Original Article

WM&R

Waste Management & Research
2015, Vol. 33(12) 1084–1093

DOI: 10.1177/0734242X15607424
wmr.sagepub.com
SAGE

Expanding worldwide urban solid waste recycling: The Brazilian social technology in waste pickers inclusion

Jacqueline E Rutkowski[1] and Emília W Rutkowski[2]

Abstract

'If an integrated urban waste management system includes the informal recycling sector (IRS), there is a good chance that more solid waste is recycled' is common sense. However, informal integration brings additional social, environmental, and economic benefits, such as reduction of operational costs and environmental impacts of landfilling. Brazil is a global best practice example in terms of waste picker inclusion, and has received international recognition for its recycling levels. In addition to analysing the results of inclusive recycling approaches, this article evaluates a selection of the best Brazilian inclusive recycling practices and summaries and presents the resulting knowledge. The objective is to identify processes that enable the replication of the inclusion of the informal recycling sector model as part of municipal solid waste management. Qualitative and quantitative data have been collected in 25 Brazilian cities that have contracted waste pickers co-operatives for door-to-door selective collection of recyclables. Field data was collected in action research projects that worked with waste pickers co-operatives between 2006 and 2013. The Brazilian informal recycling sector integration model improves municipal solid waste recycling indicators: it shows an increase in the net tonness recycled, from 140 to 208 t month^{-1}, at a much lower cost per tonne than conventional selective collection systems. Inclusive systems show costs of US$35 per tonne of recyclables collected, well below the national average of US$195.26. This inclusive model improves the quality of collected material and the efficiency of municipal selective collection. It also diminishes the negative impacts of informal recycling, by reducing child labour, and by improving the conditions of work, occupational health and safety, and uncontrolled pollution. Although treating the Brazilian experience as a blueprint for transfer of experience in every case is unrealistic, the results suggest that this approach to informal sector integration can be considered among the global best practices for informal sector integration. The article closes with recommendations for deploying technology in other urban areas throughout the world.

Keywords

Informal recycling sector, selective collection, waste pickers, tariffs, hybrid integration models

Introduction

What local authorities should 'do about' informal sector recycling and reuse throughout the world is a recurring theme in the debate about managing and processing municipal solid waste (MSW) (Ezeah et al., 2013; Scheinberg et al., 2010; Velis et al., 2012). Medina (2007) has written about the activities of recycled material gatherers dating back to ancient times. In Brazil, there are records of this activity as early as the Colonial period. The waste pickers (WP) at the base of the production chain for recycling sold paper, rags, and metal to wholesalers, who in turn sold these secondary materials to manufacturers (Souza, 2013). Several authors have pointed out that the recovery activities of the informal recycling sector (IRS) represent improved economic, social, and environmental indicators for MSW management (Ezeah et al., 2013; Scheinberg et al., 2010; Wilson et al., 2012).

In 2013, Brazil produced 76.3 million metric tonnes of MSW. Around 80% of it was recyclable and reusable material (Abrelpe, 2013). The recyclables consisted of approximately 30%, primarily paper and plastic (IPEA, 2012). Brazilian levels of recycling are similar to, or in some cases greater than, countries with older and more rigid recycling directives than Brazil's Solid Waste Act (PNRS, in Portuguese). Brazil reports recycling rates of 28% of paper, 70% of cardboard, and 56% of Polyethylene terephthalate (PET) (Valor Econômico, 2011). For PET, according to Valor Econômico (2011), the levels are higher than in the

[1]SUSTENTAR Institute for Sustainability Studies and Research and ORIS Inclusive Solidarity Recycling Observatory, Brumadinho, Brazil
[2]FLUXUS Laboratory, Sanitation and Environment Department, FEC/UNICAMP, and ORIS Inclusive Solidarity Recycling Observatory, Campinas, Brasil

Corresponding author:
Jacqueline E Rutkowski, SUSTENTAR Institute for Sustainability Studies and Research and ORIS Inclusive Solidarity Recycling Observatory, Av. Hum 2863, Casa Branca, Brumadinho 35460000, Brazil.
Email: jacqueline.rutkowski@gmail.com

USA, England, Italy, and Portugal. However, selective collection (SC) programmes for MSW are responsible for only 1% of recycled material. Only 17% of Brazilian cities, representing about 13% of the country's population, are reported to have adopted SC in their MSW management policies (CEMPRE, 2014; IBGE, 2010). Separate collection in Brazil is expensive, and costs on average four times more per household than conventional garbage collection, when offered by formal private service providers.

The IRS

Brazil, like a number of middle-income countries, recognises that informal recycling activities are responsible for largest part of urban recycling (Ezeah et al., 2013; Sanada, 2011; Scheinberg et al., 2010; UNEP/UNITAR, 2013). In Brazil, the National Waste and Citizenship Forum, through the work of UNICEF, brings together a variety of social groups and institutions at various levels of government, to address WP social, environmental, and economic inclusion. The Forum has helped the WPs to organise an even stronger national movement (MNCR, in Portuguese). The joint work of these two movements has brought the social and economic inclusion of the previously invisible informal recycling workers to the political attention of the Federal government and the governments of many Brazilian States. The Federal Government established a programme for IRS Inclusion, CATAFORTE, with a 4-year budget of around R$60 million (US$22.6 million). CATAFORTE aims to organise and create 35 networks of WP co-operatives in 22 states with the purpose of expanding capacity building.

Since 2010, the PNRS has mandated separate collection of recyclables based on WP inclusion in MSW. The Federal Law has not only recognised solid waste as economic goods with social and economic value, but has further acknowledged the importance of the activities of WPs for the entire solid waste system. Brazilian municipalities are allowed to hire waste pickers co-operatives (WPCs) as private service providers without going through the bidding process. Their key role in the recycling value chain is recognised and the municipality may take credit for the recovery levels and results produced by the WPs, in addition to enjoying the economic and operational benefits of waste diversion. Therefore, PNRS provides a type of hybrid inclusion, as described by Scheinberg (2012), promoting, beyond recognition, access, formalisation, inclusion, integration, legalisation, and professionalisation of the WPCs.

As the WPs' life story is self-organised, and dependent on solidarity, it is not surprising that co-operatives are a frequent organisational choice. WPCs represent a form of social enterprise, where the production of merchandise and services take place in a climate of respect for both technical and economic efficiency, and solidarity among workers (Gaiger, 2003; Singer, 2003). In contrast, the efficiency of many formal companies is based on a hierarchical model of work organisation that depends on 'command and control' tools. In its search for continuously increasing efficiency in production levels, such a conventional model excludes unskilled workers unable to meet efficiency standards. In contrast, waste picking represents a labour of solidarity, and one of the social functions of WPCs is allowing a significant number of 'unskilled' workers to have a place in the job market. The formal recycling value chain, with requirements for an ever-increasing level of efficiency, goes against the historical solidarity tradition of WPCs.

Table 1, based on Agathou's (2013) model, presents a variety of social agents that act in the formal and informal parts of the Brazilian integrated municipal waste management system. The informal sector refers to 'individuals or enterprises who are involved in recycling and waste management activities, but are not sponsored, financed, recognized or allowed by the formal solid waste authorities, or who operate in violation of or in competition with formal authorities' (Scheinberg et al., 2010). The Brazilian informal sector is formed by independent WPs and WPs collectively organised into co-operative organisations, the WPC. The IRS includes, also, small trading businesses ('junk shops') that buy recyclable material from either independent WPs or WPCs. These small businesses may also receive material as donations from citizens and companies, or make small payments for it. They separate, classify, and sell recyclable material in larger lots to medium-scale recovery companies. These medium-sized companies sell the recyclable material to industries that process paper, metal, glass, and other material (Agathou, 2013; Ezeah et al., 2013; Wilson et al., 2012). Concerning plastic, some small informal companies at higher levels of the recycling chain use mechanical processing of certain thermoplasts to produce flakes and pellets, which they sell directly to a processing company (Rutkowski et al., 2014).

Solidarity selective collection: A social technology

WPs, whether independent or members of co-operatives, participate in both formal and informal economic activities. UNEP/UNITAR (2013) recognises that some Latin American countries focus on integrating independent recycled material collectors into MSW management as unorganised or autonomous individuals. In Brazil, in contrast, a higher percentage of integrated WPs are organised into co-operatives than in other countries (Ezeah et al., 2013).

Brazilian WPs and co-operatives have developed, over the years, a social technology (Rutkowski&Lianza, 2004; Dagnino, 2006), which is called solidarity selective collection (CSS, based on the Portuguese). In a CSS, municipalities contract a WPC as a formalised operator in the MSW system. More specifically, the operator that collects dry waste from households and large generators, and operates materials recovery and pre-treatment facilities, functioning as a private service provider (GIZ, 2013). As a result of intense activism and a favourable political climate, Brazil has produced specific legislation to organise and standardise this relationship (Dias, 2010), which operates with public funds alongside of the CATAFORTE programme. CATAFORTE supports improvement of WP working conditions and empowers WP collective enterprises (Fischer, 2012).

Table 1. Informal and Formal Sectors Brazilian Agents in MSW Integrated Management (Source: Rutkowski et al., 2013).

Agents	Sector	Generation	Collection	Selective collection	Recycling (storage/sorting/sales/ pre-manufacturing value added)	Reuse	Final disposal
	Informal	Various	Independent street pickers	Independent street pickers; WPCs; Street sweepers	Independent street pickers; Independent dump pickers; WPCs; Small storage facilities or junk yards; Small companies in the plastic industry; NGOs	Craftspeople; NGOs	
	Formal	Various	Private contractors for cleaning public areas; Public contractors for cleaning public areas	Private contractors for cleaning public areas; Public contractors for cleaning public areas; WPCs	Storage areas/junk shops; Waste paper wholesalers/large companies seller of recyclable materials; NGOs; Public contractors for cleaning public and green space; WPCs; Networks of WPCs; MRFs; Recycling processing centres; Brokers, end-user industries	Craftspeople; NGOs; Companies	Public and private sorting and composting facilities; Private companies; Private contractors working for cleaning public areas

MRFs: materials recycling facilities; NGOs: non-government organisations; WPCs: waste picker co-operatives.

CSS starts with an environmental education process that is introduced in communities by the WPs. They teach recycling and request households to segregate recyclables and store them separately from waste. Also, they inform the households of the specific weekday and time for the material collection. During this process, citizens learn the importance of recycling and source separation, and the role of improved recycling for improving the WPs family income. This tends to motivate them to participate in selective collection.

The recyclables brought into the WPCs' storage sheds are manually sorted by types of plastics, metals, glass, and paper. The sorted material is baled and sold to intermediaries, which sell them to the industry. To improve the marketing conditions and to better respond to industry requirements, such as higher volumes of material, the WPCs organise solidarity commercialisation networks, so that several WPCs work together to market baled materials as a single lot.

The professional organisation of the WPs in co-operatives, and of these co-operatives in solidarity networks, as proposed by the MNCR, allows access to financial and human resources for the development of technical and managerial skills, as well as for facilitating dialogue and co-operation with public sector organisations. Moreover, these networks empower the WPs and their WPCs to improve their co-operation with formal MSW operators. This results in facilitated partnerships between WPCs and formal private companies in the provision of services related to MSW, and promotes dialogue with the recycling industry.

Hybrid integration

The WPC is an important link in the recycling production chain, connecting not only the formal and informal sector, but also the value chains and the service chain. WPCs strengthen the foundation of the integrated and sustainable management of solid waste (Scheinberg et al., 2014). For the MNCR, the CSS represents the formalisation of WPCs and anchors their participation in the MSW system. This hybrid model of inclusion goes beyond the basic recognition that WPs deserve, to enable revenue by contract, which guarantees better working conditions and income, in addition to creating new jobs, therefore promoting the inclusion of increasing number of WPs in the formalised system.

The CSS is an economic activity integrated with the recycling value chains and in the MSW service chain. As such, it must fit into the recyclable material market and in the MSW public policies, achieving efficiency in production, and extracting, processing, and trading consistent volumes of materials that are compatible with the demand coming from industry. Hence, WPCs monitor all value chain activities for the purposes of planning. Based on both the business needs and the WPs' characteristics, some new management technologies have been developed, in order to achieve the proposed goals and to improve efficiency and strengthen solidarity. These social technologies have been created as part of an action research project, and have come up with solutions, based on technical and practical knowledge, designed together with the workers (Rutkowski, 2008).

Table 2. Criteria for in-depth case selection.

Door-to-door separate collection under WPC responsibility
WPC service recognised by the municipality through contract
WPC service paid for by the municipality
Satisfactory service quality agreed by the municipality and WPC

WPC: waste pickers co-operatives.

Inclusive Brazilian MSW management has realised gains in effectiveness. Rapidly, the population is mobilised to segregate recyclables. Apart from that, the WP carts access places impossible for an ordinary waste collection system, covering larger areas in the cities. The WPs are efficient environmental educators, and the segregated material is less contaminated. As a result, an increasing volume of clean recyclables is being diverted from disposal at decreasing operational costs. Beyond that, the increase in income of WPCs improves productivity and working conditions, enables the use of safer equipment, provides health insurance coverage, and keeps WPs' children in school (Rutkowski et al., 2013).

The Brazilian situation meets the interfaces and interdependencies pointed out by Velis et al. (2012) for the interventions needed for the IRS integration in developing countries. Accordingly, the Brazilian case has the potential to become a worldwide benchmark, following the recommendation of Ezeah (2013), for evaluating and disseminating the approaches used in successful cases that organise and strengthen waste collection and disposal systems around the world. This study describes the best Brazilian practices, looking for the opportunities for CSS replication in a variety of cities inside and outside Brazilian borders.

Methods

The five in-depth field cases were the main research data source identified through the analysis of 25 literature cases and two series of interviews. The first set of interviews combined informants representing key stakeholders: technical experts from Government development institutions, MNCR leaders, consultants, and non-governmental organisations (NGOs) representatives that assist and support WP organising. The second group included representatives of NGOs in charge of projects funded by the CATAFORTE Programme.

The five in-depth field cases were selected from the long list by application of four criteria (Table 2), which assure the objective of describing the best Brazilian CSS practices. These four conditions were built considering the two interview series.

Information from the interviews was cross-referenced to identify 25 cities that formally included WPC in MSW management and paid for a SC service (Table 3). Applying the CSS criteria, five cities – Canoas, Londrina, Natal, Santa Cruz do Sul, Tibagi – were selected for technical visits on the CSS process. The fieldwork consisted of accompanying the WPs in their work, and interviewing specific groups of WPs: WP material collectors, WP material sorters, a variety of WPC representatives, and representatives of municipal contracting agencies. Additional information came from action research projects carried out by the

Table 3. Municipalities CSS providers in 2013.

State	Municipality	Population (IBGE, 2014*)	HDI** (2010)
Minas Gerais	Araxá	101,136	0.772
	Brumadinho	37,314	0.747
	Itaúna	90,783	0.758
Paraná	Antonina	19,414	0.687
	Londrina	**543,003**	**0.778**
	Rio Negro	33,157	0.760
	Tibagi	**20,283**	**0.664**
Rio Grande do Norte	**Natal**	**862,044**	**0.763**
São Paulo	Araraquara	224,304	0.815
	Assis	100,911	0.805
	Diadema	409,613	0.757
	Orlândia	42,354	0.780
	Ourinhos	109,489	0.778
	Ribeirão Preto	658,059	0.800
	São José Rio Preto	438,354	0.797
	São Vicente	353,040	0.768
	São Carlos	238,958	0.805
Rio Grande do Sul	Cachoeira do Sul	85,830	0.742
	Canoas	**339,979**	**0.750**
	Campo Bom	63,767	0.745
	Gravataí	270,689	0.736
	Jaguarão	28,393	0.707
	Novo Hamburgo	248,251	0.747
	Rio Pardo	38,899	0.693
	Santa Cruz do Sul	**125,353**	**0.773**

Field research municipalities in **bold**.
*Brasilian Institute of Statistics and Geography estimated population for 2014;
**Human Development Index.

National Observatory of Solidarity and Inclusive Recycling (ORIS, in Portuguese) and from the 2013 report of the Federal pro-WP City Award (http://www.secretariageral.gov.br/atuacao/pro-catador/premio/relatorio-da-1a-etapa-de-selecao/view).

Results and discussion

Brazilian municipalities adopted two SC models, door-to-door and point-to-point, where collection is organised around a *voluntary delivery point*. WPCs work in door-to-door separate collection, picking up recyclables at households and *large generators* – those businesses defined as large quantity waste generator enterprises. Such large quantity generators are required by Federal Law to guarantee an environmentally correct final disposal. These two clients require different equipment, personnel, and logistics, and SC has differing costs. There are photos of operating CSS models at www.sustentar.org.br.

CSS door-to-door: Operation

The contract between WPCs and the municipality is based on a terms of reference (ToR), which defines the services based on a previous planning process. The municipal government determines the SC zone, based, generally, on technical and political criteria. The relevant WPC establishes the number of WPs for each service area, based on the estimated volume of recyclables, and the team's abilities and productivity. Street service includes mobilisation and education activities, collection, transport, and the storage shed services of sorting, storage, baling, and transport.

In CSS door-to-door collection, the household or business generators segregate their waste into two fractions: a dry (recyclable) fraction and a wet residual fraction. The members of the WPC have routes co-ordinated with the municipality. The WPC members collect only the dry recyclables. A formal private company – usually a waste collection or public service company – collects the wet fraction, which is usually composed of organics and residual waste. The schedule, frequency, and estimated volume of recyclable material determines the numbers of WP collectors in any specific area. In pairs and wearing uniforms, WPs walk a predefined street route planned according to experience and measurements of waste generation and set-out behaviour, as analysed by the WPs and street sweepers who perform garbage collection in the region. In order to obtain the most efficient route, this knowledge is generally complemented with the use of geo-referencing software (Lima, 2013).

All establishments on each street receive the service. The WP pair moves the collected material to a temporary transfer point, the *Bandeira* (Flag), using carts. Recyclables are stored for later truck collection at the Bandeira. The truck follows a route to collect from a number of *Bandeiras* until it has reached its maximum loading capacity. A *Bandeira* can be an intersection of streets, a corner, an open area, or at another type of location with easy access for the truck. This point should also be at a comfortable

distance for the WPs pulling their carts. The location choice depends on the distance and the average amount of material collected in specific streets or establishments; and the local traffic code for pickup access. The selection of these points takes into account local topography and pedestrian access, as most WPs are moving the recyclables on foot with loaded hand carts. All these issues influence the WP transport mode and the operational costs of the services.

Another CSS technique guides the WPs in their approach to each residence. The idea is that continuous contact leads to a moment of awareness and education at the time of SC: the WP points accepts what is offered, and teaches the household member what is correct or incorrect in the sorting of materials.

There are two different ways to accomplish this CSS practice. In Natal, every 2 days the WPs collect material stored in the houses. In Londrina and Brumadinho, the residents set the material out at curbside on scheduled weekdays at a specific time. Londrina uses green bags and Brumadinho uses returnable jute (raffia, burlap) bags. The WPs return the empty bags to the residents once a week on scheduled days, providing a second moment of routine contact.

Other CSS practices are related to the WP payment and the service quality evaluation. The guaranteed service is usually monitored by a WP working as an inspector. The inspector rides a motorcycle on a defined route. He sorts out the problems with the WPs responsible for the service. The truck routes are tracked by a global positioning system (GPS) for the records of the WPC and the municipality. In addition, the material collected by each truck is weighed on highway truck scales. Every month, the amount of recycled material sold by the WPC is reported to the municipality, which inspects the amount collected. In most cases, this volume is the defining parameter for WPC payments and waste recycling indices. Another action for service evaluation is a citizen telephone hotline. The inspection and the oversight services of the municipal government also receive complaints or suggestions related to SC. This feedback service is used to verify service performance and quality by the contracting government.

In Canoas, continuous evaluation is the responsibility of a Selective Collection Management Council, a stakeholder forum where the WPC and municipality identify and analyse problems and discuss solutions. In other cities, such as Santa Cruz do Sul, this council also includes civil society representatives. These collective spaces contribute to public awareness of correct recyclables segregation protocols, and provide oversight of related public policies, to guarantee system continuity and sustainability.

In Brazil, a WPC pays its WP members based on specific criteria defined collectively in the assemblies of members. This kind of remuneration is different both from the culture of formal private companies on the one hand, and from compensation practices in other Latin American inclusive recycling systems, such as in Bogotá, Colombia on the other.

In the CSS cases studied, the compensation of WPs consists of fixed and variable components. The variable part relates to the volume of material collected and sorted, or to a set of labour benchmarks: lack of absences from work; maintaining a daily average material collected; and lack of complaints by residents. There are also benchmarks for groups of workers, such as street teams, patio staff, baler operators, sorters, truck crew and drivers, and warehouse co-ordinator. In this system, payment for all members of the team is based on of the productivity of the entire production process and is measured at a specific point, that of the sorting group. The WP staffing each function receives a percentage based on their relative importance, as defined collectively by the group of workers. Payment based on productivity helps to reduce absenteeism and encourages an increase in productivity. The WPs' remuneration is collectively earned from revenue obtained from the recyclables commercialisation and from the payment of the municipal service fee.

CSS door-to-door: Environmental education for recycling

The waste generator's commitment to participate in source separation of recyclables is fundamental to the success of any source segregation scheme. In CSS, this commitment is created by the regular personal contact, combined with information and knowledge about material separation. In Brazil, information on waste recycling is not yet widespread. Furthermore, there are few mechanisms for informing and mobilising the population to segregate for recycling. Citizens are neither compelled to source separate, nor stimulated by pay-as-you-throw (PAYT) systems, nor enlightened, informed, or mobilised by any form of continuous environmental education public.

The CSS always begins with mobilisation and education campaigns. WPs and municipal workers visit each household in the door-to-door system, while for the large generators, the WPs give seminars and take actions to mobilise and inform the workers of the company. Mobilisation includes distribution of educational pamphlets and other advertising materials about waste separation, and instructional materials telling households and businesses the days, time, and frequency of recyclables collection. During collection, the WPs sing songs or shout out instructions, and the trucks, painted to identify the service, announce the SC via loudspeakers.

Although environmental education actions are critical to the success of SC, and are delivered by WPs at reasonable costs (Lima, 2013), in most contracts and service models this is an unpaid service. Londrina and Natal provide specific payments for the WP's environmental educator performance by paying per bag delivered to each household.

CSS door-to-door: Brazilian achievements

Londrina (543,000 inhabitants) and Belo Horizonte (~2.5 million inhabitants) have consolidated and mature SC programmes. The first adopts the CSS model and the second contracts a private cleaning enterprise as a service provider. Figures 1 and 2 compare their monthly collected amount of recyclables and the operational costs.

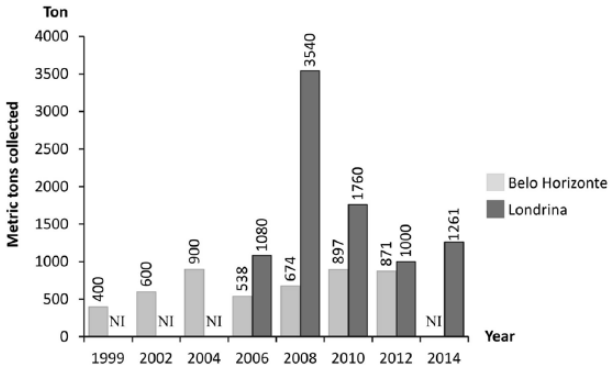

Figure 1. Monthly recyclable collected amount with different technology. Londrina: CSS; Belo Horizonte: private cleaning enterprise.

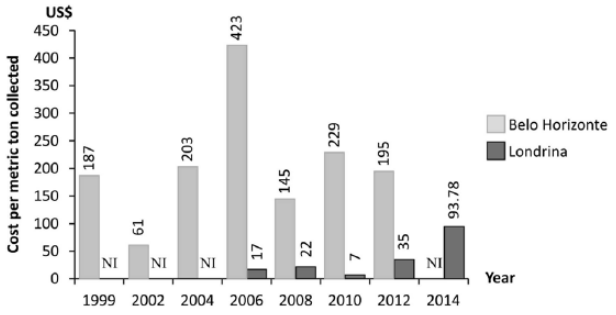

Figure 2. Recyclable collected cost with different SC technologies. Londrina: CSS; Belo Horizonte: private cleansing company.

Londrina's population is a quarter of the Belo Horizonte's, nevertheless Londrina collects more recyclable material at a lower cost. For instance, in 2012, the Belo Horizonte recycling contractor collected 871 tonnes per month at a cost of US$195 per tonne, while Londrina's WPCs collected 1000 tonnes at a cost of US$35 per tonne. Operational costs associated with landfilling the non-recyclable material are not included. Londrina reports a cost increase in 2014, attributed to a change in measurement techniques. And even with the increase, the city's SC operating cost is still below the Brazilian national average, which is US$195.26 (CEMPRE, 2014).

The CSS door-to-door expands the SC route, increases volumes collected, and reduces operational costs, thereby cutting greenhouse gas emissions by reducing truck traffic. There are gains in efficiency and coverage through efficient collection zones, which take population density into account. The WPs want to collect as much high-grade recyclable material as possible, because their payment depends not only on the absolute volume collected but on the value obtained when the sorted material is sold. To maximise the income, WPs use varied means of transport, each one implying different costs (Table 4). The choice of transport depends on local topography, and on WP preferences, approach, and work flow. The formal private enterprises are paid by kilometre driven and/or per metric tonne of collected material, regardless of quantity or quality, and therefore they collect recyclables at curbside into a truck, the most expensive option.

Table 4. Cost of transport mode on door-to-door CSS (Source: de Paula, 2012).

Transport mean	Mean cost (R$ t^{-1})
Hand carts, carrying bags + truck	28,60
Electric carts + truck	42,40
Motorcycles with sidecars	63,70
Small van with bed + WP	211,15
Truck + WP	252,25

WP: waste picker.

Table 5. Improvement in volume collected and in the rate of rejects after the CSS` implementation.

City	Time-lag (days)	Volume variation (tonnes $month^{-1}$)	Rejects rate (%)
Itaúna	30	From 140 to 208	From 70 to 30
Natal	365	From 42 to 298	⩽10

Reducing the SC cost is fundamental to maintain the political commitment, and to promote affordable recycling in municipalities. Although the waste production trend is continued growth (Campos, 2013), there is increasing pressure on the municipal budgets, and when expenditures for separate collection are too high, the service is at risk of being set aside in favour of other priorities. So lower system costs are important to maintain these policies. In addition, once installed, the systems, infrastructure, capacity, and logistics developed to collect dry recyclables may be adapted for additional recovery stream ones, WEEE (waste electrical and electronic equipment), yard waste, and spent cooking oil. This practice has already been tested in some cities, where the WPs are picking up used cooking oil, and selling it to the biodiesel industry.

The CSS door-to-door approach by WPs increases system efficiency, by avoiding costs and energy use for mixed waste collection and transportation, and by reducing dirt and contamination in the recyclables that arrive to the sorting sheds. As shown in Table 5, CSS implementation increases the volume of recyclable material collected, and diminishes the rate of rejects. Moreover, citizens react very positively to the knowledge that their recyclables support the WPs and their families.

As a social technology, CSS enables a significant increase in income earned by the WP co-operatives. As shown by Rutkowski et al. (2014), the baled material is of greater value and higher demand in the recycling supply chain. In all surveyed cities, average monthly income for WPs is more than R$1000.00 (US$430), as compared with the Brazilian minimum wage of US$305 per month). In Itaúna, the values reached R$2000.00 (US$860).

The social, political, and financial recognition of the WP as an important element of urban and environmental work, has created a turning point for the WPCs. With the WPC sustainability guaranteed, there is greater capacity for planning, reducing short-term actions, and dependency on public grants, which was previously a common feature in managing these enterprises.

All cities visited reported that CSS created jobs. WPCs invited both independent WPs and waste collectors from private companies previously responsible for the service to join the co-operative. In Itaúna, the WPC, out of political conviction and fairness, stimulated the creation of an association of homeless street WPs that work in the downtown area. They furnished a warehouse in the region for the associates to sort the collected material. The warehouse has a dining hall, kitchen, and bathrooms. The WPC pays a fair price for the sorted material, more than the local scrap yards, and helps their members in their struggle for their civil rights.

In this sense, CSS door-to-door has an extra edge, for which the WPCs are not paid nor have yet received specific support from the government. The WPCs can promote the inclusion of independent WPs with adaptation difficulties by streaming them into work in the sorting sheds, or other routine work, thereby creating another opportunity for social and economic inclusion of people that live on the street or suffer from physical disabilities or social problems.

The CSS is thus an alternative source of employment, income, and social inclusion for vulnerable populations in urban centres, whose social situation, health, and/or educational characteristics hinder their absorption by other initiatives to create jobs in the formal labour market.

CSS services for large-scale generators

In Brazil, companies considered large-scale waste generators are responsible for the disposal of the solid waste they generate, but they are unable to sell their recyclable material directly because they are not licensed as recyclers. So they donate the materials, either to organisations that sell recyclable material, or to the WPCs. This second option allows them to include the donation as a socially and environmentally responsible action. If the WPC obtains an environmental license, it can provide a certificate of correct end-of-life management to the generator, and can also charge for this service. In turn, the company can use the certificate in environmental labelling systems such as ISO 14000 certification and the Dow Jones Sustainability Index.

Obtaining high-quality material at a high volume not only leads the WPC to form networks to sales and services, but also allows the municipality to meet its goals for increasing levels of recycling.

Conclusions and recommendations

CSS is a successful social technology. Despite low levels of recognition and support received from the local authorities in some cities, CSS has proven effective to divert significant volumes of recyclable materials from disposal. The gains come from increased capture, reduction of transportation, and avoidance of disposal, as observed by Scheinberg (2010) and Wilson et al. (2012), making the whole system more sustainable.

CEMPRE (2014) observes that one of the barriers for implementing a SC programme is the operational costs to the local authority. Integrating WPCs into MSW systems is able to alleviate pressure on public budgets on a number of fronts. It improves recycling rates at a lower cost than conventional systems. CSS improves both the quality of materials and the efficiency of municipal SC. It promotes school attendance of the children of WPs, and minimises the negative impacts of informal recycling by improving work conditions, occupational health and safety, and pollution related to the informal recycling activities, as specified by Velis et al. (2012).

This social technology may help to minimise the government budget impact of social and health programmes by promoting income generation for a segment of the urban population, especially the homeless, that would seldom be incorporated in the labour force – or even into traditional programmes of job creation – because of its social and economic characteristics. Promoting income and jobs to this population, the Brazilian CSS model not only contributes to the modernisation of waste management systems, but helps to lower poverty rates in urban centres.

Hiring the WPC through CSS business networks improves efficiency, facilitates larger coverage areas in the cities, improves market reach and access, and works to spread knowledge and best practices among the WP groups. CSS networks are also fundamental to the regular marketing of recyclable materials at a regional or national level. They facilitate sales of low market value materials, such as glass and styrofoam, increasing the total volume of materials diverted from disposal in the cities where CSS is operating.

Studies have shown that the CSS model of integration conforms to both types of actions proposed by Velis et al. (2012) and the six points defined by Ezeah (2013). But to apply this model to other realities some recommendations are useful.

There is a need for transfer depots. The Brazilian transfer depots, or *Bandeiras*, are an important factor for the success of CSS, as without them, the WPs work would be impossibly arduous: transporting heavy loads on foot over a long route. So the *Bandeira* transforms an unworkable situation into a functioning system, and reduces costs as well. Moreover the cost of SC drops and the system efficiency rises with the truck use optimisation associated with this transfer system.

The organisation of WPC networks, as in any economic sector, requires time and technical support, which must be considered in the integrated planning process (Rutkowski, 2013). This organisation must take place before the moment of full and complete transfer of responsibility for source separation to the WPC. There must be sufficient preparation time for co-operative members to absorb the complexity of the process, and to help to build up support systems, such as the financial and human resources needed to access and operate the necessary infrastructure and equipment, and the training to provide a quality service.

The municipal government needs a recycling department, which is responsible for the SC programmes. The need for need for available and skilled technicians is critical, both to communicate with the WPC, and to co-develop proposals with the WPC

that meet both the joint needs: for formalisation and control inherent to public services, and for solidarity, flexibility, and inclusion, which are the hallmarks of CSS.

Two additional conditions are necessary for the replication and the expansion of the CSS' results.

Selective municipal collection, in a solidarity frame, must be seen as a public service. A public service is guided by the principle of universality, which means it must not limit the service provision to profitable sectors only. It must be an affordable service to the entire population, so that it achieves an economy of scale that makes it both efficient and affordable. Integrated MSW management plans must allocate budget resources in order to assure the priority of the WPC to organise, manage, and carry out all processes necessary for reliable SC, ranging from informing and mobilising the population, to selling recyclable material – and all the operations in between.

Specialised technical assistance must be made available for the organisation and supervision of the logistics, zoning, and route planning. This is also necessary for the participatory and inclusive design and development of facilities (like sheds and *Bandeiras)*, for selection and installation of equipment in the storage and processing sheds, and also for financial planning and budgeting of the SC. Those providing the technical assistance must be skilled in participatory planning and design methods. This is necessary to promote a shared and progressive approach to decision making related to technical choices, as well as to the organisation and management of WPCs. Decisions and developments require a constant and collective construction process involving all stakeholders. The WPs direct, practical knowledge and experience of organisation, management, and participation at all the SC steps is critical to avoid making costly errors, but it is, sadly, considered an unusual practice in most government programmes, and is seldom accepted by experts. Therefore, the criteria and ToR for selecting the technical experts should be based, in part, on their commitment to participative construction of the management plans and respect for the tacit and practical knowledge of the WPs, in combination with the technical knowledge of municipal officials and/or specialists.

The cultural diversity and the lack of specialised workforce in managing MSW in developing countries must be considered in the replication of this process of informal sector inclusion and integration. The same premise applies to the transfer of other technologies that are continuously being offered as a way to modernise MSW systems. But the social technology of CSS will certainly fit in more easily with the available capacities in middle-income countries, and at a much lower cost.

Acknowledgements

We would like to thank all collaborators – WPs, technicians, and public officials – for their kindness in sharing time and knowledge; also Interministerial Committee for Social and Economic Inclusion of WP (CIISC, in Portuguese) and Nenuca Institute for Sustainable Development (INSEA, in Portuguese) for support, especially Daniela Metello and Fabiana Goulart de Oliveira whom made the Pro-Waste Picker Prize and Community SC Service Pricing reports available. Our special thanks to ORIS participants for giving their time to discuss the subject, and to the reviewers whose suggestions have indeed improved this publication. A special thanks to Dr Anne Scheinberg.

Declaration of conflicting interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The field work was carried out with support from the Banco do Brasil Foundation. INSEA and MNCR support some ORIS activities and debates.

References

ABRELPE – Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais (2013) Panorama dos resíduos sólidos no Brasil 2013. São Paulo/SP: ABRELPE Brasil. Available at http://www.abrelpe.org.br/Panorama/panorama2013.pdf (accessed 27 December 2014).

Agathou N (2013) Profiling micro entrepreneurs in solid waste management and sanitation: A review based on 10 developing countries. In: *Proceedings of 2013 world congress of International Solid Waste Association (ISWA)*, Vienna, Austria.

Campos HKT (2013) Resíduos sólidos e sustentabilidade: o papel das instalações de recuperação. Dissertação (Mestrado). Brasília, DF: CDS-Centro de Desenvolvimento Sustentável –UnB, Universidade de Brasília.

CEMPRE – Compromisso Empresarial pela Reciclagem (2014) Pesquisa Ciclosoft. 2014 São Paulo/SP: CEMPRE BRAZIL. Available at: disponível em www.cempre.org.br (accessed 27 December 2014).

Dagnino R (2006) Tecnologia social: Retomando um debate. *Espacios (Caracas), Caracas, Venezuela* 27: 1–18.

de Paula T (2012) Palestra proferida no Encontro Frente Nacional de Prefeitos. Brasília/DF.

Dias SM (2010) *Overview of the Legal Framework for Social Inclusion in Solid Waste Management in Brazil*. Cambridge, Massachusetts, USA: WIEGO.

Ezeah C, Fazakerley JA and Roberts CL (2013) Emerging trending in informal sector recycling in developing and transitions countries. *Waste Management* 33: 2509–2519.

Fischer RR (2012) Recyclable material collectors: Overcoming poverty through dialogue. In: *Solid Waste Management and Sanitation: A Review Based On 10 Developing Countries*, *Proceedings of 2012 world congress of International Solid Waste Association (ISWA)*, Florence, Italy, 2012.

Gaiger LI (2003) *Eficiência sistêmica*. In: Cattani AD (ed.). *A outra economia*. Porto Alegre/RS: Veraz Editores, pp.125–129.

GIZ (2013) SWM *Operator Models. Respect Diversity. Concepts for Sustainable Waste Management. Sourcebook*. London: RWA Group.

IBGE – Instituto Brasileiro de Geografia e Estatística (2013) Pesquisa Nacional de Saneamento Básico, 2008. Rio de Janeiro: IBGE. Available at: http://www.ibge.gov.br/home/estatistica/populacao/atlas_saneamento/default_saneamento.shtm (accessed 27 December 2014).

IPEA – Instituto de Pesquisas Econômicas Aplicadas (2012) Relatório de pesquisa: Diagnóstico dos Resíduos Sólidos Urbanos. Brasília/DF: IPEA.

Lima FPA (ed.) (2013) *Prestação de Serviços de Coleta Seletiva por Empreendimentos de Catadores: instrumentos metodológicos para a contratação*. Belo Horizonte/MG: INSEA.

Medina M (2007) *The World's Scavengers: Salvaging for Sustainable Consumption and Production*. Plymouth: AltaMira Press.

Rutkowski JE (2008) *Sustentabilidade de Empreendimentos Econômicos Solidários: uma abordagem na Engenharia de Produção*. Tese (Doutorado em Engenharia de Produção). COPPE, Rio de Janeiro/ RJ: Universidade Federal do Rio de Janeiro, 239f.

Rutkowski JE (2013) Redes solidárias de catadores e gestão de resíduos sólidos (Solidarities networks of recyclable collectors and garbage

management). In: *Revista Tecnologia e Sociedade, Edição especial V Simpósio Tecnologia e Sociedade*, V.1, p.20. Curitiba/PR, Editora UTFPR.

Rutkowski JE and Lianza S (2004) Sustentabilidade de empreendimentos solidários : que papel espera-se da tecnologia ? In: FUNDAÇÃO BANCO DO BRASIL. *Tecnologia social: uma estratégia para o desenvolvimento*. Rio de Janeiro/RJ, pp.167–186.

Rutkowski JE, Lima FPA and Oliveira FG (2013) Aprimoramento da gestão de resíduos sólidos urbanos por meio do incentivo à reciclagem: uma metodologia para cidades mais sustentáveis In: III Conferência Internacional de Gestão de Resíduos Sólidos, São Paulo/SP.GRAL 2013, São Paulo.

Rutkowski JE, Varella CVS and Campos LS (2014) Recycling of municipal solid waste in Brazil: Challenges and opportunities for expansion. In: *Proceedings ISWA world congress 2014*, São Paulo, Brazil.

Sanada A (2011) Internalization of informal sector into formal urban waste management in low-income countries. In: *Proceedings of 2011 world congress of International Solid Waste Association (ISWA)*, EXCOD aegu, Korea.

Singer P (2003) Economia solidária: um modo de produção e distribuição. In: Singer P and Souza AR de (eds) *A economia solidária no Brasil: a autogestão como resposta ao desemprego*. São Paulo: Contexto, 2 ed, pp.11–28.

Scheinberg A (2012) Informal sector integration and high perfomance recycling: Evidence from 20 cities. WIEGO Working Paper (Urban Policies), no. 23. Manchester, UK, 2012.

Scheinberg A, Simpson, Gupt Y, et al. (2014). *Economic Aspects of the Informal Sector in Solid Waste Management*. Eschborn, Germany: GTZ and CWG.

Souza RA (2013) O Lixo E A Conduta Humana: gestão dos insuportáveis na vida urbana. 243 f. Tese (Doutorado em Psicologia) – Faculdade de Ciências e Letras, Universidade Estadual Paulista, Assis.

UNEP/UNITAR (2013) Guidelines for National Waste Management Strategies: Moving from challenges to opportunities. IOMC.

Valor Econômico (2011) Análise Setorial – Resíduos Sólidos: Logística Reversa. São Paulo/SP: Valor Econômico.

Velis CA, Wilson DC, Rocca O, et al. (2012) An analytical framework and tool ('InteRa') for integrating the informal recycling sector in waste and resource management systems in developing countries. *Waste Management & Research* 30: 43–66.

Wilson DC, Rodic L, Scheinberg A, et al. (2012) Comparative analysis of solid waste management in 20 cities. *Waste Management & Research* 30: 237–254.