Review and Gap Analysis to Improve Availability and Use of Data for Planning Mitigation Activities by Industry and Development Projects

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December 2017

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Abstract

The Wildlife Conservation Society (WCS), Forest Tends and Biotope are carrying out Project COMBO (Conservation, Impact Mitigation and Biodiversity Offsets in Africa), which aims to reconcile the economic development in Africa, including Mozambique, with conservation of biodiversity and ecosystem services. To achieve that, a policy on No Net Loss of Biodiversity (NNL) is being promoted, based on the rigorous application of the Mitigation Hierarchy, including Biodiversity Offsets. The development and application of the policies and laws on this matter depend, in part, on the existence of solid information about biodiversity and land uses as well as effective data management systems and knowledge. A rapid review and a gap analysis of the data currently available in Mozambique that could supply the foundation for the implementation of a NNL (or similar) policy and the development of mitigation and offsets systems are, therefore, important steps to achieve these objectives. The Project COMBO Mozambique, together with the company IMPACTO, undertook a detailed review and gap analysis of spatial and non-spatial data available in the country which are required for mitigation planning and decision making. The work focus consisted on identifying data that can be used to apply good mitigation practice, including in baseline studies and mitigation design (for species, habitats and ecosystems, ecological processes, etc.). The study includes two mains tasks according to a given framework and Terms of Reference initially developed: i) data capture and/or aggregation; (ii) review of obtained information to undertake the gap analysis. A workshop was also held for the validation of the obtained data and to supplement this with additional information. More than 3.000 datasets were obtained, having been inserted 1.341 entries in a metadata table, including 832 non-spatial data and 509 spatial data. The amount of biodiversity data available in Mozambique has been higher than expected, and amongst other things it can be very useful for EIA processes. This may improve the quality and effectiveness of baseline studies, impacts assessment and biodiversity management plans. The present work details and discusses the results obtained, making recommendations on several aspects, including the most suitable platforms and institutions to share the data.

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1 Introduction

The Project COMBO is being developed by Wildlife Conservation Society (WCS), Forest Trends and Biotope. It lasts for four years and aims to reconcile development and conservation of biodiversity and ecosystems in four African countries, including Mozambique. COMBO is working with these governments and other stakeholders on the implementation and mainstreaming of a policy on No Net Loss / Net Gain of Biodiversity (NNL/NG) or similar goal, based on the adequate application of the Mitigation Hierarchy, including Biodiversity Offsets. The development and application of the policies and laws on this matter depend, in part, on the existence of solid information about biodiversity and land uses as well as effective data management systems and knowledge. In most countries, available data often corresponds to large number of data sets of varying format, scope and quality. Furthermore, the list of dataset holders may include government, NGOs, academic organizations as well as private companies, yet some could be outdated, hence not useful.

Undertaking a rapid review of currently available data that could provide the underpinnings of a mitigation and offset policy and system, and conducting a gap analysis are thus important first steps towards formulating such a system.

The project COMBO has decided to undertake the present study with the aim do identify, combine and analyze available data on biodiversity in Mozambique that can be used to apply good mitigation practice, which can be found in guidance for baseline studies and mitigation design produced, for example, by international institutions such as IFC (PS6 guidance notes), CSBI (sectorial guidance), IUCN (Key Biodiversity Areas), BBOP (Mitigation Hierarchy and Biodiversity Offsets), and others. The types of data were defined according with set of criteria previously defined in the Terms of Reference (ToR) and will include data on species, habitats and ecosystems, ecological processes, as well as, other useful information on e.g. land cover and land use, wildlife uses, ecosystem service, among others.

The study aims to support impact mitigation planning and decision making in accordance with good practices and improve the sensitivity and access of Mozambican decision-makers and technicians to this kind of information. Hence, it is expected that this study can be used as a tool to inform the implementation and dissemination of a policy of NNL in Mozambique, with focus on the application of Mitigation Hierarchy to the impacts resulting from development projects.

2 Methodology

The project COMBO prepared a framework and a ToR to develop the current study. A call for proposals was launched the company IMPACTO was selected to conduct the first phase of the present study, which undertook two main activities: i) data capture and/or aggregation; (ii) revision on the information obtained to proceed the gap analysis. These activities were divided in the following tasks:

- Web search of spatial or non-spatial data and additional data on biodiversity and socio-economic aspects.
- Contacts with potential pre-defined data holders.
- Collection and storage of readily accessible data sets and information, which were stored on a hard disk in the original format.
- Preparation of a metadata table using a sample of the dataset and information provided.
- Biodiversity data gap analysis, focused mainly on geographic coverage, addressed topics, availability and terms of use of the data.

From these tasks, a draft document was prepared, which was presented in a second phase of the work: a stakeholders workshop to analyze and validate the results and obtain contributions to improve the present study, including discussing which should be the most favorable regions of Mozambique to undertake a demonstration landscape analysis with the objective of testing a framework for integrating the Mitigation Hierarchy into spatial planning.

Finally, in a third phase, the COMBO team reviewed the information presented in the draft document, adding relevant elements obtained during the workshop and undertaking a gap analysis specifically associated with the data needs for the implementation of a policy on NNL/NG (or similar goal).

2.1 Data acquisition

The data analyzed in this project were obtained between May and July of 2017 through various sources. Data from the web and other data holders were simultaneously aggregated into a single repository. As shown in Figure 1, whilst engaging with selected data holders via telephone, interviews and emails, the team was also searching on the internet for any data relevant for conservation or management of Mozambique's biodiversity.

2.2 Data catalog

For analytical purposes, data sets were separated into two groups, spatial and non-spatial. The spatial data sets include formats such as *Esri* shapefile, *rasters*, spreadsheets and text containing coordinates. As for non-spatial data sets, they refer to documents in various formats related to studies, which included books, scientific articles, reports, plans, thesis and Environmental Impact Studies (EIS).

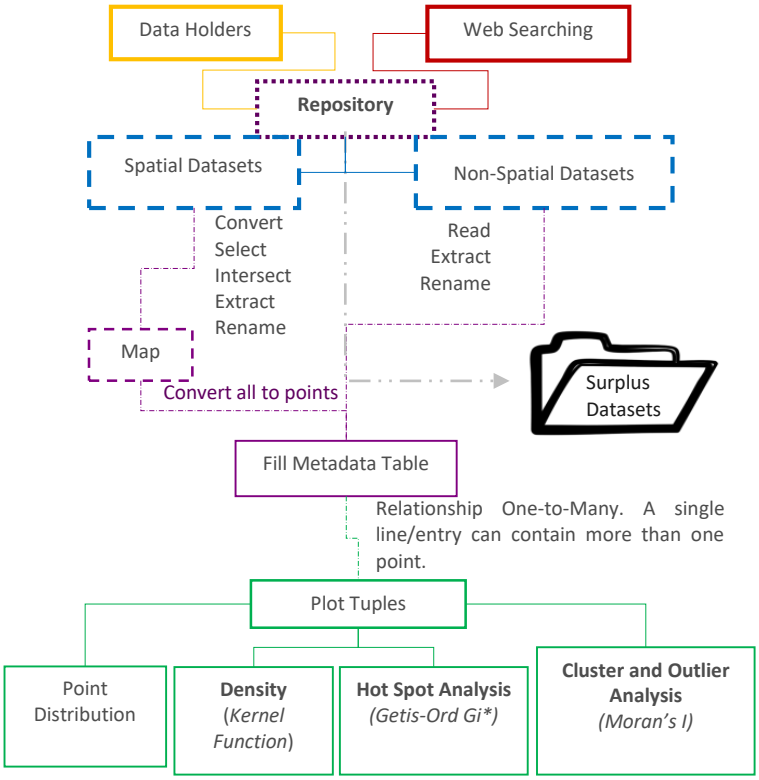

Figure 1. Methodology Workflow

After its acquisition, the data sets required processing, so most were first evaluated and later renamed and cataloged (see Box 1) . The assessment of the non-spatial data sets required reading (mostly the abstract or executive summary) for extracting details such as the spatial extent and biodiversity importance. To streamline the process and perform the individual analysis of more than three thousand documents (most files were *.pdf), the consultants developed a script to perform the task in an automated way. The script produced an archive of text with titles, authors and summaries, in order to carry out the primary assessment of each document.

Box 1. Details of Data Processing

File details:
- Name (Alias); Acquisition date; Credits (author/publisher); Link;
- Format: Map, Website, spatial (e.g. shp), Documents (pdf, word, spreadsheet), Darwin Core Archive Validator (DWCA) and only citation.

Spatial data details:
- Spatial data type; Raster format; Resolution/scale; Fields/No. of bands; No. of features;
- Vector geometry: Polygon, Line, point, and TIN.

Study details:
- Coverage (in Mozambique); Methods; Sampling frequency; Date/period;
- Season: Both, Dry and Wet.

Observations:
- How was this sourced: Download (open data), Visualized, Institutional (shared), Purchased, Collected (field) and Produced;
- Reliability/validity: between * and *****;
- Restrictions: Restricted, Allowed, Special restrictions and None;
- This was not sourced due to; Terms of use/limitations; Notes;
- Importance: Low, Medium, High and Very high.

Despite this effort, a relatively large number of studies were not cataloged due to time constraints. These were made available in the hard disk drive on a separate folder. Spreadsheets and text files containing coordinates were converted to vector and intersected/clipped to country's extent. Conversely, *rasters* were not converted due to time constraints. Each entry on the table was done considering a set of key attributes, aggregated into 4 main categories (see Box 2).

Box 2. Details Captured in Metadata Table (Key Attributes)

- **Environment: All of them, Terrestrial, Aquatic, Marine, Social;**
- **Theme**: Ecoregion, Ecosystem, Species, Ecosystem services, Land use/cover, People, Plan/Strategy/Guidelines/ESIA;
- **Region**: World, WIO, Africa, Eastern Africa, Southern Africa, Mozambique and each province;
- **IFC and/or other significance criteria**: modified, natural or critical habitat, critically endangered, endangered, endemic, restricted range, migratory and congregational species, threatened and unique ecosystems, key evolutionary processes, legally protected and internationally recognized areas, residual impacts, No Net Loss and Biodiversity Offset.

Although some entries did not fill all attributes, those essential for analysis, such as reliability (from author/source, methods and format), importance (from theme, criteria, reliability, data and coverage) were completed for every entry. These two attributes were defined by the consultants based on their knowledge of the issue at a national level.

2.3 Data analysis and Mapping

The consultants used MS Excel statistical package for the primary analysis of data in the metadata table, which included the data sources, attributes and other relevant aspects. A spatial analysis was also undertaken, which required that all entries be inserted on a map, so, each entry in the table was converted to at least one indicative point on the map, following information from the coverage column. For consistency purposes, entries representing polygons were converted into points, considering the known lowest administrative features (e.g. city, district or province).

The resulting map was processed in three steps. First, the density of points was evaluated to understand the spatial distribution throughout the country and, later, to detect geographical areas with large gaps of data. Despite providing valuable information, density analyses lack the spatial relationships between the data sets. Therefore, a *Hot Spot* analysis was performed, which presented these relations between low and high importance clusters. Furthermore, Cluster and Outlier Analysis made possible an understanding of patterns within the clusters.

As shown above in Figure 1, two approaches, one merely spatial and another statistical considering key attributes were used to analyze the gaps.

Finally, an analysis of specific gaps was also carried out on information that is considered of greater importance for the implementation of a policy on NNL. A table was prepared with those which were considered the most relevant topics, verifying if, in general, the data obtained corresponded to these needs or not. The absence or presence of such data and their type and general characteristics were identified in a column of this table.

2.4 Data sharing

A survey was carried out for the existing storage and data sharing platforms in Mozambique, in order to determine the most feasible options to make available to general public, the data obtained with the present study.

2.5 Gap analysis

After exploring the data under the approach explained in the previous topics, a gap analysis was undertaken. This was comprised of two components. One focused just generally on all biodiversity data, and another one with the specific aim of identifying gaps for developing and implementing mitigation and offsetting policy and system.

2.6 Demonstration landscape selection

One of the COMBO's objectives is to develop a framework to integrate the Mitigation Hierarchy into spatial planning in Mozambique. The findings and data obtained with this review and gap analysis are intended to be used to develop that framework, testing it in a demonstration landscape, which currently has the adequate data in the sufficient amount. Therefore, the results of this study were analyzed with that objective and discussed during the stakeholders workshop described below.

2.7 Workshop

On 7 November of 2017, a workshop was held in Maputo, at Hotel Montebelo Indy, with the objective of presenting the results of the review and gap analysis to relevant stakeholders and collect their comments and contributions. A total of 60 participants from 45 institutions attended the event, representing academy / research, government institutions, private sector (consultants and developers), NGOs, projects and bilateral institutes. The draft version of the report on the review and gap analysis on biodiversity data for Mozambique was previously sent to the participants so that they could become familiar with the content and prepare the respective comments to be presented at the workshop. After the presentation of the report, the participants were grouped, as shown in Figure 2.

Figure 2. Working groups to discuss the gap analysis on biodiversity data for Mozambique.

Each working group was comprised of individuals from different institutions, in order to obtain a greater diversity of opinions and perspectives, generating better results in the discussion of the following questions:

- Are you aware of any other important data, especially spatially explicit data, that might have not been collected during the review?
- Which data currently inexistent for Mozambique do you consider mandatory to the adequate implementation of the Mitigation Hierarchy at a spatial planning and project levels?
- What is/are the institution(s) which you consider most appropriate to host, manage and share the data that were obtained in this review and why?
- What is the most adequate Province (s)/Region (s) of the country where to carry out a demonstration exercise on how to apply the Mitigation Hierarchy to spatial planning?

After discussing the above-mentioned questions, the groups were invited to present their answers and/or contributions through one nominated representative (Figure 3).

Figure 3. Presentation of results obtained in the working groups.

3 Results and Discussions

3.1 Data sources

The records entered in the metadata table were mainly sourced from internet sites free of charge (see Box 3).

Box 3. Overview

- More Than 3,000 Datasets Sourced, Resulting in 1,341 Entries (Tuples) On The Metadata Table. These entries cover:
    - 832 Non-Spatial Data {575 Documents | 132 Websites | 122 Citations | 2 Documents-Website | 1 Image}
    - 509 Spatial Datasets {233 DWCA | 133 Spreadsheets | 130 Maps/Spatial Format | 8 Websites| 3 Documents-Spreadsheet | 1 Image-Document-Spreadsheet | 1 Image}

As shown in Figure 4, this source actually contributed the most owing to its efficient method of obtaining data, notwithstanding registration requirements(mainly for spatial data sets).

Obtaining data via Internet is probably the most important source, since the concept of free access and free sharing is growing exponentially around the world.

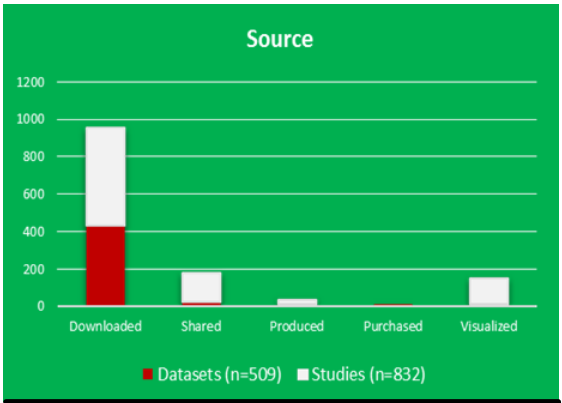

Figure 4. Data Sources.

With a growing number of computerized projects for biodiversity, namely data sets, data bases and other initiatives (considered here as spatial datasets), it is difficult clearly to define the relationships between the obtained elements in such a complex scenario (Bingham et al., 2017). Consequently, the determination of no redundancy of spatial data sets can only be detected by a thorough review of each dataset. A very recent study presented the first attempt to make such a high level review using 74 elements at a global and European level and found that the computerized universe is complex (Bingham et al., 2017).

Two other recent reports have identified and analyzed 128 (Weatherdon et al., 2015) and 103 (Weatherdon et al., 2016) global marine and coastal datasets important for biodiversity. The latter focused mostly on regional features within the region of Western Indian Ocean (WIO), therefore, more relevant for Mozambique. Some of the datasets listed by Weatherdon et al. (2015 and 2016) were obtained and reviewed as part of this study (especially those available on the GBIF[2] network and the UNEP-WCMC[3] online database), while others may not have been obtained. All links to the datasets are provided in these documents.

3.2 Analysis of the considered attributes

The datasets analyzed cover mostly the terrestrial and marine environments (Figure 5). However, a fairly high number of spatial datasets cover more than one environment ("all of them"), which is probably influenced by entries where the environment could not be determined.

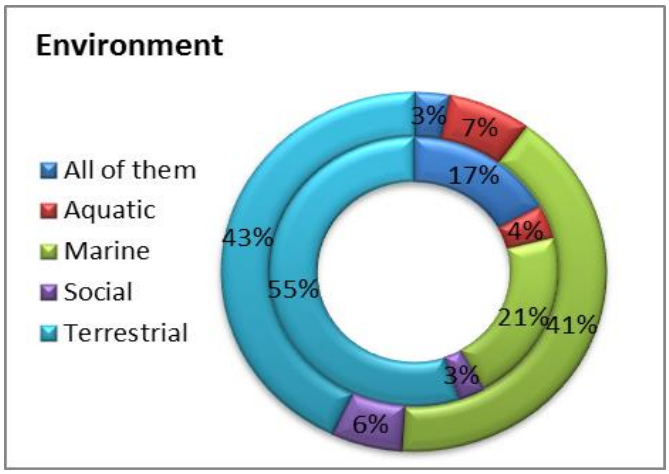

Figure 5. Data representation by Environment—Inner ring represents spatial datasets (n=509) and outer ring represents studies (n=832).

The search was focused on datasets from Mozambique (i.e. that include information on the country), so it is understandable that the majority of entries' coverage is confined to Mozambique (Figure 6). However, this is not an indication of a higher production of data from Mozambique in relation to other regions. In fact, even though this was focused on Mozambique, a fair portion of the datasets covers other regions. As a result, 25% of the non-spatial datasets present a regional, African or even global coverage, whilst 31% of the spatial datasets is mostly global or regional. It is therefore evident that wider-range studies are important in providing useful information for a country underprovided of studies, such as Mozambique.

[2] The Global Biodiversity Information Facility — an open-data research infrastructure aimed at providing anyone, anywhere access to data about all types of life on Earth.

[3] The United Nations Environment Programme World Conservation Monitoring Centre

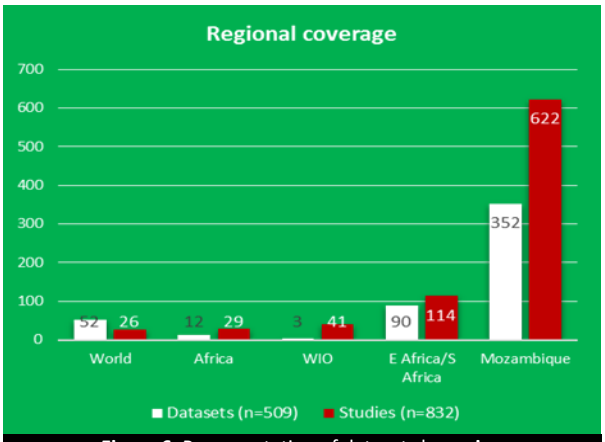

Figure 6. Representation of datasets by **region**

As an indication of the country's deficiency in scientific studies, Mozambique is ranked in 125th and 24th place in the World and in Africa (respectively) by the SCIMago Journal & Country Rank[4], in terms of published documents. A total of 2,802 documents from Mozambique, published between 1996 and 2016, are found in the Scopus database (SCImago, 2007).

A large portion of the studies are in some way focused on national protected areas and/or on significant biodiversity values (Figure 7). This might be associated to funding, as more funds may be available for undertaking biodiversity studies on protected areas and also for biodiversity inventories (e.g. biodiversity expeditions, species' inventories, distribution and taxonomy).

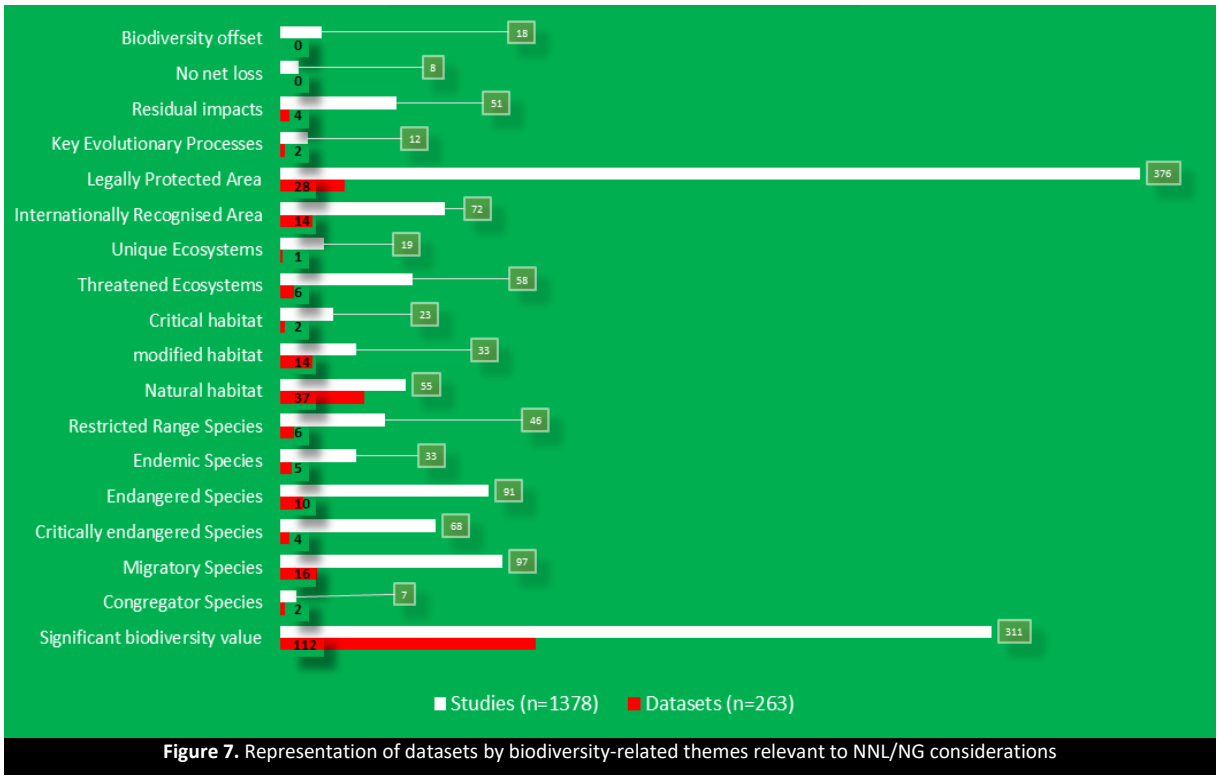

Figure 7. Representation of datasets by biodiversity-related themes relevant to NNL/NG considerations

[4] The SCImago Journal & Country Rank is a publicly available portal that includes the journals and country scientific indicators developed from the information contained in the Scopus® database (Elsevier B.V.).

Apart from the two above-mentioned criteria, issues relating to species (mostly endangered, critically endangered and migratory species), internationally recognized areas, threatened ecosystems, natural habitats and impacts on the environment constitute a fair portion of the non-spatial datasets analyzed. Those of greater importance were dominant in non-spatial data. On the other hand, the concepts of NNL/NG and Biodiversity Offsets are new in Mozambique, which explains the limited amount of data on the issue.

The criteria for classifying spatial data have proved to be more difficult as it would require further analysis (for example, analyzing the threat status of all species present in large lists).

However, those for which the criteria were assigned showed a trend similar to non-spatial data. In any case, the significant value of biodiversity was dominant (mainly due to datasheets with sighting lists or occurrences of species), followed by natural habitat and protected areas.

Overall, the majority of the datasets were classified as of medium and high importance to support Mitigation Hierarchy and NNL/NG considerations (Figure 8).

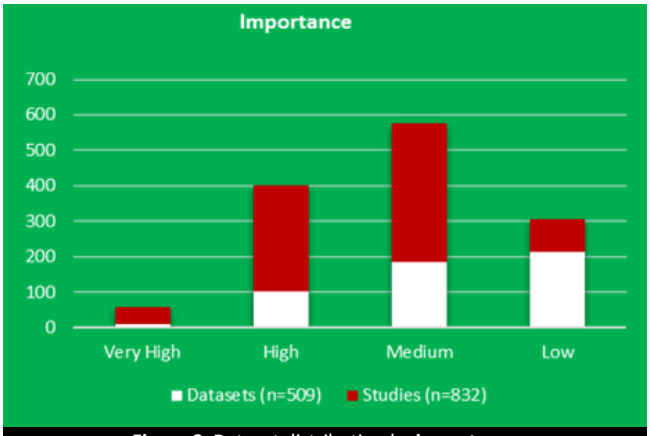

Figure 8. Dataset distribution by **importance**

In conclusion, although a good amount of high importance datasets exists, there is still a shortage of relevant datasets and studies for this subject (interdisciplinary, long-term, scientifically based and presenting clear biodiversity priorities).

3.3 Data sharing

In Mozambique, as in many other countries, data sharing is still a sensitive question and there is a general reluctance to share information. This applies, for example, to EIA Consultants, either as a business or individuals, who tend to show some reluctance to share data or information due to the non-disclosure agreements signed with their clients. On the other hand, scientists, research institutes and NGOs are usually interested to share information, especially already published papers. Government institutions usually share the information that is produced, however, as it requires authorization from the main departments, this involves bureaucracy and/or costs. Associated to an inefficient management of their libraries / databases, this makes the data acquisition process generally very slow. During the workshop it was also mentioned that, sometimes, there are cases where even in the research and teaching institutions, the data are not easily accessible or even available. Finally, specific situations on specialist studies undertaken in the offshore environment associated to *Oil & Gas* projects were also mentioned, in which they are were not disclosed or accessible. Some of the information obtained in these studies is sometimes considered as sensitive by the developers, who prefer not to make it available to the public, including to potential competitors.

The scope of this study did not specifically address the purchase of data, so the only ones that were considered "acquired" refer to datasets that had been purchased by IMPACTO as part of other projects. The studies obtained

online and that implied a payment for download (scientific journals or books) were registered as "visualized" and their format as "website"; the respective link was included in the metadata table.

New initiatives for sharing data / biodiversity studies for Mozambique are currently underway. Probably, this will improve the general access to information across the country. Some examples of these new initiatives are:

- Project SECOSUD 2 (BioNoMo platform)[5]: intends to create a national network for biodiversity data, which will likely be linked to the GBIF infrastructure in a near future. This platform will link different biodiversity databases existing in Mozambique and will provide an online platform where the public can access the data.
- FNDS[6]: this institution is preparing a Monitoring, Reporting and Verification System (MRV) which will make the measured parameters and all data produced available online (through a WebGIS). The platform will be based on the system developed by Japanese Cooperation (JICA) for MITADER and could host biodiversity data that, in some way, are related with the purpose of the platform;
    - BIOFUND[7] database: the purpose of this database is to centralize the available information on biodiversity for Mozambique (spatial and non-spatial) and make it available online.
    - CONNECT: this project is being developed by UNEP-WCMC and MITADER and the objective is to make biodiversity data available to decision-makers in a format which these can easily interpret.
    - MITADER: has a tool for sharing biodiversity data, which will probably be integrated into the BioNoMo network.

During the workshop, other potential platforms for data sharing were also identified and discussed alongside those listed above:

- MozGIS: this platform, which has a WebGIS format, is under the management of the Ministry of Transport and Communication, through the Spatial Development Program. This is a combination of information from various ministries, where each of them has the function of providing the data corresponding to their sectors. In general, it presents more global information about each thematic area. For example, for biodiversity, it shows the protected areas boundary or other type of more generic information.
- Platform associated to the Strategy for the Nacala Development: this tool is under the management of APIEX, combining information on Nampula, Cabo Delgado, Tete, Zambézia and Niassa provinces. It was a project funded by JICA that, on its scope, also included the environmental component. One of the major results of the project was the topographic mapping and production of GIS data, including biodiversity data.
- Digital platform associated with the Multi sectorial Plan, Special Territorial Planning Plan and Strategic Environmental Assessment of the Zambeze Valley: this is a platform in WebGIS format under jurisdiction of MITADER, with a great diversity and quantity of information which is available by theme. It is extremely functional in terms of easiness of use, and the data can be accessed quite fast. However, it is limited to the Zambeze Valley region and, is currently offline.

Some of the geo-referenced data that was collected as part of this study could be available to the general public through WebGIS platforms or equivalent. This subject was discussed during the workshop and the results and the additional data provided by the participants are presented further below in this document.

3.4 Gap analysis on biodiversity data and specific data for mitigation and offsetting

As explained before the gap analysis comprised one component which analyzed biodiversity data in general, and another one specifically focused on identifying gaps for developing and implementing a mitigation and offsetting policy and system. These results were grouped in the sub-sections below.

[5] Conservation and equitable use of biological diversity in SADC region

[6] National Fund for Sustainable Development

[7] A private financial institution with the aim of financing the conservation of biodiversity in Mozambique.

3.4.1 Available biodiversity information

This study found that Mozambique has more biodiversity data than may have been expected as there is a general perception that the country lacks biodiversity data. Species occurrence/distribution data from several museum collections and expeditions/visits to Mozambique, with some traced far back as three centuries, and now available online on platforms such as the GBIF. These data, along with several others found in the "biodiversity informatics landscape" (see Weatherdon et al., 2016; Bingham et al., 2017 for a list of various resources available) can be useful for Environmental Impact Assessment (EIA) processes. For example, these may enhance the quality and efficiency of baseline characterizations, impact assessments and biodiversity management plans.

The production of scientific studies in Mozambique, as well as broader studies that include Mozambique, has grown in the last decades. Hence, knowledge of the country's biodiversity is increasing, although geographically restricted, mostly concentrated in Protected Areas or regions of the country where development projects are underway. The vast majority of these studies are available online for free. In areas with high data density or in its surroundings, these can play a crucial role in the achievement of No Net Loss of biodiversity, in particular for Environmental Impact Assessment (EIA) procedures, including baseline characterization, application of the Mitigation Hierarchy and development of biodiversity action plans and Biodiversity Offset management plans.

However, is worth mentioning that there is still a lot to be done, especially in terms of producing applied and integrated (interdisciplinary and long-term) scientific studies with clear biodiversity priorities. This is foreseen in the National Biodiversity Strategy and Action Plan of Mozambique 2015-2035 (MITADER, 2015), which states in its Target 2 that "by 2020, there should be a better understanding of the value (economic, social and ecological) of biodiversity, in order to allow its better integration in the decision-making and management". Better information and appropriate tools will greatly contribute to the above-mentioned aspects of the EIA procedure, including the adequate application of the Mitigation Hierarchy. This will be the opposite of what is happening nowadays, where the processes are time consuming, expensive and not always efficient.

3.4.2. Features of the available information

Regarding the key-attributes of the metadata table, the three main parameters considered (environment, theme and biodiversity-related themes relevant to NNL/NG considerations) show a relevant gap in studies focusing on aquatic environments. Similarly, complex topics such as the themes "ecosystem services" and "ecoregions", and terms such as 'Mitigation Hierarchy', "No Net Loss", "Biodiversity Offsets", "key evolutionary processes", "critical habitat", "unique ecosystem" and "congregatory species" are not well represented in the obtained sample. The lack of these terms may indicate certain key gaps in data needed for implementing a mitigation and Biodiversity Offset framework in Mozambique (see WBG & PROFOR, 2016 for more details). It should be however noticed that due to the abundance of data collected during the review, it was only possible to make a superficial analysis of those, running a script to find key-words in the gathered documents and data sets. Further analysis should be undertaken do deepen these assumptions.

As the Biodiversity Offset is a new concept and also a Biodiversity Offset management plan can now be required as part of EIAs (according to Decree 54/2015 – EIA process regulations), studies explicitly covering themes relating to "No Net Loss", "Biodiversity Offset" and "critical habitat" topics are expected to increase over the next years. However, some of the key biodiversity related datasets required to build and support a mitigation and offsetting system in Mozambique are already available (see Annex I). These datasets may not be of quite the desired quality or in the right format yet, nor adequately analyzed and integrated (e.g. as part of a spatial assessment/plan, usable metrics / exchange rules, etc.). Yet, some of the available data (e.g. broad ecosystem types for the whole country, land cover and use data, etc.) can form the building blocks to develop a first, workable system. Data pertaining to conservation species concern, as well as to important biodiversity areas (e.g. unique ecosystems, threatened ecosystems, critical habitats, and internationally recognized areas), are considered essential for implementing a NNL/NG (or similar) framework in the country, thus the urgency for prioritizing these topics in Mozambique.

"Legally protected area" is by far the most represented criteria in the studies. This is important, as research is considered crucial for biodiversity conservation and in promoting effective protected areas. However, not all of these are well represented by datasets (Figure 9). Studies on potentially important biodiversity areas that are inserted in project development regions and corridors, as well as areas where offsets could eventually be implemented (inside or outside protected areas, should also be undertaken.

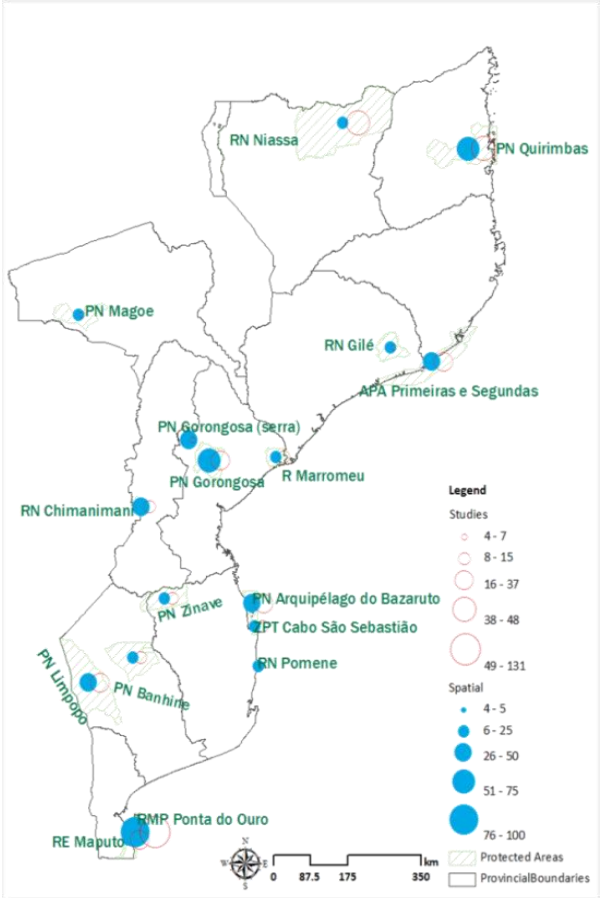

Figure 9. Studies vs Spatial datasets on protected areas

Seven protected areas (Niassa National Reserve, Quirimbas National Park, Gorongosa National Park, Bazaruto Archipelago National Park, Ponta do Ouro Partial Marine Reserve—including Inhaca Island, Primeiras & Segundas Environmental Protected Area and Limpopo National Park) congregate most of the datasets, whilst the other areas are poorly represented. One of the reasons behind this may be the date of creation of the protected area. Furthermore, this indicates that protected areas are very important catalysts of biodiversity studies, but a greater and better coordinated effort is needed to improve knowledge about biodiversity and its key values in all national protected areas.

3.4.3 Data spatial distribution across the country

In general, spatial datasets are well represented and distributed across the country (Figure 10). These are mainly comprised of observations of species done over the last three to four centuries during expeditions, visits and surveys held in various parts of the country.

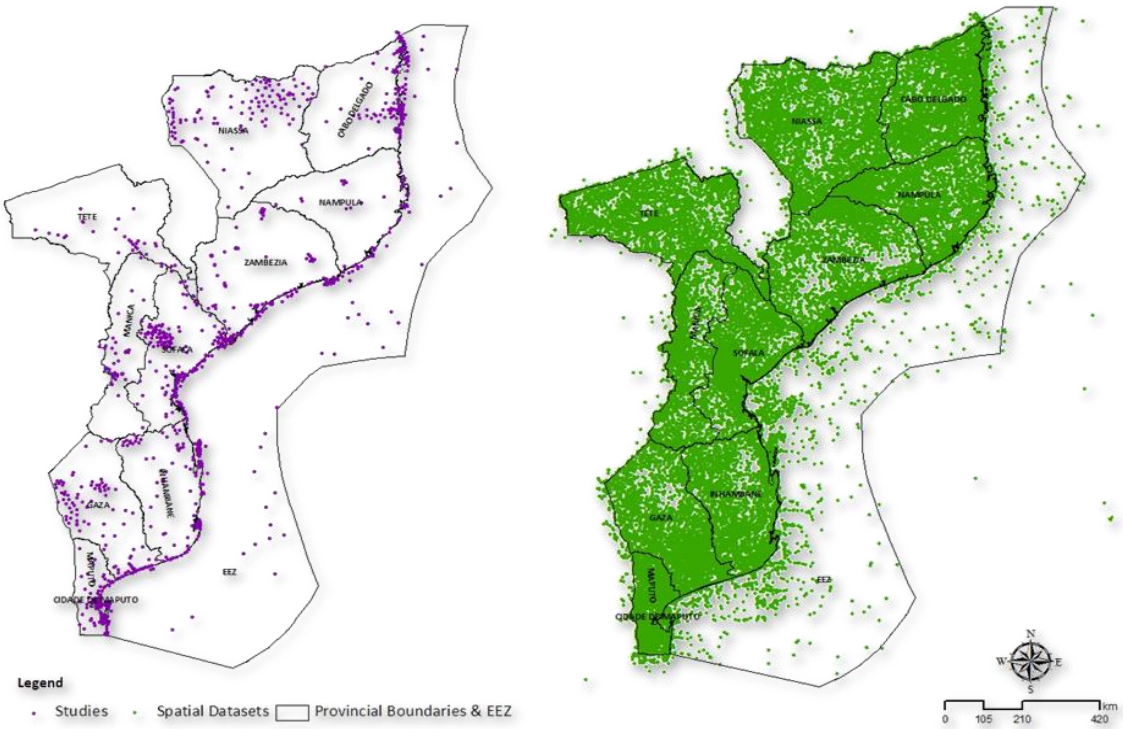

Figure 10. Point Distribution. Non-spatial datasets (left) and spatial datasets (right)

This means that there is a risk that these data are not representative of the current situation, albeit providing some valuable insight on the recent past status of biodiversity in the country. Still, some areas present high densities, such as the Southern Mozambique (Maputo city and province, South Inhambane and Southeast Gaza), Centre of the Sofala province, Northwest Zambezia, Western Nampula and the coast of Cabo Delgado province.

On the other hand, non-spatial datasets exhibit a more localized distribution (Figure 10). These are mainly focused on protected areas, some key biodiversity areas, along the Mozambican coast and the Zambezi River. Overall, the areas with higher representation of non-spatial data (studies) are: Quirimbas National Park and Quirimbas Archipelago, Niassa National Reserve, Lake Niassa, Mount Namuli, Primeiras & Segundas Archipelago, Zambezi Delta, Gorongosa National Park, Bazaruto Archipelago National Park, Limpopo National Park and Ponta do Ouro Partial Marine Reserve (including Inhaca island).

Combining spatial and non-spatial data (Figure 10), major densities of datasets are located in most of the Maputo Province, Maputo City and coast of Cabo Delgado Province, as well as in Mount Namuli (Nampula/Zambézia boundary), region of Nacala-Mozambique Island, Zambezi River and its Delta, Gorongosa National Park till Beira, south-eastern Gaza province and Inhambane City area. It should be noticed that all the coastal area of Mozambique is relatively well represented.

Density of data is largely influenced by spatial data sets, due to the large number of points that represent them, thus influencing the identification of geographic gaps. Therefore, the main geographical gaps identified are the deeper waters of Mozambique's EEZ and some spots in the interior of the provinces of Zambézia, Niassa, Tete, Manica, Inhambane and Gaza (Figure 11). Nonetheless, the majority of the country, excluding the high-density areas mentioned, is under-represented in terms of information (small gaps). The regions of the West (Gaza, Manica and Tete) and the North (Niassa, Zambézia and Nampula) were highlighted as the geographic areas with less information.

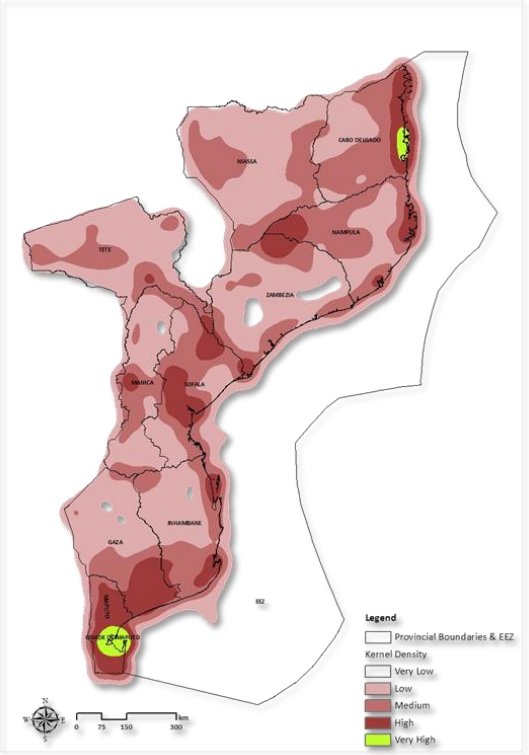

Figure 11. Kernel Density

A more thorough gap analysis, considering the importance of the datasets, reveals that areas such as the coast of Cabo Delgado (Quirimbas National Park / Quirimbas Archipelago), Niassa National Reserve, Limpopo National Park and Bazaruto Archipelago National Park have studies classified as "more important". These areas present *clusters* of very high and high importance datasets (*hot spots*) and few *outliers*[8] (Figure 12), which shows that there are efforts for producing relevant biodiversity conservation studies in those areas. Once more, conservation areas stood out in promoting studies with high relevance.

On the other hand, two areas with extremely high densities of datasets (Maputo city/province and central of Sofala province), revealed, proportionally, a shortage in important datasets, presenting *clusters* of low importance datasets (*cold spots*) and a high amount of outliers (both HL and LH). These areas are close to the three major cities in Mozambique (Maputo, Matola, and Beira), where there is more access to funds and concentration of research institutions (and other relevant institutions) and less logistical constraints, making them favorable for implementing studies and/or projects. Though, more should be done to improve the number of important studies in these regions.

Research plans and funding, such as the ones prioritized in Mozambique's 2015-2035 National Biodiversity Strategy and Action Plan, should promote studies in those areas, thus ensuring a balanced distribution of studies all over the country. Additionally, more studies should focus on under-represented areas where major developments plans are in-course, for instance, Oil & Gas projects (e.g. Mozambique's EEZ and inland Inhambane province), large forest projects (e.g. Zambézia, Manica and Niassa provinces) and mining projects (e.g. Tete, Manica and Inland Cabo Delgado and Gaza provinces).

[8] *Cluster and Outliers* – high importance datasets surrounded by low importance datasets (HL), and vice-versa (LH).

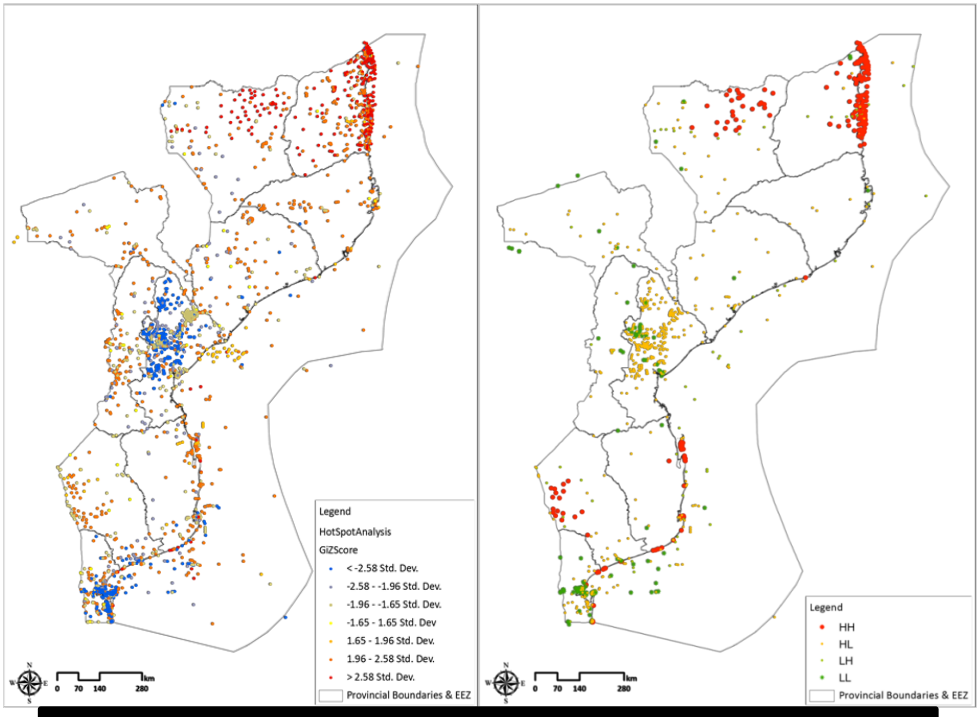

Figure 12. Spatial Statistical Analysis: Hot Spot Analysis (left) & Cluster and Outlier (right)

3.4.4 Specific gaps for a policy of No Net Loss / Net Gain of biodiversity (or similar goal)

Regarding the data considered the most relevant to the development and implementation of a policy of NNL / NG (or similar goal), Appendix I of the Annex further below identifies what would be needed and what is actually available for the country. As previously mentioned, the volume of data obtained did not allow the detailed analysis of a good part of them, nor their insertion in the metadata table. This will have to be done in the future. From those which could be analyzed, it was verified that part of the information considered relevant is available to the country, although not always in the quantity or with the desired characteristics (e.g. relating to scale and coverage, format, quality, etc.). This means that currently available data will need to be improved and complemented, for example through modelling. While some of the obtained data is quite old (especially spatial data), this can be valuable for exploratory / preliminary analysis. Therefore, it would be extremely important that, as explained in the next sub-section, databases acre created and made available to the public and adequately coordinated to avoid data omission and duplication.

One limitation identified, for example, is the absence of a recent, up to date habitat mapping and ecosystem classification across the country. The reference ecosystem type mapping dates from 1967 (Wild & Barbosa, 1976) and while it is widely used, it would benefit from a review and likely some revision. This should be rapidly addressed it is one of the corner stones for developing and implementing a mitigation and offsetting policy and system. An up to date, quite detailed land cover layer, specifically for Mozambique is another gap that needs to be addressed. There seems to be a considerable amount of relevant data, from different kinds, for some of the Protected Areas. Similarly, some provinces have been the focus of much work, quite recently, and therefore more datasets of relatively high quality and recent date are available for these (if not for the whole country). This helps to inform the selection of a landscape for the demonstration exercise for COMBO (see 3.3.6).

As for species distribution it is variable within groups but there seems to be valuable data for key species, especially those for which there is a conservation strategy and/or plan. There is already relevant information on ecosystem services for some areas of the country, particularly for mangroves. Finally, there is a huge amount of relevant non-spatial data available for the country, as it can be seen in Table 1. Such information is useful to contextualize a mitigation and NNL-type policy and system, however it tends to be most useful at the site-specific level or when dealing with particular themes.

All in all, the main conclusion of this review and gap analysis in relation to this topic is that, in general, both spatial and non-spatial data relevant for developing and implementing a policy of NNL / NG (or similar goal) are not easily accessible as there is not a centralized database or system where to store and search for this information. The next section of this study focuses specifically on this issue.

The contributions obtained during the workshop were of great value in this matter, as they emphasized some of the aspects that had already been addressed in the draft report, besides identifying additional information. Thus, regarding data not captured in the initial review, but which were mentioned during the workshop and which contribute to this analysis, the following are the ones which stand out: i) mapping of ecosystem services generated by the project about the Areas of High Conservation Value; ii) information on KBAs / IBAs; iii) deforestation maps prepared by the World Bank and IUCN; iv) information obtained by REDD+ for Zambezia and Manica provinces; v) the existence of aerial photographs at a scale of 1: 10000 in the Nacala and Nampula provinces and; vi) the GIS database in Nampula, Niassa, Tete, Cabo Delgado and Zambezia, information held by APIEX based on PEDEC, which is relative to the development corridors. In addition, SECOSUD II project is planning to collect data on the vegetation of the Limpopo National Park and Maputo Special Reserve habitats.

Regarding the information currently lacking for Mozambique at the country-level, but which participants consider to be essential for the adequate application of the Mitigation Hierarchy both for spatial planning and projects in Mozambique, the following was highlighted: i) higher resolution data (e.g. different types of forests and Inselbergs / rocky outcrops) ii) economic value of biodiversity and ecosystem services to people's livelihoods; iii) quantitative and time-series data on biodiversity loss; iv) consistently identified sensitive habitats and their spatial distribution along the country; v) biodiversity data series for specific regions/areas; vi) traditional knowledge; vii) genetic material; viii) medicinal plants distribution; ix) sacred sites of biodiversity; x) protected and endemic species; xi) systematic identification and mapping of important biodiversity areas (e.g. KBAs); xII) clear conservation priorities; xiii) bio-indicators; xiv) overlapping areas and information on terrestrial and marine spatial planning; xv) application of IUCN criteria to existing species in Mozambique; xvi) continuous updating of existing data (quality control, geographical coordinates and taxonomy).

3.4.5 Options to share the information obtained in the present study

Various datasets and studies are available for Mozambique, but the country does not have a centralized and modern database / platform to store, manage and share the biodiversity data. Ongoing initiatives can improve the public access to these resources. However, there is not yet a fully clear understanding of the work structure of these initiatives in the near future.

The institutional capacity to share the data in a simple and user-friendly way and also the capacity to maintain long-term operational services are the main decision factors for the selection of the institution (s)/project (s) that could make the information available to the public. This subject was discussed during the workshop and, although there was no consensus on which entities/projects best fit these objectives, it was clear that government institutional support is imperative. This is particularly important to guarantee that data holders share their information, whether these are research institutions, NGOs, private companies (consultancies or developers) or individual consultants. Once such a database is operational there should be the obligation of supplying any acquired data. For example, data collected under EIAs and its related specialized studies, conservation projects developed by NGOs and biodiversity related research studies, among others.

At a first glance, any of the partners / projects identified in the initial review seems to be a potential option for sharing the information and results obtained with the present study. The remaining three platforms identified during the workshop are more limited because they either refer to a specific geographic area or focus on more generic information. They could, however, be adapted to the intended purpose.

According to the review undertaken, BioNoMo and FNDS platforms have the potential for spatial data sharing in a way that the users can visualize them. The BioNoMo platform has the advantage of being exclusively dedicated to biodiversity, it is hosted by the national public university (UEM), already has partnerships established with the main data holders (for example, Natural History Museum, Department of Biological Sciences of UEM, Gorongosa National Park and Agricultural Research Institute of Mozambique - IIAM) and has capacity to increase its partners by interacting with other data holders. On the other hand, the FNDS platform which will make available the MRV information can host biodiversity data that in some way relate to the developed Web GIS platform. BIOFUND has

potential for sharing documents and spatial data, allowing them to be consulted and downloaded. On the other hand, MITADER platform is not yet fully operational and the CONNECT project strategies and solutions to make available the biodiversity information is not yet known. In any case, the aim of the CONNECT project is to provide quality information on biodiversity to decision-makers and in a way that is perceived by them. Hence, it is i) identifying decision points or processes across government sectors where biodiversity information can be influential and (ii) developing strategies so that technical stakeholders are more easily able to acquire and share relevant data, and use this to communicate effectively, for current and future information need. Therefore, the data, gaps and contributions identified in this study could and should be used by CONNECT, which could make a great contribution in the selection of the best way to share this information.

According to the analyzed information it is fundamental that the selection of the platform(s) for data sharing considers the institution's capacity for sharing such data in short-term and maintain an ongoing functional service. Some of the initiatives mentioned above (for example, MITADER, FNDS and BIOFUND) may be linked to the platform(s) which will be selected, providing financial and institutional support to ensure its long-term sustainability. For non-spatial data, the selected platform should work as a national repository, in the form of an online library of biodiversity studies, environmental impact assessments and studies and projects to achieve No Net Loss of biodiversity.

In the workshop, BIOFUND, IUCN, FNDS, BioNoMo, MIMAIP and MITADER were considered the most adequate entities/projects to store, manage and make available the data that were obtained in the review. It was however suggested that MITADER should be the institution responsible for supervising and coordinating the process. On the other hand, the academy and research centers could contribute technically and scientifically, providing, updating and controlling the quality of data. Another suggested option was to share the information between MITADER and MIMAIP, which should coordinate with each other. On the one hand, MITADER, through ANAC, already has data from terrestrial protected areas, and MIMAIP with its new mandate, would be responsible for the marine protected areas. Regardless of the entity to be selected, it was recommended that a policy of data using and sharing should be created, in which the type of available format is properly indicated. For example, a centralized platform or API for visualization could be created to harmonize information provided by different data sources. Each of these institutions would be responsible for aggregating, cleaning and validate the data but a "common data center" would ensure no duplication and redundancy, especially on studies which include both marine and terrestrial environments.

3.3.6 Potential location for the spatial demonstration landscape and exercise

According to the discussions held at the workshop, the majority of participants identified the Cabo Delgado province as the region potentially most suitable for carrying out an exercise of spatial/assessment planning to support application of the Mitigation Hierarchy. This is the province with the greatest conflict of interests, because it has great economic potential for its natural resources, it has a vast marine and terrestrial area with great conservation value, being an area of high biodiversity in the East Africa region. Additionally, there are many communities in the area, with an important cultural heritage, especially regarding traditional knowledge. Lastly, it apparently has some of the key datasets needed for such an analysis. According to some of the workshop attendees, potentially, using this area as a demonstration site would allow test several complex factors and could support the development plans for the region. However, this assumption should be carefully analyzed and a more in depth analysis should be carried out for this particular province when making the final decision. This region-specific gap analysis might eventually expose some gaps not captured by the current review.

Other provinces/regions of the country were mentioned, namely: i) Zambezia due to amount available data (area with several World Bank projects underway), its impact sources in the region, such as the high population density, the number of companies/projects in certain areas and their extent, land uses and areas of reserve/protection; ii) Manica, in particular Chimanimani or Serra Choa, due to same factors; iii) Inhambane, which has well preserved areas, currently are under pressure in terms of development projects and communities, and with a considerable amount of ecological data being collected during the past 20 years; iv) Maputo, because it is the province with the largest number of data available and with the highest density of studies undertaken.It was discussed that there are advantages and disadvantages between these options, and the final selection should be based on the interests of the demonstration exercise. Very complex landscapes can cause problems to the exercise, but it is also important to have a diversity of human actions planned for the region.

Although it was not possible to undertake a provincial/regional gap analysis on specific data to support a policy of NNL / NG of biodiversity (or similar goal) under the current review, the provinces/regions pointed out by the workshop participants match with the spatial analysis of the current review. Therefore, this could potentially be considered as an indicator of how the biodiversity data is distributed within the Mozambique. The final decision on the selection of the demonstration landscape should be based on a more thorough analysis of regional-specific data relevant to developing and implementing mitigation and offsetting policy and system. This could be done for the top two most potential regions to run the exercise. It should also be considered that not only there might be additional relevant data not inserted in the metadata table (it was not possible to insert practically half of the 3000 data sets), but additional technical and political factors also need to be taken into account.

4 Conclusions

The main conclusions of this review and gap analysis of available data on biodiversity in Mozambique are:

- This review and gap analysis provides an overview of the existing biodiversity data in Mozambique. The amount of biodiversity data available to the country is greater than initially expected by the authors and its organization, availability and sharing can be very useful for technical and scientific studies, namely EIA procedures, spatial planning, zoning and biodiversity management.
- Specifically, for the adequate application of the impact Mitigation Hierarchy, including biodiversity offsetting, although restricted to particular geographic regions, available datasets and biodiversity studies can contribute to substantial improvement in the quality and effectiveness of project-level baseline studies, environmental impact assessments and spatial and management biodiversity plans.
- A number of key, high and very high importance datasets to support a robust impact mitigation and offsetting/ NNL policy and system are also available, some at the national level but more specifically in certain provinces. These datasets can be used by the COMBO project for further refinement, analysis and integration, especially at the demonstration landscape level – ultimately to inform the development of such a policy and system in Mozambique.
- The gap analysis allowed to identify that information considered fundamental for the implementation of a policy of NNL/NG (or similar goal) is currently available to Mozambique.
- Cabo Delgado seems to be the geographic area of the country that has attracted more interest in terms of potential selection for an exercise in applying the hierarchy of mitigation to spatial planning, but there are other options that should be analyzed according to the specific objectives defined for the demonstration exercise. Further analysis need to be undertaken before a final choice is made.
- However, it is necessary to overcome certain obstacles, such as the existence of institutional restrictions, in particular, the fact that certain studies carried out by NGOs and consultancy companies are not available to the public. On the other hand, certain studies made by research institutes and the government are also not easily accessible or even available. There are also situations of relevant specialized studies for the offshore environment carried out by Oil & Gas developers that are not published or accessible.
- The results obtained with the current study also allow to guide future studies to improve the availability, quality and utility of existing information to develop effective strategies of territorial planning and impact mitigation targeting biodiversity.
- It has been identified the need to develop interdisciplinary and long-term scientific studies on biodiversity according to clear priorities previously identified, in order to contribute to the increase of the necessary information to adequately plan the above-mentioned aspects. Coordination between government institutions and the relevant stakeholders in general is, therefore, essential.
- The main gaps identified in terms of general biodiversity data correspond to aquatic studies and more complex topics, such as “ecosystem services”, “ecoregions”, “No Net Loss”, “Biodiversity Offsets”, “key evolutionary processes”, “critical habitats”, “unique ecosystems” and “congregatory species”, which may constitute important gaps in the implementation of the current EIA legal framework, which includes the

development of Biodiversity Offsets management plans to compensate for the residual impacts of development projects.

- In general, there seems to be a significant amount of data on species, but species with conservation concern (for example, threatened species, in extinction, endemic, restrict range, migratory and congregational) are not well represented. Studies focused on this type of species and in areas important for biodiversity are considered essential for the implementation of a policy of No Net Loss of biodiversity in the country and to comply with the legal framework of EIA, therefore, these should be prioritized.
- The "legally protected area" is the most represented attribute in the metadata table, but only seven national protected areas are represented in most of the datasets, and a larger and better planned effort is needed to increase knowledge on biodiversity and main conservation values in all conservation areas of Mozambique.
- There is good representation and coverage of the territory in terms of spatial datasets, as opposed to a more localized non-spatial data density in some areas of the country;
- Considering the spatial and non-spatial data, most of the country is poorly represented, with the provinces of Tete, Manica, Zambézia and Niassa being the most deficient in terms of biodiversity information;
- Higher densities of data are found in the provinces of Maputo, Cabo Delgado and Sofala, and particularly in seven conservation areas, in the sky islands (for example, Mounts Namuli and Mabu), in the coastal area and along the Zambezi River and its delta;
- Major gaps in spatial information refer to the Mozambique EEZ waters and some areas in the interior region of Zambézia, Niassa, Manica, Inhambane and Gaza provinces, therefore, a greater effort and planning are required to ensure an equitable distribution of studies across the country.
- Considering the parameter analyzed regarding the relative importance of datasets, areas such as the Cabo Delgado coast, the Niassa National Reserve, the Limpopo National Park and the Bazaruto Archipelago National Park are the ones that stand out the most, showing that there is a trend towards the production of relevant biodiversity conservation studies in these areas.
- On the other hand, areas with high densities of data, such as Maputo City, the rest of the province and the center of Sofala province have revealed, in proportional terms, a lack of important datasets. The existence of many studies in these areas may be due to its proximity to major cities, where there is more access to funds and concentration of research institutions (and other relevant institutions) and fewer logistical constraints, making them favorable for the implementation of studies or projects, even if they are not focused on priority data. It is therefore necessary to focus the studies on aspects considered of greater importance in terms of biodiversity.
- One of the major gaps identified is the absence of a recent habitat mapping and ecosystem classification. The reference ecosystem type mapping dates from 1967.
- There is a significant amount of data for some of the Protected Areas and also for the distribution of some species in the country but in general, both spatial and non-spatial data relevant for developing and implementing a policy of NNL / NG (or similar goal) are not easily accessible and will need to be developed over the next few years.
- Mozambique does not have a centralized, modern database / platform for storing, managing and sharing biodiversity data, which is likely to be supplied by ongoing initiatives such as the FNDS, BioNoMo and of BIOFUND database. The institutional support of the Government is fundamental whatever the chosen option is and this will be essential to guarantee that developers make publically available the information they gather in their specialized studies.
- It is important to highlight that although this gap analysis was based on a thorough review, it was only possible to analyze less than half of the obtained data (1,341 out of 3,000, approximately) and that is most likely that there are additional spatial and non-spatial datasets which were not found. Nevertheless, this study creates a first baseline about biodiversity data in Mozambique, which is considered to be representative of the relevant information for implementing a policy on NNL/NG (or similar goal) in the country.

5 Recommendations

The study undertaken proposes the following main recommendations:

- A greater and more coordinated effort of the conservation / biodiversity sector is needed to improve knowledge on biodiversity-related themes that are relevant to NNL/NG considerations in Mozambique, in particular which are the current main conservation values and their distribution in the national protected areas.
- There should be an equitable distribution of studies across the country, so that the biodiversity of the entire territory is known. Geographical gaps should be taken into account in project planning and funding, in order to promote studies in under- represented areas.
- Studies regarding the species of conservation concern, as well as important biodiversity areas should be considered as priorities for the country as they will contribute decisively to the implementation of a policy on NNL/NG (or similar goal) to achieve the targets to which Mozambique has committed itself internationally (NBSAP/Aichi targets).
- The study suggests that more efforts should be done on the development of studies in the less represented areas where major development plans are under way, such as Oil & Gas concessions (eg. Mozambique's EEZ and interior of Inhambane province), large forestry projects (eg. provinces of Zambézia, Manica and Niassa) and mining projects (eg. Tete, Manica and the Interior of the provinces of Cabo Delgado and Gaza).
- A habitat mapping and ecosystem type classification exercise should be done in the short term and this is one of the corner stones for developing and implementing a mitigation and offsetting policy and system.
- The COMBO demonstration exercise on how to apply the Mitigation Hierarchy in the context of spatial assessment / planning is of major importance for all stakeholders regarding environmental impacts and biodiversity conservation. However, the final selection of the area depends on the specific objectives of the exercise and the means which will be available.
- One or more of existing platforms may be selected to manage and share national biodiversity datasets and / or biodiversity studies, and it is very important that they are made available with the government institutional support. Regardless of the entity selected to store, manage and make available the data, there must be a policy for the use and sharing of data. Linkages between institutions should also be promoted to facilitate regular sharing and updating of the selected platforms. The obligation of the research institutes and private sector to contribute to these databases is extremely important, especially when these refer to applied science, conservation and specialized studies under the EIA procedure.
- It should be noted that BIOFUND, in its website, has a platform for making documents and spatial data available for download, which could be one of the fastest and most effective ways of making available the information obtained in the present study.
- As the CONNECT project aims to provide quality information on biodiversity to decision-makers and in a way that is useful for them, the results of this study could be an important basis for CONNECT, which could support the selection of the best platform and institution for sharing the information obtained.
- In order to identify more specific gaps, the hypothesis of deepening the present study should be considered, analyzing the content of all spatial and non-spatial datasets available. For example, a Masters' thesis on this topic could be promoted, putting a biggest effort on the gap analysis
- Ideally, a biodiversity research strategy with clear objectives and results in line with 2015-2035 NBSAP Strategic Objective A (Goal 2) would contribute to a more effective management and conservation of biodiversity, avoiding the dispersion of resources and uncertainty on priority subjects.

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7 Appendix

Appendix I – Specific gap analysis on data relevant for the implementation of a policy of No Net Loss of biodiversity

Theme	Attribute	Notes and examples	Results of the gap analysis
Terrestrial ecosystems	Ecosystem type classification and map (ideally also showing potential or 'original' extent of ecosystems).	Make good biodiversity surrogates, more easily mapped than species, ideally have some baseline. These types of layers will be available at different scales and will be based on some way of classifying the landscape according to ecological criteria. Examples are ecoregions and biomes at the broad scale, or vegetation types, which may be mapped at coarse or finer scales.	There is no recent classification. The classification used in Mozambique is represented in Flora Zambeziaca (Wild & Barbosa) of 1967, being a project that lasted decades, aimed at studying all the vascular plants that occur in Central and Southern Africa (Botswana, Caprivi, Malawi, Mozambique, Zambia and Zimbabwe). This study is useful for the conservation of plant formations and endangered species or in danger of extinction. Among the Mozambican scientific community there is currently interest in creating an ecosystem updated map for the country.
Terrestrial ecosystems	Land coverage (showing extent of current natural areas). Examples are usually classified remotely sensed images that show broad	This type of layer shows different types of land cover/ uses, including the extent of natural ecosystems. When combined with an ecosystem classification layer (as above), it indicates how much of each type of ecosystem remains at a specific point in time. Note: individual layers may also exist showing specific types of systems or habitats, e.g. of 'coastal forests', or 'mangrove forests' etc.	There are some land cover maps, but none are updated. The reference document is the national forest inventory (Marzoli 2007), which reports on the activities of the Integrated Forest Assessment of Mozambique. The FNDS is currently developing a land cover map with 3 different levels of land use that can become a benchmark for the country. Probably in the next years, it will be possible to classify land use only according to the first two levels.
Terrestrial ecosystems	Ecosystem condition or integrity	These could be spatial layers or systems used to classify condition[9]. This could include factors like degradation, fragmentation, invasive species, loss of fauna, etc. Also good to identify intact areas with high ecological integrity. Ideally on a condition scale e.g. values between 0-1.	There is not much information. There is at least a mapping of erosion hazard categories at the national level, the UNEP global mapping on the average fire density in which Mozambique was included, and the mapping of forest loss in 13 national protected areas (7 parks and 6 reserves) between years of 2000-2012. The mapping of

[9] NB: these condition/ integrity systems and descriptors could be 1) site-based (e.g. a system for measuring aquatic condition at a particular site) and/or 2) relevant to the entire ecosystem (e.g. threat status of rivers or vegetation types in the country, according to various criteria such as 'amount remaining', 'fragmentation levels' etc.)

Theme	Attribute	Notes and examples	Results of the gap analysis
			deforested areas is currently being finalized by FNDS and the National Land Degradation Neutrality Program will also produce maps on forest loss. In addition, there is a set of data on wilderness areas at the global level (WCS & CIESIN, 2002).
Marine ecosystems	Marine ecosystems	This may be spatial layers (point or polygon data) that serve as an indicator of ecosystem condition for any ecosystem type (e.g. coral reef, seagrass habitats) OR a system (non-spatial) that sets out such a classification acc. to different criteria or indicators.	A mapping of Mozambique's habitats was carried out by BIOFUND, which includes critical habitats in the marine and coastal environments under protection because of their contribution to global biodiversity, the ecoregion and the national economy. These areas are: the Mtwara-Quirimbas complex, the Islands Primeiras & Segundas, the Bazaruto Archipelago, the Inhambane Bay, the Inharrime Complex, the Sofala Bay, the Maputo Bay Complex and the Zambezi River Delta. In addition, there is habitat mapping, including the marine environment for Cabo Delgado province and coral reef areas produced by MICOA (current MITADER) and the global mapping of mangrove forest distribution, including Mozambique.
Marine ecosystems	Condition of marine ecosystems (e.g. water quality data)	Current and past data if possible; this includes dissolved inorganic nitrogen (DIN), suspended fine sediment, but could also include pesticides, herbicides or any other water quality indicators available	Some information was produced, such as the global mapping on coastal water quality indicators, regarding the change in the annual average concentration of chlorophyll-a between years 1998-2007 and a set of geospatial data on the coral reefs condition (including bleaching and coral disease), developed by UNEP-WCMC in 2002.
Aquatic ecosystems	Locations of wetlands. Where possible types of wetlands.	Make good surrogates for component biodiversity and function, more easily mapped or determined than species. Wetlands are usually very important from both a conservation and ecosystem service perspective.	BIOFUND mapped the Marromeu Complex and Lake Niassa, wetlands of international importance given the concentration of migratory and paleartic birds. In addition, there are global wetland networks developed by the IUCN Wetlands Program and a WWF wide database of large lakes and wetlands. During 2018, WWF and MITADER will conduct the

Theme	Attribute	Notes and examples	Results of the gap analysis
			national wetland inventory, including the respective mapping.
Aquatic ecosystems	Limits of watersheds	Needed to frame mitigation, e.g. offsetting wetland loss within the same watershed.	This information is available for the country but on a very wide scale, such as the mapping of the hydrological resources elaborated by national directorate of geography and register (DINAGECA). There is also a worldwide database of freshwater ecoregions developed by WWF and The Nature Conservancy.
Aquatic ecosystems	Watersheds and hydrology	Understanding watersheds that link terrestrial ecosystems and aquatic ones can be useful. Often based on indicators like water yield of vegetation, or water quality and flow of rivers can be useful. Linked to ecosystem services modeling noted below.	There is a map of river basins (rivers) prepared by DINAGECA and a digital map for irrigation of cultivated areas, prepared by FAO in 2006.
Aquatic ecosystems	Aquatic ecosystem condition or integrity	This may be spatial layers that serve as an indicator of ecosystem condition for any ecosystem type (e.g. wetland, estuary, mangrove forest) OR a system (non-spatial) that sets out such a classification acc. to different criteria or indicators.	This information is not available for Mozambique, only for some restricted areas that are subject to specific studies. Most of the time, these studies are part of internal consulting and are not accessible to the public.
Species	Critically endangered species (Freshwater, marine and terrestrial)	Can be point, modeled or ranges. Models are generally best for broader scale risk assessment, survey data best for EIA. It might be necessary to understand distribution or abundance globally if following IFC tiers.	The existing information for Mozambique is very limited regarding the species' distribution. There are geospatial data on turtle nesting areas and dugong habitat areas. In addition, there is information available on international data sharing platforms. For example, the global network of mammalian richness and a digital global repository with lists of critical endangered species. However, the BioNoMo platform is compiling national data that is not yet available on international

Theme	Attribute	Notes and examples	Results of the gap analysis
			platforms. An exercise was carried out by BIOFUND (available) but is still incomplete. The country has a lack of spatial information on species, most studies are based only on non-spatial data.
Species	Endangered species (Freshwater, marine and terrestrial)	Can be point, modeled or ranges. Models are generally best for broader scale risk assessment, survey data best for EIA It might be necessary to understand distribution or abundance globally if following IFC tiers.	The existing information for Mozambique is quite limited. However, the BioNoMo platform is compiling national data that is not yet available on international platforms. An exercise was made by BIOFUND (available) but is still incomplete. The country has a lack of spatial information on species, most studies are based only on non-spatial data.
Species	Species in other threatened categories (Freshwater, marine and terrestrial)	Can be point, modeled or ranges. Models are generally best for broader scale risk assessment, survey data best for EIA	The information available to Mozambique regarding species distribution is quite limited. However, there is a study on vertebrate diversity centers in Mozambique (Schneider et al., 2005) in which endangered, protected and endemic or near endemic species of flora were mapped. There is information on the distribution of key species, such as the elephant, hippopotamus, lion, cheetah, mabeco (wild dog) and some species of birds in restricted areas such as the Zambezi valley. There are megafauna census available for several protected areas and national aerial census since approximately 2008. There are also annual reports from the game farms and concessions which give population estimates for each area. A modeling work on the distribution of large ungulates is being developed, and these maps should be available soon. Otherwise there are only global mapping data.
Species	Restricted-range species (Both marine and terrestrial)	IFC uses 50000km2 or less as a restricted range threshold. KBA criteria somewhat different.	The information available to Mozambique regarding species' distribution is quite limited. BIOFUND carried out the mapping of important habitats for endemic and restricted species to Mozambique,

Theme	Attribute	Notes and examples	Results of the gap analysis
			which corresponded to only 50 km^2.
Species	Migratory routes, aggregation sites, and seasonal concentrations	IFC guidance notes has good information on this.	There are spatial data for birds from the Zambezi River and elephant routes and buffer zones in northern Mozambique. Validation of this type of data should be done with the support of local / regional experts. An exercise was carried out by BIOFUND (available) which maps habitats that support concentrations of migratory species. There is a global NASA platform on mammalian distribution.
Species	Keystone species	A keystone species is a species that has a disproportionately large effect on its environment relative to its abundance	There is no specific information on this aspect. It is very likely that there is relevant information dispersed in different studies, including some that were obtained during gap analysis. This would imply a more detailed analysis on the studies.
Species	Sites supporting biological processes	Geographic locations of ecological and evolutionary processes. Demographic processes (e.g. spawning or nursery sites), ecological refuges, places important for landscape connectivity, recruitment sources. Good to link to KBA criteria.	The information available to Mozambique on this aspect is rather limited. The mapping by BIOFUND identified a total area of 49 km^2 that corresponds to area of key evolutionary processes, including isolated sites, such as 22 islands (Quirimbas archipelago, Bazaruto, Inhaca, etc.), mountains (Chimanimani, Gorongosa), (Chiperone, Mabu, Namuli, Serra Choa and Serra Mecula) and 205 lagoons, mangroves, gallery forests and Futi corridor.
Ecosystem services**	Provisioning ecosystems services (e.g. fisheries, forestry, NTFP)	Priority ecosystem services that are locally important natural resources. Fisheries catch data – could be based on catch tonnage or catch per unit effort (CPUE). Data on production or harvest of NTFP This is usually only available at a very rough scale.	There is a mapping by BIOFUND where ecosystem services have been associated with sites mapped as critical habitats, for example: - Zambezi Delta: provision services such as mangrove and estuary as important sites for the reproduction of fishing resources; - Marromeu Complex: provision services such as mangrove and important area for marine and coastal biodiversity. The catch per unit effort (CPUE) is

Theme	Attribute	Notes and examples	Results of the gap analysis
			available in IIP reports, but is not geo-referenced, as well as the production or harvest data for NTFPs available in various studies (plans, studies, theses, etc.)
Ecosystem services**	Carbon (Regulating services)	Global datasets on carbon are available. Ideally more local data is available though.	There are studies on this subject for the geographical areas defined by the Mozambican government as priorities for REDD+, for example: - National Strategy for REDD+, 2016-2030 where one of the objectives is to design and carry out the National Carbon Inventory of forest areas. - Implementation of REDD+ in Beira corridor covering the provinces of Manica, Sofala and Zambezia. - Zambezia Integrated Landscape Management Program including 9 districts and the Gilé National Reserve. In addition, there is EnviroTrade's carbon credit marketing program (The Sofala Community Carbon Project) working with communities in the buffer zones of the Gorongosa and Marromeu national parks, and the Gilé National Reserve project with a recent report developed by EtcTerra.
Ecosystem services**	Other Regulating services	Examples include maintenance of water quantity and quality, erosion and sediment retention, carbon storage and sequestration	There is a mapping by BIOFUND where ecosystem services have been associated with sites mapped as critical habitats, for example: - Zambezi Delta: regulatory services such as wetlands and mangrove for mitigation of extreme weather events; - Bazaruto Archipelago: protection services of the continent by the parabolic dunes.

Theme	Attribute	Notes and examples	Results of the gap analysis
Ecosystem services**	Cultural ecosystem services	For example locally important cultural sites to communities. This is usually only available at a very rough scale. Info with some degree of detail (importance for local communities) can only be assessed using focus groups for example	There is no specific information on this aspect, except possibly in studies restricted to specific areas and global platforms in which Mozambique is included, and that could have been captured in the review, but this would imply to analyze the studies in detail.
Land use	Protected areas and their specific designations (e.g. National Park, private nature reserve, game farm, etc.)		There are maps and information on protected areas, however, there is no consolidated and updated shapefile for all of that areas. At least 20% of game Farms' boundaries were not captured in the review and the availability of these geospatial data are not known. At least 3 community areas, 1 environmental protection area, 24 hunting areas, 2 trans-boundary conservation areas, 40 game farms, 9 national parks, 8 national reserves, 1 special reserve, 14 forest reserves and 1 sanctuary were geo-referenced.
Land use/ plans	Conservation plans and priorities	This might include a range of different spatial layers used for a prioritization exercise, as well as outputs. Important layers would for example show areas (and actions) identified as important for conservation are important considerations for avoidance and potential offset sites. Preferably identified through a formal process with participation from stakeholders and ideally based on data.	There are data on this, but these are not centralized on a specific platform. Some were caught during the review but some were not. This is one of the major gaps identified in the study. However, on its website, ANAC has the latest versions of management plans for 11 conservation areas, which in some cases have zoning plans. Plans for conserving species are scattered. The review has captured only a few of them, for example the African Wild Dog Monitoring and Conservation Project; National Action Plan for the Conservation of Cheetah and Mabeco (wild dog); conservation of large carnivores; Strategy and Action Plan for elephant conservation and management in Mozambique (2010-2015), national strategy and plan of action for mangrove restoration (2015-2020). Usually the *shapefiles* of these studies are not available.

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Land use	Tenure and institutional arrangements	For example, if the area/DUAT is a concession or the land is public	Much of the country is not yet demarcated in terms of land tenure. This is a huge problem with community lands. There are several ongoing projects for land delimitation.
Land use	Management	Land management, production activities like agriculture. This might be easier for identifying at the landscape scale, rather than the country scale	There is an agro-ecological zoning plan, which has never been officially approved. There are some data on agricultural production that are available as spatial datasets. In addition, there is the mapping of soils susceptible to cultivation and the national Zoning report of agriculture.
Land use	Designation of land use rights	Logging and plantation concessions Mining (exploration and exploitation) concessions Etc.	There is at least one mapping of logging concessions and forest plantations developed by the Fund for Energy. There are some maps available, but there are no updated maps on forest concessions. There is a Web GIS with updated mining concessions. Data can be obtained by payment. Data for a specific area of the country can be requested.
Land cover/land use change	Land cover change risk	Risk of future land cover change usually based on the assessment of actors and drivers of land use change. Tool is used commonly for REDD+ baselines. This can help with measuring additionally and avoided loss.	There are studies on forest change due to deforestation and forest degradation (Marzoli, 2007; Ryan et al., 2011). The FNDS is developing an MRV system for REDD+ to ensure effective and adaptive implementation of system activities as well as a functional platform for managing, producing, storing and sharing data and information on the REDD+ mechanism and the their MRV system. The LAUREL project funded by World Bank is also working on the subject, as well as the United Nations Desertification Project called the Land Degradation Neutrality Target Setting Programme - LDN TSP, which assesses the risk of land coverage changes based on a specific set of

Theme	Attribute	Notes and examples	Results of the gap analysis
			indicators.
People	Population	Density of people, if possible measuring the socio-cultural attributes like indigenous people, purchasing power (PPP).	There are geospatial data on population density. Data from the new census conducted in 2017 will be released in April 2018. The National Institute of Statistics has non-spatial data on demographic statistics and social indicators at the national level. There is also a detailed mapping of the Moatize district that includes education, health, agriculture, finance and investment, business registration. In addition, there is the global mapping of anthropogenic biomes and the mapping of the human footprint worldwide.
People	Infrastructure	Roads, railways, navigable rivers, shipping routes, urban centres, electricity transmission lines etc.	Some of this information is available, namely: - Roads; - Port structures; - Railway lines - Distribution networks, transmission networks and energy substations - Urban centers, schools, health centers, fishing centers in the province of Cabo Delgado - Constructions at the level of the city of Beira and Maputo. - Fishing centers in the coastal and inland areas, health centers and urban centers of the country.
People	Development corridors	These corridors drive development across much of Africa.	This information is available for the 3 main corridors of Mozambique: Maputo, Beira and Nacala.
People	Pollution and pollution risk	Existing polluted areas and areas potentially at risk from industrial activity (e.g. shipping & transport, pipelines, industrial sites, tailings dams etc.)	This type of information could not be obtained, but some data may exist. In the case of industrial zones, there is not even a geospatial register, and are limited to physical addresses.

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People	Human-pressure	Composite metrics that explore the cumulative impacts of different threats on biodiversity. Note that this can be used as a proxy for ecological condition.	It is not available for Mozambique, except the information recently produced by WCS on Human Footprint.
Key reports and literature	Conservation vision and goals and targets (i.e. commitments made at international or national level to retain / protect / restore biodiversity)	Important information for planning environmental policy, including any NNL/NG types of policies (e.g. to set out additionality considerations, ensure transparent accounting, etc.).	This information is available, and at national level there is: - Regulation of Procedures for the Approval of REDD+ - Regulation for the Control of Invasive Alien Species - Regulations on the Management of Hazardous Wastes - Regulation on the Management of Urban Solid Waste - National Environment Policy - Conservation Policy and its Implementation Strategy. At the international level, Mozambique has ratified at least the following environmental conventions: - Convention on International Trade in Endangered Species of Wild Fauna and Flora - Convention of Biological Diversity - Convention to Combat Desertification - Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Western Indian Ocean - African Convention on the Conservation of Nature and Natural Resources - Protocol Concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region - Protocol Concerning Regional Co-Operation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency - Convention on the Conservation of Migratory Species of Wild Animals - SADC Protocol on Fisheries - *Ramsar* Convention on Wetlands of International Importance especially as Waterfowl Habitat - United Nations Convention on the Law of the Sea of 10 December 1982

Theme	Attribute	Notes and examples	Results of the gap analysis
			relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks - United Nations Framework Convention on Climate Change - Stockholm Convention on Persistent Organic Pollutants - Convention on the Prevention of Marine Pollution.
Key reports and literature	Conservation plans and priorities	Areas and actions identified as important for conservation are important considerations for avoidance and potential offset sites	As mentioned before, species' conservation plans are dispersed. The review has captured only a few of them, for example, the African Wild Dog Monitoring and Conservation Project; National Action Plan for the Conservation of Cheetah and Mabeco (wild dog); conservation of large carnivores; Strategy and Action Plan for elephant conservation and management in Mozambique (2010-2015), national strategy and plan of action for mangrove restoration (2015-2020). Relevant information associated with conservation projects in Mozambique is partially available on BIOFUND's website, examples to be named are: - Rhino protection programme, - Conservation of natural resources in the National Reserve of Gilé, - Reduce the killing of elephants in Niassa National Reserve - Protecting an elephant sub-population in Niassa Reserve, - Securing block L7 in Niassa National Reserve - Strengthening the conservation of globally threatened species in Mozambique - Support Conservation Areas - Focus on anti-poaching. More information can be found from the link: http://www.biofund.org.mz/mocambique/projectos-ambientais/

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Key reports and literature	Conservation projects, budgets and spending	Level of investment in different conservation actions can help understand additionally.	This information is available on the BIOFUND website, which lists 50 environmental projects. This list can be viewed at the link: http://www.biofund.org.mz/mocambique/projectos-ambientais/
Key reports and literature	Development plans and priorities	Areas identify as suitable or likely to be developed for a particular human activity important to consider for understanding landscapes/seascapes. This includes key development corridors.	The available and accessible information is as follows: - Development corridors (Maputo, Beira and Nacala) - Northern Mozambique Channel - Multi-sectoral Plan, Special Planning Plan, Strategic Environmental Assessment and Digital Platform of the Zambezi Valley - Areas susceptible to agriculture - Rovuma Basin - Areas of infrastructure expansion
Key reports and literature	Information on the success of / outcomes of restoration projects	This can be helpful to assess the feasibility/ viability of proposed restoration measures (as a mitigation measure) and predict likely outcomes.	It may be available in final reports or evaluations carried out for specific projects. On BIOFUND's website there is a register of some restoration projects / actions, for example: - Banhine National Park Restoration - Combat deforestation and forest degradation in the Gilé National Reserve.
Key reports and literature	Climate adaptation plans	Areas identified as important for the adaptation of climate change might be important consideration for avoidance and offsets.	The habitat mapping study conducted by BIOFUND identified areas such as the Zambezi Delta and the Marromeu Complex. There is a National Action Program for Adaptation to Climate Change and at least the following studies on the subject: - Assessment of the Climate Change Vulnerability and adaptation priorities in the Quirimbas National Park - Assessment of the Vulnerability to Climate Change and adaptation priorities in Environmental Protection Area of Primeiras & Segundas Islands - Adaptation to climate change in semi-arid environments: experiences and lessons from Mozambique - Perceptions of climate risks in

Theme	Attribute	Notes and examples	Results of the gap analysis
			Mozambique: Implications for the success of adaptive strategies - Sustainable strategies for flood risk management to reduce the vulnerability of rural communities to the floods in Mozambique. - Adaptation plans and specific projects for the Cities of Pemba, Quelimane and Beira - Ecosystem Based Adaptation Project for the Maputo Region. In addition, a number of institutions have supported capacity-building projects and adaptation measures to address climate change, for example the World Bank, USAID, the African Development Bank, FAO, KfW.
Key reports and literature	Natural resource management plans	Use of natural resources might be important for avoidance of ecosystem services and potential offsets.	There is information available, and several plans have been covered in this review, for example: Sustainable management plan for the Mangrove of the Zambezi Delta; Community management of natural resources; Management of the Zambeze Basin and Low Hydrographic Basin in Critical Periods; Co-management of coral reefs of Vamizi island in northern Mozambique; Natural Resources Management Plan for Canda-Sofala Region; Plan of forest management community for forest resources of Ndombe - District of Chicualacuala; Adaptive management for *Mimosa piagra*, a shrub species in Gorongosa National Park, etc.
Key reports and literature	Information on illegal land use activities	Illegal use of resources, illegal hunting etc.	Some information is available for wildlife crimes, but mainly for the country in general, or for protected areas or specific areas, in the case of illegal logging and uncontrolled fires. Some examples are: The study on the illegal possession and consumption of leather turtles in Mozambique, Poaching of rhino and elephant, Hunting and illegal trade in Manica: the case study of the hunting area no. 9, Illegal gold mining in the Chimanimani National Reserve, etc.