Master Thesis

Energy, Environment, and Society

Monitoring the Pulse of the Planet

Assessing the Transformative Potential of Applying the UN Biodiversity Lab as a Governance Instrument

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Abstract

The current degraded state of nature proves that global efforts to reverse the loss of biodiversity has not yet been sufficient. However, in December 2022, a significant milestone was achieved as the international community reached a consensus on the Kunming-Montreal Post-2020 Global Biodiversity Framework. The vision of this framework is for humanity to live in harmony in nature by 2050, and reaching this vision will require profound societal changes. This thesis aims at examining how the implementation of a Big Earth Data platform in the decision- and policy-making process can facilitate such transformative changes. This is explored through a case study of the UN Biodiversity Lab, a platform that explicitly aims at supporting national stakeholders deliver on the Global Biodiversity Framework.

To examine the platform, a walkthrough- and content analysis method has been applied. The results from these methods are presented and analysed through a Big Earth Data Platform framework, which aims at providing frames for how a Big Earth Data platform should optimally be designed to support sustainability. The analysis shows that the UN Biodiversity Lab to a large extent is designed in accordance with this framework, as it is embedded in society, promotes actionable intelligence, and is listed as a digital public good. Thus, the platform seems to have a large potential to provide decision-makers, practitioners, and the public access to the best available data, information, and knowledge on biodiversity matters.

The thesis contributes to theory on transformative biodiversity governance by examining the transformative potential of one specific governance instrument. Findings show that the UN Biodiversity Lab can support integrative, inclusive, adaptive, transdisciplinary, and anticipatory governance in conjunction. The platform can potentially also influence the indirect drivers of biodiversity loss through strengthening monitoring mechanisms, increasing awareness, and supporting polycentric governance. This implies that despite the indirect drivers not easily being quantified as spatial data, the platform can still target the indirect drivers of biodiversity loss by influencing key leverage points in society. The study therefore concludes that applying a Big Earth Data platform in the decision-making process can be an important tool for reaching the vision of the Global Biodiversity Framework. There are however some key challenges that must be tackled to unlock the potential of the technology. This includes solving technical issues, securing adequate funding, enabling co-production of knowledge, and establishing consistent reporting practices.

Acknowledgments

Nature and biodiversity have always been topics close to my heart, and the current degraded state of nature is something I am truly concerned about. Despite biodiversity loss being a crisis as severe as climate change, it is often put in the shadow of this pressing issue (Legagneux et al., 2018). I therefore decided to focus my thesis on biodiversity loss to shine a light on the topic, and to emphasize the need for tackling this problem to ensure a truly sustainable future. I hope this project inspires more students to do the same, and I encourage the professors of my masters' program to incorporate biodiversity loss to a larger extent into the study program.

First and foremost, I want to thank my supervisor Helle Sjøvaag for her guidance and advice. Thank you for providing me constructive feedback and clear deadlines to ensure progress in the project. You have also pointed me towards relevant theory and methods, and the knowledge you have shared on digital societies and platforms have been very valuable.

Furthermore, I want to thank my managers at Bouvet for being very supportive of my studies. Thank you for allowing me to work part time and for being super flexible regarding how I have structured my working hours. I also want to thank my amazing classmates for motivating me throughout this project, and for all the fun times we have shared together over the last years. Finally, I want to thank my boyfriend for his support throughout the process, and for making my life easier over the last couple of busy weeks.

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Astrid Nygaard

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1. Introduction

In this introductory chapter the background of the thesis is presented. This includes a description of the pressing issue of biodiversity loss and international efforts to reverse this. In addition, technological data advances that can contribute towards creating a nature positive world are introduced. Thereafter follows a presentation of the thesis' research focus and my motivation for examining this topic. Lastly the structure of the paper is presented.

1.1. Background

Nature and its contributions to people are vital for human existence and for a good quality of life. It is the core basis of humanity, our modern civilization and economy (Deloitte, 2022). We depend on nature for food, energy, materials and medicine and it also plays a role for recreational purposes, such as spending time in nature (IPBES, 2019). Through its ecological and evolutionary processes nature provide several vital services for human life. It sustains the quality of air, fresh waters, and soils which humans depends on, it distributes fresh water, regulates the climate, provides pollination and pest control, and reduces the impact of natural hazards.

Today nature and its ecosystems are more threatened than ever before due to human activities. The world's population of wild animals has declined approximately 68% since 1970, and one million plants and animal species now face extinction (Deloitte, 2022). According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (2019), 75% of the land surface is significantly altered by humans, 66% of the ocean area is experiencing increasing cumulative impacts and over 85% of wetlands have been lost.

Land-use change, direct exploitation of organisms, climate change, pollution and invasion of alien species are the five biggest drivers for changes in nature (IPBES, 2019). These direct drivers for nature loss results from an array of underlying causes which again are underpinned by societal values and behaviours. Such indirect drivers of change include production and consumption patterns, human population dynamics and trends, trade, technological innovations, and governance at all levels of society. The complexity of the indirect drivers makes their impacts less immediately visible than the impacts of the more readily observable direct drivers. Thus, a key difference between the direct and indirect drivers of biodiversity loss are their tangibility.

1.1.1. Global Efforts to Reverse the Loss of Biodiversity

The intention to reverse the loss of nature has been on the international agenda ever since the World Commission on Environment and Development (1987) released its landmark report "Our common future". In 1992 the Convention on Biological Diversity (CBD) was established to particularly address biodiversity loss (UN, 1992). They defined biodiversity as "variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (UN, 1992, p. 3)". CBD is currently signed 196 parties, making it one of the most accepted treaties in the world (CBD, 2022c).

In December 2022, CBD adopted the ambitious Kunming-Montreal Post-2020 Global Biodiversity framework (GBF) with the vision of creating a world where people live in harmony with nature by 2050 (CBD, 2022a). This framework builds on the achievements, gaps and lessons learned from the unaccomplished Aichi-targets which were adopted in 2010 as part of the CBD's Strategic Plan for Biodiversity 2011-2020. The GBF is popularly referred to as the "Paris Agreement for Nature" (e.g. Williams, 2022), and it recognizes that transformative change is necessary to halt and reverse the loss of biodiversity (CBD, 2022a). Furthermore, the framework emphasizes that a "whole-of-government" and a "whole-of-society" approach is required for accomplishing this 2050-vision. This implies that its success is reliant on political will and recognition at the highest level of government, but also requires action and cooperation at all levels of government and by all actors of society.

The GBF consists of four long-term goals for reaching the 2050 vision, along with 23 action-oriented global targets for urgent action over the decade to 2030 (CBD, 2022a). These targets include conserving 30% of the planet's oceans and lands by 2030, as well as implementing effective restoration programs for 30% of the world's degraded land and ocean ecosystems by the end of this decade. Furthermore, Target 21 aims at ensuring that the best available data, information, and knowledge is accessible to decision-makers, practitioners, and the public. This availability can guide effective and equitable biodiversity governance, while also strengthen communication, awareness-raising, education, monitoring, research, and knowledge management related to biodiversity. Thus, Target 21 emphasizes the importance of data and information accessibility in achieving the vision of the GBF.

1.1.2. Big Data and Sustainability

We currently live in an era coined as the fourth industrial revolution, characterised by the seamless integration of digital technologies into our daily lives (Miller, 2016). Central to this revolution is the data revolution, which enables the capture, processing, analysis and visualisation of an unprecedented amount of data (Runting et al., 2020). These burgeoning reserves of data, i.e. Big Data, is generated by a growing array of sensors, such as satellites, mobile phones and the internet of things which are made available for various forms of sorting, sharing and data mining (Andrejevic & Burdon, 2015; Maaroof, 2015).

Through the analysis of big data, valuable knowledge can be derived from uncovering patterns, unknown correlations, and other useful information (Andrejevic & Burdon, 2015; Maaroof, 2015). This can ultimately improve decision-making by enabling decisions based on the analysis of data rather than on the basis of intuition (Provost & Fawcett, 2013). However, the development and implementation of big data have not been without critiques (boyd & Crawford, 2012). For example, concerns have been raised about the technology creating new digital divides regarding who has access to the data and insights. Furthermore, big data favours data that fits in to a mathematical model, due to limited abilities to contextualise data. This can lead to important information being lost.

Despite these critiques, the data revolution is creating innovative opportunities for transforming society and protecting the environment (Giovannini et al., 2014). One potential area is the development of platforms containing big data obtained through earth observations, i.e., Big Earth Data (BED) (Guo et al., 2017). BED platforms have the potential to enhance humans' capabilities for monitoring and understanding society and nature, as well as helping humanity react to environmental problems from a spatial and temporal dimension. Ultimately BED, in combination with other emerging technologies such as Artificial Intelligence, can contribute towards developing a digital twin of the Earth (Guo et al., 2020). This involves creating virtual model of the planet that simulates its physical and environmental processes in real-time. Guo et. al (2020) claim that the development of a digital twin of the Earth, along with modelling techniques and visual representations of different scenarios, could be the missing tool for developing collective consciousness and action towards sustainability.

1.2. Research Focus and Motivation

This thesis aims at exploring how applying a BED platform as a governance tool can contribute towards reaching the vision of the GBF of living in harmony with nature by 2050. More precisely it aims at investigating how and to what extent the technology can contribute towards enabling transformative change by influencing biodiversity governance and the indirect drivers of biodiversity loss. The study is conducted through a single case study of the UN Biodiversity Lab (UNBL), which is a free, open-source platform that contains more than 400 of the world's most developed data layers on nature, climate change and sustainable development (UNBL, 2022b). The version 2.0 of the platform was launched in 2022 and is developed through a partnership between CBD and other multilateral organisations related to the United Nations. The platform's core vision is to support national stakeholders to deliver on the GBF.

To my knowledge, the relationship between transformative change and BED platforms is a under explored research field. Through my research, the closest I have come to anything that resembles my study is a bachelor's thesis that explores how database interfaces can contribute to conservation policies (Dinkelberg, 2022). Thus, with this thesis I aim at shining a light on a research field that can have a large potential for future research. Also, I wish to contribute towards making the technical construct "BED platform" more comprehensive for both decision-makers and scholars within sustainable development studies. Furthermore, I hope to provide inspiration to the IT-industry on how it can contribute towards creating a nature positive world.

1.3. Structure of the Thesis

Following this introductory chapter, the theoretical background for the thesis is presented in *Chapter 2,* which concentrates around literature related to transformative change. In *Chapter 3* the research questions are presented, before an analytical framework used for assessing the design of the platform is presented in *Chapter 4*. The methodological approaches and choices made throughout this project are then presented and evaluated in *Chapter 5*. This includes a presentation of the walkthrough method and content analysis, which are methods used for collecting and analysing data. Findings are thereafter presented in *Chapter 6* through an empirical analysis of the UNBL. These findings are then discussed in relation to the presented theory in *Chapter 7*. Finally, *Chapter 8* concludes the thesis with a summary, reflections, and indications for future research.

2. Theoretical Framework and Literature Review

This chapter presents the theoretical background used for grounding the thesis and its research questions in existing literature. It focuses on literature related to transformative change, as this provides an appropriate basis for discussing how applying a Big Earth Data platform can contribute towards creating a world where people live in harmony with nature by 2050. To gain a better understanding of the topic at hand, this chapter commences with an introduction to the transformative change literature. Thereafter follows a presentation of a framework on biodiversity governance before leverage points for tackling the root causes of unsustainability are presented. The chapter concludes with a brief summary of key concepts applicable for this thesis.

2.1. Transformative Change, Transformations and Transitions

The need for transformative change is increasingly being recognised as critical for reaching the global sustainability goals (e.g. CBD, 2022a; IPBES, 2019; Visseren-Hamakers & Kok, 2022b; WWF, 2022). Transformative change is defined as "a fundamental, society-wide reorganization across technological, economic and social factors and structures, including paradigms, goals and values" (Visseren-Hamakers & Kok, 2022a, p. 8). Within the literature on transformative change, transformations and transitions are important concepts. Despite often being used interchangeably, these concepts stem largely from different research communities which are concerned with either a transformation or a transition (Hölscher et al., 2018). The concepts are however not mutually exclusive, as both provide nuanced perspectives on how to describe, interpret and support desirable radical and non-linear changes for achieving a sustainable society.

Scholars concerned with global environmental change, such as resilience and planetary boundaries, have adopted the construct transformation to refer to fundamental shifts in human and environmental interaction and feedbacks (Hölscher et al., 2018). Linnér and Wibeck (2020, p. 2) define transformation as a "a deep and sustained, nonlinear systemic change, generally involving cultural, political, technological, economic, social and/or environmental processes." The term applies to large-scale changes in entire societies, which can be global, national or local, involving interacting human and biophysical system components (Brand, 2014; Folke et al., 2010, referenced in Hölscher et al., 2018).

A transition, on the contrary, has mainly been adopted to analyse changes in sociotechnical sub systems, such as energy, mobility and cities (Loorbach et al., 2017). Geels and Schot (2007, p. 399) define a transition as “changes from one sociotechnical regime to another”. The regime is known as the sociotechnical system’s deep structure and contributes towards stability by making the system resistant to change (Geels, 2004; Geels & Schot, 2007). It consists of the current mainstream technology, scientists, policy makers, companies, and users.

The regime is influenced by an exogeneous sociotechnical landscape, which consists of stable, slowly changing elements of society such as values, beliefs, concerns, the media landscape and macro-economic trends (Geels, 2012). Furthermore, the regime is influenced by the development of niches, i.e., radical innovations with initially low performance. In combination, changes in the sociotechnical landscape together with the development of niches can lead to destabilization of the current (unsustainable) regime (Geels, 2002). This destabilization creates a window of opportunity where niches can gain momentum and replace the current regime.

Noteworthy is that the term transformation is also used in the transition literature. Here it refers to a specific transition pathway, where the incumbents themselves form new regimes in comparison to being substituted by niches (Geels & Schot, 2007). However, in this thesis the concept of transformation will be referred to as described above, as the focus of the thesis is on global environmental change.

2.1.1. Combining Transformations and Transitions

Visseren-Hamakers et al. (2022) suggest that transformative change encompasses both transformations and transitions. They argue that transformative change focuses both on the generic underlying causes of unsustainability, as well as those specific to certain regimes. This implies that transformative change includes a focus on directly enabling change in the landscape, instead of only through change niches and regimes. Transformations and transitions can thus be integrated by positioning transitions in the broader societal context of transformations (Visseren-Hamakers et al., 2022). From a transition perspective this is understood as seeing transformation as a “family of transitions” (Loorback, 2014, referenced in Visseren-Hamakers et al., 2022). Reversely, seen from a transformation perspective, transformative change includes multiple specific transitions that influence each other. This is illustrated in Figure 1.

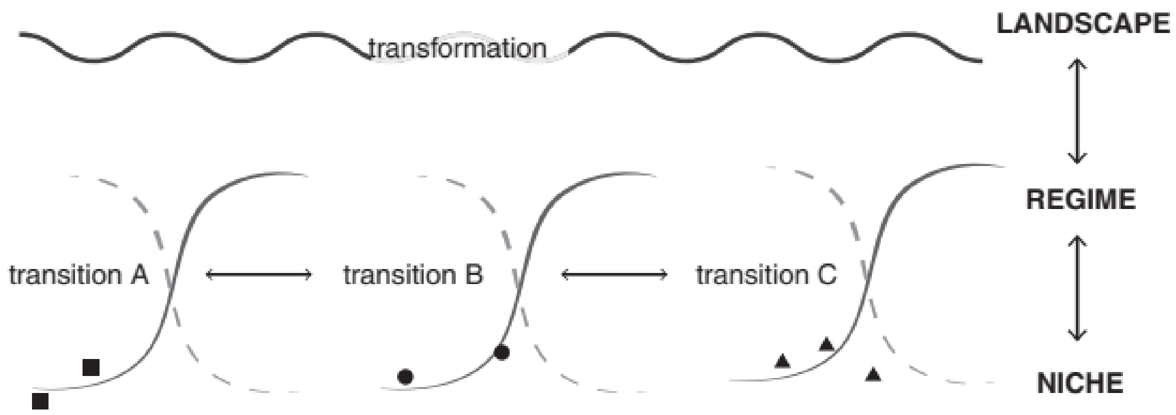

Figure 1: Transformative change encompasses both transformations and transitions and is focused on both the generic social underlying causes of unsustainability and those specific to certain regimes (Visseren-Hamakers et al., 2022).

2.2. Transformative Biodiversity Governance

Transformative governance is an emerging research field that focuses on how to enable transformations towards sustainability (e.g. Chaffin et al., 2016; Visseren-Hamakers et al., 2021; Visseren-Hamakers & Kok, 2022b). In relation to biodiversity the term is defined as "[t]he formal and informal (public and private) rules, rule-making systems and actor-networks at all levels of human society (from local to global) that enable transformative change, […] towards biodiversity conservation and sustainable development more broadly." (Visseren-Hamakers & Kok, 2022a, p. 10). It involves a broad set of governance components, including institutions, actors, networks and organizations, as well as a broad set of structures, such as legitimacy, power and human behaviours (Chaffin et al., 2016). Furthermore, transformative governance requires distributed power through polycentric governance. This is defined as a system of decision-making where multiple governing bodies interact to create and enforce rules within a specific policy area or location (Brodie Rudolph et al., 2020).

The aim of transformative governance is not to support resilience in the existing ecological or socioecological regimes but to foster new ones (Chaffin et al., 2016). This may require radical, systemic shifts in deeply held values and beliefs, patterns of social behaviour. The desired direction of the transformation is often contested and a transformation will likely result in shifting power relations (Visseren-Hamakers et al., 2021). Transformative governance therefore has a political character and vested interests may inhibit, challenge, slow down or downscale transformative change (Chaffin et al., 2016; Visseren-Hamakers et al., 2021). This political character makes governing transformative change inherently difficult. Visseren-

Hamakers and Kok (2022a) therefore argue that transformative governance needs to take on various lessons learned from niches in the governance literature.

Transformative governance should therefore include five governance approaches (Visseren-Hamakers et al., 2021; Visseren-Hamakers & Kok, 2022a). First, transformative governance should be *integrative*, implying that it should be operationalised in ways that ensures that solutions also have sustainable impacts on other scales and locations, on other issues and in other sectors. Second, transformative governance should be *inclusive* by empowering and emancipating those whose interests that are currently not being met, but who represent values that constitute transformative change towards sustainability. Third, an *adaptive* approach is needed to enable learning, experimentation, reflexivity, monitoring, and feedback. This reflects that transformative change, and its governance are moving targets. Fourth, transformative governance should recognise different knowledge systems and should focus on knowledge types that are currently underrepresented to support the inclusion of sustainable and equitable values. This implies including a *transdisciplinary* approach. Finally, transformative governance needs to take an *anticipatory* approach by applying the precautionary principle when governing in the present for uncertain future development. This is especially true for the development of new technologies.

To support transformative change these five approaches should be focused on the underlying, indirect drivers of biodiversity loss (Visseren-Hamakers et al., 2021; Visseren-Hamakers & Kok, 2022a). This focus enables addressing several sustainability issues at once, as the same indirect drivers are the root cause of several problems (IPBES, 2019; WWF, 2022). Figure 2 illustrates how the governance mix can become increasingly capable of addressing the indirect drivers of unsustainability by following the five governance approaches in conjunction (Visseren-Hamakers et al., 2021; Visseren-Hamakers & Kok, 2022a). Through the polycentric character of the governance mix, these approaches enable all actors to regularly evaluate whether the mix includes the necessary governance instruments to address the underlying causes of biodiversity loss. The governance can then become increasingly transformative, leading to more sustainable structures, which again can make transformative governance easier to implement.

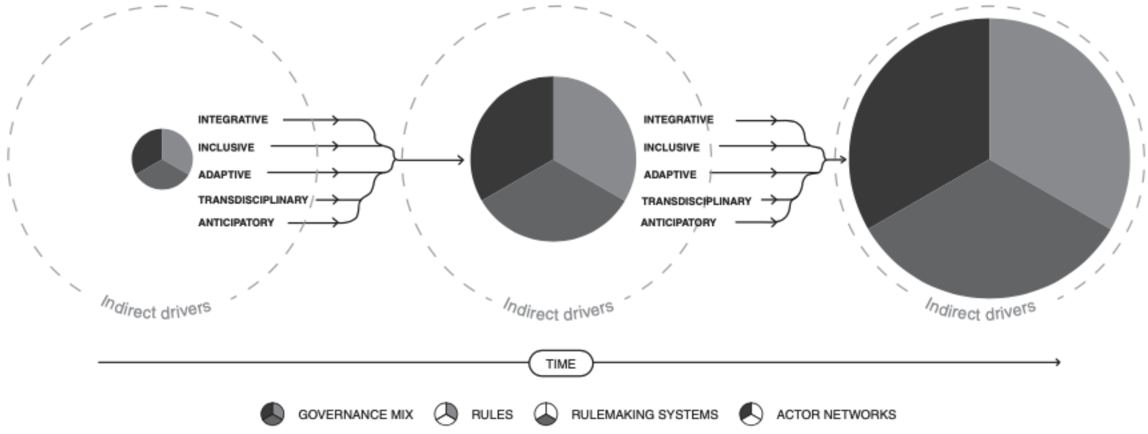

Figure 2: Governance becomes transformative by implementing five governance approaches in conjunction, while also focusing on the underlying drivers of sustainability issues. This approach enables the governance to become increasingly capable of addressing the indirect drivers of biodiversity loss over time (Visseren-Hamakers & Kok, 2022a).

To assess which governance instruments can address the underlying causes of biodiversity loss, it is necessary to understand how the indirect drivers of biodiversity loss can be influenced. This has been suggested to be effectively done by targeting key leverage points in society (IPBES, 2019; WWF, 2022). What these leverage points are and how they can be targeted will be described in the following.

2.3. Leverage Points for Transformative Change

Leverage points are defined as "points of power" in a system where a small change potentially can lead to a large shift in behaviour (Meadows & Wright, 2008, p. 145). These points ranges from being described as shallow or deep, reflecting their transformative potential (Abson et al., 2017). Historically, both sustainable science and policy have favoured shallow intervention points, which is argued to be one of the reasons why humanity remains largely on unsustainable trajectories (e.g. Abson et al., 2017; Dorninger et al., 2020). The focus on shallow leverage points is especially abundant when sustainability issues are framed as a technological problem, as in comparison to a social, ecological, political or economic problem (Dorninger et al., 2020).

In Figure 3 on the next page, the leverage points are grouped into four broad system characteristics on which sustainability interventions can be focused (Abson et al., 2017; Meadows, 1999). Both leverage points and system characteristics vary in their potential to enable transformative change. This is reflected in the vertical and horizontal arrows moving from shallow to deep, where the deep leverage points and groups are the more effective places to intervene, but which also entails higher systemic resistance to change.

Parameters The relatively mechanistic characteristics typically targeted by policymakers	Feedback The interaction between elements within a system of interest that drive internal dynamics	Design The social structures and institutions that manage feedbacks and parameters	Intent The underpinning values, goals, and views of actors that shape the emergent direction to which a system is oriented
Constants, parameters, numbers (e.g., subsidies, taxes, standards)	The length of delays relative to the rate of system change	The structure of information flows (who has access to information)	The goals of the system
The sizes of buffers and other stabilizing stocks, relative to their flows	The strength of negative feedback loops relative to the impacts they are trying to correct against	The rules of the system (e.g., incentives, punishments, constraints)	The mindset or paradigm out of which the system (goals, structure, rules, delays, parameters) arises
The structure of material stocks and flows (e.g., transport networks, population age structures)	The gain around driving positive feedback loops	The power to add, change, evolve, or self-organize system structure	The power to transcend paradigms

Shallow → Deep (rows, top to bottom); Shallow → Deep (columns, left to right)

Figure 3: Leverage points can be grouped into four broad system characteristics on which sustainability interventions can be focused. Both leverage points and system characteristics vary in their potential to enable transformative change, reflected in the arrows moving from shallow to deep (adopted from Abson et al., 2017).

System *parameters* represents the shallowest system characteristics. These represents modifiable, mechanistic characteristics such as taxes, incentives as well as physical elements of the system such as sizes of stocks or rates of material flows (Abson et al., 2017). Then follows system *feedbacks* which are the interconnections between the elements of the system which steer reinforcing or dampening feedback loops (Dorninger et al., 2020). The system's *design* is the first group of leverage points characterized as deep. These relates to the structure of information flows, rules, power and self-organization (Abson et al., 2017). Finally, the leverage points with the most transformative potential are grouped as the system's *intent.* This group includes the norms, values and goals embodied within the system of interest and the underpinning paradigms out of which they arise. This is an emerging property arising from the multiple, potentially conflicting, sets of world views, goals and purposive behaviours within a system and is considered the emergent direction to which the system is oriented.

In summary, when seeking to address the indirect drivers of biodiversity loss, the governance instruments that hold the largest potential are those capable of altering the design and intent of the system. Thus, implementing governance instruments that targets these deep leverage points can contribute towards the governance mix becoming increasingly transformative.

2.3.1. Key Realms of Leverage

To attend the deep leverage points, Abson et al. (2017) highlight three "realms of leverage" that can be of particular importance because of the strong interactions between them. These are referred to as *restructure, reconnect and rethink* and will be elaborated in the following.

Restructure refers to change, stability and learning in formal and informal institution (Abson et al., 2017). This is a critical realm of leverage as institutions guide and constrain action. Institutions tend to be self-reinforcing and resistant to change and this makes harnessing institutional change for sustainability transformations difficult. Crises can trigger institutional change towards sustainability by fostering reorganization, learning and adaptation (Schumpeter, 1950; Gunderson and Holling, 2002, referenced in Abson et al. 2017). Ensuring that institutions are designed to be open to the learning and adaptation opportunities invoked by a crisis is therefore a key lever within the realm of restructure (Eburn and Dovers, 2015; referenced in Abson et al. 2017). Enabling polycentric governance can be key for this, as multiple autonomous governance bodies allow for flexible coping with external drivers (Folke et al., 2005)

Reconnect targets the interactions between people and nature, and reflects people's connections to nature and their influence on sustainability outcomes (Abson et al., 2017). How people perceive, value, and interact with the natural world fundamentally shape the goals and paradigms underpinning many systems of interest. Scholars have found a disconnection from nature both on an individual and societal level and it is suggested that this may negatively influence sustainability (e.g., Nisbet 2009, referenced in Abson et al. 2017). Especially "inner" individual connections to nature are thought to be important for addressing deep leverage points within the realm of reconnect (Ives et al., 2018). This includes cognitive connections, i.e., knowledge or awareness of the environment and values towards nature, and philosophical connections, i.e., perspectives on what nature is, why it matters, and how humans ought to interact with it.

Finally, *rethink* refers to the knowledge production and use in transformational processes (Abson et al., 2017). It involves the understanding of how information flows through the system, how goals and expectations are set and how selected means and methods helps us get there. How problems are framed and how knowledge is produced has significant implications for policy development and societal outcomes. Hence, questioning existing perception of legitimate knowledge in science and politics has the potential to influence all the above-mentioned system characteristics. This can help us identify gaps in and strengths of the available knowledge base used in decision making. Furthermore, it can provide opportunities to assess the limitations of knowledge production and processes, as well as the settings in which knowledge is produced and used.

Within the realm of rethink, co-production of knowledge between academics and non-academics is thought to be a promising research approach for addressing sustainability issues effectively (Norström et al., 2020). Furthermore, focusing on underrepresented knowledge systems, such as indigenous and local knowledge, can contribute towards a more inclusive and plural understanding of sustainability transformations (e.g. Lam et al., 2020). This is due to their in-depth local and place-based nature, which can contribute towards more effective environmental governance systems.

These insights show that governance instruments that influences the restructure-, reconnect- and rethink realm of leverage have large potential to impact the intent and design of the system. Thus, when evaluating whether the governance mix includes the necessary governance instruments to address the indirect drivers of biodiversity loss, these realms of leverage should be considered.

2.4. Summary of Literature Review

It is increasingly recognized that transformative change is necessary to create a nature positive world (e.g. CBD, 2022a; IPBES, 2019; Visseren-Hamakers & Kok, 2022b; WWF, 2022). Transformative change refers to radical and fundamental shifts in society across technology, economy, and social factors (Visseren-Hamakers & Kok, 2022a). It encompasses both transformations and transitions, which respectively describe large-scale changes in entire societies, and regime shifts in sociotechnical sub systems. Transformations and transitions can be integrated by positioning transitions in the broader societal context of transformations (Visseren-Hamakers et al., 2022).

Transformative biodiversity governance is an emerging research field that focuses on how to enable transformative change (e.g. Chaffin et al., 2016; Visseren-Hamakers et al., 2021; Visseren-Hamakers & Kok, 2022b). It addresses rules, rule-making systems and actor-networks and recognizes that a whole-of-society approach is needed for enabling change. For being transformative, governance should be integrative, inclusive, adaptive, transdisciplinary, and anticipatory, and these approaches should be used in conjunction. Furthermore, the approaches should be focused on the indirect drivers of biodiversity loss to tackle the root causes of unsustainability.

Addressing key leverage points in society has been suggested to be an effective way to target the indirect drivers of biodiversity loss (IPBES, 2019; WWF, 2022). In particular, targeting leverage points characterised as deep, i.e., a system's design and intent, has large potential to foster change (Abson et al., 2017). These can be addressed through three realms of leverage. This involves restructuring institutions in a way that makes them open for the learning and adaptation opportunities emerging from crisis, finding ways to help people reconnect with nature, and rethinking how knowledge is produced and used in transformational processes.

Based on these insights it can be suggested that a governance instrument should align with the five governance approaches of transformative governance to support transformative change in relation to biodiversity loss. Additionally, assessing the instrument's potential to influence the presented realms of leverage will be important for determining its effectiveness in enhancing the governance mix's ability to address the indirect drivers. By considering these factors, the suitability of the governance instrument to promote sustainability can be evaluated.

3. Problem Statement and Research Questions

In this short chapter the formal problem statement and research questions are presented. These are derived from the presented background from the introduction chapter and presented theory on transformative change.

The following problem statement has been formulated:

How and to what extent can applying a Big Earth Data Platform as a governance instrument contribute towards reaching the vision of the Kunming-Montreal Post-2020 Global Biodiversity Framework?

To refine this problem statement the following research questions have been developed:

1. *How suitable is the design of the UN Biodiversity Lab for supporting sustainability?*
2. *How can the UN Biodiversity Lab support the five governance approaches of transformative biodiversity governance?*
3. *How can the UN Biodiversity Lab influence the indirect drivers of biodiversity loss?*
4. *What are key challenges for unleashing the transformative potential of the UN Biodiversity Lab?*

Question 1 intends to set the frames for the succeeding discussion by evaluating the design of the UN Biodiversity Lab (UNBL). Including this question thus provides insight to the relevance of the chosen case in relation to the problem statement. This question is assessed in the empirical analysis (Chapter 6) and is grounded in the analytical framework which will be presented in the following chapter. The three proceeding questions are assessed in the discussion (Chapter 7). *Question 2* builds on the insights that governance instruments should align with the five governance approaches of transformative governance to facilitate transformative change. Thus, this question addresses the UNBL's potential to support integrative, inclusive, adaptive, transdisciplinary, and anticipatory governance. *Question 3* assesses to what extent the platform can enhance the governance mix's ability to target the indirect drivers of biodiversity loss. This is mainly discussed by evaluating the platform against the presented realms of leverage. Finally, in *Question 4* pressing challenges that have been discovered in the preceding analysis and discussion are attended. This section also provide suggestions for how these challenges can be resolved.

4. Analytical Framework

In this chapter the analytical framework which will be used to examine the design of the UN Biodiversity Lab (UNBL) is presented. The chapter commences with a short introduction to the Big Earth Data (BED) science to familiarise the reader with the topic. Then follows a description of the framework.

BED science is an emerging research field that builds on Data Science and researches the Earth system in a new holistic, multi-disciplinary, and trans-disciplinary way (Guo et al., 2020; Nativi et al., 2021). One of its main objectives is the systematic comprehension, modelling, and implementation of processes to generate information from data and provide the knowledge required by scientists, engineers, and decision-makers. BED science is thought to be fundamental for developing a digital twin of the earth.

To enable data-driven knowledge generation to address challenges to the planet's sustainability Guo et al. (2020) suggest implementing a high-level value chain framework. The Big Earth Data Platform framework (BEDP framework) displayed in Figure 4 is to a large extent a reproduction of the framework developed by Guo et al. (2020). However, it is further developed by incorporating other principles suggested to be important for big data to foster sustainable development. This framework will be presented in the following.

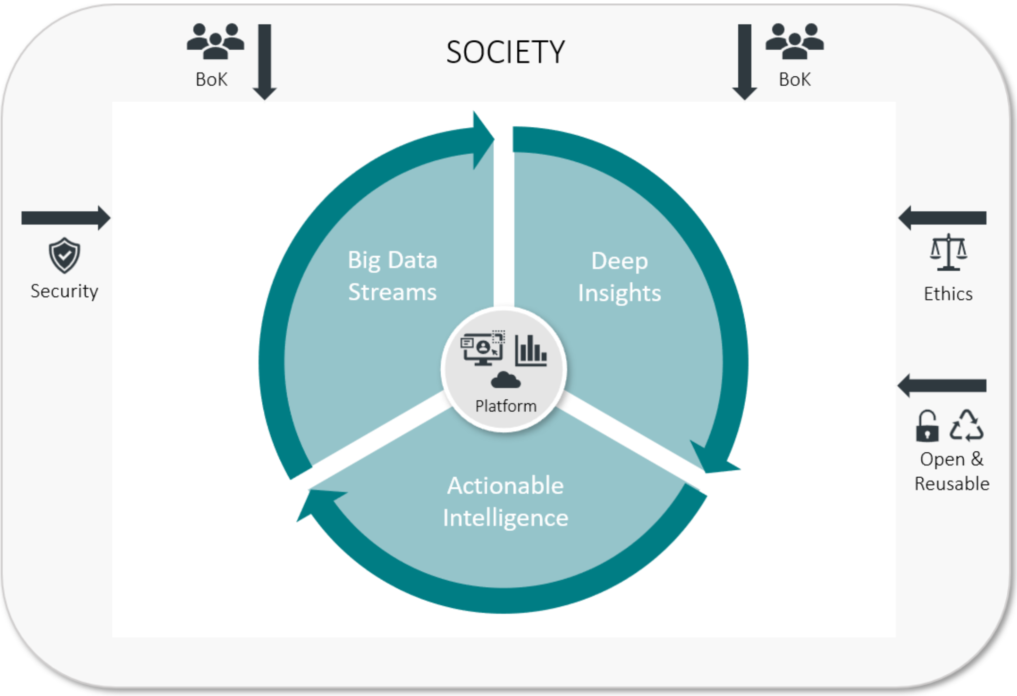

Figure 4: The Big Earth Data Platform Framework.
Adapted and further developed from Guo et al. (2020) and Nativi et al. (2021)

The end goal of the BEDP framework is to integrate the consolidated knowledge of the world and make it accessible to individuals at different levels of the decision and policy formulation process (Guo et al., 2020). This requires applying an ecosystem approach and the BED platform should therefore be embedded in society. This implies that the realisation of the framework requires engagement of-, and collaboration between stakeholders with different concerns, needs, understandings, and theories of realities. I.e., it requires collaboration between different Bodies of Knowledge (Romme, 2016), displayed as BoK in Figure 4. Different perspectives and opinions are essential for ensuring viable and sustainable solutions (Guo et al., 2020). However, productive outcomes also depend upon clear communication, a common understanding of the problem, and the agreement on a set of clear objectives.

4.1. Turning Big Data into Actionable Intelligence

As displayed in Figure 4 the BEDP framework builds on three interconnected digital processes (Guo et al., 2020; Nativi et al., 2021). *Big data streams* refer to the collection and aggregation of big (earth) data, which is generated through an array of sources such as remote sensing instruments, internet of things, citizen science, social networks, and public government. The data collected is then analysed through big data analytics techniques, such as machine learning models, to generate valuable, *deep insights*. These insights are then translated into *actionable intelligence* by being interpreted in the context of real-world problems.

The provision of actionable intelligence is achieved through specialised online platforms, i.e., BED platforms (Guo et al., 2020). These platforms are built in a network environment where components interact via effective and flexible interfaces, such as through Web APIs. Personalised services are provided to users on the platform through managing specific intelligence requested within various business domains. To enable this, the platform needs to be interactive to guarantee the reproducibility and trustworthiness of results among different research approaches. Furthermore, it should contain information visualisations, such as change trends, score sizes and object relationships, to increase the understanding of the data and support quick decision-making.

4.2. Promoting Open and Reusable data

The computing infrastructures on the BED platform must be transparent to support the application of big data analysis by third parties (Guo et al., 2020). This implies that the platform should entail open data which can be reused and shared among different stakeholders. Open data refers to data that is free from copyright and which can be shared in the public domain (Maaroof, 2015). Open data is an important characteristic of a digital public good, which the UN Secretary General (2020) state are essential tools for unlocking the full potential of digital technologies and data to attain the sustainable development goals.

To ensure the reusability of the data the BEDP framework should apply the FAIR Data Principles as guiding principles for data management (Guo et al., 2020; Maaroof, 2015). These principles propose that data should be Findable, Accessible, Interoperable and Reusable to ensure efficient data sharing (Wilkinson et al., 2016). That data is *findable* means that the data and supplementary materials are described with rich metadata and are assigned a globally unique and persistent identifier (Columbia University, 2022; Wilkinson et al., 2016). *Accessible* data implies that data and metadata can be understood by both humans and machines and is stored in a trusted open repository. Data is *interoperable* when it uses formal, accessible, shared, and broadly applicable language for knowledge representation, such as agreed-upon controlled vocabularies. Finally, data is *reusable* when data and collections are richly described with a plurality of accurate and relevant attributes and are released with a clear and accessible usage license.

4.3 Security Constraints and Ethical Considerations

The BED platform must also implement a set of security constraints and ethical considerations, as agreed upon by its stakeholders and society (Guo et al., 2020). This includes privacy considerations, i.e. the right of individuals to control what information related to them may be disclosed (Maaroof, 2015). Privacy has implications for all areas of work within big data, from data acquisition and storage to retention, use and presentation. Metadata from the users' interaction with the platform also becomes an important data source for further development of the platform (Guo et al., 2020). This is because understanding how users from different business domains interact with the platform will generate a higher application value. Privacy aspects of the platform's service provision policy should therefore be carefully considered in the design of the platform. Sensitive data could be secured by implementing various security measures, including access controls, encryption of data and intrusion detection (Sun et al., 2014).

The platform should also ensure inclusiveness of different user groups to support sustainable development. With the growing amount of big data there is a risk of growing inequality between those who know and those who do not know (Giovannini et al., 2014). The *digital divide* refers to the gap that exists between and within countries among those with access to knowledge through tools of information and communication technologies, and those without such access (Cullen, 2001).

There are striking gaps between the potential for data to be used in the implementation of sustainable development goals and the actual capacity of countries to use data for efficient decision making (Giovannini et al., 2014). The most notable gaps are found between developed and developing countries as well as between private companies and public agencies, with the former of both categories being the most able to collect, analyse and respond to real-time data as quickly as it is generated. There are several sources to why people are excluded from the world of data and information, including language, poverty, lack of education, lack of technology infrastructure, remoteness, and discrimination. The development of digital public goods can foster a revolution for equality by providing both high- and low-income countries with the same knowledge (Giovannini et al., 2014; UN Secretary General, 2020). This can in turn create a world of informed and empowered citizens who can hold decision-makers accountable for their actions.

4.4 Summary of Analytical Framework

To foster sustainability, the development of the BED platform requires an interplay between the platform and society where various stakeholders collaborate to develop viable and sustainable solutions (Guo et al., 2020). Here, clear objectives and common goals are important to ensure productive outcomes. Big data is on the BED platform transformed into actionable intelligence through three interconnected processes, which is achieved through the provision of personalised services and information visualisations. The platform should also promote open access to data and should follow the FAIR principles to ensure reusability among all stakeholders. Furthermore, the developers of the platform should implement robust measures to safeguard personal information and to comply with privacy laws. They should also strive to ensure inclusiveness to make sure that no groups are prevented from using the platform's services and data (Giovannini et al., 2014).

5. Methodology

In the following the methodological approach to this project will first be presented by discussing the thesis' research design, data collection and analytical procedure. Then follows a discussion of the quality of the methodological approach considering reliability and validity. Ethical considerations are then discussed before the chapter concludes by presenting the methodological limitations of the study.

5.1. Research Design

The research design is the general plan for how the research questions will be answered. The design can be either descriptive, explorative, explanatory or evaluative, or a combination of these (Saunders et al., 2015). The broad aim of the thesis has been to examine to what extent applying a Big Earth Data (BED) platform can facilitate transformative biodiversity change. Answering this has required a good understanding of the topic at hand and open research questions have been formulated. This speaks for the thesis having an explorative research design (Saunders et al., 2015). However, the thesis also has a descriptive element as it has been important to gain insight on the organization behind the UN Biodiversity Lab (UNBL), what type of knowledge is available, and who is providing this information. This implies that the exploratory study has been supplemented with a descriptive research design.

5.1.1. Research Approach

To answer a research question, either a deductive or inductive approach can be applied (Neuman, 2014). A deductive approach implies testing existing theory with collected data and generalises from the general to the specific. This approach can exclusively be used to answering "why" questions and is concerned with explaining some social regularity that has been discovered but is not yet understood (Blaikie & Priest, 2019). An inductive approach on the other hand commences by collecting data which is used to develop new theories and derive generalisations. This approach is essential for answering "what" questions.

The research questions of this thesis are formulated as "what" and "how" questions. Furthermore, both transformative biodiversity governance and BED science are emerging research fields, with limited existing literature. These factors suggest that this thesis primarily uses an inductive approach for gathering data and exploring the relationship between the UNBL and transformative change (Blaikie & Priest, 2019). However, the themes of the research questions are derived from existing theory on transformative change, which has also influenced the data collection process. Thus, a deductive approach has been used to structure the problem at hand and give the project direction, while an inductive approach has contributed towards exploring new aspect not yet covered in theory. According to Saunders et al. (2015), using these approaches in combination can be a beneficial when conducting explorative studies.

5.1.2. Research Method

Data can either be collected by applying qualitative, quantitative, or mixed methods in a research project (Saunders et al., 2015). Qualitative research focuses on gaining a comprehensive understanding of the phenomenon at hand and typically adopts an inductive research approach. In contrast, quantitative research is usually associated with a deductive research approach and aims at examining relationships between variables using numeric data. Mixed methods use a combination of both qualitative and quantitative methods for data collection and analysis.

This project has employed a combination of qualitative and quantitative methods for data collection. First, a walkthrough method was applied to gather non-numeric data, providing in-depth qualitative insights. Subsequently, a content analysis was conducted to quantitatively analyse patterns within the data available on the platform. This approach implies that the project has used sequential mixed methods, where a quantitative method has been applied to elaborate on the initial findings from the qualitative method (Ivankova et al., 2006). The walkthrough- and content analysis method will be elaborated in section 5.2.

5.1.3. Research Strategy

A research strategy represents the general plan for how the researcher will answer the research questions (Saunders et al., 2015). Within an explorative research design, a case study is a common strategy (Yin, 2014). This is because a case study allows for an in-depth inquiry into a topic within its real-life context, which can facilitate the generation of detailed empirical descriptions and the development of theoretical insights. The case study also provides the opportunity to use mixed methods to gain a comprehensive picture of the case subject in question (Saunders et al., 2015). Based on this background I have found a case study to be an appropriate strategy to answer the study's research questions.

When a phenomenon is minimally explored, conducting a single case study case can be advantageous over multiple cases, as it allows for less complex examination (Saunders et al., 2015). Given the limited research on BED platforms in relation to transformative change, I have therefore chosen this approach. When conducting a single case study, it is important to choose a case that represents a critical, typical, or unique instance for the phenomenon under investigation (Saunders et al., 2015). For this thesis, this implied choosing an adequate BED platform to represent the technology more broadly.

Three platforms were considered for this project: the UN Biodiversity Lab, the Ocean Data Platform and Earth Knowledge's Planetary Intelligence Platform (Earth Knowledge, 2023; Hub Ocean, 2023b; UNBL, 2023g). These platforms share the common goal of leveraging data and information to address environmental challenges, but they differ in their specific focus. The primary objective of the UNBL is to help decisionmakers deliver on the Global Biodiversity Framework (GBF). The Ocean Data Platform aims at healing the ocean through open ocean data, and Earth Knowledge specifically addresses financial risk associated with nature.

The UNBL was chosen due to its close connection to the GBF which makes the platform particularly relevant for the study's problem statement. In addition, the UNBL is designed with open access, while the Ocean Data platform is still in its private preview phase. Furthermore, Earth Knowledge's platform is only available for paying customers. This made the data on the UNBL much more accessible compared to the other platforms, and thus the platform was also chosen due to this convenience.

5.2. Data Collection

Table 1 on the next page provides an overview of how data has been gathered on the different phases of the data collection process. In the following subsections the content of this table will be elaborated. Most data have been collected through a document analysis, which is a systematic procedure for reviewing or evaluating documents (Bowen, 2009). In this approach the researcher uses existing knowledge to gain insights and draw conclusions on the topic at hand. Such data is classified as secondary data as it is originally made for another purpose. However, some primary data has also been collected through the technical aspect of the walkthrough method, in the form of detailed notes and recordings.

Phase	Element	Data Sources
Walkthrough Method: *Environment of Expected Use*	Vision	Platform Website - About - Collections UNBL Official Training Relevant Brochures
	Operation model	Relevant Brochures
	Governance	Platform Website - FAQ - Terms of use - Privacy Policy UNBL Official Training Relevant Brochures
Walkthrough Method: *Technical Walkthrough*	Mediator Characteristics	Platform Website - Collections - Navigation Platform - User Interface Arrangement - Functions and Features - Symbolic Representation
Content Analysis	Selected Categories	Platform - Information about data layers - Layer visualisations References - Authors - Methods - Descriptions - Organisations' web pages

Table 1: The different phases of the data collection process, consisting of both the walkthrough method and content analysis.

5.2.1. The Walkthrough Method

The walkthrough method, introduced by Light et al. (2018), is a qualitative research method that promotes a systematic way to critically assess a given application. It aims to examine the app's technological mechanisms and embedded cultural references to understand how it guides users and shapes their experiences. The method is underpinned by specific theoretical frameworks from Science and Technology Studies (STS) and cultural studies which supply the analytical power to identify connections between contextual elements and the app's technical interface.

This method was chosen after being suggested by my supervisor. Through snowballing from Light et al. (2018) I found that the method was being applied to other studies that qualitatively examined a specific platform at hand (e.g. Apps et al., 2022). This included the bachelor thesis mentioned in the introduction, which is the closest to a similar study I have been able to find throughout this project (Dinkelberg, 2022). Thus, based on examining other relevant case studies that applied the method I found it to be an applicable method for my project as well.

The method consists of two separate but complementary parts; the Environment of Expected Use and the Technical Walkthrough, which will be elaborated in the following. Noteworthy is that in the walkthrough method the term “app” refers to a software application that solves particular user needs (Light et al. 2020). It is not limited to mobile applications and can also refer to apps developed for the web. This implies that the walkthrough method is applicable for the UNBL despite this being an online web platform and not a mobile app.

5.2.1.1. Environment of Expected Use

The Environment of Expected Use is studied by examining an app´s vision, operating model and governance model (Light et al., 2018). This allows the researcher to understand how the provider expects users to interact with the app. The apps vision involves its purpose, target user base and scenarios of use, and provides an understanding of how the app can be used and by whom. The operating model involves the app’s business strategy and revenue sources, which indicate underlying political and economic interests. An app’s governance involves how the app provider seeks to manage and regulate user activity to sustain their operating model and fulfill their vision. This element forms boundaries to what activities can be performed and which users are allowed on the app.

As can be seen in Table 1, the main data sources for the Environment of Expected Use phase have been the UNBL’s webpage, the official UNBL training material, and relevant brochures provided by either the UNBL or one of the partners. What information to look for on the different elements has been guided by Light et al. (2018), who describe which information is relevant for each element. For the UNBL’s vision I have looked for information on how the partnership behind the UNBL describe the platform. This includes a description of their target audience and key features promoted. For the operating model I have looked for information on how the platform is funded.

The governance is often reflected in the app’s rules and guidelines (Light et al., 2018). Important sources of information for this element have thus been the pages for terms of use, frequently asked questions, and privacy policies. Through these pages I have gathered information on what constraints are put on the users and how they are guided to interact with the app. Furthermore, relevant brochures and official training has been used for gaining a better understanding of the UNBL ecosystem and the stakeholders that contribute to fulfilling the platform's vision.

5.2.1.2. Technical Walkthrough

During the Technical Walkthrough phase the researcher engages with the app's mediator characteristics to gain insight into how users construct or transfer meaning on the app (Light et al., 2018). Through this process the researcher can get a sense of what actions the app requires and guides the user to conduct, and whether these are perceived as enhancing or diminishing the user experience. Engaging with the mediator characteristics involves testing the user *interface arrangement* by tapping buttons and exploring menus, getting an impression of how the app guides its users through activities. Through engaging with *functions and features* one can gain insight on the groups of arrangement that mandate or enable activity by working through screens. Finally, the overall look and feel of the app can give an indication of the ideal scenarios of use. This is referred to as the app's *symbolic representation.*

The technical walkthrough is the walkthrough method's central data-gathering procedure (Light et al., 2018). By adopting an STS-approach of systematically interacting with the mediator characteristics, primary data has been produced through detailed field notes and recordings in the form of screenshots. As the platform is available on the UNBL's website and is closely tied to this, the technical walkthrough also includes an analysis of this webpage, in particular the front page. A key area of interest has been to understand how users are introduced to the UNBL and how easily relevant information can be obtained from the site. Furthermore, it has been important to test the features that were discovered under the environment of expected use phase, to see if these deliver on their intention. A general walkthrough of the platform has also been conducted, by navigating through menus, trying out different data layers and testing the log-in function.

5.2.2. Content Analysis Method

To address the research questions effectively a key element has been to understand what type of knowledge is available on the UNBL. To gain insight on the available data a content analysis has been applied on the whole population of analysis, i.e., on all the datasets available on the platform. Content analysis involves coding and categorising qualitative data which is subsequently analysed quantitatively (Krippendorff, 2013). Here data has been organized into categories according to the characteristics that identify or describe the variable. This has been done through a coding schedule which consists of a small number of general categories that provide the basis for analysing the relationships between the variables. The database developed from the content analysis is available in Appendix 1.

Table 2 (next page) provides an overview of the final categories that were chosen for the coding schema and applied in the content analysis. As can be seen it consists of eight descriptive categories, one numeric category and three analytical categories. Besides the count of number of data layers, it has not been possible to define the categories numerically or to rank the data. This implies that the data collected is categorical suggesting a limited level of precision compared to other data types (Saunders et al., 2015). Included categories have either been selected in advance or have been altered during or after the data collection as investigating the data sources gave more insight into what was considered valuable categories. Some categories were removed after not being included in the quantitative analysis. This included "Technology Used" and "Tags for Description" which both turned out to be too difficult to appropriately group categorical. Hence, the development of categories commenced with a deductive approach, but was altered using an inductive approach as insights emerged.

Category Name	Type	Description	Grouping
Name of Dataset	Identification	Returns the name of the dataset as listed by UNBL.	
Classification	Descriptive	Describes how the UNBL has classified the dataset in relation to the sustainable development goals.	Administrative areas, Agriculture, Boundaries, Climate and Carbon, Ecosystem Services, Human impact, Land Cover and Land Use, Natural Hazards, Nature Based Solutions, Protected and Conserved Areas, Restoration, Society, Sustainable Development, Water
Area	Descriptive	Describes for which part of the world the dataset is applicable for.	Global, Global Oceans, Tropical, Southern Hemisphere
Country of Origin	Descriptive	Returns the country the author comes from or is associated with through its organisation. This category is grouped further by continent in the analytical procedure.	Countries, Global contributors
Type of Provider	Descriptive	Describes the organisation type the author is associated with.	University, Intergovernmental, Governmental, Private, NGO, Research Institute (NGO, Governmental, Intergovernmental, International and Public)
Private Company	Descriptive	Returns the name of the private company that has contributed to the dataset, if applicable.	Name of company
Year	Descriptive	Returns the year the dataset is available for.	Year
Citizen Science	Descriptive/ Boolean	Returns “Yes” or “No” dependent on if the dataset allows for some sort of citizen involvement through the data collection process.	Yes/No
Remote Sensing	Descriptive/ Boolean	Returns “Yes” or “No” dependent on if data is collected through Remote Sensing.	Yes/No
No. Data layers	Numeric	Counts how many data layers that are available for the specific dataset.	Count available layers
Actionability	Analytical	Describes the dataset’s capability to provide information that allows planners to take action on biodiversity targets.	Actionable, Potentially Actionable, Non-actionable
Type of Driver	Analytical	Returns what type of driver the dataset is associated with.	Direct Driver (Land use change, Climate Change, Over Exploitation, Pollution), Indirect Driver, Preventor, None
Frequency	Analytical	Categorizes the dataset into how often frequently the data is likely to be updated.	Change; Likely to be updated; Scenario; Static; Trend

Table 2: Overview of the categories applied in the content analysis.

Descriptive categories

The descriptive categories have been included to gain insight on what the data concerns, who provides the information, which year is the data available for, how the data was collected and for which spatial areas the data are applicable. Hence, they provide metadata on the datasets and contributes to gaining insight on where the data comes from and for which scenarios the data can be applied.

Classification

All datasets listed on the UNBL are tagged with one or more classifications which are related to either planet or people, such as *Climate and Carbon, Biodiversity* and *Human Impact.* These are listed on the ingress of the datasets when you explore the platform. Tagged classifications have been included in the coding schedule to get an impression on which sustainable development areas the dataset is applicable.

Area

Once a data layer is included on the map one can easily see which areas the data layer applies to. Area has been included as a category understand which areas are most represented on the platform. This can provide an indication of whether decision-makers in all parts of the world can have the same benefits of the UNBL.

Country of Origin

To gain an understanding of which countries has been involved in developing the different datasets, Country of Origin has been included as a category. The intent of including this category has been to see if some countries are better represented as providers than others, giving an indication of where the data comes from. Information on this category has been found by going through the different participants listed on the datasets' references. Here I have noted what country all participants are associated with. For some datasets developed by international organizations it has not been possible to find out which individuals have contributed to the dataset and where they come from. In these cases, the dataset has been tagged with "global contributors", indicating that several countries likely are behind.

Type of Provider

To deepen the understanding of where the data comes from, Type of Provider has been included as a category to see what type of organisations deliver the dataset. Data on this category has been gathered by going through the contributors listed in the dataset's references and looking at their affiliated organisations. If no individuals have been listed, the type of organization that has published the dataset has been noted. Data has been grouped as described in Table 2. The subcategory Research Institute has further been divided to indicate what type of research institute is represented.

Private Company

Where it has been applicable the name of the private companies that has contributed to the dataset have been listed. This category was included to gain insight on what type of private actors contribute on delivering data and to see if some actors are dominating. Data on this category has been collected by going through the referenced authors to see if they are associated with private company.

Year

This category returns for what year(s) the dataset is available. It was included to get an impression of how up to date the available data is. If the year has been listed on the UNBL, this year has been noted. If this is not the case, I have looked through the references to see if they write anything about when the data was collected. If this has not been found the year the reference was published is noted. For Change datasets (see the category Frequency) the start and end year of the change period is listed. For datasets with a long data collection period but only one data layer available, the most recent applicable year is listed. For datasets containing data layers for several years, all available years are listed.

Citizen Science

Citizen science is defined as "the practice of public participation and collaboration in scientific research to increase scientific knowledge"(National Geographics, 2023). Legagneux et al. (2018) suggest that letting people contribute to data collection can be an efficient way to engage the public in biodiversity issues as it can both raise public awareness. This category was therefore included to see to what extent the public can engage in the data collection process for the UNBL. Information about this has been found by skimming through the references, looking for some indication of sources that allows for citizen science.

Remote Sensing

This category returns "yes" or "no" dependent on whether remote sensing has been used for data collection. Remote sensing is defined as the "process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance" (USGS, n.d.). This is typically achieved though satellites or aircrafts.

Numeric categories

Number of Data layers

This category counts the number of data layers available for each dataset, i.e., how many unique versions of the dataset exists. Including this category can give an indication of how nuanced the data available on the UNBL is.

Analytical categories

The analytical categories included are included to gain an impression of how relevant the dataset is in the decision-making process on biodiversity questions. Hence, they can give an indication of the datasets potential to contribute towards reaching the goals of the GBF.

Actionability

The actionability of the datasets describes the dataset's capability of providing information that allows planners to act on biodiversity targets. To address this dimension, I have used a taxonomy developed by Ervin et al. (2017) who analyse to what extent actionable spatial data layers are used in national biodiversity strategies and action plans. They categorise the data layers into three subcategories depending on how useful the data layer is to answer key questions associated with the Aichi Biodiversity Targets. These key questions include "Where is natural resource management likely to exceed safe ecological limits and where are the most important areas to implement sustainable management?" and "Where are the most important opportunities for promoting sustainable management of agriculture, forestry, and aquaculture?".

Non-actionable data layers are any maps that are unlikely to be useful neither in isolation nor combined with other data layers (Ervin et al., 2017). Example of such data layers are political maps and national boundaries, which cannot provide valuable insight on the key biodiversity questions. Potentially actionable data layers can be useful to planners, but only if they are used in combination with other data layers to provide new insight. Such data layers include forest cover and existing protected areas. Actionable data layers provide information that allows planners to take action also when the data layer is used in isolation. This is achieved by the data layer providing places that allow decision makers to develop priorities and to take action. Examples of actionable data layers include proposed new protected areas and coastal vulnerability.

To determine what is the most suitable actionability for each dataset I have compared the dataset's description to the taxonomic descriptions and examples displayed in Table 3.

Characteristic of data layers	Taxonomic Description	Examples of maps
Non-actionable data layers	Basic variable feature	Geological history map; location map of country; mountains; national map; physiographic map; precipitation; slope; temperature; topography; volcano;
	Policy and management	Administrative regions; district and regions
Potentially actionable data layers	Ecosystem services	Hazard map; wetland contributions to fisheries; water services
	Socio-economic data	Distribution of indigenous peoples; population density
	Habitat and habitat intactness	Habitat – coral reefs, mangroves, sea grass beds; phytogeography; vegetation map;
	Hydrology, water quality	Hydrological map; watershed map
	Invasive alien species	Invasive alien species distribution map
	Key biodiversity areas	Biodiversity hotspots; endemism, important bird areas, important plant areas, species richness
	Land cover/land cover change	Biogeographic data; forest cover change; land cover; wetland maps
	Land use/land use change	Land use – forest and agriculture; land use change
	Policy and management	Forest management units; conservation units
	Corridors, buffers	Biological corridors, buffer zones
	Protected areas	Protected areas (individual); protected area network; Ramsar sites; World Heritage sites
	Regions, zones	Ecological zones, ecoregion, ecosystem map, forest ecoregions, landscape map, natural zones, ocean ecoregion, terrestrial ecoregion, biosphere reserve
	Resource use intensity	Cattle distribution maps, coffee productivity, potential agricultural productivity
Actionable data layers	Climate change vulnerability	Disaster risk areas; sea-level rise
	Protected areas and biodiversity	Protected areas and key biodiversity areas; protected areas and ecoregions; biodiversity and proposed new protected areas
	Proposed buffer zones	Proposed buffer zones
	Proposed new protected areas	Proposed protected areas
	Future footprint	Mining concessions; timber concessions

Table 3: Taxonomy for analysing the actionability of a data layer. Developed by Ervin et al. (2017).

Type of Driver

Type of driver is included in the coding schema to understand how the data is targeting biodiversity loss. This category was adjusted during the data collection once patterns were discovered in the data. The final categories consist of four main types, and a single dataset can be classified as several categories, making the categories not mutually exclusive. Datasets classified as *Direct Driver* are datasets that mainly contribute towards either monitoring the impact of the direct drivers of biodiversity loss or displays an aspect where the direct driver is largely present. This category is subdivided into the five main drivers of biodiversity loss: climate change, land-use change, over exploitation, pollution, and invasive species. Datasets that are classified as *Indirect Driver* targets human society and our way of living that indirectly contribute towards biodiversity loss, such as the Human Footprint and our need for land-space to develop renewable energy infrastructure. *Preventor* are datasets that do not necessarily display a driver of biodiversity loss, but which can be used to prevent further loss by for example keeping carbon in the ground and preventing climate change, protecting important biodiversity areas, or contributing with nature-based solutions. Finally, datasets categorised as *None* are datasets where none of the above-mentioned categories were suitable.

Type of Driver	Subcategory	Examples of datasets
Direct driver	Climate Change	Coral reef connectivity; Global flood database; MODIS burned area; GLOSIS Global Soil Organic Carbon
	Land Use Change (Covering both water and land)	10m Annual Land Use Cover (9-class); Crop sustainability change; Forest Connectivity; Biodiversity Intactness Index
	Over Exploitation	Biodiversity Intactness Index; IUCN Species Richness; Global Fishing Watch: Annual Fishing Hours
	Pollution	Marine Pollution Index; VIIRS Night time Lights; NatureMap – Realised Clean Water Provision
	Invasive Species	Biodiversity Intactness Index
Indirect Driver		Human Footprint; Human Modification Index; World Atlas of Desertification; Global Wind Atlas: Wind Density; Change in Cumulative Human Impact to Marine Ecosystems
Preventor		Global mangrove watch; WDPA Protected Areas; Marine priority area; GLOSIS Global Soil Organic Carbon; Coral Reef Shoreline Protection
None		Access to Healthcare; Contiguous Zone (24 NM); Terretorial Seas (12 NM); Exclusive Economic Zone (EEZ)

Table 4: Overview of Type of Driver Categorisation.

Frequency

The final category, frequency, provides information on how relevant the dataset is based on the time frames it is available for. Datasets where you can see how the data layer changes between two specific years is categorised as *Change.* Datasets that seem likely to be updated because the dataset is available for many years, or the source data is frequently updated, is categorised as *Likely to be updated*. On the contrary, datasets that stems from what seems to be a finite study is categorised as *Static*. *Trend* datasets are datasets that uses a longer period to determine the trend of the variable but does not display a change between two specific years. Finally, *Scenario* datasets displays scenarios for how the variable will develop in the future.

5.3. Analytical Procedure

The analytical procedure of this thesis has been twofold. An inductive approach has first been applied to turn the fact findings of the content analysis into valuable research findings. A deductive approach has then been used to thematically analyse the results of the walkthrough method and content analysis in the light of the presented Big Earth Data Platform framework and theory on transformative change. Both procedures will be elaborated below.

5.3.1. Content Analysis

Applying an inductive approach in the content analysis has allowed me to generate new knowledge based on empirical observations (Saunders et al., 2015). To provide valuable research findings I have looked for patterns to explain the data collected. This has been done by using a quantitative analysis technique where the business intelligence tool Power BI has been applied to structure and visualise data. There are no references in the following paragraphs as all information comes from personal know-how from my role as a Power BI consultant.

In Power BI the data has first been prepared for analysis by being cleaned and formatted. Transformations applied include indexing each row, and capitalising entries to ensure consistent formatting. Additionally, categories containing multiple entities have been referenced in separate tables, where a split and unpivot function has been used to ensure one entity per row. The created index column has then been used to link the category tables back to the original table through a one-to-many relationship. The final data model is displayed in Figure 5 on the next page.

After the data model was developed, a measure table was created. This measure table consist of simple calculations such as "Number of datasets" and "% Datasets Containing Driver". There are also measures that are described as relative such as "% of Relative Driver". These relative measures reflect the fact that one data source can be tagged with several values. This implies that when "% of Datasets Containing Driver" is used, the total sum for all categories will extend 100%. Relative measures have therefore been created to gain a better understanding of how well one value is represented compared to the other within a category.

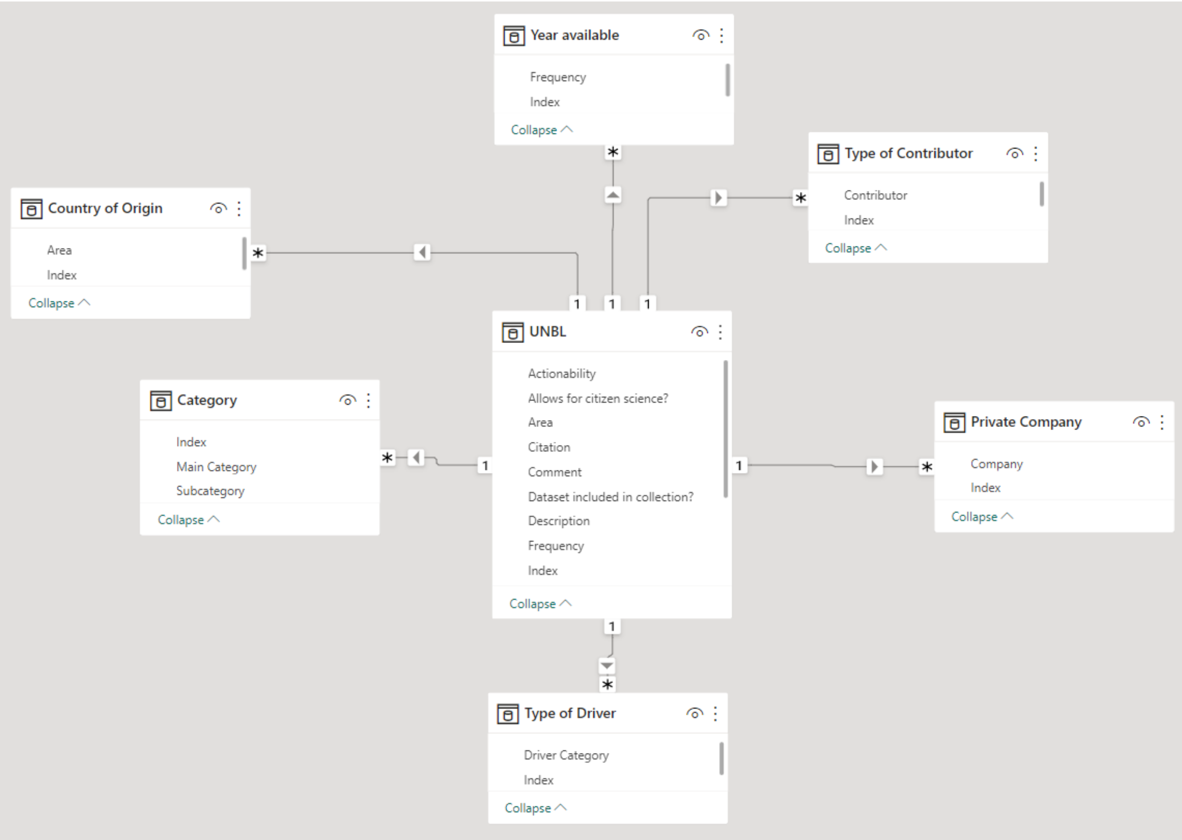

Figure 5: Data model for the Content Analysis developed in Power BI. It consists of one main table (UNBL) which links to different category tables. These category tables contain several records per row in the UNBL table, reflecting a one-to-many relationship between the tables.

Finally, data and findings have been presented in dashboards through graphs, tables, and statistics. The main findings used in the discussion was derived from the literature review and are summarised in section 6.2 of the analysis. All findings are available in Appendix 2. Here, the first page is intended to give an overall overview of the database. The following pages provide more details on the contributors, country participation, and category and driver.

5.3.2. Thematic Analysis

To process and analyse the data collected from the walkthrough method, a thematic analysis has been applied. This is a systematic yet flexible and accessible approach to analysing qualitative data (Braun & Clarke, 2012). It involves the researcher coding the data to identify themes and patterns that appear in relation to the research questions.

This process commenced by summarising the results of the Environment of Expected Use- and Technical Walkthrough phase of the walkthrough method. Subsequently, a deductive approach was employed, where coding categories were developed based on the analytical framework presented in Chapter 4. The walkthrough summary was then coded according to these categories. Once the summary was coded, I created a document to group the information based on the coding categories. The results from the content analysis also fitted nicely into one of these categories and were coded thereafter. The findings of the thematic analysis are presented in Chapter 6. A similar approach was also used to structure the discussion in Chapter 7. Here the findings from the analysis where systemised into categories from the theoretical framework presented in Chapter 2.

5.4. Evaluation of the Research Design and Approach

In the following the quality of the research design and approach will be evaluated, by addressing the thesis reliability and validity. Ethical considerations will also be discussed before limitations of the study are addressed.

5.4.1. Reliability

Reliability represents replication and consistency of the data collection and analysis (Saunders et al., 2015). For quantitative research this addresses to what extent other researchers can replicate the same research design and achieve the same findings. The same is not required in qualitative research as its context dependency can make it difficult to replicate the results at another time (Neuman, 2014). For qualitative research reliability thus focuses on whether the researcher has acted consistent and careful when collecting the data.

One factor that potentially can have lowered the reliability of the project is that the data consists primarily of secondary data. This implies that the data has been created for another purpose, which potentially can have led to me interpreting the data incorrectly (Saunders et al., 2015).

To avoid research bias in relation to secondary data, I have been conscious about which sources I have included in the analysis. I have strived after sticking to sources from relevant distributors, and the data is primarily obtained from the partners behind the UNBL, or from the platform's own web pages. These are sources I have considered both relevant and credible for the topic at hand. Applying the analytical design as described in this section has further provided me frames and guided me to which data to include in the analysis and how to interpret the results. This can have lowered the potential for researcher error and bias when handling the secondary data, by providing a procedure for collecting and managing the data.

A prominent potential research error of the content analysis is inaccurately coding the data. Furthermore, there exists a potential researcher bias in how the analytical categories have been interpreted. Despite me exercising care and concentration to ensure intra-rater reliability, a weakness of the project is that the data has not been coded by another independent researcher. Although multiple coders is the standard practice of a content analysis (Krippendorff, 2013), this was not achieved due to limited time and resources. However, a random subset of 20 datasets was re-coded two months later to test the stability of the design. This includes testing to what extent the coding procedure yields the same results on a repeated trial (Krippendorff, 2013).

The results of this stability test are available in Appendix 3. Here one can see that the test provided both an average dataset- and category accuracy of 91%, where an error is defined as a mismatch between the registered values from the first and second coding session. The percentages are calculated based on how many errors each row or column contains, out of the total registrations in the row (12 registrations) or column (20 registrations). Based on this accuracy level the database does seem to contain some errors. However, no category and only one dataset yielded a result with under 80% match, which is considered the threshold for data one can rely on (Krippendorff, 2013). Thus, the result from the re-coding yields an adequate level of stability to a large extent.

However, the fact that no one else has coded the data implies that one should be careful to draw any statistical conclusion based on the results from the content analysis. This is also reflected in the fact that the data is primarily categorical, implying a limited level of precision compared to other data types (Saunders et al., 2015). I do however argue that despite inaccuracies in the exact counts and percentages presented in the content analysis, the identified trends are substantial enough to support the insights drawn in the discussion.

5.4.2. Validity

Validity refers to the extent the study measures what it intends to measure and reflects the credibility of the research findings (Saunders et al., 2015). It ensures that conclusions drawn from the study are based on reliable and trustworthy data and that the findings can be generalised to the broader population.

Internal validation in a qualitative study assess to what extent the researcher perceives the same content as participants (Saunders et al., 2015). In the context of the UNBL this concerns whether actual users of the platform perceive the platform in the same way as the researcher. The fact that I have no experience with either biodiversity planning- and reporting, nor technical experience with spatial data, can have lowered the internal validation of the study. I have however read through use cases that describes how the platform is used, and this way I have gotten some impressions of user experience (e.g. UNBL, 2023c). Internal validity in this study also concerns whether policymakers will draw the same conclusions of applying the UNBL in the decision-making process as I have. By reading the introduction and conclusion of this thesis, one can see that my findings to a large extent are aligned with the description of Target 21 of the GBF. This seems to strengthen the internal validity of the study.

External validity concerns whether the research findings can be generalised to other relevant settings (Saunders et al., 2015). As only one BED platform has been examined, more research should be conducted before drawing a generalising conclusion on how the technology can contribute towards reaching the ambitions of the GBF. However, as argued in 5.1.3, the UNBL is perhaps one of the BED platforms most suitable to examine the technology's potential in relation to the GBF. This suggests that the UNBL could be a prime example of the potential of this technology, increasing the study's external validation.

5.4.3. Ethical Considerations

Throughout this project I have strived to follow the University of Stavanger's (2018) ethical guidelines for students. I have focused on referencing theory and method correctly in accordance with the APA 7th edition to avoid plagiarism. As all information has been collected through available sources online, no personal information has been collected. Thus, confidentiality considerations regarding personal data have not been relevant.

Over the duration of writing this thesis, language models using AI technology, such as Chat GPT, has become widely accessible. Regarding use of ChatGPT I have followed the guidelines posted by the faculty on Canvas in April (Hognestad, 2023). I have therefore used the language model as a legal aid. The robot has primarily been applied to improve my English and to help me structure some of the arguments in the discussion. Here, no direct quotes have been taken, and in the few cases a presented argument has primarily been suggested from the robot, this is referenced in the text.

5.4.4. Limitations of the Study

One prominent limitation of this study is that it has been conducted solely through available information online. This implies that besides the technical walkthrough, no data has been collected through primary sources. In addition, the technical walkthrough has only been conducted by me, who do not have any experience regarding biodiversity planning or reporting. Thus, the walkthrough-method could have been supplemented with semi-structured interview to gain a more comprehensive understanding of how users perceive and interact with the platform. This was not achieved due to the scope of the project, which has provided limited time and resources.

Additionally, the case study focuses specifically on the UNBL, which implies that findings and conclusions drawn from the analysis are primarily applicable to this platform. Although BED platforms are considered more broadly in parts of the discussion, it is important to note that other platforms should be assessed to explore whether the observed results and implications are consistent across platforms. Conducting a comparative analysis across different platforms could therefore yield a broader understanding of how BED platforms can facilitate transformative change.

6. Empirical Analysis

In this chapter the results from the walkthrough method and content analysis are presented and analysed through the Big Earth Data Platform (BEDP) framework. This includes an evaluation of the platform's objectives and to what extent the UN Biodiversity Lab (UNBL) is embedded in society. Furthermore, the three interconnected digital processes of the BEDP framework are examined in the light of the findings of the UNBL. To what extent the platform supports open and reusable data is also assessed along with security and ethical consideration. These last four aspects are evaluated by examining some of the requirements for a program to be defined as a digital public good, which the UNBL is listed as. The chapter concludes by summarising the UNBL in relation to the BEDP framework and evaluating how suitable the design of the UNBL is to support sustainability.

6.1. The Platform's Objectives and Embedment in Society

The UNBL's core vision is to support national stakeholders to deliver on the Post-2020 Global Biodiversity Framework (GBF) and the 2030 Agenda for Sustainable Development (UNBL, 2022b). The vision is refined by the UNBL three-folded mission which is to 1) democratise access to spatial data and analytic tools as a public good, 2) support decision-makers to leverage spatial data for insight, priority-setting, and implementation and 3) empower stakeholders to use spatial data for monitoring and reporting. These mission-statements establish a set of clear objectives of how to reach the UNBL's vision. In combination, the vision and mission-statements can thus ensure productive outcomes of the platform by establishing a common understanding of the problem at hand, as in accordance with the BEDP framework (Guo et al., 2020).

Furthermore, the UNBL is consistent with the BEDP framework as policymakers are the target audience of the platform (Guo et al., 2020; UNBL, 2022b). The UNBL aims at empowering national stakeholders to work with the best combination of data and analytics on sustainability issues (UNDP, 2022). The platform's relevance for the GBF and policymakers can further be understood by the fact that the platform is listed as a suggested data source for the Data Reporting Tool for MEAs (DaRT) (UNEP et al., 2020). This is a modular reporting tool the Parties of the Convention on Biological Diversity are encouraged to use on a voluntary basis to report on progress towards the goals of the GBF (CBD, 2022b). Hence, the inclusion of

UNBL in DaRT underpins the argument that making knowledge accessible for supporting the decision-making and policy-formulation process is the core objective of the platform.

However, as the platform is free of charge and open to everyone, it is not only policymakers who can take advantage of the information available on the UNBL. All non-commercial users with an interest in data related to sustainable development and biodiversity targets are welcomed to use the platform (UNBL, 2022b). Consequently, the platform can also support the work of academics, Indigenous people, NGOs, research organizations and UN agencies (UNDP, 2022).

6.1.1. Operating Model

By examining the UNBL's operating model one can gain an understanding of how the platform is embedded in society. In line with the BEDP framework, the UNBL promotes a collaborative model, where different teams focus on different aspects of the platform (Guo et al., 2020; UNDP, 2022). The platform engages a large group of organisations, and the complete UNBL ecosystem is provided in Figure 6 on the next page. From this illustration it is apparent that the UNBL follows an ecosystem approach to make knowledge on biodiversity issues accessible to its target audience, as in accordance with the BEDP framework (Guo et al., 2020).

The platform is established through a partnership between the United Nations Development Program (UNDP), the UN Environment Program (UNEP) along its specialist biodiversity centre World Conservation Monitoring Centre (UNEP WCMC) and Secretariat of the Convention on Biological Diversity (CBD) (UNBL, 2022b). The Global Environment Facility (GEF) is listed as both a partner and a funder. This is an organisation that provides funds dedicated to sustainability issues, such as climate change and biodiversity loss (GEF, 2023). This partnership leads the platform's vision and overall management, ensuring a platform firmly anchored within the UN system (UNDP, 2022). Together they have an allegedly unique ability to unite expertise in the management of environmental data, leverage on-the-ground connections to policy makers worldwide and support the CBD Secretariat's mission to support nations on their biodiversity goals (UNDP, 2022). Thus, the UNBL demonstrates a breadth of expertise to meet users' needs and represent various Bodies of Knowledge (Guo et al., 2020).

Figure 6: The UNBL's operating model. The project is established through a partnership between the intergovernmental organisations UNDP, UNEP, GEF, UNEP WCMC and CBD. They rely on project funding from donors and assistance from technical partners to ensure the success of the platform (UNBL, 2023b).

Other actors of society are represented through third-party data providers and technical partners that provide cutting-edge tools and data to take action for nature and sustainable development (UNBL, 2021b). More than 40 data providers ensures that the UNBL shares the most up-to-date version of high-quality global data on nature, climate, and human well-being (UNBL, 2022b; UNDP, 2022). The Impact Observatory team reinforces the backend of the platform, whilst the UN International Computing Centre (UNCC) provides a secure UN hosting. Microsoft contributes with their cloud computing platform and service, Azure, as well as collaboration on technical innovation through their Planetary computer. Finally, NASA applies platform functionalities as a decision support system through their applied sciences division. Here, the official UNBL Applied Remote Sensing Training Program is offered (NASA Applied Sciences, 2022a, 2022b).

Through the above-mentioned services, it is evident that the UNBL is reliant on the engagement of technical stakeholders to ensure its success. Furthermore, it relies on receiving resource support in form of donations for being able to operate. So far, the success of the platform, together with its increasing institutionalisation within the UNDP and UNEP, has enabled the UNBL to continue to fund itself through project-based funding (UNDP, 2022).

6.1.2. Summary of the Platform's Objectives and Embedment in Society

The presented findings show that the UNBL to a large extent is embedded in society, as in accordance with the BEDP framework (Guo et al., 2020). Different Bodies of Knowledge are represented through the platform's partnership, technical partners, and funders. Through their various roles these provide different perspectives and opinions which can be essential for ensuring a viable and sustainable platform. Furthermore, the platform's vision and mission statement provide clear objectives and a common understanding of the problem at hand. This can contribute towards ensuring productive outcomes of the platform (Guo et al., 2020).

6.2. Big Data Streams and Deep Insights

As in comparison to the BEDP framework, the two first digital processes, i.e., big data streams and deep insights, are to a large extent completed prior to the data entering the UNBL. This is because the data available on the platform is provided by third parties, who has collected data through various methods such as on-ground observations, remote sensing, statistics, and surveys (e.g., Gilbert et al., 2018; Soesbergen et al., 2020; Spawn et al., 2020; Williams et al., 2020). Through these methods, data is collected from national and global science teams, as well as Indigenous Peoples and local communities (UNBL, 2021b). Data is also analysed by these third parties through for example machine learning techniques. This process implies that the UNBL only works as a hub that makes datasets for biodiversity, climate change and sustainable development available in one place. However, metadata on user interaction will still be important information for further development of the platform (Guo et al., 2020). This is data that needs to be collected and analysed by the UNBL providers themselves.

The results from the content analysis provides insights into what information is available on the platform. The main findings are presented in Figure 7 on the next page, while all findings are available in Appendix 2. These findings will be further discussed in Chapter 7.

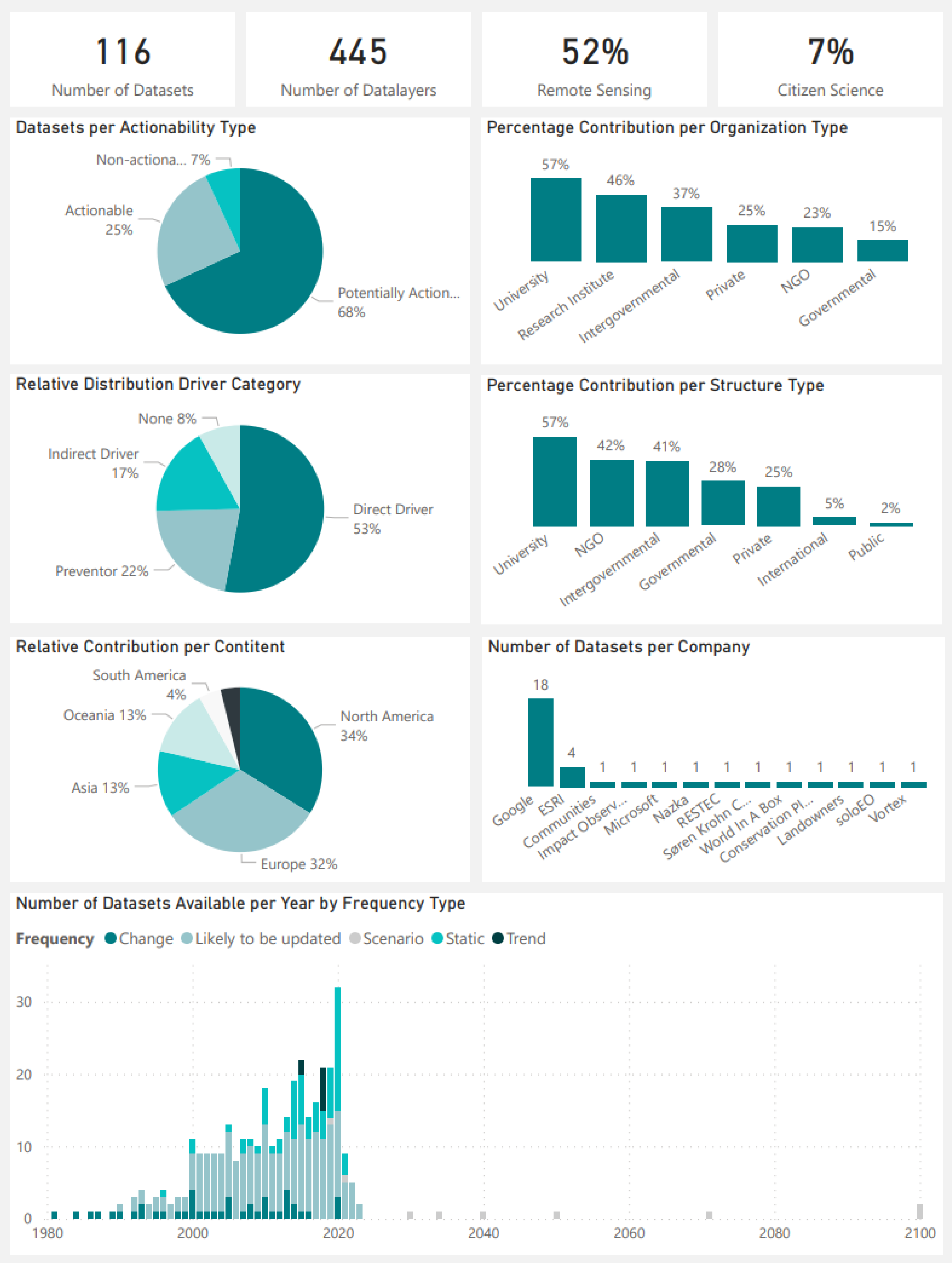

Figure 7: Main findings from the Content Analysis on the UNBL

From these main findings one can see that there exists 445 unique data layers on the platform, i.e., unique views of the 116 available datasets. Over half of the data is collected through remote sensing methods, while citizen science has only been applied at 7% of the datasets. There is an increasing trend in number of datasets available from 2000-2020, where 2020 is the year containing most datasets. Several of the datasets seem likely to be updated in the following years based on their source data. Over 90% of the datasets are classified as either actionable or potentially actionable. Furthermore, datasets tagged as targeting the direct drivers clearly makes up the largest type of driver group.

There are contributors from all continents, however North America and Europe are clearly the continents highest represented, while Africa is the lowest. Regarding organisational contribution, universities and research institutions are the most represented. When grouped by structure type, universities, NGOs and Intergovernmental organisations makes up the largest groups. Only 25% of the datasets have contributors from private companies. Google is clearly the private company that has contributed the most.

6.3. Actionable Intelligence

Through its available features, the UNBL attempts to translate the deep insights provided by third parties into actionable intelligence, by interpreting the results in the context of real-world problems (Guo et al., 2020). One of the platform's main strengths is that it is possible to select multiple data layers at once, which is something Dinkelberg (2022) found to be important for enabling database interfaces to influence conservation policies. This feature will be presented and evaluated below. Then follows an analysis of how and to what extent the UNBL offers personalised services to all its users.

6.3.1. Multiple Layers

On the UNBL users can effortlessly add several data layers to an empty canvas map by tuning on an intuitive toggle next to the data layer in the menu. Users can freely choose the order the selected data layers appear on the map and can also change the opacity of each layer. This makes it possible to optimize how the data is displayed, finding the combination that provides the greatest insight of the combined data layers. However, if too many data layers are loaded at once, it becomes difficult to distinguish between them.

Figure 8 illustrates an example of how different layers can be combined to gain new insights. This figure displays the cattle distribution in 2010 (background nuances) and the forest loss from 2000-2020 (dots on the map) in parts of South America (Gilbert et al., 2018; Hansen et al., 2013). By combining these layers one can see a correlation between the areas of forest loss and cattle distribution. This can indicate that a large part of Amazon deforestation is due to cattle ranching. Through a quick Google search this claim is found to be true, and extensive cattle ranching accounts for 80% of current deforestation in Amazon (Nepstad et al. 2008, referenced in WWF, 2020).

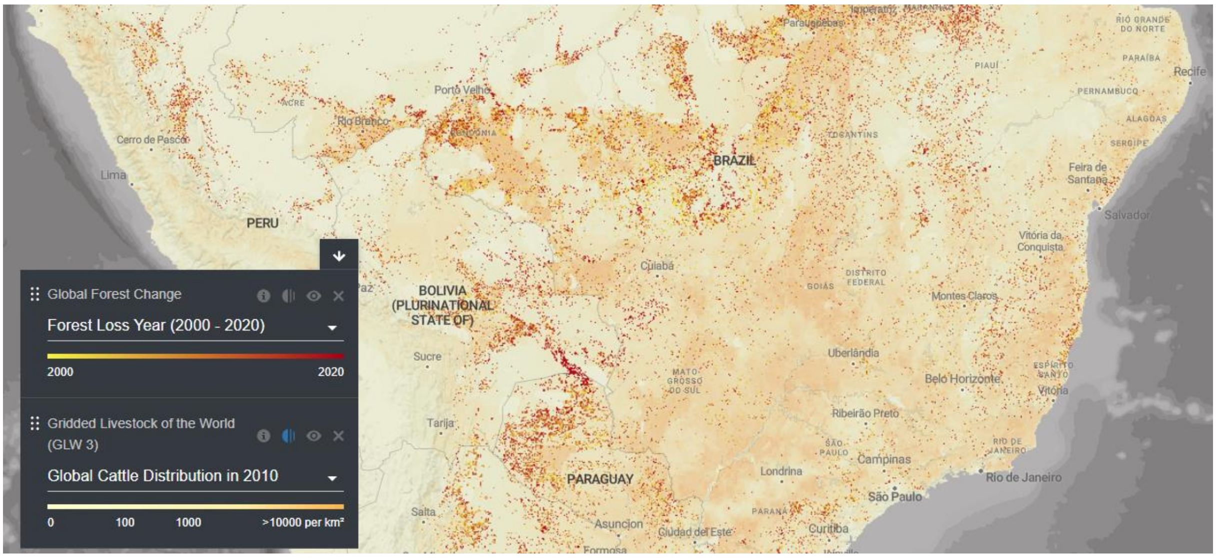

Figure 8: Forest Loss Year (2000-2020) (Hansen et al., 2013) and Global Cattle Distribution in 2010 (Gilbert et al., 2018). 1:300 000, Generated by Astrid Nygaard. Map Generated by UNBL https://map.unbiodiversitylab.org/earth?basemap=grayscale&coordinates=-5.7624414,-68.9857519,4&layers=global-forest-cover_100,gridded-livestock-of-the-world-glw-3_100 . (05 May 2023).

As the platform consists of over 400 unique data layers, it can however be overwhelming for users to know which layers to include for gaining relevant insight on a specific topic at hand. In addition, several of the datasets seems to provide to some extent the same information, as there for example exists several datasets that maps the land use of the world. To make it easier to navigate, data layers can be filtered by classification categories such as "Biodiversity" and "Climate and Carbon". The users can also search after key words, as for example "Forest" and find all data sets that contains this search word in the title. Furthermore, an information box can be opened from the dataset's legend once this is added to the map. Here the users can find a description of the dataset or learn more about it through a link to its original source. In combination these features can help the users familiarise themselves with the available data, which increases the likelihood of turning deep insights into actionable intelligence.

6.3.1.1 Pre-defined Collections

The likelihood of the user being able to turn deep insights into actionable intelligence is further increased through the pre-defined collections that are available on the UNBLs website. Here, multiple data layers are grouped into pre-defined data collections, which are tailored to generate insight for action on critical issues for nature and sustainable development (UNBL, 2023g). Per now there exists two collections. The collection "Nature-based Solutions for Climate Change" provides data layers for actions to protect, manage and restore ecosystems that provide benefits to human well-being and biodiversity simultaneously. The collection "Protected Areas" provide data layers for safeguarding biodiversity and ecosystem services. There are also two data collections forthcoming that will provide multiple data layers for actions related to the GBF and Restoration (DeSantis, 2022).

Each collection has a designated page on the website, where the user can first learn more about the collection and its use before exploring the feature. Figure 9 displays parts of the collection for "Nature-based Solutions for Climate Change". As can be seen it consist of policy-relevant questions consisting of either single and multiple data layers (UNBL, 2023e). In the example below, one can see that combining the layers "Global Tree Cover 2000", "NatureMap Live Biomass Density" and "NatureMap Vulnerable Soil Carbon Density" can provide users information on where sustainable management of forest can conserve carbon stocks.

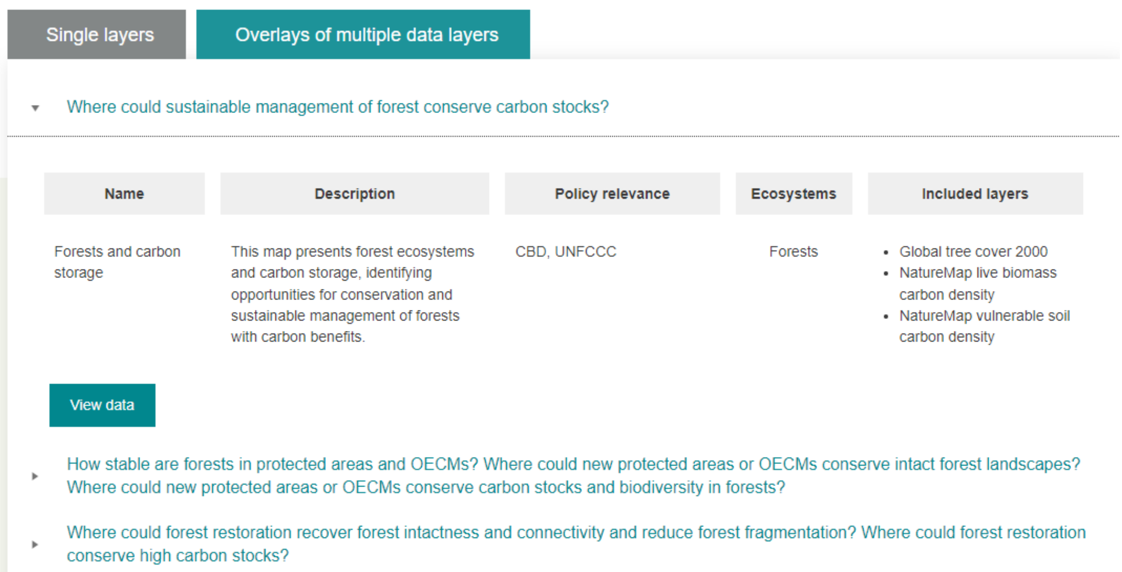

Figure 9: Screenshot from parts of the collection Nature-based Solutions for Climate Change (UNBL, 2023e). Here, several questions that can provide actionable insights on the topic at hand are listed.

For policymakers the collection feature can support a quicker decision-making process, as which layers to include for analysis are already defined based on the pre-defined question. The collections also simplify the decision-making process by lowering the domain knowledge required by end user to select the best data layers for analysis. This is because it can be assumed that the developers of the collections have the required domain knowledge themselves. Furthermore, the collections can guide the users to which questions should be asked for providing actionable insights on a particular issue. This can make it easier for policymakers to reach descisions that actually do have an impact for the topic at hand. What is more, this can help the partners of the UNBL esure consistent reporting among the Parties of CBD on critical issures for nature. For example, this can make it easier for governing bodies to compare how different countries are progressing in relation to the targets decided upon in the GBF. Especially the GBF collection which is under development seems relevant for this matter.

There are however aspects of the collection feature that indicate that it was recently launched as still is under development. For example, the collections are not available on the UNBL platform and can only be explored through the UNBL website, illustrated in Figure 10. This figure shows that when the user press “view data” on a specific question, the UNBL platform opens up in a pop-up window. This user-interface is not the most convenient as the user now has to interact with the platform through a much smaller screen than if the platform was launched directly. However, it seems like this feature will be included on the platform in a future release. This is indicated in Figure 10 where the filter menu for places holds a filter for collections which is currently empty.

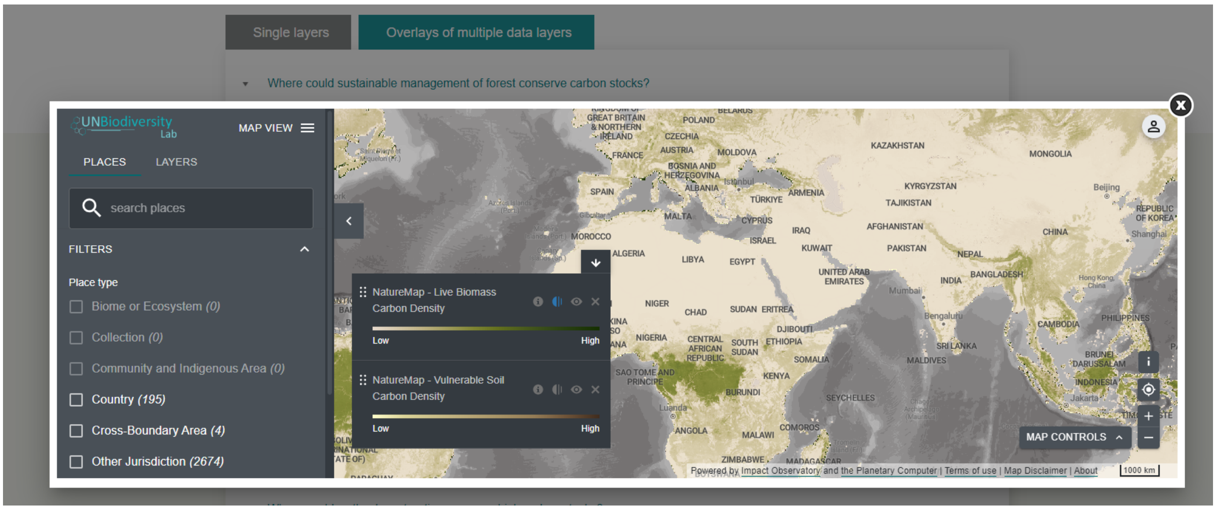

Figure 10: Illustration of how the UNBL opens when the user clicks on “view data” for the question “Where could sustainable management of forest conserve carbon stocks” on the Nature-based Solutions for Climate Change collection (UNBL, 2023e).

Furthermore, there seems to be a mismatch between the described layers that should be included on a particular question and the actual layers that are included. This can be seen by comparing Figure 9 and 10. In Figure 9, three data layers are listed as included in the collection for the specific question. However, in Figure 10 only two data layers are included, and the listed data layer for “Global tree cover 2000” is lacking. Without this data layer it is hard for this collection to provide actionable insights on the relationship between sustainable management of forests and carbon stocks.

This mismatch seems to be a recurring issue on several questions for the available collections. In addition, there are described data layers that are not available on the platform. Such an example is the data layer “World Database on Other Effective Area-Based Conservation Measures”. This is an important data layer for the Protected Areas data collection as it is included in several questions, also as a single data layer. This data layer is however not present on the UNBL, and opening the collection with this single data layer returns an empty canvas map.

In combination these limitations lower the potential the collection feature to provide actionable insights on critical issues for nature and sustainable development. Having to navigate away from the platform to explore the feature from the pop-up window can make the threshold higher for using the feature. Also, the mismatch of described and included data layers, in combination with missing data layers, can create frustration among the platform’s users. This can in turn lower the credibility of the information that can be obtained from UNBL which potentially can lead to users concluding with not using the platform for reporting- and acting on biodiversity issues. Hence, this feature needs to be improved further to unlock its potential to support a quick, simple, and consistent decisions that has a positive impact on nature.

6.3.2. Personalised Services

As described in the analytical framework, providing personalised services is a way to achieve actionable intelligence (Guo et al., 2020). The findings of the UNBL show that there are several ways the platform offers personalised services to its end users. This includes the ability to filter the UNBL by places, private workspaces and country-specific “Maps of Hope”. These features will be analysed in the following.

6.3.2.1. Places and Metrics

From the menu of Figure 10, one can see that the UNBL can be explored either by including desired data layers or by choosing a specific place for analysis. If the users choose to explore Places, either a cross boundary area, country or region can be chosen as the unit of analysis. Once a place is chosen, this area will be outlined on the map as displayed in Figure 11. As an example, for Norway it is possible to select the whole country but also the counties such as "Rogaland". This feature makes it possible for policymakers at both local and national level to choose their area of interest, which can be seen as a way of personalising the platform.

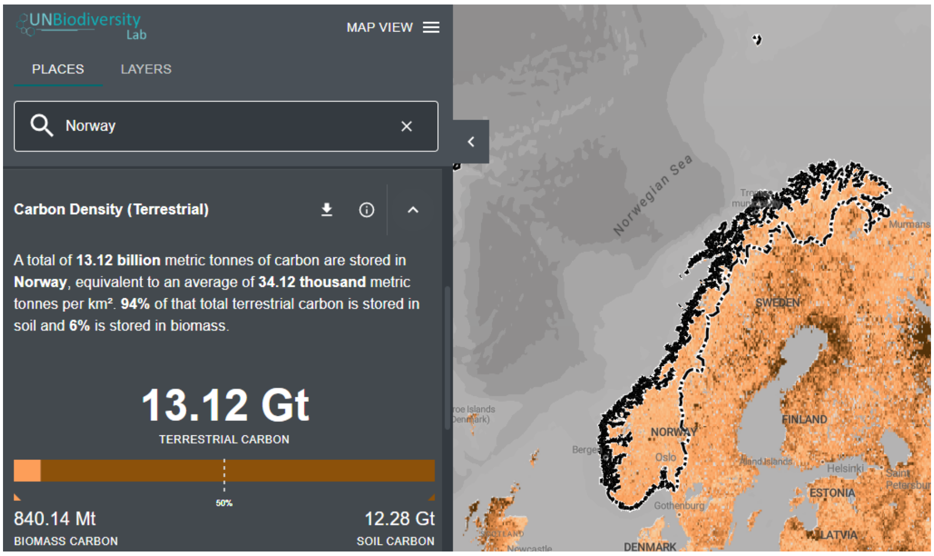

Figure 11: Example of how the Places menu and canvas map looks once a specific place is selected. Soil + Biomass Carbon (UNEP-WCMC), Generated by Astrid Nygaard. Map Generated by UNBL. https://map.unbiodiversitylab.org/location/UNBL/norway?basemap=grayscale&coordinates=60.3675013,29.2736944,3&layers=wcmc-terrestrial-carbon-2010-01_100

Once an area is selected, the places menu will expand and display eight standard dynamic metrics in the form of column-, line-, doughnut charts, gauge visualisations and score cards. The current available metrics are the biodiversity intactness index, carbon density (displayed in Figure 11), enhanced vegetation index, global land cover, monthly fire activity, protected areas, terrestrioal human footprint and tree cover loss. By clicking "show on map" the underlying data layers will appear on the canvas. Measures can also be downloaded in either CSV or JSON format, which makes it possible for the users to extract the information and use it as desired outside of the platform. The inclusion of dynamic metrics can contribute to the users gaining key insights on their chosen area. Furthermore, through the visualisations, the metrics can support quick decision-making by increasing the users understanding of the data (Guo et al., 2020).

There is however evidence that this feature is not 100% accurate for all Places. This is illustrated in Figure 12, where the "Biodiversity Intactness Index" and "Monthly Fire Acitivity" are displayed for Norway and Costa Rica. Norway is chosen as example due to this being my university's home country. Costra Rica is chosen for comparison because of the their leading role in sustainable development (UNEP, 2019).

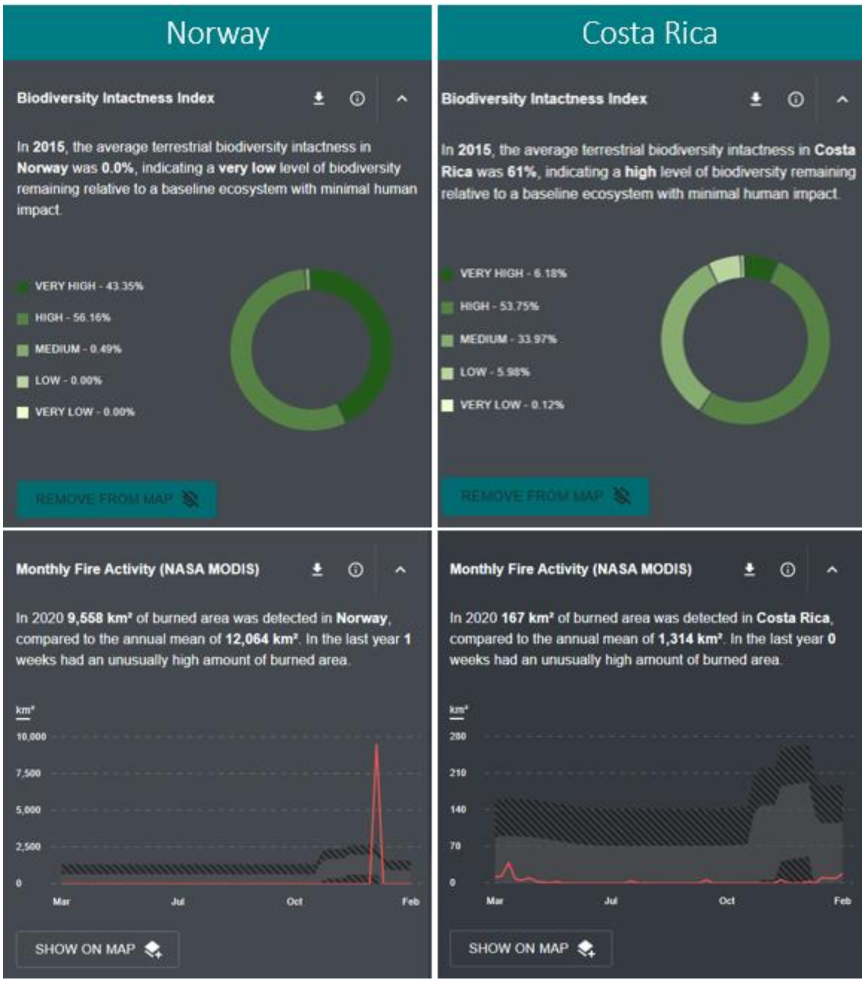

Figure 12: Comparison of the metrics "Biodiversity Intactness Index" and "Monthly Fire Activity" for Norway and Costa Rica (UNBL, 2023a).

In the two metrics displayed in Figure 12 one can easily see that policymakers in Costa Rica can get more information out of the visualisations than policymakers in Norway. In the "Biodiversity Intactness Index" metric there evidently is an error for Norway. This metric is described as 0%, indicating a very low level of biodiverisy remaining relatively to a baseline ecosystem with minimal human impact. This cannot be accurate, and by investigating the legend of the doughnut chart one can see that 97% of ecosystems in Norway are either characterised as having a very high or high biodiversity intactness. These numbers are higher than the same numbers for Costa Rica, however Costa Rica gets a total score of 61%, indicating a higher biodiversity intactness than Norway when it is actually lower. Furthermore, the metric for “Monthly Fire Activity” registers all fires in Norway in 2020 on the 31. December 2020. The registered burned area of 9,558 km^2 in 2020 might be accurate, but there is no way they all occurred on New Years Eve in the middle of winter. This measure also seems more accurate for Costa Rica, where fires are spread throughout the year. However, also for Costa Rica this visualisation could have been improved by altering the interval of the Y-axis.

The presented insights shows that the Places feature offers more personalised services to some stakeholders over others. Hence, this feature should be improved for providing actionable, trustworthy intelligence for stakeholders all over the world. Furthermore, it can be seen as a limitation that there only exists eight standardised metrics. However, custom metrics are under development (UNBL, 2023c). Once custom metrics are included the Places feature can contribute to more personalised services by managing specific intelligence requested within various business domains (Guo et al., 2020). This can again improve the ability for this feature to support quick decision-making.

6.3.2.2. Private Workspaces

By offering private workspaces to all non-commercial users, the services of the UNBL are further personalised. This feature recognises that national governments or local stakeholders might have better local data than what is available on the global level (Zhang, 2022). Through the private workspaces users can either detect an area of interest, resembling the Places feature, or they can upload a new data layer to support their analysis. Local data can be combined with the global available data as the user pleases. This can allow for a more comprehensive and nuanced understanding of the issue at hand, which in turn can lead to more targeted and effective solutions. The workspace can also be shared with different users, which can be granted the role as an owner, admin, editor, or viewer (UNBL, 2021a). The private workspace therefore works as a collaborative environment, where different users within an organisation or government can work together to analyse and make decisions based on their shared data.

It does however require some technical skills of geographic information system (GIS) to manage the private workspaces. For example, Place-shapes can only be uploaded in a GeoJSON format, which is an open geospatial interchange format that represents simple geographic features and their nonspatial attributes (OpenAI, 2023). This must be generated in advance through a GIS-tool. Furthermore, to upload a new layer one must configure the data layer settings (also in a GeoJSON format), as highlighted in Figure 13. The workspace guide provides good support for how to do this, however it might be challenging and time-consuming for a user without GIS competence to do this.


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     "sldValue": "<RasterSymbolizer> <ColorMap type=\"type\" extended=\"false\"> <ColorMapEntry
color=\"#hex1\" quantity=\"quantity1\" opacity=\"opacityvalue1\"/> + <ColorMapEntry color=\"#hex2\"
quantity=\"quantity2\" /> + </ColorMap> </RasterSymbolizer>",
        "styleType": "sld",
        "tiles": [
       "https://sls-neur-prod-unbl-services.azurewebsites.net/api/tiles/insertidentiferhere/{z}/{x}/{y}"
       ]
  },
  "legendConfig": {
    "items": [
       {
          "value": "quantity1",
          "color": "#hex1"
       },
       {
          "value": "quantity2",
          "color": "#hex2"
       }
    ],
    "type": "type"
  },
  "interactionConfig": {
    "type": "intersection",
    "config": {},
    "output": [
      {}
    ]
  },
  "applicationConfig": {},
  "staticImageConfig": {}
}
```


Figure 13: Example of data layer settings that must be configured to upload a new layer on the UNBL (UNBL, 2021a)

The various roles users can be assigned offer a solution to how one can ensure that those who upload and alter data have GIS competence. The different roles put constraints on what specific users are allowed to do in the workspace. Owners have all privileges and can change the workspace name, assign roles, upload and delete workspace data (UNBL, 2021a). Admins have almost the same rights as owners but cannot change workspace name or assign admin roles. Editors can upload and delete workspace data, while viewers can only view the available data. People in the organisation with GIS competence can thus be granted roles with more privileges than users without these skills. If policy- and decision-makers lack this technical competence, granting them the viewer-role can ensure that they only access data that is already made available for analysis. However, if there are no people in the organisation with GIS competence, the private workspace feature might be time consuming and difficult to use.

6.3.2.3. Country-Specific Maps of Hope

A final way in which the UNBL offers personalised services is through their country-specific "Maps of Hope". This feature builds on the private workspaces and identifies Essential Life

Support Areas (ELSA) through national and global datasets (UNBL, 2022a). These are areas where nature-based actions can sustain critical benefits to humanity, including sustainable livelihoods, food and water security, carbon sequestration and disaster risk reduction. Per now this function is available for 12 countries: Cambodia, Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador, Haiti, Kazakhstan, Nepal, Peru, South Africa and Uganda. These are referred to as "pilot countries" and it can therefore be assumed that this feature will be developed for more countries forthcoming. However, per now this feature shows another example of how the UNBL offers better personalised services to some stakeholders over others.

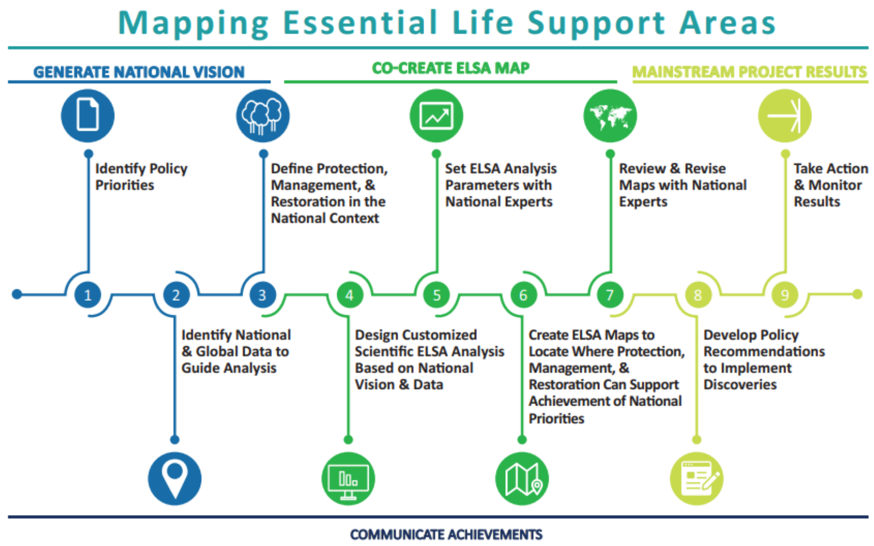

Figure 14: Illustration of the process of mapping the essential life support areas of a country, i.e., the process of creating the country's Map of Hope (UNBL, 2022a).

The process for creating the "Map of Hope" is illustrated in Figure 14 (UNBL, 2022a). It begins with national stakeholders agreeing on the country's top ten policy commitments related to nature, climate, and sustainable development. Next, national spatial datasets that represent these commitments are identified and collected. Based on these inputs, global scientists use systematic conservation planning approaches to develop a customized analysis. This leads the first version of the country's ELSA map which national stakeholders then modify and validate. Global scientists also provide the countries with an online tool to support additional refinements of the map and results. Finally, stakeholders are supported to identify opportunities and embed the results of the analysis into national policies for nature, climate, and sustainable development. In this way, governments can use the map to align nature and development policies and prioritize areas for protection, management, and restoration.

6.3.3. Summary Actionable Intelligence

The previous analysis show that the UNBL offers various features that can help users interpret the available data layers in the context of real-world problems. Through the ability to analyse several data layers at once, new insights can be obtained. Navigation of the 445 of data layers can further be simplified by using pre-defined collections and through categorisation of the data layers. This functionality enhances the potential of gaining new insights through the multiple data layer analysis. As in accordance with the BEDP framework, the platform also offers several personalised features such as exploring the platform through places and metrics, private workspaces and "Maps of Hope". Thus, in combination these features support the process of turning deep insights into actionable intelligence, which is essential for the platform being able to support sustainability (Guo et al., 2020).

There are however several aspects of the UNBL that reveals that the platform was launched in 2022 and is a work in progress. For example, the collection feature is inconsistent in which data layers are listed as included and which data layers are actually included. Also, the standard metrics are not accurate for all places. It is also evident that some technical competence is beneficial to take full advantage of some of the features of the platform, such as the private workspaces. In combination these limitations can increase the threshold for the platform being included in the decision-making process on biodiversity matters.

6.4. UNBL as a Digital Public Good

The Digital Public Good Alliance has listed UNBL as a digital public good (Digital Public Goods Alliance, 2023b). This implies that that the platform follows the alliance's nine requirements for being defined as a digital public good (Digital Public Goods Alliance, 2023a). Through assessing some of these key requirements, one can gain an understanding of how the UNBL supports open and reusable data, as well as ensures privacy and inclusiveness. These aspects of the UNBL are analysed in the following.

6.4.1. Key Requirements of a Digital Public Good

First of all, the UNBL must be relevant to the sustainable development goals in order to be listed as a digital public good (Digital Public Goods Alliance, 2023a). As previously described, the core vision of the platform is to support national stakeholders to deliver on the GBF and the 2030 Agenda for Sustainable Development. Thus, the platform is clearly relevant to the sustainable development goals.

Furthermore, the platform has to fulfil the alliance's requirement of using approved open licenses (Digital Public Goods Alliance, 2023a). This includes the use open-source software and open data, which both are features the UNBL promotes itself of having (UNBL, 2022b). Through providing accessible data, the open licenses speak in favour of the UNBL following the FAIR-principles. The use of a SpatioTemporal Asset Catalogue (STAC) further supports this claim. This is a common structure for describing and cataloguing spatiotemporal assets, which increases the discoverability of geospatial data, provides broader access and more efficient data analysis and workflows (STAC, 2023; UNDP, 2022). Thus the UNBL STAC provides and open and centralised place to discover, access and manage the available data layers.

A third way the UNBL complies with the digital public good requirements is through adherence to standards and best practices (Digital Public Goods Alliance, 2023a). This is exemplified through the process for accepting datasets to the platform. Everyone is open to suggest new datasets that should be included on the UNBL (UNBL, 2023c). However, to ensure proper data quality the partnership has adopted the "UNEP WCMC's 9 criteria for a digital ecosystem" to assist in identifying the best available data layers fit for the UNBL's mission (UNBL, 2023c; UNEP WCMC, 2021). These selection criteria groups data into three tiers based on aspects such as data relevance, open-licensing, availability, transparency, peer-reviewing process and geographic cover. Datasets that meet all the criteria are classified as "Tier 1" and only these are considered good enough to be included as a public good on the UNBL.

Finally, the UNBL has to fulfil the requirement of adherence to privacy and applicable laws for being listed as a digital public good (Digital Public Goods Alliance, 2023a). In the UNBL's privacy policy the platform is referencing both US and EU privacy law and information security (UNBL, 2023f). The UNBL can be explored without logging in, but creating an account will give greater access to data and analysis features such as clipping and downloading data from an area of interest (UNBL, 2023c). By signing up, users agree to share personal data related to the interaction with the platform (UNBL, 2023f). This includes information about views, e.g., metadata, source, and licensing information that is created on the geospatial platform. Personal information is contained behind secured networks and is only accessible to a limited number of people with special access rights. It is further encrypted via Secure Socket

Layer technology. The platform also uses regular malware scanning to detect any malicious software that can do harm to the system.

6.4.2. Ensuring Inclusiveness

From the first mission statement presented in 5.1. it is apparent that an ambition of the UNBL is to democratise access to spatial data and analytic tools. As the platform is open to everyone and is listed as a digital public good, it seems like the partners of the UNBL is accomplishing this ambition. As stated in the BEDP framework, this can foster equality between high- and low-income countries as they can access the same intelligence on the platform (Giovannini et al., 2014; UN Secretary General, 2020). In fact, it can seem like the UNBL has a particular focus on providing actionable intelligence to countries at the less fortunate side of the digital divide. This can be interpreted by the fact that the pilot countries for the "Maps of Hope" feature are all listed as developing countries by WorldData (2023). Hence, using global resources to create customised maps for these countries can contribute towards developing a better tool for prioritising nature, than what the countries could have accomplish on their own.

Inclusiveness is also ensured by the fact that the UNBL website is available in English, Spanish, French, Portuguese and Russian. Additionally, the official training is available in English, Spanish and French. This prevents the UNBL for only being accessible for English speaking users.

6.4.3. Summary of the UNBL as a Digital Public Good

Based on this analysis it can be suggested that a BED platform should strive to be listed as a digital public good to truly support sustainable development. Being listed as such implies that the platform follows key requirements in the BEDP framework, including promoting open access to data, ensuring reusability, and complying to privacy regulations. This can in turn ensure the development of an inclusive platform which is open for all groups in society. Thus, the fact that the UNBL is listed as a digital public good seems to be a good indication of the platform's commitment to supporting sustainability and inclusivity.

6.5. Summary of the Empirical Analysis

In this chapter the findings of the UNBL have been analysed in the light of the presented analytical framework of Chapter 4. Figure 15 on the next page provides an illustration of how the platform can be integrated in the Big Earth Data Platform (BEDP) framework. This illustration is summarised below. Based on this summary a conclusion for Research Question 1 will be drawn.

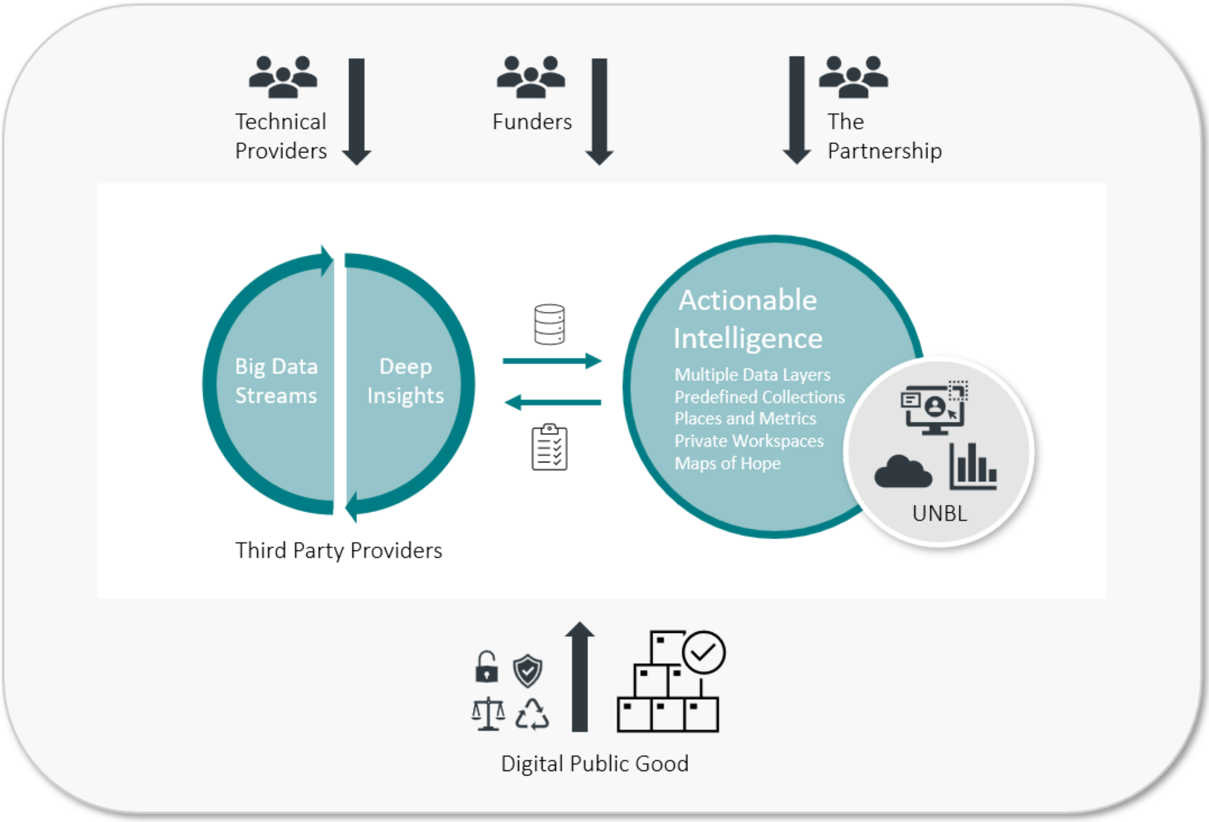

Figure 15: Integrating the UN Biodiversity Lab in the Big Earth Data Platform Framework

There are several stakeholders who contribute to the development of UNBL. The partnership consists of important intergovernmental organisations, who are concerned with sustainability issues. These provide a breadth of expertise to meet users' needs and represent various Bodies of Knowledge in society, such as politicians, NGOs, and indigenous people. Furthermore, the technical providers represent another Body of Knowledge that offer perspectives and opinions of the technical aspects of the platform. In addition, the UNBL relies on donations for being able to operate. This implies that the values and concerns of funders also must be considered. Thus, several Bodies of Knowledge are represented on the platform, and the UNBL is therefore largely embedded in society (Guo et al., 2020). The UNBL's core vision and mission statements further give the platform clear objectives and a common understanding of the problem at hand. This can contribute towards the platform producing productive outcomes.

As in comparison with the presented BEDP framework, the three interconnected digital processes are separated into two groups in the UNBL ecosystem (Guo et al., 2020). The Big

Data Streams- and Deep Insights process are mainly done by third party providers who allow the UNBL to upload their data. However, the data and analytical procedures must comply with the "UNEP WCMC's 9 criteria for a digital ecosystem" to be accepted on the platform (UNEP WCMC, 2021). This way the partnership can ensure proper data quality on the platform. This interaction is illustrated in Figure 15 with the arrows between the third-party providers and the platform.

Actionable intelligence is provided to the users of the UNBL through various features available. One important feature is the ability to analyse several data layers at once, which can lead to new insights. This feature is further improved through categorising the data layers and by offering pre-defined collections. This helps the users navigate to which data layers to include for analysis. The platform also offers several personalised features such as exploring the platform through places and metrics, private workspaces and country-specific "Maps of Hope".

Finally, the fact that the UNBL is listed as a digital public good seems to ensure that that the platform promotes open access to data, ensures reusability and complies with privacy regulations (Digital Public Goods Alliance, 2023a, 2023b). This in turn safeguards the development of an inclusive platform where everyone can explore the UNBL for free. The platforms target audience are national stakeholders responsible for delivering on the GBF. However, the UNBL points out that all non-commercial actors are welcomed on the platform. Private actors are however not excluded from engaging with the platform, but they cannot get a private workspace created.

Based on these insights it is apparent that the UNBL to a large extent is designed as in accordance with the BEDP framework. Thus, the design of the UNBL seems largely suitable for supporting sustainability, which concludes Research Question 1. This conclusion gives the platform credibility for being used as a case in the following discussion which assesses how the platform can facilitate transformative change. However, some technical issues indicates that the platform might not yet have the necessary performance to fully support policymakers in delivering on the GBF. This includes inaccurate measures and collection features. Furthermore, decision-makers who lack technical competence can find it time consuming and challenging to truly translate the deep insights available on the platform into actionable intelligence.

7. Discussion

In this chapter the remaining three research questions will be discussed and answered by exploring the insights from the analysis in relation to the presented theory on transformative change. The chapter commences with a discussion how the UN Biodiversity Lab (UNBL) can support transformative governance. Here it will be explored how the platform aligns with the principles of integrative, inclusive, adaptive, transdisciplinary, and anticipatory governance, which assesses Research Question 2. Thereafter follows a discussion of how the UNBL can contribute towards targeting the indirect drivers of biodiversity loss. Here the platform's capability to effectively monitor the indirect drivers of biodiversity loss will be assessed. Additionally, the potential of the platform to influence deep leverage points and the three realms of leverage will be discussed. Through this discussion Research Question 3 will be concluded. Finally, Research Question 4 is assessed through discussing key challenges for enabling the potential of the UNBL.

7.1. Enabling Transformative Biodiversity Governance

The most apparent way the UNBL can support transformative biodiversity governance is by enabling adaptive governance through learning, monitoring, and feedback mechanisms (Visseren-Hamakers et al., 2021; Visseren-Hamakers & Kok, 2022a). Through exploring various data layers and the correlation between them, the platform can help policymakers gain a comprehensive understanding of biodiversity patterns, ecological processes, and species distribution. This can for example provide policymakers with new insight into which areas should be prioritised for conservation, which can contribute towards the development of evidence-based conservation strategies. Periodical updates of the data can further enable monitoring and evaluation of these strategies. Through this feedback loop policymakers can adjust their policies based empirical evidence of how effective the strategies are. This can help policymakers respond to changing conditions, new knowledge, and emerging challenges (OpenAI, 2023).

Analysing the correlations between different datasets can further support integrative governance by helping policymakers understand the interdependencies and trade-offs between different issues at hand (Visseren-Hamakers et al., 2021; Visseren-Hamakers & Kok, 2022a). On the UNBL this can for example be done by measuring the dataset for "Wind Power Density" against the "Biodiversity Intactness Index" and "Belowground Biomass Carbon Density". This analysis can contribute towards selecting the optimal placement for a new wind farm, where the utilisation of wind power can be maximised while at the same time minimising impacts on biodiversity and natural carbon sinks. Hence, the UNBL can support the decision-makers in balancing multiple objectives at once, such as renewable energy, climate change and biodiversity conservation.

As the UNBL is listed as digital public good and promotes open data and open-source code, the platform also seems to facilitate inclusive governance by making actionable biodiversity intelligence available to everyone (Visseren-Hamakers et al., 2021; Visseren-Hamakers & Kok, 2022a). This can contribute towards diminishing the digital divide by providing the same data to high- and low-income countries. However, this effect depends on the low-income countries having the necessary technical infrastructure to access the platform, as well as not being discriminated on other aspects such as language (Giovannini et al., 2014). Providing the low-income countries with additional resources can thus be a way to ensure that these countries have the same opportunities as more developed countries when engaging with the platform. How the partners of the UNBL have supported developing countries with resources and global scientists for creating their 'Maps of Hope' is an example of how this can be done. In addition, the fact that the UNBL is available in several languages makes the platform more accessible for non-English speaking stakeholders.

Furthermore, embedding the BED platform broadly in society can be a way to ensure that the platform also supports a transdisciplinary governance approach, as different Bodies of Knowledge can express their opinions and values (Guo et al., 2020). However, to facilitate this governance approach it is important that valuable Bodies of Knowledge who are currently underrepresented in the sustainability discourse, such as local communities and indigenous people, are represented (Visseren-Hamakers & Kok, 2022a). The UNBL state that both indigenous and local communities are represented in the data collection process (UNBL, 2021b). However, from the content analysis is apparent that the largest part of the data stem from traditional strong western research countries in Europe and North America, as well as traditional knowledge organisations such as universities and research institutes. These countries and organisations can of course also represent indigenous and local communities in their studies, but they also represent the dominating western knowledge and culture. It therefore seems like a greater emphasis on knowledge from local and indigenous communities can be a way to make the UNBL more transdisciplinary.

Finally, sufficient security measurements and constraints for uploading data is required for ensuring that the platform supports an anticipatory governance approach (Visseren-Hamakers et al., 2021; Visseren-Hamakers & Kok, 2022a). Thus, to trust the platform, users need to know that their private or personal data is safe and not available for unwanted audience. Furthermore, there needs to be mechanisms that ensure that only the best available data is loaded to the platform. The fact that the UNBL is listed as a digital public good seems to be a good indicator that the platform is taking an anticipatory approach. This listing implies that the platform is adhering to best practices, by for example following the "UNEP WCMC's 9 criteria for a digital ecosystem" (UNBL, 2023c; UNEP WCMC, 2021). Furthermore, it implies that the platform has taken measures to ensure compliance with relevant privacy laws and regulations, which is documented in the UNBL's privacy policies (UNBL, 2023f).

7.1.1. Summary of Transformative Governance Approaches

This section has aimed at addressing Research Question 2, of how the UNBL can support the five governance approaches of transformative governance. Through this discussion it has been suggested that the UNBL to some extent can support all five governance approaches. By providing actionable intelligence through multiple data layer analysis the platform can support adaptive governance through learning, monitoring, and feedback mechanisms. Analysing multiple data layers can also contribute towards integrative governance as different objectives can be evaluated at the same time. Furthermore, by being embedded in society the platform can support transdisciplinary governance by taking the values and opinions of different Bodies of Knowledge into account. However, the platform still seems to favour traditional knowledge, and the inclusion of Indigenous Peoples' and local communities' knowledge could be improved.

Finally, the fact that the UNBL is registered as a digital public good seems to be a good indicator of the platform's commitment to promote both inclusive and anticipatory governance (Digital Public Goods Alliance, 2023b; Visseren-Hamakers et al., 2021; Visseren-Hamakers & Kok, 2022a). This listing implies that the platform promotes open access to data which can ensure that both sides of the digital divide can access the same information, i.e., it supports inclusive governance. Furthermore, it implies that the UNBL is adhering to best practices and applicable laws, and this way is taking an anticipatory approach. Thus, in general, it seems like considering the digital public good status of a BED platform can provide useful guidelines when assessing the transformative potential of the platform in question.

7.2. Targeting the Indirect Drivers of Biodiversity Loss

The fact that the UNBL can support all five governance approaches in conjunction, implies that including the platform as a tool in the policy-making process can be valuable for reaching the goals of the Kunming-Montreal Post-2020 Global Biodiversity Framework (GBF). However, to truly support transformative governance, the governance instrument must also be capable of addressing the indirect drivers of biodiversity loss (Visseren-Hamakers et al., 2021; Visseren-Hamakers & Kok, 2022a). The UNBL's potential to enhance the governance mix's ability to address the root causes of unsustainability will be discussed in the following.

The results of the content analysis can give an indication of to what extent the data on the UNBL is targeting the indirect drivers of biodiversity loss. This analysis reveals that relatively 53% of the datasets are targeting the targeting the direct drivers of biodiversity loss, as compared to only relatively 17% which are targeting the indirect drivers. At first sight it therefore does not seem like the platform to a large extent is able to target the root causes of unsustainability as in compared to targeting the direct drivers.

However, this appears to be quite logical as the indirect drivers represents complex and interconnected social structures, which to a low extent can be observed directly through for example remote sensing methods. It can therefore be difficult to turn the indirect drivers into measurable sizes which can be made available on a spatial data platform. Because of this, incorporating the UNBL or other BED platforms in the policy-making process might enhance the emphasis on the direct drivers of biodiversity loss as these become even more visible. This can again limit the potential of the BED platform to support transformative governance. This fact underpins the criticism of Big Data, i.e., that it favours data that fits in to a mathematical model, which can lead to important information being lost (boyd & Crawford, 2012).

However, relatively 22% of the datasets are tagged as preventor, indicating that the UNBL to some extent can be a useful tool for limiting further biodiversity loss. Also, despite not to a large extent targeting the indirect drivers directly, the platform could still impact these drivers through influencing key leverage points and realms of leverage in society (Abson et al., 2017). The UNBL's potential to help us rethink knowledge for sustainability, reconnect with nature, and restructure institutions will therefore be discussed in the following.

7.2.1. Rethinking Knowledge for Sustainability

In their analysis of spatial data included in the National Biodiversity Strategies and Action Plans (NBSAP) in relation to the Aichi targets, Ervin et al. (2017) found that the average number of maps per NBSAP was under four per country. Furthermore, of the 109 NBSAP, 20% contained either no maps or only non-actionable maps. 70% of the NBSAP contained no actionable maps but did however contain at least one potentially actionable map. Only 3% of the maps focused on actions for the future. Based on these figures Ervin et al. (2017) concluded that the data revolution and spatial thinking had not yet reached the policy-making process in relation to biodiversity targets. On the same note, findings from an assessment of the Norway's efforts to reach the Aichi-targets shows that a lack of knowledge-based land management is an important reason to why Norway did not reach their goals (Naturvernforbundet et al., 2020).

These findings indicate that if policymakers start to incorporate the UNBL as a basis for the decision-making process, this can have large impact on how information flows through the system and how goals and expectations are set. This implies that the platform can influence the deep system characteristics of design and intent (Abson et al., 2017). Through the UNBL policymakers will have access to more than 100 unique datasets, where 93% of the datasets are classified as either Actionable or Potentially Actionable. As this platform is available for everyone, this implies that all countries committing to the GBF can implement spatial data as a basis for biodiversity strategies. Furthermore, by using the UNBL for national reporting, the international community can use tangible achievements to monitor and compare nations' progress on GBF targets. Consequently, by promoting adaptive governance, the platform can serve as an important tool for improving the knowledge production and use in transformational processes. This can again contribute towards rethinking knowledge on sustainability by ensuring that strategies are developed and followed up based on evidence (Abson et al., 2017).

It does however seem to be a lack of co-production of knowledge on the UNBL between academics and non-academics, which is thought to be a promising research approach for addressing sustainability issues effectively (Norström et al., 2020). Only 7% of the datasets include some kind of citizen science, which indicates that the public cannot to a large extent contribute to the information available on the platform. Thus, the UNBL seems to have a limited potential for the public to contribute with their perspectives, local knowledge and observations that might not be captured through traditional scientific approaches (OpenAI, 2023). However, there is a chance that citizens have contributed with problem framing and the development of the datasets without this being explicitly reflected in the analysis. This seems to be true for indigenous people and local communities, which the UNBL explicitly mention as sources for data collection (UNBL, 2021b).

Furthermore, private actors only contribute on 25% of the datasets. Of these private actors, Google is highest represented. This can indicate that the private sector to a large extent has contributed with technical competence rather than industry data on the platform. As private actors traditionally have been on the favourable side of the digital divide regarding accessing and processing big data (Giovannini et al., 2014), they certainly hold important information for enabling transformative change. Hence, the lack of private actors contributing with their non-sensitive industry data to the digital public good can limit the UNBL's potential to facilitate rethinking knowledge on sustainability issues. The importance of sharing private industry data is something also the developers of the Ocean Data Platform recognises as critical for unlocking the potential of data to support a sustainable development of the ocean (Hub Ocean, 2023a)

7.2.2. Reconnecting with Nature

By increasing the knowledge of the actual state of the natural world, the UNBL also holds the potential to facilitate reconnection with nature (Abson et al., 2017). Through its monitoring mechanisms, the platform can help policymakers gain a more comprehensive picture of how their policies and priorities are impacting the planet. This can potentially strengthen the cognitive connections between nature and policymakers, through raising their individual awareness on biodiversity issues (Ives et al., 2018). This in turn can have positive impacts on how policymakers value nature, which can contribute towards increased prioritisation of biodiversity issues over other political issues. Furthermore, by promoting open access, the platform can contribute towards increased awareness on biodiversity matters more broadly in society, increasing the collective understanding of the urgency of reversing biodiversity loss.

In addition, through the UNBL's open access, everyone has the possibility to monitor progress on biodiversity goals. In combination with increased public awareness, this can lead to more pressure from the socio-technical landscape (Geels, 2012), demanding that nature is prioritised. This can in turn lead to altered rules of the system, where actors who are harming nature will gain larger constraints and fees, while actors who for example are developing nature-based solutions are given positive incentives and subsidies. However, there already exists many natural documentaries which addresses the urgency of reversing nature degradation. Per now, this has not created a sufficient pressure to make policymakers prioritise nature on a global scale. Thus, it is not given that the potentially increased awareness gained from the platform alone will create sufficient pressure to change current regimes. Also, it is not likely that everyone will be interested in monitoring the state of the natural world. Thus, for the UNBL to lead to increased public awareness, the public must be given incentives to engage with the platform. Citizen science can be such an incentive where individuals can be encouraged to go out and take pictures in nature. This can help individuals reconnect with nature both by spending more time outdoors, and by raising their awareness on biodiversity issues through contributions to science.

However, suggesting that digital platforms can help us reconnect with nature can seem controversial, as nature and technology represents two complete opposites. In fact, technological change has been found to be one of the main reasons to why humanity has become disconnected to nature, through promoting indoor activities and virtual recreation options (Kesebir & Kesebir, 2017). By claiming more and more leisure time, internet and television has partially substitute nature as a source of recreation and entertainment. Thus, we spend less time outdoor and in direct engagement with natural environment, which on a societal level has diminished our sense of connection, understanding, and appreciation for nature (OpenAI, 2023). This implies that the technological development in general has weakened our philosophical connections to nature (Ives et al., 2018). However, the purpose of the UNBL, i.e., to promote nature by contributing to reaching the goals of the GBF, cannot be compared with the recreational purpose of a television. Thus, based on the previous discussion it can be suggested that applying technology in ways that help us understand and engage with the natural world can serve as a means for technology to facilitate a reconnection with nature.

7.2.3. Restructure Institutions

Through promoting adaptive governance and open access, the UNBL can potentially enable all actors to assess the effectiveness of current efforts to reverse the trend of biodiversity loss. Thus, the platform can become an important tool for supporting polycentric governance, as separate governance bodies can use the same data basis both for internal planning and for holding each other accountable on biodiversity matters (Brodie Rudolph et al., 2020). This way, the platform can facilitate a regime shift towards a more polycentric governance model (Geels, 2002).

For example, local governments can use the platform for developing and implementing conservation plans and strategies at the regional level. National governments can then use the platform to analyse to what extent different municipalities are prioritising conservation and assess if new national guidelines are required to increase efforts on the matter. International bodies, such as the Convention on Biological Diversity, can further compare how different nations are delivering on the goals of the GBF, and can assess whether the agreement needs to be altered. Finally, NGOs can use the same data basis to hold policymakers at all levels accountable for their promises. However, through private workspaces and private data it is still likely that different governance bodies will have different information available. This will in turn limit the opportunity to hold other governance bodies accountable for their actions.

If the UNBL would support real-time information, it could also be used to monitor the impacts of a crisis and assess the efficiency of responses. This could provide up-to-date data on the extent and severity of specific events, such as a flooding or forest fire, which could enhance the ability to respond promptly and accurately. Moreover, the feedback mechanisms of the platform could play an important role in ensuring that institutions stay open to learning opportunities prompted by the crisis, through facilitating exchange of information, lessons learned and best practices (Eburn and Dovers, 2015; referenced in Abson et al. 2017). This could again improve long-term resilience of the future strategies and responses.

However, the UNBL does not support real-time information as only two datasets are available for 2023. This implies that per now the data available on the UNBL cannot support monitoring of acute crisis as they are happening. Hence, the UNBL cannot currenly monitor the pulse of the planet. This limitation points towards the platform being more suitable for using historical data to plan for the future, rather than responding to urgent events. However, the climate and biodiversity crisis can be seen as a creeping crisis, implying that its severity accumulates over time (Boin et al., 2020). Using historical data to alter trajectories can therefore be seen as a way of responding to the larger crisis of climate change and biodiversity loss. Through the same mechanisms as discussed in the previous paragraph, the UNBL can thus contribute towards institutions that are open to learning and adaptation opportunities when the sustainability crisis intensifies.

7.2.4. Summary of Indirect Drivers

The previous discussion has addressed Research Question 3, which explores how the UNBL can influence the indirect drivers of biodiversity loss. The discussion reveals that the UNBL seems to face challenges in monitoring the indirect drivers of biodiversity loss, as a low percentage of datasets are categorised as targeting these drivers. This is likely because the indirect drivers represent complex and interconnected social structures that are hard to quantify. Thus, the UNBL's lack of capability of monitoring the indirect drivers can prove as an example of why the current biodiversity discourse is focused on the more observable and quantifiable direct drivers of biodiversity loss (Abson et al., 2017).

However, through the discussion it has become clear that the assessed governance instrument still holds potential to indirectly address the underlying causes of unsustainability. In particular, the fact that the UNBL supports adaptive governance seems to have potential for influencing the key realms of leverage. Through its monitoring and feedback mechanisms the platform can enable data-driven decision-making and reporting, which to a large extent can alter how information flows through the system. This can in turn influence cognitive connections between people and nature, by increasing our understanding of how our actions are impacting nature (Ives et al., 2018). Furthermore, the same mechanisms can reinforce polycentric governance and make institutions more open to learning and adaptation opportunities evoked by crisis (Brodie Rudolph et al., 2020; Eburn and Dovers, 2015 referenced in Abson et al. 2017). However, these effects will only be possible if the platform also support inclusive governance through open access, which is the case for the UNBL.

Thus, by supporting the governance approaches of transformative governance the UNBL seems capable of targeting the indirect drivers of biodiversity loss through influencing the key realms of leverage. This concludes Research Question 3. Furthermore it underpins the argument presented in Chapter 2, that the governance mix becomes increasingly capable of addressing the indirect drivers by following the five governance approaches in conjunction (Visseren-Hamakers et al., 2021; Visseren-Hamakers & Kok, 2022a). Thus, this thesis contributes to theory on transformative governance by providing an example of how one specific governance instrument that follows the five governance approaches can influence the indirect drivers. This demonstrated ability to target the key realms of leverage speaks in favour of transformative governance being an important field for future studies for enabling transformative change for biodiversity.

The discussion has however pointed towards a limited ability to facilitate co-production between research institutes and other actors in society on the platform. Engaging the public more broadly could both enhance the knowledge base used for decision-making and contribute to increased awareness on biodiversity matters in society. As a results, this could lead to increased pressure on policymakers from the socio-technical landscape to prioritise biodiversity matters (Geels, 2012). Thus, finding ways to facilitate co-production of knowledge could enhance the UNBL's potential to influence the key realms of leverage. Co-production could for example be facilitated through promoting citizen science on the platform, or by encouraging private actors to share their non-sensitive data on the platform.

7.3. Key Challenges

Despite the UNBL's potential to facilitate transformative governance and influencing the indirect drivers of biodiversity loss, there are still some key challenges that must be solved to unleash this potential. Based on the analysis and discussion four main challenges have been identified, i.e., solving technical issues, securing sufficient funding, enabling co-production of knowledge and ensuring consistent reporting. These challenges will now be elaborated.

The analysis revealed that the UNBL faces some technical challenges that must be addressed to ensure the quality of the features available on the platform. Inaccuracy in both pre-defined collections and metrics can lower the trustworthiness of the information delivered on the platform. This can in turn lead to policymakers deciding to not apply the UNBL when developing policies for- and monitoring progress on the targets of the GBF. Furthermore, the fact that one cannot create personalised metrics seems to lower the potential to easily turn data in to valuable insights. However, the UNBL has stated that creating custom metrics is a coming feature (UNBL, 2023c).

These current issues and forthcoming features can reflect that the platform was launched in 2022, implying that the platform is still a niche technology with low performance (Geels, 2012). The fact that BED science is an emerging research field also speaks in favour of this being a niche technology. Furthermore, another BED platform, the Ocean Data Platform, is still in its private preview phase. It can therefore seem like BED platforms in general do not yet have the necessary performance to truly support transformative governance. However, given that the science and platforms receive sufficient funding it is likely that initial technical problems will be solved. This can again increase the performance of the technology, making it more accessible to the mainstream marked.

However, as pointed out, obtaining necessary funding is another identified key challenge. It has been argued that the BED platform should strive to become a digital public good to truly facilitate transformative change. This implies that the platform should promote open access, and thus the platform cannot rely on income from users to obtain necessary funding. The UNBL relies on donations for being able to operate. As the partners behind this platform represents top level organisations in the international community this gives them credibility in being able to provide necessary donations forthcoming. However, other sources of funding could also be explored, as for example obtaining funds through public-private partnerships. Such partnerships could further contribute towards increasing the pace of development, by including industry knowledge and capacity from the private sector. How Microsoft is engaged with the UNBL, providing both technical competence and donations, seems to be an example of such a partnership (UNBL, 2021b). In addition, public-private partnerships could also make private sector more willing to share their non-sensitive data.

The need for private data reflects the third identified challenge, i.e., improving the potential for co-production of knowledge on the platform. Co-production of knowledge can contribute towards the UNBL incorporating a whole-of-society approach to a larger extent, where non-academics can contribute to the big data streams- and deep insight processes (Guo et al., 2020). To engage the private sector, industry players need incentives to why they should want to share their data. This can be provided through demonstrating the value of data sharing, and by showcasing how data from private sector has contributed towards more accurate data models and new insights. Furthermore, emphasising the fact that biodiversity loss also represents a substantial financial risk for the private sector (e.g., Deloitte, 2022), should encourage private data sharing. A final incentive is that sharing data for the digital public good will help the company appear concerned about the sustainability crisis. This can again lead to improved reputation attracting both customers and talent.

However, the fact that private actors are excluded from using private workspaces on the UNBL seems to discourage private actors to engage with the platform. This feature could therefore be altered to encourage private actors to contribute with data. Another possibility is to offer a subscription model where private actors can pay to get private workspaces created. This could in turn lead to new revenue streams for the platform.

Co-production of knowledge could further be improved by finding ways to implement citizen science on the platform. This can however be tricky, as necessary standards are required to ensure an adequate data quality (UNEP WCMC, 2021). If citizens are allowed to upload data of any sort, this could lead to noise on the platform, making it harder to turn big data into actionable intelligence. Thus, there needs to be mechanisms that filters what data is uploaded. This could for example be a trained machine-learning model which accepts or rejects submissions based on specific criteria. Citizens could potentially also get their own version of the platform where required standards for data quality are lowered. On the official platform these data could be tagged as "citizen contribution" indicating a potentially lower data quality than other datasets. Such a model could encourage citizens to engage with the platform, which in turn could impact key realms of leverage through providing new perspectives, local knowledge and increased awareness.

A final challenge identified is the need to ensure consistent reporting on biodiversity issues. For some stakeholders who are not used to applying spatial data for reporting, the threshold to start using a BED platform can be high. This can lead to some stakeholders continuing manual reporting while others start implementing BED platforms. Furthermore, given that stakeholders apply spatial data for reporting, there is still a chance that different nations and decision-makers will use different data as a basis for reporting on the same question. Also, when reporting on biodiversity issues, decision-makers can choose to apply different BED platforms. Applying different data will make it difficult to compare progress among nations. Furthermore, this can prevent polycentric governance by making it more difficult for governing bodies to hold each other accountable for their actions.

Good reporting mechanisms can therefore be critical to ensure transparency and accountability among different governing bodies. DaRT can be an example of such a mechanism, where nations are encouraged to use UNBL as a basis for reporting on the GBF (UNEP et al., 2020). Furthermore, pre-defined collections can contribute towards decision-makers applying the same datasets for the same questions at hand. In addition, there should be a focus on training to ensure that decisionmakers take advantage of the emerging technology and start applying it for planning and reporting. The UNBL seems to address this through its official training program. Features such as the Maps of Hope can also be a way to lower the threshold of using the technology, as policymakers can get pre-made customised maps where global experts have contributed (UNBL, 2022a).

7.3.1. Summary of Key Challenges

Research Question 4 addresses key challenges that must be solved for unleashing the transformative potential of the UNBL. Based on findings from the analysis and discussion four main challenges has been identified. First, technical issues must be solved to improve the performance and reliability of the insights available on the platform. Second, sufficient funding will be required for improving the performance of the technology. This can be gained through donations or through other sources such funding through public-private partnerships. Third, an apparent lack of co-production of knowledge between academic and non-academics can limit the potential of the platform to influence the key realms of leverage. The partners behind the UNBL should therefore consider how the private sector and individuals in society to a larger extent can contribute to the data collection process. Finally, mechanisms must be in place to ensure consistent reporting. Using framework such as DaRT as well as pre-defined collections can be a solution to this.

8. Conclusion

This thesis has aimed at providing insights on how and to what extent applying a Big Earth Data (BED) platform as a governance instrument can contribute towards reaching the vision of the Kunming-Montreal Post-2020 Global Biodiversity Framework (GBF), which visualises living in harmony with nature by 2050 (CBD, 2022a). To investigate this problem statement, a case study of the UN Biodiversity Lab (UNBL) has been conducted. This is a BED platform developed a partnership consisting of multilateral organisations concerned with sustainable development. This includes the Convention on Biological Diversity, the organisation which has led the process of establishing the GBF. The core vision of the UNBL is to support to support national stakeholders to deliver on the GBF.

The analysis conducted has shown that the UNBL to a large extent is designed in a suitable way to support sustainability planning and reporting, as in accordance with the analytical Big Earth Data Platform framework applied. The platform is largely embedded in society where different stakeholders and partners represents different Bodies of Knowledge. The UNBL also supports turning big data into actionable intelligence through various features available, such as enabling the analysis of multiple data layers at once, promoting pre-defined metrics and collections, and offering private workspaces. Furthermore, the platform is listed as a digital public good which implies open access to data, adherence to best practices and compliance to privacy regulations. There are however some technical issues with the available features that suggests that the platform is still a niche technology with currently insufficient performance to truly support sustainability. This includes inaccurate metrics and collections.

The findings from the analysis have further been applied to discuss how the UNBL can contribute towards enabling transformative change in relation to biodiversity issues. Insights from the discussion show that the platform can support adaptive and integrative governance through its multi-layered data analysis feature and personalised services. Inclusiveness is also promoted through the platform's open access, where high- and low-income countries can access the same information. Sufficient embedment of the platform in society further facilitates transdisciplinary governance, while proper security measures ensure an anticipatory governance approach. The platform therefore seems to some extent capable of facilitating all five governance approaches required for transformative governance.

Due to the complex and interconnected nature of the indirect drivers of biodiversity loss, the UNBL does not seem largely capable of explicitly monitoring these as quantifiable spatial datasets. However, through its monitoring and feedback mechanisms, the platform holds the potential to influence key leverage points in society where a small change can lead to a large shift in behaviour. Applying the BED platform can enable data-driven decision-making and reporting, which can alter how information flows through the system. This can in turn raise awareness of how individual and collective actions are impacting nature, improving cognitive connections between people and nature. Furthermore, applying this technology can make different governing bodies capable of holding each other accountable for actions and promises, which can support increased polycentric governance. Through these effects the UNBL can contribute towards targeting the underlaying causes of unsustainability.

These insights show that implementing a BED platform in the policy- and decision-making process can be key for reaching Target 21 of the GBF. i.e., ensuring that the best available data, information, and knowledge is accessible to decision-makers, practitioners, and the public (CBD, 2022a). Furthermore, the findings of the thesis are consistent with Target 21's reasoning of guiding effective and equitable biodiversity governance, while also strengthen communication, awareness-raising, education, monitoring, research, and knowledge management. Hence, through supporting Target 21, the examined BED platform can to a large extent contribute towards reaching the vision of the GBF. This concludes the problem statement of this thesis.

However, some key challenges must be addressed for unlocking the transformative potential of the technology. This includes solving technical issues, securing adequate funding, enabling co-production of knowledge between academics and non-academics, and establishing consistent reporting practices. Solving these challenges can both increase the performance of the niche technology as well contribute towards increased pressure from the socio-technical landscape to prioritise biodiversity issues on the political agenda. In combination this can potentially alter the prioritisation, monitoring, and reporting procedures on biodiversity issues, resulting in a more sustainable polycentric governance model. This can in turn lead to positive large-scale changes in both local, national, and global societies, where the whole-of-society and whole-of government can safeguard and monitor the health and resilience of our planet.

8.1. Future Research

Both BED science and transformative governance are emerging areas of research, and the scholarly exploration of their interaction is even less explored. This indicates a potential large scope for future research. One prominent study is to compare the UNBL to other BED platforms, such as the Ocean Data Platform, and see if the results from this study are applicable for other platforms as well. Such as study would be beneficial for gaining a better understanding how the BED platform technology can facilitate transformative change.

Furthermore, a more detailed study of how users interact with the UNBL could be beneficial to gain a more comprehensive picture of the platform's usage. This could include semi-structured interviews with users and observations of actual usage of the platform. It would also be interesting to re-examine the UNBL in a couple of years and see how the platform has changed, perhaps through providing personalised AI features. This same study could also examine to what extent the platform is actually being applied for reporting on progress on the goals of the GBF.

Finally, it would be interesting to see if other governance tools that supports the five transformative governance approaches also influences the key realms of leverage as found in this paper. Such studies would contribute towards improved understanding of transformative governance and its impact on transformative change. Furthermore, it could help us gain a better understanding of the characteristics of the governance instruments that holds the potential to facilitate transformative change.

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10. Appendices

Name of data source	Classification	Area	Country of Origin	Type of Provider	Private Company	Year	Citizen Science	Remote Sensing	No. Data layers	Actionability	Type of driver	Frequency
10m Annual Land Use Cover (9-class)	Land Cover and Land Use	Global	USA	Private	ESRI, Impact Observatory, Microsoft	2017, 2018, 2019, 2020, 2021, 2022	No	Yes	6	Potentially Actionable	Land use change	Likely to be updated
Aboveground Biomass Carbon Density 2010	Climate and Carbon	Global	USA	Research Institute (Governmental), Governmental		2010	No	Yes	1	Potentially Actionable	Preventor	Static
Access to Healthcare - All Modes of Transport	Human impact, Public Health (Society)	Global	Global contributors	University, Private	Google	2020	Yes	Yes	1	Non-actionable	None	Static
Access to Healthcare - Walking	Human impact, Public Health (Society)	Global	Global contributors	University, Private	Google	2020	Yes	Yes	1	Non-actionable	None	Static
ALOS Global Digital Surface Model	Land Cover and Land Use	Global	Japan	Governmental		2022	No	Yes	1	Non-actionable	None	Likely to be updated
Aqueduct Baseline Water Stress	Protected and Conserved Areas, Freshwater (water)	Global	USA	Research Institute (NGO)		2014	No	No	1	Actionable	Climate Change, Indirect Driver	Static
Aqueduct Groundwater Table Decline	Protected and Conserved Areas, Freshwater (water)	Global	USA	Research Institute (NGO)		2014	No	No	1	Actionable	Climate Change, Indirect Driver	Static
Belowground Biomass Carbon Density 2010	Climate and Carbon	Global	USA	Research Institute (Governmental), Governmental		2010	No	No	1	Potentially Actionable	Preventor	Static
Biodiversity Intactness Index	Biodiversity	Global	UK, Denmark, Switzerland	Intergovernmental, Research Insitute (Public), Research Institute (Governmental), University, NGO		2000, 2005, 2010, 2015	No	No	5	Actionable	Land use change, Climate Change, Over Exploitation, Invasive Species	Likely to be updated
CBAS - Global Annual Burned Area Product	Climate and Carbon, Natural Hazards, Human Impact	Global	China	Research Institute (Governmental), University		2019	No	Yes	1	Potentially Actionable	Climate Change, Indirect Driver	Static
CBAS - Global 30-m Cropping Intensity	Agriculture, Sustainable Development	Global	China, USA, Egypt, Mozambique, Ethiopia	Research Institute (Governmental), University		2021	No	Yes	1	Potentially Actionable	Land use change, Indirect driver	Static
CBAS - Global Land Productivity Dynamic Dataset Product	Ecosystem Services	Global	China	Research Institute (Governmental)		2015	No	Yes	1	Potentially Actionable	Land use change, Indirect driver	Trend
CBAS - Global Land Cover FCS30 - 2020	Land Cover and Land Use	Global	China	Research Institute (Governmental), University		2020	No	Yes	1	Potentially Actionable	Land use change	Static
Change in Aboveground Woody Carbon Density 2003-2014	Climate and Carbon	Tropical	USA	Research Institute (NGO), University		2003, 2014	No	Yes	1	Potentially Actionable	Climate Change, Land use change	Change
Change in Cumulative Human Impact to Marine Ecosystems (2008 - 2013)	Water, Human impact, Oceans (water)	Global Oceans	USA	University, Research Institute (Governmental), Research Institute (NGO), Private	ESRI	2008, 2013	No	No	2	Potentially Actionable	Land use change, Climate change, Over exploitation, Indirect driver	Change
City Water Map (CVM) - Diversion Points	Water, Freshwater (water)	Global	USA, Canada, Germany	University, Research Institute (NGO)		2014	No	No	1	Non-actionable	None	Static
City Water Map (CVM) - Watersheds	Water, Freshwater (water)	Global	USA, Canada, Germany	University, Research Institute (NGO)		2014	No	No	1	Potentially Actionable	None	Static
Contiguous Zone (24 NM)	Administrative Areas	Global Oceans	Belgium	Research Institute (NGO)		2019	No	No	1	Non-actionable	None	Likely to be updated
Coral Reef Connectivity	Biodiversity, Water, Oceans (water), Ecosystem (biodiversity)	Global	Australia, Canada, Taiwan, USA	University, Research Institute (NGO)		2017	No	No	1	Actionable	Climate Change	Static
Coral Reef Shoreline Protection	Water, Ecosystem Services, Society, Ecosystems (Biodiversity), Oceans (water)	Global	UK, Italy, USA	Univeristy, Research Institute (NGO)		2014	Yes	No	1	Actionable	Climate Change, Preventor	Static
Crop Suitability	Ecosystem Services, Society, Climate Change Adaptation (Climate and Carbon)	Global	Germany	University		2040, 2100	No	No	2	Potentially Actionable	Climate Change, Land use change, Indirect driver	Scenario

Name of data source	Classification	Area	Country of Origin	Type of Provider	Private Compan	Year	Citizen Scie	Remote S	No. Dat	Actionability	Type of driver	Frequenc
Crop Sustainability Change	Human impact, Society, Ecosystem Services, Climate Change Adaptation (Climate and Carbon)	Global	Germany	University		1981,2010, 2071,2100	No	No	2	Potentially Actionable	Climate Change, Land use change, Indirect driver	Change, Scenario
Dam Catchments - Global Georeferenced Database of Dams (GOODD)	Human impact	Global	UK, USA	University		2020	Yes	Yes	1	Potentially Actionable	Land use change, Climate Change	Static
Dams - Global Georeferenced Database of Dams	Human impact	Global	UK, USA	University		2020	Yes	Yes	1	Potentially Actionable	Land use change, Climate change	Static
DMSP-OLS/VIIRS harmonized global nighttime light dataset 1992 to 2018	Human impact	Global	USA	University		1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018	No	Yes	26	Potentially Actionable	Pollution, Indirect Driver	Likely to be updated
Ecologically or Biologically Significant Marine Areas (EBSAs)	Biodiversity	Global Oceans	Canada	Intergovernmental		2014	No	No	1	Potentially Actionable	Preventor	Static
ESA CCI Land Cover (1992-2000)	Land Cover and Land Use	Global	EU	Intergovernmental		1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020	No	Yes	28	Potentially Actionable	Land use change, Climate Change	Likely to be updated
ESA CGLS Land Cover All Years	Land Cover and Land Use	Global	EU	Intergovernmental		2015, 2016, 2017,2018,2019	No	Yes	5	Potentially Actionable	Land use change, Climate Change	Likely to be updated
ESA World Cover 2020	Land Cover and Land Use	Global	EU	Intergovernmental		2020	No	Yes	1	Potentially Actionable	Land use change, Climate Change	Static
Exclusive Economic Zone (EEZ)	Administrative Areas	Global	Belgium	Research Institute (NGO)		2019	No	No	1	Non-actionable	None	Likely to be updated
Forest Connectivity	Biodiversity, Climate and Carbon, Ecosystem (Biodiversity)	Global	USA, Global contributors	Intergovernmental		2000, 2013	No	Yes	2	Actionable	Land use change	Static
Forest Fragmentation - 2000	Biodiversity, Ecosystem (Biodiversity), Restoration	Southern Hemisphere	USA, Global contributors	Intergovernmental		2000	No	Yes	12	Actionable	Land use change	Static
Forest Fragmentation - 2012	Biodiversity, Ecosystem (Biodiversity), Restoration	Southern Hemisphere	USA, Global contributors	Intergovernmental		2012	No	Yes	12	Actionable	Land use change	Static
Forest Integrity Project: Forest Conpy Height	Biodiversity	Tropical	USA	University, Research Institute (NGO)		2012	No	Yes	1	Potentially Actionable	None	Static
Forest Landscape Integrity Index (FLII)	Biodiversity	Global	USA, Canada, Australia, Norway	NGO, University, Intergovernmental		2019	No	Yes	1	Potentially Actionable	Land use change, Indirect driver, Preventor	Static
Forest Structural Condition Index (SCI)	Biodiversity	Tropical	USA, Canada, Australia, France	University, Intergovernmental, Research Institute (NGO)		2019	No	Yes	1	Potentially Actionable	Land use change, Preventor	Static
Forest Structural Integrity Index (FSII)	Biodiversity	Tropical	USA, Canada, Australia, France	University, Intergovernmental, Research Institute (NGO)		2019	No	Yes	1	Actionable	Land use change, Indirect driver, Preventor	Static
Global Development Potential Indices (DPI)	Society, Socioeconomic (Society), Sustainable Development	Global	USA	University		2019	No	No	13	Potentially Actionable	Climate Change, Indirect driver	Scenario

Name of data source	Classification	Area	Country of Origin	Type of Provider	Private Compan	Year	Citizen Scie	Remote S	No. Dat	Actionability	Type of driver	Frequenc
Global Distribution of Cold-Water Corals	Water, Biodiversity, Oceans (Water), Ecosystems (Biodiversity)	Global Oceans	UK	Intergovernmental		2014	No	Yes	2	Potentially Actionable	Climate Change, Land Use Change	Static
Global Distribution of Seagrasses	Biodiversity, Ecosystem Services, Water, Society, Oceans (Water), Ecosystems (Biodiversity)	Global Oceans	UK	Intergovernmental		2014	No	Yes	2	Potentially Actionable	Preventor	Static
Global Fishing Watch: Annual Fishing Hours (2016)	Water, Human Impact, Socioeconomic (Society), Oceans (Water)	Global Oceans	USA	Research Institute (NGO), Private	Google	2016	No	Yes	7	Potentially Actionable	Over Exploitation	Static
Global Flood Database	Natural Hazards	Global	USA	University, Private, Research Institute (Governmental)	Google	2018	No	Yes	1	Actionable	Climate Change	Static
Global Forest Change	Climate and Carbon, Biodiversity, Ecosystem (Biodiversity)	Global	USA	University, Private, Governmental	Google	2000, 2012, 2020	No	Yes	4	Potentially Actionable	Land use change	Change
Global Grid of Probabilities of Urban Expansion to 2030	Human Impact, Land Cover and Land Use	Global	USA	University		2030	No	Yes	1	Potentially Actionable	Indirect driver	Scenario
Global Intertidal Change	Water, Oceans (Water), Ecosystem (Biodiversity)	Global	Australia, USA	University, Private, Research Institute (Governmental)	Google	1984,1986,1987,1989,1990,1992,1993,1995,1996,1998,1999,2001,2002,2004,2005,2007,2008,2010,2011,2013,2014,2016	No	Yes	12	Potentially Actionable	Land use change, Climate change	Change
Global Land Productivity Dynamic Dataset Product	Ecosystem Services, Sustainable Development, Agriculture	Global	China	University		2015	No	No	1	Potentially Actionable	Land use change	Trend
Global Landslide Hazard Map	Natural Hazards	Global	N/A	Intergovernmental		2018	No	Yes	4	Actionable	Climate Change	Trend
Global Mangrove Soil Carbon	Climate and Carbon, Ecosystem Services, Biodiversity, Water	Global	USA, The Netherlands, Australia, UK, Costa Rica, Egypt, Canada, Cameroon, Japan, Saudi Arabia	Research Institute (NGO), University, Research Institute (Governmental)		2018	No	No	1	Potentially Actionable	Preventor	Static
Global Mangrove Watch	Biodiversity, Water, Ecosystem (Biodiversity)	Global	UK, Japan, Australia, The Netherlands, USA	University, Private, Research Institute (NGO), NGO	soloEO, RESTEC	1996, 2007, 2008, 2009, 2010, 2015, 2016	No	Yes	7	Potentially Actionable	Land use change, Preventor	Static
Global Maps of Irrigated Areas (GMIA)	Land Cover and Land Use, Human Impact, Freshwater (Water)	Global	Germany, Italy	University, Intergovernmental		2005	No	Yes	5	Potentially Actionable	Land use change	Static
Global Patterns in Marine Sediment Carbon Stocks Carbon	Climate and Carbon, Oceans (Water)	Global Oceans	USA	University, Research Institute (NGO)		2020	No	No	1	Actionable	Preventor	Static
Global Safety Net: Potential Wildlife Corridors	Biodiversity, Species (Biodiversity)	Global	USA, New Zealand, UK, Hong Kong	University, Private, NGO	Google	2020	No	No	1	Actionable	Preventor	Static
Global Safety Net: High Biodiversity Areas	Biodiversity, Species (Biodiversity)	Global	USA, New Zealand, UK, Hong Kong	University, Private, NGO	Google	2020	No	No	1	Actionable	Preventor	Static
Global Safety Net: Intact Wilderness Areas	Biodiversity	Global	USA, New Zealand, UK, Hong Kong	University, Private, NGO	Google	2020	No	No	1	Actionable	Preventor	Static
Global Solar Atlas: Yearly Average Potential Photovoltaic Electricity Production	Society, Socioeconomic (Society)	Global	N/A	Intergovernmental		2019	No	No	1	Potentially Actionable	Indirect driver	Static
Global Surface Water - Maximum Water Extent 1984-2018	Water, Ecosystem Services, Freshwater (Water)	Global	Italy, Switzerland	Research Institute (Intergovernmental), Private	Google	2018	No	Yes	1	Potentially Actionable	Climate Change, Land use change	Trend
Global Surface Water - Occurence Change Intensity 1984-2018	Water, Land Cover and Land Use, Natural Hazards, Freshwater (Water)	Global	Italy, Switzerland	Research Institute (Intergovernmental), Private	Google	2018	No	Yes	1	Potentially Actionable	Climate Change, Land use change	Trend
Global Surface Water - Recurrence 1984-2018	Water, Land Cover and Land Use, Freshwater (Water)	Global	Italy, Switzerland	Research Institute (Intergovernmental), Private	Google	2018	No	Yes	1	Potentially Actionable	Climate Change, Land use change	Trend

Name of data source	Classification	Area	Country of Origin	Type of Provider	Private Compan	Year	Citizen Scie	Remote S	No. Dat	Actionability	Type of driver	Frequenc
Global Surface Water - Seasonality 2014-2018	Water, Land Cover and Land Use, Freshwater (Water)	Global	Italy, Switzerland	Research Institute (Intergovernmental), Private	Google	2018	No	Yes	1	Potentially Actionable	Climate Change, Land use change	Trend
Global Surface Water - Transitions 2000-2018 (SDG 6.6.1 INDICATOR)	Water, Land Cover and Land Use, Freshwater (Water)	Global	Italy, Switzerland	Research Institute (Intergovernmental), Private	Google	2018	No	Yes	1	Potentially Actionable	Climate Change, Land use change	Trend
Global Wetlands: Tropical and Subtropical Wetlands Distribution	Biodiversity, Ecosystem Services, Ecosystem (Biodiversity)	Tropical	Indonesia, Sweden, USA, Germany, The Netherlands	Research Institute (NGO), University		2011	No	Yes	1	Potentially Actionable	Preventor	Static
Global Wind Atlas: Wind Density	Ecosystem Services, Biodiversity, Socioeconomic (Society)	Global	Denmark, Finland, The Netherlands, Global contributors	University, Private, Intergovernmental	Vortex, Nazka, Søren Krohn Consulting, World In A Box	2019	No	No	2	Potentially Actionable	Indirect driver	Static
GLOSIS - Global Soil Organic Carbon	Climate and Carbon	Global	Afghanistan, Argentina, Armenia, Australia, Austria, Azerbaijan, Belgium, Bolivia, Brazil, Bhutan, Bosnia and Herzegovina, Cambodia, Cameroon, Canada, Chile, Colombia, Costa Rica, Cuba, Czech Republic, Germany, Democratic Republic of Congo, Denmark, Dominican Republic, Ecuador, Eswatini, Ethiopia, European Combission, Finland, France, Gambia, Ghana, Hungary, Indonesia, India, Iraq, Italy, Iran, Jordan, Japan, Kazakhstan, Kenya, Laos, Lebanon, Sri Lanka, Lesotho, Luxembourg, Madagascar, Marocco, Moldova, Mexico, Myanmar, Mongolia, Mozambique, Malawi, Nigeria, Nicaragua, The Netherlands, Nepal, New Zealand, Palestine Authority, Panama, Peru, The Phillippines, Paraguay, Russia, Sudan, Senegal, El Salvador, Slovakia, Slovenia, Somalia, Sweden, Switzerland, Syria,	Governmental, University, Research Institute (Governmental), Research Institute (NGO)		2019	No	Yes	1	Potentially Actionable	Climate Change, Land use change, Indirect driver, Preventor	Static
Gridded Livestock of the World (GLW 3)	Climate and Carbon, Biodiversity, Ecosystem (Biodiversity)	Global	Belgium, Italy, Switzerland, UK	University, Intergovernmental		2010	No	No	8	Potentially Actionable	Land use change, Indirect driver	Static
Human Development Index 2015	Human impact	Global	Global contributors	Intergovernmental		2015	No	No	1	Potentially Actionable	Indirect driver	Static
Human Footprint 2000-2013 (v2)	Human impact	Global	Australia, Canada, The Netherlands, Italy, USA, Colombia	University, NGO, Intergovernmental, Research Institute (NGO)		2000,2005,2020,2013	No	Yes	5	Potentially Actionable	Indirect driver, Climate Change, Land use change	Change
Human Footprint 2009, 1993 (v1)	Human Impact	Global	Canada, Australia, USA, Switzerland, Spain, UK	University, NGO, Research Institute (Governmental)		1993, 2009	No	Yes	3	Potentially Actionable	Indirect driver, Climate Change, Land use change	Change
Human Modification Index	Human impact	Global	USA	University, Private, NGO	Conservation Planning Technologies	1990, 2000, 2010, 2015, 2017	No	Yes	5	Potentially Actionable	Land use change, Indirect driver	Likely to be updated
Increase in Soil Organic Carbon (SOC)	Human Impact, Ecosystem Services, Climate and Carbon	Global	China, USA, Kenya, Colombia	University, NGO, Research Institute (NGO)		2034	No	Yes	2	Actionable	Land use change, Preventor	Scenario

Name of data source	Classification	Area	Country of Origin	Type of Provider	Private Compan	Year	Citizen Scie	Remote S	No. Dat	Actionability	Type of driver	Frequenc
Intact Forest Landscapes	Protected and Conserved Areas, Ecosystem (Biodiversity)	Global	USA, Russia	NGO, University, Research Institute (NGO)		2000, 2013	No	Yes	1	Actionable	Land use change	Change
IUCN Species Richness	Biodiversity, Species (Biodiversity), Genes (Biodiversity)	Global	Global contributors	Intergovernmental		NA	NA	No	5	Potentially Actionable	Climate Change, Over Exploitation, Land use change	Likely to be updated
IUCN Threatened Species Richness	Biodiversity, Species (Biodiversity), Genes (Biodiversity)	Global	Global contributors	Intergovernmental		NA	NA	No	5	Potentially Actionable	Climate Change, Over Exploitation, Land use change	Likely to be updated
Key Biodiverisy Areas (Low Resolution)	Protected and Conserved Areas	Global	Global contributors	NGO, Intergovernmental		2021	NA	No	1	Actionable	Preventor	Likely to be updated
Mammalian Genetic Diversity	Biodiversity, Genes (Biodiversity)	Global	Denmark, Australia	University		2020	No	No	2	Potentially Actionable	Climate Change, Land use change, Preventor	Static
Marine Ecoregions & Pelagic Provinces of the World (MEOW-PPOW)	Boundaries, Biogeographical Regions (Boundaries)	Global Oceans	USA, Australia, Switzerland, Sri Lanka, Canada, UK	NGO, Research Institute (Public), Intergovernmental, Research Institute (NGO), University		2007	No	No	4	Potentially Actionable	None	Static
Marine Pollution Index	Water, Human Impact, Oceans (Water)	Global Oceans	USA, UK	University, NGO, Research Institute (Governmental), Research Institute (NGO), Private	ESRI	2013	No	No	4	Potentially Actionable	Pollution, Indirect Driver	Static
Marine Priority Areas	Biodiversity, Climate and Carbon, Sustainable Development, Oceans (Water), Ecosystem services	Global Oceans	USA, France, Canada, Germany, The Philippines, Australia	Research Institute (NGO), University, Research Institute (Governmental)		2021, 2050	Yes	No	4	Potentially Actionable	Preventor	Scenario
Marine Protected Areas WDPA	Water, Protected and Conserved Areas, Oceans (Water)	Global Oceans	Global contributors	Intergovernmental, NGO, Governmental, University, Private	NA	2021	No	No	1	Actionable	Preventor	Static
Marine Wilderness	Water, Biodiversity, Oceans (Water)	Global	USA, Australia, UK, Canada	NGO, University, Research Institute (NGO)		2018	No	No	2	Potentially Actionable	Preventor	Static
MODIS Burned Area	Natural Hazards, Human Impact, Ecosystem Services	Global	USA	Governmental		2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021	No	Yes	20	Potentially Actionable	Climate Change, Indirect driver	Likely to be updated
MODIS EVI	Land Cover and Land Use	Global	USA	Governmental		2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022	No	Yes	21	Potentially Actionable	Land use change, Climate Change, Preventor	Likely to be updated
MODIS Gross Primary Production (GPP)	Climate and Carbon, Ecosystem Services	Global	USA	Governmental		2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020	No	Yes	19	Potentially Actionable	Land use change	Likely to be updated
MODIS NDVI	Climate and Carbon	Global	USA	Governmental		2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022	No	Yes	21	Potentially Actionable	Land use change	Likely to be updated
MODIS Net Primary Production (NPP)	Ecosystem Services, Climate and Carbon	Global	USA	Governmental		2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020	No	Yes	20	Potentially Actionable	Land use change	Likely to be updated

Name of data source	Classification	Area	Country of Origin	Type of Provider	Private Compan	Year	Citizen Scie	Remote S	No. Dat	Actionability	Type of driver	Frequenc
NatureMap - Areas of Global Significance for Restoration	Restoration, Nature Based Solutions	Global	Brazil, Australia, The Netherlands, Spain, Poland, UK, Switzerland, The Philippines, USA, Austria, Canada, Argentina, Austria	University, Research Institute (NGO), Intergovernmental, NGO, Research Institute (International)		2020	No	Yes	1	Actionable	Preventor	Likely to be updated
NatureMap - Forest Biodiversity Intactness Index	Biodiversity	Global	Global contributors, Brazil, Austria	Intergovernmental, Research Institute (International), NGO		NA	No	No	1	Actionable	Land use change, Indirect driver, Preventor	NA
NatureMap - Global Habitats	Biodiversity, Land Cover and Land Use, Water, Species (Biodiversity)	Global	Austria, Italy, UK	Research Institute (International), University, NGO, Intergovernmental		2015	No	Yes	1	Potentially Actionable	Land use change, Indirect driver	Static
NatureMap - Global Potential Habitats	Species (Biodiversity)	Global	Austria, Italy, UK	Research Institute (International), University, NGO, Intergovernmental		2015	No	No	1	Potentially Actionable	Preventor	Static
NatureMap - Human Impact on Forests	Biodiversity, Human Impact, Restoration, Ecosystem (Biodiversity)	Global	Austria, Belgium, The Netherlands, Ukraine, Russia, Taiwan, Romania, India, Egypt, Germany, Pakistan, USA	Research Institute (International), Research Institute (NGO), University, Research Institute (Governmental),		2015	No	Yes	2	Potentially Actionable	Land use change, Indirect driver	Static
NatureMap - Human Pressures	Human Impact, Climate and Carbon, Ecosystem Services, Biodiversity	Global	Global contributors	Intergovernmental		2020	No	Yes	1	Potentially Actionable	Land use change, Climate Change, Indirect driver	Static
NatureMap - Live Biomass Carbon Density	Climate and Carbon, Ecosystem Services	Global	Global contributors	Intergovernmental		NA	No	No	1	Potentially Actionable	Preventor	Static
NatureMap - Potential Clean Water Provision	Ecosystem Services	Global	UK	University		2017	No	No	1	Potentially Actionable	None	Static
NatureMap - Realised Clean Water Provision	Ecosystem Services	Global	UK	University		2017	No	No	1	Potentially Actionable	Pollution, Indirect Driver	Static
NatureMap - Vulnerable Soil Carbon Density	Climate and Carbon, Ecosystem Services	Global	Global contributors	Intergovernmental		NA	No	No	1	Actionable	Land use change, Preventor	Static
Protected Area Connectivity (ProtConn)	Protected and Conserved Areas	Global	Italy	Research Institute (Intergovernmental), Intergovernmental, NGO, Private	Landowners, Communities	2016	Yes	No	2	Actionable	Preventor	Static
Subnational Infant Morality Rates (2015)	Society, Public Health (Society)	Global	USA	University		2015	No	No	1	Non-actionable	None	Static
Terrestrial Biomes (Ecoregions2017)	Biodiversity, Ecosystem (Biodiversity)	Global	USA, Sri Lanka, Kenya, Denmark, The Netherlands	NGO, University, Research Institute (NGO), Private	Google	2017	No	No	1	Potentially Actionable	None	Static
Terrestrial Protected Areas WDPA	Protected and Conserved Areas	Global	Global contributors	Intergovernmental, NGO, Private, Governmental		2020	Yes	No	1	Actionable	Preventor	Static
Teretorial Seas (12 NM)	Administrative Areas	Global Oceans	Belgium	Research Institute (NGO)		2019	No	No	1	Non-actionable	None	Likely to be updated
Tree Cover Loss	Human Impact	Global	USA	University, Private, Intergovernmental, Research Institute (Governmental)	Google	2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020	No	Yes	20	Potentially Actionable	Land use change	Likely to be updated
UNDP/GEF Funded Projects	Sustainable Development, Protected and Conserved Areas	Global	Global contributors	Intergovernmental		2020	No	No	1	Potentially Actionable	Preventor	Static
UNESCO MAB Biosphere Reserves	Protected and Conserved Areas	Global	Global contributors	Intergovernmental		2020	No	No	1	Potentially Actionable	Preventor	Likely to be updated
UNESCO World Heritage Sites	Protected and Conserved Areas	Global	Global contributors	Intergovernmental		2020	No	No	1	Potentially Actionable	Preventor	Likely to be updated
VIIRS Nightime Lights (All years)	Human impact, Society	Global	USA, Russia	Governmental, University		2014,2015,2016,2017,2018,2019,2020	No	Yes	7	Potentially Actionable	Pollution, Indirect Driver	Likely to be updated

Name of data source	Classification	Area	Country of Origin	Type of Provider	Private Compan	Year	Citizen Scie	Remote S	No. Dat	Actionability	Type of driver	Frequenc
WCMC Terrestrial Carbon 2010	Climate and Carbon	Global	UK, USA, Australia, The Netherlands, France, Brazil, Denmark	Intergovernmental, University, Research Institute (Governmental), Governmental, Research Institute (NGO)		2010	No	Yes	3	Actionable	Preventor	Static
WDPA Protected Areas	Protected and Conserved Areas	Global	Global contributors	Intergovernmental, NGO, Governmental, Private		2022	No	No	3	Actionable	Preventor	Likely to be updated
Wetlands of International Importance (Ramsar Sites - Boundaries)	Protected and Conserved Areas	Global	Global contributors	Intergovernmental, Governmental		2023	No	No	1	Actionable	Preventor	Likely to be updated
Wetlands of International Importance (Ramsar Sites - Centroids)	Protected and Conserved Areas	Global	Global contributors	Intergovernmental, Governmental		2023	No	No	1	Potentially Actionable	Preventor	Likely to be updated
World Atlas of Desertification (WAD)	Human impact, Restoration, Land Cover and Land Use	Global	Italy, USA, Germany, South Africa, Argentina, India, Australia, China, Tunisia, Sweden, Chile, Brazil, Switzerland, Indonesia, Kenya, Kyrgyzstan, Israel, Namibia, Kenya, Syria, Italy, Marocco, South Africa, Spain, Denmark, UK, Turkey, The Netherlands, Belgium, France, Uzbekistan, Peru, Uruguay, South Korea, Croatia, Hungary	Intergovernmental, University, Research Institute (Governmental), Research Institute (International)		2018	Unknown	No	13	Actionable	Climate Change, Land use change, Indirect driver	Static
World Terrestrial Ecosystems	Biodiversity, Land Cover and Land Use, Ecosystem (Biodiversity)	Global	USA, Ecuador, Australia	Private, Research Institute (Governmental), NGO,	ESRI	2015	No	No	1	Potentially Actionable	None	Static
WorldPop: Estimated Residential Population 2000-2020	Society	Global	UK	University		2000,2005,2010,2015,2020	No	Yes		Potentially Actionable	Indirect driver	Change
Global Forest Restoration Opportunities to Foster Coral Reef Conservation - Sediment export	Nature Based Solutions, Restoration, Ecosystem (Biodiversity)	Global	Australia, Italy	University		2021	No	No	4	Actionable	Preventor	Static
Global Land Cover FCS30 - 2020		Global	China	University		2020	No	Yes	1	Potentially Actionable	None	Static
Global Safety Net: Large Mammal Landscape	Biodiversity, Species (Biodiversity)	Global	USA, New Zealand, UK, Hong Kong	University, Private, NGO	Google	2020	No	No	1	Potentially Actionable	Preventor	Static
Global Safety Net: Rare Species Sites	Biodiversity, Species (Biodiversity)	Global	USA, New Zealand, UK, Hong Kong	University, Private, NGO	Google	2020	No	No	1	Potentially Actionable	Preventor	Static

116
Number of Datasets

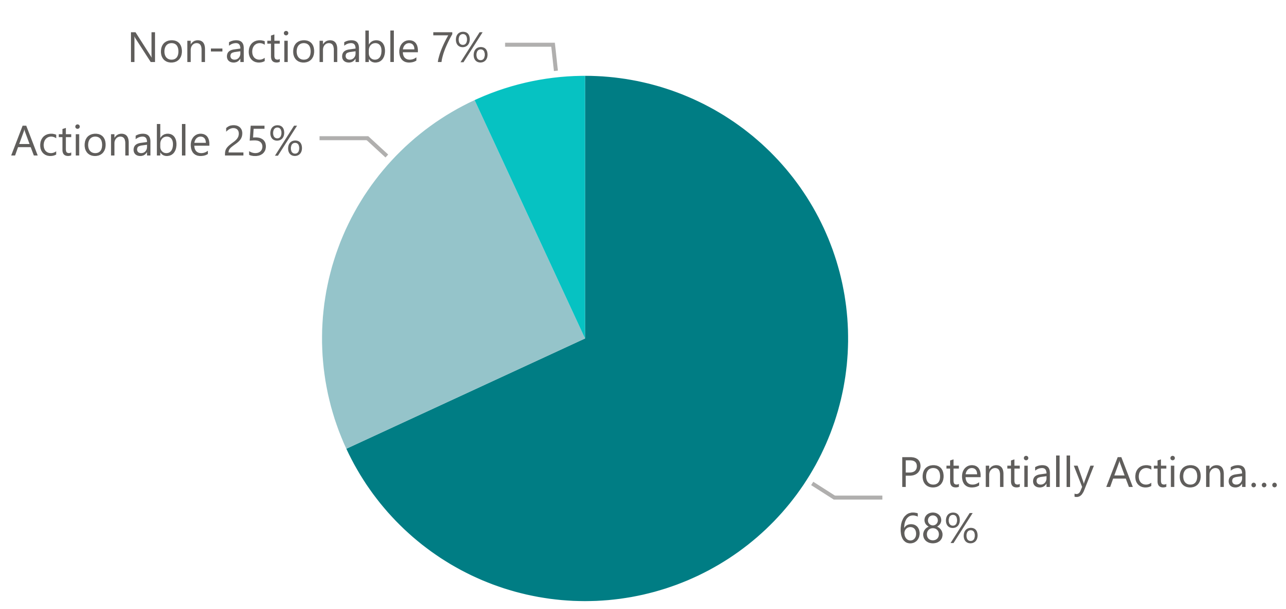
445
Number of Datalayers

4
Average Layers per Datasets

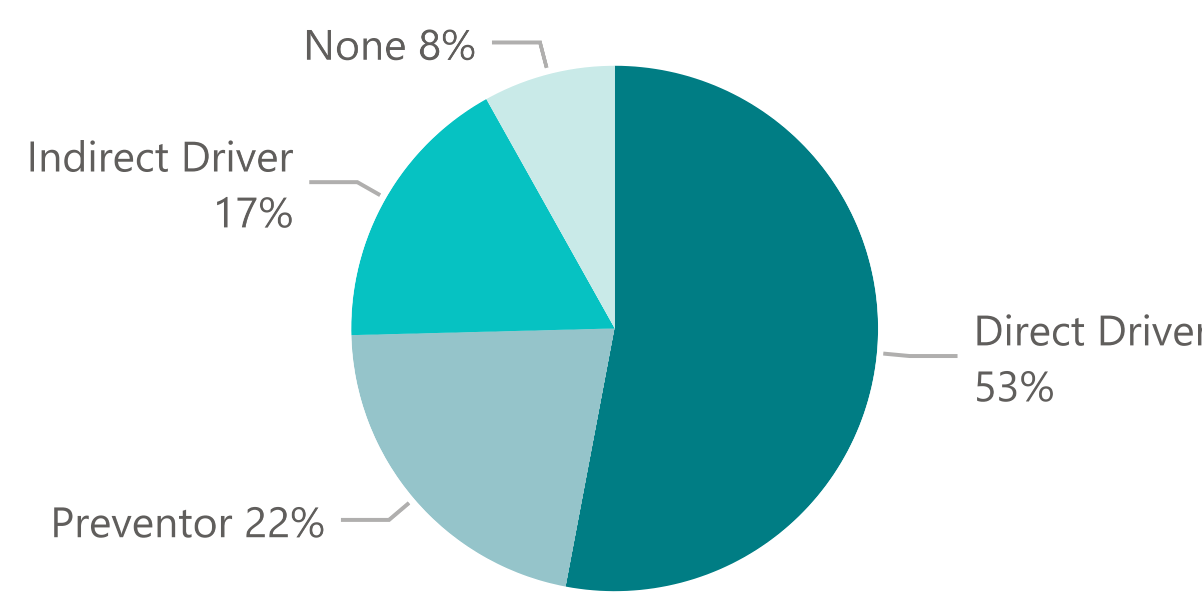
7%
Percentage Citizen Science

52%
Percentage Remote Sensing

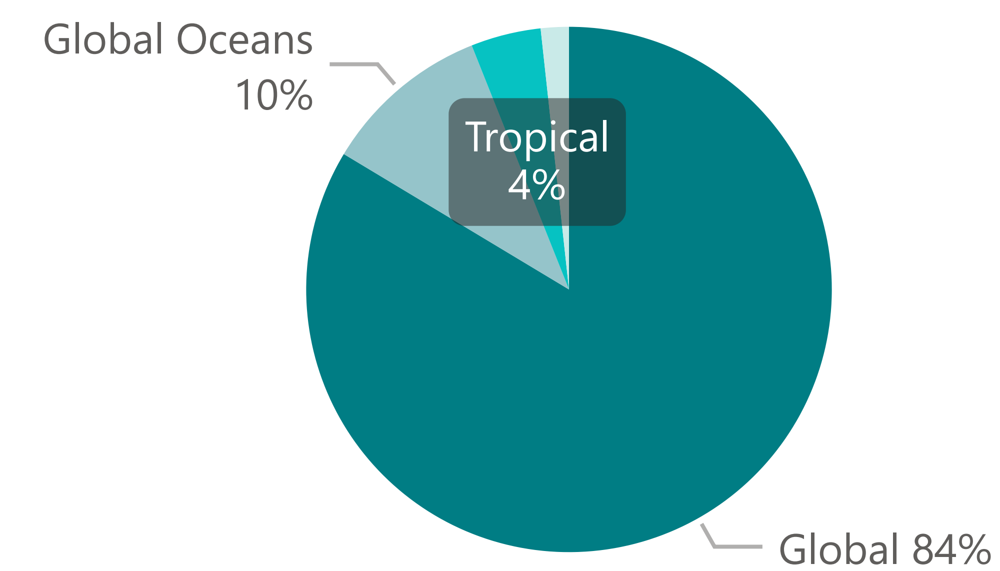
Datasets per Actionability Type



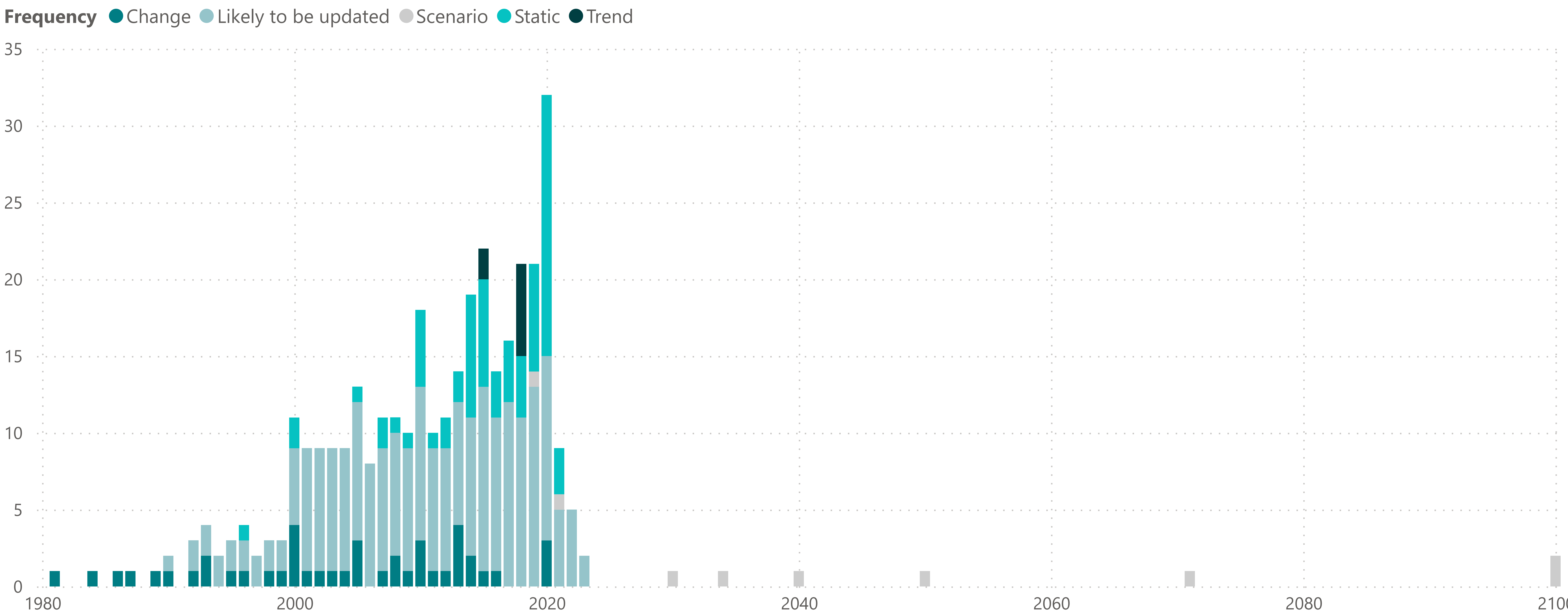
Relative Distribution Driver Category

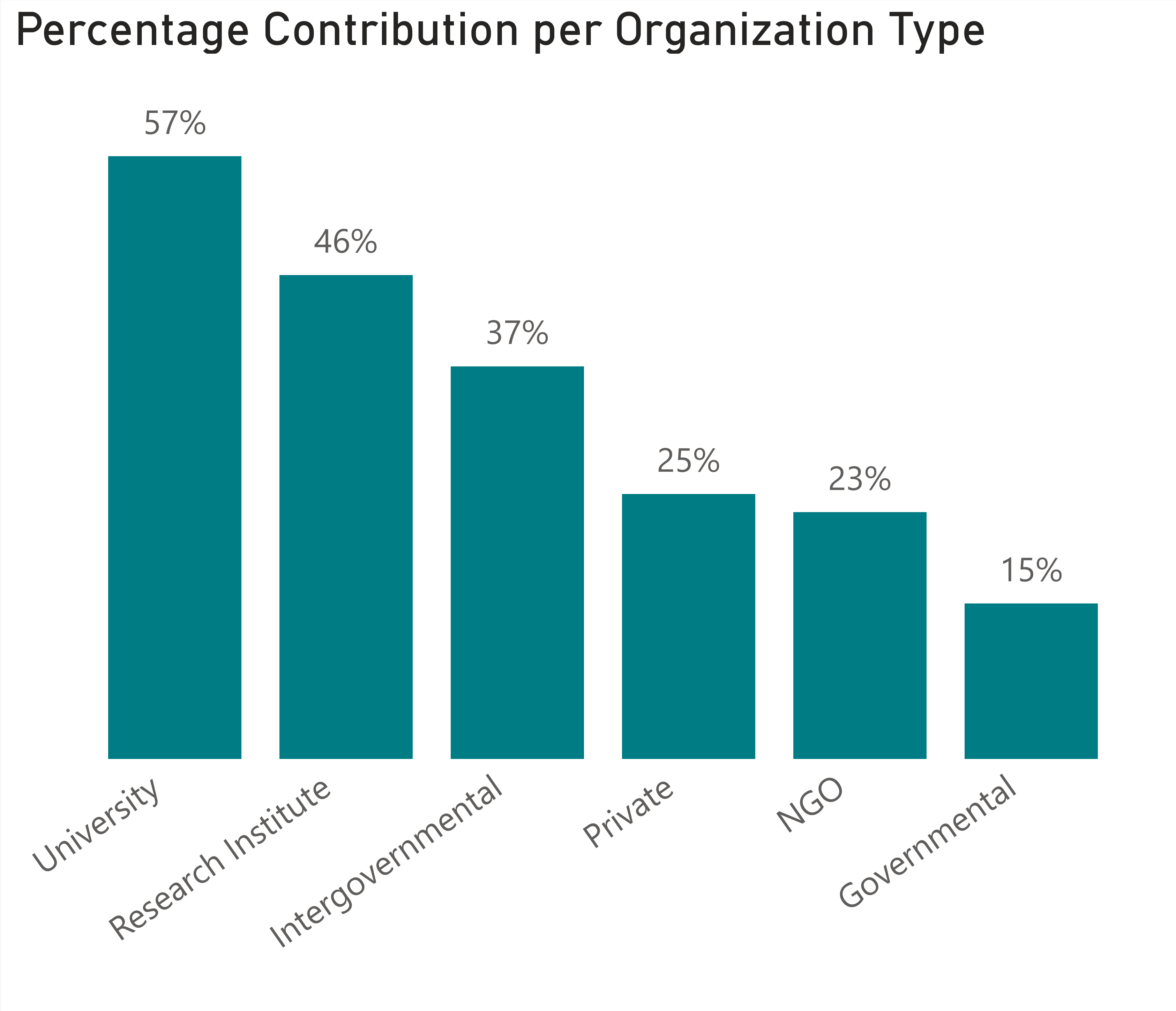


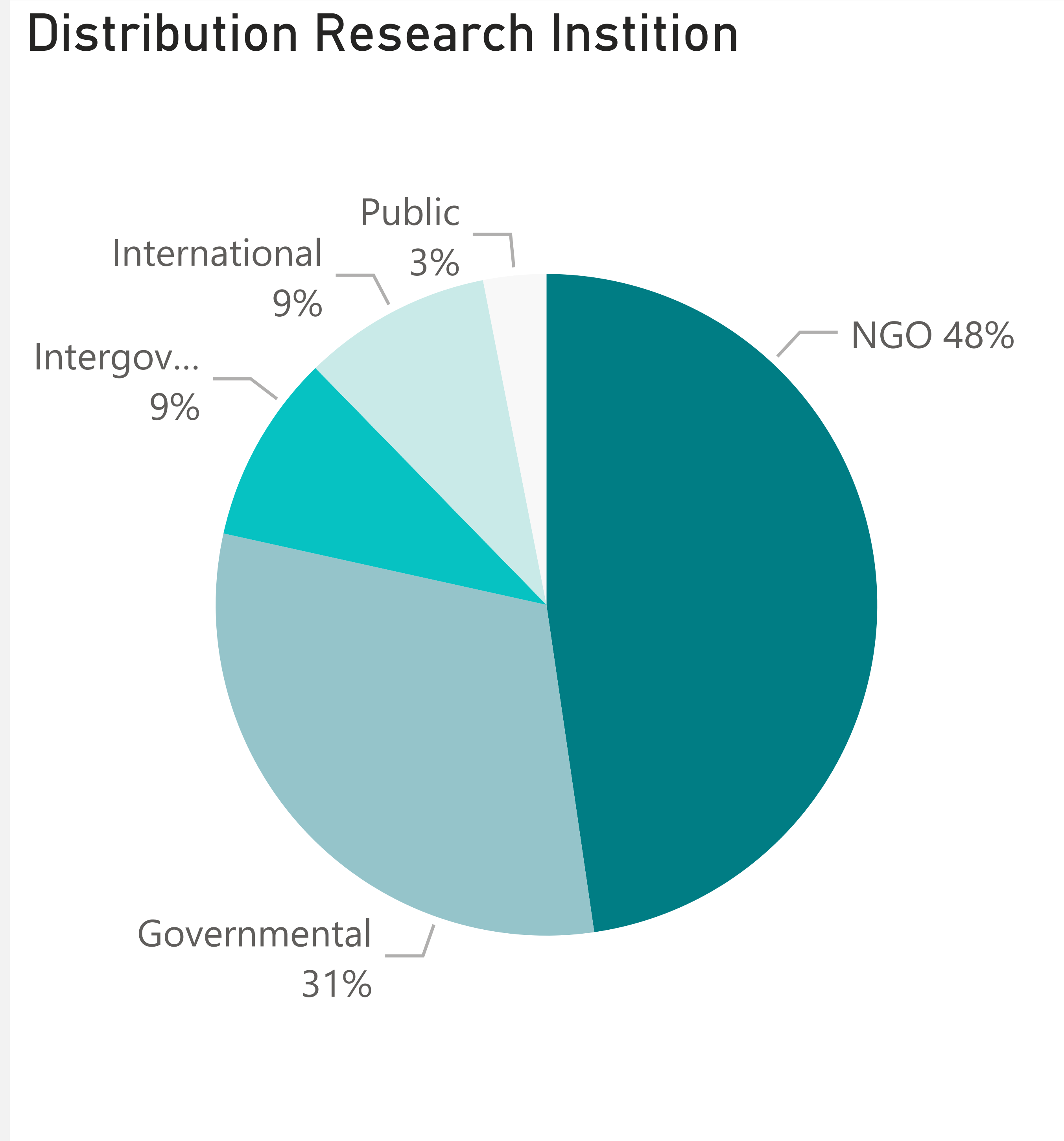
Datasets available per Area

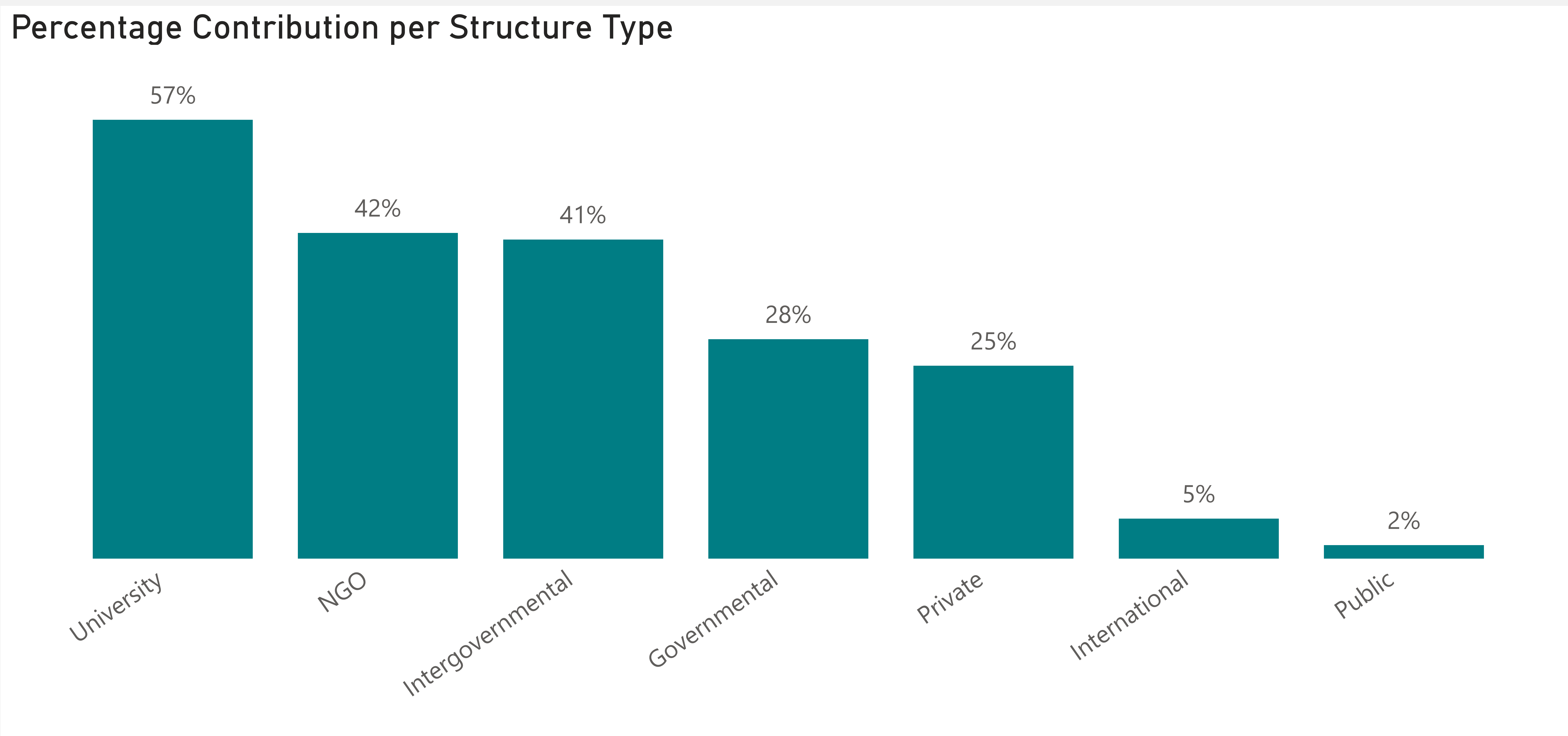


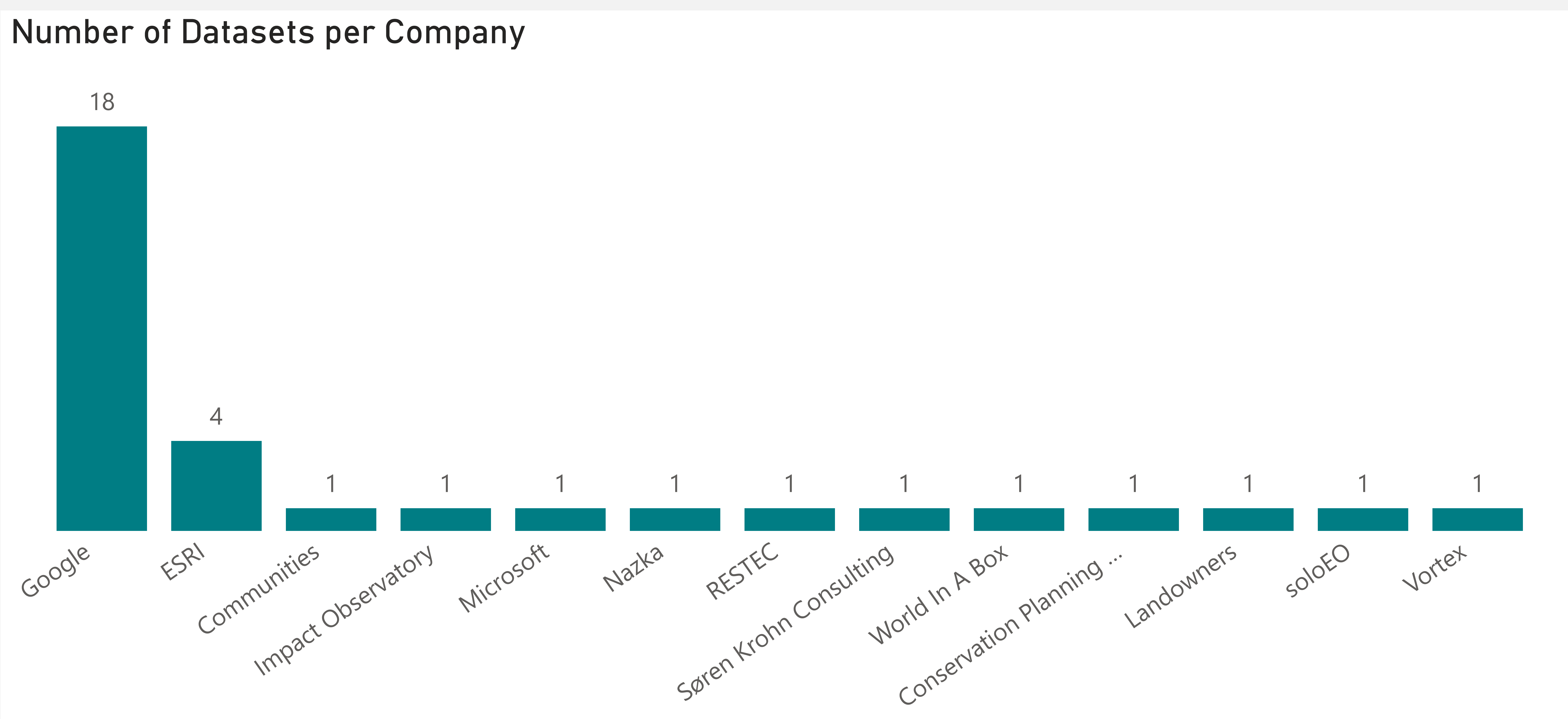
Number of Datasets Available per Year by Frequency Type




Percentage Contribution per Organization Type
57%
46%
37%
25%
23%
15%
University
Research Institute
Intergovernmental
Private
NGO
Governmental


Distribution Research Institition
Public 3%
International 9%
Intergov... 9%
NGO 48%
Governmental 31%

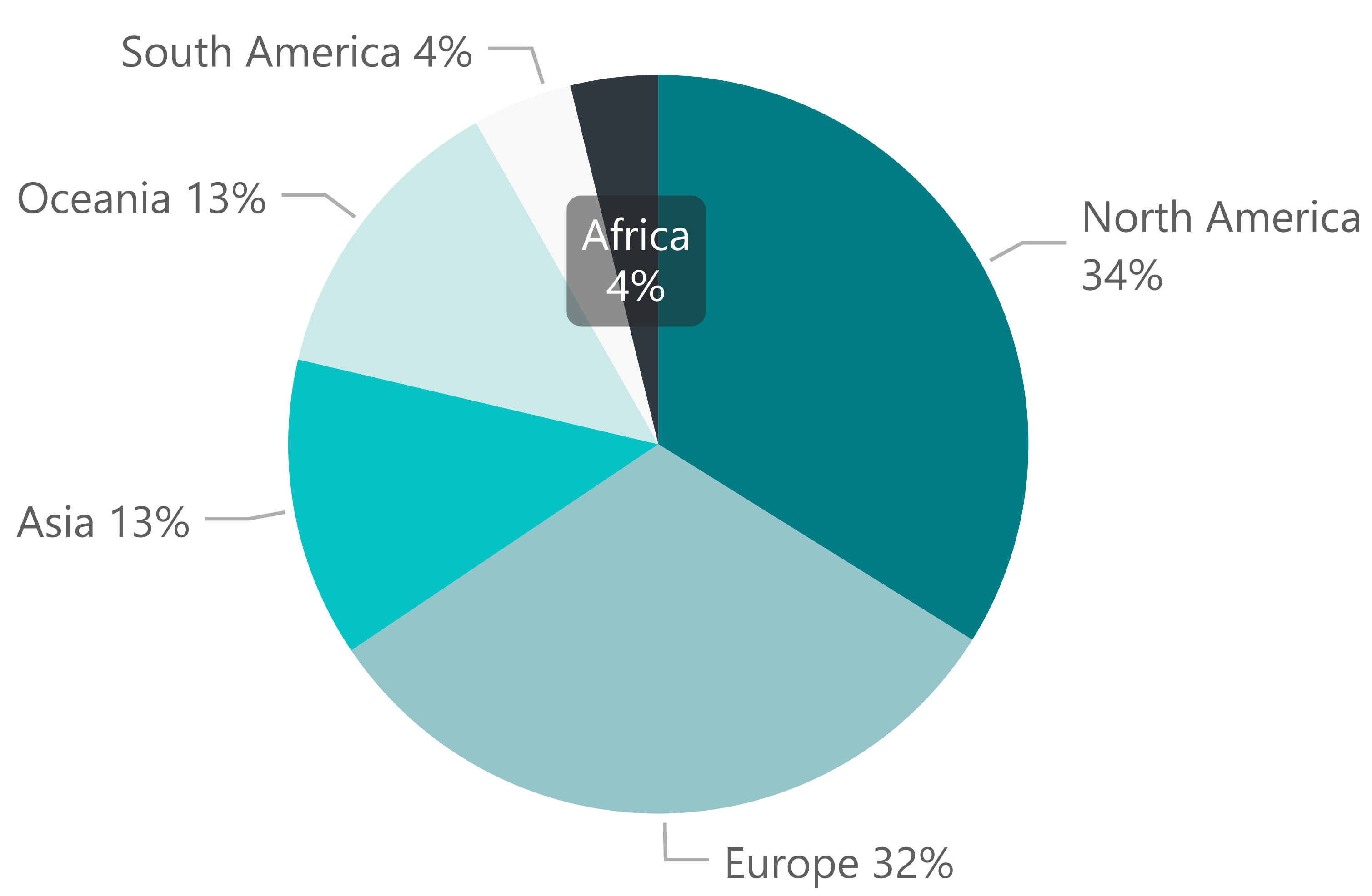

Percentage Contribution per Structure Type
57%
42%
41%
28%
25%
5%
2%
University
NGO
Intergovernmental
Governmental
Private
International
Public


Number of Datasets per Company
18
4
1
1
1
1
1
1
1
1
1
1
1
Google
ESRI
Communities
Impact Observatory
Microsoft
Nazka
RESTEC
Søren Krohn Consulting
World In A Box
Conservation Planning ...
Landowners
soloEO
Vortex

102

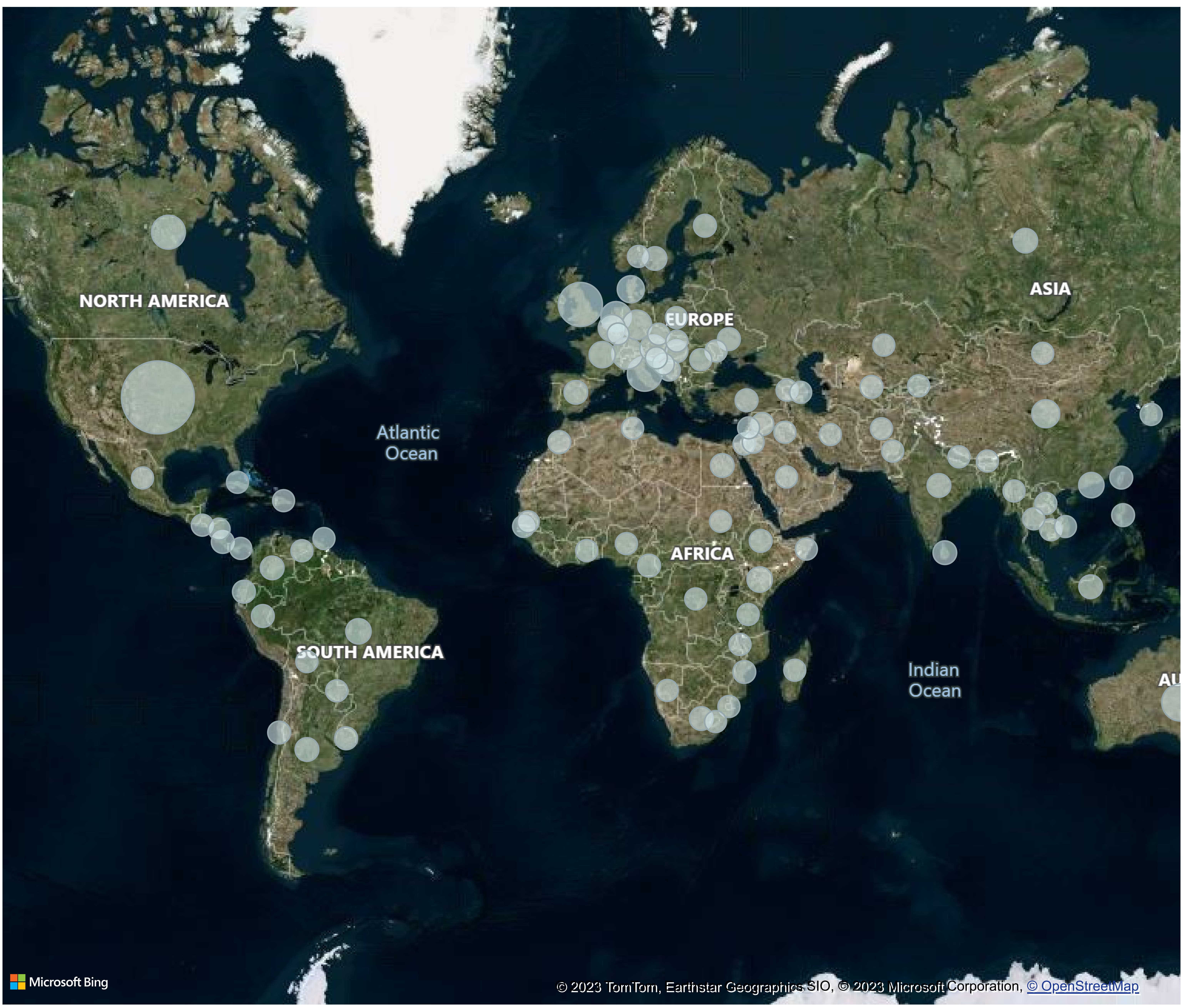
Countries contributing

Relative Contribution per Contitent

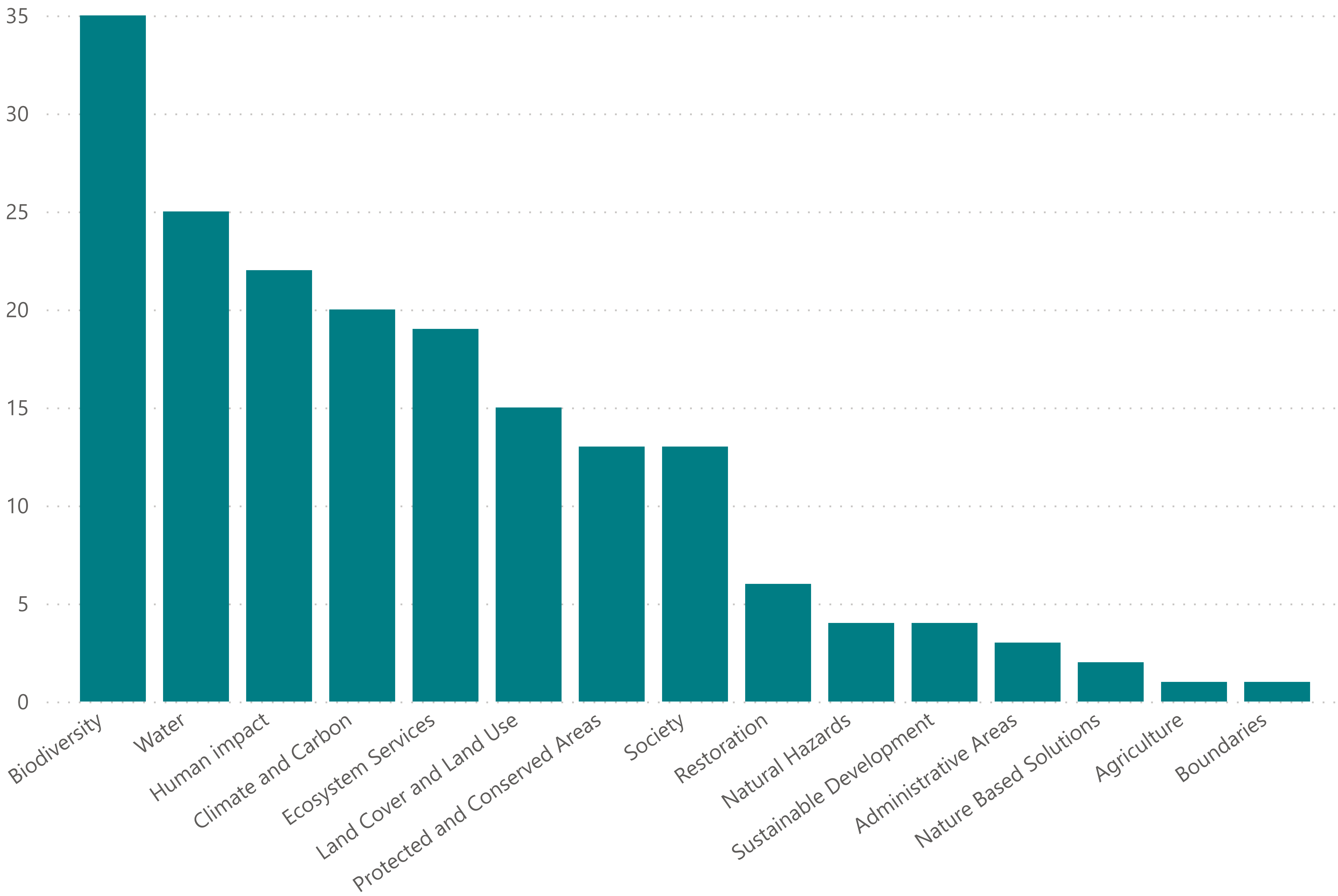


Top 15 Contributors

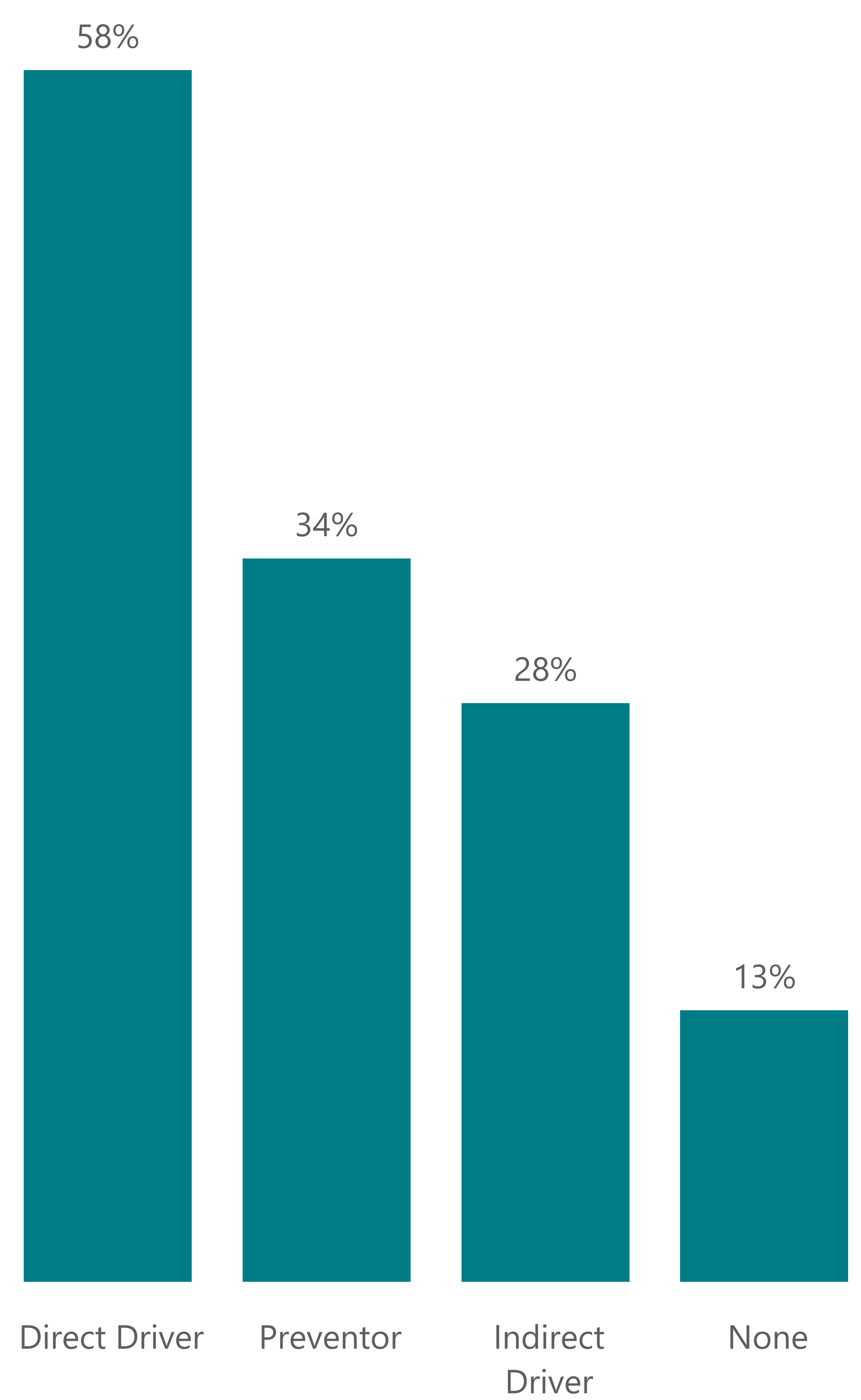
Country	Datasets	Relative Contribution
USA	61	16%
UK	27	7%
Global contributors	22	6%
Australia	19	5%
Canada	15	4%
Italy	15	4%
Switzerland	12	3%
The Netherlands	11	3%
Germany	10	3%
China	8	2%
Belgium	7	2%
Denmark	7	2%
Austria	6	2%
France	6	2%
New Zealand	6	2%



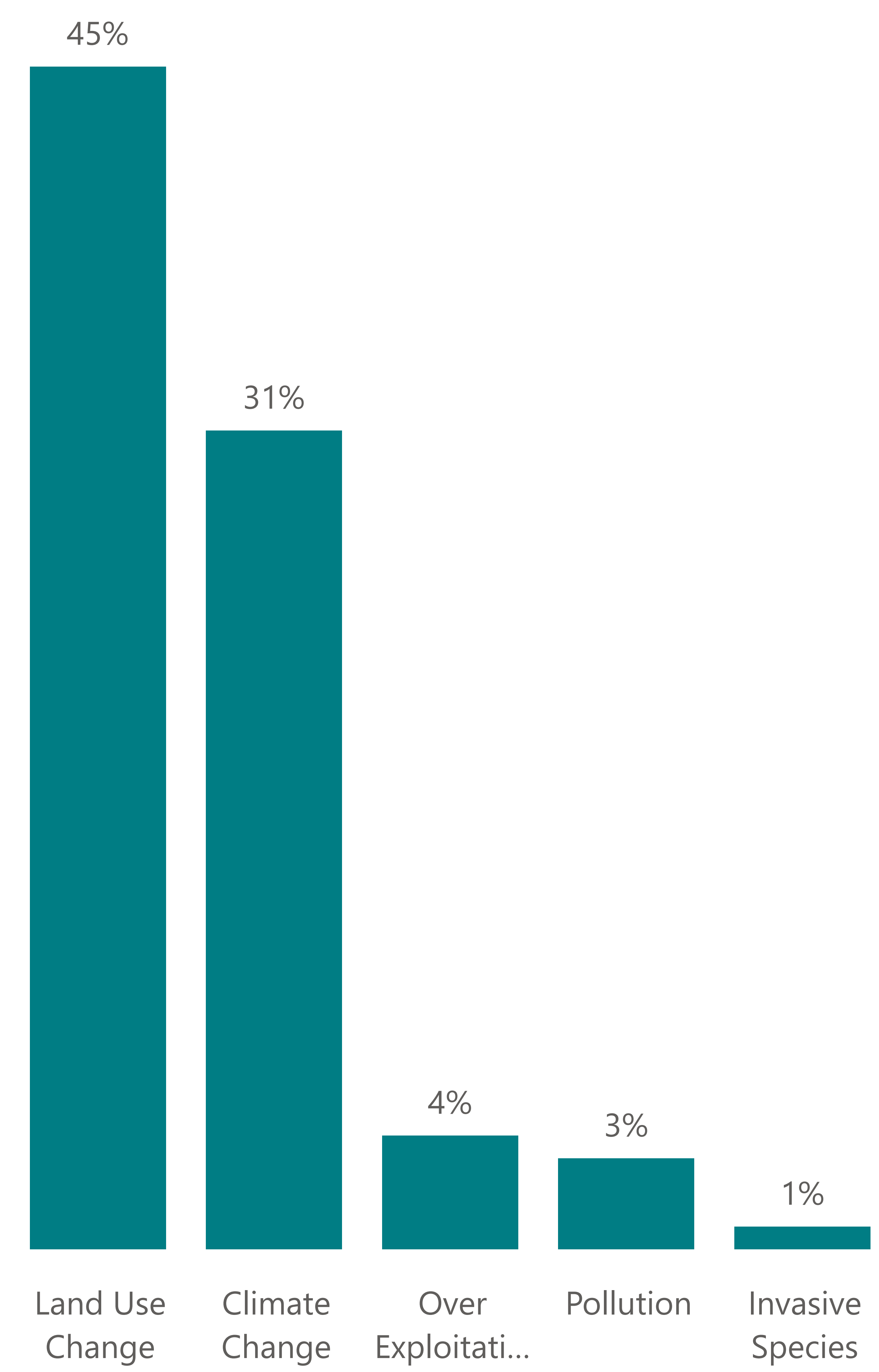
Number of Datasets per Main Category



Percentage Datesets per Driver Type



Percentage Datasets per Direct Driver



Name of data source	Classification	Area	Country of Origin	Type of Provider	Private	Year	Citiz	Remot	No.	Actionability	Type of driver	Frequency	Dataset accuracy
Global Forest Restoration Opportunities to Foster Coral Reef Conservation - Sediment export	Nature Based Solutions, Restoration, Ecosystem (Biodiversity)	Global	Australia, Italy	University		2021	No	No	1	Potentially Actionable	Preventor	Static	**83%**
CBAS - Global Land Cover FCS30 - 2020	Land Cover and Land Use	Global	China	University		2020	No	Yes	1	Potentially Actionable	Land use change	Static	**100%**
Terrestrial Protected Areas WDPA	Protected and Conserved Areas	Global	Global Contributors	Intergovernmental, NGO, Private, Governmental		2020	No	No	1	Actionable	Preventor	Likely to be updated	**83%**
Tree Cover Loss	Human Impact	Global	USA	University, Private, Governmental, Research Institute (Governmental)	Google	2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020	No	Yes	20	Potentially Actionable	Land use change	Likely to be updated	**92%**
NatureMap - Vulnerable Soil Carbon Density	Human Impact, Climate and Carbon, Ecosystem Services, Biodiversity	Global	Global Contributors	Intergovernmental		NA	No	Yes	1	Actionable	Land use change, Preventor	Static	**92%**
Global Surface Water - Occurence Change Intensity 1984-2018	Water, Land Cover and Land Use, Natural Hazards, Freshwater (Water)	Global	Italy, Switzerland	Research Institute (Intergovernmental), Private	Google	2018	No	Yes	1	Potentially Actionable	Climate Change, Land use change	Change	**92%**
Global Solar Atlas: Yearly Average Potential Photovoltaic Electricity Production	Society, Socioeconomic (Society)	Global	Global Contributors, Slovakia	Intergovernmental, Private	Solaris	2019	No	No	1	Potentially Actionable	Indirect driver	Static	**75%**
Global Forest Change	Climate and Carbon, Biodiversity, Ecosystem (Biodiversity)	Global	USA	University, Private, Research Institution (NGO), Governmental	Google	2000, 2012, 2020	No	Yes	4	Potentially Actionable	Land use change	Change	**92%**
Intact Forest Landscapes	Protected and Conserved Areas, Ecosystem (Biodiversity)	Global	USA, Russia	NGO, University, Research Institute (NGO)		2000, 2013	No	Yes	1	Actionable	Land use change	Change	**100%**
NatureMap - Forest Biodiversity Intactness Index	Biodiversity	Global	Global contributors, Brazil, Austria	Intergovernmental, Research Institute (International), NGO		NA	No	No	1	Actionable	Land use change, Indirect driver	NA	**92%**
Global Distribution of Seagrasses	Biodiversity, Ecosystem (Biodiversity), Oceans (Water), Ecosystem Services	Global Oceans	UK	Intergovernmental		2017	No	No	2	Potentially Actionable	Preventor	Static	**83%**
Global Safety Net: High Biodiversity Areas	Biodiversity, Species (Biodiversity)	Global	USA, New Zealand, UK, Hong Kong	NGO, University, Private	Google	2020	No	No	1	Actionable	Preventor	Static	**100%**
Dam Catchments - Global Georeferenced Database of Dams (GOODD)	Human Impact	Global	UK, USA	University		2020	Yes	Yes	1	Potentially Actionable	Land use change, climate change	Static	**100%**
Increase in Soil Organic Carbon (SOC)	Human Impact, Ecosystem Services, Climate and Carbon	Global	China, USA, Kenya, Colombia	University, NGO, Research Institute (NGO)		2034	No	No	2	Actionable	Land use change, preventor	Scenario	**92%**
MODIS Net Primary Production (NPP)	Ecosystem Services, Climate and Carbon	Global	USA	Governmental		2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020	No	Yes	21	Potentially Actionable	Land use change	Likely to be updated	**92%**
Forest Fragmentation - 2012	Biodiversity, Ecosystem (Biodiversity), Restoration	Souther Hemisphe re	Global Contributiors, USA	Intergovernmental, Governmental		2012	No	Yes	12	Potentially Actionable	Land use change	Static	**92%**
CBAS - Global 30-m Cropping Intensity	Agriculture, Sustainable Development	Global	China, USA, Egypt, Mozambique, Ethipoia, University	Research Institute (Governmental)		2021	No	Yes	1	Potentially Actionable	Land use change, Indirect driver	Static	**100%**

Name of data source	Classification	Area	Country of Origin	Type of Provider	Private	Year	Citize	Remote	No. Da	Actionability	Type of driver	Frequency	Dataset accuracy
Forest Structural Integrity Index (FSII)	Biodiversity, Ecosystem (Biodiversity)	Tropical	USA, Canada, Australia, Colombia, France	University, Intergovernmental, Research Institute (NGO)		2019	No	Yes	1	Actionable	Land use change, Indirect driver, Preventor	Static	**92%**
City Water Map (CVM) - Diversion Points	Water, Freshwater (Water)	Global	USA, Germany, Canada	NGO, University, Reseach Institute (Intergovernmental)		2014	No	No	1	Non-actionable	None	Stsatic	**92%**
Global Distribution of Cold-Water Corals	Water, Biodiversity, Oceans (Water), Ecosystems (Biodiversity)	Global	UK	Intergovernmental		2014	No	No	2	Potentially Actionable	None	Static	**83%**
Average Category Accuracy	**100%**	**100%**	**90%**	**80%**	**95%**	**95%**	**95%**	**80%**	**90%**	**95%**	**90%**	**90%**	

Differences compared to the coding in Appendix 1 are highlighted with red.

Average Dataset Accuracy: 91%

Average Category Accuracy: 91%

Overall Accuracy 91%