How much is Biodiversity assessed in Climate Change Litigation?

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ABSTRACT

In the context of the EU Biodiversity Strategy 2030, especially considering the post-COVID-19 era, biodiversity is acknowledged as a crucial asset for people, climate, and the planet, enhancing the resilience of our societies against future threats like "the impacts of climate change, forest fires, food insecurity, disease outbreaks - including by protecting wildlife and fighting illegal wildlife trade." The target of this paper is to investigate the extent to which biodiversity is factored into climate change litigation, at the same time exploring how courts can help achieve more biodiversity protection through climate change mitigation and adaptation. Utilizing a comprehensive review of literature and Natural Language Processing (NLP) for analyzing legal cases, we delve into the nuances of biodiversity in climate litigation, in particular how it is being considered in the valuation of environmental damage. By examining cases where plaintiffs seek remedies for climate-related damage across various jurisdictions, it becomes apparent that harm to lands, human lives, and moral injury are predominant themes in climate lawsuits. By identifying the presence of biodiversity considerations in climate litigation, our aim is to uncover the underlying patterns and implications of how biodiversity is currently addressed in these legal disputes. Considering our global analysis of climate change litigation documents, we undertake both qualitative and quantitative assessments through a combination of normative and positive analysis, including the innovative use of AI and NLP. Our initial findings suggest a notable gap in the explicit consideration of biodiversity within climate litigation, highlighting an area ripe for further exploration and potential integration into legal frameworks. This study contributes to the literature by demonstrating the current shortfall in adequately considering biodiversity in climate change litigation and suggests pathways for incorporating these critical environmental components into future legal actions. This paper can serve as a basis to improve the potential mechanisms through which such litigation can advance biodiversity protection as separate issue from climate change mitigation and adaptation.

Keywords: biodiversity, climate change litigation, environmental damage

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1. BACKGROUND

Biodiversity can be defined as the diversity of life on Earth[2] or the variety within and between all species of plants, animals and micro-organisms and the ecosystems in which they interact. It consists of richness (quantity), evenness (equity in richness) and diversity (composition of species, groups and ecosystems). While there is increasing evidence that biodiversity is declining throughout the globe, scientists proved the linkage between biodiversity and healthy functioning of ecosystems[3], hence implying that a loss in biodiversity is likely to negatively affect either the ecosystem productivity or stability. For this reason, maintaining biodiversity has become so crucial and it can be pursued by facilitating certain natural processes, such as resource partitioning[4], by implementing specific human actions (e.g., creation of biodiversity hotspots, parks) or halting anthropogenic processes that can determine considerable biodiversity loss, such as land use change, exotic species invasions and climate change.[5] In view of halting and reversing the biodiversity loss, several regional agreements play a critical role in biodiversity conservation, each tailored to address the ecological and socio-economic challenges of their respective regions. These agreements complement global efforts, like the Convention on Biological Diversity (CBD), by focusing on specific regional priorities and conditions.

For example, the European Commission in 2011 adopted the so-called 'Biodiversity Strategy to 2020' which mentioned the need to establish green infrastructures and restore at least 15% of degraded ecosystems by 2020 (Target 2).[6] That was in line with the previous

[2] Isbell, F. I., Polley, H. W., & Wilsey, B. J. Biodiversity, productivity, and the temporal stability of productivity: Patterns and processes. Ecology Letters 12, 443–451 (2009).

[3] Particularly, scientists have carried out lab experiments to test whether a change in some components of biodiversity, such as the number of species, can affect specific properties of ecosystem functioning. They concluded that the ecosystem stability is a function of species richness, composition and genetic diversity. Naeem, S. et al. eds. Biodiversity, Ecosystem Functioning, and Human Wellbeing: An Ecological and Economic Perspective. Oxford, UK: Oxford University Press, (2009).

[4] Resource partitioning means that species use different resources. For instance, in the tundra different plant species coexist because they use different sources of nitrogen or they use the same source but at different rates. Dominic Lenzi, Patricia Balvanera, Paola Arias-Arévalo, Uta Eser, Louise Guibrunet, Adrian Martin, Barbara Muraca, Unai Pascual, Justice, sustainability, and the diverse values of nature: why they matter for biodiversity conservation, Current Opinion in Environmental Sustainability, Volume 64, 2023, doi.org/10.1016/j.cosust.2023.101353.
https://www.sciencedirect.com/science/article/pii/S1877343523001008 ; https://pubmed.ncbi.nlm.nih.gov/11780117/

[5] These have been considered to be the most influential among the anthropogenic pressures that can influence biodiversity. Butchart, S. H. M. et al. Global biodiversity: Indicators of recent declines. Science 328, 1164–1168 (2010).

[6] European Commission, Brussels, 20.5.2020, COM(2020) 380 final, COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS, EU Biodiversity Strategy for 2030, Bringing nature back into our lives

objectives of both the Habitats and the Birds Directive provisions (maintaining the favourable conservation status of species, habitats and birds) but it wished to enlarge their scope to all ecosystems. The new 'Biodiversity Strategy 2030' has been adopted in May 2020 to restate and reinforce previous commitments. It distinguishes itself from the previous Communication of 2011[7] by establishing a Trans-European Nature Network of protected areas to cover 30% of EU land and EU seas, a EU Nature Restoration Plan with binding targets[8] and a set of measures to enable a 'transformative change'[9] which includes better tracking, knowledge base and financing. The overarching goal of the EU Biodiversity Strategy 2030 is to prioritize biodiversity throughout the other EU policies, including economic recovery from the pandemic and external actions.

The African Convention on the Conservation of Nature and Natural Resources, otherwise known as the Algiers Convention, is a comprehensive agreement aimed at the conservation of biodiversity and natural resources in the greater African region.[10] Revised in 2003 in Maputo, the convention emphasizes sustainable use and conservation of wildlife, protection of endangered species, and cooperation among African states in environmental management. Similarly, the Amazon Cooperation Treaty aims to promote sustainable development of the Amazon Basin. [11] Signed by eight South American countries (Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname, and Venezuela), the ACT's focus is on the conservation of biodiversity and the sustainable use of resources, recognizing the Amazon's critical role in global climate regulation and biodiversity. Other regional transnational initiatives for biodiversity protection include efforts by the Pacific Islands Forum[12] and the Association of Southeast Asian Nations (ASEAN) Center for Biodiversity (ACB).[13]

While there are indeed many rules, regulations, projects and programs globally concerning biodiversity protection, in this exploratory paper, we seek to assess the extent in which biodiversity is considered in environmental litigation. Doing so is important for many

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0380

[7] European Commission, Brussels, COM(2011) 244 final, COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Our life insurance, our natural capital: an EU biodiversity strategy to 2020 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52011DC0244

[8] Their adoption was scheduled in March 2021, but it was postponed to June 2021 due to the recent war outbreak.

[9] This expression was launched by the IPBES Global Assessment of 2019.

[10] https://au.int/en/treaties/african-convention-conservation-nature-and-natural-resources

[11] https://otca.org/en/project/amazon-cooperation-treaty/

[12] https://forumsec.org/pacific-islands-forum

[13] https://www.aseanbiodiversity.org/

reasons.[14] Litigation that emphasizes biodiversity conservation, among other environmental goals, can play a pivotal role in maintaining environmental integrity for current and future generations.[15] At the same time, biodiversity considerations in legal outcomes can drive the development and enforcement of more effective environmental policies. Environmental litigation as well as legal processes not directly related to the environment but with consequences therefore often sets precedents and can influence the creation of laws, regulations and norms that prioritize ecological well-being.[16] By explicitly recognizing the importance of biodiversity, legal systems can foster a more holistic approach to environmental governance. This includes not only protection and restoration efforts but also the implementation of sustainable use practices that allow humans to benefit from nature without compromising environmental health.

Furthermore, integrating biodiversity into environmental litigation outcomes can promote environmental justice, especially for indigenous populations.[17] Many local communities are directly dependent on biodiverse ecosystems for their livelihoods, cultural heritage, and well-being.[18] Legal decisions that prioritize biodiversity conservation can help protect these communities from the adverse effects of environmental degradation, such as human rights violations, loss of access to traditional foods and medicines, and displacement.[19] By acknowledging the intrinsic value of biodiversity, environmental litigation can contribute to fairer outcomes that respect the rights and needs of all stakeholders, including those often marginalized in environmental decision-making processes.[20] Lastly, the inclusion of biodiversity considerations in legal judgments is vital for global conservation efforts. The international community has indeed recognized the importance of biodiversity through various treaties and

[14] Judge Anthony Lucky (2018) Diversity in Judgments: The Role of the Courts in Promoting Biodiversity, Journal of International Wildlife Law & Policy, 21:1, 1-10, doi.org/10.1080/13880292.2018.1439702
[15] Bertram D. 'For You Will (Still) Be Here Tomorrow': The Many Lives of Intergenerational Equity. Transnational Environmental Law. 2023;12(1):121-149. doi:10.1017/S2047102522000395
[16] Shtob, D. and Fox Besek, J. (2021), Environmental Precedent: Foregrounding the Environmental Consequences of Law in Sociology. Sociol Forum, 36: 712-734. https://doi.org/10.1111/socf.12727
[17] https://www.iied.org/theres-justice-battle-for-biodiversity
[18] Tim K. Mackey and Bryan A. Liang, 2012:
Integrating Biodiversity Management and Indigenous Biopiracy Protection to Promote Environmental Justice and Global Health American Journal of Public Health 102, 1091_1095,
https://doi.org/10.2105/AJPH.2011.300408https://ajph.aphapublications.org/doi/full/10.2105/AJPH.2011.300408
[19] A. SAVARESI and J. SETZER, 'Rights-based litigation in the climate emergency: mapping the landscape and new knowledge frontiers' (2022) Journal of Human Rights and the Environment 7, 34.
[20] MARTIN, ADRIAN, et al. "Global Environmental Justice and Biodiversity Conservation." The Geographical Journal, vol. 179, no. 2, 2013, pp. 122–31. JSTOR, http://www.jstor.org/stable/43868542. Accessed 9 Apr. 2024.

agreements; however, glaring gaps still exist.[21] Legal systems that align with these international commitments by prioritizing biodiversity in their rulings can contribute to the global effort to bridge these gaps and halt biodiversity loss. By reinforcing the importance of biodiversity conservation through judicial mechanisms, countries not only align their actions with their treaty commitments regarding biodiversity, but also contribute to creating global customary norms for biodiversity protection.

In this paper, we chose to focus our analysis on climate litigation in particular. Doing so emphasizes the interdependence of climate change and biodiversity loss, both being deeply interconnected issues. Climate change is one of the leading causes of biodiversity loss, altering habitats and threatening species with extinction.[22] Conversely, healthy, biodiverse ecosystems play a critical role in climate regulation, through processes such as carbon sequestration by forests and oceans.[23] By incorporating biodiversity considerations into climate litigation, legal actions can address these interconnections, advocating for solutions that mitigate climate change while preserving or restoring biodiversity. This approach can lead to more effective and sustainable environmental outcomes. Secondly, mentioning biodiversity in climate litigation can help ensure that legal remedies consider the full ecological impacts of climate change. This broadens the scope of litigation beyond reducing greenhouse gas emissions to include actions that protect and restore ecosystems. For example, a legal case that leads to the protection of a forest does not only contribute to carbon storage but it also preserves habitat for countless species. Recognising the importance of biodiversity within climate litigation can thus encourage holistic solutions that address multiple environmental issues simultaneously. Finally, through the same mechanisms mentioned above, incorporating biodiversity into climate litigation can improve environmental justice outcomes as well as reinforce international environmental commitments and foster global cooperation.

This paper explores the references to biodiversity in global climate change litigation. We then discuss how international jurisprudence could, both positively and normatively, achieve

[21] Juste Ruiz, J. (2021). Gaps in International Biodiversity Law and Possible Ways Forward. In: Campins Eritja, M., Fajardo del Castillo, T. (eds) Biological Diversity and International Law. Springer, Cham. https://doi.org/10.1007/978-3-030-72961-5_3
[22] Habibullah, .S., Din, B.H., Tan, SH. et al. Impact of climate change on biodiversity loss: global evidence. Environ Sci Pollut Res 29, 1073–1086 (2022). https://doi.org/10.1007/s11356-021-15702-8
[23] Shin, Y.-J.,et al. (2022). Actions to halt biodiversity loss generally benefit the climate. Global Change Biology, 28, 2846–2874. https://doi.org/10.1111/gcb.16109https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.16109

greater production of biodiversity protection through climate change mitigation and adaptation, and explore the future of the role of law and policy in achieving stronger judicial protection of biodiversity. This paper contributes to the literature in two substantive ways. First, the paper highlights a critical gap in climate studies. We hypothesize that traditional approaches to valuing damages in formal legal proceedings often overlook the intrinsic and extrinsic values of biodiversity. This omission not only undermines a comprehensive assessment of the true costs of environmental degradation but also limits the effectiveness of legal remedies in addressing the multiple impacts of climate change on ecosystems. By explicitly identifying the absence of biodiversity considerations in these valuations, this paper prompts a re-evaluation of current valuation methodologies. This suggests the need for a more integrated approach that captures the complex interdependencies between biodiversity and climate change, thereby ensuring that legal outcomes more accurately reflect the environmental, social, and economic at stake.

Our second contribution is the application of artificial intelligence (AI) and natural language processing (NLP) techniques to empirically examine the presence of "biodiversity" and related terms in climate litigation documents by transforming litigation documents into analyzable data. This approach allows for a more nuanced textual analysis that goes beyond mere summary statistics and encompasses a broader contextual understanding of biodiversity in formal legal proceedings. To the best of our knowledge, no study of this global scope has been undertaken to date.

In Part II, we discuss the methodology we employed, the assumptions we made, and the limitations of our approach. In Part III, we discuss the results of our findings and their implications for climate litigation and general environmental protection, both in the short and long term. We conclude in Part IV.

2. METHODOLOGY

In our research, the use of artificial intelligence (AI) and natural language processing (NLP) represents a nuanced approach to treating text as data, enabling a more comprehensive analysis of biodiversity references in formal legal proceedings. Our methodology integrates

several text analysis techniques to systematically evaluate the presence and representation of biodiversity in climate litigation precedents across jurisdictions. Using natural language processing (NLP), we aim to uncover patterns, themes, and the evolution of biodiversity considerations in global jurisprudence over time. The methodology consists of the following components:

2.1 AI and NLP

1. **Basic Text Analytics:** AI and NLP technologies are employed to transform unstructured text from litigation documents into structured, analyzable data. We begin by pre-processing litigation documents, including tokenization (breaking text into words or phrases), stemming (reducing words to their root form), and removing stop words (filtering out common words), to clean and prepare the data for more in-depth analysis. These preprocessing steps are critical to converting natural language into an operable format. Summary statistics such as frequency analysis are then used to identify the most common phrases and terms related to biodiversity, highlighting key concerns within climate litigation in this regard.
2. **Pattern Recognition:** Machine learning models in the NLP domain excel at identifying patterns and trends in large textual datasets that would be impossible for humans to detect manually. We intend to use AI algorithms to extract recurring themes, concepts, terminology, and legal bases related to biodiversity in the litigation documents, providing insights into how biodiversity issues are framed and addressed in these complaints and judgments.
3. **Keyword-in-context (KWIC) Analysis:** NLP allows for the nuanced interpretation of language, allowing the research to go beyond mere word counts to understand the explicit and implicit context in which the concept of biodiversity is used. To understand the surrounding discourse in which biodiversity-related terms are used, keyword-in-context (KWIC) analysis is used to examine the proximity of relevant terms to legal arguments, reasoning, and outcomes related to biodiversity in the cases studied.

4. **Dictionary-based Methods:** The creation and application of a biodiversity-focused lexicon represents a targeted approach to textual analysis. We define, develop, and apply a concept-specific dictionary curated with terms and phrases relevant to biodiversity issues to systematically classify, analyze, and evaluate how the concept of biodiversity is discussed and prioritized in various legal documents. This approach allows for both a quantitative and qualitative assessment of biodiversity mentions and their correlation with litigation outcomes or thematic focus.

2.2 Data Plan

1. **Data Acquisition:**
    - **Source Identification:** Our primary sources will include international climate change legal databases, court archives, and repositories of environmental law organizations and other legal bodies, with the goal of providing comprehensive coverage of climate change litigation in the chosen jurisdictions around the world.
    - **Acquisition Preparation:** Prior to any analysis, we conduct a comprehensive review of license agreements and terms of use to confirm that all data can be used for research purposes. For data that is not publicly available or is subject to special terms of use, we shall obtain the necessary permissions or licenses by contacting copyright holders or institutions to secure the rights to use the data for this research.
    - **Data Extraction and Organization:** Relevant documents, including case opinions, briefs, and other legal filings, are either directly requested or digitally extracted in accordance with their respective use policies and applicable laws (e.g., General Data Protection Regulation (GDPR), California Consumer Privacy Act (CCPA)). Limited metadata, such as case dates, jurisdictions, and outcomes, may be included to support analysis, while we apply the data minimization principle to

ensure that only the data necessary for research purposes is collected and stored.

2. **Data Processing:**
    - **Anonymization:** In cases where documents may contain sensitive information, we will use anonymization techniques to protect the identities of the individuals or entities involved. We strive to maintain the highest standards of ethical research practices and privacy compliance.
    - **Preprocessing:** Text data is pre-processed to convert PDFs or scanned documents into analyzable text formats. This may include OCR processing, if necessary, followed by cleanup steps as outlined in our methodology.
    - **Analysis Dataset Creation:** The cleaned text data is organized into a structured dataset ready for analysis. This dataset is annotated with metadata and prepared for the application of NLP techniques.
3. **Data Storage and Security:**
    - **Secure Storage:** We use encrypted storage solutions to keep data secure and safeguard sensitive or personally identifiable information. Access to this data should be limited to authorized personnel.
    - **Handling Protocols:** We will also establish clear data handling protocols that outline how data is accessed, shared, and used within the research team. This includes guidelines for data encryption, secure transmission, and the eventual disposal and archiving of data.
4. **Documentation and Transparency:**
    - **Use Agreements:** We will document all data use agreements, permissions, and licenses obtained for the research. This documentation should detail the scope of permitted data use and any restrictions and should be available upon request.
    - **Transparent Reporting:** As part of our commitment to open science and the collaborative advancement of knowledge, we intend to report data sources, key analytical processes, compliance measures, and any restrictions on data use in both our publications and repositories such as GitHub. This approach not only

promotes the transparency, credibility, and integrity of our research, but also encourages peer feedback, replication of results, and further innovation in the field.

Our methodology and data plan outline a structured, compliant approach to analyzing how biodiversity is referenced and addressed in global climate litigation, using natural language processing and textual analysis to uncover insights that could guide future theory and policy development. By systematically examining the representation of biodiversity in climate litigation, this research strives to contribute to a deeper understanding of environmental jurisprudence and its evolution in response to the biodiversity crisis.

2.3 Preliminary Data Sources

Table 1 List of Data Sources

Website	Brief Description
Climate Change Litigation Databases	The Climate Change Litigation Databases, administered by the Sabin Center for Climate Change Law, include two comprehensive resources: the U.S. Climate Change Litigation Database and the Global Climate Change Litigation Database. Created to catalog climate change-related legal actions and proceedings, these databases compile case documents that directly involve environmental and climate law, policy, or science. Updated regularly, the databases serve as our central resources for understanding the scope and nature of climate change litigation worldwide.
ECOLEX	ECOLEX, a joint initiative of the Food and Agriculture Organization of the United Nations (FAO), the International Union for Conservation of Nature (IUCN), and the United Nations Environment Programme (UNEP), serves as a comprehensive environmental law information service aimed at

	building global capacity. It combines the resources of the participating organizations to provide extensive information on environmental law, including treaties, national legislation, judicial decisions, and literature. The platform is designed to make environmental law accessible worldwide and to facilitate the development of legal tools for environmental management and sustainable development.
ENCORE	The ENCORE project compiles global data relevant to natural capital assets and drivers of environmental change to assess risks of disruption. Data is collected from internet searches, scientific literature, and UNEP-WCMC projects, focusing on datasets that allow the assessment of changes in natural capital assets and environmental drivers. For each dataset, criteria such as update frequency and temporal coverage are captured to assist financial institutions in decision-making.
Equator Initiative	The Equator Initiative aims to bring together diverse stakeholders to promote local sustainable development solutions that benefit people, nature, and communities. Their Nature-Based Solutions Database is a global compilation of over 500 communities on five continents, showcasing a wealth of ideas for achieving the UN Sustainable Development Goals through nature-based actions.
Integrated Biodiversity Assessment Tool	The Integrated Biodiversity Assessment Tool (IBAT) provides access to three key global biodiversity datasets: the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, the World Database of Protected Areas, and the World Database of Key Biodiversity Areas. These databases provide comprehensive information on the conservation status of species, protected areas, and key biodiversity areas to support informed decisions for environmental protection and sustainability.

International Tribunal for the Law of the Sea	The website of the International Tribunal for the Law of the Sea details the judicial proceedings and decisions relating to international maritime disputes and legal issues. It features cases covering various aspects of maritime law, including delimitation, detention, and environmental regulation, with each case providing a unique insight into the complexities of international maritime jurisdiction on issues such as biodiversity.
Nature-based Solutions Evidence Tool	The Nature-based Solutions Evidence Tool is an interactive platform designed to link nature-based solutions (NbS) to climate change adaptation outcomes. It allows users to explore the effectiveness of different nature-based interventions, compare their social, economic, and environmental impacts, and filter results by region, ecosystem type, or outcome type. This tool facilitates direct links from scientific research to national climate policy, supporting informed decision-making on climate adaptation strategies.
SHIFT	SHIFT is a search engine for business sustainability resources, offering a curated set of sustainability frameworks, tools, and guidelines. It allows users to browse, compare, and access various resources to improve their sustainability practices, with features for rating and reviewing tools within the community.

3. PRELIMINARY RESULTS AND DISCUSSION

3.1 Preliminary Results

Using the keywords "biodiversity" and "biological diversity" as the primary filter, our very first review of case summaries from the Global Climate Change Litigation Database yields the following results:

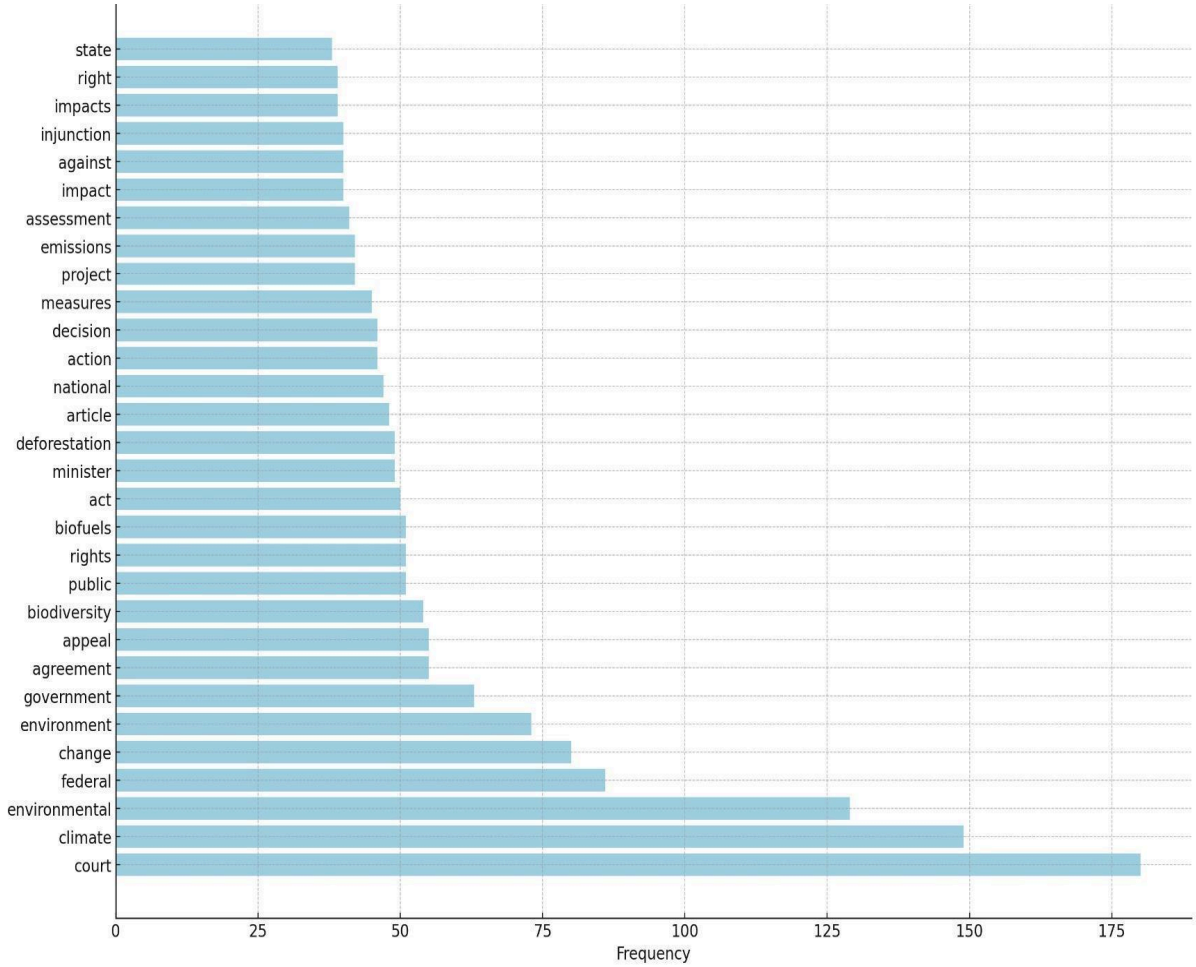
- **Summary Statistics:**
    - **Number of Unique Cases:** 47
    - **Time (in Year):** The filing years for these cases range from 2007 to 2023, with a median filing year of 2020. The median filing year is approximately 2018.
    - **Core Object:** There are 44 unique core objects identified in these cases, with some core objects appearing more than once. A notable core object that appears twice relates to whether the EU's renewable energy policies on biofuels and bioliquids are consistent with the EU's obligations under international agreements due to their impact on biodiversity.
    - **Word Count:** The combined summaries consist of 20,121 words.
    - **Unique Words:** There are 3,057 unique words across the summaries.
- **Complexity Analysis:**
    - **Lexical Diversity:** The lexical diversity is about 0.152, indicating a moderate level of vocabulary in the text.
    - **Flesch Readability Score:** The approximate Flesch Readability Score is 26.20/100. This indicates that these case documents are quite difficult to read and generally require a college-level education to understand.
- **Sentiment Analysis:** Based on the Lexicoder Sentiment Dictionary, we calculate the following sentiment matrices.
    - **Sentiment Polarity:** Polarity scores range from -1 (very negative) to +1 (very positive). The sentiment polarity score of our surveyed cases is 0.051, indicating a slightly positive sentiment overall.
    - **Sentiment Subjectivity:** Subjectivity scores also range from 0 (objective) to 1 (subjective). The sentiment subjectivity score of our cases is 0.366, indicating that the text is relatively objective.

- **Word Cloud:** The generated word cloud visualizes the most common terms within the summaries. Words such as "court", "climate change", "biofuel", "deforestation", "emission", "coal", "australia", and "brazil" appear prominently, indicating some of the key themes and concepts related to legal and environmental concerns in cases that explicitly refer to "biodiversity" or "biological diversity". In Figure 1 a word cloud visualizes the dominant terms in the cases we studied.

Figure 1: Word cloud with the dominant terms in the cases analyzed

- **Frequency Summary:** Further refinement of the word exclusions resulted in the following frequency plot showing the top 30 words used in these cases. The visualization confirms the co-occurrence of terms such as "climate" “biofuels", "deforestation", "rights", and "assessment" with the representation of "biodiversity" or "biological diversity". In Figure 2 we present a summary of the Top 30 words in our biodiversity cases analyzed.

Figure 2: Top 30 words in our studied biodiversity case summaries

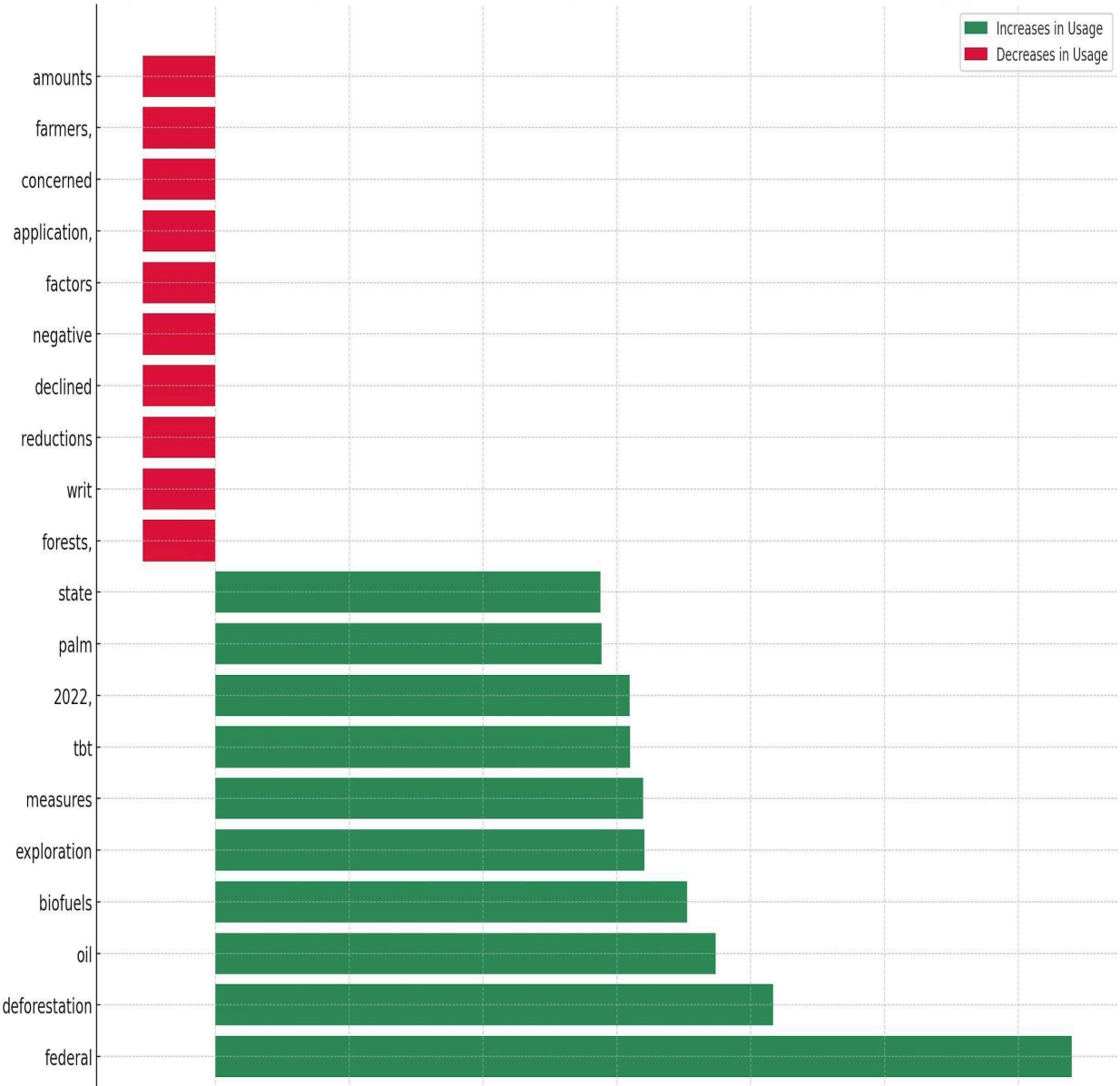


- **Relative Frequency Analysis (Keyness):** Assuming that COVID-19 provides a potentially relevant benchmark, we perform a relative frequency analysis comparing word usage before and after (including) 2019.
    - **Top 10 Increases in Word Usage:**
        - *federal*: Increase of approximately 6.40 occurrences per 1000 words
        - *deforestation*: Increase of approximately 4.17 occurrences per 1000 words
        - *oil*: Increase of approximately 3.74 occurrences per 1000 words
        - *biofuels*: Increase of approximately 3.52 occurrences per 1000 words
        - *exploration*: Increase of approximately 3.20 occurrences per 1000 words

- *measures*: Increase of approximately 3.20 occurrences per 1000 words
- *tbt*: Increase of approximately 3.10 occurrences per 1000 words
- *2022*: Increase of approximately 3.09 occurrences per 1000 words
- *palm*: Increase of approximately 2.88 occurrences per 1000 words
- *state*: Increase of approximately 2.88 occurrences per 1000 words

- **Top 10 Decreases in Word Usage:**
  - Words including *forests*, *writ*, *reductions*, *declined*, *negative*, *factors*, *application*, *concerned*, *farmers*, and *amounts* each show a decrease of approximately 0.54 occurrences per 1000 words.

Figure 3: Top 30 increases vs. Top 10 decreases in word usage, with 2019 as the benchmark.



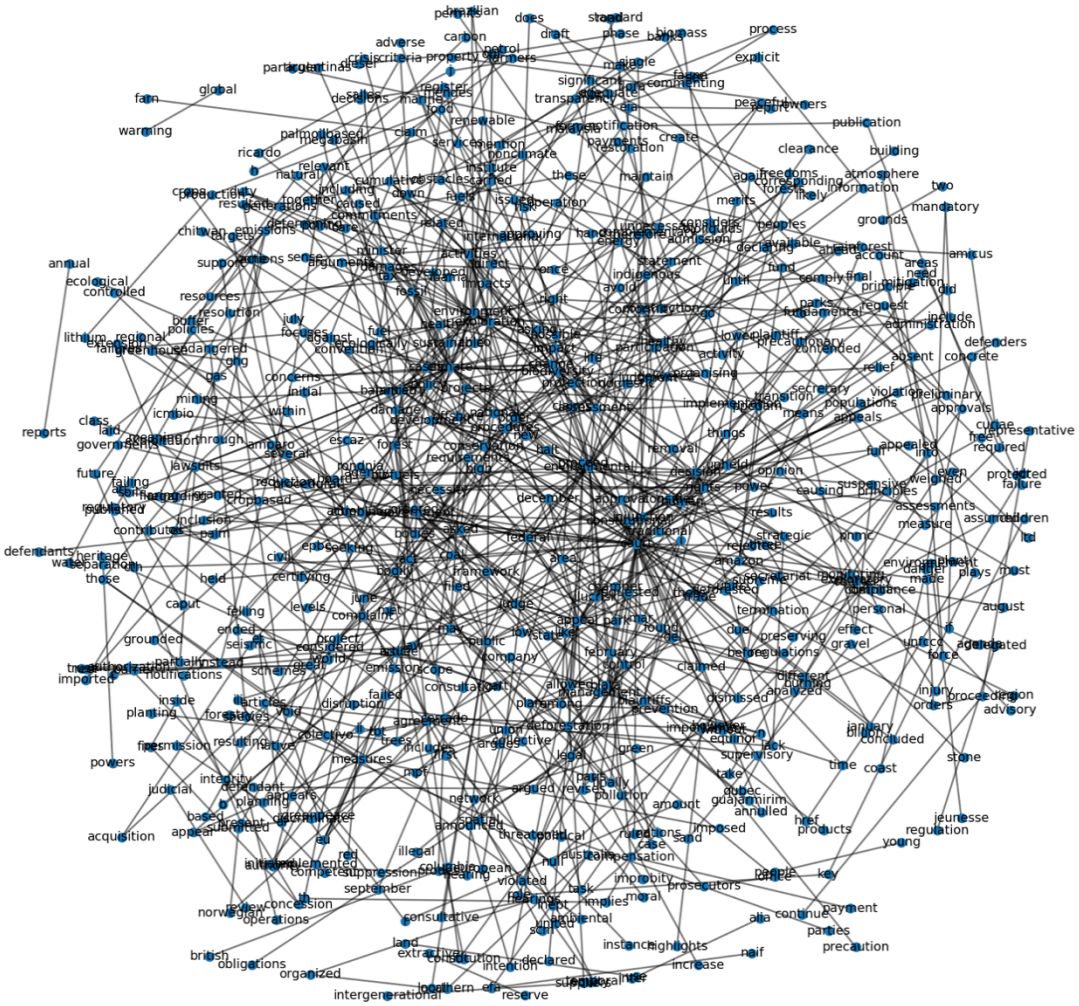
- **Text Network Analysis:** In order to gain more insight into which terms and concepts are most closely associated with each other in legal cases that contain a reference to "biodiversity" or "biological diversity," we can construct networks in which nodes represent unique words from the case summaries and edges between nodes indicate co-occurrences within certain proximity in the text.
    - **Global Network:** Based on the previously filtered text (excluding common stop words, propositions, articles, and specified words), we use text network analysis visualization to explore the relationships between key terms found in the summaries of biodiversity-related legal case summaries, focusing on words that co-occur within proximity of three words of each other.

      In Figure 4, a network graph depicts the interconnectedness the key terms in the cases analyzed.
    - **Central Network:** To get a clearer view, especially around the dense center of the network, we can further refine our approach by focusing on the nodes with the highest degree of centrality and focusing on the subgraph consisting of the top 20 most central nodes within the previous network. In the following graph, we can see that "biodiversity" is directly connected to "environment", "climate", "law", "federal court", and "decision", suggesting that not only judicial but also administrative and legislative decisions could be closely related to environmental and climate concerns in the context of biodiversity. It could also be inferred that legal frameworks and federal decisions may play a crucial role in their discourse and management, which is consistent with the observation that legal

proceedings in this area are increasingly directed not only at companies but also at governments.[24]

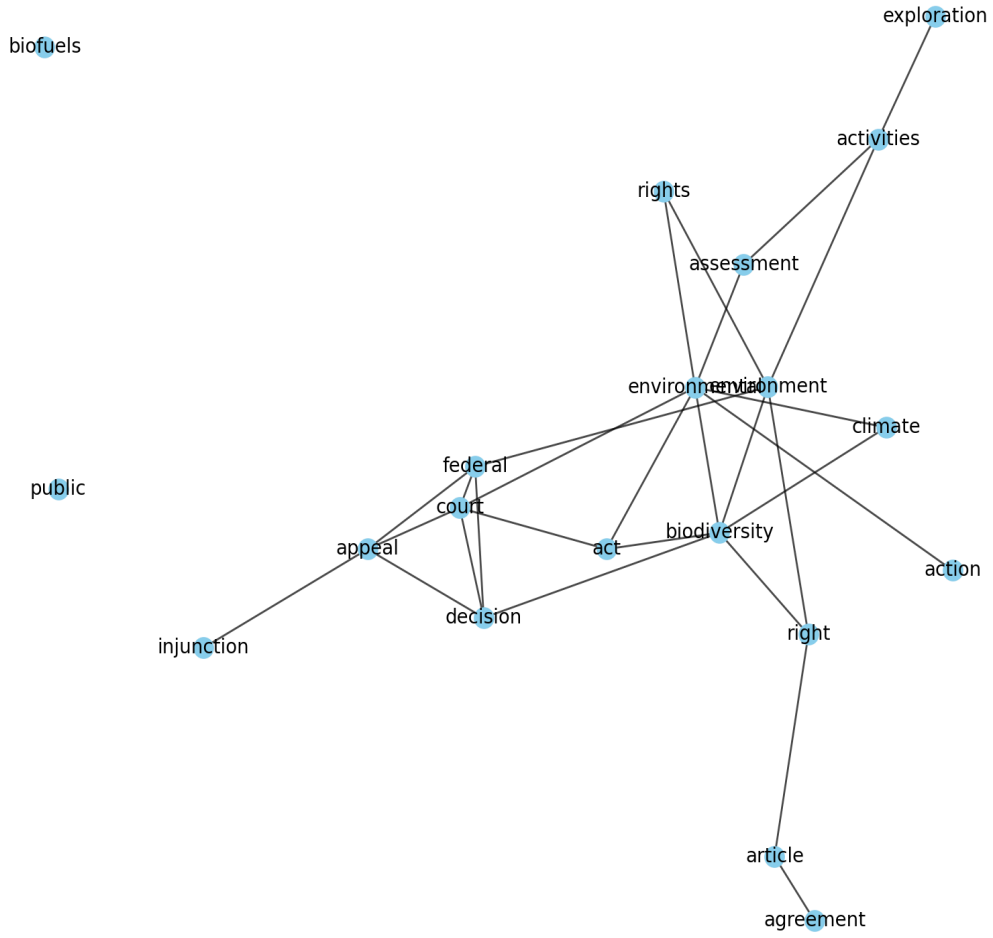
In Figure 5, a network graph depicts the interconnectedness of the most central key terms and "biodiversity" in the cases analyzed.

FIGURE 4: A network graph demonstrating the interconnectedness of the key terms in the cases analyzed



[24] https://www.dlapiper.com/en/insights/publications/2022/12/cop15-biodiversity-and-litigation-risks

Figure 5: Network graph demonstrating the interconnectedness of the most central key terms and "biodiversity" in the cases analyzed



3.2 Discussion

We divide the discussion into two main parts. First, we discuss the implications of the results above, particularly those related to lexical diversity, Flesch readability, sentiment polarity and sentiment subjectivity. Then we delve into how biodiversity is assessed in climate litigation.

Applications of NLP in Legal Research on Environmental Law and Biodiversity

The application of NLP techniques in legal research, particularly in the context of environmental law and biodiversity, can provide significant insights and aid in various aspects of legal analysis and decision-making. In this section, we cover lexical diversity, Flesch readability, sentiment polarity and sentiment subjectivity.

Lexical diversity refers to the range and variety of words used in a text. It is an important measure in natural language processing (NLP) as it helps to assess the richness of the vocabulary and the complexity of the language used. Several indices measure lexical diversity, including the Type-Token Ratio (TTR), which is the ratio of unique words (types) to the total number of words (tokens). Higher lexical diversity typically indicates more sophisticated and varied language use, while lower diversity can suggest repetition or simpler language.

In environmental law and biodiversity, lexical diversity analysis can help in understanding the complexity and range of language used in legal documents, policy papers, and international agreements. For instance, higher lexical diversity in legal texts may indicate comprehensive coverage of issues and nuanced discussion, which is crucial for addressing complex environmental challenges. Analyzing the lexical diversity of court opinions and legislative texts can also reveal how the language and focus of environmental law have evolved over time.

The current dataset shows lexical diversity of 0.152, suggesting a moderate level of vocabulary variation. While the language is somewhat varied, it may not fully capture the intricate nuances and complex terminology often required in legal arguments about biodiversity and climate impacts. Legal documents that aim to address such issues may benefit from a higher lexical diversity to encompass the wide range of scientific, ecological, and legal terms necessary for comprehensive arguments.

The Flesch Readability Score is a measure of how easy a text is to read. Developed by Rudolf Flesch, this score uses two key metrics: the average sentence length (ASL) and the average number of syllables per word (ASW).

Higher scores indicate easier readability, with scores above 60 suggesting that the text is easily understood by 13- to 15-year-olds, while lower scores suggest that the text is more complex and may be more suitable for advanced readers.

A Flesch readability score of 26.20 indicates that the text is very difficult to read, typically suited for readers with advanced education levels, such as those holding graduate degrees. In the context of analyzing legal cases where biodiversity is included in the assessment for damages in climate litigation, this low readability score suggests that the language used is highly complex and dense. This complexity could make it challenging for non-experts, including judges, juries, and policymakers, to fully understand the nuances and details of the legal arguments and scientific evidence presented. As a result, critical information regarding biodiversity and its implications for climate damages might not be effectively communicated or comprehended, potentially influencing the outcomes of these cases.

Furthermore, the low readability could hinder effective interdisciplinary collaboration, as legal professionals, scientists, and environmentalists might struggle to align their understanding and approaches. In climate litigation, where biodiversity assessments are crucial, clear and accessible communication is essential to ensure that all stakeholders are on the same page. Enhancing the readability of legal texts by simplifying language and providing clear explanations could improve understanding and facilitate more informed decision-making processes, ultimately leading to more robust and effective litigation outcomes that accurately reflect the importance of biodiversity in assessing climate-related damages.

The readability of legal documents is critical for ensuring that they are accessible to a wide audience, including policymakers, practitioners, and the public. Flesch Readability scores can help in evaluating whether environmental laws, regulations, and policy documents are written in a way that is understandable to non-experts. Improving readability can enhance public engagement and compliance with environmental regulations, as well as facilitate the dissemination of important biodiversity information.

Sentiment polarity measures the positivity or negativity of a text. It is a crucial aspect of sentiment analysis, which is the process of computationally identifying and categorizing opinions expressed in a piece of text. Sentiment polarity typically ranges from -1 to 1, where -1 indicates extremely negative sentiment, 0 is neutral, and 1 is extremely positive. This measure helps in understanding the emotional tone and attitude expressed in the text.

Sentiment polarity analysis can be employed to gauge the public and judicial sentiment towards specific environmental issues or policies. For example, analyzing public comments on proposed environmental regulations can help policymakers understand the level of public support or opposition. Similarly, analyzing the sentiment polarity of judicial opinions in environmental cases can provide insights into how courts view certain environmental policies and principles, which can influence future litigation strategies and policy formulation.

In this set of cases, a sentiment polarity score of 0.051 indicates a slightly positive sentiment, but it is very close to neutral. In the context of legal cases involving biodiversity assessments for damages in climate litigation, this near-neutral sentiment suggests that the documents maintain a balanced and objective tone. This is beneficial for presenting factual and unbiased information, which is crucial in legal settings where decisions are based on evidence and logical reasoning. Such a tone ensures that the arguments remain professional and credible, focusing on the scientific and legal merits of the case without being swayed by emotional appeals.

However, the slightly positive sentiment might also reflect a cautious optimism or a tendency to emphasize positive aspects, such as successful conservation efforts or legal precedents that favor environmental protection. This could be advantageous in highlighting the importance of biodiversity in the context of climate litigation, subtly reinforcing the need for its inclusion in damage assessments. Nevertheless, the overall near-neutral score ensures that the documents do not come across as overly biased, thereby maintaining their integrity and persuasiveness. For stakeholders involved, this balanced approach helps in comprehending the complex interplay between biodiversity and climate impacts, ultimately aiding in more informed and equitable legal outcomes.

Sentiment subjectivity indicates the degree to which a text expresses personal opinions, feelings, or attitudes as opposed to objective information. This measure ranges from 0 (completely objective) to 1 (completely subjective). High subjectivity suggests that the text is rich in personal views and opinions, while low subjectivity indicates a focus on factual and objective content.

A sentiment subjectivity score of 0.366 indicates that the surveyed legal cases have a moderate level of subjectivity. This suggests that while the documents contain factual and objective information, there is also a significant presence of personal opinions, interpretations, or speculative statements. In the context of climate litigation where biodiversity is included in the assessment for damages, this moderate subjectivity can have both positive and negative implications. On the positive side, it means that the legal arguments might incorporate expert opinions, personal testimonies, and nuanced interpretations of the law and scientific data. This can enrich the legal discourse by providing a broader perspective on the importance of biodiversity in assessing climate damages, potentially making the arguments more relatable and persuasive to judges and juries.

However, the presence of subjectivity also carries potential drawbacks. In legal contexts, where objectivity and impartiality are paramount, a moderate level of subjectivity might raise concerns about bias or the influence of personal beliefs over hard evidence. This could undermine the credibility of the arguments presented, especially if the subjective statements are perceived as overshadowing empirical data. For cases involving biodiversity and climate litigation, where scientific accuracy and legal precision are critical, ensuring that subjective elements do not detract from the factual basis is essential. Balancing subjective insights with rigorous evidence can help maintain the integrity of the legal arguments and support more robust and defensible outcomes in the assessment of climate-related damages.

Understanding the degree of subjectivity in advocacy documents, policy proposals, and public statements can help in distinguishing between factual reporting and opinion-based arguments. In environmental law, where advocacy plays a significant role, analyzing sentiment subjectivity can identify potential biases and the persuasive strategies used by different

stakeholders. This information is valuable for policymakers and legal researchers who need to assess the credibility and impact of various sources of information.

The integration of NLP techniques such as lexical diversity, Flesch readability, sentiment polarity, and sentiment subjectivity into legal research offers powerful tools for enhancing the understanding and effectiveness of environmental law and biodiversity policies. By providing quantitative and qualitative insights into legal texts and public discourse, these analyses can support more informed decision-making, improve accessibility, and foster greater engagement with environmental issues.

Biodiversity in Climate Litigation

Our preliminary findings reveal a striking deficiency: even when considering a wide array of terms associated with biodiversity, there remains a significant lack of attention to its considerations in the valuation of damages in climate change litigation. This hypothesis underscores a critical oversight in legal proceedings and suggests a systemic undervaluation of biodiversity loss. It highlights an urgent need for legal frameworks to evolve, incorporating more holistic valuation methods that recognize the indispensable role of biodiversity in sustaining ecosystems and human well-being amidst the escalating threats of climate change.

It's hard to ask for valuation when biodiversity is not valuated.

Building upon the identified deficiency in integrating biodiversity considerations within the valuation of damages in climate change litigation, it becomes crucial to examine the broader implications and delineate strategies for rectifying this oversight. The current undervaluation of biodiversity loss in legal frameworks does not merely overlook the complex interdependencies within ecosystems but also significantly jeopardizes the attainment of sustainable and resilient futures in the face of escalating climate change threats.

There is also a grey area in environmental law which uses terms related to biodiversity but not use the concept specifically, so at the end of the day the same conclusion holds: the concept of biodiversity is not included in climate litigation assessment for damages.

The consequences of this oversight are manifold. Firstly, there is a profound impact on ecological balance and resilience. Biodiversity's critical role in maintaining ecological systems

means that its undervaluation in legal adjudications can lead to decisions that exacerbate environmental degradation. This degradation, in turn, diminishes nature's capacity to adapt to changing climates, to provide essential services, and to support human and non-human life. Furthermore, the economic implications of this oversight are considerable. [25] The undervaluation of biodiversity results in an economic underestimation of the costs associated with ecological degradation. This not only affects the allocation of resources for restoration and conservation efforts but also fails to hold responsible parties adequately accountable for their contributions to biodiversity loss.

To address these challenges, a multifaceted approach is necessary. Legal frameworks must evolve to incorporate more holistic and ecologically sensitive valuation methods. These methods should recognize the intrinsic and extrinsic value of biodiversity, considering not only the direct economic benefits derived from ecosystem services but also the long-term ecological and social benefits of biodiversity conservation.

The judiciary plays an indispensable role in weaving biodiversity considerations into the fabric of climate litigation.[26] Judicial bodies hold a pivotal position in the fabric of environmental law, especially in the realm of integrating biodiversity considerations into climate litigation. This role is not only about enforcing the law but also about contributing to the evolution of legal norms and practices in response to one of the most pressing challenges of our time. Their unique adjudicative function allows them to interpret and enforce laws in a manner that can substantially elevate the legal recognition of biodiversity's intrinsic and instrumental values.[27] In this capacity, judicial bodies are not just arbiters of disputes but are instrumental in shaping the trajectory of environmental governance. They can, through judicious interpretation and the application of legal principles, embed biodiversity considerations into the core of climate litigation.

The role of the judiciary in this context goes beyond mere enforcement of existing statutes. Judicial bodies are often at the forefront of legal innovation, interpreting laws in light

[25] McElwee P., et al., Ensuring a Post-COVID Economic Agenda Tackles Global Biodiversity Loss, One Earth, Volume 3, Issue 4, 2020, pp. 448-461, https://doi.org/10.1016/j.oneear.2020.09.011.
[26] https://brill.com/display/book/9789004509405/BP000002.xml
[27] Jacob Phelps, et al., Environmental liability litigation could remedy biodiversity loss. Conservation Letters. 2021; 14:e12821. https://doi.org/10.1111/conl.12821

of contemporary challenges and evolving scientific understanding.[28] This interpretative flexibility enables them to address the complex interplay between climate change and biodiversity loss, even in the absence of explicit legislative mandates. For instance, by recognizing the interconnected impacts of climate change on ecosystems and human communities, judicial bodies can expand the legal definitions of harm and causation to include biodiversity loss. This broader recognition can lead to more comprehensive assessments of environmental damages and more meaningful remedies in climate litigation.

Moreover, through their rulings, judicial bodies have the capacity to set precedents that influence not only the outcomes of individual cases but also the broader legal and policy frameworks concerning environmental protection.[29] By explicitly incorporating biodiversity considerations into their judgments, Judicial bodies can signal the critical importance of biodiversity to policymakers, legal practitioners, and the public. This can catalyze further legislative and regulatory actions aimed at protecting biodiversity, thus reinforcing the legal mechanisms available for addressing climate change.

The integration of biodiversity considerations into climate litigation by judicial bodies also serves an educative function, raising awareness among stakeholders about the importance of biodiversity in maintaining ecological balance and human well-being. As these considerations become more prominent in legal discourse, they can drive a shift in societal values toward greater appreciation and stewardship of the natural world.

Moreover, there is a need for enhanced interdisciplinary collaboration among legal professionals, ecologists, economists, and policymakers to develop valuation models that accurately reflect the complexity and interconnectedness of natural systems. Such models would facilitate more informed and equitable decision-making in climate change litigation, ensuring that biodiversity considerations are adequately reflected in the valuation of damages.

Ultimately, this shift towards more comprehensive valuation methods in legal proceedings is not merely a technical adjustment but a necessary evolution towards recognizing the indispensable role of biodiversity in sustaining life on Earth. As we confront the escalating

[28] Gitanjali Nain Gill et al., Biodiversity and the Indian Judiciary: Tracing the Trajectory, 8(2) BRICS Law Journal 10–40 (2021), doi.org/10.21684/2412-2343-2021-8-2-10-40

[29] Petersson, M., Stoett, P. Lessons learnt in global biodiversity governance. Int Environ Agreements 22, 333–352 (2022). https://doi.org/10.1007/s10784-022-09565-8

threats of climate change, our legal systems must adapt to protect the very foundations of our natural world.

IV. CONCLUSION

In this paper, we make a compelling case for the urgent need to integrate biodiversity considerations more thoroughly into climate litigation. We argue that the absence of such considerations undermines the effectiveness of legal remedies in addressing the complex interdependencies between biodiversity and climate change. We call for a paradigm shift towards a more integrated approach that recognizes the multifaceted impacts of climate change on ecosystems, ensuring more comprehensive and sustainable environmental outcomes. The results of this work provide valuable insights into how global judicial bodies can incorporate a different level of biodiversity considerations into their legal actions, thereby enhancing the effectiveness of judicial mechanisms in protecting biodiversity and promoting a holistic approach to environmental governance.