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Review

Effectiveness and Economic Viability of Forest Certification: A Systematic Review

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Abstract: In the face of accelerating forest degradation and deforestation, forest certification emerged in the early 1990s as a voluntary and market-based mechanism to promote environmentally appropriate, socially beneficial, and economically viable management of the world's forests. A key goal of forest certification is to reduce forest degradation and deforestation while enhancing forest enterprises' economic viability. However, whether forest certification contributes to meeting such goals is unclear. We conducted a systematic literature review on such impacts, reviewing empirical studies published between 1993 and 2021 regarding the impact of forest certification on forest degradation, deforestation, and economic viability. Drawing on 98 empirical studies, we analyzed these impacts and provide an overview of the studies' findings in terms of geographical distribution, indicators considered, and the certification schemes assessed. We found that the impact of forest certification on deforestation has been specifically understudied ($n = 11$) compared to forest degradation ($n = 42$) and economic viability ($n = 45$). On deforestation, studies have focused on Africa (45%) and South America (36%); on forest degradation, studies have focused on Europe (40%) and Asia (20%); on economic viability, studies have focused on Asia (33%), Europe (33%) and South America (20%). We found positive-neutral (54%; 46%) impacts on deforestation, positive-neutral-mixed (70%; 21%; 9%) impacts on forest degradation and positive-negative-mixed (50%; 33%; 17%) impacts on economic viability. We did not find clear evidence that impact is linked to a specific region or certification scheme. However, scarce evidence on the impacts of the Programme for the Endorsement of Forest Certification (PEFC), the application of various methods, and site-specific indicators in the individual studies challenge such comparison and hamper the generalization of findings. This systematic review provides an overview of the state-of-the-art research on the effectiveness and economic viability of forest certification, evaluates and discusses the current evidence base, and concludes with future research lines.

Keywords: Forest Stewardship Council; deforestation; forest degradation; economic impact

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1. Introduction

Forests cover 31% of the global land area [1]. They provide essential social, economic and environmental benefits to society such as employment, forest products, biodiversity, carbon storage and sequestration. However, agricultural expansion, logging of timber and the collection of fuelwood, fires and livestock grazing have been driving deforestation and forest degradation at alarming rates [1,2].

Various policies have been implemented to slow down deforestation and forest degradation, such as forest laws, their increased enforcement, protected areas, or programs of payments for ecosystem services (PES) [3]. In addition, the international carbon payment mechanism under the UNFCCC has led to the establishment of the REDD+ mechanism (reducing emissions from deforestation and forest degradation) [4]. Finally, consumer countries have restricted imports of illegally harvested timber, and private supply chain actors have introduced eco-labeling and certification to ensure sustainable sourcing of products [5].

Forest certification was introduced by the Forest Stewardship Council (FSC) in 1993 as a voluntary and market-based approach to reduce tropical deforestation and the loss of biodiversity. The FSC's mission today is "to promote environmentally appropriate, socially beneficial, and economically viable management of the world's forests" [6]. In 1999, the Pan European Forest Certification Council (PEFCC) was founded to address the specifics of small forest owners in Europe [7]. In 2004, the PEFCC expanded to also endorse national standards from outside Europe and accordingly changed its name to the Programme for the Endorsement of Forest Certification (PEFC). The FSC and PEFC are today the largest certification schemes worldwide in terms of forest area covered. While the FSC sets international standards, the PEFC functions as an umbrella organization endorsing regional and national forest certification systems through independent third-party certification [8].

Since its inception, the uptake of forest certification has grown steadily and is now distributed across 89 (FSC) and 55 (PEFC) countries [9,10]. The PEFC covers 330 million hectares of certified forest (as of September 2021) [10], the FSC covers about 230 million ha [9]. There have been considerable regional disparities in certification uptake. Despite the initial intention to increase certification in tropical forest countries, forest certification has primarily expanded in the temperate forests of North America and Europe, whereas certification coverage in tropical countries has remained low. Subtropical Asia and Latin America having among the highest rates of deforestation and forest degradation (from timber logging), account for only about 4% of the total forest area covered by PEFC and FSC [1,2,9,10].

With the increasing area of certified forests, there is the question of whether forest certification is effective, that is, the degree to which it is meeting the objectives for which it was developed [11]. In the context of forest certification, effectiveness refers particularly to its capacity to reduce deforestation and forest degradation while maintaining or enhancing the economic viability of forest managers. Collecting and assessing evidence of effectiveness is essential to ensure consumers that the products they purchase do originate from sustainably managed forests [12,13] and to improve the credibility of sustainability commitments [10]. Furthermore, understanding the effectiveness of forest certification relative to other market-based or governance mechanisms can help design policy mixes targeted to reduce deforestation and degradation [12,13]. Closely linked to effectiveness is the economic viability of forest certification. Economic viability defines the capability of certified forest operation to sustain itself as an independent social, economic, or political unit [6,14,15], e.g., by keeping costs lower than benefits.

Several qualitative desktop studies address the effectiveness of forest certification. These studies compare the criteria of the FSC and the PEFC [16,17], look at the stringency of standards and modes of operations [18,19], compare drivers of certification uptake [20–22], or look at the macro-effectiveness of forest certification [23,24]. Other desktop studies discuss the role of forest certification in sustainable forestry on larger spatial scales [18,25–27]. However, while such studies have contributed to the general understanding of the impact of forest certification, findings are often built on limited empirical evidence, thus not allowing for inferences about the actual effectiveness of forest certification on a larger scale [28,29].

Only a few studies have synthesized empirical evidence of impacts on deforestation, forest degradation, and economic outcomes. For example, Burivalova et al. [30] compared the environmental, social, and economic impacts of forest certification and community forestry [30] and compared forest certification impacts with other conservation strategies such as Reduced Impact Logging (RIL) [31]. In addition, a qualitative literature review conducted by Di Girolami and Arts [32]analyzed the environmental impacts of the FSC and PEFC schemes by assessing their impact on fauna, flora, and ecosystem services (ES) in the boreal, temperate and tropical forests [32]. All these studies found that certification has substantial environmental benefits [27,30–32], typically achieved at the cost of reduced short-term financial profit and accompanied by some improvement to the welfare of neighboring communities [30]. However, most of these desktop studies and reviews have focused on tropical countries and the FSC scheme and have focused on specific management or conservation strategies such as RIL [31].

In the background of the scattered evidence, we conduct a systematic review and assessment of the available literature on the effectiveness of forest certification schemes in reducing forest degradation and deforestation, and for the economic viability of forest certification for forest managers. Specifically, we ask the following questions: (1) What is the effectiveness of forest certification in reducing deforestation and forest degradation? (2) Is forest certification economically viable for forest managers? We synthesize and structure our findings in terms of indicators of deforestation, forest degradation and economic outcomes studied and the impacts per world region. We discuss the findings in terms of the research questions posed, reflect the challenges and uncertainties of synthesizing the current evidence base, and identify critical research gaps to advance research in this field.

2. Materials and Methods

2.1. Systematic Review

This systematic review follows the Guideline of the Collaboration for Environmental Evidence Reporting Standard "Reporting standards for Systematic Evidence Synthesis (ROSES)". This standard was developed from the PRISMA protocol for meta-analysis and systematic reviews of medical sciences, and it specifically caters to the field of environmental conservation and management [33].

Before starting the review, the first author prepared a systematic review protocol following the ROSES guidelines (https://www.roses-reporting.com/, accessed on 2 May 2021). This protocol contained the planned method based on listed standards and was critically evaluated by the co-author and another reviewer within the Thünen Institute of Forestry. After the protocol was agreed upon, the following steps were taken:

2.2. Search Strategy

The first step was the formulation of search strings for deforestation, forest degradation, and economic viability. The keywords for the search string were selected based on an initial screening of the literature, the theory of change in the FSC [6] and the standards and criteria of the FSC and PEFC schemes [7,15]. For example, we extracted keywords from the FSCs theory of change intended environmental impacts: "halting the conversion of natural forests to plantations and other land uses" and economic impacts "forest management operations should gain market advantages through certification" [6].

We searched for all major forest certification schemes, including the Forest Stewardship Council (FSC), the Programme for the Endorsement of Forest Certification (PEFC), and the PEFC endorsed national schemes: the Canadian Standard Association (CSA), Sustainable Forestry Initiative (SFI), Argentine Forest Certification System (CERFOAR), Brazilian Forest Certification Programme (CERFLOR), among others. The final search string (Scopus format) was composed as follows (Table 1).

Table 1. Final search strings. The truncation symbol (*) behind/before a word stem ensures that other word forms can be retrieved, e.g., carbon* = carbon sequestration, carbon emissions, or *plantations = forest plantations, etc.

Search Field	Final Search String (Scopus Format)
Search field #1	
TITLE-ABS-KEY	"Forest Certification" OR "Forest Stewardship Council" OR "Programme for the Endorsement of Forest Certification" OR "The Council for Sustainable Forest Management in the Republic of Macedonia" OR "Council for Sustainable

	Forest Management and certification in Bulgaria" OR "Naša Šuma" OR "The Federation of Thai Industries" OR "China Forest Certification Council" OR "Hungarian Forest Certification" OR "Institute for Forest Certification" OR "Association for Sustainable Forest Management Forest Products and Services Certification" OR "CERFOAR" OR "Guyana Forestry Commission" OR "Brazilian Forest Certification Program" OR "CERFLOR" OR "New Zealand Forest Certification Association" OR "Responsible Wood" OR "SGEC" OR "South African Forestry Assurance Scheme" OR "Pan African Forest Certification" OR "Network for Certification and Conservation of Forests" OR "Indonesian Forestry Certification" OR "Malaysian Timber Certification Scheme" OR "Vietnam Forest Certification Scheme" OR "Sustainable Forestry Initiative"
Search field #2	
TITLE-ABS-KEY (Deforestation)	deforestation OR *plantation* OR *conversion*
TITLE-ABS-KEY (Degradation)	degradation OR "tree cover loss" OR "biological diversity" OR biodiversity OR "species composition" OR "species diversity" OR "genetic diversity" OR "ecosystem services" OR "ecosystem function" OR carbon* OR "landscape values" OR "soil erosion" OR "water regulation"
TITLE-ABS-KEY (Economic viability)	"economic viability" OR efficiency OR *benefit* OR *cost* OR profit OR "financial gain" OR economic OR "market access" OR revenue* OR expense*

We searched for peer-reviewed and grey literature using the bibliographical databases Web of Science and Scopus. We included the search engine Google Scholar, limiting the screening of articles to the first 250 results. In addition, we reviewed references of peer-reviewed articles relevant to the research questions. Reports from the certification organization (i.e., FSC, PEFC) were not considered. We searched articles from January 1993 onwards, the starting year of the FSC. The literature review was conducted between May and June 2021. Search records were exported into the reference manager Citavi and duplicates were removed.

2.3. Article Screening and Selection Criteria

In the next step, the literature was screened and assessed in two stages. For Scopus and Web of Science, first, the title, abstract, and keywords were screened based on predefined selection criteria (Table 1). For grey literature, such as reports, the executive summary, objectives, and methods were screened. For Google Scholar, only the title was screened. Based on this screening, a first set of articles was selected. In a second step, the full text of the selected article was read and analyzed by the first author. In order to ensure the consistency of the first authors´ decisions, about 20% of analyzed studies (title/abstract/full text) were independently screened and reviewed by the co-author and another scientist of the institute. Articles, where the reviewer was undecisive, were discussed with these two "reviewers".

Studies were selected based on the pre-condition to address the relationship between forest certification and deforestation, forest degradation, and economic viability (Table 2). This relationship was measured by specific indicators: for deforestation: tree cover loss, conversion from forest to non-forest, from natural forest to plantation forest; for forest degradation: impact on carbon, biodiversity, ecosystem services, environmental values; for the economic viability: the economic viability of a firm, cost-effectiveness, economic benefits/revenues. We considered studies in English, German and Spanish.

Table 2. Eligibility criteria and key words used to compile the search string. The truncation symbol (*) behind/before a word stem ensures that other word forms can be retrieved, e.g., carbon* = carbon sequestration, carbon emissions, or *plantations = forest plantations, etc.

Target Variable	Eligibility Criteria/Description	Key Words (Search String)
Deforestation	Tree cover loss or forest conversion in or outside a certified concession or as a result of certification or after ending certification. Deforestation also includes the conversion from a natural forest to a plantation forest.	Deforestation *plantation* *conversion*
Forest degradation	A reduction in the capacity of forest ecosystems to provide ecosystem services and biodiversity. It can be measured by changes in ecosystem services and functions (carbon sequestration and storage, erosion control, water and soil regulation) and environmental values concerning carbon stocks/climate mitigation potential and landscape values. Biodiversity includes species composition, species diversity, genetic diversity. Forest fragmentation or tree cover loss can negatively affect biodiversity and ecological integrity and is thus often associated with forest degradation.	Degradation tree cover loss biological diversity biodiversity species composition species diversity genetic diversity ecosystem services ecosystem function carbon* landscape values soil erosion water regulation
Economic viability	"The capability of developing and surviving as a relatively independent social, economic or political unit. Economic viability may require but is not synonymous with profitability" [14] This includes the relationship between inputs and outputs of certification, including cost–benefit ratios of monetary and non-monetary values for the forest managers who may benefit economically from certification, i.e., additional revenues and/or fewer expenses and/or fewer revenues induced by certification.	efficiency *benefit* *cost* profit financial gain economic economic viability market-access revenue* expense*

2.4. Critical Appraisal

The final step of the selection process was the critical appraisal of the studies. One important criterion was the method to be clearly stated and described and the certification scheme specified. Articles were excluded if they solely compared or assessed the stringency of certification schemes. Studies that briefly mention a relationship between forest certification and one of the three topical areas of interest, without further assessment, were also excluded. Several studies assess sustainable forest management practices or conservation management (i.e., RIL or High Conservation Value Forest (HCV)). Such studies were only included if assessed in the forest certification context.

In terms of economic viability, studies that addressed organizational changes from implementing forest certification, consumer responses, or consumers' willingness to pay for certified products were also excluded. In addition, since we were interested in the economic viability of forest management certification, we excluded studies on chain of custody certification. Finally, studies based merely on comparing Corrective Action Requests (CARs) were excluded as well, since these are not based on on-the-ground measurements, rendering it uncertain if impacts were actually produced [32,34]. The derived eligibility criteria and keywords of the search string are compiled in Table 2. The ROSES flow diagram can be found in Appendix A, Figure A1.

2.5. Analysis of Articles

After critical appraisal, the studies were analyzed in terms of the following criteria: target variable (i.e., deforestation, forest degradation, economic viability), study aim, study type (empirical, desktop, model/scenario or macro-economic), method (quantitative, qualitative), certification scheme (i.e., FSC, PEFC, other), indicators assessed, geographic region, forest type (i.e., plantation or native forest) and impact on the variable under study. For the analysis of economic viability, we also considered the size of the operation, the cost-income relationship of a firm, and price premiums gained from certification. The information was extracted and compiled in an excel sheet and summarized in the Supplementary Information, Tables S1–S5. We distinguish three main groups of studies: (a) empirical studies that generate data through, e.g., interviews, surveys, field studies; (b) desktop studies that base their findings on existing literature; (c) models or scenarios that generate findings through simulations.

We analyze all groups of studies but only synthesize the empirical studies' findings that provide information on the measured impact of forest certification schemes. This decision was made to reduce double counting of empirical studies analyzed in desktop studies. An overview of the desktop and model or scenario studies for the three themes is provided in the Supplementary Information, Tables S6–S11. Since empirical studies often contain more than one case study location, we assess the impact on each case study location as having "positive", "negative", "neutral" or "mixed impacts". Mixed impacts contain positive effects on one proxy indicator and negative effects on another.

We synthesize our findings per world region: Asia, Africa, Europe, South America, North America, Central America and Oceania (incl. Australia) according to FAO [35]. North America and Central America are usually merged in one world region; we separated them due to different socio-cultural and economic characteristics of the regions that we deem important for interpreting results. Finally, we mapped the distribution of case study locations, using OpenStreetMap in a geographic information system.

3. Results

3.1. Existing Evidence Base

The initial search on the effectiveness and economic viability of forest certification hit 1595 articles in Scopus and Web of Science. Regarding deforestation, we found 195 and 113 articles in Scopus and Web of Science, respectively; for forest degradation, 273 and 195; and economic viability, 538 and 281. In addition, we screened the first 250 results of Google scholar. After an initial screening of the title, abstract, and keywords, 42 publications appeared relevant for our review question on deforestation, 133 concerning forest degradation, and 210 concerning economic viability. After thoroughly reading the text and critical appraisal, 23 publications were selected on deforestation, 61 on forest degradation and 64 on economic viability (based on selection criteria, Section 2.3 and Table 2). These are primarily academic journal articles, with some grey literature. Overall, we found most publications conducted in Europe, Asia, and South America. However, considering the total number of case studies extracted, we found most case studies in Asia (Figure 1). In addition, we found case studies on all three themes in each world region with the exception of Oceania, where we only found case studies on economic viability, and Europe, where no case study on deforestation was found (Figure 1). Due to the fact that a publication (i.e., empirical study) contained multiple case studies, we refer to publications as "studies" and to the study locations as "case studies." Since a study often contains more than one case study location, the number of studies is smaller than the number of extracted and analyzed case studies (Figure 1). The results are presented in (a) general findings per theme (proportion of study type, publication year, method, indicators, geographical distribution, certification scheme studied, forest type) and (b) the findings of the empirical case studies (evidence of impact presented per world region) (Section 2.3).

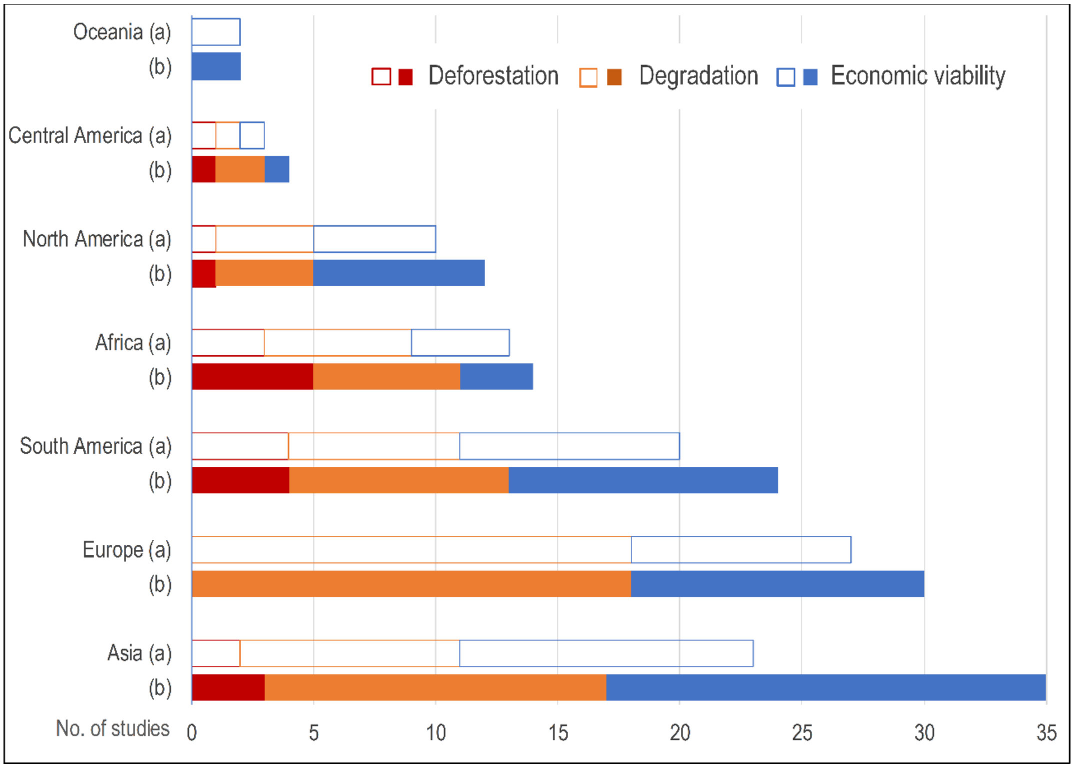

Figure 1. Regional distribution of (a) publications and (b) case studies per target variable (deforestation, forest degradation, economic viability).

3.2. Deforestation

3.2.1. General Findings

We found 23 publications on the impact of forest certification on deforestation. Of these publications, 11 are empirical studies, 7 desktop studies, and 5 macro-economic studies. The studies were published between 2003 and 2020, with the most empirical studies published in 2015 and 2018 (Figure 2A). Most empirical studies use forest or tree cover loss ($n = 6$) or forest or tree cover change ($n= 4$) as an indicator . Except for two studies that assessed the impact of forest certification in natural forests, studies did not specify the forest type, so that we were not able to compare potential differences in impacts on natural and plantation forests. The largest share of the empirical studies assessed deforestation impacts in Africa ($n = 5$) and South America ($n = 4$) with a few studies located in Asia ($n = 3$), Central America ($n = 1$) and North America ($n = 1$). No study was found in Oceania and Europe (Figure 3). Since the empirical studies included several case studies, we analyzed the impacts of 14 case studies on 11 locations. Except for one study that assessed the FSC in combination with the PEFC-CERFLOR scheme [36], all studies assessed the FSC scheme. The regional distribution of the empirical studies and certification schemes, as well as the reported impact, can be found in the Appendix A, Figures A2–A4.

All studies applied quantitative methods to assess the impact of certification on deforestation. Methods applied include spatial analysis or spatial explicit econometric methods, quasi-experimental methods or matched difference-in-difference models. One study combined spatial analysis with interviews [37]. Most studies compared deforestation in certified and uncertified logging concessions to assess the impact of forest certification in reducing deforestation. A few studies also compared the effectiveness of certification to public instruments, such as protected areas [38–40], a national moratorium on clear-cutting [36], and approved forest management plans [41] or compared the effectiveness of different certification schemes [36]. However, leakage effects, effects on land-use conversion outside the concession, were only assessed in one study [36]. Changes in tree/forest cover were assessed within a timeframe of 7–13 years, with all of the studies having a starting date of 2000/01.

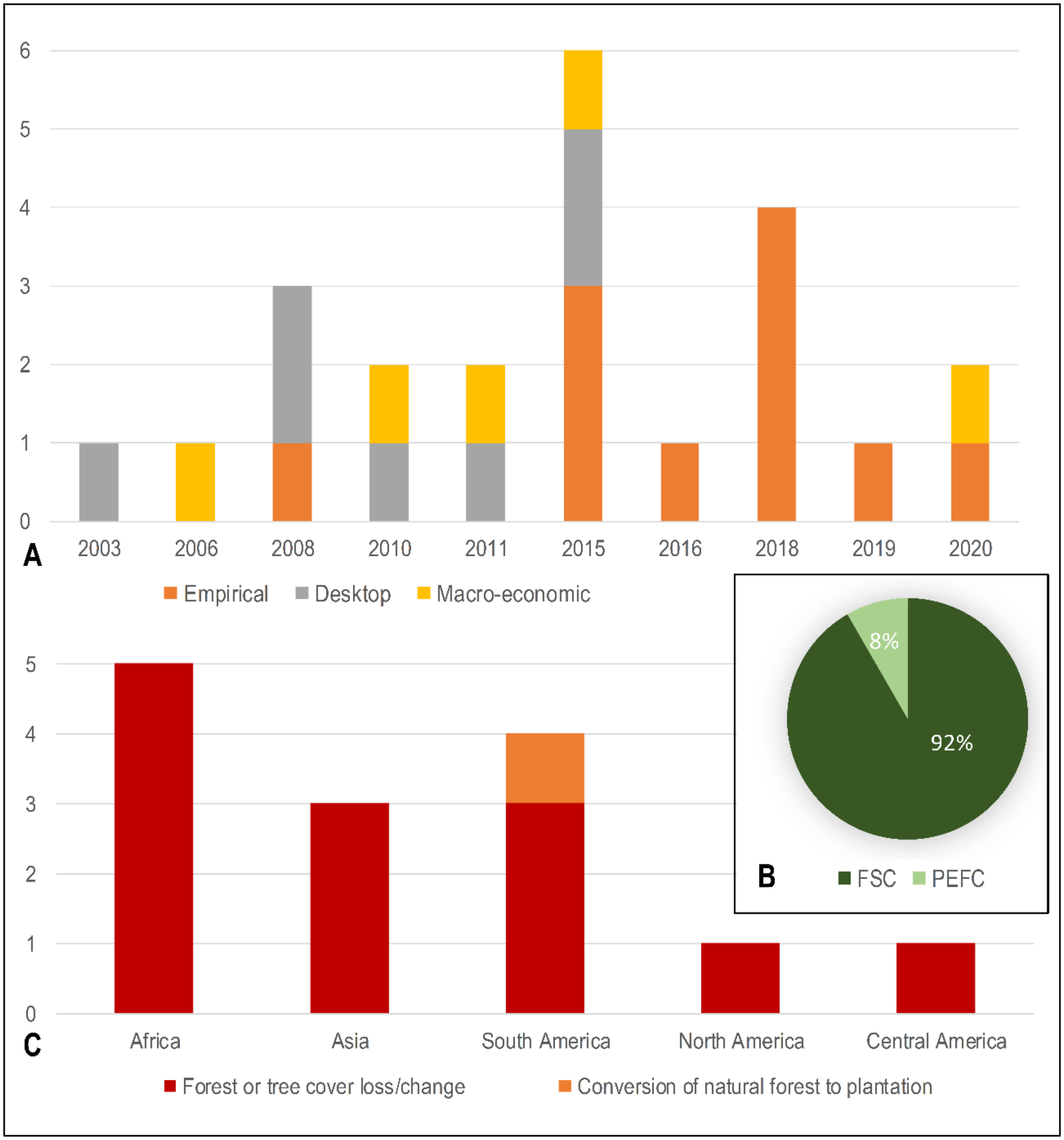

Figure 2. Number of publications on deforestation presented by year of publication and publication type (**A**). Share of certification scheme in the case studies (**B**). Distribution of empirical case studies, presented per world region and indicator (is not equal to the number of publications) (**C**).

3.2.2. Impact on Deforestation

Of the empirical studies, 54% (n = 6) reported a positive effect of forest certification against deforestation. However, these impacts were mostly minor, with less than 1% reduced deforestation in the analyzed forest concession compared to non-certified concessions. A total of 45% (n = 5) of the studies reported a neutral impact of forest certification, i.e., no difference in tree cover change between certified and non-certified concessions was observed (Figure 3). No study reported a negative effect, i.e., increased deforestation due to certification.

Based on the findings and the small number of case studies, we cannot find a relationship between impact and region studied. In the Congo basin (spanning Cameroon, Congo, Gabon and the Central African Republic (CAR)), 48% less deforestation was observed in FSC-certified concessions between 2005 and 2010 compared to uncertified concessions [41]. In Kalimantan, FSC certification reduced aggregate deforestation by 5% between 2000 and 2008 compared to uncertified concessions [42]. In the Maya Biosphere Reserve, Guatemala, the average annual deforestation rate for the FSC-certified concessions was 0.04% between 2002 and 2007, about twenty times less than the average annual deforestation rate of 0.88% for the entire reserve and the average annual deforestation rate of 0.79% in protected areas [40]. In Chile, FSC certification reduced annual rates of forest conversion by 0.91% in the period 2001–2011, with a rate of forest conversion of 1.15% compared to 2.06% in control groups where no policy was implemented. Deforestation in FSC-certified concessions was also lower than in properties managed under regional non-state-market-driven governance regimes (e.g., CERTFOR standard) or public conservation strategies [36].

In the Madre de Dios region in Peru, FSC certification impacts were very small, with an average reduced deforestation rate of 0.07–1% per year in the period 2000–2013 [39,43]. Minor effects were also found in Cameroon, with an average reduced deforestation rate of 0.02% in the period 2000–2013 in FSC-certified concessions [38,43,44]. However, another study conducted in Cameroon found no effect on deforestation, with certified and uncertified concessions having the same forest loss rates. In addition, no difference between certified and non-certified concessions was found in Russia (Primorsky Krai) [37], Peru (Madre del Dios) [39,43], Mexico [45] and Gabon [46]. The findings per indictor and world region are summarized in Figures 3 and 4.

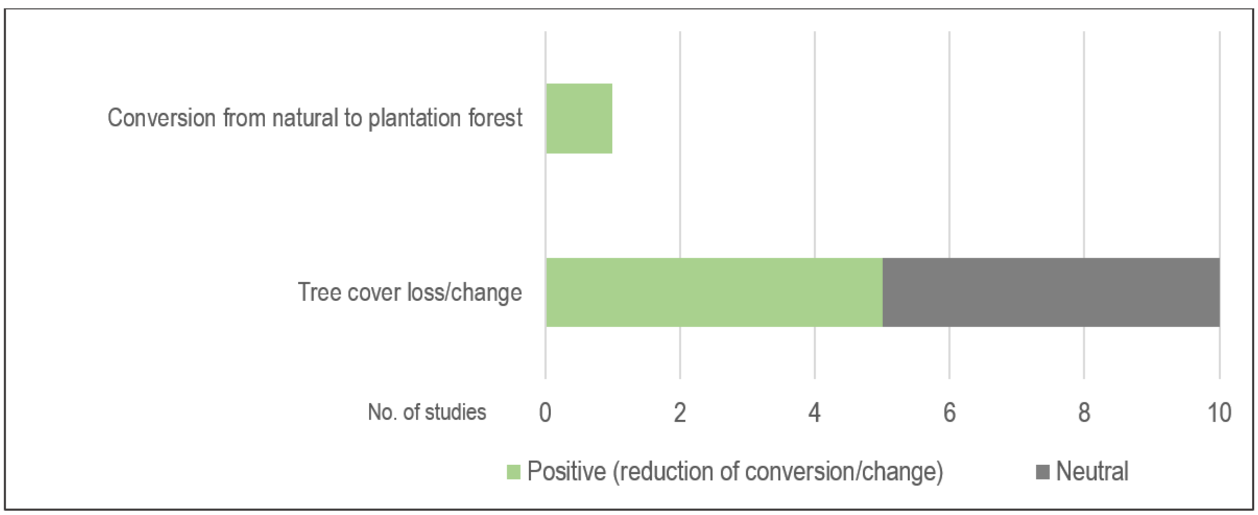

Figure 3. Impact of forest certification on deforestation. Presented by indicator and number of case studies.

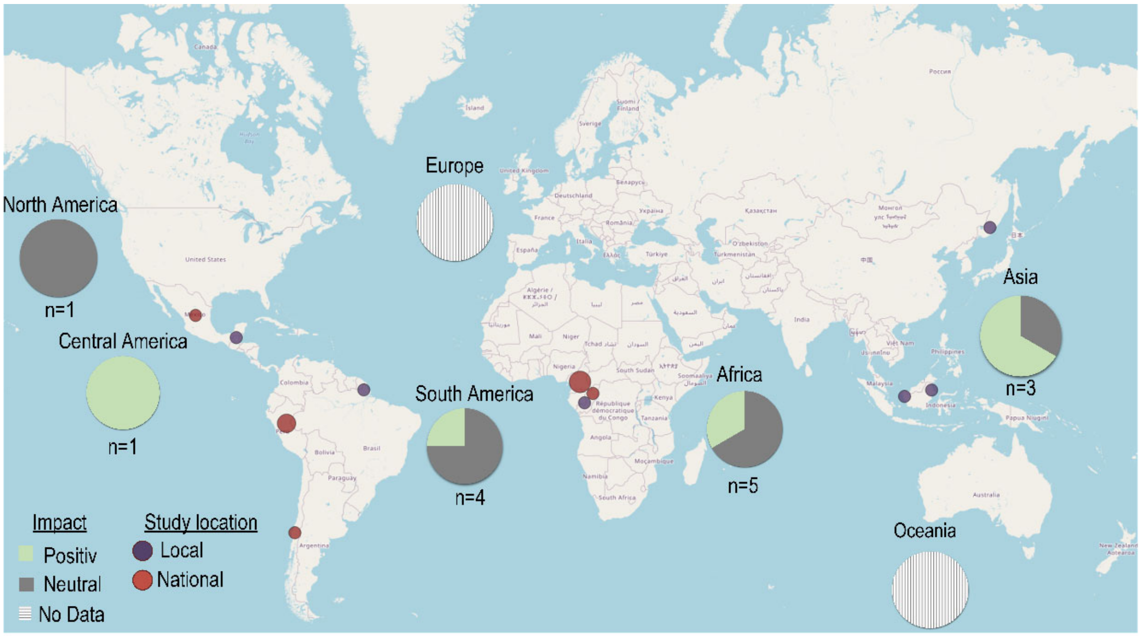

Figure 4. Global distribution of case studies on the impact of forest certification on deforestation. The size of the dots represents the relative number of case studies per location. Study location: Local studies are here equal or smaller than districts/states. National studies indicate that multiple case studies across the country were investigated. Pie charts show the number of case studies and the reported impact per region. Base map: © OpenStreetMap-contributors.

3.3. Forest Degradation

3.3.1. General Findings

We found 62 publications that analyzed the impact of forest certification on forest degradation. Of these publications, 45 are empirical studies, 14 are desktop studies, and 3 are model and scenario studies. The reviewed studies were published between 2001 and 2021, with most of them published between 2013 and 2020. Until 2007, most of the publications were desktop studies; from 2008 to 2021, empirical studies have increased, and scenario studies have emerged (Figure 5A).

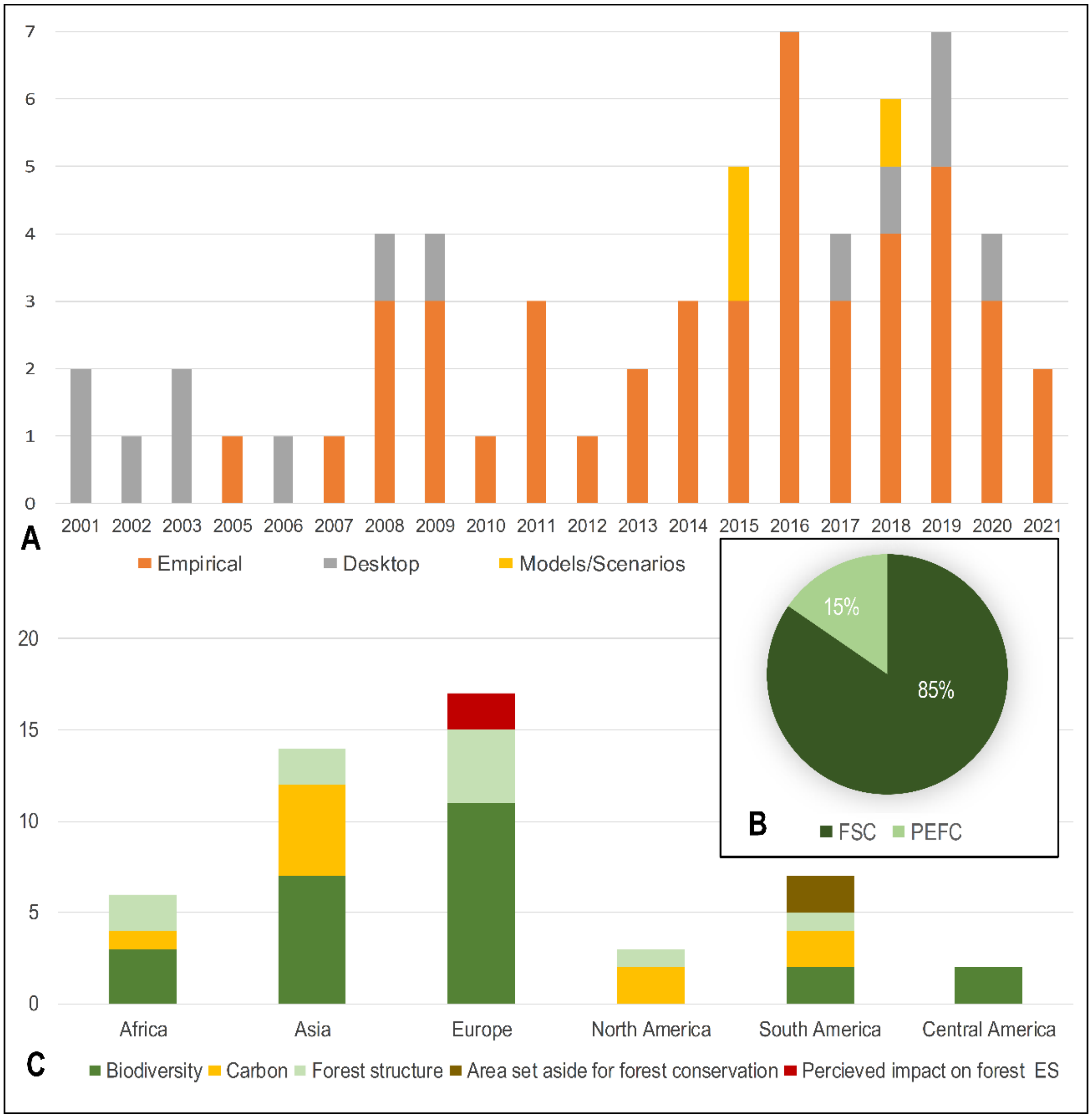

Figure 5. Number of publications on forest degradation presented by year of publication and publication type (**A**). Share of certification scheme studied in the case studies (**B**). Distribution of empirical case studies, presented per world region and indicator (is not equal to the number of publications) (**C**).

Most of the empirical studies assess the impact on forest biodiversity (*n* = 25), followed by carbon stocks and emission reductions (*n* = 10) and forest structure (*n*= 10). In some cases, indicators were assessed in combination. Less frequently analyzed indicators are the perceived role of forest certification on forest degradation (*n* = 2), and the area voluntarily set aside for forest conservation (*n* = 2). In total, the empirical studies assessed these indicators across 54 case study areas (Figure 5) with most of the areas located in Europe (*n* = 18), Asia (*n* = 14) and South America (*n* = 9). Six case studies are located in Africa, four in North America, and two in Central America. No study was found in Oceania. We observe a relatively large share of biodiversity studies in Europe, and carbon studies in Asia. (Figure 5C). From all studies, 47% specified the forest type, of which 57% are natural forest, 10% plantation forest and 19% of the case studies include both plantation and natural forest. From the total number of empirical studies, all but one study assessed the FSC (85%;), 15% assessed the PEFC (including CERFLOR, CSA and SFI) (Figure 5B).

Most empirical studies were assessed through fieldwork and surveys combined with (forest inventory) data and statistical analysis. Other methods include camera trap surveys, morphological spatial pattern analysis, habitat suitability index modelling, and emission calculations. Usually, studies compare average outcomes on different indicators in experimental plots in certified, and uncertified logging concessions, sometimes also natural forests, at similar points in time, usually before and after logging.

In 70% of the empirical case studies, a positive impact of forest certification and its associated management practices on biodiversity, carbon stock and emission reductions, forest structure, and conservation areas were found,(n = 38). Conversely, 20% of the case studies reported a neutral impact, meaning no impact was found from certification (n = 11), and 9% found mixed results (n = 5).

3.3.2. Impact on Biodiversity

From the twenty-five studies that assess the impact on biodiversity, most are located in Europe (n = 12) and Asia (n = 7) (Figure 5C). From the seven studies conducted in Asia, five are located in the Deramakot forest reserve in Malaysia Borneo. The most common indicators to assess biodiversity are the presence or richness of (threatened) species and the diversity, composition, or density of species or habitats. Other indicators are structural connectivity of habitats, ecological integrity or forest intactness.

A total of 74% of the studies report a positive impact of forest certification on biodiversity, 19% report no effect (i.e., no difference in indicator analyzed between certified and uncertified unit) and 7% mixed results. Positive impacts on biodiversity were found in the majority of case studies in Africa, Asia, South and Central America.

In Tanzania, forest certification in community forests significantly maintained higher tree (adult) species richness, diversity, and density than open access forests and state forest reserves [47]. In the northern Republic of Congo, RIL practices associated with FSC-certification maintained the occurrence of chimpanzees and gorillas [48]. In central Gabon, FSC-certified logging concessions support important densities of the golden cat compared to non-certified concessions [49].

Similarly, in Asia, certification positively impacted biodiversity (i.e., species richness and composition). In Malaysian Borneo, Deramakot Forest Reserve species richness was higher in the certified site, particularly for threatened species [50,51]. Reduced-impact logging maintained the richness and composition of the canopy tree community at a level equivalent to the pristine forest and enhanced carbon stock, where this management scheme had long been implemented [52]. In Indonesia, West Papua, tree species composition became more diverse over time in certified mangrove forests, but did not yet attain the same structure and composition as baseline forests at 25 years [53]. Additionally, in Nepal, higher species richness and lower ecological threat index was found in certified community forests, compared to non-certified ones [54].

In Argentina, logged forests under FSC-certification had a similar diversity, density and dominance of potentially suitable cavity trees for secondary cavity-nesting birds similar to unlogged forests for this group of birds [55]. Another study found jaguars and reasonable assemblages of their prey across twelve sites across Latin America, thus illustrating that selective logging in association with FSC and PEFC can maintain jaguars in managed forests [56].

In Europe, the impacts of forest certification on degradation vary with about half of the studies reporting positive (53%) impacts, followed by neutral (30%) or mixed (15%) results. Positive impacts were found in Portugal, where cork oak woodland regeneration (consisting of e.g., cork oak *Quercus suber L.*, holm oak *Quercus ilex L. rotundifoli*, and Pine species *Pinus* spp.) was more abundant in conservation zones, increasing species richness and diversity of shrubs [57]. Forest certification of cork oak woodlands also positively affected the ecological condition of surveyed streams after five years of certification [58].

In Sweden, certification contributed to biodiversity conservation and improved the structural diversity of landscapes [59,60]. In Estonia, increased number of biotope trees, deadwood, and habitat for endangered species was observed in association with FSC-certification [61]. Another study conducted in Estonia found that functional characteristics of old-growth forest were present in the FSC-certified, mostly naturally regenerated, commercial stands yet lacking very large trees, mainly of late-successional deciduous species [62]. In Bosnia-Herzegovina and Romania, conservation gains were related to ES, such as the prevention of soil erosion and conservation of threatened, endangered, and endemic species [63]. From the four studies reporting no difference in impact on certified and commercial forests, three are located in the Arkhangelsk Region in Russia. For this region, no substantial differences between FSC-certified forestry operations and conventional practices were reported. Timber was harvested in equal amounts in certified and uncertified concessions. Large-scale clear-cuts contributed to tree cover loss in primary forests, associated with significant structural and functional ecological change [64,65]. Neutral impacts were also found in Portugal, where species richness in certified areas was not significantly greater than in non-certified areas [66]. In Norway, forest certification increased the amount of retention trees and induced wider buffer zones in riparian forests, but several regeneration units cut after forest certification were found to not comply with all the forest certification criteria [67]. In Lithuania, FSC certification could not maintain the structural and functional connectivity of forests for species across larger scales. The Lithuanian minimum standard of 5% forestland set aside for biodiversity could only satisfy forest species with small habitat requirements [68].

3.3.3. Impact on Carbon Stocks and Emissions

From the ten studies that assessed the impact of forest certification on carbon, most are located in Asia (n = 5), South America (n = 2), and North America (n =2); one study is located in Africa (Figure 5C). Most often, the impact of forest certification on carbon stocks and emissions reductions was assessed by quantifying carbon stock/density and carbon emissions from logging in certified compared to uncertified forests with samples usually taken within a few months or years spanning across the logging cycle. Only one study assessed the spatio-temporal changes in both carbon stocks and forest intactness over a five-year timeframe [52]. Most of the studies assessed changes in carbon stocks and emissions in the context of reduced-impact logging (70%).

In total, 66% of the studies reported a positive impact of forest certification on carbon stocks, followed by mixed results (22%) and no impact (11%). Positive impact of forest certification on carbon, i.e., greater carbon sequestration found in certified compared to uncertified forests was reported for all studies in Asia. For example, in Malaysia Borneo, RIL associated with FSC certification increased carbon in forests and aboveground vegetation [52,69,70]. In Nepal, higher carbon stock, species richness and lower ecological threat index were found in the certified forests compared to non-certified forests [54]. Mixed impacts were found in Indonesia, Kalimantan. Here, FSC-certified concessions did not have lower CO_2 emissions from logging activity (felling, skidding, and hauling) when compared with non-certified concessions, but lower emissions from one type of logging impact (skidding) [71].

A positive impact of reduced carbon emissions from felling, skidding, and hauling was reported in the Madre de Dios region in Peru [72]. Additionally, in the Mexican Yucatán peninsula, there were overall lower committed emissions from the collateral damage of felling and skidding [73,74]. In southern Amazonia, harvesting rates, below the limits set by RIL and forest certification, reduced disturbance rates and emissions relative to conventional logging, yet only at greater volumes of timber extraction [75]. In Africa, no difference in carbon emissions between FSC-certified and uncertified concessions was found in the Democratic Republic of Congo and Gabon [76].

3.3.4. Impact on Forest Structure

From the ten studies that assessed the impact of certification on forest structure, 50% found a positive impact of certification on forest structure, 40% neutral, and 10% mixed impacts. Positive impacts were reported for all case studies in the tropics, across Africa, Asia and South America. Neutral and mixed impacts were found in Europe and North America.

In Africa, Tanzania, FSC-certified forests were found to have better forest structure, appropriate regeneration, and lower fire incidences than open access forests and state forest reserves [77]. In Gabon, fewer trees were damaged through felling in FSC-certified plots and logging roads were smaller creating less impacts on the surface than conventionally logged forest. Overall, logging caused declines in above-ground biomass of 7.1% and 13.4% at the FSC and conventionally logged sites, respectively [78].

In Indonesia, East Kalimantan, selectively logged forests showed an improved forest structure and composition with positive impacts on plant diversity, indicating a possible impact on biodiversity conservation [79]. In West Papua, forest structure appeared to follow a natural regeneration dynamic over-rotation period [53].

In Europe, all of the four studies report neutral to mixed impacts on forest structure. In Estonia, forest certification neither reduced the share of clear-cut free forestry nor increased the share of mixed forest stands [80]. Both studies in Sweden report that certification has not led to any additional improvements in environmental outcomes compared to non-certified forests. In fact, 64% of inspected plots did not comply with environmental considerations, and most sensitive habitats were not saved during felling [81]. Johansson and Lidestav [82] found that more harvesting activity had taken place on certified small-scale forest properties than on non-certified properties, with potentially more negative effects on biodiversity. In Russia, Arkhangelsk Region, the extent of tree cover loss in large-scale clear-cuts after the introduction of FSC remained equally high compared to that before certification or without certification within the sampled area [64].

In the USA, FSC-certified hardwood stands showed similar above-ground tree carbon storage, live tree structure, and greater residual coarse woody debris than uncertified harvested stands in Vermont [83]. In Brazil, forest disturbance was minor in forest inside an FSC-certified logging company than outside due to illegal mining outside the certified forest [84].

3.3.5. Perceived Impact on Forest Ecosystem Services

Two studies report on the perceived impact of certification on sustainable forest management practices and the provision of forest ES. Both of these studies were conducted in Southern Europe and reported positive impacts. For example, ES were enhanced, and more rare and threatened species and water bodies were conserved through certification [85]. Furthermore, in Slovakia, a questionnaire survey revealed that certificate holders perceive a strong relationship between certification and the provision of ES, such as the control of erosion, soil formation, natural composition, species and ecosystem diversity, and the provision of aesthetic, scientific, and educational values [86].

3.3.6. Areas Set Aside for Forest Conservation

In South America, certification of plantation forests resulted in larger protected forest area voluntarily set aside for forest conservation, which had a positive effect on avoided degradation. Companies holding certified plantations played an important role in protecting large areas of native forest, especially under the FSC and PEFC and specifically in countries such as Brazil, Colombia, Paraguay, and Chile [87]. In Brazil, certified companies in most cases protected larger areas than required by law, contributing to forest conservation of the country [88]. A summary of the findings per forest degradation indicator and the geographical distribution of analyzed studies can be seen in Figures 6 and 7.

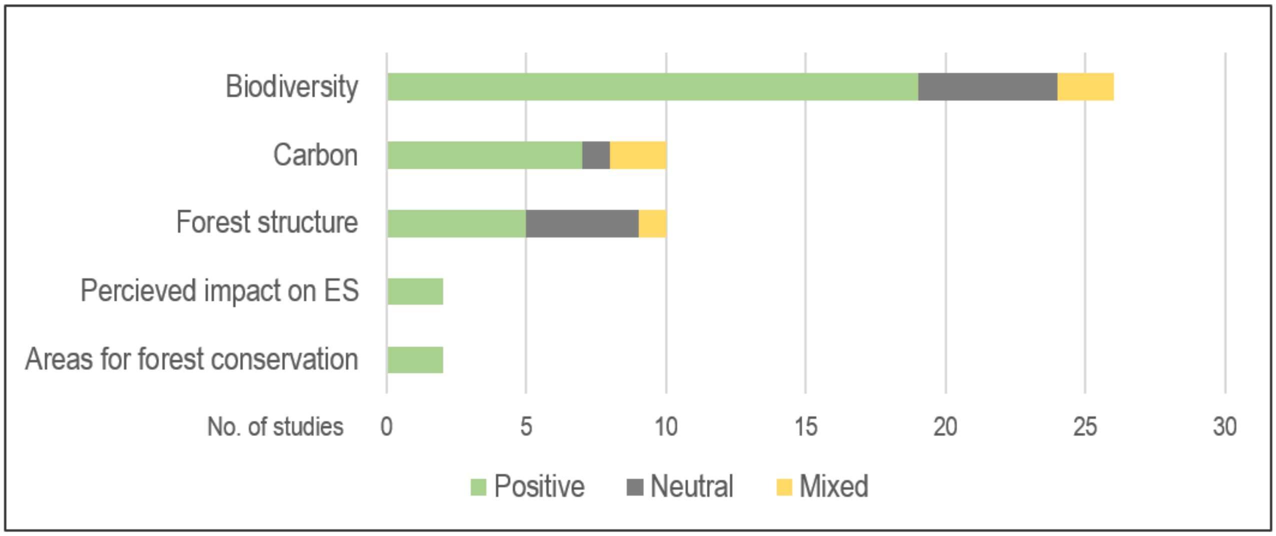

Figure 6. Impact of forest certification on forest degradation. Presented by indicator and number of case studies.

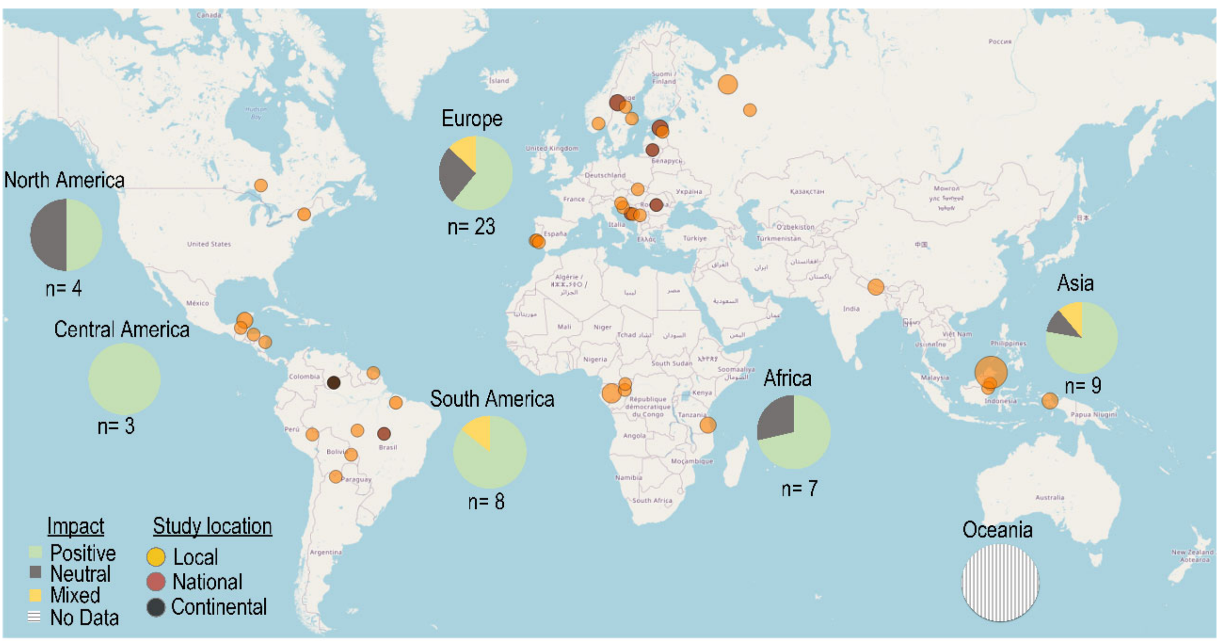

Figure 7. Global distribution of case studies on the impact of forest certification on forest degradation. The size of the dots represents the relative number of case studies per location. Study locations: Local studies are here equal or smaller than districts/states. National studies indicate that multiple case studies across the country were investigated. Pie charts show the number of case studies and the reported impact per region. Base map: © OpenStreetMap-contributors.

3.4. Economic Viability

3.4.1. General Findings

We found 64 publications on the economic viability of forest certification. Of these studies, 42 were empirical, 18 desktop and 4 macro-economic/modelling studies. The studies were published between 1998 and 2021. However, there is no clear trend in the timespan specific study types were published (Figure 8). In general, empirical studies have increased from 2008 onwards. Most of the case studies are located in Asia ($n = 18$)

and Europe ($n = 12$), followed by South America ($n = 11$) and North America ($n = 7$), Africa ($n = 3$), Oceania ($n = 2$), and Central America ($n = 1$) (Figure 8A,C).

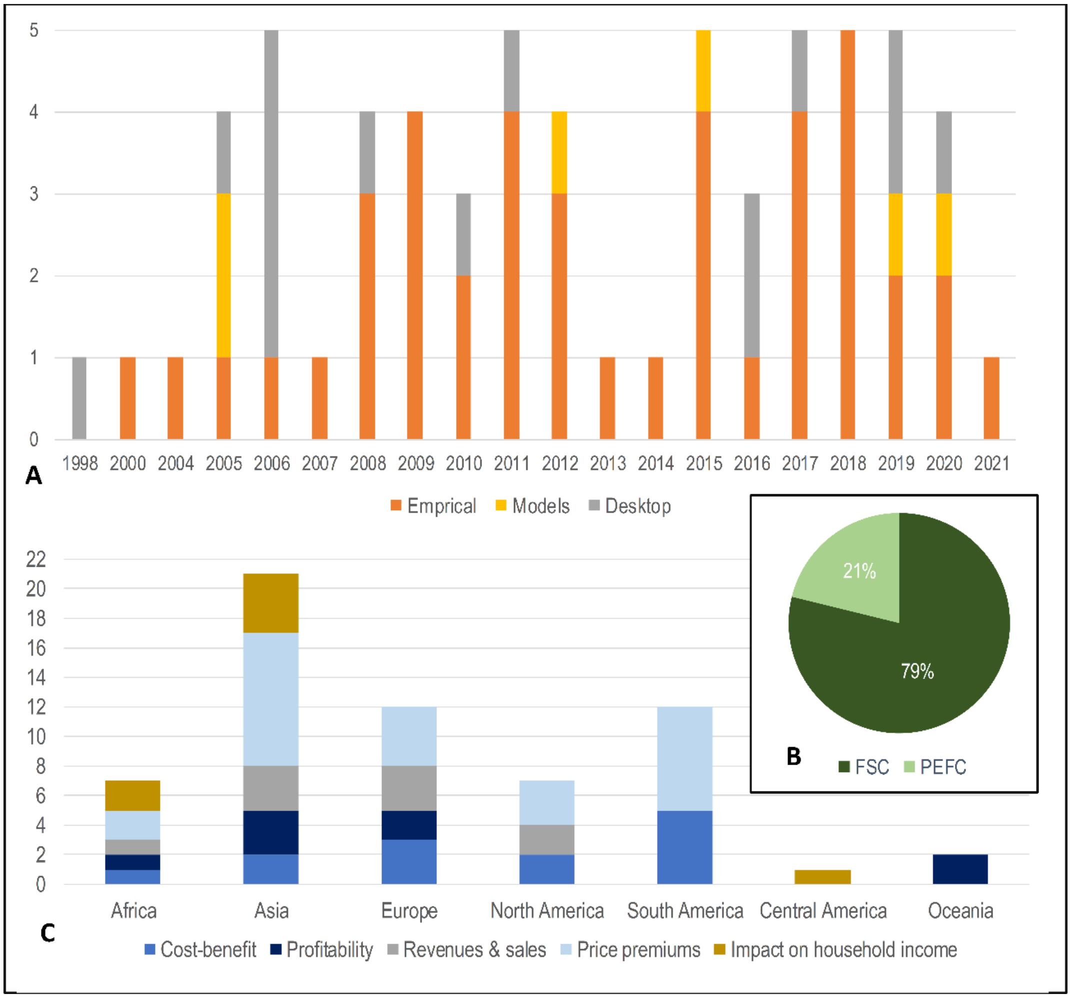

Figure 8. Number of publications on economic viability presented by publication year and publication type (**A**). Share of certification scheme studied in the case studies (**B**). Distribution of empirical case studies, presented per world region and indicator (is not equal to the number of studies) (**C**).

From the empirical studies, the most frequently assessed indicators are price premiums ($n = 25$), followed by cost–benefit ratios ($n = 13$), revenues and sales ($n = 9$) and profitability ($n = 8$). Finally, six case studies evaluated the impact of certification on household income (Figure 8C). In some cases, indicators were assessed in combination. Thus, of the 43 empirical studies, we extracted information from 54 case studies across 42 locations, of which most have focused on Europe ($n = 16$), Asia ($n = 13$), and South America ($n = 13$). Since studies often assessed multiple indicators, we synthesized information on 62 economic indicators for this analysis (Figure 8C).

Half of the studies report a positive impact of forest certification on economic indicators ($n = 21$), 33% negative ($n = 14$), and 17% mixed impacts ($n = 7$). From the studies that specified the forest type (62%), most assessed the economic impacts of plantation forests (50%), such as *Acacia* spp., balsa (*Ochroma pyramidale*), and rubber (*Heveabrasiliensis),* almost exclusively in Asia. In addition, 27% of the studies assessed plantation forest in combination with natural forest, of which most studies are located in South America (*Eucalyptus* and *Pinus*). Finally, 23% assessed natural or semi-natural forests across different world regions.

In 82% of the studies, interviews, questionnaires or surveys were applied to assess economic outcomes, often combined with statistical or cost–benefit analysis. Five studies base their findings on perceptions alone. Other methods applied include economic and financial valuation, discounted cash-flow analysis, and the analysis of reports and corrective action requests (that report the compliance with specific principles, criteria, or indicators in the FSC standards that require rectification). Usually, data was assessed in timeframes before and after certification.

The FSC scheme was assessed in 79% of the studies (Figure 8B). Of these studies, nine assessed both the FSC and PEFC schemes. Two studies focused on the PEFC alone. As the indicators assess different aspects of economic outcomes, both directly and indirectly, the findings cannot be aggregated and are thus summarized per indicator.

3.4.2. Impact on Price Premium

Price premium was the most frequently addressed indicator, with 58% (n = 25) of studies reporting on this indicator. Price premium refers to the percentage to which the products selling price (here of certified timber/forest products) exceeds or falls short of a benchmark price of a similar product (non-certified timber/forest product traded via the market) and measures how the price compares to that of its competitors [89]. Price premiums are often reported in studies that assess the cost and benefits of forest certification or the impacts of certification on household income. In 56% of the case studies, a price premium was gained, while 44% report not gaining any premium.

Price premiums were most frequently reported in Asia, specifically in FSC-certified plantation forestry. What has to be noted is that 56% of these case studies are located in Vietnam, Quang Tri province, and focus on smallholder *Acacia* spp. plantations. [90–94]. Price premiums in this region range between 18% and 25%. While such premiums increased the net revenue of smallholder farmers in this region, they depend on continued donor support to pay the auditing fees required to maintain group certification [90,95]. In another study conducted in central Vietnam, price premiums of FSC and non-FSC-certified saw logs were 12%, with certified forest enterprises generally having better access to markets, market information, and support services such as credit or training programs [96]. Additionally, in Nepal, FSC certification supported national and international market access to Europe and the US, helping to increase product prices by 50–150% [97]. In Malaysia, price premiums were in the range 2–56% and were strongly dependent on the type of wood. Lower quality timbers, such as kapur (*Dryobalanops* spp.) or seraya (*Shorea* spp.), fetched low premiums of about 2% to 30%, whereas the high-quality hardwoods selangan batu (*Shorea* spp.) or keruing (*Dipterocarpus* spp.) destined for the export market fetched a price premium of 27–56% [98].

In Africa, price premiums were studied in the context of certified community forest management. These studies found negative effects [99–101]. Additionally, in South America, no premiums could be gained for both certified natural and plantation forests alike. It has to be noted that 86% of the studies conducted in South America focus on perceptions, and 57% focus on Brazil [102–105].

In Europe, price premiums were only reported in one out of four studies, with premiums ranging between 1–10%. In Slovakia, 74% of forest owners received a price premium for certified wood in the range of 1–5%; 9% of forest owners received price premiums of 6–10%; 12.7% did not receive a premium [106]. In Poland, no additional price premium was reported in association with FSC forest management certificates [107]. Price premiums perceived by experts remained largely absent in the forest sector of the European Union [108].

In North America, only one out of three studies reported that price premiums were gained, with certified wood products receiving a price premium of 10.5% and certified stumpage premiums in the range 1.6–4.3% [109]. Price premiums for finished wood products were much higher for domestic sales than for export sales, with a price premium of 30% for domestic markets compared to premium for exported wood products of 3.4%

[109]. In Virginia, premiums were occasionally realized, but no value was reported [110]. In Minnesota no price premium could be gained [111].

3.4.3. Impact on the Cost–Benefit Ratio

The second most frequently analyzed indicators are the costs and benefit ratio of certification. The cost–benefit ratio is "an indicator showing the relationship between the relative costs and benefits of a proposed project, expressed in monetary or qualitative terms" [112]. In the context of forest certification, cost and benefits are either measured in financial metrics such as revenue earned and costs saved as a result of forest certification or as intangible effects from certification, such as learning, reputational image and customer satisfaction. Most of the studies found positive (57%) or mixed results (36%) on the cost–benefit ratio of certification [113]. Notable is that these indicators were predominantly based on perceptions, assessed through a mix of interviews and surveys to collect primary data. In 29% of the cases, perceptions were combined with cost–benefit analysis.

In South Africa, the long-term cost-effectiveness of plantation forests was predominantly perceived positive by private timber growers, indicating that certification benefits will offset future costs. However, some farmers felt the costs were too high and that the benefits derived from certification did not cover the costs [114].

In Asia, studies report positive cost–benefit ratios for FSC-certified plantation forests. For example, in Thailand, the production cost and return of FSC rubber (*Hevea*) plantations were similar for all sizes of rubber plantations, with the larger plantations having the highest rates of return [115]. In Vietnam, performance, economic and financial efficiencies for FSC-certified *Acacia* spp. plantations were positive with a net present value of VND 52,378 million per hectare over seven years, approximately VND 20 million greater than the amount earned by non-FSC plantations [94]. However, cost-effectiveness was most often reported to be dependent on external donors.

In the Nordic countries of Europe, FSC and PEFC certification did not bring significant economic benefits to forest owners. However, forest owners gained a better environmental image of timber and wood products in the international markets, enhancing the long-term market access for timber and wood products. Cost-efficient group certification arrangements allowed reducing the costs and served as the primary driver for forest owners to participate in certification [116]. In Switzerland, only 8–10% of all forest wood suppliers generated additional revenues for specific product ranges, given the significant oversupply of certified wood on the Swiss market [117]. In Italy, the higher operating costs necessary to obtain the certification and compliance could only partially be compensated by the company's ability to establish new business relationships with a consequent increase in sales [118].

In North America, direct and indirect costs and benefits calculated for The Forestland Group, an independent Timberland Investment Management Organization, found forest certification to be a net-positive program, earning an estimated USD 771,000 additional annual net revenue, about USD 0.24 per acre per year (USD 0.10 ha^{-1} yr^{-1}) [109]. However, roughly two-thirds of land managers across North America indicated that certification costs currently outweighed the benefits; nearly half said that benefits might outweigh costs in the future [113]. In the state of Virginia, stakeholders of certified community-based forest initiatives felt that certification costs were high yet worth the expense. Economic expectations were generally low, and greater importance was put on non-economic benefits, such as relationships, public image, and value alignment. However, group certificates and external funding significantly reduced certification costs [110].

In South America, case studies report mixed results. A study by WWF (2015a) comparing the profitability of countries across South America, Africa, and Asia found that the financial benefits of FSC tend to outweigh the costs, however varying between companies. On average, the companies earned an extra USD 1.80 for every cubic meter of FSC-certified roundwood or equivalent, over any additional costs. In particular tropical forest managers and small/medium producers experienced significant financial gains, while temperate and large producers experienced small losses [119]. In Brazil, companies did not perceive higher prices for certified products, yet they perceived high satisfaction with non-economic benefits [105]. More than half of land managers throughout Brazil perceived additional costs associated with FSC forest certification, explicitly linked to integrated pest management, but shared few details on these costs [104]. Cubbage [120] compared economic costs and benefits across the Americas and found that average total costs for certification were a function of ownership size (cost decreasing with ownership size <4000 ha), but did not vary significantly among certification systems or countries. In addition, costs were higher in South America compared to North America [120]. In Chile, increased costs emerging from certification were counteracted by international market access of plantation forestry businesses. However, some large native forestry businesses did not benefit from better market access. Thus, certification yielded the most significant impacts in plantation forestry business, particularly in large corporations [121].

3.4.4. Impact on Revenues and Sales

Revenues are defined as "money generated from selling goods and services over a specific period of time and is composed of the selling price times the quantities sold" [122]. Sales are the exchange of commodities for money. In total, 19% of the empirical studies reported on these indicators (8) with predominantly negative to mixed impact.

In Europe and North America, this indicator was almost exclusively assessed through stakeholder perceptions. In the European Union, most forest experts (87.5%) believed that certified wood is sold at the same price as non-certified wood, while 12.5% perceived prices to increase [108]. More than half (58%) of the respondents in Romania indicated that the revenues did not increase after certification. At the same time, 42% considered that the FSC certification positively influenced the revenues [123]. In Canada, forest certification had on average a negative impact on the firm's financial performance. However, differences between certification schemes existed. For example, while the FSC had a neutral impact on financial performance, the industry-led certification (SFI, CSA, ISO14001) had a negative impact on financial performance [124].

In Asia and Africa, forest certification resulted in higher revenues earned by forest owners. In Vietnam, the revenue of selling FSC-certified timber was reported to be much higher than for non-certified timber and higher incomes allowed forest owners to cover the costs [93]. Group certification of FSC plantations created higher net revenues for smallholders by cutting out rent-seeking intermediated traders and selling directly to downstream buyers [90,92]. However, revenues differed among households according to plantation area and rotation length [93]. Additionally, in south-eastern Tanzania, villages of FSC-certified community forests earned higher net revenue than non-FSC villages [101].

3.4.5. Impact on Profitability

Profitability is defined as "the ability of a company to use its resources to generate revenues in excess of its expenses" [125]. This indicator is closely linked to efficiency in forest management. In the context of forest certification, profitability is used overarchingly with economic viability and profit. Of the empirical studies, 18% assessed this indicator, of which 38% report a positive, 50% a negative and 12% mixed impact on profitability. Positive impacts were found in Asia and Oceania. For Europe and Africa, the impact on profitability was negative. However, only two studies were found in these regions, providing an insufficient evidence base.

In Vietnam, Quang Tri, the financial returns from certified forest products were reported to be much higher than for non-certified forest products, both at 7% and 12% interest rates [95]. The profitability of FSC-certified smallholder plantations was found to be a result of the proximity to regional countries with high demand for wood products, such as China and Japan, creating some of the world's best roundwood pulp/chip price (USD 40/m^3) [91]. In Japan, the FSC certification of wood products did not result in higher sale prices, and certification costs negatively affected profits [126].

In Africa, Tanzania, community forestry was not economically viable, with forest management costs 2.6 times forest revenues over a five-year study period. However, revenues appeared to be increasing and cost decreasing over time [99]. In Europe, forest certification had negative or mixed impacts on profitability. For example, in the Czech Republic, certification costs of the FSC were higher than financial revenues. However, the effect of the certification on sales, profits, and added value of companies seemed more effective over a longer timeframe (from 4 years to >10 years) [127]. In Sweden, 37% of forest owners considered certification to affect profitability positively, 28% thought it had no noticeable effect, 27% had no opinion, and 5% considered any effect to be negative [128].

In the Solomon Islands, forest certification of plantation forests was profitable, realizing a weighted average price premium of 36% and an actual cost of sustainable forest management of USD 0.4 per cubic meter during the period 1999–2002. The profitability was due to capturing niche markets in Vietnam with strong trading networks with retailers and manufacturers in Europe [129]. Thus, overall, specific market niches, proximity to markets, and more extended time frames seemed to alter profitability positively.

3.4.6. Impact on Household Income

The impact of forest certification on household income was assessed in 14% of the studies ($n = 6$), almost exclusively in the context of community forestry. All of these studies found a positive impact on this indicator. Forest certification increased household income in Vietnam and Tanzania, accounting for 33–56% and 12% of household income, respectively [96,101]. Incomes earned from forests were spent on procuring farming implements, fertilizer and pesticides and were invested in other income-generating activities. In Tanzania, 95% of the revenue of the FSC villages was spent for forest protection (40%) and community development projects (55%) such as water, health and education [101]. In Indonesia, FSC group certification improved local incomes and social attitudes and strengthened farmer groups to manage existing community forests more effectively [130]. However, one study mentioned that, while being the main contributor to poverty reduction, forest certification contributed to income inequality. Because acacia hybrid timber production (combining species *Acacia auriculiformis* A. Cunn. ex Benth. and *Acacia mangium* Willd) was the largest contributor to total household income in the case studies, the distribution of timber production communities correlated with total income distribution [96]. The findings are summarized in Figures 9 and 10.

Figure 11 provides an overview of the study results, illustrating the distribution of case studies and their reported impact on deforestation, forest degradation, and economic viability.

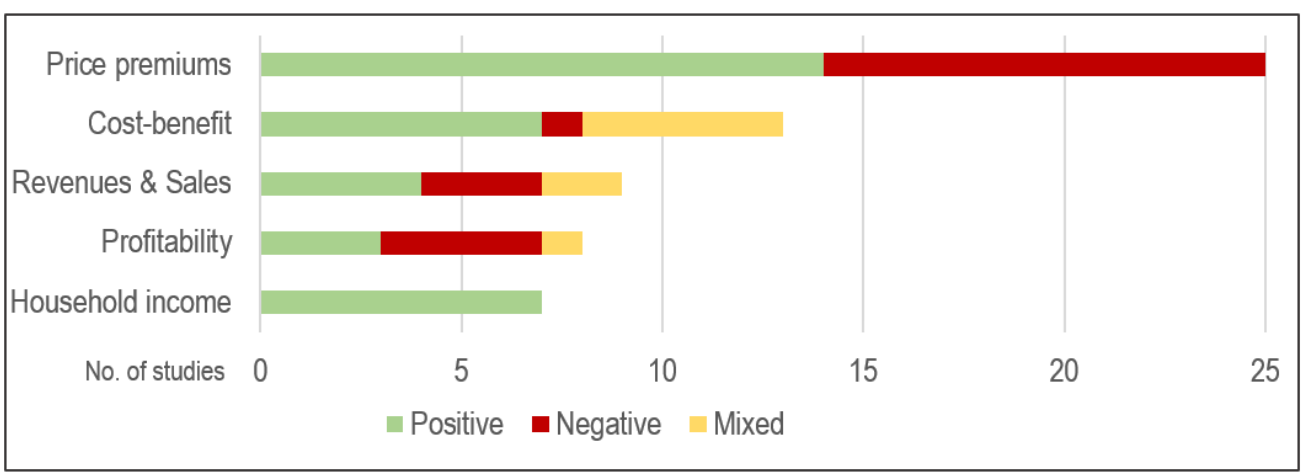

Figure 9. Impact of forest certification on economic viability, presented by indicator and number of case studies.

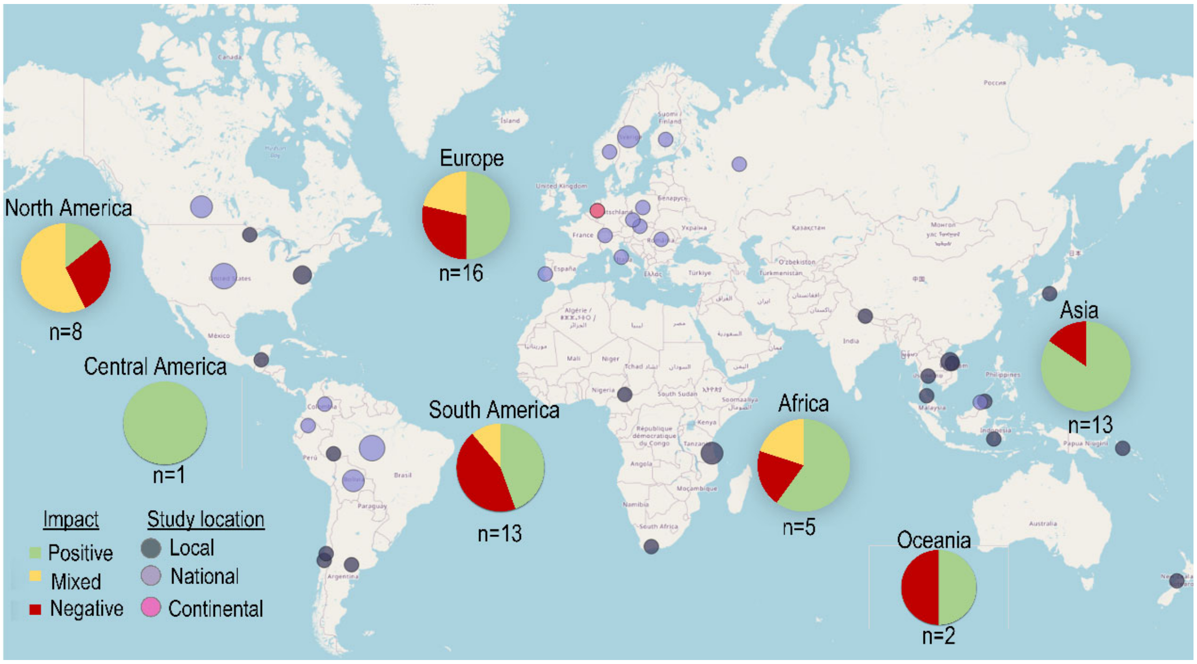

Figure 10. Global distribution of case studies on the impact of forest certification on economic viability. The size of the dots represents the relative amount of case study per location. Study location: Local studies are here equal or smaller than districts/states. National studies indicate that multiple study sites or enterprises across the country were investigated. Continental studies include studies conducted on the scale of a political union (i.e., EU). Pie charts show the number of case studies and the reported impact per region. Base map: © OpenStreetMap-contributors.

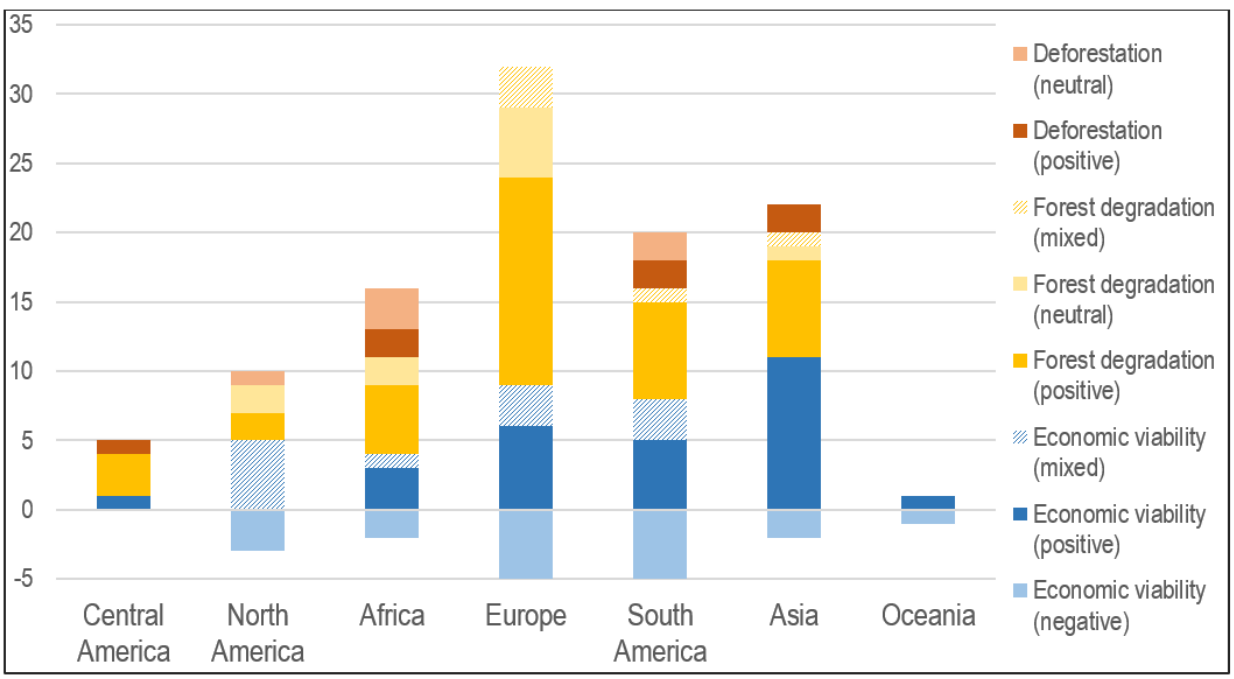

Figure 11. Distribution of case studies and their reported impact on deforestation, forest degradation and economic viability.

4. Discussion

4.1. Empirical Evidence on the Effectiveness and Economic Viability of Forest Certification

We found 98 empirical studies for all themes analyzed that met our selection criteria, with most studies found on forest degradation (*n* = 45) and economic viability (*n* = 42) and only a few studies on deforestation (*n* = 11). Based on the findings obtained, it is challenging to draw aggregate conclusions about the effectiveness of forest certification, due to specific indicators analyzed, different study designs, methods applied, and the over-proportional share of studies focused on the FSC scheme. For example, studies that assessed forest degradation applied four indicators quantified with 27 proxy indicators. Different indicators, such as species richness, habitat composition or fragmentation, give different insights into forest degradation in specific contexts, thus challenging the generalization of impacts across scales. Similarly, multiple indicators were studied in the context of economic viability, not always providing a complete picture of the economic impacts of certification over time. An explanation of this scattered evidence may derive from the fact that some forest managers were not fully aware of the financial costs and benefits of certification, sometimes due to indirect benefits perceived as necessary for having a potential long-term economic effect (e.g., improved market access) [127]. In addition, some studies indicated that cost data was treated confidentially and as proprietary [105] or was not fully reported [116]. Despite this, most studies assessed perceived rather than actual on-the-ground impacts; only a few studies measured and reported the costs of forest certification based on actual organizational data [99,109,120,129,131]. While qualitative information can provide important insight into the local context and stakeholders' perceptions, the reliance on qualitative data creates a certain bias, e.g., linked to the researcher or participant. To allow for assessing long-term changes in economic viability, there is thus a need to combine a contextually grounded qualitative analysis with quantitative assessment of the economic costs and benefits linked to forest certification [12].

4.2. Spatial Distribution of Studies and Involvement of Nongovernmental Organizations

Studies on the effectiveness and economic viability of forest certification have focused on Europe, South America, and Asia. Despite the large certified forest area in North America, surprisingly little research has been conducted in this region. Deforestation studies have focused on Africa, Latin America, and Asia and almost exclusively on the FSC scheme. Our findings are consistent with desktop and review studies that have focused on the FSC scheme and tropical regions [26,30,31,132–134]. The focus on the effectiveness of the FSC scheme in the tropics likely stems from the fact that it is the most prevalent and sometimes only existing certification scheme in these regions, particularly in South America and Africa [9,10]. In addition, interest in the effectiveness of both market-based and public instruments to tackle deforestation has been particularly high in these regions hosting among the highest values of biodiversity and carbon storage and experiencing the highest deforestation rates [2,135,136]. In this context, the environmental NGOs the World Wildlife Fund (WWF), Nature Conservancy, and Rainforest Alliance were involved in 55% of the empirical studies on deforestation impacts. On degradation, 24% of the studies involved the WWF, Nature Conservancy, or the Wildlife Conservation Society, and on economic viability, 7% of the studies involved the USDA, World Bank, and the WWF.

Forest degradation research, on the other hand, has focused on Europe, and particularly on the impact of forest certification on biodiversity (70% of studies conducted in Europe assessed biodiversity impacts). The impact of forest certification on carbon stocks and emission reductions has also been studied frequently, especially in Asia and Africa, likely stemming from the global policy and scientific interest in biodiversity loss and climate mitigation and adaptation. This could explain why we did not find any studies on landscape and environmental values or soil erosion, although these terms were included in our search string on degradation. Research on the economic viability has focused on Europe and Asia, of which 69% of studies were conducted in Asia and have focused on plantation forests, such as rubber and acacia. Of these studies, 48% have focused on acacia plantation forests in the province of Quang Tri, Vietnam. This bias can be explained by the significant increase in plantation forestry in Asia, particularly in Vietnam, and the widespread support of the Vietnamese government and NGOs in forest certification [92,137].

4.3. Temporal Changes in the Effectiveness and Economic Viability of Forest Certification

The effectiveness and economic viability of forest certification develops over time, and measurable impacts emerge. Therefore, any analysis needs to consider extended time frames. Most of the studies on deforestation were conducted in a time frame of 7–13 years. Usually, studies analyzed tree cover loss before, during, and after certification [44–46]. However, significant temporal trends could not be detected in the time frame considered. On forest degradation, average outcomes on experimental plots were primarily established at similar points in time, usually before and after harvesting, with only a few studies comparing before and after certification situations [138]. Studies that assessed changes within extended time frames (>5 years) were rare and based analysis on regeneration monitoring [81], changes in the forest canopy [84], above-ground biomass [52], or forest cover [82]. In the field of economic viability, analysis of the long-term economic effects of forest certification were scarce, indicating time frames of 5–6 years [119] and 9–12 years [115] to break even on the investment in forest certification. Nevertheless, several studies based on perceptions underlined the importance of time for generating economic benefits [114,129]. These findings indicate that economic viability increased with time being certified, decreasing cost and increasing revenue [99,115]. Understanding the development and changes in economic viability can help determine financial support over a critical period before forest certification becomes economically viable, such as in the context of community forest management in the tropics that largely depend on donor support [39,92,97,99,101].

4.4. Factors Contributing to the Effectiveness of Forest Certification

Different factors contribute to the effectiveness of forest certification [18,19]. These include the stringency of standards, certification uptake, patterns of adoption, compliance and enforcement of standards, and the long-term direct and indirect effects of certification [18,60]. These factors are closely linked to the local context in which certification is applied, affecting the outcome of the intervention and changes over time. To understand the local impact of forest certification, the political economy of the forest sector in a region that includes governance, legal frameworks, and socio-economic changes needs to be understood [139]. However, additionally, market structures and access to capital determine the economic viability of forest certification and can impact whether differences between countries can be detected or not [21,139,140]. Only a few studies considered contextual factors in explaining results. Of those studies, the most frequent explanations given for the poor effectiveness of certification in reducing degradation were the lack of compliance [67], weak standard setting [65,68,81], and insufficient conservation area set aside for HCV. In terms of standard setting, the standards can vary depending on, e.g., the country's definition and practices of sustainable forest management. In Russia and Sweden, for example, the FSC standard allowed for continued clear-cutting within certified forest concessions [64,141]. It has to be acknowledged that the practice of clear cutting is typical in the boreal biome despite standards that still need to be followed, such as the FSC principle 9 to "enhance high conservation values in the forest management unit" [142]. Thus, to fully understand the effectiveness of forest certification, different components of effectiveness, contextual factors, and the implementation on the ground need to be understood [60,138]. Finally, indirect effects, including spill-over and leakage effects, have only been addressed in two studies on deforestation [36,45]. Nevertheless, these are essential factors in evaluating forest certification's broader and long-term effectiveness across regions, actors, or commodities outside certified concessions [18,143].

In economic terms, specific market niches, proximity to markets, and a longer duration of certification were the main explanatory factors positively affecting economic viability and, especially, profitability [97,129]. Group certification and the financial support of external donors and NGOs were critical determinants of economic viability in community forestry in the tropics [39,92,97,99,101]. Market characteristics, access to capital, and changes over time need to be considered to understand economic viability, including a comparison of profitability before and after certification, to reduce selection effects.

5. Conclusions and Future Research Lines

In this study, we have conducted a systematic literature review on the effectiveness and economic viability of forest certification. We found site-specific and scattered evidence, mainly focusing on the FSC scheme, thus challenging the generalization of findings. In the literature, there has been a tendency toward specific indicators studied in specific regions, e.g., biodiversity in Europe, price premiums, carbon stocks, and emissions reductions in Asia. Considering these biases, we carefully conclude that the impact of forest certification on deforestation is positive-neutral (54%; 46%), forest degradation positive-neutral-mixed (70%; 21%; 9%), and economic viability positive-negative-mixed (50%; 33%; 17%) with half of the positive impacts on economic viability reported for Asian plantation forests.

Considering that our review mainly includes published work, it is acknowledged that a publication bias might occur. For example, the tendency of journals to avoid publishing small-N studies or studies with negative or no results might imply an overestimation of positive effects in literature reviews. Donor involvement and a potential research bias that steers results to those they prefer may have also created a bias. By comparing the study's findings with the involvement of NGOs, we have tried to illustrate potential biases; however, these could not be detected. To conclude, it should be noted that despite the critical appraisal of the studies reviewed, a detailed evaluation of study designs and methods was not within the scope of this review. Thus, potential pseudoreplication of empirical studies cannot be ruled out.

Based on the review and assessment of studies, we identify several future research lines that require further attention:

Empirical research on the impact of the PEFC scheme: More empirical research on the impact of the PEFC scheme is needed in all world regions, especially on the impacts of the PEFC scheme in reducing deforestation. Such insights will allow evaluating and comparing the effectiveness of different certification schemes across locations.

Study the indirect and long-term effectiveness of certification: To evaluate the effectiveness of forest certification on larger spatial scales, more research on the indirect and long-term impacts of certification (i.e., spillovers and leakage) should be conducted. Such analysis requires a sound understanding of the causal mechanisms, economic processes, and socio-ecological interactions that affect certification effectiveness [13,144,145] and the consideration of extended time frames. Examples of indirect and long-term effects are the impact of road construction that facilitates access to forest clearing or post-logging effects on concessions that lost their certification status [146].

Complement site-specific case studies with large-scale impact studies: Concerning the impact of forest certification on degradation, there is a need to complement the variety of site-specific case studies with cross-regional or cross-continental studies that compare single indicators across several case study regions. For example, such a study could compare the impact of forest certification on carbon sequestration and emission reductions or forest fragmentation over time. These indicators hold the potential to be quantified on larger spatial scales, given the availability of global remote sensing datasets and developed methodologies.

Study the drivers and changes in the economic viability over time, based on quantitative data: Such studies should consider the influence of financial support or market structures on economic performance over time. More quantitative research on the direct and indirect costs and benefits is needed in this context, including the need to assess scenarios comparing with and without certification situations. Mixed methods that combine quantitative approaches with contextually grounded qualitative methods could improve the assessment and understanding of economic viability [147].

Understand contextual factors that influence the effectiveness of forest certification: Case studies should be accompanied by a contextual background analysis, including an analysis of site-specific characteristics of the forest management unit, macro-economic structures, governmental policies, and donor support. Such insights would allow for understanding different influencing factors in the forest management unit, reduce selection bias and thus better assign the effect of forest certification.

Finally, to address the research gaps above, there is a need to increase the transparency and accessibility of spatial and economic data of both the FSC and PEFC schemes. These data should be made publicly available to allow for independent impact evaluation and increase the global credibility of forest certification schemes.

Supplementary Materials: The following supporting information can be downloaded at: www.mdpi.com/article/10.3390/f13050798/s1, Table S1: Empirical studies on deforestation included in the review; Tables S2–S4: Empirical studies on forest degradation included in the review; Table S5: Empirical studies on economic viability included in this review; Table S6: Desktop studies deforestation; Table S7: Macro-economic studies and scenarios—deforestation; Table S8: Desktop studies forest degradation; Table S9: Models and Scenarios—forest degradation; Table S10: Desktop studies economic viability; Table S11: Macro-economic studies—economic viability [148–152].

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

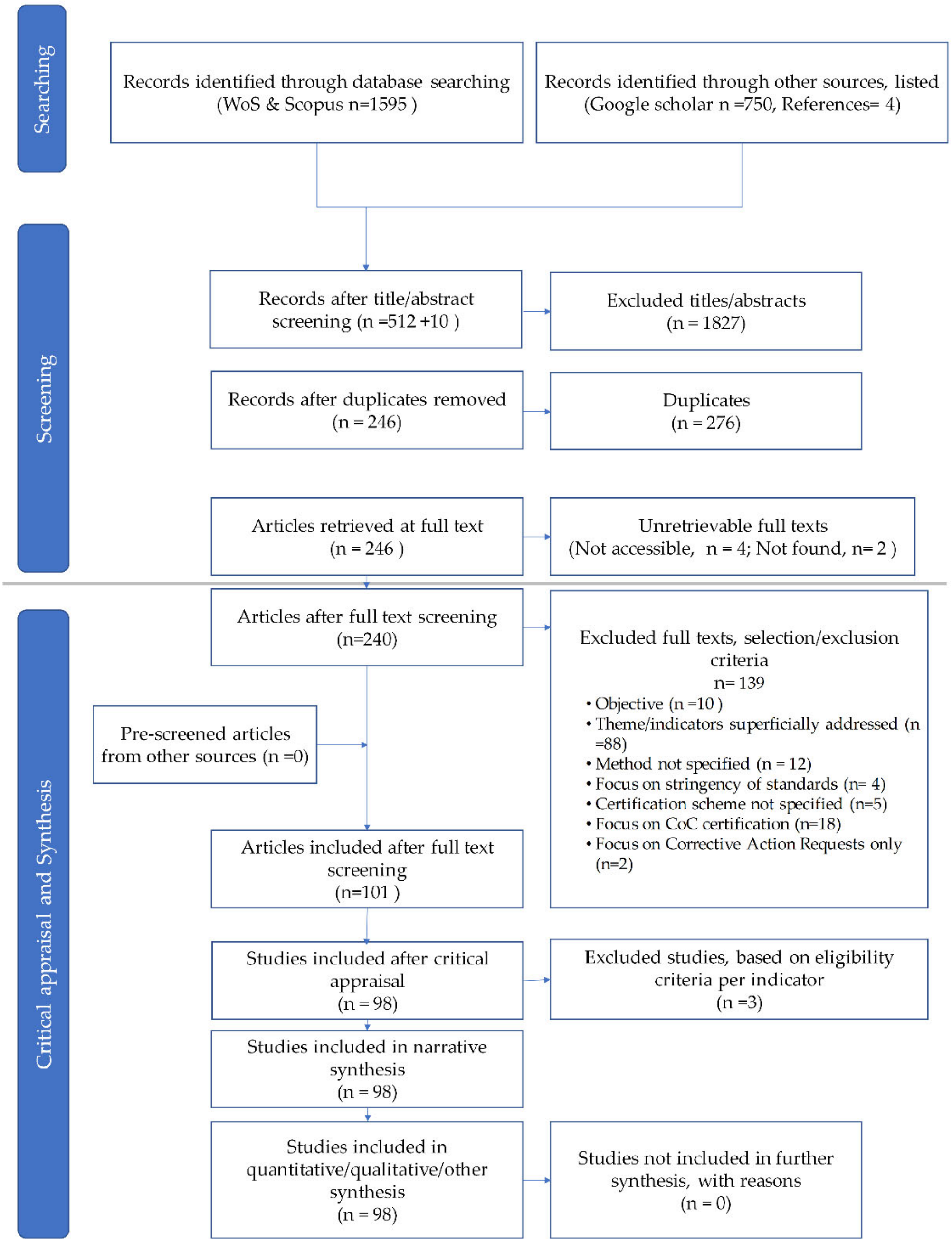

Figure A1. ROSES flow diagram for the systematic review of empirical studies.

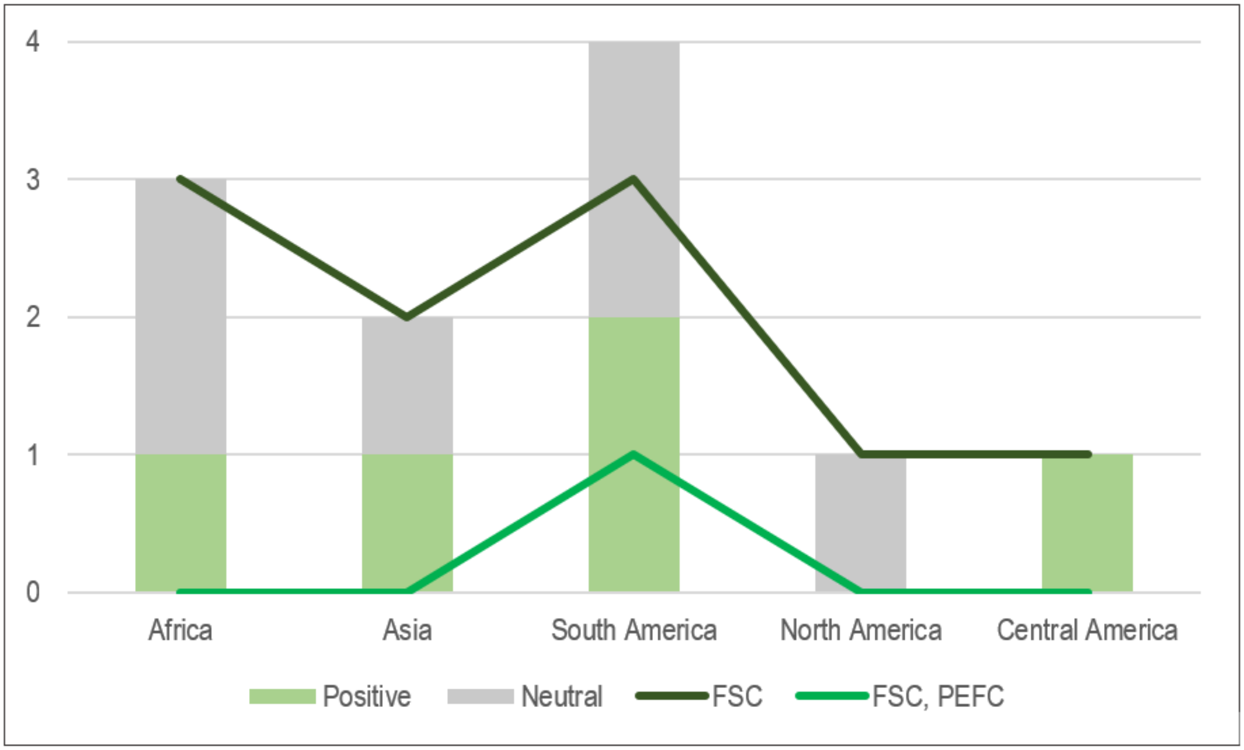

Figure A2. Distribution of empirical studies on deforestation, illustrated by impact and certification scheme.

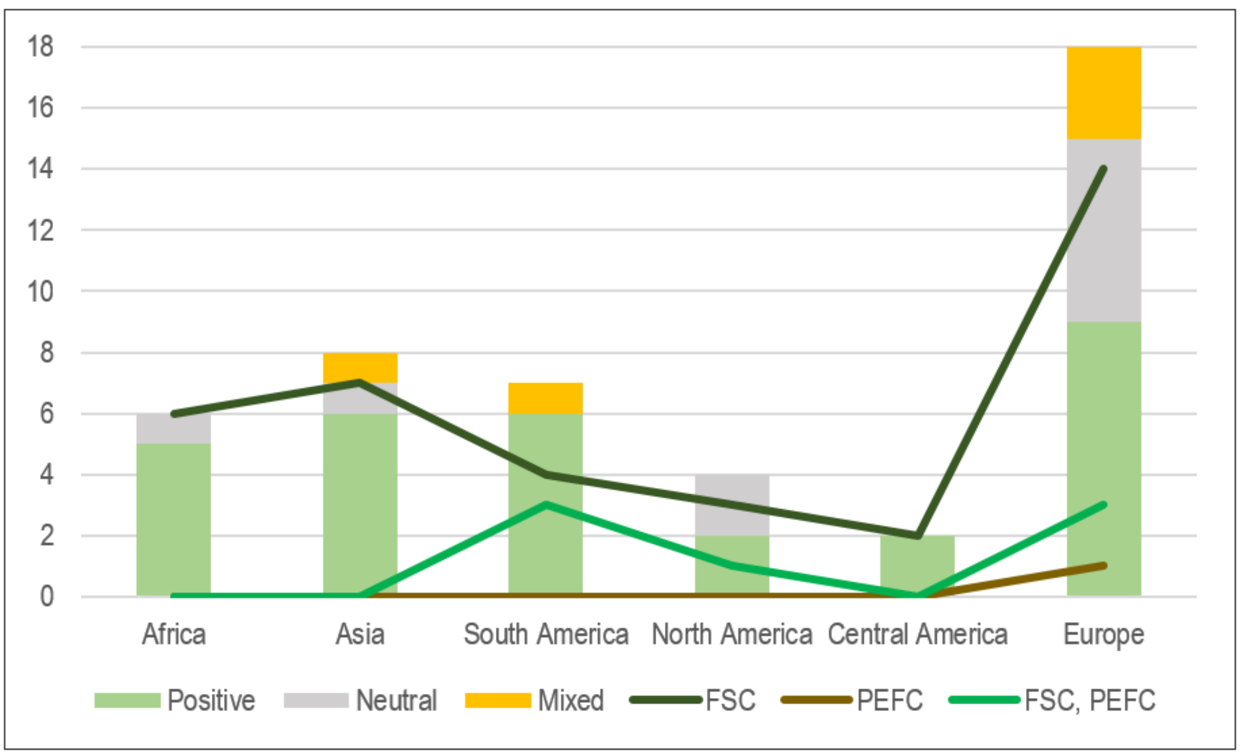

Figure A3. Distribution of empirical studies on forest degradation, illustrated by impact and certification scheme.

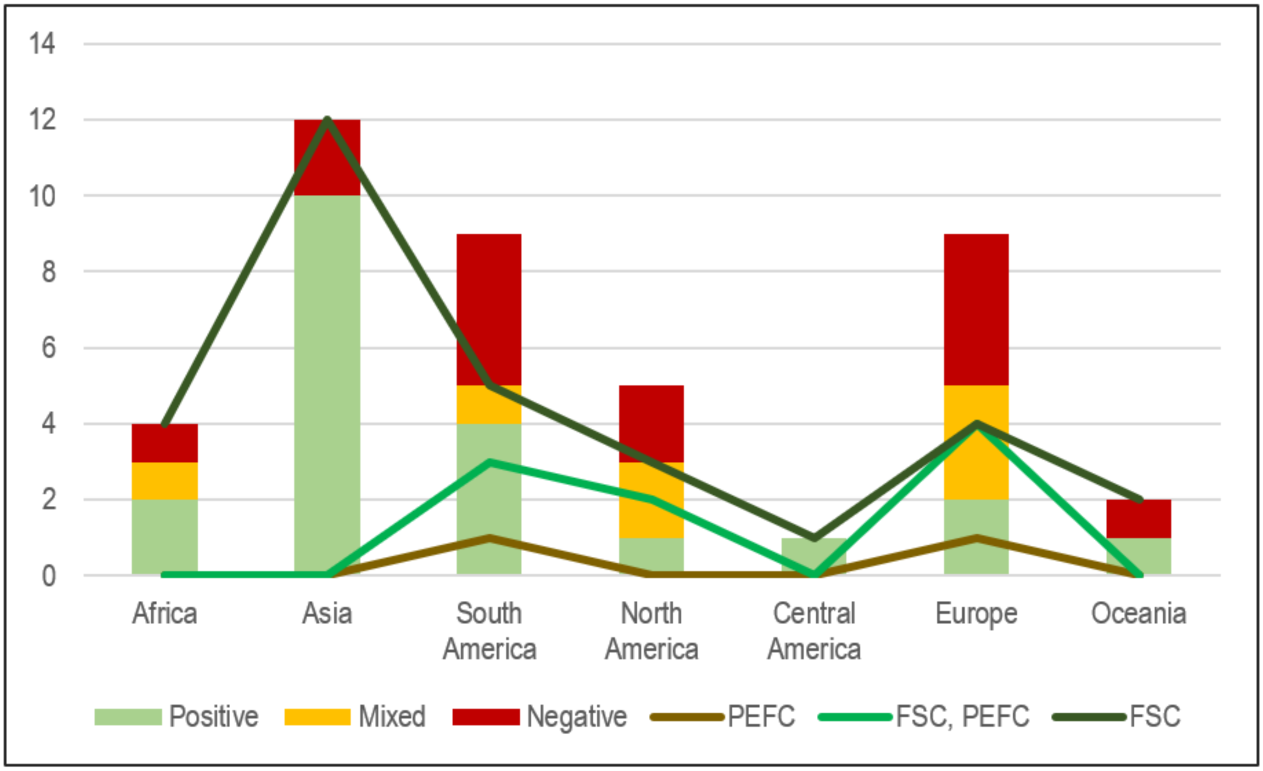

Figure A4. Distribution of empirical studies on economic viability, illustrated by impact and certification scheme.

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