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Analyzing deforestation drivers, policy impacts, and mitigation strategies to review the Collaborative Partnership on Forests' 'Turning the Tide of Deforestation' Statement

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ACRONYMS AND ABBREVIATIONS

CPF	Collaborative Partnership on Forests
EUDR	European Union Deforestation Regulation
EUTR	European Union Timber Regulation
FAO	Food and Agriculture Organization
FLEGT	Forest Law Enforcement, Governance and Trade
IPLCs	Indigenous Peoples and Local Communities
JI	Joint Initiative
PSALSAR	Protocol, Search, Appraisal, Synthesis, Analysis, and Report
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SDGs	Sustainable Development Goals
TTD	Turning the Tide on Deforestation
UN	United Nations
UNEP	United Nations Environment Programme
VCM	Voluntary Carbon Market

ABSTRACT

The Collaborative Partnership on Forests (CPF) was established following a United Nations (UN) resolution to enhance the contribution of forests to the Sustainable Development Goals (SDGs). In 2019 the CPF launched a Joint Initiative (JI) on Turning the Tide on Deforestation (TTD) and, in April 2021, during the 16th session of the UN Forum on Forests, the CPF released a joint statement addressing 14 key points on halting deforestation.

This thesis aims to analyze the CPF joint statement in "Challenges and Opportunities in Turning the Tide on Deforestation" through a semi-systematic literature review, focusing on updating scientific data and promoting discussion on what has changed around the subject from the original publication date, in 2021, to the present days, considering the mentioned deforestation drivers and the proposed approaches for combating deforestation.

The research goals are to analyze this statement, provide suggestions on new sources of scientific data, and propose approaches to these issues considering current discussions regarding deforestation. The first part of this study consists of a manual review of the latest related reports on the subject, as well as a Protocol, Search, Appraisal, Synthesis, Analysis, and Report (PSALSAR) semi-systematic literature review, which entails an extensive search and selection of recently published scientific papers. The findings of these review offer insights and guide the next stage, which provides data and discusses potential revisions to the TTD statement.

The findings of the semi-systematic literature review present a detailed recommendation to update the "Challenges and Opportunities in Turning the Tide of Deforestation" statement, ensuring that the most recent scientific data and perceptions on deforestation are incorporated. The discussion highlights some context-specific strategies and emphasizes the importance of integrating socio-economic and political factors, in a scientific way, into deforestation mitigation efforts. Ultimately, the analysis made in this study provides an overview of current deforestation dynamics and the importance of policy-oriented statements in contributing to global efforts in sustainable forest management and halting deforestation.

1. INTRODUCTION

The Collaborative Partnership on Forests (CPF) was established in April 2001 following an invitation issued in the resolution 2000/35 by the Economic and Social Council of the United Nations (ECOSOC) (The Economic and Social Council, 2000). Consisting of sixteen international organizations and secretariats, of which six are part of the United Nations (UN), the partnership aims to increase the contribution of forests and trees to the 2030 Agenda for Sustainable Development and other global development goals (Collaborative Partnership on Forests, 2020). One of the means of the CPF to enhance substantial forest programs and forest-related policy is by providing scientific and technical advice to support countries and other key stakeholders.

An example of this is provided by the global conference "Working Across Sectors to Halt Deforestation and Increase Forest Area: From Aspiration to Action" organized by the CPF in February 2018. The event attracted around 300 multi-sector participants from governments, international organizations, the scientific community, the private sector, and farmer organizations (FAO and UNEP, 2020). The conference outlined actions to halt and reverse deforestation, emphasizing the need for governments to lead sustainable forest management initiatives to commit to zero deforestation.

This discussion perpetuated, and in 2019, in response to the UN Secretary-General's call for 'Turning the Tide on Deforestation', the CPF Joint Initiative (JI) on Turning the Tide on Deforestation was launched. This JI aimed to address global deforestation by scaling up efforts within and beyond the UN system, supporting countries and local communities with forest assessments. The JI TTD runs from 2022 to 2024 and it is aligned with the CPF's general core functions, which include: "*Support the work of the United Nations Forum on Forests and its member countries; Provide scientific and technical advice to the Forum and governing bodies of other CPF members, at their request; Enhance coherence, cooperation as well as policy and program coordination at all levels, including through joint programming and the submission of coordinated proposals to members' governing bodies, consistent with their mandates; Promote the implementation of the UN Forest Instrument and the United Nations Strategic Plan for Forests as well as the contribution of forests and trees to the 2030 Agenda for Sustainable Development and other major forest-related agreements*" (CPF, 2024).

Under the JI TTD, the CPF released a joint statement entitled "Challenges and Opportunities in Turning the Tide on Deforestation" in April 2021, during the 16th session of the UN Forum on Forests (UNFF16). This statement covered 14 key points on the matter of deforestation, from services provided by forests to deforestation drivers, providing scientific findings for each of them. Despite raising awareness, this statement aimed to support countries and stakeholders in addressing deforestation, clarifying the consensus on the topic, and providing

data and analysis for accelerating action (Joint Statement of the Collaborative Partnership on Forests, 2021).

The JI TTD is just one example of how deforestation has become an important issue in international policy discussions, as it is directly related to the global climate and biodiversity crises. Throughout the last few decades, numerous other initiatives have emerged to address these pressing issues. For example, the Reduction of Emissions from Deforestation and Forest Degradation (REDD+) framework has become a pivotal for incentivizing forest conservation, whereas the Kunming-Montreal Global Biodiversity Framework, adopted in 2022, establishes ambitious targets for halting biodiversity loss, with forest protection at its core. These efforts highlight deforestation's growing importance on the global environmental and socioeconomic agenda, as well as its critical role in mitigating climate change and conserving biodiversity.

Moreover, besides global actions and policies, regional and national initiatives have been adopted to contrast illegal logging and deforestation as well as forest degradation processes. These include, for example, the European Union (EU) Forest, Law Enforcement, Governance and Trade (FLEGT) program, the EU timber Regulation (EUTR) and other similar initiatives such as the amended Lacy Act in the United States of America (USA) and the Australian Illegal Logging Prohibition Act, the new EU Deforestation Regulation (EUDR) and many others.

Considering the end of the first cycle of the JI TTD, which is in 2024, and the importance of addressing deforestation in the UN Decade of Action to achieve the SDGs by 2030, it is necessary to update the data used in this statement. Thus, this thesis aims to analyze the CPF's "Challenges and Opportunities in Turning the Tide on Deforestation" through a semi-systematic literature review, understanding the listed drivers of deforestation, updating relevant scientific data for these drivers, and promoting a discussion on strategies for halting deforestation.

1.1. OBJECTIVES

The general objective of this work is to review the current relevance of the data from the "Collaborative Partnership on Forests' Joint Statement on Challenges and Opportunities in Turning the Tide on Deforestation" and promote a discussion on its strategies for halting deforestation.

Building on the above-reported general objective the following specific objectives are identified:

1. Update information and scientific data for deforestation drivers since the publication of the TTD Statement (2021) through a semi-systematic literature review.

2. Discuss the relevance of the strategies for mitigating the drivers of deforestation proposed by the TTD Statement based on the literature review.
3. Organize findings in the form of lessons learned to inform a review of the TTD Statement.

These objectives allow addressing research questions reported below:

1. What are the objectives, key contents, and proposed strategies of the "CPF's Joint Statement on Challenges and Opportunities in Turning the Tide on Deforestation"?
2. What is the most recent scientific evidence, from 2021 to 2024, on different deforestation topics mentioned in the Statement?
3. How do recent developments on different deforestation matters relate to the deforestation mitigation strategies proposed by the Statement?
4. What changes might be proposed to review the Statement vis-à-vis these developments?

It shall be stressed that in addressing research questions and achieving research objectives, the thesis aims to define a clear and replicable approach that could be adopted and replicated in the future for additional updates and development of this document as well as similar ones.

1.2. THESIS STRUCTURE

The thesis is organized into five main chapters. The first chapter, i.e. the present one, introduces the research topic and background, defines research objectives and describes the thesis structure. The second chapter presents the research methodology, focusing on the steps involved in the semi-systematic literature review. Chapter three provides a synthesis of the results, presenting an overview of the gained insights. The fourth chapter offers a critical discussion of these key-findings, reflecting on the methodology, and addressing related issues pertinent to the research topic. Finally, the fifth chapter presents the conclusion, along with a disclaimer and acknowledgments. The thesis is further complemented by a comprehensive list of references cited throughout the text, and three annexes containing additional materials and supporting information that enrich and reinforce the main discussion.

2. METHODOLOGY

In this study, the Protocol, Search, Appraisal, Synthesis, Analysis, and Report (PSALSAR) method, proposed by Mengist, Soromessa, and Legese (2020) was applied to analyze existing data on arguments used in the TTD Statement. The PSALSAR method includes the following steps:

1. **Protocol:** research scope definition.
2. **Search:** search for studies within the scope.
3. **Appraisal:** select studies using inclusion and exclusion criteria.
4. **Synthesis:** data extraction and categorization.
5. **Analysis:** results and discussion.
6. **Report:** writing and compiling all information in this document.

This method aims to ensure a structured approach to gathering relevant scholarly records, providing a transparent and replicable methodology for the literature review. This will facilitate the extraction of valuable insights and guide subsequent stages of the study.

Within this chapter we outline the first three steps of the PSALSAR systematic review method: 1. Protocol, 2. Search, and 3. Appraisal. These steps correspond to the methodology applied in the semi-systematic literature review, which involved searching for and assessing reports and recent papers relevant to the defined scope.

Steps from 4 to 6 of the PSALSAR systematic review method represent the key results of this thesis and are fed with outcomes of the previous steps. Therefore, these parts are presented in detail when reporting the key findings within chapters 3 and 4.

2.1. STEP 1: PROTOCOL

The first step in the PSALSAR systematic review method is to define the research scope. This Protocol stage coincides with a methodology known as Evidence, Population, Intervention, Comparison, Outcome, and Timeframe (EPICOT) (Brown et al., 2006; Booth, Sutton, and Papaioannou, 2016) which establishes a framework for scope definition, allowing a better research structure (Table 1). The framework was filled in keeping in mind the research questions and objectives outlined within chapter 1.

Table 1 – Application of the EPICOT concepts

Concept	Definition	Application
Evidence	What is the current state of the evidence?	Official reports, policy documents, and peer-reviewed scientific articles on deforestation drivers within the timeframe
Population	What is the population or the area of interest?	Communities and stakeholders involved in deforestation or forest regions affected by deforestation
Intervention	What are the interventions of interest?	The CPF's Joint Statement on Challenges and Opportunities in Turning the Tide on Deforestation
Comparison	What are the comparisons of interest?	Deforestation trends from the intervention of interest with actual deforestation data from new reports and scientific literature
Outcome	What are the outcomes of interest?	Data updates regarding deforestation and discussions on the intervention of interest
Timeframe	What is the date span of interest?	From January 2021 to August 2024

2.2. STEP 2: SEARCH

Based on this scope, when analyzing the 14 sections of the TTD Statement, we selected a list of data and arguments (which included affirmations and assertions) that required a reference update, based on the following arbitrary criteria:

- References older than 2021 are considered outdated and require updating.
- Quantitative data must be updated, and recent information included, if available.
- Qualitative data may be updated, if:
    - it is not consolidated knowledge (i.e. it is not yet fully integrated and accepted by experts and systematically/largely reported within existing scientific and technical literature),
    - it is not linked to any quantitative argument,
    - it requires argumentation support from a reference (e.g., affirmations or assertions without any references are found in need of updating due to the lack of citation support).

The literature search process was then divided into two distinct sub-steps: the first involved the review of relevant reports (i.e. technical and grey literature), while the second concentrated on the analysis of scientific literature. Although the review of reports was initiated prior to the literature analysis, the two sub-steps were then executed concurrently (Figure 1).

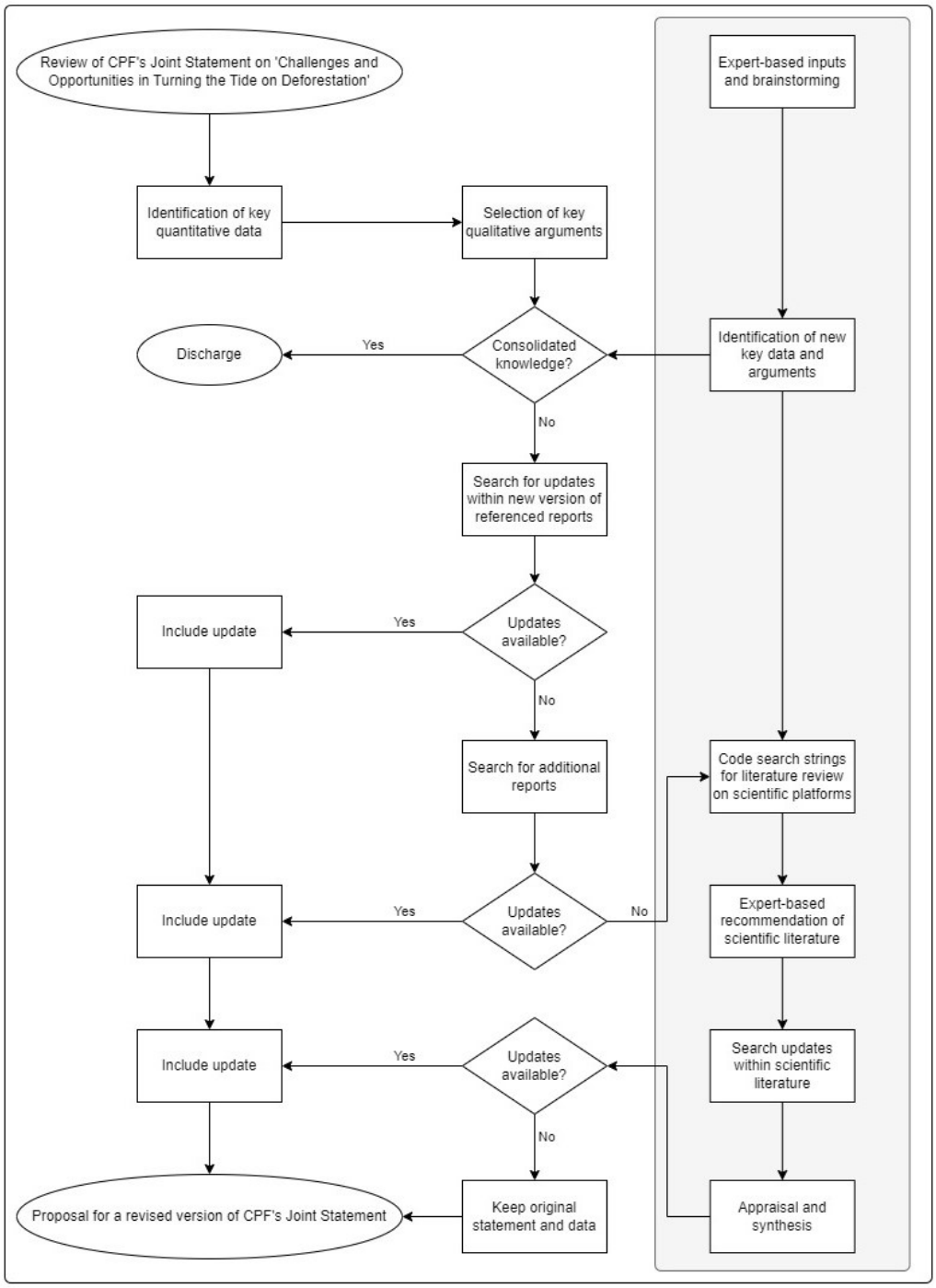

Figure 1 – Step 2: Search's workflow

In both cases, support was granted by experts from the UN's Food and Agriculture Organization (FAO), who provided inputs in terms of possible new data and sources, and helped analysing the findings of the review process through brainstorming and feedback sessions. Such a support allowed enriching the amount of literature and information considered and, at the same time, gaining a more in depth and wide perspective on the addressed topics.

The sub-steps followed the established Protocol from the previous step, such as only consulting data from 2021 to 2024. The only exception is the Global

Forest Resources Assessment from 2020 (Food and Agriculture Organization of the United Nations, 2020), which is still relevant and corresponds to the most recent version of this report.

In total, 40 arguments were selected to be checked whether they can be updated or not. To facilitate the literature review process, each of these arguments was assigned a code based on which of the 14 sections of the TTD statement it is associated with. Throughout the methodological description, an example of an argument is used to demonstrate the steps taken (Table 2). However, since some sections did not require any data updates in terms of scientific evidence and the final list is extensive, the full compilation is presented in the thesis's annexes (see Annex 1).

Table 2 – Example of an argument to be updated

Section	Code	Argument or data to be updated
1. Deforestation	1.1	"Forests cover 31 percent of the Earth's land area, which is just over 4 billion hectares."

2.2.1. STEP 2.a: REPORT ANALYSIS

Given that a portion of the data referenced in the TTD Statement originated from reports issued by international organizations such as the FAO, the World Wide Fund for Nature (WWF), the Intergovernmental Panel on Climate Change (IPCC), and the World Bank, the most recent editions of these reports were thoroughly reviewed. If a particular argument or data point could not be found in the newest version of the equivalent report, meaning the one used as a reference, cross-referencing with other selected reports was then conducted to obtain updated information.

As the findings from the report analysis refer to the latest versions of documents already referenced in the TTD Statement, they did not undergo step 3 (Appraisal) and step 4 (Synthesis) of the PSALSAR systematic review method. For arguments and data that could not be updated from these reports – either due to the absence of relevant information or because they were deemed important from an expert-based perspective – a parallel literature review step was conducted.

2.2.2. STEP 2.b: SCIENTIFIC LITERATURE ANALYSIS

Search strings were set by linking selected keywords with *Boolean operators* ('*OR*' and *'AND*'). Given the arguments that were not updated from reports, 13 search strings with a total of 117 keywords were defined to be used in an

exploratory (or naïve) search that identified articles with titles, abstracts, and keywords matching the terms established in the search strings.

The search was then conducted using two scientific databases, *Clarivate Web of Science* and *Elsevier Scopus*, chosen for their data robustness, accessibility, and comprehensive appraisal options. A total of 1,337 records were retrieved on August 6th, 2024.

This initial search was conducted as a preliminary exploration to evaluate the potential effectiveness of these search strings and to provide input for the *litsearchR* package in *R software*. The *litsearchR* package can provide various functions to assist in the systematic planning of a scientific literature search.

Using data from this exploratory search, the package was employed to generate additional keywords to complement those initially defined. To accomplish this, the databases of articles retrieved from *Clarivate Web of Science* and *Elsevier Scopus* were merged, and duplicates were removed to avoid repetitions. Two different methodologies were then applied in an R script (see Annex 2):

- *Raked* (Rapid Automatic Keyword Extraction): This method was used to extract terms based on their frequency of occurrence within the dataset, more specifically with a focus on titles and abstracts of listed papers.
- *Tagged*: This method used a set of character vectors provided by authors and/or databases, focusing on terms with a maximum of three words. It was applied to the keyword's dataset.

Simultaneously, keyword suggestions were solicited from experts at the University of Padova and the FAO (Table 3).

Table 3 – Keywords suggestion

Suggested keyword	Origin	Action
"mammalia"	Litsearchr: tagged keywords	Add on the search string 3.1
"species richness"	Litsearchr: raked keywords	Add on the search string 3.2
"diversity"	Experts	Remove from search string 3.2
"species richness"	Experts	Remove from search string 3.2
"forest"	Experts	Add on the search string 3.3
"fragmented"	Experts	Add on the search string 3.6
"forest patch"	Experts	Add on the search string 3.6
"forest management"	Litsearchr: raked keywords	Add on the search string 7.3
"voluntary certification"	Experts	Add on the search string 7.3
"forest landscape"	Litsearchr: raked keywords	Add on the search string 8.2

Suggested keyword	Origin	Action
“landscape restoration”	Litsearchr: raked keywords	Add on the search string 8.2
“forest landscape restoration”	Litsearchr: raked keywords	Add on the search string 8.2
“reforestation”	Litsearchr: tagged keywords	Add on the search string 8.2
“restore”	Experts	Add on the search string 8.2
“restoration”	Experts	Add on the search string 8.2
“climate change”	Litsearchr: raked keywords	Add on the search string 11.1
“forest degradation”	Litsearchr: raked keywords	Add on the search string 11.1

Another recommendation from experts was to use only the singular form for keywords that are regular nouns, as the singular form can encompass both singular and plural instances. Additionally, it was also suggested to add an extra search string to argument 11.1, due to the broadness of the subject.

The final set of search strings (Table 4) was then employed to conduct a comprehensive search across the same scientific literature platforms as before. This search was performed on August 13th, 2024, resulting in the retrieval of 307 records from *Clarivate Web of Science* and 952 *Elsevier Scopus*, yielding a total of 1,259 records.

Table 4 – Final search string terms

Code	Search String
3.1	"forest" AND ("habitat" OR "ecosystem" OR "environment") AND ("amphibian") AND ("bird" OR "avian") AND ("mammal" OR "mammalia") AND ("biodiversity" OR "wildlife diversity")
3.2	"vascular plant" AND ("tropical forest" OR "rainforest") AND "biodiversity" AND ("percentage" OR "proportion" OR "amount")
3.3	"forest" AND ("pollination" OR "pollinator") AND ("food crop" OR "agricultural crop" OR "crop production") AND ("food production" OR "food supply") AND ("global" OR "world")
3.6	"integrity" AND ("global forest" OR "boreal forest" OR "coniferous forest" OR "tropical forest" OR "rainforest") AND ("fragmentation" OR "continuous" OR "fragmented" OR "forest patch")
3.7	("conversion" OR "change" OR "transformation") AND ("Amazon basin" OR "Amazon rainforest") AND ("Congo basin" OR "Congo rainforest")
4.5	("depend" OR "dependency" OR "rely" OR "relies" OR "income generation") AND ("agroforestry" OR "agricultural forestry") AND ("people" OR "livelihood" OR "population") AND ("million" OR "billion" OR "amount" OR "number")
6.4	("frequency" OR "occurrence" OR "incidence") AND ("intensity" OR "severity") AND ("uncontrolled fire" OR "wildfire" OR "forest fire") AND ("climate change" OR "global warming" OR "climatic change") AND ("environmental impact" OR "ecological impact")

Code	Search String
6.5	"wildfire" AND ("policy" OR "policies" OR "governance" OR "planning" OR "government") AND ("climate change" OR "global warming") AND ("ignite" OR "spread" OR "suppress")
7.3	("certification" OR "voluntary certification") AND ("roundwood" OR "timber") AND "production" AND "forest management"
8.1	("corporate" OR "company" OR "companies") AND ("deforestation commitment" OR "environmental commitment" OR "sustainability commitment") AND ("result" OR "progress")
8.2	("Bonn commitment" OR "Bonn Challenge") AND "progress" AND ("restore" OR "restoration" OR “forest landscape” OR “landscape restoration” OR “forest landscape restoration” OR "reforestation")
11.1	("voluntary carbon market" OR "carbon market") AND "price" AND ("forest" OR "nature") AND ("article 6" OR "REDD" OR "REDD+")
11.1	("private" OR "business" OR "corporate" OR "company") AND ("climate" OR "climate change" OR "environmental" OR "sustainability") AND ("carbon offset" OR "carbon credit" OR "carbon trading") AND ("deforestation" OR "forest degradation")
12.1	("indigenous people" OR "native communities" OR "aboriginal group") AND "land" AND "area" AND ("protected" OR "conservation") AND ("global" OR "world") AND ("percentage" OR "proportion" OR "amount")

2.3. STEP 3: APPRAISAL

Exclusion criteria were systematically applied to streamline the selection process, thereby reducing the number of studies for further review. Expert recommendations were also considered, which led to the inclusion of additional papers. Documents were filtered according to the criteria outlined in Table 5.

Table 5 – Filtering criteria and relative number of records

Criteria	Inclusion / exclusion	Web of science	Scopus	Total
Initial (pre-filter)	-	307	952	1,259
Date before 2021	Exclusion	105	331	436
The document is not in English	Exclusion	105	321	426
Grey literature	Exclusion	96	272	368
Duplicate documents	Exclusion	-	-	307
Expert’s recommendation	Inclusion	-	-	314
Relevance	Exclusion	-	-	116
Manual scan	Exclusion	-	-	**33**

Following the protocol step, only papers published from 2021 onwards were included, in order to ensure that the review focused on recent literature. Studies

were also restricted to those published in English. Grey literature, such as policy documents, working papers, newsletters, and speeches, was excluded; the review was limited to articles and books, with only specific and relevant reports being analyzed separately.

After that, the datasets obtained from *Clarivate Web of Science* and *Elsevier Scopus* were merged, duplicate records were removed using *Microsoft Excel,* and papers suggested by experts were incorporated into the dataset. Furthermore, a relevance filter was applied based on citation metrics.

Upon analyzing the 314 papers, including those recommended by experts, it was observed that the average citation rate was three citations per year. Consequently, only papers with three or more citations per year were deemed relevant for the next filtering step, as this indicated they were above the average citation rate within the dataset.

To account for articles published in 2024 and to avoid undervaluing them, the analysis considered that this step was conducted in August 2024 (67% of the year). Therefore, the following formula was applied:

Formula (1): $$Citation\ per\ year = \frac{Total\ number\ of\ citation}{2024.67 - Year\ of\ publication}$$

Finally, a manual review of abstracts was conducted to assess the direct relevance of each paper. This process involved evaluating whether the papers could effectively update the arguments they were associated with, as similarity in keywords did not necessarily indicate relevance. As a final result, 33 articles were selected for a complete analysis and possible update of the TTD Statement. The detailed results of the analysis of such shortlisted papers are presented within chapter 3 through steps from 4 to 6 of the PSALSAR systematic review method.

3. RESULTS

This chapter presents the results of the literature assessment conducted through the PSALSAR systematic review method to consider possible updates to the TDD Statement. More in detail, results are presented separately for the step 4 (Synthesis) of the review method, while steps 5 (Analysis) and 6 (Report) are used to discuss results within chapter 4.

3.1. STEP 4: SYNTHESIS

The results include the synthesis of both extraction and classification of pertinent data from selected papers. The data was organized into *Excel* spreadsheets for data processing, and variables of interest were categorized based on the articles' general characteristics, such as year of publication.

To better evaluate the information from this literature search, the original databases from *Web of Science* and *Scopus* were merged, before filtering publications by language and type. Moreover, duplicates were removed, yielding a total of 1,048 records. This approach made it easier to categorize and observe trends, such as the annual distribution of publications (Figure 2).

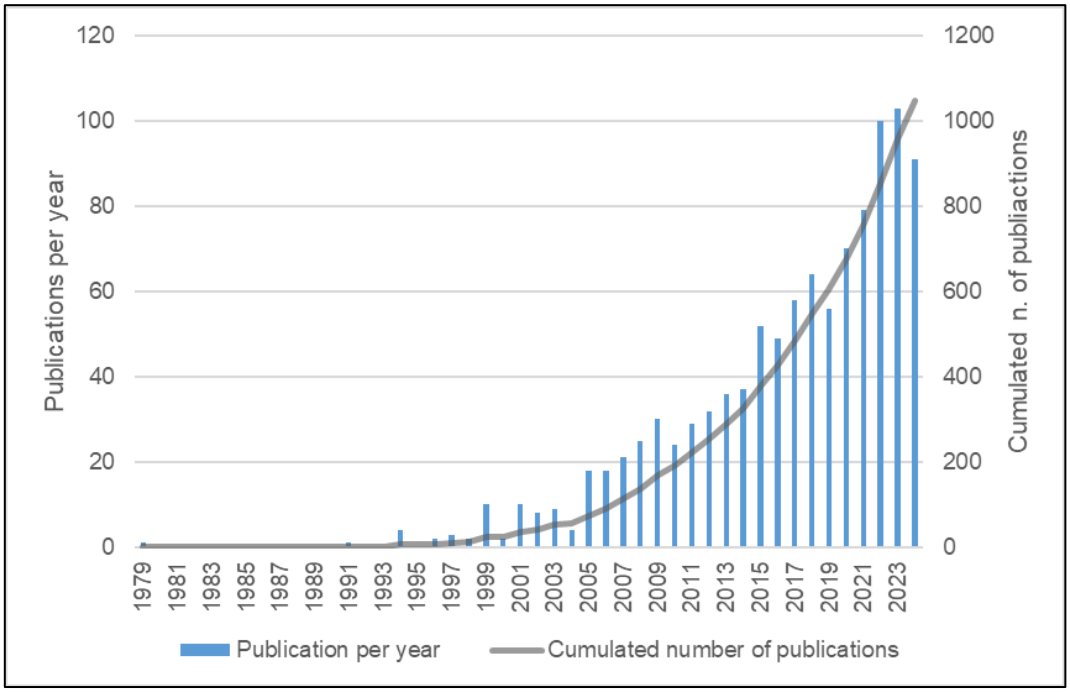

Figure 2 – Total number of publications per year and cumulated

Additionally, the database allowed analyzing the number of articles corresponding to each topic selected to be updated, providing insights into the frequency they were identified in the scientific platforms using the search strings and which were most filtered out during the appraisal process (Table 6).

Table 6 – Number of records per topic before and after appraisal

Code	Before appraisal	% on total	After appraisal	% on total	Reduction
3.1	208	19.8%	2	6.1%	99.04%
3.2	18	1.7%	1	3.0%	94.44%
3.3	9	0.9%	2	6.1%	77.78%
3.6	107	10.2%	4	12.1%	96.26%
3.7	30	2.9%	1	3.0%	96.67%
4.5	73	7.0%	2	6.1%	97.26%
6.4	42	4.0%	2	6.1%	95.24%
6.5	86	8.2%	7	21.2%	91.86%
7.3	165	15.7%	2	6.1%	98.79%
8.1	206	19.7%	7	21.2%	96.60%
8.2	7	0.7%	0	0.0%	100.00%
11.1	84	8.0%	2	6.1%	97.62%
12.1	13	1.2%	1	3.0%	92.31%
Total	**1,048**	**100%**	**33**	**100%**	**96.85%**

For all topics the appraisal led to a reduction rate higher than 90%, except for the topic 3.3 (about 78%). This topic focuses on the significant contribution of forest pollinators to the world's major food crops. In contrast, for Topic 8.2, which addresses the fact that only a few countries have met their Bonn commitments, all papers were excluded after the appraisal. The overall reduction rate in passing from 1,048 to 33 papers was then close to 97%.

Among selected papers, about one fifth (21%) each refer to topics 6.5 and 8.1, with topic 3.6 totaling another 12%. Topic 6.5 examines the link between extreme wildfires, policymaking, and climate change, while Topic 8.1 discusses the limited information available on companies' actions and progress in meeting deforestation commitments. Finally, Topic 3.6 provides data on the percentage of the world's forests that maintain a high level of ecological integrity.

3.2. EXPLORING THE DATA UPDATE PROPOSAL

Out of the 40 selected arguments, 26 (65%) could be updated with findings from recent reports, and 5 (12.5%) with information from the literature review. On the contrary, 6 arguments (15%) could not be updated based on this study's literature review findings. Finally, 3 arguments (7.5%) are recommended for removal from the TTD Statement after reviewing the selected reports and papers, due to several reasons, such as inconsistent or even contradictory information found, or for semantic reasons, that will be further explored.

The report analysis process comprehended reviewing 15 reports directly used

to update 26 of the 40 arguments (see Annex 3). This eliminated the need for further literature review concerning these specific data points.

As the final phase in proposing revisions, the scientific literature review also considered information or data that may not update the statement, but support the arguments. For example, in some cases specific data being sought to be updated was not found, but some other supplementary data was. In this approach, some arguments remained relatively unchanged, but the update proposal brought more recent references. In doing so, 5 arguments were proposed to be updated from the 33 papers examined (Table 7).

Table 7 – Arguments updated from literature review

Section	Codes	Revised argument or data	Reference
3. Forests & Biodiversity (linkage)	3.1	"*Forests are home to more than twice as many species of birds, reptiles, and mammals as any other type of habitat, Forests provide habitats for 83 percent of amphibian species, 56 percent of bird species, 67 percent of reptile species, and 70 percent of mammal species*."	Cox et al., 2022
	3.6	"*However, edge effects caused by forest fragmentation can reduce overall biodiversity and ecosystem functionality, even within the core areas of larger forest fragments*."	Hending et al., 2023
6. Forest fires	6.4	"*Climate and land use change is Available data shows a trend of increasing the frequency and intensity of uncontrolled fires adversely affecting biodiversity, ecological services, human well-being and livelihoods and national economies*."	Cunningham , Williamson, and Bowman, 2024
	6.5	"*Extreme wildfires are the result of past and present policy, planning and governance decisions that – coupled with increasingly adverse weather conditions due to climate change – create the conditions for fires to ignite and spread across landscapes beyond the capacity of societies to suppress them. Immediate action is required to prevent extreme wildfires where possible and to limit the of such events. The impacts of extreme wildfires can be significantly reduced through investments in wildfire prevention, early warning, and integrated fire management, and active forest management*."	Cardil et al. 2021; Crist 2023; Miezïte et al., 2022
12. Participation of IPLC, women and youth	12.1	"*Indigenous peoples make up 6 percent of the world's population*."	Redvers et al., 2023

It was not possible to update 6 of the arguments (15%), either because no papers or no data were identified during the literature review, or because the data obtained did not fit either as an updated version or as supplementary information (Table 8).

Table 8 – List of arguments that could not be updated from the report or the literature review

Section	Codes	Argument or data	Comment
3. Forests & Biodiversity (linkage)	3.2	"*Approximately 60 percent of all vascular plants are found in tropical forests*."	Since only one study was chosen and it focused solely on epiphytes, the argument is suggested to remain unaltered.
	3.3	"*An estimated 75 percent of the 115 leading food crops globally – together representing 35 percent of global food production – benefit from pollination by animals, many of which live in forests*."	Since the studies analyzed used the same reference as the one cited in the TTD Statement, the argument is suggested to remain unaltered.
4. Forests & Livelihoods (linkage)	4.5	"*An estimated 1.2 billion people depend on agroforestry farming systems*."	Since there was no update on the literature review, the argument is suggested to remain unaltered.
7. Timber legality and trade	7.1	"*The International Criminal Police Organization (INTERPOL) estimates that the value of illegal timber trade lies in the range of USD 51–152 billion per year*."	Since there was no update on the literature review, the argument is suggested to remain unaltered.
	7.3	"*Voluntary certification is also a valuable tool and already covers more than one-third of industrial roundwood production*."	Since there was no update on the literature review, the argument is suggested to remain unaltered.
8. Public and private commitments to halt deforestation	8.2	"*Few countries have met their Bonn commitments thus far, with only two completed (Pakistan and the United States of America) and limited reporting on progress in most other countries*."	Since no records were selected after the appraisal step, the argument is suggested to remain unaltered.

In addition to providing updated references and supplementary arguments, it was suggested that 3 arguments (7.5%) should be removed from the statement (Table 9). The comment's column provides a brief explanation for the removal recommendation.

Table 9 – List of arguments suggested to be removed from the statement

Section	Codes	Argument or data	Comment
3. Forests & Biodiversity (linkage)	3.7	"*In the Amazon and Congo basins, however, land-use conversion is causing rapid change*."	The analyzed study did not show a correlation between biodiversity and land-use conversion. The original sentence also appears to be out of context, and it is unrelated to other sentences. Therefore, it is suggested to remove the argument from the text.

Section	Codes	Argument or data	Comment
8. Public and private commitments to halt deforestation	8.1	"*There is still too little information from companies on their actions and results to judge their progress in achieving their commitments*."	It came to light during the data synthesis that this argument may no longer be valid, as many other studies on the subject have been undertaken. It is suggested to remove the argument from the text.
11. Climate finance	11.1	"*Private sector climate commitments and related interest in carbon offsets from reducing deforestation have increased significantly in recent years, both project developers and corporate buyers expect more stable market conditions*."	Expert discussions and literature reviews suggested that the voluntary carbon market is currently volatile, especially for forest projects. As a result, it is suggested to remove the argument from the text.

Argument 8.1 was suggested for removal based on the synthesis of data from the literature review. Although the TTD Statement specifically addresses deforestation commitments, the search string for this argument was expanded to include related terms such as "environmental" and "sustainability" commitments (as it can be seen in Table 4) to capture a broader range of publications that may use synonymous language.

Moreover, as seen in Table 6, this argument had a substantial number of records identified, and Figure 3 shows that publications on this topic are still on a rising trend. These observations raised the question of whether this argument remains valid to stay in text or not. The decision could be to reformulate the original phrase, emphasizing that topic 8.1 is trending and recommending further monitoring. In this case, this approach could be used to amend or improve Table 7. However, the decision to for such direct update would require more in-depth analysis and consultation with experts, resulting, alternatively, in the recommendation of removing it from the statement's text.

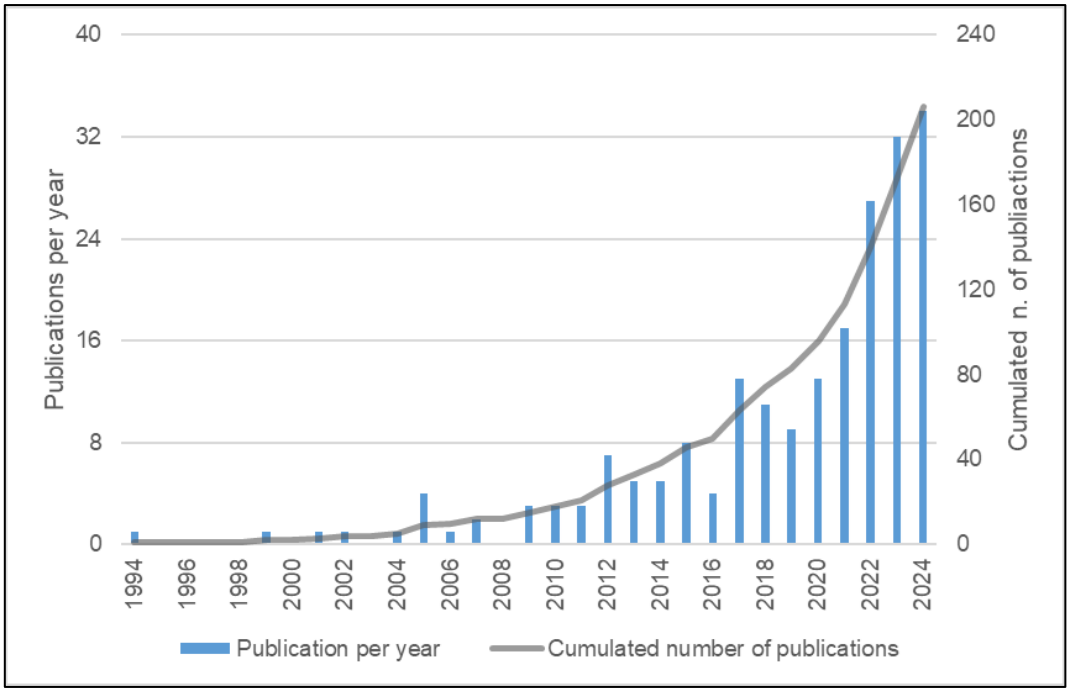

Figure 3 – Number of publications – per year and cumulated – for topic 8.1

4. DISCUSSION

The following discussion steps correspond to PSALSAR's Step 5, Analysis, which involves a critical examination of the systematic literature review findings. The discussion will summarize the key findings, set the stage for future research directions, and discuss the broader understanding of deforestation mitigation strategies, thereby suggesting a path forward in the ongoing policy effort to turn the tide on deforestation.

When analyzing the results of the literature review, several recurring themes and trends in the broader context of deforestation research and policy were revealed. Initially, the most frequently encountered topics were on forests as habitats for various faunal classes (Topic 3.1) and on the importance of voluntary certification as a tool for sustainable forest management (Topic 7.3). This can highlight the essential role forests play in preserving biodiversity (FAO and UNEP, 2020; Gagen et al., 2023; Pacheco et al., 2021) and the importance of voluntary certification as a tool for sustainable forest management (Mitsugi and Ikram Yaakob, 2028). It is important to note that, while significant differences exist among certification standards, no voluntary certification scheme is currently considered fully compliant with the European Union Deforestation Regulation's (EUDR) requirements (Cosimo et al., 2024). Many of them, however, are updating and/or integrating and improving their requirements and procedures to move them closer to EUDR compliance.

Nevertheless, following the appraisal process, that filtered the most recent and relevant studies, the focus shifted to topics such as public and private commitments to halt deforestation (Topic 8.1), the relationship of forest fires to policymaking and climate change (Topic 6.5), and the integrity level of global forests (Topic 3.6). This change may indicate a growing concern about the effectiveness of current commitments to combat forest loss, as indicated by Niel et al. (2019) and Sommer (2021).

On the other hand, several significant scientific gaps remain, which prevent a full comprehension of deforestation dynamics and policy implications. One of the critical technical gaps identified by the CPF's TDD Statement is the need for composite biodiversity indices, such as species richness and evenness measuring, as it can provide a more accurate assessment of forest viability. However, it is important to note that, while the TTD Statement addresses multiple complex deforestation drivers, it primarily focuses on mitigating deforestation effects rather than tackling its root causes.

The literature review also revealed additional gaps in forest and biodiversity linkage, including limited studies on topics such as vascular plant diversity in tropical forests (Topic 3.2) and the impact of forest-dependent pollination animals on leading food crops (Topic 3.3). The current progress of countries' Bonn commitments (Topic 8.2), as well as the numerical participation of

indigenous people in global landscape management (Topic 12.1), were also underrepresented in the scientific literature.

The scarcity of research on these topics highlights the need for a more comprehensive approach to deforestation studies that takes into account socioeconomic factors (Prochazka et al., 2023). Also, as proposed by Kinda and Thiombiano (2024), tackling the lack of transparency and accountability in the extractive industries can be significantly positive in combating deforestation in developing countries. By identifying recurring themes and gaps, this review illustrates the current state of deforestation research in policymaking, allowing for a more precise update proposal.

4.1. THE CRITICAL DECISION-MAKING PROCESS OF A POLICY-ORIENTED DOCUMENT

The decision-making process for updating, maintaining, or removing specific arguments and data points in the TTD Statement was guided by a semi-systematic review of the most recent literature, including official reports, and by discussions with experts while cross-referencing multiple sources and considering the broader context of each selected argument. By focusing on the most impactful updates, this analysis ensures that the data and the arguments presented within the TTD Statement are still relevant and up to date, providing a solid foundation for future versions of this document.

For instance, the suggestion to remove the argument on Voluntary Carbon Market (VCM) data was driven by significant changes in market dynamics and regulatory frameworks that have emerged since the original TTD Statement, like price volatility and risks of scandals (Mateo-Márquez, González-González, and Zamora-Ramírez, 2022; Michaelowa et al., 2023). Notably, while 2023 marked the fourth consecutive year of an upswing in VCM value, the market experienced a 56 percent year-on-year decline in transaction volume in 2023 (Procton 2024). On the other hand, policies and initiatives to regulate and monitor this market are being developed, including the Carbon Removals Certification Regulation by the European Commission (European Parliament, 2016).

On the argument of rates of deforestation in key regions such as the Amazon and Congo Basins, on the other hand, the literature review proved that this still holds truth (Chen et al., 2022; Gagen et al., 2023; Pacheco et al., 2021). However, the suggestion of removing it from the statement came purely semantically, as the argument seemed misplaced from the rest of the section's text, not making any connection with biodiversity-related issues, which is the focus of its section.

In addition, certain deforestation data points were debated with experts

throughout the updating process, particularly when related to agriculture. Even though there is plenty of robust data and information on how agriculture, as a whole, is one of the primary drivers of deforestation (Food and Agriculture Organization of the United Nations, 2022b), this may be a sensitive topic to discuss with some countries or stakeholders who rely heavily on agriculture for business and lobbying. These discussions are taken carefully, and negotiations occur over whether a piece of information should be disclosed or not in a policy-oriented document.

4.1.1. AN OVERVIEW OF THE METHODOLOGY

This study was guided by four central research questions designed to explore the current relevance of the CPF's Joint Statement on "Challenges and Opportunities in Turning the Tide on Deforestation". Through a semi-systematic literature review, the study successfully updated the scientific data on deforestation dynamics since the publication of the TTD Statement in 2021, providing a thorough analysis of how recent developments relate to the proposed mitigation strategies on deforestation.

By doing so, the research questions were effectively addressed and the objectives achieved: the study clearly outlined the key objectives, contents, and strategies of the TTD Statement, while incorporating the most recent evidence on deforestation topics from 2021 to 2024. Moreover, the study organized and critically examined the alignment between the recent developments and the original strategies, proposing changes to improve the relevance and effectiveness in light of new findings.

The PSALSAR methodology proposed by Mengist et al. (2020) was critical to answering the research questions and providing a strong update proposal. However, to achieve these results, the methodology had to be modified to a semi-systematic literature review, with the search step divided into two parallel sub-steps.

This adjustment was made as this study required a more strategic and direct approach, which included reviewing not only scientific literature but also reports related to the data and arguments of interest. This approach emphasized the importance of expert consultation, which is critical for documents of political significance.

A key limitation of this methodology is that a comprehensive update proposal for the TTD Statement should involve a broader stakeholder consultation, including the engagement of a wider range of experts from other CPF participants. While the semi-systematic literature review provides valuable insights, it may not capture all relevant inputs, as certain topics in the scientific and technical literature may reflect "popular" areas of focus rather than

representing the full spectrum of critical deforestation issues. That's a critical matter as the selection of experts involved in the consultation process can significantly influence the direction and outcomes of the updates, introducing potential bias.

Another limiting factor is the reliance on literature predominantly in English, which may exclude important local, national, and regional studies, particularly those published in languages such as French, Spanish, or Portuguese—languages commonly used in regions like Africa and South America, where deforestation is a pressing concern. This geographic aspect could bring future improvements thorough a geographical distribution analysis of the studies found in the literature review, in order to better understand the focus areas of the research and ensure a more globally representative approach to deforestation mitigation.

Future research should focus on improving the keyword selection and search string building stages, ensuring enough time is available to experiment and refine various keyword combinations, before creating exploratory search strings. Furthermore, this refinement should be applied to multiple scientific search platforms, as the results may vary. For example, one platform may treat singular and plural keywords differently, while another may not, influencing search results.

Nevertheless, the methodology proposed in this study serves as a foundational framework that should be revised, refined, and further tested for future applications. If established a more robust methodological approach, it could be strongly recommended for similar projects that aim to update or verify the relevance of data in official reports, such as the TTD Statement. This aligns with the broader need for international policies and commitments to be supported by a transparent, reliable monitoring and reporting system.

4.1.2. THE ROLE OF INTERNATIONAL POLICY IN TURNING THE TIDES OF DEFORESTATION

The TTD Statement proposes several strategies to halt deforestation, focusing on both immediate actions and long-term policy changes. In the field of sustainable forest management and agriculture practices, some recommendations include implementing nature-based solutions to prevent ecological tipping points and holistic land management practices that integrate both forest conservation and agricultural resilience. The Statement also calls for improving forest monitoring systems and data quality, gaps that are not recent according to Rasmussen and Jepsen (2018), and which are essential for informed decision-making and effective management.

On strategies that focus on legal frameworks, the TTD Statement emphasizes

the importance of strengthening land tenure and securing rights to land and resources. Furthermore, it brings the importance of demand-side commitments, such as those under the EU FLEGT Action Plan, and of international trade regulations through legislation, EUTR, which will be repealed by the EUDR, requiring future versions of TTD to take this into account.

Another critical point that the TTD emphasizes is the importance of adequate financial mechanisms and economic incentives for reducing deforestation, such as the Reducing Emissions from Deforestation and forest Degradation (REDD+). The statement also calls for strengthening the rights and participation of Indigenous Peoples and Local Communities (IPLCs), women, and youth as agents of change for sustainable forest management.

However, the TTD also identifies some challenges, such as ensuring consistent funding and achieving policy coherence. A stable union between politics and science is essential for developing actionable, policy-oriented solutions to deforestation, thereby addressing these challenges. Pielke (2008) argues that politicization of science is inevitable and that accepting this reality can lead to more effective governance strategies. Given this, fostering collaboration among international organizations, governments, academia, and stakeholders can help to achieve a more effective and equitable approach to halt deforestation.

Furthermore, international policy-oriented documents in halting deforestation should also aim at awareness-raising and education initiatives. By disseminating clear information, these initiatives can inspire action at all levels of society, while equipping policymakers with the necessary knowledge and tools. One example of such an initiative is the EMMA4EU project, which supports the implementation of the EUDR by bridging sectors such as forestry, agriculture, and business, while connecting key actors.

Finally, limited progress has been made in addressing and reducing the highlighted problematic issues. This raises a common challenge with large-scale commitments and statements – ensuring their effectiveness in achieving real impact and establishing robust monitoring systems to track progress (Walcott et al., 2022). However, knowing that countries that have strong institutional coordination and capacity are more likely to align their national policies with international commitments (Adipudi and Kim, 2024; Victor, Lumkowsky, and Dannenberg, 2022), international policy frameworks and collaborations, like the CPF's TTD, can play an important role in combating worldwide deforestation.

CONCLUSION

This study adopted a semi-systematic literature review to critically examine the Collaborative Partnership on Forests' Joint Statement on "Challenges and Opportunities in Turning the Tide on Deforestation" revealing key related themes and an ongoing focus on assessing data on forest integrity and biodiversity. The findings also highlighted how complex and multifaceted forest loss mitigation is, emphasizing the need for more comprehensive scientific studies that can inform policymaking and provide practical applicability, from the international or national to the local level.

This study establishes a foundation for future research and policy development by providing a comprehensive analysis of the current version of the TTD Statement, as well as updated proposals based on the most recent scientific data and engaging in diverse discussions about the role of international policy. While the findings are valuable, the study remains exploratory, aiming to establish and test a potential approach for updating policy documents, like the TTD Statement, which can be further refined and integrated in future efforts. The results confirm that deforestation remains a pressing global issue, and that global commitments and policies must be paired with effective, transparent monitoring, accounting, and updating systems to ensure they translate into real-world impact.

DISCLAIMER

Any opinions and thoughts expressed in this thesis, especially during the discussion part, are solely those of the author and do not necessarily reflect the views or positions of any other individual or organization that were engaged somehow with this study. This thesis has been composed entirely by the author solely, and it has not been submitted, either in whole or in part, for any previous degree or qualification at any other institution.

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ANNEX 1: List of arguments and data to be updated

Section	Code	Argument or data to be updated
1. Deforestation	1.1	"*Forests cover 31 percent of the Earth's land area, which is just over 4 billion hectares*."
	1.2	"*Approximately half of the forest area is relatively intact, and more than one-third is primary forest*."
	1.3	"*Since 1990, an estimated 420 million hectares of forest has been lost through deforestation. From 2015 to 2020, the rate of deforestation was estimated at 10 million hectares per year, down from 16 million hectares per year in the 1990s*."
	1.4	"*At the global level, the rate of deforestation exceeds the rate of forest expansion – through natural regeneration, afforestation and reforestation – resulting in a net loss of 178 million hectares of forest since 1990*."
	1.5	"*Africa had the highest net loss of forest area from 2010 to 2020 followed by South America. Since 1990, Africa has reported an increase in the rate of net loss, while South America's losses have decreased substantially, by more than half since 2010 relative to the previous decade. Asia showed the highest net gain in forest area in the period 2010–2020*."
2. Deforestation & Climate (linkage)	2.1	"*The net anthropogenic greenhouse gas (GHG) emissions due to forestry and other land use activities (FOLU) – primarily emissions due to deforestation – account for 11 percent of global emissions*."
	2.2	"*A broad range of nature-based solutions can provide up to one-third of cost-effective climate mitigation needed between now and 2030 to stabilize warming to below 2º C*."
	2.3	"*Among these, reducing deforestation and forest degradation – including of peatlands and mangroves – are some of the most effective, mature and robust options*."
	2.4	"*More than 50 countries specifically refer to REDD+ in their NDCs.*"
3. Forests & Biodiversity (linkage)	3.1	"*Forests provide habitats for 80 percent of amphibian species, 75 percent of bird species and 68 percent of mammal species*."
	3.2	"*Approximately 60 percent of all vascular plants are found in tropical forests*."
	3.3	"*An estimated 75 percent of the 115 leading food crops globally – together representing 35 percent of global food production – benefit from pollination by animals, many of which live in forests*."
	3.4	"*Reductions in forest patch size and increases in patch isolation have been shown to decrease the abundance of birds, mammals, insects and plants by 20 to 75 percent, impacting ecological functions such as seed dispersal and, hence, forest structure while also contributing to a reduction in ecosystem services such as carbon sequestration, erosion control, pollination and nutrient cycling*."
	3.5	"*A forest-specialist index that represents forest ecosystem health, focusing on forest dependent species, fell by 53 percent between 1970 and 2014, highlighting the increased risk of these species becoming vulnerable to extinction*."
	3.6	"*Only 40 percent of the world's forests still have a high level of integrity with boreal coniferous forests and tropical rainforests being the least fragmented and most continuous*."
	3.7	"*In the Amazon and Congo basins, however, land-use conversion is causing rapid change*."

Section	Code	Argument or data to be updated
4. Forests & Livelihoods (linkage)	4.1	"*Worldwide, around 1 billion people depend to some extent on forest foods such as wild meat, edible insects, edible plant products, mushrooms and fish*."
	4.2	"*Some 2.4 billion people – in both urban and rural settings – use wood-based energy for cooking*."
	4.3	"*Roughly one-third of the world's population has a close dependence on forests and forest products*."
	4.4	"*Around 820 million people live in tropical forests or savannahs*."
	4.5	"*An estimated 1.2 billion people depend on agroforestry farming systems*."
	4.6	"*Forests play a key role in water security for over half of the world's population and their domestic, agricultural and/or industrial needs*."
	4.7	"*Taking into account direct, indirect and induced employment, the formal forest sector provides an estimated 45 million jobs globally and labor income in excess of USD 580 billion per year*."
	4.8	"*The informal sector is estimated to provide employment for an additional 41 million people*."
5. Deforestation & Agriculture (linkage)	5.1	"*Agricultural expansion is the most significant driver of global deforestation and accounts for about 73 percent of tropical deforestation, of which 40 percent is due to large-scale commercial agriculture and 33 percent to small-scale subsistence use. Other drivers are mining (7 percent), infrastructure (10 percent) and urban expansion (10 percent)*."
	5.2	"*Underlying factors affecting the conversion of forests to agriculture include population growth, agricultural development, a lack of land-tenure security and the poor governance of land-use change*."
6. Forest fires	6.1	"*An average of 122 million hectares of forests are annually affected by forest fires, pests, diseases, invasive species, drought and adverse weather*."
	6.2	"*76 million hectares affected by forest fire alone*."
	6.3	"*A mutually reinforcing cycle of climate change and wildfire is emerging. Wildfires increase degradation through their impacts on forest ecosystems, and degradation contributes to wildfires in altered and secondary forests with exposed fuels, invasive species and recurring fires, and associated impacts on forest health*."
	6.4	"*Available data shows a trend of increasing frequency and intensity of uncontrolled fires adversely affecting biodiversity, ecological services, human well-being and livelihoods and national economies*."
	6.5	"*Extreme wildfires are the result of past and present policy, planning and governance decisions that – coupled with increasingly adverse weather conditions due to climate change – create the conditions for fires to ignite and spread across landscapes beyond the capacity of societies to suppress them*."
7. Timber legality and trade	7.1	"*The International Criminal Police Organization (INTERPOL) estimates that the value of illegal timber trade lies in the range of USD 51–152 billion per year*."
	7.2	"*The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) promotes the sustainable trade of approximately 300 timber species that*

Section	Code	Argument or data to be updated
		are at risk of over-exploitation through sustainability and legality standards."
	7.3	"*Voluntary certification is also a valuable tool and already covers more than one-third of industrial roundwood production*."
8. Public and private commitments to halt deforestation	8.1	"*There is still too little information from companies on their actions and results to judge their progress in achieving their commitments*."
	8.2	"*Few countries have met their Bonn commitments thus far, with only two completed (Pakistan and the United States of America) and limited reporting on progress in most other countries*."
9. Policy coherence	9.1	No argument or data to be updated.
10. True costs of deforestation	10.1	"*Agricultural production support amounts to well over USD 500 billion every year, but, according to the Organisation for Economic Co-operation and Development (OECD), most current support to agriculture distorts markets, stifles innovation and harms the environment rather than financing long term investment*."
11. Climate finance	11.1	"*Private sector climate commitments and related interest in carbon offsets from reducing deforestation have increased significantly in recent years, both project developers and corporate buyers expect more stable market conditions*."
	11.2	"*Investments in land-based mitigation measures make up a mere 2 percent of climate finance*."
12. Participation of IPLC, women and youth	12.1	"*Indigenous peoples manage approximately 28 percent of the world's land surface, intersecting with 40 percent of terrestrial protected areas and ecologically intact landscapes, and 37 percent of all remaining natural lands*."
13. Land use data	13.1	No argument or data to be updated.
14. Partnerships and cooperation	14.1	No argument or data to be updated.

ANNEX 2: R script

```
rm(list=ls())

# loading packages (it must be installed if it has not already been done) #
library(ggplot2)
library(ggraph)
library(igraph)
library(readr)
library(devtools)
library(Rcpp)
library(dplyr)
library(here)
library(ggraph)
library(remotes)

# installing and loading the LITSEARCHR package #
install.packages("litsearchr")
devtools::install_github("elizagrames/litsearchr", ref = "main")
library(litsearchr)

# checking the current version of the package #
packageVersion("litsearchr")

# installing and loading the STRINGI package #
# that's a function that prevents abstract's special characters from becoming N/A characters #
install.packages("stringi")
library(stringi)

### CHANGE THE NAME TO EACH DATASET ###

# importing .csv files from scientific literature database, such as Scopus or Web of Science #
naiveresults <- (exploratorysearch12_2)

# merging both keywords columns into one #
naiveresults$keywords <- paste(ifelse(is.na(naiveresults$keywords.author), "",naiveresults$keywords.author), ifelse(is.na(naiveresults$keywords.plus), "",naiveresults$keywords.plus),sep = "; ")

# removing special characters #
naiveresults$abstract <- stri_trans_general(naiveresults$abstract, "Latin-ASCII")

# removing non-alphanumeric characters and fixing multiples spaces #
remove_special_chars <- function(text) {
  cleaned_text <- gsub("[^[:alnum:]\\s]", "", text, perl = TRUE)
  cleaned_text <- gsub("\\s+", " ", cleaned_text)
  return(cleaned_text)
}

# checking for N/A values in columns and replacing them with an empty string #
naiveresults$title[is.na(naiveresults$title)] <- ""
naiveresults$keywords[is.na(naiveresults$keywords)] <- ""
```

```
naiveresults$abstract[is.na(naiveresults$abstract)] <- ""

# fixing missing values and non-ASCII characters #
naiveresults$title <- iconv(naiveresults$title, from = "UTF-8", to = "ASCII//TRANSLIT")
naiveresults$abstract <- iconv(naiveresults$abstract, from = "UTF-8", to = "ASCII//TRANSLIT")
naiveresults$keywords <- iconv(naiveresults$keywords, from = "UTF-8", to = "ASCII//TRANSLIT")

naiveresults$title <- tolower(naiveresults$title)
naiveresults$abstract <- tolower(naiveresults$abstract)
naiveresults$keywords <-tolower(naiveresults$keywords)

# replacing the "0" value from the last step #
naiveresults$title <- gsub("0", " ", naiveresults$title)
naiveresults$abstract <- gsub("0", " ", naiveresults$abstract)
naiveresults$keywords <- gsub("0", " ", naiveresults$keywords)

# fixing special characters #
remove_special_chars <- function(x){
  gsub("[^[:alnum:][:space:];]", "", x)
}
naiveresults$title <- sapply(naiveresults$title, remove_special_chars)
naiveresults$abstract <- sapply(naiveresults$abstract, remove_special_chars)
naiveresults$keywords <- sapply(naiveresults$keywords, remove_special_chars)

# removing duplicates #

naiveresults <-
  litsearchr::remove_duplicates(naiveresults, field = "title", method = "string_osa")

# checking if the N/A issue in the abstract persists #
nas=is.na(naiveresults$abstract)
summary(nas)

### END OF DATA CLEANING ###

# counting words ##
count_words <- function(text){
  words<-unlist(strsplit(text,"\\s+"))
  length(words)
}

abstract_and_title_words_count <- sum((sapply(naiveresults$abstract, count_words)),(sapply(naiveresults$title, count_words)))
print(abstract_and_title_words_count)

keywords_words_count <- sum(sapply(naiveresults$keywords, count_words))
print(keywords_words_count)

### CHANGE THE NUMBERS TO EACH DATASET ###

# extracting raked-keywords from title and abstract #
```

```
rakedkeywords <-
  litsearchr::extract_terms(
    text = paste(naiveresults$title, naiveresults$abstract),
        method = c("fakerake"), min_freq = 11, # 0,15% of the abstract and title words count #
        ngrams = FALSE,
        stopwords = NULL,
        language = "English")

# extracting tagged-keywords from keywords #
taggedkeywords <-
  litsearchr::extract_terms(
        keywords=naiveresults$keywords,
        method = c("tagged"), min_freq = 7, # 1,5% of the keywords count #
        ngrams = TRUE,
        min_n = 1,
        max_n = 3,
        stopwords = NULL,
        language = "English")

# building the keyword co-occurrence network, without duplicates from raked and tagged #
all_keywords <- unique(append(taggedkeywords,rakedkeywords))
docs <- paste(naiveresults[, "title"], naiveresults[, "abstract"])

# finalizing the data frame #
all_keywords= as.data.frame(all_keywords)
```

ANNEX 3: Information updated from reports

Section	Code	Revised argument or data	Reference
1. Deforestation	- 1.1	"The world's forest area covered 3.97 billion ha in 2018, i.e. 30.8 percent of the global land area." "The global forest area in 2020 is estimated at 4.06 billion ha, which is 31 percent of the total land area"	(Food and Agriculture Organization of the United Nations, 2022a)
	- 1.2 - 1.3 - 1.4 - 1.5	"Based on the provided data, the area of primary forests worldwide is estimated at 1.11 billion ha, or about one-third (34 percent)." "An estimated 420 million ha of forest has been lost worldwide through deforestation since 1990, but the rate of forest loss has declined substantially. In the most recent five-year period (2015–2020), the annual rate of deforestation was estimated at 10 million ha, down from 12 million ha in 2010–2015." - Table 5: Forest area, by region and subregion, 1990–2020 "Africa had the highest annual rate of net forest loss in 2010–2020, at 3.9 million ha (...) The rate of net forest loss has increased in Africa in each of the three decades since 1990. It has declined substantially in South America"	(Food and Agriculture Organization of the United Nations, 2020)
2. Deforestation & Climate (linkage)	- 2.1	"In 2019, approximately 34% (20 GtCO2-eq) of net global GHG emissions came from the energy sector, 24% (14 GtCO2-eq) from industry, 22% (13 GtCO2-eq) from AFOLU, 15% (8.7 GtCO2-eq) from transport and 6% (3.3 GtCO2-eq) from buildings (high confidence). About half of total net AFOLU emissions are from CO2 LULUCF, predominantly from deforestation."	(Calvin et al., 2023) – Synthesis Report of the 6th Assessment of the Intergovernmental Panel on Climate Change
	- 2.2	"Nature-based solutions (NBS) with safeguards has immense potential for cost-effective adaptation to climate change; but their impacts will vary by scale and contexts (high confidence). Griscom et al. 2017 estimate this potential to provide 37% of cost-effective CO2 mitigation until 2030 needed to meet 2°C goals with likely cobenefits for biodiversity"	(Griscom et al., 2017) cited on (Shukla et al., 2022) – Full report of the Working Group III contribution to the 6th Assessment of the Intergovernmental Panel on Climate Change
	- 2.3	"Mangroves are among the most carbon-rich ecosystems on Earth."	(Food and Agriculture

Section	Code	Revised argument or data	Reference
			Organization of the United Nations, 2023)
	- 2.4	"The inclusion of the forestry sector in the mitigation actions of the 'second generation' NDCs in 2020 has risen from 59% to 69%, compared to the first round of NDCs submissions in 2015. The most anticipated mitigation actions related to forests featured in NDCs focused on 'Afforestation, reforestation and forest ecosystem restoration' (58%) and 'Reduce deforestation and degradation' (49%)." "(REDD+) is increasingly being integrated to contribute to meeting the Paris Agreement goals, with approximately one-third of countries mentioning REDD+ in their most updated NDCs - a total of 56 countries: 23 countries in Africa, 20 countries in Latin America and 13 in Asia-Pacific."	(United Nations Climate Change, 2022)
3. Forests & Biodiversity (linkage)	- 3.4	"The changes in spatial pattern and structure by fragmentation of forest into smaller patches or 'islands' damages forest functions (e.g. carbon storage, water provision, maintenance of species habitat)." "The increasing isolation of forest patches from each other or from core forest contributes to long-term changes in biodiversity, including species richness and productivity, creating fundamental and sometimes irreversible changes in forest landscapes."	(Pacheco et al., 2021) - Deforestation fronts: Drivers and responses in a changing world from WWF
	- 3.5	"The abundance of 1,428 observed populations of 343 forest specialist species monitored across the globe declined by 79% on average between 1970 and 2018."	(World Wide Fund for Nature and Zoological Society of London, 2022) cited in (Gagen et al., 2023) – The Forest Pathways Report from WWF
4. Forests & Livelihoods (linkage)	- 4.1 - 4.3	"Estimates based on recent empirical studies of the number of users of non-timber forest products (defined as wild native or non-native biological organisms and materials, other than high-value timber, collected from landscapes and habitats) put the lowest and median values at 3.5 billion and 5.76 billion people, respectively."	(Shackleton and De Vos, 2022) cited on (Food and Agriculture Organization of the United Nations, 2024)
	- 4.2	"Unprocessed biomass (wood, crop waste, dung), a polluting alternative, was the main fuel for 26 percent of people (1.7 billion)."	(IEA et al., 2024)

Section	Code	Revised argument or data	Reference
	- 4.4	"An estimated 4.17 billion people – 95 percent of all people outside urban areas – live within 5 km of a forest, and 3.27 billion live within 1 km."	(Food and Agriculture Organization of the United Nations, 2022b)
	- 4.6	"Burek et al. (2016) estimated that 4.8 billion–5.7 billion people could be living in water-scarce areas at least one month per year by 2050. Investing in healthy forests would help in sustaining water services, with FLR a cost-effective measure for maintaining water-holding capacity, soil fertility and soil stability."	(Burek et al., 2016) cited on (Food and Agriculture Organization of the United Nations, 2022b)
	- 4.7 - 4.8	"The estimated combined direct contribution of the formal and informal forest sector to employment in 2017–2019 was 33.3 million jobs (based on 185 countries representing 99 percent of the global forest area. This comprises about 1 percent of total employment globally for all economic activities."	(Lippe et al., 2022) – Contribution of the forest sector to total employment in national economies by FAO and the International Labour Organization (ILO)
5. Deforestation & Agriculture (linkage)	- 5.1	"FAO's recent remote sensing survey found that, between 2000 and 2018, almost 90 percent of deforestation was related to agriculture (52.3 percent from expansion for cropland and 37.5 percent from expansion for livestock grazing)." "Urban and infrastructure development caused 6.2 percent of global deforestation between 2000 and 2018. In addition, 3.7 percent of forest was lost due to severe degradation affecting its sustainability to regenerate naturally"	(Food and Agriculture Organization of the United Nations, 2022b)
	- 5.2	"It is also important to consider the dynamics of future drivers. For example, the global population is projected to reach 9.7 billion people by 2050;105 taking dietary changes and other factors into account, this implies an increase in food demand of 35–56 percent, potentially increasing demand for land and pressure on forests."	(Van Dijk et al., 2021) cited on (Food and Agriculture Organization of the United Nations, 2022b)
6. Forest fires	- 6.1	"An average of 122 million hectares of forests are annually affected by forest fires, pests, diseases, invasive species, drought and adverse weather."	(Food and Agriculture Organization of the United Nations, 2020)
	- 6.2	"Recent research shows that 29–37 percent of global forest loss (measured as permanent and non-permanent tree-cover loss) in 2003–2018 was fire-related."	(Van Wees et al., 2021) cited in (Food and Agriculture Organization of the United Nations, 2022b)

Section	Code	Revised argument or data	Reference
	- 6.3	“The frequency and intensity of wildfires is increasing, including in areas not previously affected, particularly due to climate change and land-use change.”	(Food and Agriculture Organization of the United Nations, 2024)
7. Timber legality and trade	- 7.2	“The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) promotes the sustainable trade of more than 900 timber species that are at risk of over-exploitation through sustainability and legality standards.”	(Convention on International Trade in Endangered Species of Wild Fauna and Flora, 2024)
10. True costs of deforestation	- 10.1	“In 2021, FAO, the UN Development Programme and the UN Environment Programme estimated the value of support for agricultural producers globally at almost USD 540 billion per year and noted that this support is heavily biased towards measures that are distorting (thus leading to inefficiency), unequally distributed, and harmful for the environment and human health.”	(Food and Agriculture Organization of the United Nations, United Nations Development Programme, and United Nations Environment Programme, 2021)
11. Climate finance	- 11.2	“Overall, climate finance to agrifood systems has been strikingly low considering its mitigation potential: it represents just 4.3% of total climate finance with an annual average of USD 28.5 billion in 2019/2020.”	(Buchner et al., 2023) – Global Landscape of Climate Finance by the Climate Policy Initiative