

RESEARCH REPORTS

## Environmental data through de-centralised collection: An assessment of environmental data sovereignty in Maldives

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**ABSTRACT** *Environmental data collected independently for research or development projects presents a valuable opportunity for Least Developed Countries and dispersed Small Island Nations (LDCs/SINs) to obtain regular, long-term, information about their ecosystems without the typical financial and logistical challenges. However, effectively utilizing this independently collected environmental data requires a robust data governance approach which establishes the principles of data sovereignty. This study evaluates the data governance principles and data management mechanisms needed to gather, host, and disseminate de-centrally collected environmental data so that it can be used for sustainable development and informed decision-making. Using the 1200+ dispersed islands of the Maldives as a case study, this research examines the existing national environmental regulatory framework of the country within the context of environmental data management, to better understand the challenges associated with governance of de-centrally collected data and thereby derive recommendations for improvement. Limited technical infrastructure and capacity to securely store and host environmental data is identified as potentially being at the root of a lack of enforcement of existing regulations that govern the consolidation of data currently collected by third parties in the Maldives. Moreover, where data is available, conflicting mandates within the legal framework of the roles of different levels of government create barriers to collaboration and data sharing, leading to duplication of collection and management efforts. These challenges appear to be commonly faced by other LDCs/SINs. Recommendations for improvement included legally defining government roles, developing a national data management system, and reforming the research permit system. The results of this study provide a reference for other LDCs/SINs on mechanisms to efficiently gather, host, and make accessible data collected within national borders by independent researchers or during development activities, so that it can be used to effectively manage the environment and safeguard their environment, culture, and economy.*

**Keywords:** *Environmental Governance, Data Governance, Data Management, Environmental Policy, Small Island Nations*

## **Introduction**

Collecting long-term data on key environmental vulnerabilities on an ongoing and regular basis presents significant challenges for Least Developed Countries (LDCs) or dispersed small island nations (SINs). These difficulties arise from logistical constraints, financial limitations, and issues related to accessibility, making sustained data collection efforts particularly demanding. Consequently, countries that are the most vulnerable to the impacts of changes in the environment can at times, be least equipped to monitor and understand these changes (Limonés et al., 2020), hindering their ability to develop and implement appropriate and effective adaptation measures to safeguard their environment, culture, and economy.

However, these vulnerable countries are largely the focus of independent academic studies by foreign researchers that aim to identify the effects of these environmental changes (McCubbin, Smit, and Pearce, 2015; Islam et al., 2023). These studies typically involve ‘parachute science’ (Asase et al., 2022; Stefanoudis et al., 2021) in which external experts conduct field studies in a vulnerable country, and publish the research for academic purposes without meaningful engagement or communication with local researchers and communities. In such cases, apart from the focused output of the research project, the countries from which this data is collected do not typically see the continued benefits from the raw data, through inclusion in ongoing or future research and initiatives. Similarly, research and development projects undertaken by local stakeholders within these countries also require collection of environmental data, as well as ongoing monitoring for the duration of these projects. However, given the administrative systems within a country, these projects may be carried out in silos with minimal interaction with past projects, future projects, or even projects being carried out simultaneously (e.g., Scott and Gong, 2021).

Considering the challenges LDCs and dispersed SINs encounter in gathering long-term, continuous environmental data, the information collected through academic research and development activities present a valuable resource. If effectively utilized, this data could facilitate collection of environmental data across the geographical extent of these nations at minimal cost and effort to a central government institution. Within this context, the concept of ‘data sovereignty’ becomes particularly pertinent. Much like the principle of state sovereignty, the idea of ‘data sovereignty’ revolves around the notion that data collected within the borders of a country, by individuals or entities, remain under its sovereign control, independent of external influence (Bhatt, 2021). Only by regulating and supervising this collected data and ensuring that the information is in alignment with the laws, norms, and customs of the data jurisdiction where it is located or stored, can a country guarantee this (Alboai & Cosovan, 2017; Snipp, 2016). Such a task necessitates a robust data governance framework that addresses collection of the data, mechanisms for hosting it, and effective forms of dissemination.

The current study aims to evaluate the data governance principles and environmental data management mechanisms required to gather, host, and disseminate de-centrally collected environmental data, ensuring data sovereignty for a nation, so that the data can be utilized effectively for sustainable development and informed decision-making. This is achieved by carrying out a case study on environmental data management in the Maldives. The study reviews the state of environmental data management in the Maldives to firstly evaluate the provisions

within the existing legal framework for the management of environmental data collected within the Maldives. Second, the practicalities of implementing the regulations defined within the legal framework are evaluated to identify the challenges with consolidating, archiving, and disseminating environmental data collected within Maldivian borders. In recognising these challenges, recommendations are made to address present barriers and improve the utilization of de-centrally collected environmental data. The results of this study will serve as a reference for other nations that wish to utilize environmental data governance frameworks to effectively harness environmental data that is collected within their borders by independent researchers and during development activities.

While ‘environmental data’ is a broad term that encompasses several facets, for the purposes of this review, ‘environmental data’ is defined as data collected on physical environmental variables in a non-invasive manner through observations only, and not through experimentation. For example, monitoring coral cover to evaluate growth rates and changes over time as opposed to carrying out an experiment involving transplanting coral to different environments and evaluating impacts on growth, or collecting data on coastal erosion through beach profiles and satellite data as opposed to an experiment involving construction of a temporary breakwater to evaluate changes in sediment transport rates. Within this context, environmental data collection which involves biological sampling such as of fish, coral, vegetation or otherwise, are outside the scope of this study as these involve other considerations including ethical management of the samples.

### **Methodology**

The analysis in this study was carried out through two primary modes. A systematic review of the Maldivian constitution was initially undertaken by registered legal counsels from the Maldives to identify the legislative framework surrounding data management in the Maldives with a specific focus on legislative tools for environmental data management. This was followed up with a series of formal requests for information (submitted under the Maldives’ Right to Information Act - Law No. 1/2014) and confidential unstructured interviews with a range of government ministries, independent researchers, non-governmental organisations, and corporations who actively collect environmental data in the Maldives for the purposes of scientific research, management, and development activities.

### **The Maldivian Context**

The Maldives is an archipelago of coral reef islands widely recognised for its rich biodiversity and distinctive ecosystems (Bacmeister et al., 2018; Harvey et al., 2018). The nation is heavily reliant on its natural environment, affecting various aspects such as the economy, social well-being, and overall way of life. According to the Strategic Action Plan 2019-2023 (The President’s Office, 2019), biodiversity contributes to 71% of employment, 89% of Gross Domestic Product, and 98% of exports. However, the natural environment and ecological systems in the Maldives are undergoing unprecedented changes (The President’s Office, 2023) due to pressures from population growth, urbanisation, and economic expansion. Understanding these changes from the regional-scale to the island-scale, mitigating their impacts, and developing appropriate, sustained, and effective adaptation measures to protect the environment, culture, and economy of the

Maldives is rooted in the collection and analysis of environmental data. However, the dispersed nature of the Maldives, which constitute 1200+ islands that form only approximately 1% of the 859,000 km<sup>2</sup> total area of the Maldives, (Ministry of Planning and National Development, 2008) presents logistical, financial, and accessibility challenges that prevent the collection of regular, long-term in-situ data on fundamental vulnerabilities such as coastal erosion patterns across the Maldives, which are critical for informed decision making.

However, activities carried out by third parties within the country involve the collection of this, much needed environmental data across the archipelago, though not in an organised or centrally managed manner. For example, the unique and complex environment of the Maldives attracts interest from researchers all over the world with data being collected in a range of fields including coastal geology (Gischler et al., 2008; Lüdmann et al., 2013), coastal dynamics (Beetham & Kench, 2014; Kench & Brander, 2006; Matheen & Kench, 2023) and marine biology (Andréfouët et al., 2012; Jaleel, 2013; Naseer & Hatcher, 2004; Pisapia et al., 2016). Additionally, in recent years, major projects like the Hulhumale' development projects including the Male'-Hulhumale' bridge (Wille, 2023; Zhu et al., 2017), the Addu development project (Addu Development Project: About the Project, 2022), and land reclamation activities (Duvat, 2020) have required studies of the environment to be carried out, generating substantial amounts of data throughout the lifecycle of these projects. Furthermore, the construction of stand-alone resort islands which the Maldives is well known for, requires the collection of in-situ data and the forecasting of future scenarios to ensure resilience and reduce the risks to these multi-million-dollar investments (e.g., Adam, 2011; Water Solutions, 2014).

### **The Legal Context of Data Management in the Maldives**

Under Article 22 of the Constitution of the Maldives, the state is required to safeguard the environment, biodiversity, and resources for current and future generations, and is obligated to promote environmental conservation and prioritise sustainable development, all of which requires data collection. However, the legal mandates for this data collection and management are fragmented, with different institutions tasked with collection of certain types of environmental data, often with no clear delineations and significant overlap. For example, Section 12 of the Maldives Energy Act (2021) mandates the Energy Authority and the relevant Ministry to compile an inventory of the renewable energy resources in Maldives, which can be inferred as the collection of environmental data related to energy generation potential such as tides, ocean waves, etc. Meanwhile, under Section 28 of the Disaster Management Act (2015) the National Disaster Management Authority is required to collect and disseminate 'information' related to disaster management, including hazards that may affect Maldives, which can also be interpreted as collection of environmental data such as tides and ocean waves which are associated with wave-induced flooding disasters (Wadey et al., 2017). Additionally, under Section 34 of this same act, the Maldives Meteorological Service is required to maintain a multi-hazard early warning system to provide information on potential disasters. Such a system would again require collection and management of data related to tides and ocean waves (e.g., Turner et al., 2024) in order to provide reliable early warnings.

Additionally, though the collection and management of environmental data is crucial to enable the state to fulfil this constitutional mandate, the Constitution does not directly address the concept of environmental data sovereignty. However, certain sections of Acts which relate to data collection can potentially be interpreted as allowing for harnessing of environmental data independently collected by third parties in Maldives. For example, under the Climate Emergency Act (2021) the Climate Change Directorate is tasked with responsibilities including maintaining and disseminating data crucial to climate change, including greenhouse gas inventories; changes in wind and ocean current patterns; statistics on impacts of climate change including extents of erosion, rainfall patterns, tidal swells, coral bleaching; impacts of climate change on tourism, fisheries, agriculture; etc (Section 18 Climate Emergency Act, 2021). This directorate also has the responsibility of implementing a mechanism by which such data can be reported in accordance with this Act. Depending on the interpretation of wording of the Act, this mechanism could potentially be designed to compile environmental data independently collected by third parties within the borders of the Maldives. Similarly, Sections 9 and 12 of the Maldives Energy Act (2021), Section 9 of the Waste Management Act (2022), Sections 28 and 34 of the Disaster Management Act (2015), Section 5 of the Plants Protection Act (2011), and even Section 10 of the International Trade Control Act for Endangered Species (2022), can potentially be interpreted in such a manner. However, these Acts do not directly address the ownership of the collected data or its management once collected. As of this study, no legislative tools under these Acts or practical mechanisms developed as part of these Acts facilitate harnessing of environmental data collected, including data collected by third parties, as a sovereign resource.

While the above mentioned legislation mention data collection in specific contexts and may often be open to interpretation, the legal instruments that directly define and regulate environmental data collection in the Maldives are the Environment Protection and Preservation Act of Maldives (1993) and the Regulation on the conduction of Marine Research in the Maldives (2020) implemented under the Fisheries Act of the Maldives (2019).

The Environment Protection and Preservation Act of Maldives (1993) serves as the primary legal framework for environmental management. It addresses a range of issues related to environmental preservation, planning, and the impact of climate change. Under this legislation, the concerned government authorities are obligated to provide the necessary guidelines and advice on environmental protection in accordance with the prevailing conditions and needs of the country. However, this regulation does not govern the ownership and management of environmental data that is collected through activities mandated through this legislation. For example, under the Environmental Impact Assessment Report Regulations (2012) which comes under this Act, the Environmental Protection Agency (EPA) has provided guidelines for data that is collected for the purposes of Environmental Impact Assessments, but not the ownership and management of the data. As such, the EPA does not receive raw data collected for the purposes of EIA; instead, it usually receives access to the processed data in the form of a report which is then archived in a Google Drive cloud storage system and made available through the Agency's website (Environment Protection Agency, n.d.).

The Regulation on the conduction of Marine Research in the Maldives (2020)

lays out requirements and procedures regarding the issue of research permits, particularly the application of permits by foreign individuals or entities wishing to conduct research within the maritime zones of the Maldives. Activities that are governed by this regulation include research on the maritime zones, marine organisms, and marine resources within the marine environment of the Maldives. The regulation provides a legal framework for the collection and use of marine research data, and states that the research data collected falls within the purview of the regulation, and so must be shared with the ministry (Section 12 Regulation on the conduction of Marine Research in the Maldives, 2020). This includes all statistics compiled and any reports prepared using the data collected, which may then be used by the Ministry for official purposes of government. By way of example, the research arm of the Ministry of Fisheries and Agriculture, the Maldives Marine Research Institute (MMRI), has a coral database (MMRI, 2024) to manage information and data collected concerning the state and health of coastal, oceanic, reef, and other ecosystems found in the Maldives. This platform enables different national and international programmes as well as other organisations and citizens collecting data on the coral reef environment under the National Coral Reef Monitoring Framework, to store data in a centralised national repository of marine information. Most of the collected data is, however, not open access to the public or other users of the platform. This limitation in ensuring open-access to collected environmental data extends to any collected data, as there are no legal tools or requirements to facilitate access, even if the collection was supported by public funding.

Neither of these two legal instruments directly address the ‘sovereignty gap’ nor empower an institution with this potential. However under Section 2 of the Maldives Statistics Act (2021), the Maldives Bureau of Statistics has the responsibility of establishing the principles and guidelines for collecting, processing, publishing, and disseminating data needed to assess the situation of the country, which includes the environment. The Maldives Bureau of Statistics therefore could be tasked with management of environmental data being collected within the Maldives. The National Strategy for the Development of Statistics 2021-2030 (Maldives Bureau of Statistics, 2021) proposes national indicators which would require collection and management of environmental data, potentially indicating plans to develop mechanisms to manage environmental data and facilitate these statistics. However, as of this study only a handful of key environmental indicators are included in the Bureau’s List of Designated Statistics (Maldives Bureau of Statistics, 2024) and no regulations have been identified which govern environmental data independently collected by third parties within the borders of the Maldives.

### **Discussion on the challenges with environmental data governance in the Maldives**

While existing laws in the Maldives stipulate the collection of environmental data for various purposes, the responsibility of collection and reporting is fragmented between institutions and there is limited regulation for overseeing the appropriate management of this data once collected. Moreover, there are no legal requirements ensuring that data collected within the borders of the country should be presented in an easily accessible or interoperable manner that can be integrated with existing applications or workflows.



Regulation on the conduction of Marine Research in the Maldives (2020) provides the most direct and only framework for management of this data by obligating research parties to share marine research and data. However, consultations with international researchers in the Maldives identified that this regulation is rarely (if ever) enforced. Instead, the accessibility of environmental data collected for the purposes of carrying out research relies heavily on contractual agreements between a specific ministry or agency, and the private entity, individual, or institution carrying out research in the Maldives. These bilateral contractual agreements typically stipulate the dissemination of the data collected in a processed format, via a specific workshop or report. The consultations highlighted that in many cases beyond these very specific submissions, environmental data was not being stored or managed in any systematic, organised, transparent, or accessible manner. In one case, an external researcher shared how, notwithstanding the requirements of the permit agreement, they were eager to routinely share raw data from their environmental monitoring work but had not been provided with guidance on a mechanism for sharing the data itself or how best to go about providing large volumes of data, in the realm of Terabytes (Anonymous, interview, December 13, 2023). Furthermore, the Regulation on the conduction of Marine Research in the Maldives (2020) provides an obligation on research parties to share only marine research and data, with specific definitions of what this entails. This leaves a large category of environmental data collected within Maldives unregulated.

The limited legal framework governing environmental data collection in the Maldives makes it challenging for institutions to effectively coordinate their approaches and organise their capacities to manage environmental data collection and ownership. It is therefore not unexpected that consultations with relevant government stakeholders revealed that no significant national effort has been made to consistently manage environmental data across the Maldivian research landscape, nor does there appear to be significant interest from within institutions to address the challenges. Specifically, the absence of coherent cloud or physical databases makes the storage, organisation, and accessibility of data extremely difficult. As such, the notions of ‘sovereign control’ are challenged not only by data access but also by data accessibility. If raw data gathered by external researchers is not being retained either in full or as a copy within the country, and there exist no robust regulations governing the processing, storage, and sharing of such data, then there is a lack of sovereign control over the data collected within the Maldives.

Furthermore, the lack of systemic organisation of environmental data makes it challenging to identify and find data which have been collected through previously completed projects. This has led to duplication of collection efforts and associated research, particularly in the case data collected specifically for a project (as opposed to ongoing data collection such as for Environmental Impact Assessments). An example of this can be seen in Laamu atoll where data collection was carried out between 2012 and 2017 for the Low Emissions Climate Resilient Development (LECRd) Programme during which comprehensive environmental datasets were collected across the atoll to establish the baseline conditions (Clissold et al., 2020; McNamara et al., 2016; UNFPA Maldives, 2016). However, the consultations identified that at the beginning of the Enhancing National Development through Environmentally Resilient Islands (ENDhERI) project in 2020 (Global Environment Facility, 2020) this baseline data could not be found and as a result

a new environmental baseline had to be established. This duplication of efforts is further driven due to a hesitancy in sharing data between government institutions as well as between government and non-government entities not specifically involved in a project, potentially stemming from a sense of ownership over the data due to the financial and logistical challenges associated with collecting the datasets.

The Privacy and Personal Data Protection Bill (Privacy and Personal Data Protection Bill, draft) currently being drafted potentially becomes relevant within the context of environmental data management. The legislation will regulate the collection, processing, and transmission of personal data in the Maldives, intending to establish a regulatory framework for overseeing personal data within the country and to enforce rights and obligations concerning cross-border data transmission of data. If the Parliament approves this Bill, it will represent the first introduction of the concept of data sovereignty into the legislative framework of the Maldives. The legislation extends its governance framework to data collected within the Maldives or concerns Maldivian data subjects that are processed outside the jurisdiction of the Maldives. This would require parties to comply with data protection regulations and imposes an obligation to safeguard the rights of data subjects as granted by this legislation. Although the Bill mentions personal data collected for scientific purposes, it does not establish regulations for scientific data, nor does it directly govern environmental data. Nevertheless, it serves as a valuable legislative primer on the broader issue of data sovereignty, articulating clear territorial boundaries for data subjects and codifying data-related obligations within the framework of Maldivian jurisprudence. This is not dissimilar to the European Unions' 'General Data Protection Regulation', the Chinese 'Personal Information Protection Law', or the Indian 'Digital Personal Data Protection' which regulate and protect privacy and personal data and incorporate the principle of data sovereignty within the jurisdictions which the regulations govern. The growing political interest in formally enshrining the principle of data sovereignty into law, coupled with the introduction of the Privacy and Personal Data Protection Draft Bill, presents a critical opportunity to examine mechanisms for ensuring environmental data sovereignty and to develop appropriate legislative frameworks for its governance.

It is worth noting that the data management challenges identified in the Maldives have similarly been observed in other SIDs and LDCs. Historically, poorly developed institutional frameworks for ministries and a lack of technical capacity in disseminating data in a useful manner were identified as key barriers to effective decision-making and policy development in the Pacific Islands (Aston, 1999; Crawley & Aston, 2003). More recent reviews of data management practices within Pacific Island SIDS have identified the persistence of these data management challenges, especially the lack of systemic data management principles across government bodies which discourages sharing of data between institutions (Mackay et al., 2019). Initiatives such as the CliDE (Climate Data for the Environment) data management system (Martin et al., 2015) have been developed to tackle aspects of data management challenges across the western pacific region, but many of these initiatives do not address the aspect of sustainable long-term in-situ data collection which is founded in the implementation of data sovereignty through good data governance and management practices.



### **Recommendations**

Based on the review of environmental data collection, management, and dissemination of the Maldivian landscape, the following key recommendations are made to address the identified challenges and better harness environmental data that is being gathered in the Maldives.

#### **Development of national regulatory framework that defines roles and responsibilities for environmental data management**

Currently, two key ministries are accountable for different aspects of environmental protection in the Maldives. The Ministry of Fisheries and Ocean Resources, which oversees the coastal and marine environment, and the Ministry of Climate Change, Environment and Energy, which includes the EPA, the Maldives Meteorological Service, and affiliated departments. However, within the current regulatory framework, there is limited understanding of the roles of these different Ministries and their departments, the responsibilities of institutes with whom bilateral research projects are carried out, and the researchers who collect the data. This ambiguity inhibits collaboration and data sharing, and in many cases leads to duplication of collection, processing, and dissemination efforts. The challenge posed by the dispersion of responsibilities across ministries was also noted in a study by Techera and Cannell-Lunn (2019). These limitations present challenges to collaborations between government and non-government entities because data is often perceived as a commodity to be protected due to the demanding nature of collecting it. This creates a working environment where the sharing of data for collaboration becomes completely dependent on the disposition of the project leads involved.

The Privacy and Personal Data Protection Bill (Privacy and Personal Data Protection Bill, draft) intends to establish a 'Data Protection Office' which is to be the already existing Information Commissioners Office and envisages establishment of a data protection commission. However, the bill neither explicitly covers environmental data nor does it set out a robust framework that clearly defines and articulates the roles and responsibilities of stakeholders in collecting, hosting, and disseminating environmental data, which is imperative to fostering a more unified approach to environmental data management. A possible approach is to include the regulation of environmental data within this legislation. This would entail empowering the 'Data Protection Office' established by the bill, as the central regulatory authority overseeing all data types in the Maldives. Alternatively, the Maldives Bureau of Statistics could be provided with this authority under the existing framework of the Maldives Statistics Act (2021).

Alternatively, a more effective strategy may involve the development and implementation of regulatory measures under the Environment Protection and Preservation Act of Maldives (1993), a legislative framework specifically designed to govern the collection and management of environmental data within the Maldivian jurisdiction. This approach is preferable because a comprehensive framework delineating the roles and obligations of stakeholders involved in collecting, hosting, and disseminating environmental data is more relevant and distinct compared to regulations concerning privacy and personal data. Amendment of the Environment Protection and Preservation Act of Maldives (1993) would also allow extension of the scope of environmental data governed in the Maldives to go beyond just the marine data identified in the Regulation on the conduction of Marine Research in

the Maldives (2020), by introducing clear definitions of what ‘environmental data’ entails and obligations on those collecting data within the borders of the Maldives.

### **Development of national data management system**

The lack of technical infrastructure and the capacity to securely store and host environmental data has been identified as potentially being at the root of a lack of enforcement of existing regulations that govern the consolidation of collected data by independent researchers. The establishment of a national, publicly accessible, data storage system with relevant redundancies, where all raw data collected in the Maldives can be sorted and stored in line with international best practices presents a potential solution.

There are many directions that such a national database could take, with both centralised and decentralised combinations of predominantly cloud or server-based approaches proving successful in different contexts. As an example, The Coral Database (MMRI, 2024) initiated by the MMRI which compiles information obtained through the National Coral Monitoring Framework and Seagrass Monitoring from both individuals and organisations, including resorts, could potentially be linked to several other decentralised databases through a central link management system that allows querying of these decentralised databases to identify data that is available. Such national databases already exist in other SINs. For example, the Environmental Information System of Mauritius which is managed centrally by a unit within the Department of Environment (Thaunoo-Chadee & Sham-Jacmohum, 2007), and can offer invaluable lessons for developing the system architecture.

Regardless of whether a centralised or decentralised national database approach is implemented, relying solely on physical data storage carries inherent risks associated with it. The vulnerability of Maldivian islands to extreme weather such as wave-induced flooding (e.g., Wadey et al., 2017), natural disasters such as Tsunamis (Papadopoulos et al., 2006), and even accidental events such as fires (Avas, 2024; The Edition, 2024), offers no geo-redundancy, leaving a physical data storage system at risk and highly exposed. Third-party cloud-based data storage options such as those offered by Microsoft or Amazon Web Services operate secure server sites offshore and provide data architectures and security systems which few national databases can compete with and therefore may be appealing. However, utilizing third-party databases for national datasets carries further challenges especially those associated with potential data breaches. While these services can be used for data visualization and analysis, the actual datasets should be stored within the jurisdiction of the Maldivian government, with sufficient effort made to ensure redundancy. In this regard, having robust cyber security laws is crucial. As the current legal framework barely covers cybercrimes, an amendment to the Penal Code or enacting a special law such as the Computer Crimes Act, Malaysia (Computer Crimes Act of Malaysia, 1997) could address this gap in law and ensure better cyber security.

The development of such a system would also facilitate the improved management of data that is currently being collected through existing legal frameworks. For example, the EPA could begin collection of the environmental data surveyed for the purposes of Environmental Impact Assessments, which is an invaluable source of independently collected data that is currently not being harnessed. It would also

make possible the bi-lateral sharing of data between government, international, and non-government institutions such as NGOs and independent researchers, allowing successive work to build on top of previous efforts and progress, rather than duplicate it.

### **Reformation of the research permit system**

The unique and diverse environment of the Maldives attract researchers from all corners of the globe, each generating invaluable data across various fields. However, the current legal framework only governs the management of marine research data, leaving a large set of environmental data unregulated. A review of the existing permit system and suggestions of improvements to the system is needed, potentially through a cross-Ministerial working group that reviews research activities and holds researchers accountable, so that research activities are sanctioned in a standardised fashion where researchers are required to follow common sets of rules, data sharing stipulations, and research publication time horizons. Permits issued for research can also be cross-referenced against the proposed national data management system to verify the activities of researchers and ensure data is provided as needed.

### **Conclusion**

Logistical and financial barriers can make it challenging for LDCs and dispersed SINs to collect long-term environmental data on the regular basis required to establish trends, understand the changing environment, and facilitate informed decision making. However, the environmental data collected independently for academic research and during development activities presents an opportunity to gather data at minimal cost and effort to the state budget. This requires establishing and enforcing data sovereignty through robust mechanisms for governance and management of environmental data collected within the borders of a nation.

This study has explored the data governance principles and environmental data management mechanisms required to effectively harness this de-centrally collected environmental data by carrying out a case study of the environmental data management principles in place across the dispersed islands of the Maldivian archipelago. A review of the existing legal framework for the management of environmental data collected within the Maldives identified that the absence of a systematic approach to the collection, hosting, management, and accessibility of environmental data presents a significant missed opportunity for the country. Limited technical infrastructure and capacity to securely store and host environmental data has been identified as potentially being at the root of a lack of enforcement of existing regulations that govern the consolidation of data currently collected by third parties in the country. Where limited data is available, a lack of a clear legal understanding of the roles of different levels of government, the responsibilities of institutes with whom bilateral research projects are carried out, and the researchers who collect the data, create barriers to collaboration and data sharing between both government institutions as well as government and non-government entities, in many cases leading to duplication of collection, processing, and dissemination efforts. These challenges within the legal framework disincentivise efforts to tackle issues regarding collection, management, and ownership of environmental data.

Addressing key and critical areas in the current data governance framework

through (i) legal reforms that clearly define the roles and responsibilities of different government institutions within the context of data management, (ii) development of a national, publicly accessible, data storage system with reliable redundancy measures, where all raw data collected in the Maldives can be sorted and stored in line with international best practices, and (iii) reformation of the permit system through which foreign institutions are allowed to carry out research in the Maldives, by the establishment of a cross-Ministerial working group that reviews research activities and holds researchers accountable, would streamline government coordination efforts and facilitate better environmental data management.

The results of this study provide a reference for other LDCs and dispersed SINs in approaching environmental data sovereignty through data governance, to effectively manage environmental data collected within the borders of the nation. Such mechanisms would greatly facilitate the harnessing of environmental data to understand the changing environment, support sustainable development practices, and effectively utilize the natural capital in a manner that safeguards the environment, culture, and the economy of the nation.

### **Conflict of Interest**

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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### **Data availability**

No new data were created or analysed in this study.

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