Reviewing the impacts of eco-labelling of forest products on different dimensions of sustainability in Europe

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Abstract

Europe has been implementing eco-labelling on forest products for the last two decades as a market-oriented tool to combat forest degradation and manage forest resources sustainably. Numerous studies have investigated the impacts of eco-labelling from different perspectives and geographic locations. Nevertheless, holistic reviews to disentangle the impacts of eco-labelling on forest sustainability are lacking. This study proposes a conceptual framework to collate and qualitatively analyse existing literature regarding forest eco-labels for disclosing its effects on social, ecological, and economic sustainability. With regard to social sustainability, forest eco-labelling has established itself as a credibility icon that enhanced end-consumption patterns and successfully institutionalised the discourse over customary rights, despite insufficient procedural justice for indigenous communities and workers. In the economic dimension, forest eco-labelling enhanced market competitiveness; however, increasing costs continue to be a huge setback for producers. The ecological dimension demonstrated restored landscapes as a result of disturbance reductions. Nonetheless, insufficient preservation of trees and areas with high conservation values during felling have undermined forest integrity and biodiversity protection. More rigorous marketing strategies and campaigns might be needed to address the profitability issue. Also, quantitative measures for on-the-ground performance should be enacted to leverage the unique strengths of forest eco-labelling in institutionalising cross-sector cooperation and normalising environmental discourses in forestry.

Keywords: forest certification, eco-labelling, forest products, sustainable forest management, Europe, impacts, Forest Stewardship Council, Program for Endorsement of Forest Certification

1. Introduction

Entering an era when human activities have unprecedented impacts on the planet, sustainability has never been more articulated on the global agenda. Forestry is no exception because of the vigorous disturbances posed to forest landscapes. Across the globe, approximately 500,000 hectares of logged forests have been converted into profitable plantations, whose monoculture has degraded the resilience and regenerative capacity of forest landscapes (Harrison, 2011; PEFC Council, 2017b). Europe, as a net exporter of wood products (Guan et al., 2019), plays a pivotal role in timber production and heavily engages in silviculture. Historically, temperate forests in Europe had been cleared for energy, agriculture and settlements, affecting over 50% of the original forest areas (Dauvergne & Lister, 2010). The region is now experiencing a significant shift in species composition and tree standing due to timber-production activities which undermine ecological resistance to the natural disturbances (e.g., storm and frost) prevalent in temperate forests (Spiecker, 2002) and endanger the survival of red-list category species (Seibold et al., 2014). The growing commercial logging industry and illegal logging have also ignited disputes among indigenous people and local inhabitants (Reboredo, 2013).

As a consequence, sustainable forest management (SFM) has been developed as a concept to balance the ecological, economic and socio-cultural values of forest resources. In the broadest sense, such an ecological management approach emphasises the relationships between economies, nature, and intra-

and intergenerational fairness (Andersson et al., 2006; Martínez Pastur et al., 2020). SFM is streamed by involved actors, enforcement and geopolitical scale (Sotirov et al., 2020). One of the prominent non-state, market-driven voluntary measures guiding forest management practices at a global scale is forest certification. Forest certification uses market incentives to foster ecologically responsible forest management and changes in the market ecology. The most distinctive feature of voluntary certification is chain of custody (CoC) in green procurement, which is identified by eco-labels on forest products. Eco-labels become the instruments that alleviate information asymmetry among consumers by providing classifications and identification of product sourcing and origins (Koos, 2011). Simply put, eco-labels make consumption "greener" by increasing awareness of their underpinnings. Europe has long been practising forest certification and eco-labelling to protect forest resources, with Sweden being one of the earliest European countries to adopt a set of nationally adjusted standards from an independent forest certification system – the Forest Stewardship Council (FSC) (Boström, 2006). Hence, a suitable question to pose might be, "In the past 20 years, what have been the consequences of forest certification and its eco-labelling strategy?"

Scholars often investigate the ecological impacts of certified forests on sustainability. Specific attention has been paid to tree retention practices or voluntary set-asides guided by certification systems since these constitute one of the key elements to regulate and safeguard biodiversity in certification systems. Several studies have accounted for positive relations between retention practices and biodiversity in Europe, such as minimising drastic vegetation change by supplying substrates in early succession stages, which benefits species richness (Gustafsson et al., 2010; Shorohova et al., 2019) due to the release of ephemeral resources (Koivula & Vanha-Majamaa, 2020). However, evidence of forest landscape protection is often ambivalent. The relations between tree retention level in certified forests in Finland and biodiversity have been explored by Kuuluvainen et al. (2019). Retention level in the certified forest was found to be compromised for production. Thus, prior research shows mixed views about the effectiveness of forest eco-labelling in providing tangible ecological results. It calls attention to sorting out the environmental consequences that are scattered across different regions in Europe. Recently, there have been more economic and social studies that reviewed the normative impacts of forest certification in conserving other aspects of sustainability and institutional effectiveness (Gulbrandsen, 2005a; Gustafsson et al., 2010; van der Ven & Cashore, 2018). Articulating the socio-economic processes involved in the implementation of forest eco-labelling helps comprehend its potential in expanding sustainability capacity. This underscores the need to collate the sustainability efforts of eco-labelling from different domains to generate a deeper understanding of eco-labelling on forest products.

The current study aims to provide a comprehensive review of eco-labelling of forest products by collaging the contributions of the major forest certification systems towards ecological, economic and social sustainability. By synthesising the European experience of practising eco-labelling on forest products, more insight about the potential of forest certifications could be inferred, contributing to the understanding of eco-labelling future roles and values in SFM. Another goal is to propose a framework to organise and analyse the impacts of eco-labelling of forest certification systems.

2. Development of SFM in the European context

The sustained yield (SY) paradigm is the earliest forest management approach developed in Europe (Wiersum, 1995). SY is a supply-oriented approach that aims to secure the largest harvest amount without degrading the productivity of the stock. Optimal yield rates (i.e., allowable cut) and biological rotation have been employed to transform forests into timber production systems. Its command-and-control foci and perception of forest resources as economic assets have been heavily criticised for altering the natural dynamics and ecological integrity of forest landscapes (Elbakidze et al., 2013). Its negligence of non-timber products and a reductionist interpretation of nature were often considered the cause of continued forest degradation and irreversible resource depletion. Concurrently, the substantial demand for forest products has depleted forest resources more swiftly during the SY period. Although most forests in Europe (e.g., Croatia, Sweden, Switzerland, Estonia and Lithuania) have been primarily planned for economic production (Marx & Cuypers, 2010), the strain from over-productivity and anthropocentric focus on yield might overwhelm forest health in the long run.

Thus, attention has focused more on the biocentric integrative and adaptive approaches to forest management. Adaptive management such as the ecosystem approach emphasises retaining natural variations and respecting the limits of biophysical functioning (United Nations, 2007). Structures, processes and functions should be captured when managing landscapes, where extensive knowledge about the sophisticated relations existing between ecological processes and resource regeneration in landscapes should be applied (Andersson et al., 2006). The biocentric approach has evolved as the broad term "SFM". SFM represents a framework that promotes the delicate balance between the ecological, economic and socio-cultural considerations of forest management. The key elements of SFM prioritise dynamics, regenerating power, and the balanced use of forests. To operationalise this concept, criteria and indicators (C&I) have been formulated to assess forest conditions, activities, policy formulation and sustainability efforts (Stupak et al., 2011). At the global level, SFM has developed 7 criteria that are at the core of sustaining biologically diverse and healthy forest ecosystems, long-run functionality and profitability, as well as the socio-cultural identity of forest landscapes (FAO, 2015).

The first debate on SFM in Europe began in the early 1990s when ministerial conferences, such as the Ministerial Conference on the Protection of Forests in Europe (MCPFE), engaged with the potential of SFM to tackle forestry issues and maintain the vitality of forest ecosystems (Köhl & Rametsteiner, 2009). In the second MCPFE, SFM was officially outlined in Helsinki resolution H1 and contextualised 6 pan-European C&I to protect regional forests. Currently, the MCPFE is branded as FOREST EUROPE, a voluntary political process that strengthens intergovernmental dialogue and cooperation in European forestry (FOREST EUROPE, n.d.). Thus, SFM has been successfully institutionalised in regional policies and continues to mature. With the acknowledgement of SFM by FOREST EUROPE state members, more tools and initiatives have been adopted to support sustainable ecosystem management alongside international cooperation. For example, in 2003, the EU adopted the Forest Law Enforcement, Governance and Trade Action Plan as a transnational governance tool to stop illegal timber trading with other countries (Sotirov et al., 2020). Europe enacted the EU Timber Regulation (known as EUTR) as a response to illegal logging and wood circulation and to mitigate negative environmental impacts posed upon forest landscapes (Gavrilut et

al., 2016). Nevertheless, the state-led or transnational legal-binding regulation was constrained by institutional challenges and negotiation with low-awareness states (Sotirov et al., 2020). Thus, other pathways to achieve SFM have also been adopted in European forestry (e.g., transnational non-state-led instruments and voluntary tools). At the Madrid Conference, the role of market-based instruments in the green economy continued to be recognised and commended for protecting forest ecosystem services among other national forest programmes and policies (FOREST EUROPE, 2015). Forest certification often received the most attention in terms of its performance in protecting forest resources and landscapes.

3. Forest certification and eco-labelling

Forest certification is a market-based instrument that protects forests by differentiating forest products with desirable sustainable management from other competitive goods. Such differentiation is achieved by third-party certification, where a third party assesses whether a management unit complies with the standards (Marx & Cuypers, 2010). Its independence from state actors is also the major source of authority and legitimacy to its audience. A team of biologists, foresters and experts from a third-party certifying body complete the assessments by conducting a series of field inspections at the forest unit and consultations with local communities (Auld et al., 2008). Assessment principles mirror the vision of SFM and target environmental impact, economic viability and benefits to social communities. The certification body provides written assurance and accreditation to certify that a product and its production process abide by the standards. If a non-conformance is spotted, the third-party certifying body will inform forest managers or producers about the modification needed to comply with standards (Darnall et al., 2018).

The market-based nature of forest certification is unique because it provides economic incentives for multiple stakeholders in industries to voluntarily produce and obtain forest products that fulfil higher environmental standards. The certificate intends to provide a competitive edge, or space, for bargaining price premiums on the market where responsibly sourced products are in demand (Lewin et al., 2019). Forest certification is believed to be a powerful tool because it creates demands along the chain of production and recruits more producers for adopting certification (Boström, 2006). It is thus an information-based system that allows both consumers and businesses to distinguish and purchase forest products from producers and owners that comply with higher environmental standards. In short, forest certification scrutinises owners' and producers' practices and informs consumers about product origins for how to make environmentally responsible and sustainable choices.

Introduced in 1993, the FSC is the pioneering certification system that has served as a model for most other systems (Hall, 2020). Other competing systems with variated target regions and policy scales arose to challenge the prominence of the FSC; one of which is the Program for Endorsement of Forest Certification (PEFC), originally titled as Pan-European Forest Certification in 1998. The FSC and PEFC are by far the leading and most widespread certification systems, accounting for over 8.3% of world forests in the 2000s (Stupak et al., 2011). PEFC is an umbrella system that endorses different national forest certification schemes to form an alliance of certification systems. While the FSC

upholds a set of standards that apply to the international community, the PEFC focuses on forestry standards at a national level. Although the two systems are distinct in their target audience and framework, they consist of similar components (Cadman et al., 2015). In general, there are three inseparable components involved in certification systems: *forest certification, CoC, and eco-labelling*. Forest certification pinpoints the code of practices of forest managers. Their forest management systems and field operations are examined and audited by an independent certification body to verify that the products from the forest unit fit the standards. On the other hand, CoC functions as a bridge between forest certification and the market. CoC tracks the origins of materials used along the supply chain to ensure that products originate from certified forests. This leads to the eco-labelling step, which benchmarks whether a product is derived from certified forests and adheres to CoC guidelines. While eco-labelling commonly exists in the form of a logo, it is also represented as multiple labels that specify the percentage content of certified material or informative text (Wingate & McFarlane, 2005). Eco-labelling is an information-based tool that targets consumers of forest products and hints at the sourcing of products. It also reminds consumers to exercise their economic power to change the market ecology.

These two prevailing eco-labels are usually examined with regard to their C&I and standards. Clark and Kozar (2011) conducted a meta-analysis to compare how well the FSC or PEFC systems had served the purpose of SFM. FSC outperformed a PEFC-endorsed scheme (i.e., Sustainable Forestry Initiative) in most ecological, social and economic indicators, while under par performance was found for stakeholder participation and credibility. Major forest certification systems in Europe and North America have also been compared extensively for their regulatory frameworks, prescriptiveness, CoC flows and differentiation of different wood materials (Garzon et al., 2020; Wingate & McFarlane, 2005). Thus, a comprehensive investigation of the regulatory frameworks and written protocols of forest certification contributed to the understanding of law enactment and on-paper forest protection. Nevertheless, these analyses call for further study on the actual effects and on-the-ground performances of forest certification to determine whether the standards were sufficient to achieve SFM goals (Clark & Kozar, 2011). More field studies and thematic reviews were conducted in the past two decades with a broad focus on sustainability. For instance, ecological studies specifically concentrated on retention level, tree cover and species abundance in Northern Europe (Gustafsson et al., 2010; Kuuluvainen et al., 2019; Shorohova et al., 2019). These ecological studies often show a mix of evidence about the effectiveness of forest certification, specifically regarding retention level and whether deforestation could be halted. Economic studies about eco-labelling shed light on the motivation for certification adoption, different firm-level interactions and global market shares, often debating over the issue of profitability and trade volumes (Trishkin et al., 2014). Social studies, on the other hand, investigated the role of states, trust for third-party certification (Darnall et al., 2018), influences on political or legal institutions (Cashorea et al., 2003) and forestry conflicts among multiple stakeholders in forest management (Overdevest, 2009). These field studies and reviews often covered a wide array of themes which were packed with useful clues about the effectiveness of three-pillared sustainability. They are, however, scattered according to study areas and the outcome variables covered (van der Ven & Cashore, 2018). To understand the effects produced by eco-labelling, the diverging evidence needs to be collated and re-organised to portray a holistic picture of eco-labelling. Therefore, the current study aims to provide an organised conceptual framework to structure and analyse the effects brought on by eco-labelling.

4. Research framework and methodology

This study employed a qualitative literature review approach to synthesise existing findings of the impacts of major forest certification systems (i.e., FSC and PEFC) in Europe presented in peer-reviewed journal articles and grey literature. Grey literature refers to any technical assessment reports and organisation publications from public agencies. Such an approach was adopted because of the large variation in effect size and disciplinary focus of existing literature, where qualitative thematic analysis would be more advantageous in synthesising the state of the art in forest eco-labelling (Snyder, 2019). Moreover, a conceptual framework was proposed to collect and organise knowledge and analyse findings of the impacts of forest eco-labelling (Fig. 1). The framework conceptualises eco-labelling as a tool rooted in and developed from the themes of SFM. The impacts of eco-labelling are underpinned by three pillars, which branch out as **social**, **ecological**, and **economic** dimensions and their corresponding sub-themes. The three pillars serve as the skeleton of the framework to capture the effects of eco-labelling. The sub-themes are attributable themes that refer to the effects of implementing eco-labelling (Cubbage et al., 2010). The sub-themes also break down the dimensions into specific items that help lay out the effects of forest labels. This conceptual framework does not aim to critique or compare the effectiveness of major forest certification systems but rather constitutes a structured method to disentangle the changes driven by eco-labelling and infers implications for future practices.

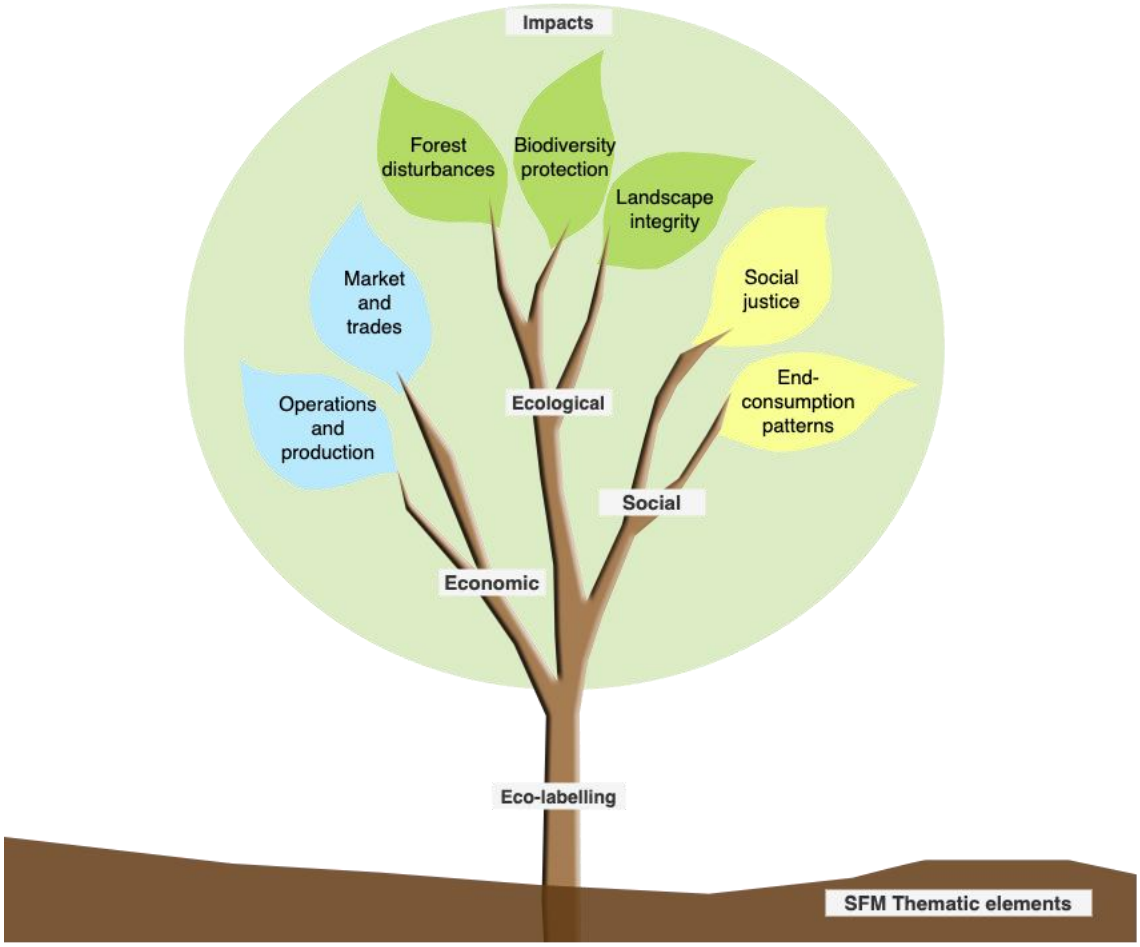

Fig. 1 Conceptual framework for organising and analysing the impacts of eco-labelling on forest products.

Regarding the **social dimension**, the sub-themes cover *social justice* and *end-consumption patterns*. One of the roles of forest certification is to promote socially beneficial forest management practices. This implies that local inhabitants and society should be able to gain forest benefits when they commit to long-term forest management (Auld et al., 2008). Thus, it is necessary to investigate issues related to equity in forest management. Pinto and McDermott (2013) developed a framework containing four parameters to assess equity among certification stakeholders. Specifically, content of equity suggested by Pinto and McDermott (2013) is adopted in this study as it facilitates the exploration of the existing social benefits in decision making and the share of power. Hence, the current framework incorporates the concept of equity under the sub-theme *social justice*, which covers participation (Tsanga et al., 2014) and a range of rights for vulnerable groups, such as labour and indigenous people. Apart from equity, this framework adds the discourse on social awareness towards forestry. One of the intentions of eco-labelling is to communicate environmental information about forest products to consumers so as to change forestry practices. End-consumption decisions and patterns provide information about social awareness and intentions in forest protection. To understand whether this intention has a social impact, purchasing habits and consumers' consciousness about forestry practices should then be examined. Thus, the social dimension mainly focuses on equity and end-consumption patterns.

Under the **ecological dimension**, sub-themes include *forest disturbances*, *biodiversity protection* and *landscape integrity*. Both the FSC and PEFC systems target environmental values, conservation and ecosystem vitality as their core principles in guiding forest management units. Thus, the three sub-themes tap into ecosystem indicators related to wood mass, diversity and landscape ecology that help capture a myriad of effects on forest health (Trumbore et al., 2015). The first sub-theme is *forest disturbances*. According to the evaluative framework proposed by Tikina and Innes (2008), problem-solving can be seen as an important indicator of effectiveness. Given that forest certification intends to address forest degradation at a regional and global level, how certification systems have monitored or checked against forest degradation uncovers their contribution to forest health protection. Thus, this framework considers a series of indicators of forest health (e.g., tree cover, zonation, tree standing size, and soil and water condition) to investigate whether eco-labelling could impact on managing forest landscape risks and slacken deterioration from logging, clear-cutting or other silvicultural activities. In addition, *biodiversity protection* emphasises species diversity in forest landscapes. Studies have shown that forest management practices under certification interact closely with biodiversity (Eriksson & Lindhagen, 2001). Wood debris, tree types, tree standing sizes and ages in the post-logging period are interrelated with the survival of endangered species. Therefore, the survival of endangered species and tree species at production sites becomes the key concern in this sub-theme, which also reveals potential influences on ecosystem services in forests. *Landscape integrity* is another sub-theme that investigates the functional connectivity and spatial configuration of habitats (Angelstam et al., 2001), which are prerequisites for species survivability. Habitat loss results in landscape patchiness and fragmentation, which increase the risk of local species extinction after exceeding thresholds (Angelstam et al., 2001). This sub-theme is thus closely related to species populations, biodiversity and forest disturbances. Therefore, investigating landscape functionality helps understand forest health and biodiversity protection under eco-labelling.

For the **economic dimension**, both the FSC and PEFC systems accentuate the productive functions and economic viability of forests and management planning. Economic viability means that profits

are generated without limiting forest resources, ecosystems and communities (Pinto & McDermott, 2013). Thus, the sub-themes encompass *operations and production* and *market and trades*. *Operations and production* examine corporate management practices and attitudes towards SFM among management units and producers. Producers' recall of management practices is considered a market-related element as it reflects the climate in the sector and subsequently its influences on timber production procedures. Furthermore, part of the certification mechanism is that producers will change their practices to meet the certification standards if they receive price premiums after becoming accredited. Thus, internal management and field practices reflect the intended impacts of eco-labelling. Not only is the behavioural effectiveness of producers and operators worth attention (Tikina & Innes, 2008), but their mindset also implies indirect impacts and changes that might contribute to sustainable forestry practices. Producers' attitudes influence how production and procurement are modelled and practised (Jakobsson et al., 2021). Both the behavioural and attitudinal change of producers might normalise a new market ecology and corporate culture. Therefore, changes in producers' attitudes and operations were accounted for in the current framework to analyse the economic impacts of eco-labelling. For the sub-theme *market and trades*, price premiums, production costs and trade volume flows generated by eco-labelling are indicators of the economic viability of eco-labelling. Costs of forest certification refer to both direct and indirect costs. The former includes payment for accreditation and internal and external auditing, whereas the latter covers the costs of changing operational forest practices based on standards (Van Deusen et al., 2010). These indicators reflect the external effects of eco-labelling on economic performance as well as on the profitability resulting from eco-labelling.

In short, the conceptual framework considers a wide range of sub-themes under social, economic, and ecological sustainability to maximise the angles taken to capture the effects and outcomes of eco-labelling. The following keywords (i.e., search terms) derived from the conceptual framework were shuffled and employed to gather relevant literature through database searches in SpringerOpen, ScienceDirect, MDPI, Wiley Online Library and Google Scholar:

"Forest certification" AND "impacts" OR "effects"
"eco-labelling" AND "forest"
"forest certification" AND "Europe" OR "EU"
"ecological" OR "social" OR "economic" AND "impacts" AND "forest certification"
"biodiversity" OR "degradation" OR "landscape integrity" OR "forest certification"
"Indigenous rights" OR "equity" OR "consumption" OR "willingness to pay"
"costs" OR "producers" OR "market" OR "procurement" OR "certified wood product"

The choice of materials was based on their research quality and relevance to forest certification and eco-labelling. To filter and solicit appropriate literature for the data analysis, a set of reflective criteria targeted (i) research objectives of the literature; (ii) authority and trustworthiness of the literature; and (iii) a specific time frame. Criterion (i) ensured that literature must be relevant to forest certification systems (FSC and/or PEFC) and the search terms. The focus areas in the literature must be either located in or involving Europe. For generating a more holistic understanding of the impacts created by the eco-labelling strategy, the focussed effects in the literature could be direct or indirect outcomes of forest certification (van der Ven & Cashore, 2018). For instance, tree cover change in certified forests is considered the direct impact of certification systems because the changes stem

from altered practices. On the contrary, indirect impacts refer to the far-reaching changes pertaining to the implementation of forest certification, e.g., opening up dialogues about workers' rights or forest policies (van der Ven et al., 2017; van der Ven & Cashore, 2018). While criterion (ii) mainly concerned the status of publication and authority of the publisher (e.g., peer-reviewed or grey literature), criterion (iii) narrowed the scope of publication to the 2000-2021 time frame, which covered most of the momentum when European countries implemented either the FSC or PEFC system.

5. Results

A total of 41 papers matched the selection criteria and were collected for analysis. Direct and indirect research was combined to discuss the impacts of the two forest certification systems (Table 1). European countries covered in the materials were spread across the European continent, e.g., ranging from Russia, the Czech Republic to Italy and Sweden (See Appendix A). The literature was examined and analysed by applying the proposed framework (Fig. 1). Three sets of literature contained compliance reports from the PEFC, which were considered grey literature. Rather than compare the superiority between the systems, this study's objective was to collate the existing evidence observed across different European countries and certification systems and to assist the investigation of the potential of eco-labelling.

Table 1. Overview of the changes in ecological, social, and economic impacts induced by forest certification systems in solicited literature.

Dimension	Sub-themes	Outcomes	FSC	PEFC	Literature support[#]
Social	Social justice	Customary rights for local communities and indigenous populations	+/-	-	Gulbrandsen (2005b) Hain and Ahas (2007) Keskitalo et al. (2009) Malovrh et al. (2019) PEFC Council (2015, 2016, 2017a) Tysiachniouk et al. (2021)
		Working conditions for forest workers	-	-	Hain and Ahas (2007) Hain and Ahas (2011) Mikulková et al. (2015)
	End-consumption patterns	End-consumer behaviours and awareness	+/-	+/-	Aguilar and Cai (2010) Darnall et al. (2018) Holopainen et al. (2017) Petrescu et al. (2020)
Economic	Operations and production	Management practices, operations, and environmental attitudes	+/-	+/-	Galati et al. (2017) Hain and Ahas (2007) Johansson and Lidestav (2011) Paletto and Notaro (2018) Paluš et al. (2018) Paluš et al. (2021) Petrescu et al. (2020)

	Market and trades	Market penetration and competitiveness	+	+	Auld et al. (2008) Chen et al. (2020) Gulbrandsen (2005a) Gulbrandsen (2006) Halalisan et al. (2019) Owari et al. (2006) Paluš et al. (2017) Paluš et al. (2018) Savcor Indufor Oy (2005) Zubizarreta et al. (2021)
		Production costs, trade volumes and profitability	+/-	+/-	Fernholz and Kraxner (2012) Galati et al. (2017) Gomez-Zamalloa et al. (2011) Gulbrandsen (2006) Gullison (2003) Michal et al. (2019) Paletto and Notaro (2018) Paluš et al. (2017) Paluš et al. (2018) Petrescu et al. (2020) Savcor Indufor Oy (2005)
Ecological	Forest disturbances	Soil erosion, chemical use, illegal logging	+	+	Auld et al. (2008) Blumröder et al. (2020) Dias et al. (2015) Hain and Ahas (2007) Halalisan et al. (2019) Sverdrup-Thygeson et al. (2008)
	Biodiversity protection	Biodiversity (e.g., deadwood, stands, biomass, species abundance)	+/-	( )	Blumroeder et al. (2019) Elbakidze et al. (2011) Elbakidze et al. (2016) Johansson and Lidestav (2011) Kuuluvainen et al. (2019) Simonsson et al. (2016) Sverdrup-Thygeson et al. (2008)
	Landscape integrity	Connectivity, habitat fragmentation, functionality	-	-	Blumroeder et al. (2019) Johansson and Lidestav (2011) Villalobos et al. (2018)

+: positive changes; -: negative changes; +/-: mixed evidence; ( ): lack of relevant literature support.
[#]Literature might repeat because of its multiple study objectives.

5.1 Social dimension

5.1.1 Social Justice

Eco-labelling helped enact a comprehensive legal framework to protect the customary rights of different social groups, especially in the case of the FSC system. The formulation of operational standards and explicit emphasis on the role of indigenous communities strengthened the significance and voice of this community under the FSC system. Principles 3 and 4 were dedicated to the rights of indigenous people and local communities in forest management. Principle 3 specifically stated that indigenous communities have the right to own, use, and manage their territories and resources. Detailed criteria were also set accordingly to operationalise the concept in the industry. Indeed, some protection of local and indigenous rights was observed. Before the increasing prescriptiveness of the international policy Free Prior and Informed Consent (FPIC) on the FSC, the established FSC guidelines arrangement had effectively enhanced indigenous rights by (i) a broader definition of indigeneity (i.e., self-identification); (ii) the requirement of consensus from indigenous and local communities in forest management; and (iii) the normalisation of negotiations among the Social, Economic and Environmental chambers in Russia (Keskitalo et al., 2009; Tysiachniouk et al., 2021). Similarly, the Swedish FSC standards marked the Sami minority people's grazing areas as concession areas and increased consultation opportunities to protect their reindeer herding rights (Keskitalo et al., 2009). The customary rights of indigenous communities were recognised and articulated in the FSC system. As for the PEFC system, indigenous rights were not made as explicit as in the FSC system. Yet, stakeholder engagement and consensus were highlighted in standard-setting procedures. To promote procedural justice, the PEFC certification system clearly stated that stakeholders are to be mapped according to the UN definition, where indigenous communities must be included before proceeding to any standard-setting activities (PEFC Council, 2017b). This represented a big leap forward in acknowledging the stake of indigenous communities in this system as compared to the earlier decade of implementation of the PEFC. The comprehensive rules and regulations recognised and included indigenous communities, which signified the normative and regulative impacts of eco-labelling.

Nonetheless, there was a lack of actual empowerment of indigenous communities. Despite the comprehensive regulations enacted for customary rights protection, its stringency evaporated in implementation. In recent years, several compliance assessments from the PEFC system highlighted a repeated pattern of non-conformities related to representativeness in standard-setting procedures across Sweden, Norway and Hungary. Similarly, forest units in these areas failed to invite stakeholders to standard-setting activities. For example, the Sami people, social NGOs and scientific organisations in Sweden were not present at the procedures (PEFC Council, 2015, 2016, 2017a). This acted against the principle of the PEFC system because it should have highlighted stakeholder engagement and transparency in forest management. Another study that compared private certification systems also echoed the condition where stakeholders were overlooked in most procedures (Gulbrandsen, 2005b). It further explained that consultations in the PEFC still taking place exclusively among forest owners undermine the empowerment of indigenous and local communities in decision making (i.e., hindering procedural justice). In short, the regulations in the PEFC were insufficient to ensure the actual participation of indigenous and local communities. For the FSC

system, despite a better legal foundation for customary rights protection, the increasingly stringent rules under the FPIC ironically narrowed the definition of indigeneity, which reduced the coverage of communities protected under the FSC principles (Tysiachniouk et al., 2021). Another study in Estonia also reported similar exclusion and communication problems with representatives in Tallinn, as well as insignificant benefits offered to indigenous/local communities (Hain & Ahas, 2007). The exclusion of indigenous rights was also applicable to other regions. A study of 4 southeast European countries demonstrated that "P4 Community relations and workers' rights" showed the highest proportion (32.4%) of non-compliance, with a majority violating "Criterion 4.2 protection of customary rights" (Malovrh et al., 2019). These findings showed that genuine empowerment of minority groups in forest management might still be a challenge.

Furthermore, the workers' rights studies, which are scant in number, noted a lack of increasing recognition of labour rights in both certification systems. Eco-labelling had little to no effect on protecting workers' rights. Despite a significant improvement in workplace safety in an Estonian FSC case study (Hain & Ahas, 2007), no noticeable post-certification improvement in workers' welfare has been commonly highlighted in recent research. For instance, out of the 156 certificate holders surveyed in the Czech Republic, none had reported effects of the PEFC system on the social area (Mikulková et al., 2015). Shockingly, 0 respondents reported improvement in the social area and working environment as the real benefit of the PEFC system. This was further underpinned by a high share of non-compliance in Criterion 1 and Criterion 4 (i.e., communication and worker safety) in a nationwide study that investigated FSC audit reports from 32 countries (Hain & Ahas, 2011). Also, local unemployment was not considered as a side-effect of the increased costs from CoC and forest certification (Hain & Ahas, 2007).

5.1.2 End-consumption patterns

The public's opinion of eco-labelling was positive and their willingness to purchase eco-labelled products increased. The research conjointly analysed the US and UK, pointing out that consumers preferred wood products with eco-labels 3.9 to 15.6 times more than non-eco-labelled products (Aguilar & Cai, 2010). The recognition of label meaning affected the final decision and consumer preference. The fact that the adoption of forest certification was a response to market demand indirectly signified an increased environmental sensitivity in consumer markets (Petrescu et al., 2020). Another study in England reported that the FSC label would alter consumers' in-store decisions because the environmental information provided was considered legitimate and trustworthy (Darnall et al., 2018). Interestingly, when a business was distrusted to provide credible environmental information, consumers in England were 15% more inclined to buy products that carried the FSC label. In other words, these labels displayed a high potential of becoming credibility icons of sustainably sourced products and a determinant of consumption choices.

Despite the signs of increased consumption of certified products, studies also highlighted that consumers might not have paid much attention to certification attributes of the products per se. The decision-making process was heavily dependent on product prices, product origin, product quality and loyalty to the brand. An experiment analysis that simulated scenarios with different combinations of attributes showed that forest certification only contributed 13.7% to decking material choice while material and price mattered the most in affecting purchase choice (Holopainen et al., 2017).

Interestingly, consumers who preferred PEFC products prioritised price, whereas those who looked for FSC products valued material. Aguilar and Cai (2010) further highlighted that consumers were more willing to purchase labelled forest products if the base price was relatively low. As a result, whether eco-labelling fostered environmental communication and awareness remains an unsolved issue. Furthermore, increased willingness to buy certified forest products was observed in companies that already have a higher level of environmental awareness, raising the concern of "preaching to the choir" (Petrescu et al., 2020). The Nordic study also informed that market sensitivity is more predominant in business-to-business trade instead of end-consumption markets (Holopainen et al., 2015). Therefore, the actual effect on enhancing environmental awareness and communication with end-consumers about SFM might be rather ambiguous. Another point to note is that most consumption literature of labelled forest products employed choice analysis or modelling to investigate the willingness-to-pay for eco-labelled wood products. It was an estimation rather than an actual relation between eco-label and purchase habit. Thus, findings and remarks about consumers' environmental awareness and behaviours were more anticipatory and implicative.

5.2 Economic dimension

5.2.1 Operations and production

The attitudes of producers and forest owners towards eco-labelling were positive in the studies collected. An in-depth understanding of SFM concepts and principles in corresponding forest certification systems was highlighted by studies in Eastern Europe. Most of the literature investigated producers' understanding of SFM and the requirements from corresponding certification systems to unpack their environmental awareness. Double-certified and PEFC-certified firms in Slovakia had a better understanding of SFM concepts and perceived the impacts of forest certification more positively compared to firms solely certified by the FSC system (Paluš et al., 2018). Such a pattern continued in the newly conducted survey-based study in Slovakia, such that the level of understanding of the SFM concept among the certified forest owners remained high, with better performance among managers and owners of larger forest areas (Paluš et al., 2021). Such differences in understanding might stem from the relatively proactive promotional strategies and communication in the PEFC system. In the case of Estonia, staff and contractors also acknowledged that enhanced environmental awareness was the main impact of the FSC certification system on local forestry. Noticeably, the senior management level became more environmentally educated after participating in FSC certification, which increased participation at different internal policy levels (Hain & Ahas, 2007). Similar acknowledgement of SFM concepts was reported in Italian firms as well (Paletto & Notaro, 2018). Yet, the literature highlighted that the motivation behind adopting certification and making corresponding changes was more likely the result of market response to consumers' demand and needs (Petrescu et al., 2020). Thus, whether forest certification impacted the sense of environmental responsibility and awareness in the industry was ambiguous, despite the upward trend in certification adoption.

Some changes were also spotted in management and production practices amid the increasing adoption of eco-labelling. In general, management practices received more attention and improvement effort. A study surveyed 500 forest-based companies in 20 Italian regions about their perceived effects of the FSC system. An absolute majority (94.2%) of respondents reflected that

ample training was required of employees before allowing them to manage internal processes and procedures (Galati et al., 2017). Fifty percent of the respondents expressed that they would hire external consultants to ensure adherence to FSC standards if internal training was unavailable. The stringent training provided to workers implied a fundamental change in production and operations (e.g., learning more about regulations, mechanisms and documentation). Apart from increased training, record-keeping and awareness of biodiversity protection were enhanced with the FSC system. The Italian case demonstrated the potential of certification systems in pressuring firms and owners to change their production practices and model. Also, the owners in Slovakia perceived both the PEFC and FSC systems positively in terms of improvement in management practices (Paluš et al., 2018). Regular reviews of logging rules, drafting protection measures and inventory monitoring were conducted, as compared to being almost non-existent before the Estonian firm became FSC-certified (Hain & Ahas, 2007). Owners from FSC-certified firms in Sweden stated that environmental considerations were taken into account when planning silvicultural activities, e.g., leaving potential trees and deadwood and establishing set-aside areas (Johansson & Lidestav, 2011). The experiences in Eastern, Southern and Northern Europe highlighted a change in environmental attitude, which heightened environmental sensitivity in firm operations and production procedures. Thus, eco-labelling was to some degree impactful on corporate culture, especially in its organisational and timber production practices.

5.2.2 Market and trades

Market competitiveness was the most recognised positive outcome in the literature. Eco-labelled products are highly competitive, especially in environmentally sensitive markets. Forest certification improves the green quality level of products and the credibility of product sourcing, which create a competitive edge for certified products on the global market (Chen et al., 2020). A study focussing on three Nordic countries also showed enhanced timber quality and quantity after improved management (Savcor Indufor Oy, 2005). Quality improvement was mostly a result of upgrading timber production methods and communication. Apart from better product quality, research conducted in Italy, Romania, the Czech Republic, Finland and Slovakia reported improved corporate image and competitiveness as the most significant economic impacts of forest certification (Halalisan et al., 2019; Mikulková et al., 2015; Owari et al., 2006; Paluš et al., 2017; Paluš et al., 2018). Producers agreed on market penetration and the competitive edge in maintaining market share. Indeed, producers rated signalling and market mechanism as the most important drivers in getting eco-labelled (Galati et al., 2017; Halalisan et al., 2019; Paluš et al., 2017; Zubizarreta et al., 2021). These two motivational mechanisms concern the benefits of exhibiting corporate effort in achieving higher environmental standards to consumers and the economic interests of corporates, respectively. This implies that the obtainment of eco-labels and accreditation provide market competitiveness to forest firms.

Eco-labelling also created impacts by changing market ecology and normalising itself as a credible icon. The market segment perceived forest certification systems as a credible icon in verifying and providing information about the origin of materials thanks to third-party verification. Exporters to Europe claimed that accreditation from the FSC has become a prerequisite for most European forest market access (Auld et al., 2008). This implies that eco-labelling has established itself as a benchmark for sustainability and market requirements. Indeed, multi-lateral institutions also recognised and

emphasised certified forest products to a greater degree. For instance, governments in the UK, the Netherlands, Denmark, Germany, and France required or prioritised the FSC certification system or certified timber and forest products (Gulbrandsen, 2006), increasing the market influence of eco-labelled products. Market pressure translated the FSC system into a competitive advantage for forest companies, making it a novel and widely recognised business performance indicator. In this way, producers whose products become eco-labelled can expand and penetrate new markets more easily, thus changing market ecology. In addition, forest certification also fostered new supply chain support. For instance, influential brands in Sweden, e.g., IKEA Sweden, which are heavily involved in the FSC certification system, established a close communication network with environmentally concerned importers in Germany and the UK (Gulbrandsen, 2005a). Eco-labelled forest products thus created new market pressure and potential partnership networks, generating momentum in market access and expansion.

As for trades, procurement of certified wood products showed positive outcomes in a survey study (Paluš et al., 2017). A significant majority (over 50%) of respondents purchased certified products from forest owners' wood manufacturers in the Czech and Slovak Republics (Paluš et al., 2017). Furthermore, spurred by the buyers' group network, FSC-certified forest products account for 16% of total British wood consumption (Gulbrandsen, 2006), while certified wood products contributed to about 30% of the sales revenue in the Czech Republic and Slovakia (Paluš et al., 2017). As the market segment became increasingly reliant on certification-labelled wood products, about one-third of respondents were willing to pay price premiums to buy certified wooden planks (Paletto & Notaro, 2018; Petrescu et al., 2020). In contrast, another Romanian study that surveyed 214 companies showed an increased willingness to replace conventional products with FSC products only if prices were reasonable (Petrescu et al., 2020). While the FSC certification system took around 26.5% of the market share in global forest products, Europe contributed up to 12.7% of the proportion of total roundwood from certified forests in 2012 (Fernholz & Kraxner, 2012) compared to 5% of the market share of certified forests products in 2002 (Gullison, 2003). There was an overall sign of increased trade volume of certified products in the European and global context.

Nonetheless, the actual economic return seemed dimmer when the price premiums were not as significant as expected. Studies on the economic impacts of forest certification prevailingly pointed out an inevitable increase in production costs after certification. In the study investigating the Czech and Slovak Republics, extra costs after forest certification stood at nearly 50% (Paluš et al., 2017), which was a similar concern in another study in the Czech Republic (Michal et al., 2019). Short-term profitability was not as respectable as expected. Though sales and trade volume in Romania increased after getting eco-labelled, the premium was not economically significant (Halalisan et al., 2019). This finding again echoes the study of Paluš et al. (2017) where an astounding majority stated that no premiums were generated from selling certified products because buyers perceived certified products to be overpriced. The case of the Czech and Slovak Republics applies to the wider European context as well. A study that surveyed industry experts from EU27 showed small price differences between certified and non-certified products, undermining the obtainment of premiums despite increased production costs (Gomez-Zamalloa et al., 2011). The profitability from obtaining eco-labels seemed skeptical. The Finnish study indicated that an increasingly higher number of competitors were able to supply certified products locally and across the borders, which increased competition and made securing price premiums difficult (Owari et al., 2006).

Indeed, Galati et al. (2017) revealed that the high costs were partly compensated by new partnerships established in the supply chain network instead of by the increment in the sale price of certified products. The green premiums from selling certified products were intended to be the biggest selling point and compensation of the indirect costs from management corrections or upgrades. Some owners and producers were thus skeptical and hesitant about the economic return of eco-labelling. Nonetheless, the scale determines whether long-run profitability will be affected. The costs due to changed management training were indeed more fixed, whereas unit costs might be reduced as more areas become certified (Savcor Indufor Oy, 2005). Also of note is that the scale of the company affects affordability (Paluš et al., 2018). The additional cost of certification might be burdensome to some companies. Yet, when the scale is enlarged, the interpretation of economic return and profitability may completely change. Given that the collected literature from Eastern Europe predominantly includes small-to-medium private firms, the conclusion of the marginal return may be highly variable, and profitability from forest certification could either be underestimated or overestimated.

5.3 Ecological dimension

5.3.1 Forest disturbances

In an attempt to halt disturbances posed to forest landscapes, eco-labelling lowered the frequency of disturbance-causing practices at the remedial level and zoned set-aside areas as a preventive measure. Felling-free periods were emphasised with forest certification, which reduced disturbances posed to fauna. A case study in Estonia demonstrated that the FSC certification system had catalysed the cancellation of felling works during spring and the suspension of amelioration networks in forests (Hain & Ahas, 2007). At the same time, assessments were carried out when renewing the existing drainage system and a new drainage system was banned from national forests as a result of forest certification. Disturbances from felling and related activities were minimised. Indeed, the audits required by eco-labelling specifically addressed concepts such as natural regeneration, reduced-impact harvesting and the use of chemicals (Auld et al., 2008). The reduction of chemical use, such as fertilisers and pesticides, was also frequently reported in other studies about the effectiveness of eco-labelling (Hain & Ahas, 2007; Halalisan et al., 2019). In other words, eco-labelling was able to reduce the frequency and abundance of disturbances present in some forest landscapes, which are often the major source of forest degradation. Moreover, forest certification systems specifically drafted step-by-step guidelines on the zonation of set-aside areas to restore or prevent areas from suffering disturbances caused by silvicultural activities. More buffer zones in swamp forests were set up and observed after certification, where large trees in only 29% of the buffer areas had been removed compared to 43% in the pre-certification period (Sverdrup-Thygeson et al., 2008). Similar practices were implemented in some regions in Portugal, and signs of habitat restoration were also detected in studies in Mediterranean streams possibly owing to the removal of ecological disturbances under certification (Dias et al., 2015). In sum, the FSC certification system helps reduce disturbances introduced in productive forest areas and contributes to biodiversity and habitat restoration to some extent.

However, there is also a flip side to the ecological protection provided by eco-labelling. A more recent study in Russia demonstrated that clear-cut areas did not reduce in size after FSC certification in

Russian forests, with up to 97% of investigated areas still in complete clearance (Blumröder et al., 2020). This indicates that forest areas were still heavily affected by the negative consequences derived from any logging and silvicultural activities (e.g., soil erosion, noise disturbance, loss of habitat). In addition, skid trail density had not been reduced in clear-cut forest areas. Such a high density of skid trails severely impacted the soil of the forest floor, especially the top-most layer (Blumröder et al., 2020). Damage to coarse logs during logging after certification is still trending upward, causing damage to decaying logs and terrain in Norway (Sverdrup-Thygeson et al., 2008). Concomitantly, disturbances from off-road transport trails or the use of clear-felling affected 79% of certified areas. Final felling was twice as frequent in certified forests as in non-certified forests. As a side note, the ecological literature which covers the PEFC certification system was scant. Compared to the PEFC system, the FSC system has a more comprehensive archive of Corrective Action Requests; thus, more existing literature was able to develop their work based on those available data (Visseren-Hamakers & Pattberg, 2013). Given that the PEFC certification system is different from the FSC system in terms of policy scale and target forest firms, insufficient findings related to the PEFC system may have affected the overall interpretation of the ecological dimension.

5.3.2 Landscape structure and biodiversity protection

Some degree of positive impact on landscape functionality could be observed in certified forests across Northern Europe. A study in Sweden and another comparative study conducted by Sweden and Northwest Russia both highlighted that voluntary set-aside forests under forest certification enhanced structural diversity (Elbakidze et al., 2011; Simonsson et al., 2016). Nevertheless, the spatial scale used (e.g., edge width) significantly affected landscape pattern interpretation. Another study conducted by Johansson and Lidestav (2011) reported some evidence of biodiversity improvement in certified forests. The volume of deadwood increased in Swedish regions and an increasing number of old broad-leaved trees was found in small-scale certified areas. Retaining old trees is important to biodiversity conservation because the old-growth features enhance habitat variability, which is valuable to regeneration and stability. Retained trees also increase carbon storage for soil and hydrology in forests (Santaniello et al., 2017). Despite the improvement experienced in Northern Europe, more studies have highlighted the ineffective outcomes from eco-labelling, especially in retaining tree mass and landscape intactness.

Johansson and Lidestav (2011) raised concerns over the difficulty in contributing improvement to forest certification when only one FSC ecological indicator in large-scale firms and a limited number of firms at the Södra and Norra regions showed improvement. Another study in Lithuania reported that in 18.5% of formally protected areas and voluntary set-asides, only less than 10% constituted older forests (Elbakidze et al., 2016). Also, a Russian study flagged that the volume and availability of different types of deadwood are insufficient to conserve biodiversity in clear-cutting areas under FSC certification (Blumroeder et al., 2019). Although the fragmented forests in certified areas demonstrated a higher level of diversity, the low volume of tree biomass spared from felling reduced the cooling capacity in primary forests, posing risks to various ecosystem functions. The edge effect from clear-cutting led to dieback of the tree species adjacent to the felling areas (Blumroeder et al., 2019). Similarly, the Lithuanian study demonstrated that structural fragmentation deteriorated in certified areas with an increasing edge and islet classes and decreasing total core areas as edge width

increased (Elbakidze et al., 2016). In the long run, potential functionality and biodiversity would be undermined if species required spruce, broad-leaved and deciduous forests as habitats.

The case studies across the four countries show that old forest patches existed in low numbers and were scattered across certified areas, which undermined functional connectivity at various scales and failed to support structural variation. Few positive outcomes were found to be related to the preservation of biomass and microhabitats (e.g., tree species and deadwood), which conserve biodiversity by mimicking the natural forest habitat after felling (Kuuluvainen et al., 2019). Failing to retain old tree mass may hinder biodiversity conservation due to the absence of old-growth features that aid regeneration, stability, and carbon storage for soil and hydrology in forests (Santaniello et al., 2017). Indeed, the problem of low retention had already been flagged by an older study in Norway, although the volume of retained spruce trees increased twofold after forest certification (Sverdrup-Thygeson et al., 2008). The average number of remaining trees and high stumps were 8.8/ha and 1.4/ha, respectively, which failed to meet the requirements in both the FSC and PEFC certification systems. This finding shows that the problem of landscape protection has alarmingly persisted for decades across the continent. It warrants attention to the retention level of trees as the means to protect biodiversity and landscape functionality. Furthermore, Villalobos et al. (2018) compared the before- and after-felling forest inventory data for both systems in Sweden. Their study indicated that neither the FSC nor the PEFC system significantly increases the preservation of environmentally sensitive areas or tree stumps during felling (8.7 trees/ha after felling). Although certified forest areas generally showed a lower non-compliance rate and a larger quantity of remaining high stumps, the differences diminished as the spatial and temporal scales were adjusted. In short, the measures to protect biomass and habitats brought on by forest certification still need to be improved to halt forest landscape fragmentation and degradation.

6. Discussion

The current research employed a qualitative paradigm to disentangle and synthesise existing findings regarding the impacts of forest eco-labelling on the social, economic and ecological dimensions of sustainability in Europe. The conceptual framework included broad and general themes related to the various dimensions of sustainability as the study aimed to provide an overview of multiple research areas. Undeniably, the flip side of this qualitative strategy was the increasing risk of inaccuracy or biased interpretation. Although the study developed a conceptual framework to collect and analyse findings in an organised fashion, there is still a lack of consensus on appraisal techniques for qualitative studies (Mallett et al., 2012). This leads to the problem of evidence selection bias, as some relevant and available data on the topic might be overlooked or excluded unintentionally, undermining the accuracy of the literature abstraction process (Drucker et al., 2016). Because the process is susceptible to selection bias, its interpretation might under-represent certain eco-labelling cases in forest management practices. Although more rigid methods exist, such as meta-analysis or quantitative systemic review, the issue of vastly different statistical measures and effect size is still the biggest hurdle to any synthesis about the impacts of SFM tools. Future research might need to address the knowledge base of eco-labelling by drawing on both quantitative and qualitative methods to investigate its impacts on SFM.

While this study did not attempt to generalise the effects of eco-labelling, it highlighted several observations and concerns that are shared across European countries regarding market demand, profitability and ecological performances. The first issue concerns profitability and end-consumption in the socio-economic dimension. As a management tool that utilises market incentives and affects market planning, the economic performance of eco-labelling received the greatest attention. The designated mechanism of eco-labelling is to provide better prices for certified products as compensation for increased operating costs and rewards for adhering to sustainable forestry practices. In recent decades, the debate on profitability has been ongoing without a clear-cut interpretation. The difficulty lies in the scale of the firm studied. As presented in the results, most small- to medium-scale firms suffer from increased costs because of the holdings of forest areas and productive resources. On the contrary, large firms might already own more forest areas and a higher quality management system in response to existing forestry regulations (Owari et al., 2006). Such incongruent increments in cost and revenue also hold back producers and owners in tropical countries (Dauvergne & Lister, 2010). Although long-run financial returns have been reported in forest-rich Nordic countries, the under par short-term financial performance makes more producers reluctant to get on board. This drastically undermines the potential of eco-labelling in halting deforestation. Indeed, a lukewarm market response (i.e., underdeveloped demand) might be the greatest obstacle to reward participating firms. Although there have been positive signs of more sustainable end-consumption patterns and procurement, the hurdles to enhancing green consumption behaviours still predominate. Few studies have highlighted a drastic improvement in consumer behaviour after certification, although consumers demonstrated an increasing understanding of eco-labels and producers changed their supply chain (Aguilar & Cai, 2010; Darnall et al., 2018). These trends create an unfavourable market orientation for the uptake or undermine the effects of forest certification.

Enhancing the end-consumption market in the social dimension is a possible breach of this vicious loop. Producers in Europe pointed out that the demand for certified products is still skewed towards business-to-business networks (Holopainen et al., 2015), which is in line with the observation in the *end-consumption patterns* where increasing awareness seemed insignificant and lagging. Low awareness might be the result of a lack of information and marketing of eco-labels. End-consumers often had little knowledge about the underpinnings of eco-labelling, slackening the change in purchase patterns. While knowledge and trust are the key factors influencing actual green consumption (Daugbjerg et al., 2014), forest certification lacked campaigns and informative label design (Horne, 2009). The environmental claims of eco-labels are complex and implicit; for instance, FSC labels have multiple categories to indicate whether product sourcing is pure, mixed or other (Dauvergne & Lister, 2010; Gulbrandsen, 2006). This might explain the slow bloom in the end-consumption of certified forest products. Thus, the marketing strategy and social promotion of eco-labels should step up to raise consumers' awareness and create a positive climate to encourage consumption of certified forest products (Horne, 2009). For example, the communication campaign administered by a retailers' association showed a significant positive effect on increasing knowledge for FSC and other eco-labels, which positively related to consumers' likelihood to purchase products with superior environmental performance (Testa et al., 2015). If consumption of certified forest products is promoted, the green market can be better secured which, in turn, supports the profitability of eco-labelling. Thus, the marketing strategy needs to generate greater impetus and norms in society to address the profitability issue in the long run. Improving the eco-label design and communication

campaigns could be a starting point to effectively convey environmental claims and boost the expansion of end-consumption of eco-labelled forest products.

The second issue highlights the contradictory performance between producers' environmental attitude and actual ecological performance. The literature collected in this study listed positive changes to owners' and producers' forestry practices, whereas on-the-ground ecological indicators predominantly accounted for ineffective outcomes. The survey-based studies investigated how producers changed corporate management practices after adopting forest certification, such as conceptualising high-conservation-value areas, zonation, and altering the felling period. Yet, the protection offered to forest landscapes seemed unsatisfactory. The performance gap may be due to an imbalanced representation of the PEFC and FSC certification systems in the collection of existing studies on managers' forestry practices and ecological impact studies. The two systems are different in terms of stringency, where the PEFC is relatively flexible and less rigorous with regulations (Malets, 2015). The flexibility offered by the PEFC system might have contributed to the positive perceptions towards forest certification and practices. On the contrary, on-the-ground ecological performance was evidenced by the stricter FSC requirement. The gap is thus magnified in the current study, where the highly positive attitude contrasted against stricter audits on ecological performance under the FSC system.

Moreover, such a gap between operations and on-the-ground practices drew attention to indicator design, which influences the quality of forestry practices. A common critique for most forest certification systems, whether the FSC or PEFC system, is that ecological indicators are not precise and technical enough. Angelstam et al. (2013) pointed out that only one of 23 indicators in the FSC system in Sweden met the SMART criteria (i.e., Specific, Measurable, Accurate, Realistic and Timebound), indicating that specificity and measurability were questionable. Stringency is more conceptual, whereas the implementation of goals might be lost in translation throughout different processes in forest management. Eco-labelling was thus stronger in prescriptiveness but often lacked technicality in the recommendation. Among the compliance reports collected from the PEFC Council (2015, 2016, 2017a), improvement and recommendations were often written qualitatively and descriptively, without suggestions for concrete actions. This led to the paradox of under par ecological performance amid improved corporate practices and attitudes because management units, especially small- to medium-scale firms, had little information about the actual pathway to modify malpractices. Simply put, managers often struggle to proceed from the non-compliances pointed out in audits (Gutzat & Dormann, 2020). Thus, the indicators in eco-labelling may be insufficiently quantifiable, leading to ambiguous implementation and lower stringency. Indeed, the value-laden and qualitative approach in regulation is a double-edged sword, as it empowers socio-political communities with flexibility while causing ambiguity in implementation. To improve on-the-ground effectiveness, the ecological sustainability requirement in forest certification systems could incorporate evidence-based indicators (Angelstam et al., 2013). This line of action would have profound impacts on both developed and developing countries. The European experience highlighted such pitfalls in securing ecological sustainability despite the greater availability of forestry knowledge and professionalism. Yet, tropical forests predominantly located in developing countries may have worse equipment level and forestry knowledge. Specific expectations and precise indicators are thus pivotal to protect forests in both the developed and developing context, as they provide management units with the necessary technical assistance to effectively correct any forestry malpractices.

On a brighter note, such pitfalls can be overcome, and strengths were commonly highlighted in studies on the FSC and PEFC certification systems. Eco-labelling is unique in spurring motivation towards sustainability among consumers and producers. Forest certification has established itself as a credibility icon in market ecology, upon which consumers can rely for ecological information and producers for market access and supply network. More importantly, the supply side believes that benefits potentially outweigh the costs, as evidenced by the continual uptake of forest certification across Europe. This reflects its consolidating legitimacy in the sector and societies. Legitimacy consists of legality and public acceptance (McDermott, 2012). Because eco-labelling is not a mandated legal requirement, its legitimacy is predominantly rooted in public acceptance and collective belief. The fact that both consumers and producers in Europe view forest eco-labelling as a legitimate icon reflects high environmental sensitivity towards sustainable forestry among actors in the market. Such a profound trust and appreciation will have far-reaching implications on the adoption of eco-labelling, as they will become the cornerstone for expanding the green market in the long run. As previously mentioned, incremental support among producers and consumers is somewhat slow-moving. However, existing literature has examined the impacts of eco-labelling at a single point in time, limiting the analysis on progressivity and momentum over time (van der Ven & Cashore, 2018). Eco-labelling still boasts a strong potential to introduce socio-economic impacts in civil society. Its interplay with the public and private sectors could also be observed in the establishment of a new supply chain of timber products in Scandinavian countries, as well as in the market's penetration and uptake of certification across Europe. Pressure from NGOs and green groups has led to changes in the sustainability standards of the supply chain, which also pressured other managers to adopt certification to avoid being left out from market share. The acknowledgement by the state and requirement from the EUTR urged an upgrade in their forestry practices altogether. Even in developing countries, forest certification has interacted delicately with the state's regulatory process, especially in legal enactment and procedure setting (Savilaakso et al., 2016). In addition, its non-state voluntary nature has made it easier to shed light on indigenous and local inhabitants, as compared to state actors who are often politically constrained to introduce such dialogues. Forest certification is thus a unique approach that provides prescriptiveness and generates normative impacts (Johansson, 2014).

7. Conclusions

In an attempt to broaden the discourse on the impacts of eco-labelling, the current study proposed a conceptual framework that considers direct or tangential indicators to eco-labelling. The framework organised the direct and indirect collated evidence on social, economic, and ecological sustainability from existing literature. In the social dimension, while procedural justice was seen as insufficient in addressing forest rights issues with indigenous communities and workers, impacts were generated by establishing trust with end-consumers in their purchasing decisions and extending the discourse over forest customary rights in a normative framework. For the economic dimension, skeptical notions about profitability were articulated regarding the scale of economies and market demand, despite the positive change in corporate operation and competitive market access. While the ecological dimension demonstrated restoration of landscapes consequent to the reduction of disturbances, the protection of biodiversity and landscape integrity appeared weaker when existing field studies highlighted insufficient tree stumps and fragmented forest landscapes. Nonetheless, extra caution

must be taken when concluding the evidence and outcomes, which vary according to context and scale of study. Eco-labelling should be understood as a rigorous tool that addresses a delicate balance between different dimensions of sustainability. The European experience has made clear the interplay that exists between the three pillars of sustainability. The impacts in each dimension are intertwined. Thus, society needs to become more creative and holistic when approaching eco-labelling to leverage its strengths and overcome its weaknesses. Eco-labelling should be understood as a softer, yet more mindset-changing approach that makes use of social dynamism and market psychology to advance the long-term and far-reaching changes necessary for managing forests sustainably.

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Appendix A

Appendix A. Overview of the literature that matched search criteria and was used to analyse the impacts of forest eco-labelling in Europe.

Author(s)	Year	Publication status	Study focus	Forest certification	Study area	Methodology	Related themes
Aguilar & Cai	2010	peer-reviewed	consumer preference for wood products, eco-label	Forest eco-labels	The UK and the US	choice-based conjoint analysis	consumption preference and patterns, social impacts
Auld et al.	2008	peer-reviewed	impacts, forestry, effectiveness	FSC, PEFC	global (Europe)	literature review	forest degradation, biodiversity, production practices
Blumröder et al.	2020	peer-reviewed	clear-cut areas, boreal, ecological effectiveness	FSC	Russia	spatial analysis	biodiversity, landscape integrity, forest degradation
Blumroeder et al.	2019	peer-reviewed	clear-cut areas, boreal, ecological effectiveness, before-and-after certification comparison, forest operation	FSC	Russia	spatial analysis	biodiversity, landscape integrity
Chen et al.	2020	peer-reviewed	international trade, economic effect, price	FSC, PEFC	global (Europe)	modelling	market trade
Darnall et al.	2018	peer-reviewed	third-party certification, consumer trust	FSC, forest eco-labels	The UK	survey	consumer preference and patterns
Dias et al.	2015	peer-reviewed	river restoration, ecological impacts	FSC	Portugal	SVAP	biodiversity
Elbakidze et al.	2011	peer-reviewed	boreal, biodiversity conservation, standards	FSC	Sweden, NW Russia	field study assessment	forest degradation, biodiversity, production practices
Elbakidze et al.	2016	peer-reviewed	biodiversity, functional habitat connectivity	FSC	Lithuania	spatial analysis	biodiversity, landscape integrity, forest degradation
Fernholz & Kraxner	2012	grey	market review, market share, certified area increment	FSC	global (Europe)	literature review	market trade

Galati et al.	2017	peer-reviewed	motivations, voluntary certification, operation costs	FSC	Italy	questionnaire	production practices, working condition
Gomez-Zamalloa et al.	2011	peer-reviewed	status of forest certification, ecological impacts, price of certified wood, market access, social impacts	FSC, PEFC	EU countries	Delphi method, questionnaire	market competitiveness, production practices
Gulbrandsen	2005a	peer-reviewed	effectiveness, non-state governance systems, market penetration, forestry practices	FSC, PEFC	Norway, Sweden	literature review	market trade, production practices
Gulbrandsen	2005b	peer-reviewed	role of state, rule-making authority, competition of forest certification systems, stakeholder interests	FSC	Sweden	literature review	customary rights, legal framework
Gulbrandsen	2006	peer-reviewed	consumer influence, market, eco-labelling	FSC	Europe	literature review	consumption patterns, market trade
Gullison	2003	peer-reviewed	biodiversity conservation, cost and benefits	FSC	Estonia, Poland, Sweden	literature review	biodiversity, market trade
Hain & Ahas	2007	peer-reviewed	forest management, business perception, biodiversity, soil damage	FSC	Estonia	mixed method	forest degradation, biodiversity, production practices, working conditions
Hain & Ahas	2011	peer-reviewed	impact, European forest, operations, non-conformities	FSC	Europe	desk study + documentary analysis	customary rights, legal framework
Halalisan et al.	2019	peer-reviewed	perceived cost-benefit, motivation, chain of custody, CSR	FSC	Romania	questionnaire	market trade, production practices

Holopainen et al.	2017	peer-reviewed	choice, outdoor decking material, certified product market, consumption preference	FSC, PEFC	Finland	choice experiment analysis	consumption patterns
Johansson & Lidestav	2011	peer-reviewed	voluntary standards, environmental impacts	FSC, PEFC	Sweden	documentary analysis + questionnaire	forest degradation, biodiversity, production practices, landscape integrity
Keskitalo et al.	2009	peer-reviewed	local consequences, environmental and social impacts at local level	FSC, PEFC	N. Sweden, N. Finland, N. Russia	case study + interviews + lit review	customary rights, legal framework
Kuuluvainen et al.	2019	peer-reviewed	certification, retention forestry, biodiversity	PEFC	Finland	case study	biodiversity, landscape integrity
Malvorh et al.	2019	peer-reviewed	non-conformities, FSC principles, business operations, workers' rights, indigenous rights	FSC	Bosnia and Herzegovina, Croatia, Serbia, Slovenia	audit review, interview	customary rights, legal framework
Michal et al.	2019	peer-reviewed	socio-economic impacts, business, consumers' perception	FSC, PEFC	Czech Republic	questionnaire	consumption patterns, production practices, market trade
Mikulková et al.	2015	peer-reviewed	perceived cost-benefit, economic results	PEFC	Czech Rep.	questionnaire	market trades, production practices, social impacts
Owari et al.	2006	peer-reviewed	wood products marketing, price, procurement, market share, adoption motivation	PEFC	Finland	questionnaire	market trades, production practices
Savcor Indufor Oy	2005	peer-reviewed	efficiency, impacts, costs	FSC, PEFC	Sweden, Finland, Norway	pilot study + comparative analysis	market trade, production practices, forest degradation
Paletto & Notaro	2018	peer-reviewed	willingness-to-pay, manufacturers	PEFC	Italy	questionnaire	consumption patterns, market trade
Paluš et al.	2017	peer-reviewed	chain-of-custody, company perception	FSC, PEFC	Czech Republic, Slovakia	questionnaire	market trade, production practices, working conditions

Paluš et al.	2018	peer-reviewed	forest owners' perception, perceived benefits, perceived problems	FSC, PEFC	Slovakia	questionnaire	market trade, production practices, social impacts
Paluš et al.	2021	peer-reviewed	perception of forest owners, understanding of SFM and forest certification, adoption motivation, perceived cost-benefits	FSC, PEFC	Slovakia	questionnaire	production practice, market competitiveness
PEFC	2015	grey	conformity assessment	PEFC	Norway	desk study	working condition, customary rights, forest degradation
PEFC	2016	grey	conformity assessment	PEFC	Sweden	desk study	working condition, customary rights, forest degradation
PEFC	2017	grey	conformity assessment	PEFC	Hungary	desk study	working condition, customary rights, forest degradation
Petrescu et al.	2020	peer-reviewed	green procurement, willingness-to-buy, perceptions	FSC	Romania	questionnaire	consumption patterns, market trade
Simonsson et al.	2016	peer-reviewed	conservation, certified-driven voluntary set-asides	FSC, PEFC	Sweden	documentary analysis	forest degradation, biodiversity, production practices
Sverdrup-Thygeson et al.	2008	peer-reviewed	before-after comparison, boreal forest, regeneration areas, biodiversity	PEFC	Norway	database analysis	biodiversity, landscape integrity, forest degradation
Tysiachniouk et al.	2021	peer-reviewed	global governance, local rights	FSC	Russia	interviews + documentation review	customary rights, legal framework
Villalobos et al.	2018	peer-reviewed	environmental outcomes, non-compliance, tree standings, set-aside areas	FSC, PEFC	Sweden	Control group + observations	forest degradation, landscape integrity
Zubizarreta et al.	2021	peer-reviewed	certification drivers, adoption motive	FSC, PEFC	Spain	questionnaire	market competitiveness, production practices

1173 FSC, Forest Stewardship Council; PEFC, Program for Endorsement of Forest Certification; FPIC, Free Prior and Informed Consent; SVAP, Stream Visual Assessment Protocol;
1174 CSR, Corporate Social Responsibility.