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Environmental impacts of certification programmes at Colombian coffee plantations

Diego Ivan Caviedes Rubio[a], Daniel Ricardo Delgado[a] & Alfredo Olaya Amaya[b]

ABSTRACT: Certification programmes are often promoted as a sustainable solution for the negative environmental and socio-economic effects generated by agricultural activities. This scope review assesses the seven most adopted certification programmes in Colombian coffee plantations and their ecological, economic and social impacts. In addition, this scope review characterises the coffee regions where the studies are conducted and the main methodological approaches that are used. The review revealed that the main methodological approach used in the studies is the mixed approach and that the largest number of studies is not conducted in the departments that report the highest coffee production rates. The main certification program assessed in this review is the Rainforest Alliance. However, this study also reports the existence of several gaps caused by multi-certification effects. In total, 87 reports of ecological, economic, and social impacts were identified. Out of the 87 environmental impact reports of the certifications identified in this study, 66 were positive and only 21 were negative.

Impacto ambiental de los programas de certificación en fincas cafeteras de Colombia

RESUMEN: Los programas de certificación a menudo se promueven como una solución sostenible para los efectos ambientales y socioeconómicos negativos generados por las actividades agrícolas. Esta revisión de alcance evalúa los siete programas de certificación más adoptados en los cafetales colombianos y sus impactos ecológicos, económicos y sociales. Además, esta revisión de alcance caracteriza las regiones cafetaleras donde se realizan los estudios y los principales enfoques metodológicos que se utilizan. La revisión reveló que el principal enfoque metodológico utilizado en los estudios es el mixto y que la mayor cantidad de estudios no se realiza en los departamentos que reportan las mayores tasas de producción de café. El principal programa de certificación estudiado es Rainforest Alliance (RA). Sin embargo, este estudio también reporta la existencia de vacíos en los efectos generados por la multicertificación. En total, se identificaron 87 impactos ecológicos, económicos y sociales. De los 87 impactos identificados, 66 fueron positivos y solo 21 negativos.

KEYWORDS / PALABRAS CLAVE: Coffee plantations, certification, environmental impact, scope review, Colombia. / plantaciones de café, certificación, impacto ambiental, revisión de alcance, Colombia.

JEL classification / Clasificación JEL: Q01, Q56

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[a] Programa de Ingeniería Civil, Grupo de Investigación de Ingenierías UCC – Neiva, Facultad de Ingeniería, Sede Neiva, Universidad Cooperativa de Colombia, Neiva 410001, Colombia.

[b] PhD programa en Agroindustria y Desarrollo Agricola Sostenible, Universidad Surcolombiana, Neiva, 410001, Av. Pastrana Borrero - Carrera 1. Huila, Colombia.

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Corresponding author: Diego Ivan Caviedes Rubio. E-mail: diego.caviedesr@campusucc.edu.co

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1. Introduction

Colombia is the third largest coffee producer in the world. In 2021, 12.6 million 60 Kg sacks of dry parchment coffee (dps) were produced in the country and this particular annual harvest was valued at over $10.8 billion (FNCC, 2022a), which has a meaningful contribution to the GDP growth for the national agricultural sector. In fact, out of 3.3 % GDP increase in 2022 for this sector, 15.3 % was exclusive contribution by the coffee production (FNCC, 2021a; FNCC, 2021b).

After hydrocarbons, coffee is the fourth highest export product in Colombia (Piraquive *et al*, 2017). The coffee exports during 2021 were 12.4 million of 60 kg bags (ICO, 2022), exceeding a 17 % of the production value reached the previous year. The revenue from this harvest is distributed among 563,000 producing families, with 93 % of them owning less than 5 coffee hectares (Bravo *et al*., 2016; FNCC, 2021b) and generating about 2.5 million jobs, 960,000 of these jobs are direct, which represents approximately 26 % of all agriculture and livestock farming jobs, a significantly higher number than any other agricultural activity (FNCC, 2021b; Ministerio de Agricultura y Desarrollo Rural de Colombia, 2022).

In the last 20 years, a number of certification schemes have been adopted by some Colombian coffee producers that consist of developing a series of sustainable production practices, verified by a certifying entity or body that grants the farm and the product a certification represented on a label. The objective is to obtain a better price and increase competitiveness in the market, since it indicates to consumers that the coffee they buy and for which they pay an additional premium comes from production processes under proper agricultural management, that makes them economically viable, environmentally adequate and socially beneficial and equitable (Jurjonas *et al*., 2016; Bray & Neilson, 2017).

The benefits from these certifications have been discussed in several studies conducted in different coffee-producing regions around the world. The most frequent impacts described in the studies, correspond to those related to the reduction in the use of agrochemicals, which are reported in all the producing regions (Milder & Newson, 2015; Ibanez & Blackman, 2016); the increase in biodiversity is reported in studies from Central and South America (Komar, 2012; Milder & Newson, 2015; Hardt *et al*., 2015), however, there is no real evidence that this is the case in Asia (Kessler *et al*., 2012). The most frequent social impacts correspond to the reduction of child labor in Asia (Auriol & Schilizzi, 2015); the reduction of the level of poverty in African communities (Chiputwa *et al*., 2015); and improvement in working conditions in South America (Guhl, 2009; Caviedes & Olaya, 2020). Finally, in the economic aspect, price stability and guarantees are described more frequently in all producing regions, however, in some regions of Africa and Central and South America, coffee growers indicate that it is not enough to mitigate the investment of certification (Van Rijsbergen *et al*., 2016; Dietz & Grabs, 2022). These results show divergences in the impacts that certification schemes generate in each region (Blackman & Rivera, 2011; DeFries *et al*., 2017; Caviedes & Olaya, 2020).

The variations presented above are attributable to the context and the actors involved in the implementation of the voluntary sustainability standards, to the level of effort of the institutions (including public ones) or coffee grower cooperatives to support obtaining certification and expand coverage without discriminating the degree of sustainability of the producer at the beginning of the process, so that not only pre-existing behaviors are certified (Dietz *et al*., 2020; Dietz & Grabs, 2022). Similarly, it is also attributable to aspects such as industrial relations, labor law, property rights and cultural aspects, such as the idiosyncrasy of the communities and the resistance to compliance with standards due to the low cost-benefit ratio found with the implementation of the programs (Amengual & Chirot, 2016; Caviedes & Olaya, 2020; Graz, 2022)

In Colombia, local or regional studies have been carried out, but none at the national level that list and describe the impacts generated by certification programs in coffee production. The question that guides this review is, what are the effects of the adoption of certification programs in coffee farming aimed at sustainability in its ecological and socioeconomic components, reported in the existing literature? The objective of this study was to compile and identify, through the information obtained in the field and published by various researchers and institutions, using different methods, the presumed ecological, economic, and social impacts generated by the certification programs in good agricultural, administrative and fair-trade practices in the Colombian coffee production.

The importance of the results of this study, given the quality of the existing information, lies mainly in the recognition of the coffee regions in which these academic efforts have been concentrated to a greater extent. Likewise, in the estimation of the perception of the coffee growers of these regions, presented in these studies, regarding the effects attributed to the adoption of certification schemes, which will eventually be useful as input for the design of other studies that seek to evaluate these aspects, so that the scope of research on this topic and literature gaps are identified.

2. Methodology

Since most review studies do not offer an updated and representative synthesis of all research publications available for a given topic (Créquit *et al*., 2016), the methodology for a scoping review was defined based on the Joanna Briggs Institute (JBI) methodology for scoping reviews (Peters *et al*., 2020) and recommendations from Higgins *et al*. (2019) in the *Cochrane Handbook for Systematic Reviews of Interventions* Version 6.0. According to Munn *et al*. (2022) a scoping review is defined as a synthesis of evidence whose objective is to systematically identify the breadth of available evidence on a specific topic or problem within or across particular contexts, without discriminating the type of information source. This type of review allows a greater breadth and inclusion of studies related to this context without evaluating the methodologies of the different studies reviewed and analyzed

(Terstappen *et al*., 2013). In the same way, it allows identifying key ideas, types of evidence and information gaps (Pollock *et al*., 2021; Khalil *et al*., 2021).

The scope of the objective of this article was initially established for the search, review, selection, and synthesis of the literature, thus referring to recognizing, identifying, and reporting on the presumed ecological, economic, and social impacts of the certification programs in good practices in the Colombian coffee production and identify the most assessed regions, according to various studies. The dimensions considered in each aspect were defined by the original authors according to the certification program they were assessing in their study.

2.1. Identification of studies

The scope review is inclusive, allowing all types of studies to be integrated, without necessarily evaluating the methodological quality of the evidence and its related risk of bias (Pollock *et al*., 2021; Munn *et al*., 2022), which for this context is pertinent. It is due to the scarce literature published in specialized journals whose area of study is Colombia, therefore it was decided to include the graduate thesis published in the repositories of the universities.

To identify the studies considered in this review, searches were conducted in the following databases: Science Direct, Springer Link, JSTOR, Taylor & Francis, Web of Science, EconLit, Latidex, Redalyc and Scielo. Likewise, search in Google Scholar was made as well as the repositories at 16 Colombian universities were reviewed, including *Universidad Nacional de Colombia, Universidad del Valle, Pontificia Universidad Javeriana, Universidad de Nariño, Universidad Surcolombiana and Universidad Tecnológica de Pereira*, in addition to free publications available on the Internet. The studies considered for selection include journal articles, graduate thesis (including master's and PhD's) and documents or reports from public and private entities. A total of 292 records were found, of which 164 were excluded, because they appeared more than once in the searches carried out. Finally, 128 studies were obtained that were preliminarily screened.

2.2. Study Selection

After the search, review, and preliminary evaluation of the existing information available in the different sources consulted, the selection of the studies or publications for review and analysis was carried out. Following Munn *et al*. (2018) and Pollock *et al*. (2022), the team of researchers defined and established the following elements or selection criteria that the documents should meet to be included in this review.

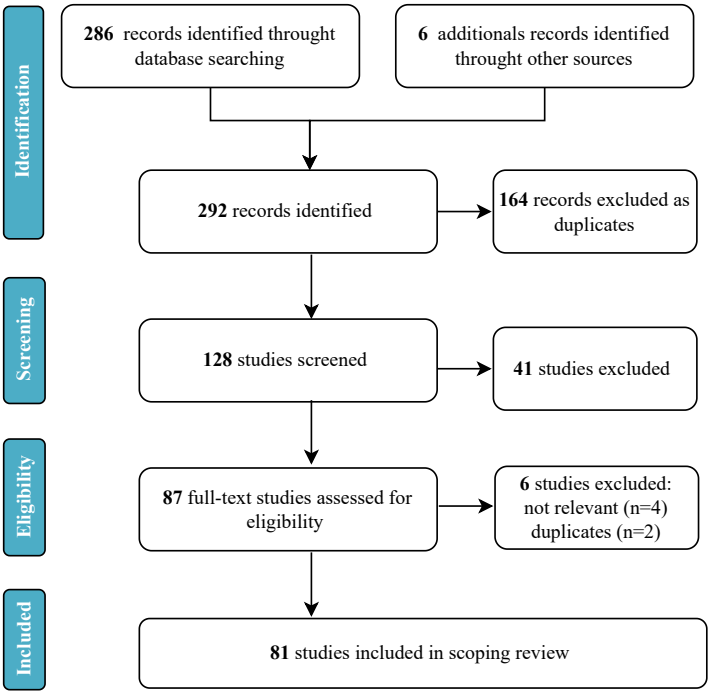
1) Be related to certification programs or labels in Good Agricultural Practices (GAP), fair trade or socially beneficial practices adopted in the Colombian coffee production. This criterion includes reports from entities engaged in coffee production without being exclusively an original research article.

2) Clearly indicate the program or groups of certification programs in good agricultural practices that are friendly to the environment, fair trade, and socially beneficial and equitable practices to which they refer to and name or present one or more impacts.
3) The publication or study must have been published in the period between 2000 and 2021.
4) Be published as journal articles, thesis, book chapters, entity reports and conference presentations, provided that, full access has been granted to these documents.

By applying the above criteria to the 128 screened documents, 87 documents were preliminarily selected, which were analysed as a whole once again under the same criteria by a second reviewer, producing a total of 81 selected to be included in this review. Of these, 21 are thesis, 58 are scientific journal articles, and two correspond to the category of institutional document. Figure 1 shows the identification and selection process carried.

FIGURE 1

Identification and selection of studies for scope reviews



Source: Author´s own elaboration.

2.3. Data Treatment

Following Pawson's method (Pawson, 2002), which corresponds to a descriptive-analytical method, an overview table was created to examine, identify, detail, and organize the information found in each of the 81 selected studies, according to the objective of the study. This table, which gives rise to a data matrix based on text and not on specific data or on the use of statistical methods (Terstappen *et al*., 2013), was periodically evaluated during the data extraction process of each source, to guarantee the relevance of the structure and contents of the table or realize if it needed to be restructured.

The data extractions will include the following aspects: 1. A component that identifies the type of source (article, master's thesis, doctoral thesis, book chapters, entity reports and/or conference presentations), 2. Origin of the publication (journal or university repository), 3. Title, 4. Year of publication, 5. Authors, 6. Area of study by departments and municipalities, 7. Sample (number of people surveyed and/or units of agricultural production), 8. Impacts (ecological, social and/or economic), 9. Description of the impact, 10. Program or certification programs, 11. Research methodology (qualitative, quantitative or mixed), 12. Reported limitations.

The table content extracted from the various sources, allowed for examining and analysing in a homogeneous way all the selected studies and in this way identify the coffee regions, the most evaluated certification programs; the methodologies used, the key considerations reported in each document; the categories of impacts according to their ecological, economic and social dimension; as well as, the homologation of the impact names with the same meaning in order to avoid counting the same impact several times.

3. Results

3.1. Most Evaluated Coffee Regions

In Colombia, 23 departments with Andean areas engage in coffee production, covering approximately 840,110 hectares (ha) of coffee plantations. However, 70.2 % of these plantations are located in only 6 departments (Table 1) using different levels of crop technology to generate more than 70 % of the country's total coffee production. The departments of Huila and Antioquia are the first and second coffee producers in the country, respectively, with 31.6 % of the country's production.

The 81 documents selected and reviewed revealed that the assessments or studies are concentrated on 15 departments (Table 2), comprising 104 coffee-producing municipalities. The departments of Santander, Cundinamarca and Huila are the most commonly selected for conducting studies that address the effects from certification programmes. It is evident that, with the exception of the department of Huila, in the departments with the largest planted area and the highest production (Table 1), a greater number of studies have not been carried out in this regard. It is important to make clear that some documents include several departments as study areas.

TABLE 1

Main coffee producers in Colombia, their cultivation areas and technification level to 2021, according to the FNCC (2022) and Agronet (2022)

Department	Production (%)	Plantation Area (thousands of ha)	Plantation Area at National Level (%)	Technification Level* (thousands of ha)		
				Traditional	Old Technified	Technified
Huila	22.86	144.12	17.75	0.09	18.85	125.17
Antioquia	13.69	116.29	13.84	0.00	19.26	97.02
Tolima	10.57	107.03	12.73	0.65	26.76	79.61
Cauca	11.24	93.00	11.06	0.96	16.61	75.44
Caldas	6.41	59.28	7.05	0.01	7.54	51.72
Valle del Cauca	5.78	51.38	6.11	0.38	8.59	42.42

Note:* In thousands of hectares up to December 2021.
Traditional: Typical without traces, or typical with a density under 2,500 trees.
Old Technified: Sun-grown crops older than 9 years, or total or partial shade-grown crops older than 12 years.
Technified: Sun-grown crops less than or equal to 9 years, or total or partial shade-grown crops less than or equal to 12 years.
Source: Author´s own elaboration.

TABLE 2

Studied coffee-producing departments in the selected documents

Department	Frequency (studies)
Santander	17
Cundinamarca	16
Huila	13
Antioquia	10
Nariño	9
Cauca	9
Caldas	8
Tolima	7
Valle del Cauca	5
Quindío	4
Magdalena	4
Risaralda	3
Cesar	3
Boyacá	1
Norte de Santander	1

Source: Author´s own elaboration.

3.2. GAP Certification Programmes in Colombia

The ‘sustainable coffee’ category seeks to rigorously monitor social, environmental, and economic factors associated with coffee production and to guarantee the future of ecosystems, coffee growers and their communities (FNCC, 2015). In Colombia, the most common following certifications are Rainforest

Alliance (RA), Fairtrade Labelling Organisations International (FLO), UTZ Certified, Organic, Bird-Friendly (Smithsonian Migratory Bird Centre), AAA Sustainable Quality and 4C Code of Conduct. The first four programmes are the most reviewed in terms of ecological, social, and economic impacts.

Table 3 shows the frequency of Colombian studies included in this review, indicating the ecological, economic and/or social effects from the certification program used. In fact, many of the studies reviewed included the evaluation of several certification programs and many study or evaluate farms with two or more certification programs simultaneously, so the combinations of programs studied are included.

TABLE 3

Frequency of Good Agricultural Practices (GAP) certification programmes used as object of study in the publications reviewed

Certification Programme	Frequency of Studies				TOTAL
	Art	Doc. Inst.	Thesis		
			MSc	PhD	
Rainforest Alliance (RA)	15	1	4		20
Fairtrade Labelling Organizations International (FLO)	3		1		4
UTZ Certified	1	1	2		4
Organic	10		1		11
AAA Sustainable Quality	2		1		3
Bird-Friendly (Smithsonian Migratory Bird Center)	2				2
4C Code of Conduct.	1		3		4
RA and Organic	4				4
RA and Bird-Friendly	3		1		4
RA and UTZ	2				2
RA and FLO	3		2		5
RA, FLO and UTZ	3		2		5
RA, FLO and Organic	2			1	3
RA, FLO, UTZ and Organic	2			1	3
RA, FLO, Orgánico and Bird-Friendly	2				2
RA and AAA Sustainable Quality	1		1		2
FLO and Organic	2		1		3
TOTAL	58	2	19	2	81

Source: Author´s own elaboration.

The RA certification presents the highest number of case studies reviewed, and its study area is distributed throughout the entire coffee production area in the country, just like for the Fairtrade Labelling Organisations International (FLO) and UTZ

Certified programmes. Case studies on the certification of organic coffee and AAA Sustainable Quality predominate in the departments of Santander, Cundinamarca, Huila, Nariño and Antioquia. In addition, studies on Bird-Friendly (Smithsonian Migratory Bird Centre) certifications are mostly reported in the departments of Caldas and Risaralda.

On the other hand, the case studies selected in this scope review include a diversity of methodological approaches adopted by the authors of the different investigations. Table 4 sorts the studies according to the quantitative, qualitative and mixed research types, along with the frequency or number of case studies selected under each category.

TABLE 4

Methodological approaches used in selected studies

Methodological Approach	Frequency (Studies)
Qualitative	12
Quantitative	10
Mixed	50
Review	5
Methodological approach not specified or unclear.	4
TOTAL	81

Source: Author´s own elaboration.

The most widely used data collection instrument was the interview, supplemented with quantitative methods, such as the propensity score assessment. The most frequently adopted methodological approach in these studies is the mixed approach (61.7 %). In the graduate thesis, the approach used is observed with greater clarity, given the length of these documents, while in scientific journal articles, categorising the methodological approach is more difficultwould make the study replicable.

The scope review did not assess the rigour of the research studies selected. However, the review did include the number of plantations evaluated and the number of coffee growers or experts interviewed as indicators. 23.5 % of the studies presented representative samples, the rest are limited to small samples or case studies. The departments with the highest frequency of studies that include representative samples were Santander, Cundinamarca, Caldas and Risaralda.

3.3. Environmental Impacts

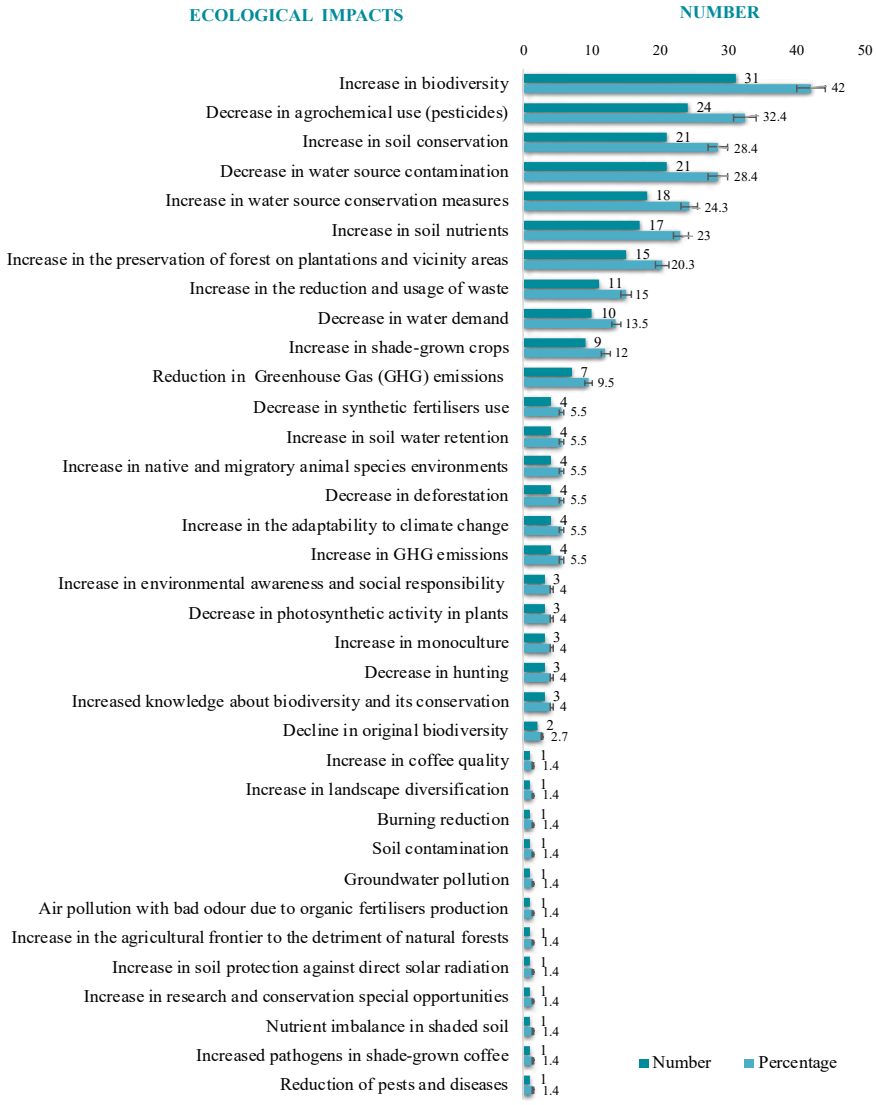
The review yielded 87 environmental impacts, 35 of which can be considered ecological impacts, 29 economic impacts and 23 social impacts.

3.4. Ecological Impacts

In total, 35 ecological impacts were named in 74.7 % of the documents reviewed: 25 positive (P) and 10 negative (N). Figure 2 denotes the ecological impacts found and frequency with which the impact is mentioned in the studies assessed.

FIGURE 2

Ecological impacts and number of occurrences in the documentary review



Source: Author´s own elaboration.

The increase in biodiversity was the most frequently impact named (González *et al*., 2021; Armbrecht *et al*., 2005; Farfán & Sánchez, 2007; Jha *et al*., 2011; Rojas *et al*., 2012; Trimarchi, 2014; Vargas *et al*., 2015; Atallah *et al*., 2018), which is supported by studies that report increases in the diversity of arboreal and epiphytic species (Andrade, 2016; Del Rio, 2016; Ibanez & Blackman, 2016; Moreno & Romero, 2016; Ramírez & Granobles, 2015; Bravo *et al*., 2015; Aguirre *et al*., 2022), as well as an increase in birds, mammals and macroinvertebrate species. The birds are the taxonomic group most studied in coffee plantations, where it is observed that, due to high landscape heterogeneity, there is a high diversity of habitats with different landscape elements that confer favourable structures for diversity and the conformation of communities from other taxonomic groups (Bosselman *et al*., 2009; Botero *et al*., 2014; Calderón *et al*., 2011; Caviedes, 2012; Lentijo & Hostetler, 2013; Muñoz & Villota, 2014; Gómez *et al*., 2018; Roach *et al*., 2021; Suarez *et al*., 2019; Valente *et al*., 2022).

Coffee growers consider that certification increases environmental awareness, fosters the conservation and protection of fauna and flora, and decreases hunting (Gómez *et al*., 2018; Rueda & Lambin, 2013; Valencia, 2010). Likewise, the development of agroforestry systems improves species environment (Mancilla, 2012; Méndez, 2016; Polo, 2013; Salazar, 2008; Valente *et al*., 2022). The decrease in deforestation and controlled burning in certified plantations is also repeatedly mentioned (Bosselmann *et al*., 2009; Rojas *et al*., 2012) as well as the increase in the preservation of existing forest remnants on plantations and surroundings (Calderón *et al*., 2011; Hughell & Newsom, 2013; Trejos *et al*., 2011). The increase in shade-grown coffee crop areas, which affects the generation of several ecological impact topics is also named (Farfán & Baute, 2009; Gómez, 2012; Ibanez & Blackman, 2016; Moreno & Romero, 2016; Rojas *et al*., 2012). However, many coffee growers indicate a significant reduction in the original biodiversity in ecosystems (Botero *et al*., 2014; Lentijo & Hostetler, 2013), an increase in the agricultural frontier against natural forests (Trimarchi, 2014); and increase in monocultures (Trimarchi, 2014; Oberthür *et al*., 2011) and the reduction of coffee photosynthetic activity due to the shade required by some brands (Atallah *et al*., 2018; Brunner, 2018; Mancilla, 2012).

The second most frequently named impact in the studies reviewed studies was the decrease in agrochemical applications, mainly used for managing the coffee berry borer (*Hypothenemus hampei* Ferrari) and the coffee rust (*Hemileia vastatrix* Berk and Broome) (Ibanez & Blackman, 2016; Mancilla, 2012; Valbuena *et al*., 2017). Over 72 % of all certified plantations do not use pesticides. Those who use them, do it in a controlled way and under technical recommendation, using substances with active principles that are not prohibited by international organizations (Cruz *et al*., 2014; Ramírez & Granobles, 2015; Trejos *et al*., 2011; Trimarchi, 2014). This reduction is due to the integrated management to the control and reduction of pests and diseases adopted by coffee growers (Farfán & Sánchez, 2007; Moreno & Romero, 2016).

The third most frequently named impact in the studies reviewed was the increase in measures for the conservation of water sources and the decrease in their pollution (Aristizábal, 2005; Del Rio, 2016; Grabs *et al*., 2016; Hughell & Newsom, 2013; Oliveros-Tascón & Sanz-Uribe, 2011; Ospina *et al*., 2003; Rueda *et al*., 2015; Trejos

et al., 2011). The main conservation measure conducted by coffee growers is the reforestation of the micro-watersheds within the plantations (Mosquera, 2018; Jha *et al*., 2011; Bosselmann *et al*., 2009). However, the reduction in agrochemical use is also important; as well as the increase in the implementation of practices that reduce waste and increase its uses (García *et al*., 2014; Grabs *et al*., 2016; Hughell & Newsom, 2013; Ibanez & Blackman, 2016; Valbuena *et al*., 2017), as well as a decrease in the amount water demanded by wet coffee processing methods, thus reducing the amount of pollutants discharged (Araque, 2015; Galindo *et al*., 2014; García *et al*., 2014; Mancilla, 2012; Solano, 2014).

The fourth most significant environmental impact of certified coffee production in Colombia was the improvement of soil quality, expressed as an increase of the nutrients found in the soil used for coffee production (Bosselmann *et al*., 2009; Díaz, 2014; Farfán & Sánchez, 2007; Jha *et al*., 2011; Mancilla, 2012; Ospina *et al*., 2003; Ramírez & Granobles, 2015; Valbuena *et al*., 2017). This effect has reduced the use of synthetic fertilisers and increased the use of organic fertilisers (Bosselmann *et al*., 2009; Ceballo & Ocaña, 2014; Escobar *et al*., 2012; Trimarchi, 2014), which translates into a reduction in production costs and an improvement in coffee quality. However, the production of organic fertilisers has caused air pollution through foul-smelling emissions and the contamination of and groundwater through leachate flows (Moreno & Romero, 2016).

Finally, the reduction in Greenhouse Gas (GHG) emissions represents the fifth most frequently reported environmental impact in the studies reviewed (Andrade, 2016; Díaz, 2014; Jha *et al*., 2011; Mancilla, 2012; Navia *et al*., 2016). This impact is generated by the reduction of burned and buried waste (Rueda & Lambin, 2013; Trimarchi, 2014), the reduction of plant biomass burnings (Navia *et al*., 2016) and the increase in agroforestry systems that increase carbon sequestration and make adaptability to climate change viable (Andrade, 2016; Jaramillo *et al*., 2017; Atallah *et al*., 2018; Aguirre *et al*., 2022). However, (Ceballo & Ocaña, 2014) report an increase in GHG emissions.

3.6. Economic Impacts

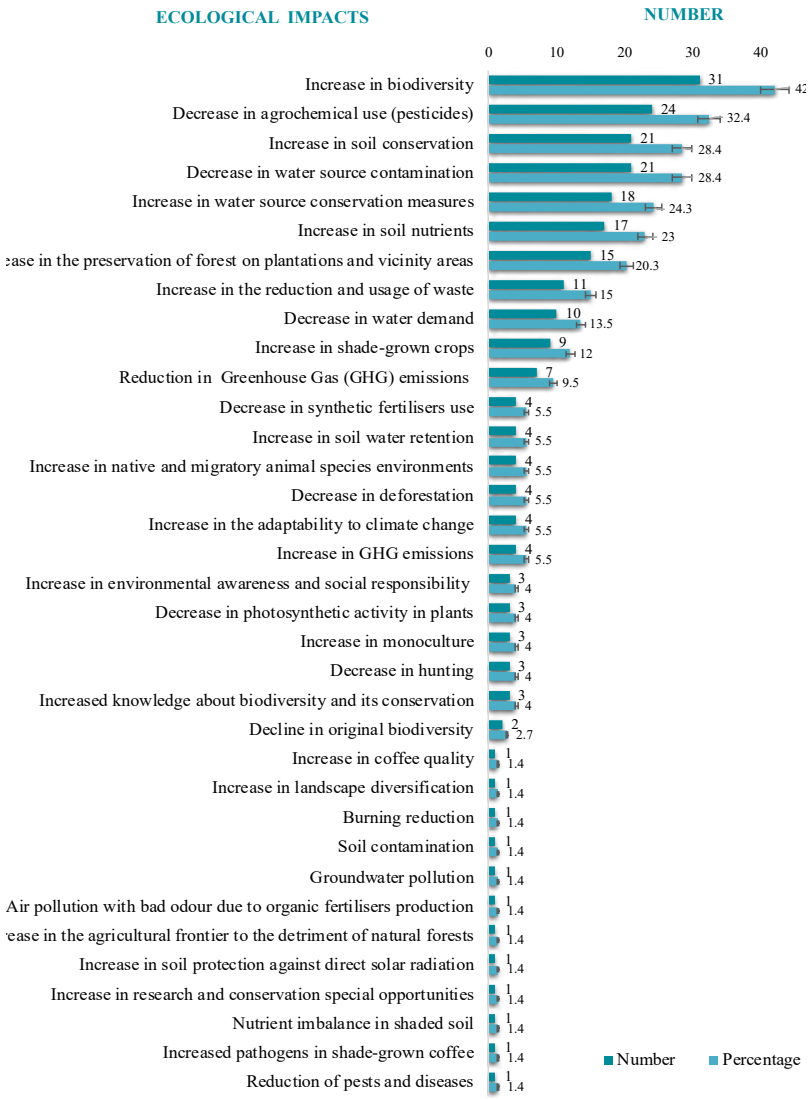
In terms of economy, 74.7 % of the documents reviewed identified 29 impacts: 21 positive and 8 negatives. Figure 3 lists these economic impacts found, the frequency with which each impact is mentioned in different studies and the percentage of documents where each impact is mentioned against the total number of documents.

The main economic impact caused by certification programmes in Colombian coffee production was a revenue increase for coffee growers (Andrade, 2016; Aristizábal, 2005; Calderón *et al*., 2011; Giuliani *et al*., 2017; Moreno & Romero, 2016; Peñuela-Martínez *et al*., 2007; Rueda & Lambin, 2013; Trejos *et al*., 2011; Trimarchi, 2014; Vellema *et al*., 2015; Melo *et al*., 2017). This effect is not only attributed to an increased grain production, but also to the increase in production projects and the larger variety of agricultural products in these plantations (Grabs *et al*., 2016; Mancilla, 2012; Ramírez & Granobles, 2015; Solano, 2014). This additional revenue also increases purchasing power and provides coffee growers with greater economic sustainability. Furthermore, it fosters the general economic development of the region and the national Gross

Domestic Product (Felipe & Cano, 2013; Grabs *et al*., 2016). However, other authors indicate that certification programmes exert a strong impact on reducing the variety of products produced at plantations, which increases dependence on coffee crops (Vellema *et al*., 2015; Oberthür *et al*., 2011; Guhl, 2004).

FIGURE 3

Economic impacts and number of occurrences in the documentary review



Source: Author´s own elaboration.

The second and third most frequent impacts on this review are closely related to the first one. They were, respectively, the increase in the price of coffee (Grabs *et al*., 2016; Acevedo, 2015; Cano *et al*., 2012; Del Rio, 2016; Gómez, 2012; Ibanez & Blackman, 2016; Mejía & Orozco, 2011; Rueda *et al*., 2015; Ramirez *et al*., 2022) and the increase in productivity (Alzate, 2013; Armbrecht *et al*., 2005; Felipe & Cano, 2013; Oberthür *et al*., 2011; Serna *et al*., 2010; Trejos *et al*., 2011; Trimarchi, 2014; Valbuena *et al*., 2017; Vellema *et al*., 2015), which could be explained by an increase in crop intensity (Farfán & Baute, 2009; Jiménez, 2018; Serna *et al*., 2010). However, regarding this third impact, some researchers claim that some certification programmes with strict shade requirements in fact reduce crop productivity by decreasing the plant's exposure to solar radiation (Díaz, 2014; Jaramillo *et al*., 2017; Mancilla, 2012). In the case of organic one, the price increase is only viable if there is not a significant loss of productivity, caused by dependence on organic fertilization and pest control (Roach *et al*., 2021). Similarly, the increase of the price of certified coffee is not manifested as a net gain or poverty reduction due to higher family income (Andrade *et al*., 2021; Dietz *et al*., 2020; Ramirez *et al*., 2022).

The fourth most frequently economic impact mentioned refers to the increase in demand and purchase security for certified coffee (Araque, 2015; Giuliani *et al*., 2017; Grabs *et al*., 2016; Vargas *et al*., 2015). Nevertheless, some studies discuss cases where profitability has decreased due to over production (Felipe & Cano, 2013). Certifications have also increased brand protection, competitiveness, product accessibility and differentiation in the market (Ibanez & Blackman, 2016; Oberthür *et al*., 2011; Vargas *et al*., 2015; Vellema *et al*., 2015). Here an increase in consumption patterns changes has implications on global coffee markets (Rueda *et al*., 2015; Ramirez *et al*., 2022), which generate an increase in price fluctuations of certified coffee, as well as a decrease in the prices of conventional coffee (Burgos, 2015; Muñoz & Villota, 2014; Navarro, 2016; Rueda *et al*., 2015).

The fifth impact from certified coffee production was an increase in the product quality, both in terms of safety and organoleptic quality (Andrade, 2016; Gómez, 2012; Ibanez & Blackman, 2016; Jaramillo *et al*., 2017; Mancilla, 2012; Oberthür *et al*., 2011; Quiñones-Ruiz *et al*., 2015; Trimarchi, 2014). The sixth impact evidences an increase in investment and dedication of coffee growers. This impact can be detected in production costs, inputs, investments efforts to achieve and maintain a certification, and an increase in agronomic practices (Andrade, 2016; Burgos, 2015; Del Rio, 2016; Hughell & Newsom, 2013; Ibanez & Blackman, 2016; Mancilla, 2012; Valbuena *et al*., 2017). Alternatively, this phenomenon causes the marginalisation of producers who cannot pay or support certification (Ramirez *et al*., 2022; Solarte *et al*., 2014; Quiñones-Ruiz *et al*., 2015; Rueda *et al*., 2015; Del Rio, 2016; Giuliani *et al*., 2017).

In addition, as the technological development of the plantation increases, an increase in investments in plantation improvements and technical efficiency is also evidenced (Araque, 2015; Burgos, 2015; Giuliani *et al*., 2017; Lentijo & Hostetler, 2013; Peñuela-Martínez *et al*., 2007; Suárez *et al*., 2021). These investments increase the value of the plantation and facilitate access to loans for coffee growers, who are now able to use their plantations as collateral (Alzate, 2013; Ibanez & Blackman, 2016; Peñuela-Martínez *et al*., 2007; Vargas *et al*., 2015).

The review also identified other economic impacts that were less frequently mentioned in the documents, but have allegedly not been evaluated before. Among these, the increase in investments for research and development (Araque, 2015; Rueda *et al*., 2015) to expand crop lifespans (Mancilla, 2012; Valbuena *et al*., 2017). Likewise, there is an increase in the number of coffee grower associations or cooperatives, which is a good strategy for obtaining certifications or multi-certifications, since it reduces costs and allows coffee growers to guarantee fair trade (Ibanez & Blackman, 2016; Serna *et al*., 2010). Finally, some authors also mention an increase in ecotourism and agritourism projects in the coffee production areas around Colombia (Ramírez & Betancur, 2015).

3.7. Social Impacts

Within 57.6 % of the documents reviewed, this study identified 23 social impacts: 20 positive and only 3 negatives. Figure 4 lists the social impacts identified, frequency with which each impact is mentioned in different studies and percentage of documents where each impact is mentioned against the total number of documents.

The most frequently referenced impact was the increase in educational/training processes associated coffee activities. This increases industry professionalism and the training of leaders who participate in decision-making bodies at local, regional and national levels (Bosselmann *et al*., 2009; Jiménez, 2018; Mejía & Orozco, 2011; Ramírez & Betancur, 2015; Rueda *et al*., 2015; Trimarchi, 2014; Valencia, 2010; Vellema *et al*., 2015; Suárez *et al*., 2021).

The second most frequent social impact was increased job creation (Araque, 2015; Solarte *et al*., 2014; Grabs *et al*., 2016; Hughell & Newsom, 2013; Ibanez & Blackman, 2016; Jaramillo *et al*., 2017; Méndez, 2016; Mosquera, 2018; Rueda *et al*., 2015; Vellema *et al*., 2015). This has also fostered the inclusion of minorities employed in coffee production and an increase in the expertise of coffee growers (Muñoz & Villota, 2014). The increase in employment is intricately linked to the reduction of rural poverty in production areas (Giuliani *et al*., 2017; Moreno & Romero, 2016). However, the evidence of these effects from certification programmes on agricultural producers and workers is limited. Prices and income from product sales are higher for certified coffee growers. Still, worker salaries do not increase based on the adoption of labels (Vellema *et al*., 2015; Oya *et al*., 2018).

The requirements from certification programmes have also exerted influence in safety and prevention measures among coffee growers (Del Rio, 2016; Manrique & Rosique, 2014; Ramírez & Betancur, 2015; Trejos *et al*., 2011; Vellema *et al*., 2015). Hence, this was the third most referenced social impact on the documents reviewed as part of this study. A decrease in occupational health risks is reported when properly handling agrochemicals, tools and agricultural machinery, as well as an increase in the training of emergency brigade members (Rueda *et al*., 2015; Solano, 2014; Trejos *et al*., 2011; Trimarchi, 2014).

FIGURE 4

Social impacts and number of occurrences in the documentary review

Source: Author´s own elaboration.

The fourth most frequent impact was the improvement in working conditions, as it can be evidenced through better health and social security system accessibility (Calderón *et al*., 2011; Del Rio, 2016; Ramírez & Betancur, 2015; Solano, 2014; Trimarchi, 2014), an increase in agricultural labor stability (Calderón *et al*., 2011; Giuliani *et al.*, 2017; Valencia, 2010) and the improvement in hygienic and sanitary conditions at worker facilities (Del Rio, 2016; Ramírez & Betancur, 2015). Another impact refers to the reduction in food safety risk due to the requirements from some certifications, which demand shade-grown crops, thus allowing for other productive tree species (Manrique & Rosique, 2014; Sánchez & Felipe, 2016; Solano, 2014; Vargas *et al*., 2015; Macchiavello & Miquel, 2019). However, other studies mention

a reduction in food security as fertile lands are dedicated to a single crop (Polo, 2013; Sánchez & Felipe, 2016).

In most Colombian coffee-growing regions, an increase in education is evident. This is a direct consequence of the impact generated by the certification programmes, which promote schooling (Calderón *et al*., 2011; Rueda *et al*., 2015; Valencia, 2010; Vellema *et al*., 2015) and a decrease in child labour. In fact, the training processes for certification programmes place special emphasis on enacting legislation to eradicate child labour and on enforcing International Labour Organisation regulations that restrict the employment of school-age children and teenagers in agricultural tasks (Calderón *et al*., 2011; Giuliani *et al*., 2017; Ramírez & Betancur, 2015; Trejos *et al*., 2011; Vellema *et al*., 2015).

Not only the increase in women participation in the activities of coffee plantations, but also an increase in gender inclusion in coffee grower associations and even their organisation levels are some impacts referenced in different case studies (Araque, 2015; Burgos, 2015; Calderón *et al*., 2011; Grabs *et al*., 2016; Ramírez & Granobles, 2015). Furthermore, there is an increase in the number of coffee growers associations and cooperatives, which, in turn, provides greater recognition to coffee farmers, the community and the region at large (Burgos, 2015; Solarte *et al*., 2014; Ramírez & Betancur, 2015; Trimarchi, 2014; Suárez *et al*., 2021).

Another impact associated with certification programmes, but has been referenced to a lesser extent, is an increase in the acquisition of lands or properties for coffee production. These studies observed that many coffee producers bought additional hectares or transformed more territory to coffee plantations (Navia *et al*., 2016; Vargas *et al*., 2015). Moreover, there is increase in structural improvements at the coffee growers' homes (Peñuela-Martínez *et al*., 2007); as well as better maintenance of tertiary roads and accessibility to transport systems (Rueda *et al*., 2015). In addition, young farmers who do not migrate to cities can be retained (Solano, 2014; Trejos *et al*., 2011; Valencia, 2010). Negative impacts are manifested in the decrease of certified coffee growers and plantations due to the increase in the requirements established by each certification and ignorance of certification mechanisms among coffee growers (Solarte *et al*., 2014; Gómez, 2012).

4. Conclusions

In brief, the documents assessed as part of this study all recognise that coffee plantation certification programmes generate positive impacts on the ecological, economic, and social spheres. However, negative impacts are also reported on the three areas. In all these categories, the total of favourable impacts is significantly higher than the number of adverse impacts. Here, we might highlight the presence of ecological impacts in the first position, followed by economic, and finally at a lower proportion, social impacts. Ecological and economic impacts were reported in about 75 % of the documents reviewed, many of which focused specifically on them. In contrast, social impacts were only reported in 57 % of the documents assessed, thus proving they were not as frequently assessed. This interest in evaluating the economic

or ecological effect lies in the fact that they are the most emphasized components by most voluntary sustainability standards. These are the most relevant aspects for producers and consumers, since they have a direct impact on the willingness to pay more for the product and do not incur social desirability or strategic "Free rider" biases (Lopez-Becerra & Alcon, 2021; Takahashi, 2021).

The environmental impacts of certified coffee growing in Colombia coincide with those reported in other coffee-producing countries, mainly in Latin American countries such as Honduras, Nicaragua or Mexico (Dietz *et al*., 2020; Estrella *et al*., 2022). However, there are also contrasts in impacts attributable to the geographical conditions of the producing countries; the social organization of the producing communities as occurs mainly in Africa and some Asian countries and the different economic systems in which production takes place (Auld, 2010; Caviedes & Olaya, 2020).

Ecological impacts are mainly focused on changes that favour or disfavour conservation (such as biodiversity, forests or wildlife). Second, they refer to the conservation or deterioration of soils and water resources. However, these topics exhibit a greater tendency towards positive consequences. To a lesser extent, a reference is made to the impacts that beneficially or adversely modify air quality and pests or diseases, as well as improvements in solid waste management, landscape, scientific research, and responses against climatic threats. In countries with high coffee production such as Vietnam and Indonesia, the findings on these issues indicate that there is no effect of certification on the efficient use of water (Tscharntke *et al*., 2015; Ho *et al*., 2021), nor is there a direct relationship between increased carbon sequestration by agroforests and their biodiversity (Kessler *et al*., 2012). In the same way, in Kenya, Cameroon or Tanzania, where rainfall is limited and the dry season is long, it is observed that agroforests negatively affect productivity due to strong competition between native trees and coffee for available soil moisture. (Van der Vossen, 2005). In Ethiopia, it is commonly observed that the use of pesticides is restricted, not because of the initiative of the coffee growers, but because of the lack of resources (Caviedes & Olaya, 2020). It is important to assess the pollutant load in wastewater generated in post-harvest processes and demand the implementation of treatment systems; For this, it is necessary to create financing or sponsorship methods to facilitate their acquisition. Similarly, as recommended by Valbuena *et al*. (2021), it is important to implement a transparent system of information and monitoring of the use of pesticides in production activities, which ensures the reduction of the risk of exposure to humans and the environment to substances with a high level of toxicity.

The economic impacts basically refer to investments, prices, income or profitability, production, productivity, coffee products and certification benefits or costs. With less emphasis, technology or scientific research, plantation lifespans and the areas for potential coffee plantations are referenced. Alternatively, it is noticed that certified coffee production contributes to the economic development of the coffee growers, coffee production regions and the entire country in general. However, the increase in income, which is the main objective that coffee growers have for the adoption of certification programs, seems not to be fully verifiable and less evident in small

producers, because although income from coffee increases, they reduce income from other products, not to mention that the workforce that must be intensified does not obtain higher returns (Vellema *et al*., 2015); coinciding with the findings made by Van Rijsbergen *et al*. (2016) in Kenya, Estrella *et al*. (2022) in Honduras and Ho *et al*. (2021) in Vietnam, who indicate that certifications increase production costs, thus reducing income. This shows the need to intensify intervention in the coffee value chain, reduce input costs and other production components in order to improve gross profit (Dietz *et al*., 2020). According to Ramirez *et al*. (2022) and Dietz *et al*. (2020) institutions are fundamental actors not only to provide access to credit, but also leading to a close balance between production costs and prices that allow the coffee grower greater net profits.

Social impacts are related to employment, education, gender equity, road and transportation infrastructure, food security, housing, legislation and technical certification standards and empowerment of coffee growers, regarding their resilience capacity, expertise, organisation and recognition by the community. These impacts are also common in African countries such as Uganda and Ethiopia, where women's participation is perceived to be at a higher level and there is greater interest in worker safety (Elder *et al*., 2013). However, in these same countries it has been shown that although certification programs are associated with the schooling of children, they are not associated with the reduction of child labor time (Akoyi *et al*., 2020). In Mexico, Guatemala, Nicaragua and El Salvador, certification did not show significant effects on the schooling of minors, nor on the access to health services for producers (Mendez *et al*., 2010; Grabs *et al*., 2016). In Asian countries, the reduction of child labor in coffee production is ambiguous, since small producers consider it a family activity. (Auriol & Schilizzi, 2015). Nevertheless, despite the fact that women's coffee growers' associations have proliferated in Colombia and the social dynamics in rural areas have changed after the peace accords, the evidence from studies that relates these phenomena to certified coffee farming and its effects is non-existent.

Within this context, more clarity is needed regarding the research methodologies used in studies shared with the scientific community. Nevertheless, the methodology applied in this study was able to successfully identify the impacts from case studies commonly addressed in degree thesis. Still, many methodologies used in the documents assessed are neither clear nor replicable. None of these studies evaluate impacts before and after certifications, although some studies do make comparisons between certified and non-certified plantations. In fact, there is not enough rigour in methodologies, strategies or procedures and many documents are only case studies. Due to the different levels of accuracy and the diverse methodologies applied, some important testimonies from different certified coffee plantation actors could even be excluded or marginalised.

There is strong homogeneity in the results reported by most studies since most of them do not reveal aspects such as subject gender distribution, whether subjects are owners or hired hands, plantation sizes, production areas and alternative production approaches, which can hide specific certification details and make it more difficult to properly identify impacts.

Still, we must mention that several factors, such as market dominance, competition, or sector changes, may modify certification standards and criteria over time. As this documentary review includes information comprised between 2000 and 2021, it is possible that certification programmes may have experienced different changes throughout this period that could have generated new impacts or change their scope. Likewise, it is observed that the studies are concentrated in regions of interest for the country's coffee entities, where there are academic programs related to agricultural and agro-industrial production, research centres or researchers specialized in the subject, easy access to farms and without public order restrictions. A large number of studies discussed RA and organic certification programmes, while there are few studies on the effects of multi-certification. This aspect represents one of the main gaps while determining the environmental impact caused by certification programmes in Colombian coffee producers.

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