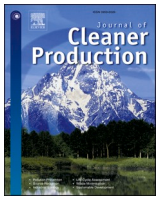
Journal of Cleaner Production 468 (2024) 143079

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro



Review

Sustainability certification of bio-based products: Systematic literature review of socio-economic impacts along the supply chain

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ARTICLE INFO

Handling Editor: Jian Zuo

Keywords:
Sustainability certification
Biobased supply chain
Socioeconomic impacts certification
Smallholder certification
Low-income countries certification
Biobased ecolabels

ABSTRACT

Voluntary certification schemes and labels are used as a means to improve the sustainability of biomass feedstock production and biobased products. To ensure the viability of certification, it is important to understand its socioeconomic implications for certificate holders. Existing literature focuses on the economic impacts of certification within specific contexts (e.g., specific feedstock, regions, supply chain elements), and rarely addresses the social impacts. The present systematic literature review analyses the findings of 75 scientific articles covering the socioeconomic impacts of certification on producers of biobased feedstock (i.e. palm oil, maize, natural rubber, soybean, sugar cane, wood, and raw cotton) and related supply chains. The socioeconomic impacts are aggregated into 7 economic outcome categories (direct costs, indirect costs, revenues, income, productivity, price premiums, market access) and 5 social ones (health, education, poverty reduction, labour conditions, well-being). The results show that the economic impacts of certification are generally positive, with economic benefits compensating for the increased costs faced by companies after certification. Smallholders and companies located in low-income countries are more likely to experience negative economic impacts after certification because they have less access to resources for financing high upfront costs or legal documents on certification requirements, and face proportionally higher certification costs. The social impacts have been less investigated than the economic ones, and the results showed more mixed findings, although still mostly positive. Looking across the supply chain, both economic and social impacts were found to be investigated more for feedstock producers compared to other actors in the supply chains. New policy should focus on mitigating the negative impacts on vulnerable groups to improve their participation in certification programmes.

1. Introduction

Sustainability certification schemes and labels (CSLs) are guidelines that define a set of environmental, economic, and/or social requirements to enhance the sustainability of products or services (Edwards and Laurance, 2012). Although CSLs are often voluntary market-based tools, their adoption as co-regulation instruments by governments across different sectors has been increasing over the past years (Gaebler, 2014). They already play a key role as a co-regulation instrument in bio-economy policies of the European Union (EU). For instance, the Renewable Energy Directive (RED, RED II, RED III) has set sustainability requirements for biofuels, bioliquids, and biomass for energy. In this context, certification schemes are used as instruments to prove compliance with those sustainability requirements (STAR-ProBio, 2020). Similarly, the EU Deforestation Regulation (EUDR) Regulation (European Parliament, Council of the European European Parliamentcouncil of the European Union, 2023), which applies to soy, beef, palm oil, wood, cocoa, coffee, rubber and derivative products, prohibits imports and exports of products associated with deforestation and forest degradation. The regulation enables certification to be used for risk assessment and mitigation processes.

For the bioeconomy, the importance of ensuring sustainability of feedstocks and biobased products is recognised by producers, consumers, and policymakers alike, underscoring the necessity of comprehensively understanding the environmental, social, and economic implications associated with their production (Falcone and Imbert, 2019). Sustainability certification can be used to monitor and improve these aspects, and communicate to consumers the sustainability of

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https://doi.org/10.1016/j.jclepro.2024.143079
Received 19 February 2024; Received in revised form 1 July 2024; Accepted 2 July 2024
Available online 4 July 2024

biobased products. To do so, it is important to ensure that certification both actually improves the sustainability of products, and is economically feasible for the companies that want to get certified or include certified products in their supply chains. Economic feasibility of CSLs is an important aspect influencing their uptake by companies. This is because certification needs to be economically profitable for companies to be competitive on the market. Economic feasibility is determined by the trade-off between the costs and benefits of getting certified. The costs and cost structure vary across different CSLs, but it generally consists of direct costs (certification fees, administrative fees, cost of audits) and indirect costs (costs to upgrade the management and production system to meet certification requirements) (Durst et al., 2006; Midderndorp et al., 2018; So and Lafortezza, 2022). As a result of certification, environmental, social, and economic benefits are expected. For example, the environmental benefits include better soil quality, reduced deforestation, increased tree and animal diversity (Burivalova et al., 2017). The expected economic and social benefits consist of price premiums, increased market access, better public image, improved working conditions, reduced inequalities, and more (Camilleri, 2022; Chen et al., 2010; So and Lafortezza, 2022). These benefits must outweigh the costs for certification to be feasible for companies. However, the overall feasibility still remains unclear.

The current study focuses on the socio-economic impacts that certification has on companies. Preivous reviews on socio-economic costs and benefits of CSLs present mixed findings (Blackman et al., 2010; 2011; Carlson and Palmer, 2016; Chen et al., 2010; So and Lafortezza, 2022; Tey et al., 2021; Traldi, 2021). In particular, certification seems to sometimes enhance the socio-economic sustainability of certified firms, and other time to have no or even negative impacts. For instance, palm oil farm income was found to increase (Aisyah et al., 2021; Brako et al., 2021; Morgans et al., 2018) or decrease (Bok et al., 2022; Hutabarat et al., 2018) after certification by different studies. Another example is the impact of palm oil certification on the health of workers involved in its production; this was shown to improve (Lee et al., 2019; Morgans et al., 2018) or worsen (Brako et al., 2021) depending on the study.

The reasons behind the heterogeneity in the results are not entirely clear. The characteristics of the case studies reported in literature might explain the mixed results (Durst et al., 2006; Meemken, 2020; Oya et al., 2018). Studies vary for which standards, feedstocks, locations, years, stakeholders, sampling strategies and methods are used to assess the costs and benefits (Meemken, 2020; Oya et al., 2018). It was found, for instance, that the costs of certification tend to be higher in low- and middle-income countries, resulting in less profits for the producers compared to high-income regions (Durst et al., 2006). The stringency of the CSL was also determined to be a relevant factor, as more stringent labels (which have higher certification costs) are less profitable if not balanced by increased market coverage and price premiums (Yenipazarli, 2015). The economic feasibility also seems to increase over time because the costs decrease and the revenues grow (Wolff and Schweinle, 2022). The size of the production area certified is an additional element influencing the outcome of studies, given that certification costs can be harder to cover for smallholders compared to large plantations (DeFries et al., 2017; Durst et al., 2006; So and Lafortezza, 2022). Also, the distribution of costs and benefits can be uneven across the value chain, with higher costs upstream and greater benefits downstream (Blackman et al., 2011).

The majority of these studies focuses on the economic impacts of certification within specific contexts (e.g., specific feedstock, regions, supply chain elements). However, they highlight the importance of further investigating the broader socio-economic effects of certification and looking beyond specific contexts. For instance, Wolff and Schweinle (2022) focuses on the economic impacts of forest certification. Durst et al. (2006) covers the challenges associated with forest certification in low-income countries. Meemken (2020) focuses on the economic impacts of certification for smallholders, and concludes that further research is needed especially incorporating social impacts. In addition, previous studies have focussed on feedstock production. For example, Arton et al. (2020) found that the impacts of certification on producers are investigated more than the rest of the supply chain. Also Oya et al. (2018) indicate that, although certification seems to have a positive impact on prices, incomes, and schooling for feedstock producers, more research is needed across the rest of the supply chain to understand impacts of certification on other actors.

Existing literature reviews also indicate that further research is necessary to address the mismatch between the relevant certified products and their coverage in literature. In particular, certain feedstocks (i.e., cotton, sugar, cocoa, soy, palm oil compared to coffee or tea) relevant for the EU bioeconomy are currently underrepresented in literature compared to their certification area. Traldi (2021) points out that future research should especially focus on covering these underrepresented crops. The same applies to literature coverage of specific certification focuses (i.e., sustainability certification compared to organic) and certified regions (i.e., some European countries, North America, Australia) (DeFries et al., 2017).

Taking these knowledge gaps into account, the current study aims at:

- Synthesising the state-of-the-art knowledge related to social and economic costs and benefits of CSLs for agricultural and forestry products that are so far underrepresented in the literature (in particular, palm oil, maize, natural rubber, soybean, sugar cane, wood, and raw cotton);
- Determining the economic and social costs and benefits of certification on feedstock producers (individuals, households, etc.) and on the rest of the bio-based supply chain.

The current paper is structured as follows: first, the methods used for the research are presented (section 2). The results (section 3) are divided into 3 sub-sections, where the findings collected from literature are aggregated and presented. Section 3.1 shows an overview of the reviewed studies in terms of how many were included and their general characteristics. Section 3.2 presents the findings from literature on the socio-economic impacts of certification on feedstock producers, and Section 3.3 on the rest of the supply chain. The discussion (section 4) expands on the results by inserting them in a broader context and focusing on the reasons behind the heterogenous impacts of certification. It also discusses the main implications of the results for CSLs owners and EU policymakers. Also, the main limitations of the study are discussed and future research avenues are identified. Section 5 draws the conclusions of the research.

2. Methods

The present study followed a systematic review approach based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). The available peer-reviewed scientific literature on the social and economic impacts of sustainability certification for biobased products was scanned and analysed. This approach was chosen as it allows to comprehensively assess the coverage of existing research and minimise bias in synthesising knowledge.

2.1. Selection of literature

The literature search was carried out between January and July 2023. The search strategy consisted of scanning Web of Science and Scopus, using combinations of keywords such as “soci* OR economic”, “impact* OR effect*“, “certify* OR label*” and feedstocks of interest (palm oil, natural rubber, soybean, etc). The feedstocks were chosen because they are relevant in terms of sustainability impacts but underrepresented in literature. A second round of searches combined the above-mentioned words with “supply chain*” to obtain information related to the entire supply chain (cradle-to-consumer) and not only on

feedstock production. The full list of search strings as well as the number of papers that were retrieved can be found in Appendix A (Tables A1 and A2).

The eligibility of the studies retrieved from each search was determined by reviewing title and abstract. After this first screening, the duplicates were removed, and the full texts were read to determine whether the study could be included in the analysis.

The inclusion criteria were:

- Peer-reviewed scientific papers (quantitative and qualitative original studies and review papers);
- Publications with main text in English (publications with title and abstract in English but main text in a different language were not included);
- Published between 2005 and 2023;
- Covering economic and/or social impacts of certification;
- Covering at least one of the selected feedstocks and/or related value chains (palm oil, maize, natural rubber, soybean, sugar cane, wood, raw cotton).

2.2. Data extraction

Relevant information, including authors, publication year, study type, data collection and analysis method, covered regions, feedstocks, and more, was extracted and stored in a dataset for further analysis. Most studies examined the effects of certification on different variables, such as farm income, yields, production costs, input costs, workers wages, and so on. These variables were aggregated into outcome categories. The economic outcome categories were cost, revenue, income, productivity, price, and market access. The social ones were education, health, poverty reduction, labour condition, and well-being. A comprehensive list of all extracted data is available in the associated dataset and a definition of the outcome categories is available in Appendix A (Table A3). Moreover, Table 1 in the results shows the original outcome categories as found in included literature and the corresponding outcome category used in the current study.

Since many studies covered multiple regions, feedstocks, or outcome categories, each combination was recorded in the dataset as a separate observation. An observation is therefore representative of the effect that certification has on a specific outcome category in a specific combination of conditions (i.e., a specific feedstock in a specific region). Some studies focused on specific countries or feedstocks, while others only mentioned that the focus was on low-income countries or agricultural products in general. Nevertheless, these observations were still deemed important and therefore included in the analysis in these aggregated categories.

2.3. Data analysis and presentation of findings

The impacts of certification were reported differently in different studies. The quantitative studies often presented numerical values for outcome categories for certified and uncertified products; for instance, farm income reported for the certified farm and for a comparable uncertified one, used as a counterfactual. In these cases, the difference between the two values was used to determine whether certification entailed an increase, decrease, or no effect on the outcome category. The same method was applied to studies reporting pre- and post-certification values. The extent of the increase or decrease is not reported in the present study because the same outcome category was often measured in different ways by different studies, which did not allow a numerical comparison.

Previous literature reviews often contained quantitative observations collected from single studies. In some cases these observations could not be included in the current study because the authors did not specify which observations came from which individual study. This omission made it impossible to determine whether the same observation

Table 1
The table shows the terminology used for different outcome categories in the original studies and the correspondent outcome category used in the current review. The last column shows the references of the studies treating each outcome category.

Outcome category	Outcome categories as presented in original study	Studies
Direct cost	Certification fee, pre audit cost, main audit cost, training of managers cost, cost of acquiring documentation, cost for group certification documents, internal assessment cost, membership registration cost	Aisyah et al. (2021); Frey et al. (2021); Hidayat et al. (2016); Hutabarat et al. (2018); Purbasari et al. (2020)
Indirect cost	Cost certified crop, fertilizer cost, pesticide cost, group member trainings cost, investment costs, labour cost, operating costs, production cost, weighing and transport of harvest cost, Incident Command System establishment cost, Incident Command System training cost	Aisyah et al. (2021); Cox et al. (2018); Hidayat et al. (2016); Hutabarat et al. (2018); Meemken (2020), 2021; Oya et al. (2018); Reddy et al. (2022); Tey et al. (2022)
Productivity	Changes in management practices, Fresh Fruit Bunch (FFB) production, FFB yield, productivity, stability of production, yield	Blockeel et al. (2023); Brako et al., 2021; Chalil and Barus, 2020; Cubbage et al. (2010); Furumo et al. (2020); Hutabarat et al. (2018); Meemken (2020), 2021; Morgans et al. (2018); Oya et al. (2018); Reddy et al. (2022); Rodhiah et al. (2019); Tey et al. (2021); Traldi (2021)
Revenue	Farm revenue; farm sales, FFB sale, gross revenue, partial returns, revenue from certified crop sale, total FFB revenue	Bok et al. (2022); Cox et al. (2018); Fikri et al. (2022); Frey et al. (2021); Hidayat et al. (2016); Hutabarat et al. (2018); Kato and Soda, 2020; Meemken (2020); Reddy et al. (2022); Wolff and Schweinle, 2022
Income	Income, income from certified production, market mechanism, net revenue, profit (gross revenue-costs), household income, WATP (willingness and ability to pay), Net Present Value, value creation	Aisyah et al. (2021); Bok et al. (2022); Brako et al., 2021; Burivalova et al. (2017); Dompreh et al. (2021); Hidayat et al. (2016); Humphries and Kainer, 2006; Hutabarat et al. (2018); Kato and Soda, 2020; Meemken (2020); Mook and Overdevest, 2018; Morgans et al. (2018); Oya et al. (2018); Purbasari et al. (2020); Reddy et al. (2022); Santika et al. (2021); Schleifer et al. (2020); Tey et al. (2022); Traldi (2021); Vogt et al. (2022); Wolff and Schweinle, 2022
Market access	Market access, market performance, positional advantage, stability of market	Blockeel et al. (2023); Burivalova et al. (2017); Fikri et al. (2022)
Price premium	FFB price, price premium, selling price	Burivalova et al. (2017); Chalil et al. (2020); Hutabarat et al. (2018); Meemken (2021); Meemken et al. (2018); Oya et al. (2018); Tey et al. (2022); Wolff et al. (2022)
Health	Child mortality, food security, health facilities, illness, nutrition, workspace safety and health provisions	Blockeel et al. (2023); Brako et al., 2021; Lee et al. (2019); Morgans et al. (2018); Oya et al. (2018); Schleifer et al. (2020)

(continued on next page)

Table 1 (*continued*)

Outcome category	Outcome categories as presented in original study	Studies
Education	Child school attendance, number of educational facilities, years of schooling	Brako et al., 2021; Lee et al. (2019); Oya et al., 2018
Poverty reduction	Reduced number of poverty letters, poverty incidence	Meemken (2020); Santika et al. (2021)
Labour condition	Employment relations, number of workers, worker salary	Blockeel et al. (2023); Furumo et al. (2020)
Well-being	Access to basic needs, households assets, capacity development, conflict resolution, gender equality, perception/satisfaction, reduced water and land grabs, power dynamics, social mechanism, social network	Blockeel et al. (2023); Dompreh et al. (2021); Forrer and Mo (2013); Meemken (2021); Meemken and Qaim, 2018; Mook and Overdevest, 2018; Morgans et al. (2018); Oya et al. (2018); Santika et al. (2021); Selfa et al. (2014); Traldi (2021)

had already been included in the present analysis. In these cases, the results from the reviews were not included in our quantitative analysis, and instead only used to enrich the discussion of our results.

Some qualitative studies also allowed to extract observations; the impacts of certification on outcome categories were not reported numerically but were described in terms of increase, decrease, or no effects after certification. In these cases, they were treated as the quantitative ones and inserted in the dataset. Other qualitative studies did not report the impacts of certification on specific outcome categories but described them in a more general way. In these cases, the information was used to enrich the discussion of the results, and was summarised in two tables (Tables 1 and 2).

The data inserted in the dataset were further analysed by determining how many observations reported an increase, decrease, or no impacts of certification for each outcome category. The effects on the outcome categories were further aggregated by feedstock and region. This was done to determine whether the effects of certification changed across different regions or feedstocks. Other study characteristics (such as farm size, CSL, etc.) could not be used for the same purpose, as this information was not consistently available throughout the studies.

As the papers focusing on the producers generally provided more quantitative information on the impacts of certification, the results section is divided into a quantitative analysis of the impacts on the producers, and a descriptive one on the impacts on the rest of the supply chain. Fig. 1 provides a visual representation of how the selected literature was used in the present review.

The findings are presented and discussed in the results and discussion section. The results section only mentions and discusses studies that were included in our review. The discussion section, although mainly referring to papers included in the review, also includes studies that were not selected. This is done to place our findings in a broader context. When the cited studies are not included in our review, this is specifically mentioned.

3. Results

3.1. Overview results from literature

In total, 75 peer-reviewed published scientific articles respected the inclusion criteria and were selected for the present review. 54 were original studies, while 21 were reviews. 47 out of the 75 papers focused on feedstock producers, and 28 on the rest of the supply chain (Fig. 2). The papers were published between 2005 and 2023. An increase in the number of publications over the years was registered: only 20 of the selected papers were published between 2005 and 2017, while 55 were published from 2018 onwards. This shows an increasing interest in sustainability certification in recent years.

Table 2
Overview of the impacts of certification on feedstock producers as collected from literature. More information is available in the dataset.

Impact of certification	Main reasons as reported in literature	Studies
Positive economic impact	• Price premiums for certified products. • Increased market access. • Improved reputation • Higher yields due to improved management and production techniques	(Blockeel et al., 2023; Burivalova et al., 2017; Chalil and Barus, 2020; Fikri et al., 2022; Furumo et al., 2020; Hutabarat et al., 2018; Morgans et al., 2018; Oya et al., 2018; Rodhiah et al., 2019; Tey et al., 2021; Wolff and Schweinle, 2022)
Neutral economic impact	• Certification mostly impacts environmental sustainability and not other sustainability dimensions. • Not profitable if there are no price premiums. • High costs don't compensate for increased income	(Burivalova et al., 2017; Cubbage et al., 2010; Traldi, 2021)
Negative economic impact	• Costs too high (especially for marginalised groups) • No price premiums • Decreased/unmodified productivity doesn't compensate for increased costs. • No improved market access.	(Furumo et al., 2020; Meemken, 2020, 2021; Oya et al., 2018; Reddy et al., 2022; Tey et al., 2021, 2022)
Positive social impact	• Improved access to healthcare and education • Poverty reduction	(Blockeel et al., 2023; Brako et al., 2021; Forrer and Mo, 2013; Lee et al., 2019; Meemken, 2020; Morgans et al., 2018; Santika et al., 2021; Traldi, 2021)
Neutral social impact	• Certification mostly impacts environmental sustainability and not other sustainability dimensions.	(Kamali et al., 2018; Selfa et al., 2014; Traldi, 2021)
Negative social impact	• Increased conflicts due to land grabbing	(Ayompe et al., 2021; Morgans et al., 2018)

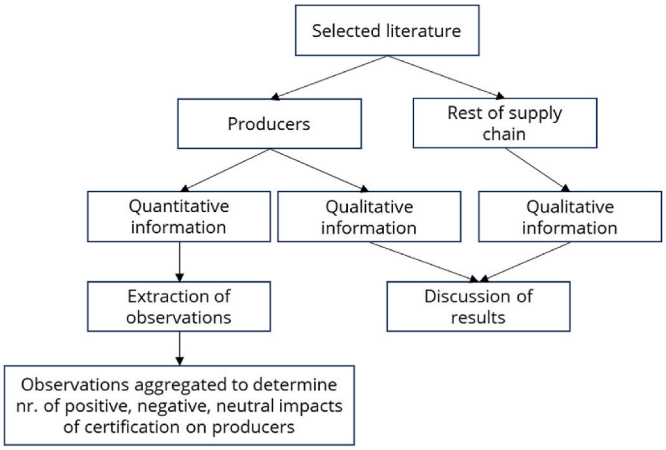

Fig. 1. Visual representation of *how the selected literature was used in the present study.*

3.2. Impacts of certification on feedstock producers

3.2.1. Study coverage

Out of 47 studies covering the economic and social impacts of sustainability certification on producers of selected feedstocks, 28 provided results that could be included in the dataset for further quantitative analysis. An example is the income of a certified company compared to that of an uncertified equivalent one. Table 1 displays the outcome

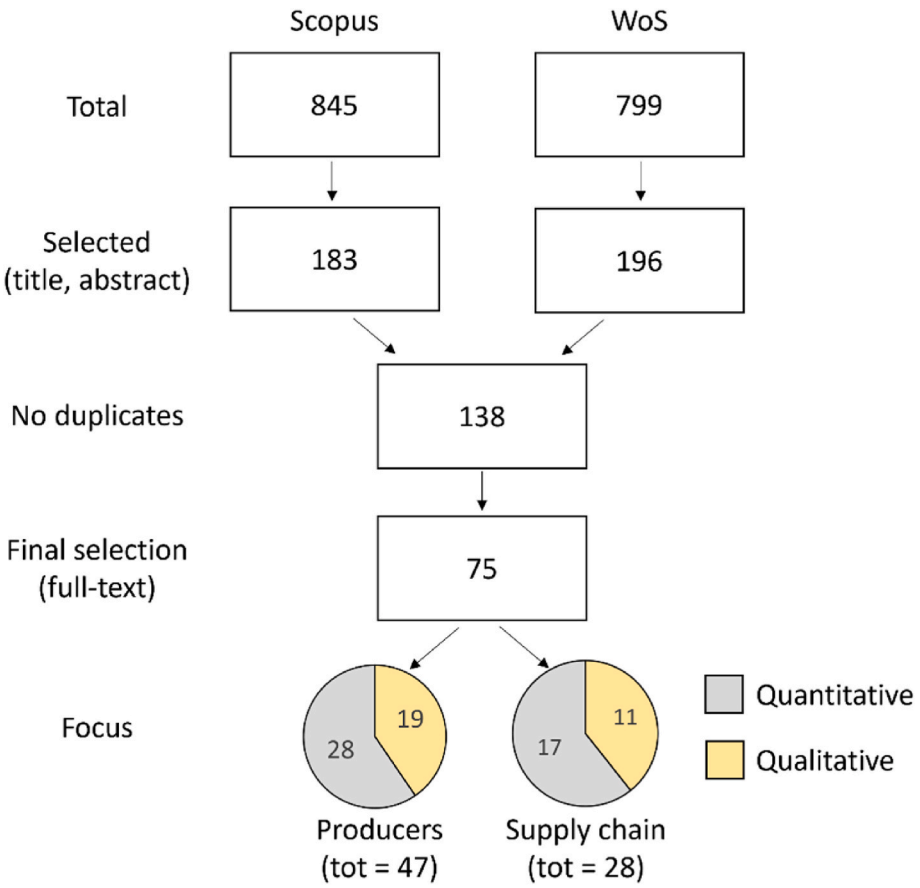

Fig. 2. Overview of papers collected at each stage of the review process. The pie charts represent the number of quantitative and qualitative studies collected for producers and the rest of the supply chain.

categories examined in the studies incorporated within this literature review, along with the corresponding outcome categories utilized in the present study.

From the 28 studies, 218 observations were extracted, each representing a specific combination of region, feedstock, and outcome category.

Fig. 3 presents an overview of the observations collected from literature. It is evident that specific combinations of feedstock, region, and outcome category are covered more than others. Overall, more observations were available for the economic impacts of certification compared to the social ones. Out of the 218 observations collected, 192 were categorised as economic and only 26 as social. For the economic categories, cost, revenue, and income were covered the most, especially for Asia and low-income countries (Fig. 3). In contrast, only few quantitative observations on the impacts of certification on selling prices and market access were found. Regarding the social outcome categories, health, education, and well-being were covered more than the rest. Particularly few observations represented the impacts of certification on poverty reduction and labour condition.

Lower-income regions such as West Africa, East Africa, and Southeast Asia were investigated more than the ones with higher incomes. Europe and North America had few data points and the variety of feedstocks covered was limited. This might be due to the fact that feedstock produced in Europe and North America already need to respect the governmental sustainability requirements for the region, so there is less need for CSLs.

Regarding the feedstocks, the majority of observations collected were on palm oil (122), followed by forest and agricultural products (41 each) (Appendix, Table A4). Very few (less than 10) observations were available for soybeans and maize, and no quantitative data were found on sugar cane and raw cotton. The high number of observations for palm oil reflects the high interest in palm oil that was generated in recent years around its sustainability concerns.

The majority of observations focused on the economic outcomes of certification in Asia, with a particular emphasis on Southeast Asia, predominantly associated with palm oil. However, it is worth noting that the number of available observations for each specific combination of feedstock, region and outcome category was quite limited, with less than 30 observations per combination.

3.2.2. *Impacts of certification on feedstock producers*

Each observation collected from the studies reported the impact of certification on specific economic or social output categories for the producers. The output categories were divided into costs (subdivided into direct and indirect costs) and benefits. Overall, most observations showed that companies experienced an increase in both costs and benefits following certification (Fig. 4). In many cases, the positive benefits compensated for the increased costs.

The increase in benefits is particularly evident for the economic ones. For producers, this happens when better management and production practices lead to increased yields, which, associated with price premiums and improved market access, cause higher income, as indicated in Brako et al. (2021). Additionally, as pointed out by Bok et al. (2022), the costs, especially the indirect ones, tend to decline over time, increasing the economic benefits. The indirect costs consist of expenses needed to meet the sustainability criteria set by a CSL. For this, companies generally face higher upfront investments to get certified, followed by lower maintenance costs to uphold the certificate (Hutabarat et al., 2018). Also, the extent of indirect costs associated with certification depends on how closely the farm's management and production

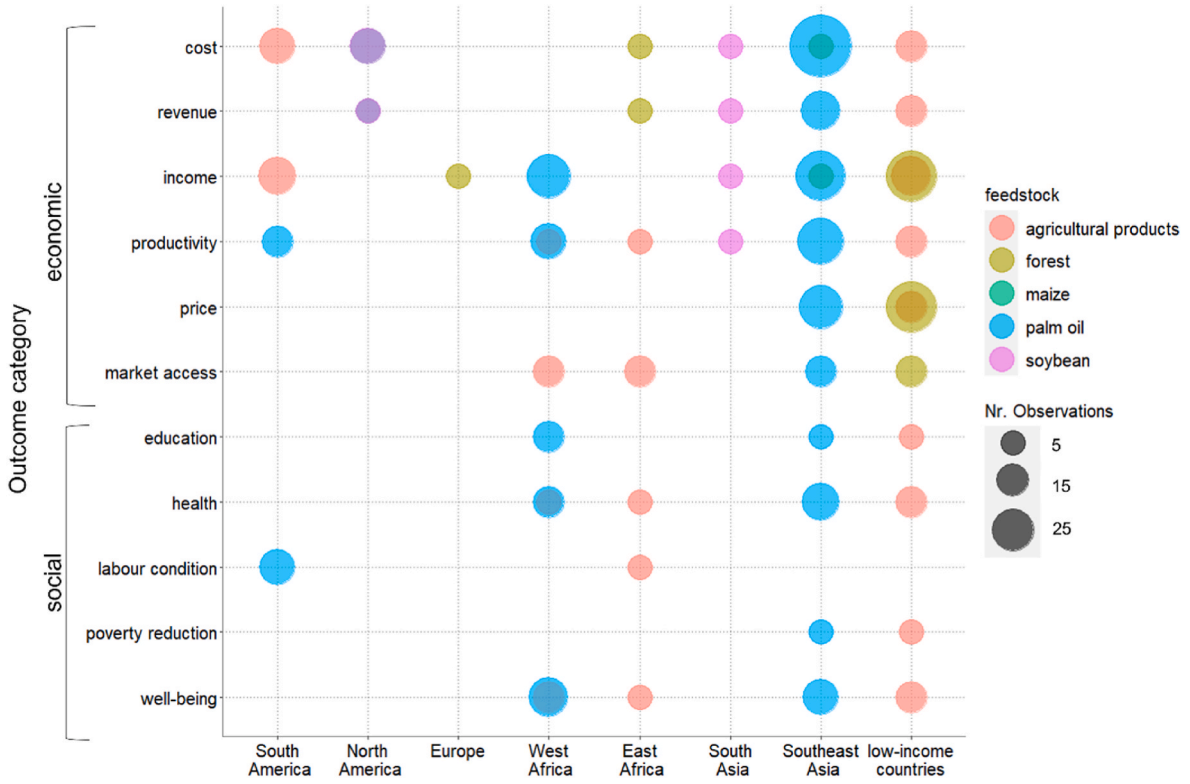

Fig. 3. Overview of number of observations (total observations = 218) collected from literature covering different feedstocks, regions, and outcome categories. For this figure, direct and indirect costs are grouped into "costs" to increase readability. The category "low-income countries" on the x-axis represents studies that mentioned the location being in lower-income regions, without specifying the exact country. Similarly, the feedstock category "agricultural products" includes results from studies that did not separate the observations by specific feedstocks. No observations were found for sugarcane and raw cotton.

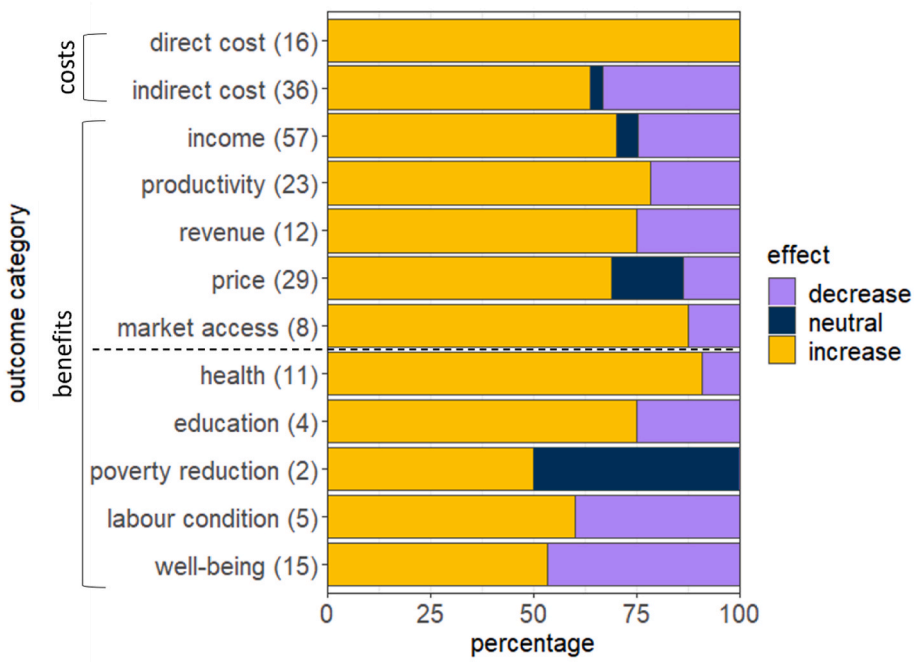

Fig. 4. Percentage of observations indicating an increase, decrease, or neutral effect on outcome categories after certification. The dotted line indicates the separation between economic categories (top part) and social ones (bottom part). The numbers in brackets indicate the number of observations recorded for each outcome category.

system aligns with the CSL's requirements before undergoing certification. In cases where the pre-certification practices closely match the CSL's standards, the indirect costs are likely to be lower (Hidayat et al., 2016).

The findings on social benefits were more mixed than the economic ones (Fig. 4). Social impacts are generally complex to determine

precisely and are often measured in different ways in different studies. For instance, health was measured as exposure to toxic chemicals during production process in Blockeel et al. (2023), child mortality and nutrition in Brako et al. (2021), or number of new health facilities built in villages nearby certified areas in Morgans et al. (2018).

Similarly, education was measured by different indicators, e.g. years of schooling, child school attendance in Brako et al. (2021), and number of education facilities built in the certified area in Lee et al. (2019). All these indicators are important contributors to health and education but, if not consistently measured, make it hard to aggregate and compare the results from different studies. Still, our analysis identified an overall positive impact of certification on health and education. This is probably linked to the increase in farmers income, which might improve the access to healthcare and education for the farmers and their household members. The only negative impact that was found on health in the studies included in our review is in relation to nutrition (Brako et al., 2021); this might happen if certified areas replace areas were food for local use was previously grown.

CSLs can also contribute to mitigate wage inequalities by imposing minimum wage levels and requiring employers to train workers and encourage them to negotiate collectively (Fernandes Martins et al., 2022). Yet, the impact on poverty reduction was found to be somewhat limited, probably because, as stated by Morgans et al. (2018), many other factors determine poverty (i.e., the income of other members of the household, expenses, etc.). The impacts collected from literature on well-being are very mixed; this is due to the fact that this category is broad and contains a variety of variables that impact the well-being of people and/or could not be included in the other outcome categories (i.e., social relations, satisfaction, access to basic needs, social mechanism, conflicts, etc.).

For instance, in the case of palm oil production in Indonesia, land-grabbing and loss of land-tenure rights were reported often, and might increase with increased feedstock production (Ayompe et al., 2021). Although not a result of certification, the certification process may reveal such impacts. The negative impacts we found on well-being might therefore reflect not an adverse outcome from certification itself', but more the impact of large-scale industrial plantations, and this impact may not even be compensated with certification (Santika et al., 2021). Table 2 presents an overview of the main reported reasons behind the different economic and social impacts of certification.

Aggregating the result per feedstock and region shows similar results (Fig. 5). In the case of feedstocks, both the costs and the benefits mostly increase. Soybean represents the only exception, as the costs and benefits decrease. This is likely due to the fact that all the studies collected on soybean compared certification of organic versus conventional farms. Organic farming imposes restrictions to farmers on the use of pesticides and fertilisers. On the one hand, this causes a reduction in the costs because of the use of less input materials. On the other hand, organic farming often results in reduced yields compared to conventional agricultural practices (Jouzi et al., 2017). The loss of productivity can normally be compensated by selling the organic products for higher prices. Nevertheless, if there is no proper labelling and certification, the price premium does not apply, leading to reduced economic benefits for the producers, as indicated by Reddy et al. (2022).

When looking at how different regions perform in terms of costs and benefits, there is also mainly an increase. The only exception is that the benefits in South Asia mostly decrease (Fig. 5). The reason is that the studies on South Asia and the studies on soybeans coincide, so the same

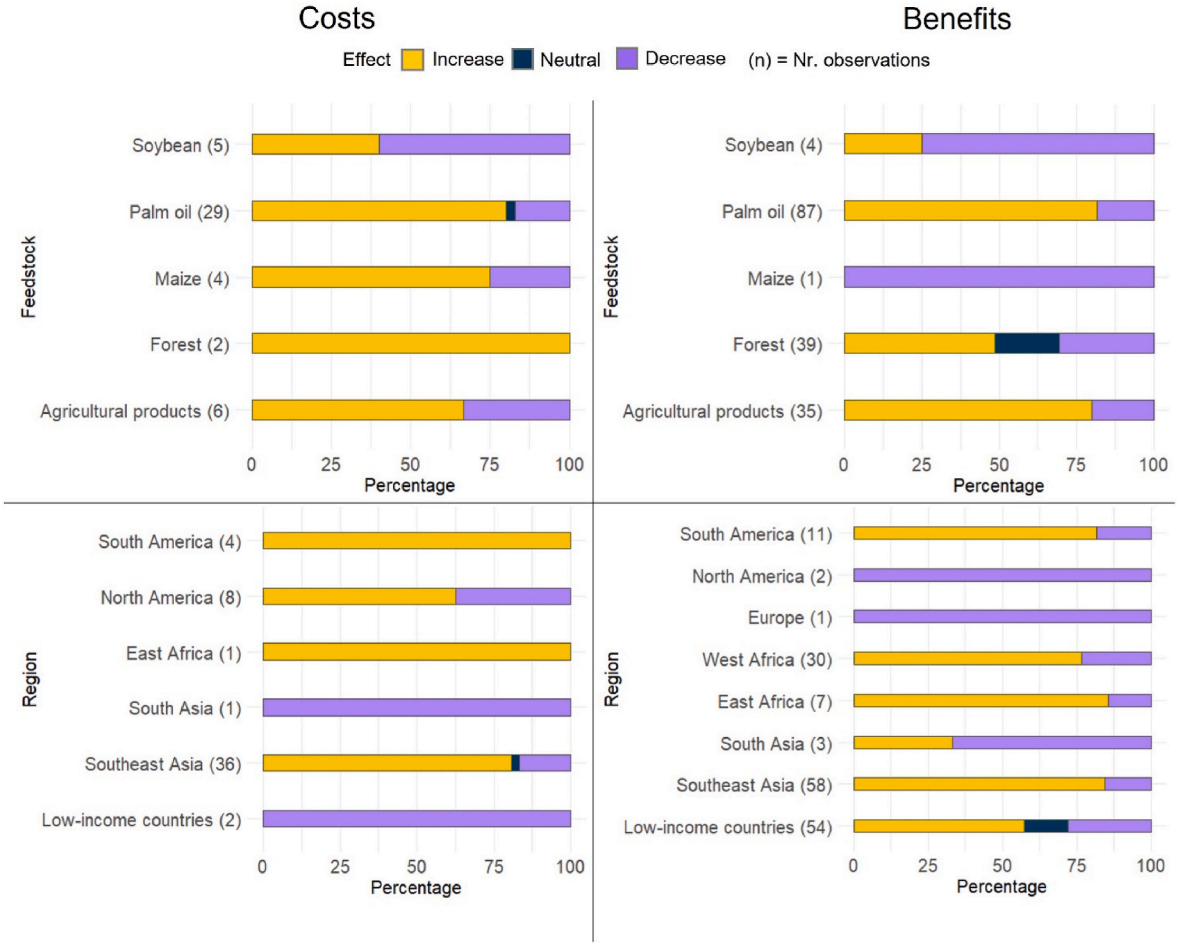

Fig. 5. Number of observations showing increase, decrease, or neutral impacts of certification on costs and benefits divided by feedstocks and regions.

explanation applies to this case as provided above.

3.3. Impacts of certification on the rest of the supply chain

Out of the 75 studies included in this review, 28 focused on the entire supply chain or on parts other than the producers. Overall, the findings were more qualitative than those on the producers. Moreover, the studies usually referred to economic or social impacts in general, without further specifying the exact outcome categories that were affected by certification. Most studies reported that there was a positive economic impact on various elements of the supply chain after certification. The main reported reasons behind this included a higher efficiency of the supply chain, the possibility to sell the certified products at higher prices (price premiums), increased market access and brand recognisability, and a higher willingness to pay (WTP) for certified products (Table 3). Furthermore, as concluded by Younis and Sundarakani (2020), a positive correlation was found between firms size and increased post-certification economic and social sustainability.

11 studies specifically focused on end-consumers and their willingness to pay (WTP) price premiums for certified products compared to uncertified alternatives. All these studies concluded that the WTP is generally higher for certified products. It is worth noting that the higher WTP was usually positively correlated to female customers with high-income and high-educational levels (Aguilar and Vlosky, 2007).

Another aspect mentioned by different studies was the correlation between level of awareness and WTP. As indicated by Giam et al. (2016), Panico et al. (2022), Richartz and Abdulai (2022), and Wassmann et al. (2023), the more the consumers were informed about the negative sustainability impacts of a product and the meaning and role of certification, the higher their WTP premiums for certified products. When consumers were not informed about certification, the price premium of certified products did not seem justified to them, and they tended to prefer the cheaper, uncertified option. The price premium of certified products is one of the ways in which companies compensate the increased costs from certification (Lang and Mendell, 2012). Consumers not being willing to pay the price premium for certified products was therefore reported as one of the principal reasons why certification might not be useful to increase the economic sustainability of companies (Ibanez and Laye, 2017).

The social impacts of certification along the supply chain were investigated less than the economic ones, similarly to what was found for the feedstock producers. Within the supply chain (excluding producers), certification initiatives primarily centred around evaluating the environmental performance of firms rather than addressing the social dimensions (Govindan et al., 2014).

Table 3
Impacts of certification on the entire supply chain as collected from literature. Rows for positive and negative social impacts are omitted from the table as no studies included in the present review mentioned these.

Impact of certification	Main reasons as reported in literature	Studies
Positive economic impact	• Price premiums for certified products. • Increased efficiency of supply chain; • Market benefits. • Higher consumers WTP for certified products.	(Aguilar and Vlosky, 2007; Bozza et al., 2022; Deniz, 2023; Germain and Penfield, 2010; Ferioli et al., 2022; Fernandes Martins et al., 2022; Fizaine et al., 2018; Gassler and Spiller, 2018; Giam et al., 2016; Ibanez and Laye, 2017; Morone et al., 2021; Narasimhan et al., 2015; Samad et al., 2021; Panico et al., 2022; Richartz and Abdulai, 2022; Ruan et al., 2022; Silva et al., 2018; Wassmann et al., 2023)
Neutral economic impact	• Certification mostly impacts environmental sustainability and not other sustainability dimensions. • Not profitable if consumers are not aware of certification. • No price premiums for certified products.	(Govindan et al., 2014; Ibanez and Laye, 2017; Palus et al., 2017)
Negative economic impact	• Increased direct and operating costs and decreased NPV.	(Lang and Mendell, 2012)
Neutral social impact	• Certification mostly impacts environmental sustainability and not other sustainability dimensions.	Govindan et al. (2014)

4. Discussion

The following subsections discuss the results from the literature included in our review and places them in a broader context by integrating them with additional studies. When the cited studies are not included in the review, this is specifically mentioned.

4.1. Economic impacts for feedstock producers

While this systematic literature review showed largely positive impacts of certification on feedstock producers, it is still important to comprehend why, in some cases, certification was not financially beneficial, or even resulted in negative outcomes (Fig. 4). Two groups were consistently indicated in the included literature as bearers of greater costs and lower benefits: low-income countries compared to high-income ones, and smallholders compared to large-scale farms or plantations. As highlighted by Durst et al. (2006), low-income countries face higher direct costs of certification because many certification bodies are located in Europe and North America, and they charge high fees relative to local price levels. Moreover, the indirect costs can also be higher for low-income countries, for instance in the case of tropical forests, where the complexity of this ecosystem results in higher management costs compared to temperate forests (Durst et al., 2006).

Similarly, high certification costs constitute an important barrier to certification for smallholders. In particular, it has been shown by Purbasari et al. (2020) and Meemken and Qaim (2018) that certification can cause a 15–20% increase in the costs and the short-term financial benefits do not cover for these expenses (Hutabarat et al., 2018). This might also partly explain the findings of e.g., Aisyah et al. (2021) and Purbasari et al. (2020) that smallholders' willingness to pay (WTP) and willingness and ability to pay (WATP) for certification is lower than that of large-farm owners. For instance, smallholders in Indonesia reported low WTP for forest certification, and the main reasons were that they expected a lack of price premiums for certified timber and no improved market access (Purbasari et al., 2020). Moreover, smallholders often lack the skills, knowledge, and the instruments necessary to acquire legal documents, implement better management practices, keep records, and meet certification requirements (Hutabarat et al., 2018). The difficulties that smallholders might encounter in dealing with legal documentation constitutes an important barrier to certification, and it is likely to enhance the perception that certification is a top-down approach that has low effectiveness (Blockeel et al., 2023).

To overcome these limitations, smallholders can be supported by other plantation companies. This allows smallholders to gain better access to credit, information, and production inputs, such as better-quality seedlings, fertilisers, etc. As a downside, as it was highlighted by Watts et al. (2021) in a study not included in our review, it also requires them to enter into long-term contractual obligations with plantation companies. This means they have to accept the selling prices and repayment terms for loans set by the company, which may offset many of the benefits of such a setup. Overall, sustainability initiatives such as certification may raise the bar for market entry and increase the burden

of monitoring and compliance, reducing the profits for smallholders and increasing the control of already leading firms (Ogahara et al., 2022). The development of national CSLs, such as Indonesia Sustainable Palm Oil (ISPO) and Malaysian Sustainable Palm Oil (MSPO), might be a solution to mitigate these barriers and increase the involvement of local small stakeholders. This is because national CSLs can better tailor their requirements to align them with the specific needs of the country (Durst et al., 2006). Still, the issue of market entry for smallholders would not be solved if these new schemes were not recognised and not considered effective by stakeholders in high-income countries. This would reinforce the barriers causing limited access of smallholders to these markets. It is important to mention that no benefits of certification can happen if there is no market for the products certified by a CSL (Flanagan et al., 2020).

Some international certification schemes, such as the Forest Stewardship Council (FSC) and the Roundtable for Sustainable Palm Oil (RSPO), offer more tailored solutions for smallholders and are increasing their efforts to involve them in certification programs. However, the certification costs are still too high compared to the income of most smallholder producers. This is also in line with recent findings from Ayompe et al. (2024) not included in our systematic literature review, stressing the importance of providing external financial support and assistance to smallholders. Although external support is important, it would also be beneficial that CSLs themselves increased their effort to include smallholders, for instance by actively including them in stakeholder consultations for the setting and revision of new standards. In the case of palm oil, smallholders control over 40% of the total production area in Malaysia and Indonesia (RSPO, 2024a, 2024b). Therefore, it is crucial to not only ensure they adopt sustainable practices but also to facilitate their inclusion in certification programs and the economic feasibility of certification for them.

4.2. Economic impacts across the supply chain

The costs and benefits of certification are unequally distributed across the supply chain, with upstream producers facing higher costs and lower benefits compared to downstream firms. Additionally, the interests of upstream firms are often less represented. For example, the majority of board seats in RSPO are allocated to downstream firms, which acquire more decisional power than the producers and tend to prioritise their own interests (Ruysschaert et al., 2019). Since the majority of downstream firms are in high-income countries and many upstream producers are in low-income ones, CSLs risk to exacerbate the inequalities among the two (Flanagan et al., 2020). Similarly, it was argued that CSLs currently tend to reflect more the needs of consumers rather than those of producers (Fernandes Martins et al., 2022). Ensuring that local stakeholders groups are thoroughly represented in CSLs decision making processes is an important element of a solution to better safeguard the interests of local producers.

Moreover, enhancing the involvement of end consumers is fundamental to maximise the efficacy of certification efforts, as they drive the final demand. Overall, studies on consumers' purchasing behaviour in respect to certification show a growing interest of consumers in 'green products' and highlight the importance that certification and labelling can play to support this. As highlighted by Morone et al. (2021), certification can significantly influence purchase decisions by offering consumers assurance regarding the actual sustainability of products. It was demonstrated by previous studies that consumers' WTP for price premiums is generally higher for certified compared to uncertified products. This is especially true for people with higher incomes (Aguilar and Vlosky, 2007; Bozza et al., 2022; Giam et al., 2016), but also valid for lower-income consumers. It was evident that, if given the knowledge and option to choose between uncertified and certified products, most consumers would choose the latter if they had the financial means to do so (Gassler and Spiller, 2018).

A solution to level the prices between certified, more sustainable products and cheaper uncertified alternatives could be mandatory certification. No study on the socioeconomic impacts of mandatory versus voluntary certification was found and therefore included in our analysis. However, studies on mandatory certification not included in this review indicate that it could level prices between certified and uncertified products, as the prices would not depend on the products being certified or not. Mandatory state-driven certification was implemented for instance in Indonesia, with the *Pengelolaan Hutan Produksi Lestari* (PHPL) and Indonesian Sustainable Palm Oil (ISPO) (Pramudya et al., 2022), and Malaysia with the Malaysian Sustainable Palm Oil (MSPO) (Abdul Majid et al., 2021). In these cases, certification was made mandatory because private certification schemes aimed at addressing forestry issues showed limited success in tackling illegal logging and deforestation (Wibowo and Giessen, 2018).

Mandatory state-required certification could therefore increase the sustainability of various products, especially in context where voluntary certification is not yet widespread. Additionally, it could remove the market advantage of uncertified products, although likely inflating all prices (Roe et al., 2014). An important risk to take into account is that, as discussed above, the impacts of certification on certified companies tend to be context specific, and smallholders tend to experience more negative impacts. Mandatory certification could therefore exacerbate the marginalization of economically disadvantaged groups, potentially leading to their complete exclusion from the market. To mitigate this risk, additional policies would be necessary to provide support to vulnerable groups.

4.3. Social impacts

Overall, the social impacts of certification were found to be investigated less than the economic ones. As many studies suggested, one reason may be that the social aspects are not sufficiently tackled by CSLs, which focus more on the economic and environmental dimensions of sustainability (Govindan et al., 2014; Kamali et al., 2018; Ogahara et al., 2022). This could be a consequence of the fact that social impacts are less interesting for industry-related stakeholders than economic ones (Brandi et al., 2015). This finding is in line with existing literature not included in this review showing that the main drivers to obtain forest certification are expected improved market access and price premiums, followed by sensitivity to environmental sustainability (Zubizarreta et al., 2021). Similar concerns were raised in the palm oil sector, where greater emphasis is posed on opening environmentally conscious markets rather than on protecting the local communities (Ogahara et al., 2022). Moreover, as already mentioned in the results section, social impacts are generally harder to measure compared to economic and environmental ones. This is because they are often based on perception and rely on less objective observations compared to the other impacts.

An aspect to keep in mind regarding the social impacts of certification is that CSLs do not target all companies and workers, but focus on agribusinesses, leaving a large segment of employed agricultural population out of the intervention and evaluation; in particular, labour standards seem to not be consistently applied to workers employed by small farmers (Oya et al., 2018). This might partly explain the mixed results found for labour conditions. Another group consistently excluded from the benefits of certification are women (Brako et al., 2021; Oya et al., 2018; Traldi, 2021). As crop-producing households are mostly male-led, and women tend to be poorer and more vulnerable, they are harder to reach and therefore less frequently included in certification programs (Brako et al., 2021). Yet, not many studies tackled the issue of gender equality in certification, and more research is needed on this topic.

4.4. Implications

4.4.1. Implications for certification schemes and labels

Certification was found to be less profitable for smallholders and companies in low-income countries. Providing external financial

support to smallholders, for instance from governments or other companies later along the supply chain, is important for enabling smallholders to participate in certification programmes. In particular, support is essential to cover the high upfront costs of certification and deal with the certification process. Nevertheless, it is also important that CSLs provide better solutions tailored around the difficulties that smallholders encounter with certification, especially considering their significant contribution to feedstock production. CSLs could, for instance, make sure to include smallholders in their decision-making processes, especially for local adaptation measures. The inclusion of smallholders in such processes would also help CSLs to better tackle issues related to land-rights that still happen even in certified areas.

4.4.2. Implications for EU policy

The European Union acknowledges the significance of the bioeconomy and the role of biobased products in achieving sustainability goals. However, the production of sustainable biobased products is more expensive than that of their fossil-based alternatives. The EU is already taking action to mobilise funds and invest in sustainable initiatives, and one of the key points of the EU Green Deal is a sustainable finance strategy and enabling framework that directs investments on the European market towards sustainable projects and activities. Initiatives such as, for instance, the EU Taxonomy, aim at enabling the scale-up of such investments and increase the competitiveness of sustainable products. Yet, issues regarding lack of transparency, accuracy, comprehensiveness, and quality persist (Quatrini and Costanza, 2023).

In this framework, certification can be a tool to prove compliance with sustainability requirements and can be used by policymakers as a co-regulation instrument to safeguard the sustainability of biobased products. For this, policymakers should be aware of the impacts that certification has on certified entities and local communities. In particular, since certification is currently mainly a voluntary market-based tool, the high costs of certification, when not balanced by increased profits, can result in feedstock producers and companies deciding not to get certified and selling their products in other markets/regions. This can ultimately result in less sustainable production practices, especially within vulnerable groups such as smallholders.

Policies should be designed to avoid or at least mitigate the negative impacts that smallholders and companies in low-income countries tend to experience. Additionally, since the impacts of certification are context-specific, it is important to design policies that properly adapt to different contexts and protect the well-being of local communities. Finally, the lower presence of social aspects compared to economic ones found in literature is also present in current EU regulations on sustainability. The EU Taxonomy, for instance, focuses mainly on environmental and economic sustainability, and does not include social indicators (Hitaj et al., 2023). It is important for future policies to better represent and tackle the social pillar of sustainability, and more research should be conducted on this topic to support this development.

4.5. Limitations and future research

The current study has two main limitations. Firstly, a susceptibility to geographical bias was present. Notably, the vast majority of reviewed papers originated from authors affiliated to European (29) and North American (19) institutions, with a minority from South America (4) and Asia (17). This increases the risk of geographical bias (Skopec et al., 2020). In an attempt to mitigate this, an exhaustive literature search across two distinct databases was conducted. While the inclusion of articles in various languages was not feasible, the search process was documented thoroughly. Search strings, inclusion criteria, and a full list of all references are provided in Appendix A and the associated dataset. Including non-English studies in systematic reviews has been reported to be important for the comprehensiveness of the results, yet it is rarely applied (Rasmussen et al., 2018). In many cases, including the present study, the reason is lack of resources and time constraints. Future research might focus on including studies in different languages to further explore literature originated in producing countries. An example is to include Bahasa, Malay, French, and Spanish for studies related to palm oil.

In spite of most authors being affiliated to European and North American institutions, only eleven studies covered the impacts of certification in European countries, of which one focused on feedstock producers and ten on the rest of the supply chain. For North American countries, two studies focused on feedstock producers and four on the rest of the supply chain. This is in line with findings from previous reviews included in the present study (DeFries et al., 2017; Traldi, 2021) and might be due to the fact that feedstock production is already regulated by national governments and therefore certification is not strictly needed to enter the market. More studies on Europe and North America cover the rest of the supply chain because downstream firms and especially end-retailers might be more interested in certification as it improves the brand image and reputation for consumers.

A second important limitation is due to data availability. As also mentioned in the results, the number of papers that were included is relatively limited, especially for some feedstocks (i.e., soybeans), regions (i.e., Europe), and outcome categories (i.e., social impacts, market access, price premiums). This can be used as a starting point to conduct future research to fill-in these knowledge gaps. In particular, it is important to better determine the drivers behind the mixed results currently found in literature to understand the role that context plays in the feasibility of CSLs. For instance, it could be investigated how regional and local conditions influence the outcomes of certification. Another aspect to investigate could be how the characteristics of the CSLs contribute to the impacts in order to provide recommendations for the design of effective and viable CSLs. For instance, a relevant question is whether the stringency of a CSL's requirements has an impact on the costs and benefits for the certified company. Moreover, more research is also necessary to gain a better understanding on many outcome categories. Market access and price premiums are important economic indicators that have not yet been covered much by literature, especially in quantitative terms. The same is valid for many social impact categories, which would benefit from more research and a better understanding on how to measure them. Finally, better harmonisation in how the outcome categories are measured would ease cross-study comparisons and ultimately allow to gain a clearer overview of certification impacts.

5. Conclusions

The purpose of this review was to examine the economic and social implications of sustainability certification throughout various supply chains. Existing studies on the topic focus on the economic impacts of certification within specific contexts (e.g., specific feedstock, regions, supply chain elements), and rarely tackle the social impacts. This review complements previous studies by providing a comprehensive overview of the economic and social impacts of certification on supply chains that are crucial in terms of sustainability impacts but still underrepresented in literature (DeFries et al., 2017; Traldi, 2021). The present analysis therefore focused on palm oil, natural rubber, maize, soybean, sugar cane, wood, and raw cotton supply chains. Additionally, differences in impacts of certification between different regions were analysed.

Overall, the economic impacts of certification were covered more in the literature than the social ones. Moreover, both types of impacts were more commonly investigated for the feedstock producers than the rest of the supply chain. Generally, certification tends to result in positive impacts for the company or farm that gets certified. This means that even though certification usually increases the costs that companies incur, the profits often compensate for this. A surprising result was the lack of literature on the effect of certification on market access and price premiums, in spite of these categories being major certification drivers (Zubizarreta et al., 2021).

Although most of the data collected from literature showed an

increase in profits after certification, there were still some cases that experienced no or even negative impacts. In particular, more negative results are often associated with smallholders compared to large plantations and companies in low-income countries compared to those in high-income ones. For smallholders this usually depends on the high certification costs and lack of the instruments necessary to acquire legal documents, implement better management practices, keep records, and meet certification requirements (Hutabarat et al., 2018). For low-income countries the problem is similar, with the addition that some areas (i.e., tropical areas) are associated with complex ecosystems that have higher management costs (Durst et al., 2006). The impacts of certification on social categories (such as labour conditions, access to healthcare, education, poverty reduction, etc.) were more mixed than those of the economic ones. Very few studies covered the social impacts across elements of the supply chain beyond the feedstock producers. Moreover, the social impacts were often measured in different ways by different studies, which made it difficult to aggregate and compare the results.

Our findings imply that financial support from external organisations and governments is crucial to enable smallholders to participate in certification programmes. In addition to this, CSL owners should offer more tailored solutions to address the unique challenges that smallholders face during and after the certification process. Moreover, policy should be designed to mitigate the negative impacts of certification on smallholders and adapt to different contexts to protect local communities' well-being. Finally, future policies should address the social aspects of sustainability more comprehensively, as current regulations mainly focus on environmental and economic aspects, neglecting social indicators.

CRediT authorship contribution statement

Costanza Rossi: Writing – review & editing, Writing – original draft, Visualization, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Li Shen:** Writing – review & editing, Validation, Supervision. **Martin Junginger:** Writing – review & editing, Validation, Supervision, Funding acquisition. **Birka Wicke:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Funding acquisition, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data is submitted with the manuscripts and can be published

Acknowledgements

This research was funded by the Horizon Europe projects HARMONITOR [grant number 101060133] and 3CO [grant number 101086086].

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclepro.2024.143079.

Appendix A

Table A1
List of search strings with records of articles found, scanned, and selected for effect of certification on producers.

Search string	Database	Tot number	Tot useful (title + abstract)	Tot removing duplicates	Tot/feedstock removing duplicates
economic AND (impact* OR effect*) AND (certif* OR label*) AND (palm oil)	WoS	54	8	18	22
	Scopus	70	16		
cost* and benefit* AND (certif* OR label*) AND (palm oil)	wos	13	5	3	
	scopus	17	5		
(soci* OR economic) AND (impact* OR effect*) AND (certif* OR label*) AND (natural rubber)	wos	2	1	1	1
	Scopus	9	1		
cost* and benefit* AND (certif* OR label*) AND (natural rubber)	Wos	0	0	0	
	Scopus	0	0		
economic AND (impact* OR effect*) AND (certif* OR label*) AND (soy*)	wos	37	6	6	8
	scopus	57	4		
cost* and benefit* AND (certif* OR label*) AND (soy*)	Wos	10	1	2	
"cost* and benefit*" AND (certif* OR label*) AND (soy*)	scopus	4	1		
economic AND (impact* OR effect*) AND (certif* OR label*) AND (sugar cane OR sugarcane)	wos	17	3	5	8
	scopus	15	4		
cost* and benefit* AND (certif* OR label*) AND (sugarcane)	Wos	6	3	3	
	scopus	7	3		
("economic impact*" OR "soci* impact*") AND certif* AND (forest OR wood OR timber)	wos	36	11	18	26
	scopus	65	23		
"cost* and benefit*" AND (certif* OR label*) AND (forest OR wood OR timber)	Wos	18	5	8	
	scopus	26	9		
economic AND (impact* OR effect*) AND (certif* OR label*) AND (cotton)	wos	21	5	5	5
	scopus	24	3		
cost* and benefit* AND (certif* OR label*) AND (cotton)	Wos	9	1	0	
	scopus	12	0		
("economic impact*" OR "soci* impact*" OR "economic effect*" OR "soci* effect") AND (certif* OR label*) AND (maize OR corn)	wos	3	0	0	0
	scopus	8	0		
"cost* and benefit*" AND (certif* OR label*) AND (corn OR maize)	Wos	1	0	0	

(continued on next page)

Table A1 (*continued*)

Search string	Database	Tot number	Tot useful (title + abstract)	Tot removing duplicates	Tot/feedstock removing duplicates
	scopus	2	0		
Impact of sustainability certification AND agricultur*	wos	220	20		9
	scopus	188	8		

Table A2
List of search strings with records of articles found, scanned, and selected for effect of certification on elements of the supply chain other than the producers.

Search string	Database	Tot number	Tot useful (title + abstract)	Tot removing duplicates
economic AND impact* AND sustainab* AND certification* AND supply AND chain*	Wos	79	22	25
	Scopus	60	19	
economic impact* chain* of custody	Wos	18	9	7
	Scopus	17	7	
(impact* OR effect*) certification supply chain* palm oil	Wos	36	19	16
	Scopus	27	12	
(impact* OR effect*) of palm oil certification on consumer*	Wos	16	8	14
	scopus	26	16	
(Economic impact*) of (sustainab* certification*) on consumer*	Wos	76	17	13
	Scopus	93	16	
(impact* OR effect*) certification supply chain* soy*	Wos	18	8	8
	Scopus	12	7	
(impact* OR effect*) certification supply chain* (sugar cane OR sugarcane)	Wos	5	4	2
	Scopus	1	1	
(impact* OR effect*) certification supply chain* (forest OR wood OR timber)	Wos	90	34	36
	Scopus	84	19	
(impact* OR effect*) certification supply chain* (cotton OR textile OR wool OR jute OR hemp)	wos	14	6	0
	scopus	21	9	

Table A3
Outcome categories used to categories effects of certification and their description.

Outcome category	Description
Direct cost	Costs directly requested by the CSL, such as certificate fee, auditing costs, etc.
Indirect cost	Costs of meeting the sustainability requirements set by the CSL (investments to upgrade management system, production techniques, new machinery, etc.)
Productivity	Usually measured as crop output over a period of time
Revenue	Total amount of income generated by the sale of products
Income	Revenue - Costs
Market access	The ability of a company to enter the market and sell their goods
Price premium	Difference in price between a certified product and the uncertified equivalent
Health	The impact of certification on the health of people working in companies (i.e., illness rate, access to healthcare, safety in the workplace)
Education	Assessment of whether certification improves access to education of people working in the companies and their households (i.e., years of schooling of children in farmers households, school drop-out rates, access to trainings, etc.)
Poverty reduction	Measures whether certification has a positive impact on poverty of people living in certified areas (i.e., number of people living under poverty line)
Labour condition	Covers workers' conditions such as salary, employment conditions, etc.
Well-being	Broad category covering a variety of variables that impact the well-being of people and/or could not be included in the other outcome categories (i.e., social relations, satisfaction, access to basic needs, social mechanism, etc.)

Table A4
Overview of regions and feedstocks found in quantitative studies on cost and benefits of certification for producers.

	South America	North America	Europe	West Africa	East Africa	South Asia	Southeast Asia	Low-income countries	Tot
Agricultural products	9	0	0	6	6	0	0	20	41
Forest	0	0	1	0	2	0	2	36	41
Maize	0	5	0	0	0	0	0	0	5
Palm oil	6	0	0	24	0	0	92	0	122
Sugar cane	0	0	0	0	0	0	0	0	0
Raw cotton	0	0	0	0	0	0	0	0	0
Soybean	0	5	0	0	0	4	0	0	9
Total	15	10	1	30	8	4	94	56	

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