutriorchis astur*. *Bird Conservation International* **33**, e48.

Thiollay J.M. (2006). The decline of raptors in West Africa: long-term assessment and the role of protected areas. *Ibis* **148**, 240–254.

Thiollay J.M. (2007). Raptor declines in West Africa: comparisons between protected, buffer and cultivated areas. *Oryx* **41**, 322–329.

Thomas L., Buckland S.T., Rexstad E.A., Laake, J.L., Strindberg S., Hedley S.L., Bishop J.R., Marques T.A. and Burnham K.P. (2010). Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology* **47**, 5–14.

Underhill L.G. (2016). The fundamentals of the SABAP2 protocol. *Biodiversity Observations* **7**, 1–12.

Wotton S., Eaton M., Sheehan D., Munyekenye F., Burfield I., Butchart S. et al. (2020). Developing biodiversity indicators for African birds. *Oryx* **54**, 62–73.

Xie J., Zhong Y., Zhang J., Liu S., Ding C. and Triantafyllopoulos A. (2023). A review of automatic recognition technology for bird vocalizations in the deep learning era. *Ecological Informatics* **73**, 101927.

Young D.J. and Harrison J.A. (2020). Trends in populations of Blue Crane *Anthropoides paradiseus* in agricultural landscapes of Western Cape, South Africa, as measured by road counts. *Ostrich: Journal of African Ornithology* **91**, 158–168.

zu Ermgassen S.O., Baker J., Griffiths R.A., Strange N., Struebig M.J. and Bull J. W. (2019). The ecological outcomes of biodiversity offsets under "no net loss" policies: A global review. *Conservation Letters* **12**, e12664.

https://doi.org/10.1017/S0959270925100397 Published online by Cambridge University Press