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Biodiversity data at your fingertips: The Freshwater Biodiversity Information System

Dr Helen Dallas is the Executive Director of the Freshwater Research Centre. The Freshwater Biodiversity Information System (FBIS) was developed by the Freshwater Research Centre (FRC) and its technical partner Kartoza. The FBIS Team is the recipient of the 2022/2023 NSTF-South32 Data for Research Award for the development of FBIS, a powerful, open-access system for hosting, analysing and serving freshwater biodiversity data for South Africa, to facilitate decision-making on freshwater systems.

Significance:

The Freshwater Biodiversity Information System (FBIS) is a powerful, open-access platform for hosting, sharing, and analysing freshwater biodiversity data for South Africa. Platform design and functionality were strongly informed by the requirements of key data end-users and decision-makers. The platform has over 790 000 occurrence records, which are freely available to data-users and are now being converted into impact through incorporation in national decision-support tools. With better data comes better decisions, and access to a data repository like FBIS means that the monitoring, management and conservation of our freshwater ecosystems can be improved, for the long-term betterment of both people and biodiversity.

Introduction

Freshwater ecosystems are among the most biologically diverse habitats on Earth, but they are also among the most threatened and vulnerable, with numerous anthropogenic activities compromising these ecosystems.[1] Land-use change, catchment transformation, flow regulation, water abstraction, pollution, invasive species, and global climate change all threaten these ecosystems.[2] Monitoring, managing and conserving freshwater ecosystems require access to reliable, long-term biodiversity data.[3] Such data are critical for measuring the impact of anthropogenic activities on freshwater ecosystems and biodiversity, informing national and international biodiversity assessments, and enhancing our ability to make informed policy, management, and conservation decisions.[3]

The Freshwater Biodiversity Information System

The Freshwater Biodiversity Information System (FBIS; https://freshwaterbiodiversity.org), developed by the Freshwater Research Centre (FRC) and technical partner Kartoza, is a powerful, open-access system for hosting, sharing, and analysing freshwater biodiversity data for South Africa.[3] The FRC recognised that access to long-term freshwater biodiversity data sets was vital, but lacking for monitoring, managing and protecting freshwater ecosystems in South Africa. While there was a wealth of biodiversity data in existence for freshwater ecosystems, there was not an operational platform providing access to these data. Existing systems were isolated, difficult to access, not well maintained, and had limited capacity for managing freshwater biodiversity data. In addition, FRC wanted to promote the concept of recycling data, where data collected for one purpose could be reused for another. The FBIS was thus developed to address this knowledge gap by providing a platform for hosting high-quality biodiversity data, and by making these data freely available to a wide range of stakeholders.

Consultation with end-users and stakeholders

Platform design and functionality were strongly informed by the requirements of key data end-users and decision-makers, and by the desire to ensure FBIS functions as a 'data source' rather than a 'data sink'. Key end-users were consulted early in the project at workshops to identify their specific data requirements in terms of reporting, outputs, analyses, scale, visualisation, etc. and this information was then used to inform the design and functionality of the FBIS. Key end-users from both governmental and non-governmental organisations included (1) water resource managers, (2) biodiversity/conservation managers, (3) researchers and (4) environmental consultants. These end-users have played an integral role in guiding the development of the platform, and the refinement of its functionality, through feedback and testing of each version of FBIS released. This approach has resulted in a growing community of practice amongst organisations and individuals using the FBIS, encouraging collaboration and data sharing.

Data currently included in FBIS

The primary data provided by the FBIS are biodiversity occurrence records for freshwater ecosystems, with FBIS currently serving five biological modules, for the taxonomic groups anurans, fish, aquatic invertebrates, plants and algae (Figure 1). Associated abiotic data such as physicochemical data are provided when available. These biodiversity occurrence records currently come from three sources: (1) data harvested from the Global Biodiversity Information Facility (GBIF), (2) non-GBIF data collated and mobilised by the FRC, and (3) data (OdonataMap and FrogMap) harvested from the Virtual Museum (Fitzpatrick Institute of African Ornithology, University of Cape Town 2021). Legacy databases that existed pre-FBIS, including the Rivers Database[4] and Biobase[5], were integrated into FBIS. For the non-GBIF or 'FBIS' data, the FRC collaborated with project partners to undertake South Africa's biggest freshwater data consolidation to date. Data were collated from all available sources including peer-reviewed scientific articles, published reports, university theses, and unpublished reports. The FBIS now has >790 000 occurrence records, which are freely available to its data users via the open-access FBIS website (see Dallas et al.[3] for further details). The FBIS community is now regularly adding new data to the platform, and data flow into the system will soon be boosted via the release of the FBIS mobile app. All data in the FBIS are freely available

and follow the FAIR data principles (Findable, Accessible, Interoperable, and Reusable). Data entered into FBIS are validated and quality checked and all data have associated metadata, so that contributors to the FBIS can be fully acknowledged through appropriate citation. Data uploaded to FBIS are also pushed to GBIF under 'The Freshwater Biodiversity Information System (FBIS) Dataset', with the recent addition of > 30 000 fish occurrence records[6] to GBIF.

Key features of the FBIS

In designing the FBIS, the FRC aimed to complement the GBIF, which is widely used by organisations across the globe, including local organisations such as the South African Institute for Aquatic Biodiversity and several museums, to publish and share their biodiversity data. GBIF serves as a global data repository with simple species occurrence record data from a range of different institutions, with limited functionality for querying, visualising and analysing the data. In comparison, FBIS is a customisable platform that can harmonise and add value to GBIF and other non-GBIF data through data querying, visualisation and analysis tools according to the specific needs of a country or organisation. FBIS also allows for the inclusion of more detailed biodiversity information than does GBIF, and has powerful tools for user administration, data management and data upload. Key features of the FBIS are summarised in Table 1.

Converting data into impact

Access to reliable biodiversity data underpins informed conservation and management decisions. Access to a data repository like FBIS means that the monitoring, management and conservation of our freshwater
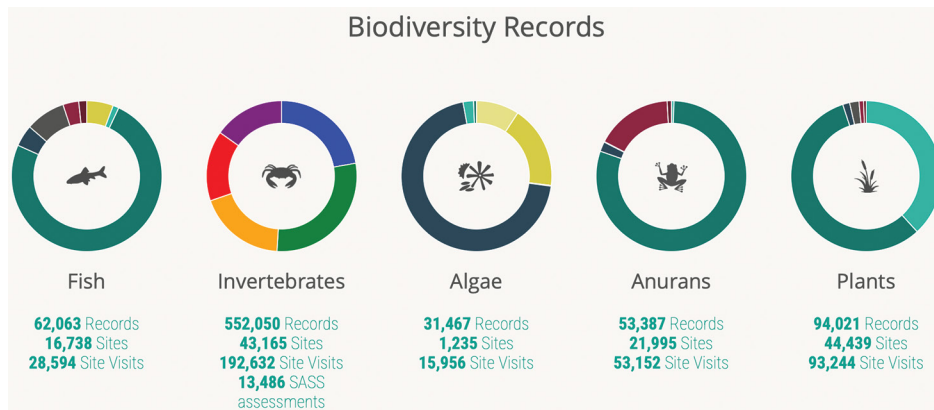

Biodiversity Records

Fish	Invertebrates	Algae	Anurans	Plants
62,063 Records	**552,050** Records	**31,467** Records	**53,387** Records	**94,021** Records
16,738 Sites	**43,165** Sites	**1,235** Sites	**21,995** Sites	**44,439** Sites
28,594 Site Visits	**192,632** Site Visits	**15,956** Site Visits	**53,152** Site Visits	**93,244** Site Visits
	13,486 SASS assessments			

Figure 1: Biodiversity occurrence records for five biodiversity modules currently in the Freshwater Biodiversity Information System. The number of site visits and sites are also provided for each.

Table 1: The Freshwater Biodiversity Information System (FBIS) and Global Biodiversity Information Facility (GBIF) are complementary platforms. The table summarises several advantages of working through the FBIS platform.

FBIS and GBIF
FBIS provides open access to **comprehensive and standardised** freshwater biodiversity data.
FBIS has powerful tools for **visualising, querying and analysing data**.
FBIS has an autonomous, flexible **user administration management system** that allows for hierarchical management and assignment of user access and rights.
FBIS overcomes the GBIF shortcoming of **distinguishing freshwater taxa** from non-freshwater taxa.
FBIS adds value to existing biodiversity data by allowing for **custom management of taxon lists and adding taxon (species) attributes** like threat status, endemism, and migratory species to support management-based data queries.
FBIS allows users to add (and download) **more detailed data** from biodiversity surveys, including information on sampling effort, method, species abundance, species photographs, habitat information and an extensive range of habitat and environmental variables accompanying the biodiversity data.
FBIS **harmonises GBIF and non-GBIF data** sets (biodiversity data sets not yet on GBIF) for improved data access and analysis.
FBIS can be used to **harvest data from GBIF**, and functionality is being developed to seamlessly **push data from FBIS to GBIF**.
FBIS allows users to add (and download) **abiotic data** in addition to biodiversity data.
FBIS allows users to add (and download) ecological condition (river health) data based on bioassessment metrics.
FBIS allows **custom spatial layers to be added** for visualising and filtering biodiversity data sets.
FBIS has **user-friendly data upload forms** for everything from a single sample to a large spreadsheet data set.
FBIS allows **data quality labelling and filtering**.
FBIS has a comprehensive **source reference management system** to link to online citations and/or to upload PDF documents for access by users.
FBIS can be customised **to link to existing databases where APIs exist** and are available to use, e.g. IUCN Red List of Threatened Species website; IUCN Red List 2020.
FBIS encourages a **community of practice** amongst organisations and individuals using the information system, encouraging collaboration and data sharing.

ecosystems can be improved, for the long-term betterment of both people and biodiversity. In South Africa, the data from FBIS feed into key national South African freshwater decision-making tools, such as the River Ecostatus Monitoring Programme, Climate change monitoring and management, National Biodiversity Assessment, Department of Forestry, Fisheries and the Environment Environmental Impact Assessment Screening Tool[7], National Freshwater Ecosystem Priority Areas, and Global and National Species Red List assessments. FBIS is becoming an indispensable resource for water resource managers, biodiversity/ conservation managers and planners, researchers, environmental consultants, and citizen scientists. Reports, scientific papers, river health assessments, biodiversity assessments, gap analyses, funding proposals, to name but a few, are all types of products produced using the FBIS. A recent example of how FBIS data are deepening our understanding of patterns in South Africa's freshwater biodiversity is the publication[8] on the status of South Africa's freshwater fish fauna, which provides a spatial analysis of diversity, threat, invasion, and protection of fishes in South Africa based on occurrence data extracted from the FBIS.

Deployment beyond the borders of South Africa

The long-term vision of the FRC and Kartoza was to develop the FBIS in a generic way such that the technological infrastructure could be deployed in other countries and regions. To date, the information system has been deployed in Rwanda (Rwanda Biodiversity Information System) and Botswana (Okavango Repository for BlodiverSity data) and systems currently under development include the FIPbio in Europe (FIPbio to replace the Freshwater Information Platform data portal) and the South African National Parks Biodiversity Management System. Further expansion of the platform is envisaged across Africa and beyond freshwater ecosystems.

Acknowledgements

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Data availability

All data and tools developed in the FBIS project are accessible. Data are available via the Freshwater Biodiversity Information System (FBIS) (https://freshwaterbiodiversity.org). FBIS was built with open source software and all digital data products are published on GitHub with the bulk of the core logic available here: https://github.com/kartoza/django-bims. The FBIS mobile app is available on Google Play and the App Store. FBIS tutorials and other resources are available on the FRC YouTube channel (https://www.youtube.com/@freshwaterresearchcentre2825).

Declarations

AI was not used during the preparation of this manuscript. Both authors read and approved the final version.

Competing interests

We have no competing interests to declare.

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