

Payment for Environmental Services for Waste Pickers: Systematic Literature Mapping

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Abstract

In Payment for Environmental Services (PES) systems, environmental service providers receive compensation for a conservationist action that implies the preservation of natural resources. The objective of this systematic mapping was to identify and discuss scientific articles that address the theme 'Payment for Environmental Services - PES for Waste Pickers Organizations', to understand the state of art of hiring these workers as environmental service providers. The study was developed using the method of systematic mapping of literature, from 2009 to 2019, considering qualitative and quantitative aspects. Results indicated that the countries that most investigate this theme are Brazil, China, India, and Indonesia. The articles portray the informal work of waste pickers, working conditions and the transition from informal systems to waste management in public services. The relationship between payment for environmental services and the work of waste pickers is not yet evident. Furthermore, research on PES and recycling are developed along distinct lines, without interdisciplinarity. However, PES shows itself as an important socio-environmental management tool that has the potential to solve relevant problems of recyclable waste management, because it presents congruent characteristics with the public procurement systems for waste pickers.

Keywords: environmental externalities, payment for environmental services, waste pickers

1. Introduction

Ecosystems provide environmental resources that promote human well-being (Millennium Ecosystem Assessment [MA], 2005). However, the predatory exploitation of these resources has exceeded the natural regenerative capacity to rebuild the environmental assets necessary for human activities and ecological balance (Arriagada & Perrings, 2011; Steffen *et al.*, 2011). The excessive consumption results in biodiversity loss, species vulnerability and genetic impoverishment of populations (The Economics of Ecosystems and Biodiversity [TEEB], 2010). For this reason, an alternative to improve the balance of natural resource provision and conservation is the use of environmental management mechanisms, such as payment for environmental services (PES) (den Uyl & Driessen, 2015; Jackson & Palmer, 2015; Pellegrino *et al.*, 2017; Puydarrieux & Mésenge, 2018; Wunder *et al.*, 2018, 2014). In these systems, producers receive proceeds from beneficiaries, who make direct payments, through a contract that specifies conditions to provide an environmental service (Hanley & White, 2014; Minaverri, 2016; Wunder, 2015, 2005). These services are converted into environmental assets, such as water, forest resources, climate protection or soil regeneration.

The Organization for Economic Cooperation and Development (2005) defines "environmental good" as services provided for the prevention and control of pollution, with the use of natural resources. This may include air pollution control, waste and effluent management, reducing soil and water contamination, adopting clean technologies, conserving forests and natural resources, and reducing disasters.

Environmental services were classified by the Millennium Ecosystem Assessment (2005) in four groups. The provisioning group is related to products obtained from ecosystems, such as food, fuel, fiber, fresh water, and genetic resources. The cultural group encompasses non-material benefits (spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences). The regulators are those linked to the maintenance of air quality, climate regulation, erosion control, flood and drought regulation and water purification. The support services are related to the production of oxygen and soil formation, which are indispensable for ecological functions.

However, there are other activities that promote ecosystem services, such as those carried out by waste pickers of recyclable materials. These workers are fundamental to the recycling chain that contributes to reduce the amount of waste sent to landfills (Sant'ana & Metello, 2016) and the exploitation of virgin raw materials, which consequently diminishes energy costs (Damásio, 2010; Instituto de Pesquisa Econômica Aplicada [IPEA], 2010; Ribeiro *et al.*, 2014; Silva *et al.*, 2013) and atmospheric emissions (Silva, 2017; Burneo *et al.*, 2020). In addition, it minimizes the environmental and health impacts of inadequate waste disposal (Oliveira, 2011; Siqueira & Moraes, 2009).

A survey developed by the World Bank showed that recycling percentages in the world are uneven and depend on cultural, economic, and social factors, and on technological waste management models. In Europe and Central Asia 20% of waste is recycled. In North America 33.3%. In Latin America and the Caribbean, Middle East and the North African region, South Asia, East Asia, and Pacific recycling rates are 4.5%, 9%, 4% and 9%, respectively, with active pickers and strong participation of the informal sector. Sub-Saharan Africa has recycling rate of 7%, but recycling initiatives are most common in touristic cities (Kaza *et al.*, 2018).

Waste pickers are important especially in the stages of collection, segregation, packaging, storage, and routing to recycling plants (Silva, 2017). The hiring of waste pickers has obtained positive results in municipalities that adopted this model, with increases in the amount of material collected, improvements in the income of collectors, reductions in landfilled waste, and in the costs of collection and final disposal (Oliveira, 2011; Ribeiro *et al.*, 2014; Sant'ana & Metello, 2016).

According to IPEA (Institute of Economic and Applied Research) of Brazil, waste pickers are doing an important environmental service. They contribute to recycling, as this activity allows a reuse of materials that were extracted from natural environments and transformed into consumer goods, guaranteeing, and maintaining the integrity of ecosystem services, such as climate regulation, soil formation and the supply of drinking water, among others. These add up to the reduction of material discarded in the environment, which offers positive externalities in urban environments (IPEA, 2010).

Urban environmental services are related to public services, such as proper waste disposal, water quality improvement, reduction of greenhouse gas emissions, sewage treatment and maintenance of green areas (IPEA, 2010). Most of these services are pure public goods; meaning that users cannot be restricted from their use and the consumption of one individual does not affect that of another (no rivalry). Thus, the public strength of an incentive policy comes from the buyer on behalf of a collective, which, through hiring, pays participants in PES systems for conservation practices (Raes *et al.*, 2016; Vatn, 2015, 2010; Zhang, 2016).

Thus, waste pickers develop activities with environmental conservationist character and contribute to reduce the negative externalities of waste management in urban areas. Therefore, their activities should be compensated through PES (IPEA, 2010).

The objective of this article is to show results of a literature review on PES, to verify if it is being adopted for waste pickers' activities.

The main contribution of this work is to identify the important characteristics of public contracts with associations of waste pickers for urban solid waste management, and to verify the applicability of PES to this context.

2. Method

The bibliographic research used the method of systematic mapping of literature, which consists of categorizing the existing literature, considering qualitative and quantitative aspects (Grant & Booth, 2009).

The research strategy focused on two fields: economic literature on PES, and literature on recycling with waste pickers to identify and discuss scientific articles that address the theme 'Payment for Environmental Services - PES for Waste pickers'. The central idea was to find if, where, and how waste pickers are being recompensed for the environmental services they provide. The first step was to investigate the economic literature about PES, aiming to understand its application, geographical regions, and essential characteristics. As the provision of these environmental services, in many cases, is characterized as public services, in the second stage, manuscripts that

reported the hiring of waste picker organizations by the government were searched. The aim was to detect characteristics of this model for waste management and likely payment applications for environmental services. And finally, it aimed to establish relationships between the PES systems and the public hiring of waste pickers to identify convergences and gaps in literature.

The investigated period was from 2009 to 2019, observing, for 10 years, how science approached payment for environmental services. The keyword groups used and their combinations with boolean operators are described in Table 1.

The search for primary studies was conducted in Scielo, Pubmed, Web of Science, LiLacs, EconLit and Scopus, including only academic articles. The choice of the platforms was based on the areas of knowledge related to the research topic and its relevance, e.g., EconLit, is a platform that focuses on publications in economics, including studies of environmental economics and environmental public policies. Lilacs is also an important platform for the subject, geographically, considering similarities between Latin American countries.

The files in RIS, BIBTEX and MEDLINE format were extracted from the platforms and imported into the Start software. Start is a free program developed by the Software Engineering Research Laboratory of the Federal University of São Carlos - UFSCar. In this program, it is possible to insert inclusion and exclusion criteria to define the works that will be accepted or rejected and to produce a synthesis of the research results. Appendix A is the summary of results and Appendix B is the spreadsheet of selected papers.

The studies were selected using inclusion and exclusion criteria. In the first phase of the research, the established criterion was to contain in the title the defined keywords. The second selection phase was carried out observing if the work referred to the subject studied, evaluating the title and the abstract. Duplicate works were excluded, and no geographical restriction was applied.

The systematization and classification of the studies consisted of selecting them by source (author and year of publication), geographic location (country and continent), area of environmental service provision (rural or urban), theoretical studies and main themes addressed in the studies.

To analyze the data extracted, key information was verified during the reading of articles that dealt with the hiring of waste collectors. Items analyzed were the location of the study, forms of integration of waste pickers organizations as public service providers, values of hiring or received by waste collectors, working conditions and the process of formalization of the sector based on incentive policies.

In addition, the quantitative return of the platforms was important information, indicating the development of this study theme in each area.

Preliminary tests were performed on the data bases selected for the study with the search strategy "payment for environmental services for waste pickers' cooperatives", but this search was not successful in any of the bases consulted. Therefore, it was necessary to fragment the strategy into two separate searches: in the first phase using "payment for environmental services" and in the second, using "Recyclable waste pickers" AND "Recycling" (Table 1).

Table 1. Search Strategies Employed

Platform	Search 1	Search 2
<i>Scopus</i>	("Payment for environmental services") AND (LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2011) OR LIMIT-TO (PUBYEAR, 2010) OR LIMIT-TO (PUBYEAR, 2009) (DOCTYPE, "ar"))	recycling AND recyclable AND waste AND pickers AND (LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2011) OR LIMIT-TO (PUBYEAR, 2010) OR LIMIT-TO (PUBYEAR, 2009) AND (LIMIT-TO (DOCTYPE, "ar"))
<i>Web of Science</i>	("Payment for environmental services") Allotted time: (2019 OR 2015 OR 2011 OR 2018 OR 2014 OR 2010 OR 2017 OR 2013 OR 2009 OR 2016 OR 2012).	(Recycling AND Recyclable waste pickers) (2019 OR 2015 OR 2011 OR 2018 OR 2014 OR 2010 OR 2017 OR 2013 OR 2009 OR 2016 OR 2012).
<i>PubMed</i>	((Payment) AND environmental) AND services	(Recycling) AND Recyclable waste pickers
<i>Scielo</i>	"payment for environmental services" AND year_cluster:("2016" OR "2015" OR "2011" OR "2010" OR "2014" OR "2017" OR "2019" OR "2009" OR "2018" OR "2012" OR "2013") AND type:("research-article")	(*recycling) AND (recyclable waste pickers) AND year_cluster:("2015" OR "2014" OR "2017" OR "2016" OR "2018" OR "2013" OR "2012" OR "2011" OR "2010" OR "2019" OR "2009") AND type:("research-article")
<i>EconLit</i>	((Payment) AND environmental) AND services	Recycling AND Recyclable waste pickers
<i>Lilacs</i>	tw:((tw:(payment)) AND (tw:(environmental)) AND (tw:(services))) AND (year_cluster:[2009 TO 2019])	tw:((tw:(recycling)) AND (tw:(recyclable waste pickers))) AND (db:("LILACS")) AND (year_cluster:[2009 TO 2019])

Source: Elaborated by the authors

3. Results and Discussion

3.1 Studies Identified in the Systematic Mapping of the Literature

The bases consulted in search 1 returned 2,082 articles. Considering the total number of papers, the platforms with more results were PubMed and Scopus, with 29% each. EconLit identified 19% of the articles, followed by Lilacs with 11%, Web of Science with 10% and Scielo 2%. The papers selected in the first phase, had "payment for environmental services" in the title. In the second phase, the subject was observed in the title and the abstract. Duplicate works were excluded, and no geographical restriction was applied. From the first selection to the second, 1,040 articles were eliminated, and 34 duplicate works were discarded, leaving 1,008.

In the next phase, 290 works that did not meet the inclusion criteria were eliminated. Thus, 710 studies were systematized, and classified according to the origin of the environmental service studied, whether in rural or urban areas, or being theoretical research. A total of 569 papers addressed topics related to environmental services in rural environments, 20 in urban areas and 121 were theoretical studies. For the theoretical studies, where it was not possible to identify the geographical location of the case studied, the origin of the researchers was considered.

The term "payment for environmental services - PES" or its similar ("payment for ecosystem services" or "payment for ecological services") appeared 448 times, in titles or keywords in surveys conducted in countries such as the United States, England, China, Colombia, Australia and Morocco. Showing that this is a consolidated term in international literature.

The countries where the studies were carried out from 2009 to 2019 are diverse and are in all continents. However, Brazil, China, Indonesia, United States and Mexico stand out.

South America is the continent where authors investigated most about payment for environmental services in the period, accounting for 26% of the studies. North America and Asia published 24% and 21% of the manuscripts,

respectively (Table 2).

The main issues addressed in the papers were forest conservation (23.10%), environmental management (13.74%), PES implementation (15.50%), water resource conservation (11.70%), participation of farmers (8.92%), local participation (7.75%) and PES design (7.60%) (Table 2). The classification of studies in these categories was carried out according to the themes covered in the paper.

Table 2. Places and themes of studies on Payment for Environmental Services published (2009 to 2019)

Continent	%	Country	%
Oceania	3	Vietnam	2.6
Africa	9	Ecuador	3.0
Europe	17	Australia	3,1
Asia	21	Colombia	3.2
North America	24	Indonesia	4.3
South America	26	China	4.7
		Costa Rica	6.3
		USA	8.0
		Mexico	8.5
		Brazil	11.3
Main Themes Addressed in Studies about PES			%
Indigenous participation			1.32
PES as Concept			2.0
PES Impact			2.92
Climate Change			3.36
PES Design			7.6
Local participation			8.0
Farmer Participation			9.0
Water Resource Conservation			11.7
Environmental management			13.74
PES Implementation			15.0
Forest Conservation			23.10

Source: Results of the literature review prepared by the authors.

The conservation of forests is addressed in PES systems that aimed to climate maintenance and the preservation of biodiversity and ecosystems. PES is used as a tool for environmental management of territories with a focus on sustainability and conservation. There are studies that have a theoretical character and address the design and implementation of systems. Water resources conservation, local, and farmers' participation are themes that are addressed in systems that aim to preserve water quality and watershed areas, as well as ways of engaging residents, indigenous and farmers.

As manuscripts that address payment for environmental services for waste pickers were not identified, the second strategy was adopted as previously described. The key terms used were "Recyclable waste pickers" AND "Recycling". The same criteria were used for the selection of the articles, in first and second stages. This analysis was applied to 233 articles, and Scopus was the platform that returned most results (65%). The Web of Science platform obtained 15%, followed by 14% from PubMed, 5% from Scielo and Lilacs each, and 1% from EconLit. Of this total, 26 were excluded for being duplicates, only 13 entered the two selection phases, and had their results systematized.

This shows that 'payment for environmental services' is not yet a consolidated term in the literature regarding waste management, mainly applied in systems for waste pickers. Based on this result, it was decided to evaluate the papers on the hiring of waste pickers, as the PES systems for waste pickers would fit into this field because it

consists of public services of collective provision. In addition, the theoretical papers of research 1 were used to discuss the converging characteristics among PES systems and public hiring of waste pickers.

The regions of the globe where recycling and waste pickers are most studied are Latin America, Asia, and Africa, mainly in Brazil, China, South Africa, and India. The studies address informality, working conditions and the transition from informal management systems to formal public service management (Table 3).

The themes most studied were waste management (29.9%), the informal work of waste pickers (24.1%) and occupational health (14.3%) (Table 3). The management of urban solid waste is mainly addressed in studies that show indicators of generation, treatment, final disposal, and operational control measures. Informal work is discussed as a recurrent theme on the activities of waste pickers in urban areas and dumps, highlighting the precarious working conditions of adults, elderly, and children in vulnerable situations. Occupational health appeared highlighting the conditions and risks of the work performed by waste pickers with diseases such as hepatitis, HIV, and chronic diseases, including diabetes and hypertension. The classification of studies in these categories was carried out according to the themes covered in each paper.

The results in table 3 confirm data presented by the World Bank survey (Kaza *et al.*, 2018). Countries in Asia, South America and Africa continue to rely on the work of waste pickers. This may reflect the social context of these regions, where informality of waste pickers, precarious and unhealthy working conditions, and shortage of investments for improving waste management systems are main challenges for local governments.

The hiring of cooperatives or associations to provide environmental services was the focus for this literature review. Thus, 5.8% of the papers were selected for an in-depth analysis. These manuscripts, mostly, do not explain the provision of environmental services by waste pickers, but were chosen because they consider the provision of services by waste picker organizations as a public service, indicating a transition from informal work systems to public management of sanitation services, with the socio-productive inclusion of waste pickers. This transition might be important for the recognition of this worker as an environmental service provider.

These investigations were conducted in Brazil, Philippines, Tanzania, China, Chile, South Africa, and Colombia. Half of those were Brazilian case studies. This expressive contribution of Brazil in research on this theme is due to the model adopted in the country, with policies that encourage the integration of waste pickers in waste management systems. Examples are the recognition of the profession by the Brazilian Code of Occupations (BCO) (Brazil, 2002) and the National Solid Waste Policy - Law n°. 12 305 (Brazil, 2010a) and Decree n° 7 404 (Brazil, 2010b), which provide for the socioeconomic inclusion of waste pickers. In addition, the country has a strong articulation of the National Movement of Waste Pickers (MNCR) to improve the work conditions of waste pickers and expand recycling. MNCR joins the Latin American and Caribbean Recyclers Network (Red LACRE), which is a founder of the Global Recyclers Alliance that brings together waste pickers' associations from Latin America, Asia, and Africa (Global Recyclers Alliance, 2020; MNCR, 2011; Rede Lacre, 2020). Due to these public policies, there are 1.829 waste pickers' organizations, according to the yearbook of the National Association of Waste Pickers of Recyclable Materials and Pragma Solutions Sustainable (2020).

Table 3. Place and theme of Studies on Recycling from 2009 to 2019 as (%)

Continent	%	Country	%
Oceania	0.4	Nigeria	0.9
North America	4.0	Canada	1.3
Europe	7.0	Pakistan	1.7
Africa	13	USA	2.1
South America	48	Indonesia	4.3
Asia	27	India	5.6
		South Africa	6.0
		China	6.4
		Brazil	33.5
Main Themes of Studies on Recycling			%
Impact of Waste on the Environment			1.3
Selective Colletion			1.8
Waste Pickers in Landfills			1.8
Circular Economy			1.8
Social Tecnology			2.2
Reverse Logistics			3.1
Recycling potential			3.6
Cooperative Contracting			5.8
Work Conditions			6.3
Occupational Health			14.3
Informal Work			24.1
Waste Management			29.9

Source: Results of the literature review prepared by the authors.

3.2 Hiring of Waste Pickers Organizations

The mapping allowed us to verify that the research on waste pickers still address issues mainly related to waste management and labor difficulties of waste picker activities (Coelho *et al.*, 2016; Gutberlet & Uddin, 2017; Kumar *et al.*, 2018; Martin *et al.*, 2019). This allows us to infer that, in general, countries still face basic difficulties, without progressing to deeper discussions on the socio-productive insertion of waste pickers in payment systems for environmental services.

Studies on the hiring of waste pickers for public service have indicated that countries are implementing policies to integrate waste pickers into formal systems of work, such as the research developed by Godfrey *et al.* (2017) in South Africa and Paul *et al.* (2012) in the Philippines. However, actions are insufficient to reduce environmental impacts and socially insert an excluded population. Studies do not identify the activities of waste pickers as provision of environmental services. In most cases, their work is understood as public services or as urban cleaning services for waste management. Only in the research by Rutkowski & Rutkowski (2015) in the cities of Londrina and Natal, in Brazil, and by King & Gutberlet (2013), in Ribeirão Pires, also in Brazil, there are mentions to the work of waste pickers as environmental services. In the first case, as an environmental educator (waste pickers receive per bag delivered to houses with information for selective collection). In the second case, the study calculated how much a cooperative contributed to reducing greenhouse gas emissions, concluding it reduced 1,434 - 3,241 t of CO₂- eq./year. However, both studies do not mention 'environmental service' or recognized the environmental work provided.

The papers are mainly linked to urban cleaning services (Charles, 2019; Martínez & Piña, 2017; Silva & Bolson, 2018), the reduction of clogging of urban drainage systems, important for adapting to climate change (Paul *et al.*, 2012), the diminution of waste sent to landfills and, consequently, an increase in their useful life, (Fergutz *et al.*, 2011; Godfrey *et al.*, 2017; Silva & Bolson, 2018).

The reuse of materials in production cycles (Paul *et al.*, 2012; Rebehy *et al.*, 2017), pollution control (Rutkowski & Rutkowski, 2015), environmental protection (Navarrete-Hernandez & Navarrete-Hernandez, 2018), minimization of environmental impacts (Charles, 2019; Martínez & Piña, 2017; Silva & Bolson, 2018), reduction of pressure on resources (Navarrete-Hernandez & Navarrete-Hernandez, 2018; Yang *et al.*, 2018) and potential benefits for public health are other benefits from the collection of materials by pickers (Marello & Helwege, 2018).

Regarding socioenvironmental impacts and their relationship with the services provided by waste pickers, the manuscripts show the potential for generating employment (Charles, 2019), income (Silva & Bolson, 2018) and training for workers (Charles, 2019). Few papers highlight the waste picker's recognition as an environmental educator in their communities (Oliveira & Góes, 2019; Rutkowski & Rutkowski, 2015), fostering empowerment and change in the social status of these workers (Rebehy *et al.*, 2017).

The money compensation they receive is, in many situations, less than a minimum wage, even if their work has contributed to an increase in the rates of recovered materials and a reduction in selective collection costs (Fergutz *et al.*, 2011; Godfrey *et al.*, 2017; Navarrete-Hernandez & Navarrete-Hernandez, 2018). The values received by the waste pickers hired indicate that there is no standardized information, making it somewhat difficult to systematize the results. In some cases, the values of the contracts are evident, as in Santa Cruz do Sul, in Brazil, where the group of waste pickers signed an agreement with the city worth R\$ 31,000 (US \$ 5,545) (Oliveira & Góes, 2019). In other studies, such as those carried out in Santiago, Chile, and Iloilo, Philippines, it is only noted that the collectors have a guaranteed monthly income, without mentioning values (Navarrete-Hernandez & Navarrete-Hernandez, 2018; Paul *et al.*, 2012). Only Rutkowski & Rutkowski (2015), for 25 Brazilian cities, and by Martínez & Piña (2017), for Bogotá, Colombia, mention values. The studies show that in Brazil the waste pickers receive on average from 1 to 2 local minimum wages.

Other papers state that waste pickers receive fees from municipal collection services, as is the case evidenced by Charles (2019) in Dar es Salaam, in Tanzania, and by Rutkowski & Rutkowski (2015) who studied Brazilian cities. In the Brazilian case, the payment formula is based on a set of variables, with a fixed part and another variable (volume of collected material; number of absences from work; complaints of the residents). This shows that the environmental service is still largely unconsidered even when there is payment for waste pickers.

The waste pickers' income is made up of the amount received for the fees, or payment for the collection, processing and forwarding services for recycling, and the sale of recyclable materials (Charles, 2019; Martínez & Piña, 2017). In other cases, they do not receive cash, but the infrastructure for operating the service, such as rent of a warehouse, purchase of equipment, purchase of trucks, hire of drivers for selective collection and fuel supply (King & Gutberlet, 2013; Marello & Helwege, 2018; Oliveira & Góes, 2019; Paul *et al.*, 2012; Silva & Bolson, 2018).

Comparing the income of the waste pickers, the Brazilian waste pickers received higher wages, on average 268 dollars per month approximately, US\$179 to US\$358 (Rebehy *et al.*, 2017; Rutkowski & Rutkowski, 2015; Silva & Bolson, 2018). It is higher than that received by the Colombian waste pickers who earn less than 1 local minimum wage per month (Martínez & Piña, 2017), based on a rate of US\$ 10 cents per kg of recyclable material recovered.

South African earns around 176 US dollars a month (Godfrey *et al.*, 2017) and Filipino earns approximately 90 to 150 US dollars (Paul *et al.*, 2012). This results from investments in infrastructure and greater support for the integration of waste pickers into systems of public service provision of socio-productive inclusion. The cases in which waste pickers had the highest returns were those with investments in infrastructure. According to Navarrete-Hernandez & Navarrete-Hernandez (2018), in cooperatives supported by the local government, in Chile, investments in equipment increase the recovery rate of waste pickers by 2,380 kg/hour of work, the adoption of motorized vehicles increases at 0.44 times/month, productivity and institutionalization increases the yield by 0.93 times.

With the hiring of cooperatives, improvements in working conditions and in productivity have been achieved: switching from animal-drawn vehicles to self-propelled vehicles (Martínez & Piña, 2017; Silva & Bolson, 2018), division of functions, training, team engagement (Charles, 2019), implantation of sorting and processing centers (Fergutz *et al.*, 2011; Paul *et al.*, 2012; Silva & Bolson, 2018), payments for services according to productivity (Martínez & Piña, 2017), removal of waste pickers from the waste disposal site (Fergutz *et al.*, 2011). In Nicaragua and in the Philippines waste pickers have stopped working in dumps to operate in waste sorting centers with access to water, sanitation, and protective equipment (Marello & Helwege, 2018; Paul *et al.*, 2012).

Other relevant results for waste management were: increased recycling rates (Fergutz *et al.*, 2011; Godfrey *et al.*, 2017; Navarrete-Hernandez & Navarrete-Hernandez, 2018; Rutkowski & Rutkowski, 2015), as in Ribeirão Pires, from 10 tons to 30 tons per month (King & Gutberlet, 2013), and in Nicaragua; increase in plastic recovery

(Marello & Helwege, 2018); reduction in public spending due to lower costs for recycling (Rutkowski & Rutkowski, 2015); strengthening of enterprises; networking of cooperatives promoting the direct trade of recyclables with industry (Marello & Helwege, 2018); increase in the number of recycling industries (Fergutz *et al.*, 2011). In Brazil, a network of cooperatives in the Metropolitan Region of São Paulo quintupled the sale price of materials (Marello & Helwege, 2018). Moreover, according to Navarrete-Hernandez & Navarrete-Hernandez (2018), hired waste pickers recover almost three times more toxic materials, and more types of materials than other waste pickers.

The social results include minimization of the vulnerability of waste pickers, greater work stability, opening a bank account, accessing social and health insurance (King & Gutberlet, 2013; Paul *et al.*, 2012); social mobility and poverty reduction, by improving income (Navarrete-Hernandez & Navarrete-Hernandez, 2018; Paul *et al.*, 2012; Rutkowski & Rutkowski, 2015); reduction of the social stigma that devalues waste pickers (Godfrey *et al.*, 2017; Oliveira & Góes, 2019; Paul *et al.*, 2012).

Nevertheless, the inclusion of waste pickers still faces difficulties related to the stability of enterprises and jobs. Examples are: insufficient capital of cooperatives; limited access to loans and lines of credit (Charles, 2019; Fergutz *et al.*, 2011; Martínez & Piña, 2017; Paul *et al.*, 2012); lack of infrastructure; limited space, machinery and equipment (Charles, 2019; Godfrey *et al.*, 2017; Martínez & Piña, 2017; Silva & Bolson, 2018); unhealthy work environment (Silva & Bolson, 2018); exhaustive working days (Silva & Bolson, 2018); limited government support (Charles, 2019; Godfrey *et al.*, 2017; Yang *et al.*, 2018); political instability of ties between cooperatives and governments (Marello & Helwege, 2018); short incubation period (Godfrey *et al.*, 2017; Paul *et al.*, 2012; Rutkowski & Rutkowski, 2015); low level of schooling of waste pickers and little business experience (Charles, 2019; Godfrey *et al.*, 2017; Marello & Helwege, 2018; Martínez & Piña, 2017; Navarrete-Hernandez & Navarrete-Hernandez, 2018; Paul *et al.*, 2012; Rebehay *et al.*, 2017); and informal work, with occupational risks and soil and water contamination (Paul *et al.*, 2012; Yang *et al.*, 2018).

Additional challenges for associations of waste pickers pointed in the articles are: the volatility of prices of material (Charles, 2019; Marello & Helwege, 2018; Martínez & Piña, 2017; Paul *et al.*, 2012; Silva & Bolson, 2018); the expansion of selective collection and the promotion of a culture of waste segregation (Charles, 2019; King & Gutberlet, 2013; Marello & Helwege, 2018; Martínez & Piña, 2017; Oliveira & Góes, 2019; Rutkowski & Rutkowski, 2015; Silva & Bolson, 2018); the insertion of technological means (containers and robotic collection) (Martínez & Piña, 2017; Oliveira & Góes, 2019; Yang *et al.*, 2018); dependence on intermediaries for trading (Paul *et al.*, 2012; Silva & Bolson, 2018; Fergutz *et al.*, 2011); and oligopolist recycling industries (Silva & Bolson, 2018).

Given the need to incentivate and to support activities that provide environmental positive impacts and social inclusion, the economic literature points to some instruments, as PES systems (Rodríguez *et al.*, 2011; Wünscher & Wunder, 2017). According to Rodríguez *et al.* (2011), they provide conservation of natural resources and poverty alleviation. For this, an appropriate and consistent amount of compensation must be defined, using a variable benefit formula with fixed payments, providing more benefits to poorer participants who provide more environmental services (Raes *et al.*, 2016; Tacconi, 2012; Vorlauffer *et al.*, 2017; Wunder *et al.*, 2018; Zabel & Roe, 2009). Bullock *et al.* (2011) and Wunder *et al.* (2018) add that it is necessary to develop local and regional institutional structures to address the complexity of PES systems (Engel, 2016; Fauzi & Anna, 2013; Fernandes & Botelho, 2016; Hanley & White, 2014; Kerr *et al.*, 2014; Legrand *et al.*, 2013; Muradian *et al.*, 2010; Van Hecken *et al.*, 2012; Vatn, 2010; Wang *et al.*, 2017), as well as to bear the costs of restauration and to mediate possible conflicts of interest (Banerjee *et al.*, 2017; Pascual *et al.*, 2010; Vatn, 2015).

Börner *et al.* (2017) and Wunder (2015) understand that adaptative management of PES systems is an important strategy in the application of policies in complex intervention contexts, capable of correcting possible design flaws during system implementation (Engel, 2016; Smith *et al.*, 2019; Tacconi, 2012; Van Hecken *et al.*, 2012; Wunder *et al.*, 2018).

Houdet *et al.* (2012) point that many organizations and public policies must consider ecological principles in the adoption of technologies, raw materials, products, and energy sources (Prager *et al.*, 2016). These principles go beyond the mitigation of impacts and consider development coupled with environmental conservation (Pistorius *et al.*, 2012). This approach makes the environmental factor essential in decision-making and management of assets, liabilities, skills, and technological innovations. Governments should consider the environmental factor in decision-making, in a practical way, encouraging conservationist actions, such as the work developed by the collectors by inserting them in their waste management models.

Among the benefits identified in the studies regarding the work of waste pickers in public hiring are: recognition

of the service provided (Martínez and Piña, 2017; Rutkowski & Rutkowski, 2015); social and environmental solution for waste management (Charles, 2019); creation of links in the waste value chain (Charles, 2019; Godfrey *et al.*, 2017); reduction of accidents at work and of working hours (Navarrete-Hernandez & Navarrete-Hernandez, 2018); promotion of a strategic link between the collector and the local community (Fergutz *et al.*, 2011; Rebehy *et al.*, 2017; Rutkowski & Rutkowski, 2015); reduction of informal work (Navarrete-Hernandez & Navarrete-Hernandez, 2018; Rutkowski, 2013); reduction of poverty, inequality and vulnerability (Rebehy *et al.*, 2017; Rutkowski & Rutkowski, 2015; Yang *et al.*, 2018); minimization of extraction of virgin raw material, consequently, decreasing deforestation and loss of natural habitat (Rebehy *et al.*, 2017).

Some of these positive aspects are also in the literature on PES systems, as it is emphasized that social groups that have the greatest influence over a given target population can help by promoting conservationist behavior and efforts to promote the belief that this is important. PES implementation can be more successful through inclusive design, with the participation of local institutions and individuals who have intrinsic and extrinsic motivations (Handberg & Angelsen, 2019; Kallis *et al.*, 2013; Pirard *et al.*, 2010; Tacconi, 2012). The intrinsic motivations are part of the particularities of everyone to be part of the PES system, and extrinsic motivations are the attractions of the project, which move each participant towards a collective aim (Ezzine-de-Blas *et al.*, 2019). According to Börner *et al.* (2017), motivation is an important factor in the long term, potentially putting the provision of services at risk, i.e., a provider may decrease provision compared to the initial periods of the PES system, due to decreased payment or motivational issues.

Despite positive factors, there is a need for structuring public authorities to hire waste picker organizations (Godfrey *et al.*, 2017), and to recognize and provide incentives through resources to integrate them into the formal municipal services (Charles, 2019; Martínez & Piña, 2017). There is also a need to train government teams to coordinate and supervise the integration of waste pickers in their legalization into associations and the construction of support systems, with financial and human resource infrastructure and training (Paul *et al.*, 2012; Rutkowski, 2013; Rutkowski & Rutkowski, 2015; Silva & Bolson, 2018).

For the organizations to remain in recycling market, there is an underlying need to evaluate the potential of recyclable materials, new markets, local supporters (Paul *et al.*, 2012), to create a committee of co-financing with participation of local companies, a national network of marketing of recyclables, an investment and exchange fund with waste pickers and recycling industries (Fergutz *et al.*, 2011), to consolidate business, and partnerships with productive sectors and industries (Martínez & Piña, 2017). It is also important that the partnering municipalities ensure the necessary infrastructure, with the acquisition of processing machines, vehicles, and warehouses for waste storage (Navarrete-Hernandez & Navarrete-Hernandez, 2018). These actions would strengthen these organizations, so that, in the long term, they decrease their dependence on public subsidies (Rutkowski & Rutkowski, 2015). Understanding this context is essential to design a socio-productive system for waste pickers, considering adaptive management, including public, institutional, and private sector in favor of a circular chain, which will provide, over time, socio-financial autonomy for waste pickers.

Low and middle-income countries have, globally, about 15 million collectors, who classify, collect, transport, and sell waste (Yang *et al.*, 2018). Marelló & Helwege (2018) point out that inclusion is not a fair and far-reaching process because the forms of integration and exclusion are not clear. Inclusion efforts guarantee income for some workers, limiting the participation of others who do not have social networks that fit into the institutionalized structure.

It is in this sense that the waste picker organizations seek to build, in partnership with public authorities, projects that are aligned with their essential characteristics and their inclusion in circular production systems (Silva & Bolson, 2018). These proposals strengthen waste picker organizations and promote dialogue among agents in this chain, recognizing the political, economic, and social aspects that are inherent to the performance of each social actor (Fergutz *et al.*, 2011).

In general, the literature review showed that there are characteristics of public procurement by waste picker organizations that are also relevant in PES systems, such as the promotion of conservationist behaviors, the environmental education of the local community and the consideration of the environmental factor in public management of public services for collective use. Moreover, the use of PES systems can be an important tool for waste management in territories where it is desired to reduce informal work and poverty, considering the local socio-ecological context, with the engagement of institutions, in favor of adaptive management in the control of pollution caused by residues, and in generation of decent jobs (Figure 1).

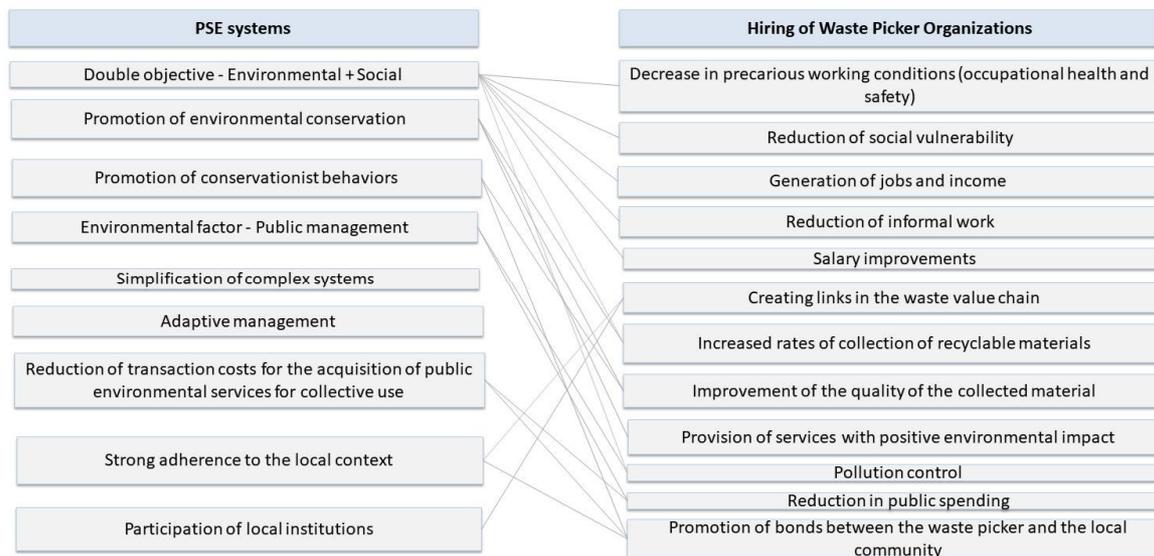


Figure 1. Congruent characteristics between PES systems and public procurement of waste pickers organizations. Source: Elaborated by authors

The interrelationships of the PES systems and the public hiring of waste pickers, shown in figure 1, highlight the double objective (Bullock *et al.*, 2011; Rodríguez *et al.*, 2011). In the environmental aspect it would encourage an increase in recycling rates (Fergutz *et al.*, 2011; Godfrey *et al.*, 2017; Navarrete-Hernandez and Navarrete-Hernandez, 2018) and, consequently, greater control of the negative impacts of waste on the environment (Rutkowski, 2013; Yang *et al.*, 2018). The social objective (Bullock *et al.*, 2011; Rodríguez *et al.*, 2011) is related to improving working conditions (Navarrete-Hernandez & Navarrete-Hernandez, 2018), reducing social vulnerability, generating employment and income, reducing informal work and low earnings (Navarrete-Hernandez & Navarrete-Hernandez, 2018; Rutkowski, 2013). This set of benefits is based on structuring the work of waste pickers, their formalization and public investment for the development of this activity. The PES system would become attractive and stimulating to reduce informality in this sector, inducing the inclusion of waste pickers in formalized organizations, while providing better payments, considering the environmental factor. This would be a mechanism for minimizing the social fragility of these workers and would reduce the financial instability of waste pickers' cooperatives.

Environmental education of the local community in PES systems is one of the main instruments for their success (Kerr *et al.*, 2017). According to the literature, in places where waste pickers work in partnership with the government there is a bond between the waste pickers and the local community (Fergutz *et al.*, 2011; Rebehy *et al.*, 2017), providing motivation and the development of conservationist behaviors that can culturally transform a more environmentally committed and responsible population. In this model there is an improvement in the quality of the recyclable material collected (Fergutz *et al.*, 2011; Rutkowski, 2013), precisely because of the awareness and guidance work carried out with the population. This allows obtaining better sales prices for these materials, use of materials, and lower levels of waste sent to landfills, dumps or incinerators.

PES systems would have a close relationship with pollution control (Houdet *et al.*, 2012; Vatn, 2015, 2010; Wunder *et al.*, 2018), by encouraging and financing conservationist programs, metrics, and indicators of environmental (Kroeger, 2013). The environmental factor is also directly related to the reduction of public spending (Wunder *et al.*, 2018), by lower cost of the service (Oliveira & Góes, 2019; Ribeiro *et al.*, 2014; Sant'ana & Metello, 2016), and by reducing externalities caused by inadequate waste management.

In the local context, the promotion of the bond between the waste pickers and the community has the potential to develop the feeling of belonging both in the system providers (waste pickers) and in the population (Fergutz *et al.*, 2011; Rebehy *et al.*, 2017). At the regional level, this aspect relates to the links in the value chain formed in the context of recycling (Charles, 2019). These interrelationships generate synergies in favor of the PES system in expanded links between local institutions from various sectors interested in reducing the externalities caused by waste, the circularity of recyclable materials, and the generation of jobs and income in a fair and equitable manner.

4. Conclusions

The mapping showed that the scientific literature on payment for environmental services has focused in recent

years on rural environments, mainly for the conservation of water and forest resources. However, human activities in urban areas, mainly based on predatory models of exploitation, have contributed greatly to the ecological imbalance. For this reason, the studies highlight the need for the recognition of labor practices that have a conservationist character, such as the work carried out by waste pickers of recyclable materials, because of their contribution for reducing materials disposed in sanitary landfills, of energy expenses and of extraction of natural resources.

Moreover, the mapping evidenced that there is a scientific gap in the literature. The work of waste pickers is not yet being related to environmental services or, perhaps, this literature is being disseminated in journals not indexed in the scientific platforms. Another possibility is that the lines of research are not converging; as observed in the data, investigations on payments for environmental services are concentrated in rural areas. On the other hand, those who approach the hiring of waste pickers do not directly link the subject with environmental services. Thus, it is necessary to integrate these two lines of research and improve their development, given that most of the articles synthesized in this mapping point to the need and to the environmental relevance of the work of waste pickers.

The literature on the hiring of waste pickers did not show the relationship of the work undertaken with the environmental services for which they are facilitators. These studies still address primary problems such as labor hardships, informality, and occupational risks. This indicates that public policies, with the application of economic instruments, such as payments for environmental services for waste pickers, is a new theme, hardly discussed by countries, mainly because they still face basic problems of transition from informality to contracting for public services.

Studies have evidenced that in cases when cooperatives were hired by local governments, improvements in working conditions have been achieved, providing healthier and safer environments, in addition to improving the life conditions of waste pickers, offering the opportunity for social mobility to a population historically excluded and stigmatized by the activity. In the environmental sphere, the recognition of the service provided, and the structuring of projects provide higher recycling rates, in partnership with the community, which has the greatest potential for the development of social technology capable of promoting structural changes linked to consumption habits and the responsibility for waste after its disposal. The waste pickers as facilitators in this process become environmental agents, public service providers and entrepreneurs.

Another important finding of the research was to identify characteristics of payment systems for environmental services from the economic literature and to relate them to relevant aspects pointed out in research on public hiring of waste pickers for the management of recyclable waste. This comparison showed important congruencies between these two modes of management, such as the promotion of conservationist behaviors, the environmental education of the local community, the consideration of the environmental factor in the public management of public services for collective use, and the reduction of public spending.

The mapping reflects the situation of several countries, in Asia, South America and Africa, where waste pickers have a strong acting, working in an organized manner in cooperatives, but also, in informality, in adverse conditions of social vulnerability and unhealthy activity. This shows the importance of more public investments and policies for waste pickers. A possible solution to this issue is the application of the PES, as this research indicated. Based on the principles of sustainability the focus would be on the circularity of the materials, reducing the impacts caused by the exploitation of virgin raw material, prioritizing the environmentally safe and healthy disposal of waste after consumption, and socio-productive inclusion of waste pickers in formal work systems, minimizing anthropogenic interference in natural resources essential for life.

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