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Development of a sustainable and inclusive solid waste management system in Colombia

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DEVELOPMENT OF A SUSTAINABLE AND INCLUSIVE SOLID WASTE MANAGEMENT SYSTEM IN COLOMBIA

By

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Abstract of Thesis

Managing solid waste is a pressing environmental issue worldwide. This is especially observed in developing countries, where the main concern is to provide the service of waste collection, usually lacking a formal recycling program. Instead, recycling is often conducted by an informal sector composed of recyclers-by-trade. What has been found is that the current informal recycling sector — if approached differently — can offer a financially viable and an environmentally and culturally sound solution. A case study approach was chosen and questionnaires were conducted with recyclers-by-trade and dealers in Cali, Colombia. An interview was conducted with the President of the Recyclers' Association of Bogotá, Colombia. A normative system is proposed as an alternative context-based solution in developing countries that focuses on the inclusion of organized recyclers-by-trade into the formal solid waste management in order to increase recycling rates, extend the lifespan of landfills and improve the living and working conditions of this informal recycling sector.

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Table of Contents

List of Tables

List of Figures

List of Appendices

Abbreviations

ANR	National Association of Recyclers (Asociación Nacional de Recicladores)
ARB	Recyclers' Association of Bogotá (Asociación de Recicladores de Bogotá)
ASE	Areas of Exclusive Service (Areas de Servicio Exclusivo)
CBO	Community Based Organizations
CIIA	Engineering Centre for Research of Los Anders University (Centro de Investigación de Ingenieria de los Andes)
DSD	Duales System Deutschland
GFE	Garbage for Eggs
GIS	Geographic Information System
IPCC	Intergovernmental Panel for Climate Change
ISWM	Integrated Sustainable Waste Management
MAVDT	Ministry of the Environment, Housing and Territorial Development (Ministerio de Ambiente, Vivienda, Desarrollo y Territorio)
MSW	Municipal Solid Waste
NGO	Non-governmental organizations
NLGP	Nonlinear Lexicographic Goal Programming
PGIRS	Integral Solid Waste Management Plan (Plan de Gestión Integral de Residuos Sólidos)
PRM	Potentially Recyclable Materials
RRS	Selective Micro Routes (Ruta de Recolección Selectiva)
RSW	Residential Solid Waste
SISWMS	Sustainable and Inclusive Solid Waste Management System
SUI	Unique Information System of Public Services of Colombia (Sistema Único de Información de Servicios Públicos)
SWMS	Solid Waste Management Systems
UAESP	Special Administrative Unit of Public Services (Unidad Administrativa Especial de Servicios Públicos de Bogotá)

Chapter 1. Introduction

Currently, waste is an increasing issue and creative management decisions are needed to address this environmental problem, particularly in the developing world where conditions may not be addressed in the same way as in wealthier countries.

Worldwide, Municipal Solid Waste (MSW) has increased and with it, higher pressure has been placed on Solid Waste Management Systems (SWMS). This is due to the overall growing population best categorized as a "consumption-oriented society", with less conscientious consumption patterns and with higher living standards. In addition, there has been an increase in packaging and lower material bio-degradability, especially among plastics (Messineo and Panno, 2008; Amponsah *et al.* 2009). Construction and demolition processes, along with the generation of waste from households and private and public service establishments, have also increased due to population growth and urban expansion (Roper, 2006). In 2001, the global production of MSW was estimated to be 1.5 billion tons and since then, it has grown considerably (Themelis and Ulloa, 2007).

Currently, the conventional and broadly used waste management practices around the world have been documented to cause numerous environmental problems. According to Cen *et al.* (2007), costly MSW incineration plants are considered a problem due to the production of noxious emissions. On the other hand, landfilling contaminates the soil and ground water, while emitting greenhouse gases and degrading the landscape (Sharholy *et al.* 2008). Thus, it is of great importance to maximize re-use and repair practices, as well as overall recycling and composting activities which may subsequently reduce the amount of waste for collection and disposal, increase the lifetime of landfills, reduce transportation costs and offset the use of primary raw materials, if thoughtfully implemented. There may be other concerns that would also benefit society and specific communities as MSW is more carefully managed.

In the developed world, SWMS have been adopted for MSW, with a broader intention of reducing resource consumption and increasing current recycling rates. On the other hand, the developing world is characterized by presenting low standards regarding its SWMS: improper disposal methods, insufficient waste collection coverage and overall inefficient practices

(Lardinois and van de Klundert 1995; Armijo *et al.* 2002; Cheeseman *et al.* 2006; Themelis and Ulloa, 2007; Amponsah *et al.* 2009). The main concern in these countries is to provide the basic service of garbage removal, not recognizing the gains provided by a formal recycling program. Instead, if recycling exists it is often performed by an informal sector composed of recyclers-by-trade or waste pickers (Cheeseman *et al.* 2006). To date, in developing countries, SWMS is a precarious practice compared to the developed world. However, copying procedures and models for SWMS from these developed countries has not provided successful results.

In the face of rising poverty levels in the developing world and the knowledge of the current environmental impacts associated with waste management, environmental and social goals in this field have been receiving more attention. International interest has been raised by the work of Cheeseman *et al.* (2006), Jaffe and Nas (2004), Gutberlet (2008) in Brazil, Beukering (1994) and Dikshit *et al* (2006) in India and Armijo *et al.* (2002) in Mexico. These countries have responded due to the increasing volume of MSW, as well as international awareness of sustainability as a goal, and the plight of their urban poor. What has been found is that the current informal recycling sector — if approached differently — can offer an environmentally and culturally sound solution. SWMS must be able to deal with a growing awareness of environmental issues and the scarce budget allocated to waste management in developing countries.

It has been observed that integration of the informal recycling sector into a formal SWMS can increase the efficiency and working conditions of those involved (Cheeseman *et al.* 2006). Successful initiatives have been achieved when a combination of stakeholders from the public and private sectors come together cooperatively with non-governmental organizations (NGO) and community based organizations (CBO). These partnerships are seen to be important in institutionalizing and legalizing the informal sector's activities, as well as generating stable and long-term solutions (Lardinois and van de Klundert, 1995). However, the long-term sustainability of the integration of the informal sector into the formal SWMS remains to be demonstrated, suggesting the need to model their SWMS, including their context, capacity and support structure (Anschutz *et al.* 2006).

The purpose of this research is to evaluate opportunities for increasing recycling rates in developing countries by providing a context-based solution which works towards the inclusion of the informal recycling sector into a formal SWMS. For the purpose of this thesis research, a case study approach has been chosen, to take into consideration the unique circumstances present in a specific context. The case study takes place in Colombia, where data were made available by the cooperativeness of local authorities and others representing the major stakeholders in SWM. The details of the specific data and the nature of the case study are presented later.

Chapter 2. International Municipal Solid Waste (MSW) Variations and the Green Agenda's Direction

The following chapter describes the existing differences between waste generation and composition amid developing and developed countries. A review of the various components of solid waste management system is also presented, followed by the goals of the green agenda regarding solid waste management.

2.1 Comparison of Municipal Solid Waste Generation and Composition between and within Countries

As a result of economic development, population growth and higher consumption levels, MSW continues to be generated at an alarming rate; however, there are significant differences among various countries. According to Cointreau (2006), with higher income levels there is a higher production of waste (Table 1).

Table 1. Solid Waste Generation Worldwide (Cointreau, 2006)

	Low Income Country	Middle Income Country	High Income Country
Mixed Urban Waste of Large City (kg⁄capita⁄day)	0.5 – 0.75	0.55 – 1.1	0.75 – 2.2
Residential Waste Only (kg⁄capita⁄day)	0.25 – 0.45	0.35 – 0.65	0.55 – 1.0

Many studies have been carried out relating income levels of a population with its MSW generation to enable development of mathematical models. These have proven to be of some use for predicting Residential Solid Waste (RSW) production. A study carried out in Mexicali by Armijo *et al*. (2008), analyzed the differences among three distinct socioeconomic strata and the waste production rates and composition. It was observed that the average RSW generation and composition differs among the different socioeconomic strata, showing that the medium socioeconomic level presented the highest waste generation rate. Also, in regards to family

typology, it was observed that the nuclear family (composed by parents and unmarried children) presented the highest waste production.

Orccosupa (2002) carried out a similar study in the municipality in Peñalolen, Chile. In this study, the relationship between the RSW generation per capita and socioeconomic factors was analyzed. The "polluter pays" principle was considered throughout his work, as municipal waste management service — unlike electricity or water services — is the only one that charges a standard rate, without considering the actual demands placed on the service. The relationship was found to be strong between the per capita generation of RSW and the per capita gross income, which translates into an expected increase of RSW generation per capita, to result from the expected economic growth in subsequent years. It was also noted that waste management focused on a preventive principle which required the conjunct work of three stakeholders: producers aiming to include cleaner production, responsible consumers and the government as a regulator and implementer of incentives and sanctions (Orccosupa, 2002).

The composition of waste, especially the presence of packaging, is also affected by income level and the degree of industrialization. This phenomenon has shown changes throughout the years. Such is the case of the USA, whose waste in 1960 was 12.3% (% by wet mass) metals and only 0.4% plastics, compared to 1996 with 9.4% plastics and only 7.7% metals (Conitreau, 2006). In 2007, according to the reported waste composition data at landfills and waste to energy facilities —after recycling and composting activities have taken place— plastics accounted for 31.4% and metals 2.9% (Barlaz and Staley, 2009).

According to Dahlen and Lagerkvist (2008), the main components analyzed in waste composition studies are diverse: biodegradable waste (consisting of yard waste and animal refuse); paper and cardboard; plastics; glass; metals (ferrous and non-ferrous); wood; textiles and leather; hazardous waste (including medical waste and special waste); other organics (miscellaneous combustibles); other inorganics (miscellaneous non-combustibles, ceramics and minerals) and residue.

Table 2 shows the composition of waste from three cities in Canada, Colombia and Ghana. Although it is not possible to extrapolate these values to all the developed and

developing countries, with different population densities and conditions, this reflects the relationship between the type of waste generated by a country and the mean living standards of its inhabitants. It is noted that organic waste represents the main component for Bogotá and Kumasi, double the amount from London. Another component that shows differentiation is paper, highlighting the value in London three times higher than Bogotá and ten times higher than Kumasi. The values of metals and glass in London are three and six times respectively higher compared to Bogotá and Kumasi.

Table 2. Waste Composition in London, Canada, Bogotá, Colombia and Kumasi, Ghana.

Waste component	London, ON Canada**	Bogotá, Colombia***	Kumasi, Ghana**
GDP (millions of USD)*	$1 336 067	$230 844	$15 619
Biodegradable/Organic %	30.00	61.58	64.00
Paper %	32.00	9.68	3.00
Plastics %	10.00	19.71	4.00
Metals %	3.00	1.13	1.00
Glass %	6.00	1.72	-
Wood %	-	1.03	3.00
Textile %	-	4.45	3.00
Others %	19.00	0.50 (leather + clays + bricks)	-
Inert %	-	0.38 (minerals)	22.00

(*World Bank, 2009; **Amponsah *et al.* 2009; ***SCS Engineers, 2007)

Similar results comparing low-, middle- and high-income countries and their waste composition have been reported by Cointreau (2006), which provide similar quantities and the same tendencies as presented above, but provide some further details (Table 3).

There are evident differences between the socio-economic conditions of developed and developing countries. For instance, as a result of a lower biodegradable content in waste from higher income countries, the moisture level is lower and the calorific value is higher. This differential accounts in part for the viability of incineration as a final disposal method in high income countries.

Table 3. Worldwide Perspective of MSW Composition (Cointreau, 2006)

Waste component	Low Income Country	Middle Income Country	High Income Country
Biodegradable %	40 to 85	20 to 65	7 to 55
Paper and cardboard %	1 to 10	15 to 40	15 to 50
Plastic %	1 to 11	2 to 13	2 to 20
Metal %	1 to 5	1 to 5	3 to 13
Glass %	1 to 10	1 to 10	4 to 10
Rubber, Miscellaneous %	1 to 3	1 to 5	2 to 12
Fines % (ash, broken glass, sand)	15 to 50	15 to 40	5 to 20
Moisture %	40 to 80	40 to 60	20 to 35
Density in Trucks kg/m^3	250 to 500	170 to 330	120 to 200
Lower Heating Kcal/kg	800 to 1100	1000 to 1500	1500 to 2700

In the developed world, SWMS were previously concerned with environmental health protection including human safety considerations and the reduction of environmental impact. Currently, they have been centred on the optimization of SWMS practices with a broader intention of reducing resource consumption. In addition, political pressure triggered by public opposition to landfilling, has pushed the MSW agenda towards higher recycling rates (Armijo *et al.* 2002; Anschutz *et al.* 2006).

In these countries, the sophisticated and costly recycling practices are part of the formal SWMS, achieving up to 50% recycling rates. Such is the case of the USA with an overall recycling rate of 32.5%, which is related to curbside recycling programs serving 51% of the population (Bohm *et al*. 2010). Similarly, Canadian cities like London and Toronto have achieved 40% and 44% recycling rates as a result of a series of initiatives. These initiatives include the introduction of the blue bin recycling system, curbside recycling, self-management of yard waste programs, and electronics recycling depots, among others (Amponsah *et al.* 2009; City of Toronto, 2010).

The European Union perceives SWMS as fundamental issues relating to sustainable development. Consequently, the European Commission published New Waste Directive legislation in 2008. This legislation seeks to encourage reuse and recycling practices, as well as environmental health through energy recovery and the reduction of greenhouse gas emissions

while focusing on waste prevention. Such are the cases of Austria and the Netherlands, where they have implemented the treatment of biodegradables by providing decomposable bins to insure source separation. Other European Union member states have put into practice economic measures, such as the "Pay-As-You-Throw" charges, as well as incentives for the diversion of the biodegradable fraction of MSW. The Landfill Allowance Trading System applied in the United Kingdom increased the waste diversion through transferable allowances by selecting inexpensive and convenient sites to do so. In addition, an extended producer responsibility system, such as the Duales System Deutschland (DSD) (for packaging waste in Germany) has increased the reuse and recycling rates. Part of this system consists of labelling the packaging materials for collection purposes. The labelling system allows the identification of the specific recycling process each packaging material will subsequently go through (Chang *et al.* 2011).

In contrast, the developing world is characterized by rapid population growth, rural migration to cities and an overall low-skilled population, which results in the creation of unplanned settlements that lack proper infrastructure and which are frequently located in disaster-prone regions. This situation often sets low standards regarding its SWMS: improper disposal methods such as open dumps, insufficient waste collection coverage and inadequate operation (Cheeseman *et al.* 2006; Amponsah *et al.* 2009). These low standards in turn hinder developing countries' capacities to handle properly the increasing volume of MSW (Armijo *et al.* 2002). This is usually a result of a lack of finance, poor environmental controls and deficiencies in the regulatory framework, as well as scarce sanitation measures (Lardinois and van de Klundert, 1995).

In addition, illegal dumping of waste in waterbodies or open lands, as well as burning of waste can occur in areas that lack waste collection service, which could subsequently impose environmental and human health risks (Medina, 2000). The main concern in these countries is to provide the basic service of garbage collection, while lacking the formal recycling practice promoted by the different jurisdictions and supported by a population of knowledgeable residents, as seen in developed countries. Instead, it is performed by an informal sector

composed by recyclers-by-trade or waste pickers and itinerant waste buyers. Some developing countries have achieved high recycling rates, which oscillate between 20% and 50%, with a high percentage being contributed by the informal recycling sector. An exceptional case was observed in Cairo which had an 80% recycling rate (Cheeseman *et al.* 2006).

The socioeconomic characteristics of a population have been found to play an important role in determining the nature of SWMS. The observed relationship between waste constituents and high and low income levels, has suggested a link among waste composition, generation and broader socio-economic conditions (Armijo *et al*. 2008). Thus, it has been implied that for planning SWMS strategies for a specific region, it is necessary to possess a deep understanding of the population's characteristics. Such characteristics include: income and consumption levels, the quantity and composition of waste generated, operating costs, education and values, as well as the socio-cultural aspects and the policies related to MSW (Burnley, 2006; Dahlen *et al.* 2007).

Grodzinska *et al.* (2006) have suggested that public consent and the degree of involvement directly affect the effectiveness of waste management goals, especially when focusing on recycling efforts. This is due to the importance of understanding the principles of source separation of recyclable materials —free of impurities — and their proper placement.

According to Cointreau (2006), estimations regarding the price ranges of waste management in low- middle- and high-income countries, are a function of the average GNP. Although the per capita workforce costs and waste generation in developing countries are low, the price of waste management services —including collection, transportation and sanitary landfill as final disposal method— are not proportionally low. The analysis of the costs as a percentage of personal income shows that waste management services in developing countries are costly even with prevailing inefficient operations (Cointreau, 2006).

A study carried out in six municipalities in Sweden that exhibited similar socio-economic characteristics but different waste collection systems, analyzed the waste generation and composition per person (Dahlen *et al.* 2007). Three municipalities had drop-off systems of sorted recyclables; two municipalities had extensive curbside collection of sorted recyclables

including biodegradables, and one municipality had curbside collection of dry recyclables. The results indicated that more recyclables were collected with curbside collection systems compared to drop-offs. It was also observed that there was an increase of dry recyclables, when biodegradable material was collected separately in the curbside collection system. Although weight-based billing decreased the amount of delivered household waste, it was suspected that improper paths, such as illegal dumping or burning of waste were developed.

A very different scenario took place in Pakistan (Anshutz and van de Klundert, 2001). There, the city's waste managers could not understand how, after implementing penalizing measures, residents would still not place the waste put out for collection properly. It was only with the intervention of an NGO that they found that men rejected the task of waste handling, as they viewed it as a dirty job relegated by social norms to women. Simultaneously, the seclusion imposed on women did not allow them to exit their homes nor to be in contact with men, so taking household waste out for collection was not an option. The NGO's context-based solution consisted of the collaboration of children that could be from the households or elsewhere, in which case they would be remunerated.

Similar socio-cultural aspects have been observed to influence waste management in developing countries like Thailand. In this country, waste handling at the household level is regularly a task undertaken by servants and house cleaners, who lack education and awareness regarding source separation. This situation is worsened by the existence of a marked socio-economic differentiation, in which no recycling behaviours or incentives exist (Mongkolnchaiarunya, 2005).

The above characteristics of waste, the socioeconomic conditions and the socio-cultural characteristics of a population — illustrated in the Swedish, Pakistani and Thai examples — are reminders of the importance of the context-based approach. In order to develop and implement an appropriate SWMS, it would seem wise to take into account the environment, the waste characteristics and the population's socio-cultural and socioeconomic opportunities.

It would seem that attempts to import and implement the SWMS of developing countries, usually involve sophisticated and costly technologies. Negative results have been

observed when applying these foreign systems that seem to not match the context and needs of developing countries. These negative results could be associated in the first place with the different characteristics of waste composition. There are higher organic matter and moisture levels in the waste stream of developing countries compared to developed countries which consequently affects the efficiency of technologies. Such is the case of incineration plants or in-vessel composting, which requires electrical power and expensive equipment for its operations. Similarly, a high degree of public involvement is required for a large scale recycling system to function, which is generally a challenging task to achieve even in developing countries (Jaffe and Nas, 2004).

According to Muraleedharan *et al.* (1996) SWMS should be perceived as a result of rapid urban growth, instead of a solely technical problem concerning collection and disposal. A broader perspective that includes the socio-cultural and economic aspects of a given population could elucidate the various limitations and problems present in waste management. It is important to understand that due to the different circumstances as described in the research literature, developing countries entail distinctive situations regarding their SWMS, than those applied in developed countries. A model that is sensitive to local social conditions would therefore be seen to facilitate introduction of sustainable and inclusive SWMS in developing countries.

2.2 Review of Solid Waste Management Systems

Solid waste can be categorized according to its source, such as industrial, hazardous, agricultural, medical or municipal. Municipal solid waste encompasses all the discarded materials which result from the household, industrial, institutional and commercial activities of a community (Pitchel, 2005). It is therefore important that waste management takes under consideration the diverse nature of MSW which results from the various sources.

Solid waste management is defined by Eliassen *et al.* (1977) to include procedures, values and community decision-making infrastructure:

> The field associated with the management of MSW regarding its generation, storage, collection, transfer, processing and final disposal, in a way that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics, and other environmental considerations. In addition, it includes all administrative, financial, legal, planning, and engineering functions involved in solid waste (Eliassen *et al.* 1977).

If SWMS are to be tailored to the needs and characteristics of a given community, then aspects such as financial resources, population size, physical infrastructure, as well as the volume and composition of solid waste would need to be taken into account (Pitchel, 2005). In addition, the design of the suitable waste treatment and collection plans and strategies, must be accompanied by awareness campaigns directed to the community, when implementing a SWMS (Calvo *et al.* 2009).

Sustainability goals are the current focus for many environmental concerns, including the designing, planning and operating of SWMS. These goals include socially sound solutions, maximization of recycling efforts, environmental conservation and the optimization of renewable energy supplies, while being cost-effective (Chang *et al.* 2011). The main components of Municipal Solid Waste Management Systems have been described in a number of contexts, from collection systems to waste disposal systems.

2.2.1 Waste Collection Systems

The literature suggests that one of the first steps in SWMS for mixed or source-separated waste is collection. The latest advancements in waste collection include the collection of organics (including yard waste) and other recyclable materials, as well as hazardous waste. Options for

consideration would seem to include the frequency of collection, the prospects and impediments for source separation, the technology of the vehicles (from low-tech to garbage trucks) and waste storage containers and their capacity. Particular attention is paid to the frequency of collection, as it has been reported that the costs increase with higher collection frequency (Pitchel, 2005).

In developed countries, the majority of MSW is collected (although "transfer depots" are also used in some SWMS). The waste placed for collection must be properly sealed and its loading is often done with fully mechanized systems. This is due to substantial labour costs and a stringent policy framework that assures the minimization of occupational health risks (Armijo *et al.* 2002). On the other hand, according to (Cheeseman *et al.* 2006) developing countries present lower rates of MSW collection. In low-income nations, collection varies from 30% to 60%, while in middle-income nations it ranges from 50% to 80%. The loading of waste is performed in a less mechanized way and the waste not collected poses public health risks (Lardinois and van de Klundert, 1995; Amponsah *et al.* 2009).

There are mainly four types of waste collection described in the literature. These include: curbside or alley collection; setback collection; backyard collection; and drop-off at specified collection point.

In the first type, collection days must be scheduled and residents place garbage containers at the roadside or in rear alleyways on the scheduled day. The collection crew proceeds to empty the waste containers into the garbage truck. The residents are responsible for returning the waste containers.

The second and third types share some similarities. According to Pitchel (2005) the second type, collection days are not scheduled and a special collection crew is responsible for carrying the waste containers from backyard to curb and back to their storage place, while the emptying of containers is done by the collection crew. Residents are not involved in this method, which increases the time of operation. In the third type, the collection crew goes onto the property where containers can be transported directly to the garbage truck or emptied first into a cart and then returned back to their storage place. As with the second type, residents are

not involved in this method. Setback collection and backyard collection are the most expensive methods due to the time-consuming procedure. In the last type, which is the least expensive method, residents are responsible for transporting their waste to specific points that can be transfer stations or disposal sites (Pitchel, 2005).

The designs of optimized routing models that can reduce the overall costs of collection have been proposed in recent years in order to achieve optimal results; the routing system must be tailored to the local conditions. Thus, the models need to consider the population density, waste containers, waste generation and composition, economics, road network type and length, collection vehicles, travel time, cultural aspects and geographic dimensions of each of these. Other models focus on the reduction of greenhouse gases and fuel consumption. Special attention has been paid to Geographic Information System (GIS) route modelling software, which provides the opportunity to establish the minimum cost-distance collection routes for the transportation of MSW to its final disposal. ArcGIS Network Analyst is a GIS application which offers routing, service area delineation and facility proximity analysis (Calvo *et al.* 2009).

One example of the benefits of using GIS routing technology is provided by a study carried out in Churriana de la Vega (cited by Calvo *et al.* 2009) to improve the waste collection system in Spain. The proposed new collection route reduced the distance covered by trucks by 40.6% compared to the previous routes, optimizing the collection time, vehicle maintenance and personnel costs.

2.2.2 Transfer Stations

Some municipalities mainly in the developed world transport the collected MSW to transfer stations prior to taking it to the final disposal site. These can offer a variety of benefits such as the chance to recover recyclables; lower garbage collection-truck maintenance costs, as well as the possibility of partially processing the waste. Transfer stations in the United States can vary in size from small and medium—with the capacity to receive 100 to 500tons/day — to large

transfers with the capacity to handle very large volumes and provide areas for storage (Pitchel, 2005).

2.2.3 Waste Disposal Systems

The following will describe some of the most common waste disposal methods. The description will include the main characteristics of each final disposal method, as well as the negative environmental effects associated with it.

2.2.3.1 Landfilling

Worldwide, a typical landfill contains many materials that could well be recycled or converted into compost but instead they are buried in a landfill. This highlights the linear approach or "cradle-to grave" waste management model. In this model, resources are extracted and transformed into products designed for a specific lifespan. Subsequently, the remainder are disposed of in a "grave" that could be a landfill or an incinerator (McDonough and Brungart, 2002). There is no planned sustainability for the materials.

Traditionally landfill dumps receive MSW, which is deposited into a site lacking a liner and leachate collection system. Once its capacity has been reached, the dump's closure is completed by capping it with a layer of soil. On the other hand, sanitary landfills are those with a leachate collection and treatment systems, as well as an impermeable liner and cap. The sanitary landfill is covered with an impermeable layer when its closure occurs. This technology offers some protection against pollutant migration to adjacent soil, surface and groundwater. The bioreactor landfill which applies newer technology recirculates the leachate throughout the waste, in order to promote the decomposition of MSW (Themelis and Ulloa, 2007).

According to Cointreau (2006), landfilling presents various environmental impacts. It contaminates the soil and ground water, degrades the landscape and releases all sorts of noxious gases, while contributing to global warming. Such by-product gases include carbon

monoxide, methane, benzene, carbon tetrachloride, ethylbenzene, dichloro methane and toluene. In fact, it accounts for 6-18% of the total methane emissions worldwide. According to Yip and Chua (2008), approximately 200 m^3 of greenhouse gases are released into the atmosphere, for each ton of MSW disposed of in a landfill. Also, methane is roughly 23 times more potent as a greenhouse gas compared to carbon dioxide (Themelis and Ulloa, 2007). In addition, adverse health effects might threaten surrounding communities, as a result of these emissions (Sharholy et al. 2008; Yip and Chua, 2008).

In a study assessing 40 generic municipal waste management scenarios it was shown that the best landfill scenario included source separation of recyclables and the diversion of the organic fraction, which was sent to anaerobic digestion with electricity production (Christensen *et al. 2009*).

Landfilling with Gas Harvesting

Biogas or landfill gas is a by-product of land-filling. It is mainly composed of methane (around 54%) and carbon dioxide (around 46%), coupled with minimum quantities of hydrogen sulphide, ammonia, water vapour and other trace components (Themelis and Ulloa, 2007). In recent years, biogas harvesting has gained momentum. Due to the high level of methane the collected biogas can be utilized as a sustainable energy source. As a result of this, biogas harvesting can potentially offer environmental and financial advantages. It also offers social benefits, as it can supply energy to surrounding communities (Yip and Chua, 2008).

The range of choices for landfill gas harvesting, ranges from simple combustion to conversion to natural gas, direct use and electricity generation. Usually the technology involved in this process consists of a network of gas wells and blowers, flaring equipment, landfill gas pre-treatment facility and landfill gas reciprocating combustion engines (Yip and Chua, 2008).

2.2.3.2 Incineration

Incineration is explained as:

> The controlled burning of waste, which could be solid, liquid or gaseous. The controlled conditions might include an oxygen-enriched combustion chamber under elevated temperatures, the use of auxiliary fuel, and vigorous agitation of incoming waste. The main goal of incineration is to reduce the volume of waste, in order to extend the lifespan of a landfill (Pitchel, 2005).

The use of MSW incineration plants is limited due to their high cost. However, a more serious issue is associated with the generation of noxious emissions, such as dioxins which are troublesome and persistent environmental pollutants (Cen *et al.* 2007). Incineration plants can also contribute to the release of heavy metals, such as cadmium, mercury, arsenic and lead. These metals can be discharged as fly ash or bottom ash as well as volatilized compounds, which can travel long distances and pose high a risk to human health (Cointreau, 2002). In addition, incineration promotes the generation of waste due to the constant level of MSW required for its operation. This could potentially lead to a decline in recycling rates, and disregard for waste reduction strategies (Cen *et al.* 2007).

2.2.3.3 Composting

A way to divert the organic portion of MSW from landfilling is through composting. This process involves the enhancement of natural aerobic decomposition of organic matter by microorganisms. The process of composting can be explained as:

> The conversion of the organic waste fraction of MSW into more complex and stable material, which is performed through controlled aerobic and biological processes. The final humus-like product has aesthetically and hygienically safer qualities, as well as a major reduction of its original odour. The final organic product is usually utilized for agriculture and landscaping, as well as in landfill operations as a daily cover material and for remediation of contaminated sites (Pitchel, 2005).

2.2.3.4 Anaerobic Treatment

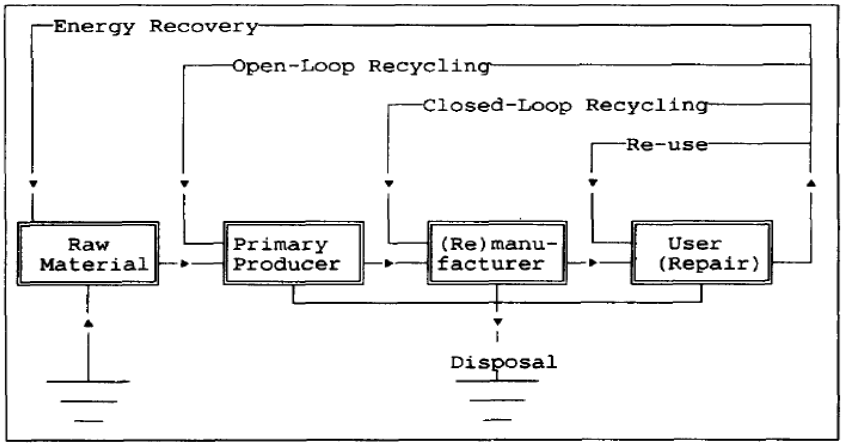
The anaerobic treatment for waste management involves a series of procedures under anaerobic conditions, using microorganisms to break down the biodegradable material. As a result of this anaerobic process, carbon dioxide and methane are released as biogas. Due to the fact that this process does not require the use of oxygen, electricity consumption is reduced. In addition, another major advantage of this method is the use of the biogas sub-product for energy generation. Overall, this system involves four phases: hydrolysis, acidogenesis, acetogenesis and methanogenesis; at the same time, specific mesophilic bacteria are linked to each one of these steps. The temperature of the reactor is maintained at 35°C, due to the mesofilic characteristics of the bacteria used (Spachos and Stamatis, 2011).

2.2.3.5 Recycling System

The broad area of interest of this research is recycling, defined by Beaukering (1994) as “the means of reprocessing waste to recover an original raw material in order to avoid disposing of potentially valuable materials, as well as offsetting energy usage and the consumption of virgin materials”.

In general, recycling encompasses different categories of solid waste recovery, such as re-use and repair, closed-loop and open-loop recycling and energy recovery (Figure 1). The first step in a recycling system usually observed in developed countries is source separation, which implies the separation of recyclables from the waste stream. This first step is usually performed at the household level, as well as commercial and institutional establishments (Pitchel 2005).

Figure 1. Material Resource Balance



Beukering (1994)

Pieter van Beukering (1994) performed an economic analysis of the formal and informal entrepreneurs recovering MSW in Bangalore, India. He found that re-use and repair is a method that reclaims material in its final-use form to be used in the same way, with only minor changes and with the use of simple technology. Closed-loop recycling recovers materials and reuses them in the same manufacturing activity. Waste is reprocessed at the industrial level and does not enter the waste market. Open-loop recycling —the most common type— requires sophisticated technology, which will process materials after they have entered the recycling market.

Energy recovery is considered the last choice when waste can neither be re-used nor recycled in a cost effective way. This process can entail the direct combustion of waste in order to harvest energy, or the conversion of waste into intermediate fuel products (Beukering, 1994).

According to Anschutz and van de Klundert (2001) source separation, re-use and recycling are of great importance in waste management; especially source separation, as it increases the value of the collected recyclables. Similarly, the value of recyclable materials increases with each step of the recycling chain. First, the retrieval of items from mixed waste

converts the retrieved items into a resource. Second, the sorting process increases the value of recovered materials due to higher categorization. Such is the case of plastics separated by subcategories such as high-density polyethylene, polyethylene terephthalate and polyvinyl chloride. Third, the accumulation of large volumes increases the profit margin. The last step consists of pre-processing activities, such as washing, compacting, cutting, granulating and baling (Cheeseman *et al.* 2006).

Factors Influencing Recycling

A study carried out in Israel assessing the financial viability of formal recycling —performed by private or public sectors— reported that when performed efficiently, municipal recycling was less costly than conventional waste disposal methods. The results suggested that recycling represented a financial advantage in over 50% of the municipalities in Israel, as it would reduce approximately 11% of the costs of conventional disposal, while obtaining environmental benefits (Lavee *et al.* 2009).

Recycling depends on the value added to discarded or secondary materials, compared to their value as primary raw materials. The physical characteristics of primary or secondary raw materials will determine the economic opportunities. The value is determined by the quantity (mass), location (dispersion of mass) and quality (homogeneity and contamination) of primary and secondary raw material. Subsequently, residuals must be produced in high volumes in order to warrant a cost-effective recovery process (Beukering, 1994). In addition, the purchase and sale of recyclable materials depend on the supply and demand of the material in question, both internationally and locally. This uncertainty creates a problem when it comes to selecting the types of material to recycle (Armijo *et al.* 2002).

Lavee *et al.* (2009) have suggested that a possible way to deal with this uncertainty is by governmental intervention. Such intervention could promote recycling through Pigouvian taxes. These taxes can be applied to municipalities, consumers and producers, while providing subsidies to reduce recycling costs. Another intervention policy that might help dealing with

price uncertainty is price stabilization for recycling. However, they have found that the implementation of this requires a long-term contract between recycling plants and municipalities in order to secure a fixed price for their waste. This policy addresses the price uncertainty issue, instead of a subsidy program that could boost recycling, but not eradicate uncertainty.

Technological development also influences recycling of materials. This becomes evident with the improvement of the technology employed in the production of primary and secondary materials. If secondary materials can be easily replaced by primary materials, then the value of secondary materials will increase. However, if the technology is undependable, then the value of the secondary materials will diminish. The improvement of technologies used for primary material extraction also affects the value of such materials. Such is the case of innovations in logging methods, which decrease the price of wood pulp and can potentially affect paper recycling (Beukering, 1994).

Plastic recycling has the advantage of reduced space requirements after being converted to pellets and processed to granules, which is about equal to the space required for virgin operations (Beukering, 1994). However, it is a difficult process as each type of plastic goes through a different process and the contamination associated with its recycling poses major concerns (Pitchel, 2005).

Cullet or broken glass recovering is one of the most ancient types of recycling, and its quality loss is significantly less compared to that of other materials (Pitchel, 2005). However, some decontamination before processing is needed. In general, virgin glass production costs are high due to the equipment required and higher cleaning efforts. This makes cullet reprocessing attractive, as does the energy savings it can offer, mainly due to the cullet's lower melting point (Beukering, 1994). In order to create new glass products, the first step consists of separating the glass into clear, green and amber, followed by the crushing of containers into little pieces and finally, it goes into the furnace mixed with limestone, silica and soda ash (Pitchel, 2005).

Paper recycling is very common in industrialized countries. In developing countries, however, its collection is not as organized. Recovered paper can be categorized as: bulk paper such as corrugated paper and newspaper, and high grade paper such as manila folders. The bulk collections are mainly used to produce construction paper and paperboard among others, while high-grade material is mainly used as a pulp substitute. The main disadvantage of paper recycling is the fact that its quality downgrades in the process. This is due to the fibres shortening and the loss of bonding capacity and flexibility. On the other hand, each ton of recycled paper prolongs the landfill's lifespan, while saving 7000 gallons of water, along with 4100 kWh of energy (Pitchel, 2005).

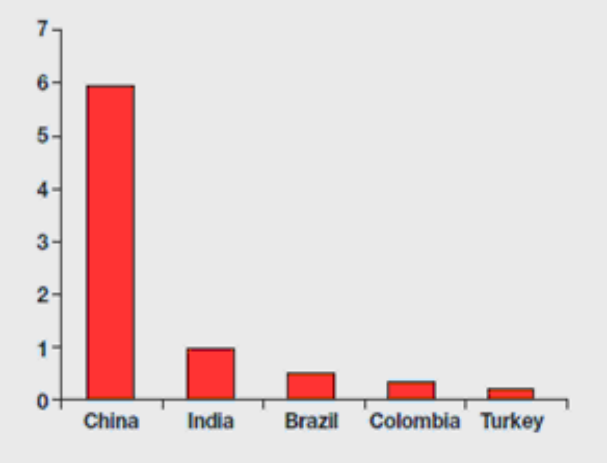
Recycling of non-ferrous metals such as lead, copper, aluminum and zinc is very popular in both developed and developing countries. Their recycling presents various advantages compared to mining. Since less energy is required, it does not impose a loss of quality, generates lower emissions and presents stable prices. These characteristics of non-ferrous metal recycling create exceptionally profitable conditions (Beukering, 1994). Such is the case of steel recycling which presents various advantages like significant water and energy savings due to avoided mining or impurity treatment, as well as lower greenhouse gases emissions and the preservation of its quality properties. This means that it does not lose its qualities as a result of undergoing several recycling processes (Pitchel, 2005). However, there is a limited availability of non-ferrous metals in the recycling market (Beukering, 1994; Pitchel, 2005).

The Social Component of Recycling

Recycling of materials is part of the formal waste management system in some jurisdictions, while it remains an informal practice in others. This situation highlights a contrast between costly and sophisticated MSWMS throughout various cities in North America and European countries, with recycling at the household level and curbside collection, compared to more rudimentary systems where recycling is performed informally, and often lacks source separation at the household level.

In the majority of developing countries, recycling is carried out by informal recyclers or recyclers-by-trade (Figure 2) (Medina, 2008). In fact, it represents a significant income source in Asia and Latin America, where 1 to 2% of the population relies upon waste picking for their subsistence (Cheesman et al. 2007). For the purposes of this paper, the terms "informal recyclers" and "recyclers-by-trade" will be used synonymously.

Figure 2. Estimated Number of Waste Pickers (millions)



Medina (2008)

This informal recycling sector has been defined by Cheesman *et al.* (2006) as "the unregistered, unregulated, casual activity performed by individuals or organized informal recyclers, which are small scale with minimal capital input and labour-intensive methods". According to Armijo *et al.* (2002) this informal recycling sector has a flexible and adaptive nature that responds to limited local conditions and scarce financial resources, which increase in the face of economic crisis. As stated by Gutberlet (2008) this vulnerable sector is characterized by a lack of influence in local decision-making.

In addition, recyclers-by-trade are unlicensed, thus escaping tax payments and lacking social welfare (Cheeseman *et al.* 2006). According to Jaffe and Nas (2004), informal recycling systems are very dynamic, presenting cultural, political and organizational aspects that are likely to exist as long as waste and poverty coexist. However, they argue that there has not been sufficient research done on this topic, thus the up-to-date descriptions of the informal recycling sector fall short and cannot describe their diversity.

2.3 Green Agenda in Solid Waste Management Systems

Currently, the role that urban sustainable development is playing in policy-making is believed to be gaining momentum with recognition of climate change issues, especially in developed countries. According to Roper (2006), the reduction of MSW generation, followed by an increase of reusing, recycling and composting are crucial to alleviating the difficulties faced by waste management. Furthermore, Muraleedharan *et al.* (1996) suggested early in the sustainability debate within SWMS that planning required intra- and inter-generational aspects to be taken under consideration. These aspects include the conservation of resources, public health concerns, environmental contamination of waste disposal methods, as well as the livelihood of all the stakeholders involved in SWMS, including informal recyclers.

Following the sustainability trend, SWMS has begun to include strategies to reduce the quantity of the raw materials utilized, as well as to reuse and recover recyclable materials. These strategies are implemented through regulations that create incentives for industries. However, according to Brungart and McDonough (2002), even these measures cannot solve the intrinsic problem of waste generation under the current industrial model. By themselves, such measures do not address the long-term effects of environmental pollution and the toxicity of manufactured goods and their subsequent disposal. They argue that it is necessary to take a further step, in which materials can be recycled. Even better, they should be "upcycled"— conserving the high quality and usefulness of the original material, and using only non-toxic compounds.

A further step introduced by Brungart and McDonough (2002) is a new way of looking at industrial design that embraces the challenge of replacing eco-efficiency with eco-effectiveness. Although eco-efficiency aims for a more sustainable approach —doing more with less material, energy consumption, and time— it does not provide a successful strategy in the long run. This is due to the lack of a comprehensive analysis of the long-term cumulative impacts that industrialization coupled with waste production and contamination impose on the environment and human health. It primarily focuses on reducing the negative impact of the old and

destructive system which is evidenced in its policies of reducing the amounts of toxic waste released into environment every year, meeting stipulations of complex laws to prevent ecosystems and people from being poisoned too quickly, and calculating prosperity by less activity. In addition, eco-effectiveness embraces a more complex mix of considerations and aspirations. It promotes doing things right from its origins, instead of making the wrong ones less harmful.

Following the concept of eco-effectiveness, a zero waste strategy is not only a target to attempt but also a useful strategy that some producers have already implemented. Under this framework, a producer is responsible for the life cycle of the products manufactured. This falls under the Extended Producer Responsibility policy, which deals with the process of goods until the consumer is done using them (Roper, 2006).

Chapter 3. Review of Informal Recycling Considering the Social, Economic, Environmental, Political, Technical and Organizational Aspects

The following chapter describes the nature and characteristics of the informal recycling sector in developing countries. This description includes the social, economic, environmental, political, technical and organizational aspects that are associated with waste management in these countries.

3.1 Social Aspects of Informal Recycling

The recycling performed by informal recyclers began with the rapid industrialization of European and North American cities primarily in the 19th century, along with the introduction of the first waste collection systems (Anschutz *et al.* 2006, Cheesman *et al.* 2009). With modernization of waste management in these industrialized countries, access to recyclables found in the waste stream became restricted to the formal sector, ignoring the role the informal recycling sector had been providing. This denied informal recyclers so much of their livelihoods that they subsequently discontinued their activities (Anschutz *et al.* 2006).

Although in the majority of European and North American cities this informal recycling practice has been replaced with formal and more costly and sophisticated recycling technologies, the informal recycling practice is still prevalent in most developing countries (Lardinois and van de Klundert, 1995; Araba *et al.* 2009).

Different types of informal recycling have been described in the literature depending on where and how recyclables are recovered. The most common types of informal recyclers or recyclers-by-trade in developing countries encompass the group of itinerant waste buyers, street waste pickers and dump and landfill waste pickers. Itinerant waste buyers specialize in one or two kinds of recyclable materials, which they purchase directly from households. Street waste pickers recover recyclables from waste found on streets and communal bins or bags prior to collection, while dump and landfill waste pickers, live on or near the open dumps and landfill

sites where they recover recyclables (Medina, 2000). The recyclable materials collected by this informal recycling sector are usually sold to dealers. The transportation mode of the collected recyclables in developing countries depends on recyclers-by-trade's income, and includes sacks, wheelbarrows, hand-push carts, tricycle carts, rickshaws, horse-pulled carts and motorized-tricycles (Araba *et al.* 2009).

A common method used by the World Bank to determine the poverty line is the purchasing power parity (PPP), and those who present incomes below the established PPP are considered poor (Dikshit *et al.* 2006). According to Cheeseman *et al.* (2006), it has been observed that the recycling network in developing countries has a hierarchy in which individual recyclers-by-trade (itinerant waste buyers, street- and dump-waste pickers) belong to the base of the pyramid, which limits their earnings. This is mainly due to a lack of storage space and limited processing capacity of individual recyclers-by-trade. The next level is composed of family units, which provide social and economic support to their members. Next are recyclers-by-trade organised into small enterprises or cooperatives. These organizations have the ability to increase the value of the materials collected and legitimizes their activities. The network hierarchy is followed by dealers or middlemen, who purchase directly from informal recyclers or recyclers-by-trade, then wholesalers who purchase from dealers and sell directly to recycling industries.

Through questionnaire surveys in Delhi, India, Dikshit *et al.* (2006) studied the entire chain of the informal recycling sector, which included waste producers, informal recyclers (composed of street waste pickers and itinerant waste buyers), dealers and wholesalers. They argued that the urban poor participate in environmental conservation and economic development and that little attention has yet been paid to the study of their activities. These researchers found that informal recyclers, particularly street waste pickers in Delhi were incapable of ascending to higher levels within the recycling trade due to social segregation and a lack of network connections. Thus, a chronic state of poverty within the informal recycling community prevailed.

Informal recyclers have been characterized as being marginalized socially and politically in the jurisdictions where they operate. Their work is usually thought to be dirty and low-status. They frequently belong to the most disenfranchised minority groups and their work is associated with illegal activities (Lardinois and van de Klundert, 1995).

In most cases, they are migrants or belong to ethnic or religious minorities. This is the case of the Dalit, who under the traditional Indian caste system, have been relegated to waste picking and latrine cleaning. Similar cases occur in Muslim countries where non-Muslim or ethnic minorities are confined to waste management activities. Such are the cases of the Palestinian community of waste pickers in Lebanon and the Zabaleen community of Coptic Christians in Egypt (Anschutz *et al.* 2006).

Overall, there is very limited research and fieldwork done regarding the informal recycling practice. This is associated with the difficulties presented at times by the unsafe conditions surrounding these marginalized communities, as well as the fact that only recently has this topic gained momentum in the academic world (Jaffe and Nas, 2004). Due to the difficulty of measuring the informal recycler's performance, quantitative data on waste management in these countries are limited and often unreliable. This is especially true of information regarding recycling rates (Araba *et al.* 2009).

3.2 Economic Factors of Informal Recycling

The informal recycling sector is characterized by having a flexible and adaptive nature that responds to local economic conditions (Jaffe and Nas, 2004). From a macroeconomic standpoint, the informal recycling system would seem to be well adapted to developing countries' conditions, which include scarce capital and a large low-skilled workforce. The informal sector offers a stable and consistent supply of secondary materials to local industries, replacing more costly imported raw materials (Cheeseman *et al.* 2006).

According to Medina (2000) recyclers-by-trade act in response to the market's needs; they are not driven by environmental concerns. The logic of their response is linked to the

market's demand for a particular material and a sufficient price being paid for its collection to attract recyclers.

Recycling activities of any kind including formal recycling performed in developed countries contribute to local economies worldwide. However, recycling in developing countries as discussed previously is mainly performed by the informal sector. Due to this scenario, the following economic benefits are attributed to the informal recyclers' labour in the developing world.

According to Medina (2000), informal recycling enhances the commercial sector by boosting industrial competitiveness, as the recovered valuable materials can be locally utilized without loss of hard currency. In addition, less energy is consumed using recovered materials, resulting in lower operational costs for industries. This was observed in Mexico, where importing wood pulp was seven times more expensive than using recovered waste paper. As a result, Mexican paper mills improved their relationship with street waste pickers in order to lower their costs and be competitive with North American paper makers (Medina, 2000).

Recycling represents an essential source of informal employment for a large portion of the urban poor, which would otherwise not have had paid work. They obtain revenues exclusively from the direct sale of the collected recyclable materials (Lardinois and van de Klundert, 1995). In fact, the labour-intensive characteristics of informal recycling consist of an exhaustive set of collection circuits around the city and extensive material selection activities, which require a large workforce. This labour-intensive characteristics and large workforce requirements might have not existed if production was limited to the extraction and the industrial processing of virgin materials (Beukering, 1994). In the case of itinerant waste buyers, they also contribute to an increase in the incomes of waste producers —like household residents or business owners, by purchasing their recyclable materials (Dikshit *et al.* 2006).

The savings to municipalities consist of a reduction in the volume of waste that would otherwise be collected, transported, and disposed of in landfills (Jaffe and Nas, 2004). Reported data suggest that in Jakarta, Indonesia, in 1988, recyclers-by-trade's activities saved the city

about US$300,000 per month, while recovering 25% of the daily waste production (Lardinois and van de Klundert, 1995).

In Surabay, Indonesia, recyclers-by-trade collected 12% of the city's waste, while recovering 31% of the recyclables (Armijo *et al.* 2002). In Delhi, India, the resulting profit generated from waste marketing activities performed by street waste pickers, itinerant waste buyers, dealers, wholesalers and recycling industries, was estimated to be US $74 million per year. Over 40% of the total value was destined to waste producers, 50% was internalised as the private incomes of waste traders and the remaining sum resulted in budget savings for waste disposal (Dikshit *et al.* 2006).

The profits of the different players involved in the informal recycling chain highlight marked differences, in which earnings vary according to the player's position in this chain (Araba *et al.* 2009). While the earnings of middlemen can reach USD$4 248 per year, large itinerant buyers earn USD$3 058 per year and street waste pickers earn just USD$510 per year in Port Harcourt, Nigeria (Chinwah, 2006).

In Delhi, India out of 1kg of recyclable material sold to recycling industries, 52% of the earnings went to waste producers, followed by wholesalers with earnings of 25%, itinerant waste buyers with 12% and lastly dealers or middlemen with 11% (Dikshit *et al.* 2006). A study carried out in various cities in Mexico showed that waste pickers enjoyed an income five times higher than the minimum wage. This study surveyed approximately 3,000 recyclers-by-trade, who collectively processed 353 000 tons of waste per year. A similar situation occurs in Sao Paulo, Brazil, where the members of recyclers-by-trade's cooperative collected and sold 100 tons a month and earned US$300 a month - fully twice the minimum wage. Lastly, in Buenos Aires, Argentina, over 40,000 waste pickers produced revenues of US$178 million a year (Medina, 2000, 2008). The above case studies showcase how informal recyclers' activities can result in substantial savings in fuel and labour, as they reduce the volume of waste collected and transported to final disposal. Subsequently, they also contribute to prolonging the life span of sanitary landfills and promoting environmental conservation (Medina, 2008).

According to Medina (2000), in some low-income neighbourhoods where there is a lack of waste collection services and difficult topographic conditions, informal recyclers provide the service by charging a fee to residents. Such is the case of Santa Cruz, Bolivia where informal recyclers serve 37% of the city, showing the willingness of residents to pay for this service. In addition, municipal waste collection using garbage trucks presents a disadvantage over informal recyclers, as their transportation methods are better suited to the hilly conditions and the narrow and unpaved streets. However, illegal dumping is a negative effect associated with this waste collection system where the distance to the final disposal sites is located too far away for transport modes of limited capacity to transfer the collected waste.

3.3 Environmental and Health Aspects of Informal Recycling

Due to the manual handling of waste, as well as the lack of health and safety standards regarding protective gear and clothing, informal recyclers face occupational workplace risks. The direct contact with waste can potentially represent occupational risks. Such risks include encountering broken glass, hazardous substances, faecal matter, leachate, toxic chemicals, pesticides, needles and infectious and allergenic materials (Cointreau, 2006; Anschutz *et al.* 2006; Cheesman *et al.* 2006). The decomposition of waste also represents health risks, associated with inhaling dust, bio-aerosols and fumes caused by open burning of waste. Handling waste also presents health and safety risks, which are linked to the constant lifting, odour, working in traffic, and accidents. In fact, children waste pickers, which account for a significant portion of recyclers-by-trade, are the most vulnerable. This is due to a higher ingestion of toxins per unit of body weight. Subsequently, disturbances throughout their growth period can negatively affect the functionality of their reproductive, immune, endocrine and nervous systems, as well as their organ development (Cointreau, 2006).

Although there is scarce data availability regarding the health issues associated with informal recycling, data suggest that as a result of their direct contact with waste, pickers are prone to certain health problems. Such problems include, eye infections and skin and

respiratory complications (Cheeseman *et al.* 2006). According to Cointreau (2006), studies carried out worldwide have reported that solid waste workers experienced a higher risk of acquiring different diseases "they have 10 times more risk for acute diarrhea (Romania); 6 times more risk for infectious disease (Denmark); 3 times more risk for parasites (India); 2.6 times more risk for allergic pulmonary disease (Denmark); 2.5 times more risk for chronic bronchitis (Switzerland) and 2 times more risk for coronary disease (USA) and 1.2 times more risk for hepatitis (Italy)".

Environmental benefits include reduction of greenhouse gases, the conservation of virgin resources and a reduction of environmental exploitation activities and the prevention of ecological damage. This is the case of paper recycling which reduces logging activities that promote flooding and soil erosion. Likewise, metal recycling reduces mining activities, which are associated with the release of toxic substances that can potentially increase air and water contamination (Dikshit *et al.* 2006).

By recovering 378 000 tons of paper per year, waste pickers in Jakarta have saved six million trees from being cut (Lardinois and van de Klundert, 1995). Although it is complicated to measure these environmental benefits in monetary figures, they are likely to be significant (Dikshit *et al.* 2006).

3.4 Political Aspects of Informal Recycling

As stated previously, although the services performed by informal recyclers reduce the overall costs of SWMS, in various places a negative perception and a hostile relationship between the informal and formal sectors continues to prevail. This negative perception is mainly associated with street litter when garbage containers are not put back in place, or if their contents are spilled. There are also issues where traffic is interfered with by street waste picker's carts, as well as concerns related to sanitation. Furthermore, there is often embarrassment associated with having informal recyclers in the cities, as they symbolize failed attempts at modernisation.

In some cases, municipal authorities ban the informal sector's activities which results in them being considered criminals (Medina, 2000; Jaffe and Nas, 2004; Gutberlet, 2008).

Extreme cases of hostility and violence towards the informal recycling sector have been reported in Colombia, where they were expelled from certain neighbourhoods and killed by paramilitary groups who performed "social cleansing" (Medina, 2000). In other cases, municipal employees working at open dumps, the waste collection crew and the police force have received bribes for allowing informal recyclers to access the dumps, or to recover recyclables directly from the garbage trucks or the streets. The presence of these scenarios also reinforces contention that there is exploitation of informal recyclers (Dikshit *et al.*2006).

The Zabaleen community of itinerant waste buyers in Cairo has had an exceptionally high recycling rate of 80%, and has been active for over 70 years. However, faced with social and political marginalization together with a lack of political power and a dependency on local political decisions, this group has suffered from this vulnerability (Cheeseman *et al.* 2006). In 2003, Egyptian authorities privatized waste collection and in 2009 they ordered the culling of all pigs. These animals were vital to the elimination of organic waste, and this action in turn threatened the livelihood of Cairo's informal recyclers and jeopardized their efficient system (Slackman, 2009).

Experiences similar to the one describing Cairo's recyclers-by-trade have been observed throughout the developing world. Such is the case of the study conducted in Brazil by Gutberlet (2008) on a recycling co-operative called CooperPires. In this study, recyclers-by-trade, the local government, and the business community were interviewed and video documented. The study illustrated the social and economic challenges faced by the CooperPires co-operative created in 2004, and how quickly they lost all governmental support due to changes in municipal politics.

These scenarios highlight the vulnerability recyclers-by-trade experience, due to their dependency on local authorities, as well as their marginalized social and political status. These circumstances are a result of the frequent social perception that informal recyclers represent an undesirable set of actors in waste management systems (Jaffe and Nas, 2004). However, it has been noted that previous attempts to abolish informal recycling in developing countries,

followed by encouraging them to engage in different activities, have not been successful (Medina, 2000).

Evidence that the effects of public policies regarding recyclers-by-trade have been influenced by public perception has been summarized by Medina (2000) who identified four scenarios. These include repression, neglect, collusion and stimulation. As described above, one scenario is the situation in which informal recyclers are considered illegal and a very negative perception towards them prevails. This setting is characterized by repressive policies accompanied by a hostile relationship between the informal and formal waste management sectors.

Another scenario is one in which local authorities do not recognize recyclers-by-trade activities, as they are ignored and are not provided with appropriate support. The collusion scenario is typified by a political clientelism relationship, where local authorities exploit informal recyclers. This exploitation takes place in the form of monetary bribes.

The "stimulation" scenario legalizes informal recyclers' activity and recognizes the environmental, economic and social benefits they are accountable for. This recognition is accompanied by the provision of support, programs and training. It also foments higher organizational structures of recyclers-by-trade and grants their organizations or cooperatives contracts related to waste management. Subsequently, Jaffe and Nas (2004) developed a hypothetical model using the four public policy scenarios identified by Medina, to improve recyclers-by-trade's working conditions. This is described in more detail in section 4.2.

3.5 Technical Aspects of Informal Recycling

It has been observed that transfer stations can substantially increase recyclers-by-trade's working efficiency as they provide space to sort, accumulate large volumes, and even pre-process the collected materials prior to selling (Baillie and Feinblatt, 2010). According to Armijo *et al.* (2002), it appears that if transfer stations are equipped with scales, boxes for storage, grinders for waste processing and showers; recyclers-by-trade can potentially improve the

value of sale of recyclable materials, due to higher volumes, added value of pre-processing activities and savings in transportation costs.

It has been suggested that the majority of the informal recycling sector is mainly dedicated to collection and separation activities of potentially recyclable materials prior to their sale. Pre-processing activities can potentially present various benefits. Advantages have been observed in Cairo, where a family of informal recyclers had purchased extruders — small processing machines — in order to sell the collected plastic in the form of pellets (Baillie and Feinblatt, 2010). A similar case has been reported in Buenos Aires, Argentina where the Cooperativa Nueva Mente of recyclers-by-trade has been using a hotpress technology, in order to convert natural fibres and plastic waste materials into composite materials (Waste for Life, 2011). Another case in Argentina is the cooperative Reciclando Sueños, which made the transition from collecting, sorting and selling recyclables materials to manufacturing. Currently, they process plastic by chopping, cleaning, drying and injecting it into a mould that they can subsequently assemble and sell as a painting sponge product (Baillie and Feinblatt, 2010).

3.6 Organizational Aspects of Informal Recycling

Recyclers-by-trade belong to the bottom of the recycling chain and occupy a marginalized social and political status, as described previously. It has been observed that when they are organized into cooperatives — instead of working individually — they gain public recognition, while improving their living conditions and income and increase their recycling rates (Baillie and Feinblatt, 2010).

Such organized systems can confer legal status on the activities of the informal sector, provide its members with more stability, as well as increase their self-esteem and influence their decision-making. It can also prevent health risks by avoiding working directly on dumpsites (Gutberlet, 2008).

According to Medina (2000), it appears that informal recyclers' organizations can be successfully run as small businesses, cooperatives or public-private partnerships. The small-

business organizational type usually occurs when there is no municipal waste collection system at all in a given neighbourhood, thus opening the door to entrepreneurs. Partnerships are characterized by municipally-supplied equipment and infrastructure. The waste pickers themselves provide only their labour. This partnership operates a recycling plant, fed by recyclables separated at source (Medina, 2000, 2008). Cooperatives are the most common organizational type throughout Latin America. Such is the case of Brazil, which has over 500 street waste picker cooperatives boasting 60,000 members. It has been suggested that this organizational type requires long-term governmental support to improve health and hygiene, promote self-confidence, provide technical training and help commercialize recycled materials (Gutberlet, 2008).

3.6.1 Cooperative Systems

Currently, researchers' interest in economic democracy like cooperatives and associations — also called self-management companies — has risen as a result of the negative effects of globalization and neoliberal policies (Hernandez, 2006). A solidarity economy is an alternative way of production, capital distribution and organization system. It seems to be an attractive option particularly to informal recyclers in developing countries, as it appears to allow them to defeat social exclusion, while self-generating employment and income (Amato, 2008).

According to the International Cooperative Alliance (ICA) (2010), a cooperative is defined as "an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly owned and democratically controlled enterprise".

For the case of the recyclers-by-trade, the Production Cooperativism Model might be an interesting alternative. This model consists of a cooperative system that produces specific goods while being managed in an autonomous way by its workers (Amato, 2008). The workers' autonomy or full control is achieved by democratic decision-making, collective ownership and common objectives (Hernandez, 2006; Martinez, 2008). The existence of a common cultural

and historic background is an important element in a cooperative system, as it facilitates the communication and the creation of cooperative ties (Cabaleiro and Fernandez, 2007).

The cooperativism system has seven governing principles established by ICA in 1937 and last reviewed in 1995. These are: the membership is voluntary and open to all individuals who are willing to commit to the responsibilities of being a member; each member has an equal voting right, thus presenting a democratic system; members have economic participation in the cooperative, where part of the capital belongs to the cooperative and members obtain some degree of compensation; the co-operative has an autonomous nature and is fully controlled by its members; the cooperative is in charge of providing its members with training, education and information; there is a sense of cooperation amongst cooperatives in order to support the cooperativism movement; and it is in the co-operative's interest to improve their community by focusing on sustainable development (Rufino, 2002).

In most cooperatives, the internal government presents similar characteristics. According to Martinez (2008), the governing system is characterized by a hierarchical structure where power is exercised by delegation; the members must voice their concerns to their representatives, who will subsequently communicate the information to the higher management level. The leadership is centred in the directive members and the professional management; which are responsible of achieving the social objectives along with the market competitiveness.

Although collective decision-making can lead at times to a conflictive environment, if focused strategically, it can contribute to the development of the organization; which showcases the dynamic nature of this system (Hernanadez, 2006). The greatest challenge of self-management companies is to assure their efficiency and competitiveness in the market, while safeguarding their solidarity principles (Rufino, 2002).

Chapter 4. Sustainable and Inclusive Solid Waste Management Systems

The following chapter describes the focus and main goals of the sustainable and inclusive solid waste management system. This description includes the different approaches regarding the informal recycling sector; the legal and economic aspects influencing the integration of the informal recycling sector; the worldwide initiatives working towards inter-sector integration in SWMS; and the models proposed in the published literature regarding the integration of the informal recycling sector into the formal SWMS.

4.1 Approaches to Informal Recycling

According to Gutberlet (2008) there is a growing necessity for implementing Sustainable and Inclusive Solid Waste Management Systems (SISWMS) policies, which support the incorporation of marginalized communities of recyclers-by-trade into the formal SWMS. The necessity of inclusive policies is based on their capacity to reduce poverty and enhance environmental health.

SWMS present certain financial and institutional barriers that limit the development of integrated and sustainable systems. This situation is exacerbated when there is a narrow-sighted view of waste management; as a strictly technological problem excluding the needs of the local social system (Lardinois and van de Klundert, 1995).

This narrow-sighted view misses out on the opportunities that could result from including the existing local social system. Such is the case of an alliance between the two sectors —formal (private and public) and informal (informal recyclers) — that could potentially create a win-win scenario. This win-win scenario is likely to improve working conditions, increase recycling rates, address social issues and be financially convenient for municipalities. According to Anschutz and van de Klundert (2001), the sustainable aspect would depend on the capacity of the waste management system to avoid depleting the resources it depends on for its existence.

It has been suggested by Anschutz *et al.* (2006) that the traditional approaches aiming to aid recyclers-by-trade have failed to succeed due to ignoring their professional role in the waste management systems. These approaches have perceived informal recyclers as a social issue instead of as economic actors, which are part of the SWMS. Such approaches include: the development-based approach, the welfare-based approach and the rights-based approach (Anschutz *et al.* 2006).

The development-based approach identifies recyclers-by-trade as a social identity and views them as an unfortunate community faced with a precarious livelihood. Although this approach focuses on reinforcing their capabilities and providing them with new opportunities —by fomenting education and access to credits— it ignores their professional role in waste management. The welfare approach as its name suggests, focuses on recyclers-by-trade's lack of welfare and it works towards improving their living conditions, yet it neither acknowledges their economic role in SWMS nor addresses their political issues. The right-based approach centres on institutional, political and social issues. It works towards increasing their political intervention by strengthening their legal status and setting them up in organizations. Although this approach recognizes informal recyclers as social and political stakeholders, it still ignores their economic role in SWMS (Anschutz *et al.* 2006)

According to Gutberlet (2008), countries that are more progressive have now begun to invest in social programs that support organized selective waste collection, recycling and commercialization. One of the first steps towards this change is the recognition of the informal sector's current contribution to recycling in developing countries. To achieve this change of perception, it is crucial for decision makers to acknowledge waste pickers as an asset to be engaged as potential partners in SWMS (Medina, 2008). To this end, Armijo *et al.* (2002) suggest that recyclers-by-trade must be moved higher up in the recycling hierarchy and become small recycling contractors.

Armijo *et al.* (2002) have suggested that engaging citizens and various stakeholders can contribute to the increase of recycling rates. This includes schools, universities, businesses, hospitals, industries and religious communities, among other important community groups. The

following methods have been identified as helpful tools for increasing the overall recycling rates: implementing campaigns at a national and local level, developing workshops targeting various stakeholders, as well as reaching the public through TV and radio programs. These methods can potentially promote recycling at the source within the entire population. In addition, it can contribute to a more complete collection of recyclable materials performed by recyclers-by-trade.

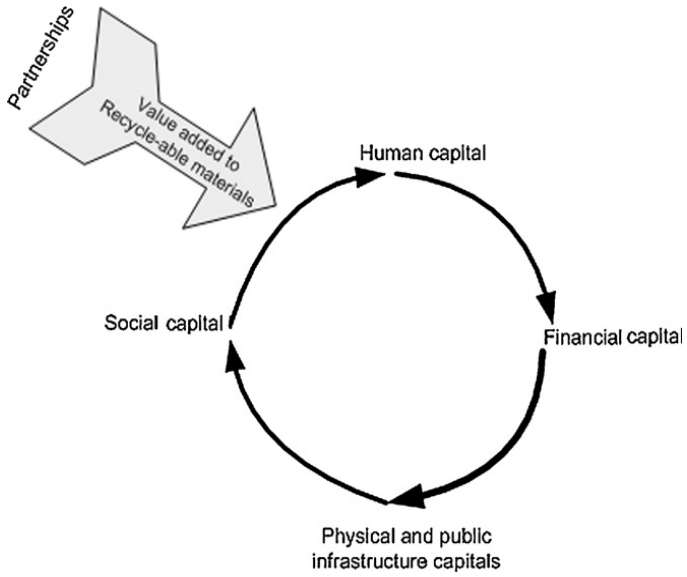
In searching for alternative solutions, Scheinberg *et al.* (2006) have suggested exploring the economic activities carried out by the informal sector within the waste management system. They have also suggested four types of recyclers-by-trade's involvement. To involve recyclers-by-trade in new service roles both in collection and recycling requires an increase in their participation. To improve sorting activities and increase recycling capacity and working conditions requires the construction of transfer stations. To enhance the market leverage requires the creation of recyclers-by-trade's cooperative organizations. To assure good management requires the promotion of good communication among all stakeholders involved in the waste management system and the planning process.

Nitivattananon and Sembiring (2010) have suggested the use of the conceptual approach when working towards the inclusion of informal recyclers into the formal SWMS. This conceptual approach consists of five types of capital that influence their integration. These five types of capital include public infrastructure, financial, human, physical and social capital. Public infrastructure includes roads, hospitals, schools, etc. Financial capital comprises the available monetary assets. Human capital covers the education, skills and abilities of individuals. Physical capital comprises land, property and machines. Social capital represents rules, norms, value and networks.

It has also been argued by Nitivattananon and Sembiring (2010) that the informal sector must improve its ability to add value to their collected material prior to their integration into the formal SWMS. An increase in their earnings is positively correlated to their living conditions and social acceptance. Figure 3 shows the existence of a capital cycle that affects the integration of the informal recycling sector into the formal SWMS. By raising the financial

capital through social and human capitals, the physical and infrastructure capitals can also increase. Thus, it seems that by strengthening the partnership between the informal and formal sectors, it is possible to improve living conditions of informal recyclers involved in SWMS.

Figure 3. Cycle of Capital in the Integration of the Informal Recycling Sector in an Inclusive Society



Nitivattananon and Sembiring (2010)

Anschutz *et al.* (2006) have suggested a systems approach that views informal recyclers as economic players and valuable stakeholders within the waste management system. In order to stimulate recyclers-by-trade in their economic role, they center their efforts on the following measures:

1. Creation of new opportunities for collection and recycling, with the participation of informal recyclers in system design and implementation
2. Creation of transfer stations for sorting purposes, to guarantee better working conditions, while reducing health risks and accidents, an idea which is similar to Scheinberg *et al.* (2006)

3. Improvement of their negotiation power by reinforcing the relationship between the recycling market and informal recyclers, by creating cooperatives to secure better selling prices, as well as purchase of equipment
4. Facilitation of communication among the informal recycling sector, the formal waste management sector and the decision makers to allow consideration of informal recyclers' concerns in the planning process.

Although the systems approach provides an integral solution that considers informal recyclers as important economic actors and stakeholders within the waste management system, Anschutz *et al.* (2006) also identified challenges to be overcome in order to deliver successful results. They pointed out the need to understand the economics of the waste sector in question, as the collection of materials is only sufficient to support a specific number of cooperatives. They also reported the importance of only working with the population of recyclers-by-trade that are enthusiastic to be part of the process of improving their working conditions. Another challenge they identified is the long-term commitment of the various stakeholders involved and the provision of training.

The Advisers on Urban Environment and Development (WASTE) (Anschutz and van de Klundert, 2001) is a non-profit organization based in based in Gouda, the Netherlands. Through their research in developing countries, they have developed the Integrated Sustainable Waste Management (ISWM) methodology and conceptual framework. This framework takes into account the elements of the waste system, sustainability characteristics and the stakeholders involved. The components to ISWM they identified are: political and legal concerns; technical and performance elements concerning the equipment and facilities of waste systems as well as their implementation and maintenance; social and political institutional structures including roles and responsibilities; cost recovery and reduction, privatization and how recycling infrastructure links to the marketplace; the way that culture influences waste generation and management; and environmental context related to health risks, pollution control and impacts on water, land and air caused by the waste system.

ISWM also promotes the incorporation of waste management into other municipal programs, such as the use of compost in urban agriculture or public parks to reduce the use of chemical fertilizers.

4.2 Legal and Economic Aspects Influencing the Integration of the Informal Recycling Sector

A regulatory framework that excludes the participation of the informal recycling sector in SWMS can potentially affect worker integration. This usually occurs due to their lack of institutional and financial background as described previously.

Gutberlet (2008) has suggested considering the development of the following policies when trying to achieve an inter-sector (formal and informal sectors involved in waste management) integration. These public policies consider: the inclusion of organized recycling groups; the establishment of fair wages and social benefits; eradication of exploitation and bribing; proper health and safety conditions for recyclers-by-trade; and environmental protection and source separation.

Dikshit *et al.* (2006) have suggested that the interference of the government by publishing the market prices of recyclables through mass media can potentially increase the transparency in transactions. However, they have also implied that governmental regulation and control of prices, business licensing and interest rates may have counterproductive effects on the recycling system. This is due to the difficulties of enforcing such rules on an informal sector, as well as the potential to lower the incentives of private traders and decrease the earnings of informal recyclers.

According to Baillie and Feinblatt (2010), positive policies aiming to acknowledge and legitimize informal recyclers and encourage their integration have been observed in Buenos Aires, Argentina. There, Decree No. 622 created a registry of the existing cooperatives, as well as small and medium-size enterprises that would contribute to achieve the newly stipulated mandatory recycling targets. In addition, the Urban Recoverer's Program was established and

vaccinations, identification cards and uniforms were provided. This program enabled the coordination of endeavours in order to accomplish the decree's vital objectives.

It has been implied by Cheeseman *et al.* (2006) that the provision of incentives to both formal and informal stakeholders contributes to achieving an integration of both sectors. Public-private partnerships (PPP) are an alternative way to involve small and medium enterprises with SWMS.

4.3 Worldwide Initiatives Working Towards Inter-Sector Integration in SWMS

NGOs have played a vital role organizing recyclers-by-trade into cooperatives. The fact that NGOs are acquainted with the local conditions, has allowed them to develop interesting initiatives, obtain grants and have access to loans, while providing business, legal and technical support to the cooperative. According to Medina (2000), in Madras, India waste pickers were not organized into a cooperative; however, an NGO created a waste collection program that legalized their livelihood. The program consisted of the integration of waste pickers or "street beautifiers" into the waste collection system of slums, and enabled them to leverage loans to pay for tricycle carts. In addition, residents paid US $0.30/month for the collection service, which was used to pay their salaries and repay the loans. This system evolved to include middle and high-income neighbourhoods that include 900 collection units run by street beautifiers.

Another example of recycling enhancement at a local level is the initiative carried out by Yuyun Ismawati. This work contributed to the development of a worker-owned solid waste cooperative in Indonesia, while generating employment and increasing economic stability (GAIA, 2010).

In the case of Brazil, waste picking has been recognized as a valid occupation. There, organized informal recyclers have been enjoying the status of legitimate stakeholders that can influence decision-making at various governmental levels. Such are the cases of Rio de Janeiro with 14 cooperatives, as well as Porto Alegre where informal recyclers have been integrated into the municipal recycling program of SWMS, serving almost 80% of the city (Medina, 2000;

Medina, 2008). It is therefore not surprising that in 2004, informal recyclers in Brazil recycled approximately 95% of all aluminum cans, 47% of steel cans, 46% of glass containers, 33% of paper and 16.5% of plastics. In São Carlos, it was observed that informal recyclers had reduced the weight of the city's waste by fully 39% (Gutberlet, 2008). Lastly, another program was founded by the World Bank's integrated Solid Waste and Carbon Finance Project. The aim of this program was to create an inclusive SWMS that would integrate waste pickers into the formal sector in Brazil (Medina, 2000, 2008).

A successful case of inclusive waste management has been implemented in Belo Horizonte, Brazil. There, the municipal authorities chose to integrate an association of informal recyclers into their sustainable waste management model. Under this framework, informal recyclers became the preferred agents in charge of recyclables collection. Informal recyclers were also provided with training, education and technical support. As a result, the city's cleanliness improved along with the living and working conditions of informal recyclers (Jaffe and Nas, 2004). According to Medina (2000), Rio de Janeiro is the home to one of the most successful informal recyclers' cooperatives. The cooperative is called Coopamare and its members were reported to have recovered 100 tons of recyclables a month while earning US $300/month per member, which was twice the minimum wage in Brazil at that time.

Juarez, Mexico is also a case of prosperity for informal recyclers. In this city the creation of the cooperative Socosema was able displace the middleman who exploited them and instead, obtain a direct contract with the municipality to recover recyclable materials at the open dump (Medina, 2000).

Another successful cooperative case is the Renacer Lanzone cooperative of informal recyclers in Argentina. The members of this cooperative were trained by professors at the National Institute of Industrial Technology in Argentina, regarding the different categories into which to sort plastics. The result of this training provided to the members of the cooperative, an increase in earnings of 300% (Baillie and Feinblatt, 2010).

Research conducted in Yala, Thailand analyzed the capacity of citizens' participation in solving municipal waste management issues (Mongkolnchaiarunya, 2005). For this purpose,

alternative solid-waste solutions were tested and for each, estimates of the sustainability of community-based initiatives were developed. The alternative solid-waste program consisted of a recycling project called “Garbage for Eggs” (GFE) led by a community-based organization. The study showed that projects like GFE are effective for cleaning the streets of very poor areas in a short period. It was also observed that with social empowerment the bargaining power increased, while the dependency on local government decreased. Lastly, it was suggested that projects such as the GFE should be perceived as learning processes that could lead to changes regarding the policy-making, cultural perception and environmental awareness of the population towards waste.

Manila, Philippines, is another interesting case where the recycling rate increased from just 6% in 1997 to 25% in 2006, with over 65% performed by itinerant waste buyers (Araba *et al.* 2009). The vital contribution of the informal sector is attributed to an NGO program initiative called the “Linis Ganda”. The NGO’s main objectives included the strengthening of the relationship between middlemen and itinerant buyers and their organization into cooperatives. This improved their negotiating power, while enhancing their social standing and facilitating their access to credit. Itinerant waste buyers were provided with uniforms and ID cards, push carts, a fixed route and were renamed “eco-aides” (Araba *et al.* 2009). According to Anschutz and van de Klundert (2001), the implementation of the program was done in three stages. The first stage consisted of women collecting recyclable materials from 21 locations, including high-income areas where itinerant waste buyers had not been previously allowed. For this purpose, they used flyers to announce the program to potential participants. The second stage involved the participation of 10 middlemen who would purchase the collected recyclables. The third stage identified the industries which were dedicated to process and recycle materials and created links between middlemen and these industries.

The recycling rates have significantly increased and the members recovered 4 000 tons of recyclable materials per month. Each of the 17 cities in Metro Manila developed an informal recyclers’ cooperative, which could obtain low-interest loans from the Land Bank and the Department of Trade and Industry of Philippines (Medina, 2000).

Waste for Life (2011) is an innovative not-for-profit organization that is composed by a team of cooperative participants working alongside designers, engineers, scientists, architects, artists and educators composes this organization. This diverse network of actors focuses on poverty-reduction solutions linked to environmental issues. Their efforts have concentrated on adding value to non-recycled plastic waste materials, with scientific and technological knowledge, while improving the livelihood of the urban poor. For this purpose, a hotpress technology has been developed to convert natural fibres and plastic waste materials into composite materials which can be subsequently used as building materials as well as in domestic products. Currently, their project in Argentina has the first prototype hotpress that has been incorporated into the regular recycling activities at the Cooperativa Nueva Mente in Buenos Aires.

It can be inferred therefore that informal recyclers contribute to society by reducing the waste disposed which saves the municipalities' expenditure, as well as providing a vital environmental service. Considering the successful scenarios described above, it is reasonable to think that it should be possible to expand these experiences throughout the developing world. In particular, it should be possible to spread out the alternatives involving grassroots development which offer environmental benefits, financial feasibility, as well as socially responsible solutions. As observed in the different scenarios, it is crucial to support informal recyclers' organizations with better infrastructure and social services, in order to reduce poverty and increase their recycling rates.

4.4 Models Proposed in the Published Literature

According to Muraleehdharan *et al.* (1996), various models have been designed to deal with certain matters in waste management. These models can be used to analyze the location of disposal sites and processing or transfer facilities and determine the appropriate disposal options. Such models include the Resource Recovery Planning Model; the Harwell Waste Management Model; and the MINES-WASTE or Model for Description and Optimization of

Integrated Material Flows and Energy Systems. The MINES-WASTE model is the most comprehensive one including waste composition, as well as the impact of source sorting and emissions. However, these details are applicable in systems with controlled boundaries where recycling occurs at the source or as an end-of pipe practice. Thus, it is not applicable for developing countries, where emissions are not a main concern and recycling usually takes place between the source and the waste collection phases. In general, all three models are limited to the formal waste management system focusing in operational efficiency and resource needs, excluding informal recycling's role.

According to Jaffe and Nas (2004) it is necessary to contextualize the informal recycling sector, as well as capture its dynamic nature in order to develop a model to improve the system as a whole. They have proposed a hypothetical model that analyzes the interactions of the political context, the technology employed in a given SWMS, the social setting and the organizational advancements of recyclers-by-trade. These variables were obtained from an historical and comparative perspective based on available case studies in the literature. Their model considers four distinct scenarios, ranging from A to D (Table 4). The purpose of this model was to see how the interaction of such variables can affect the success level of integrating the informal recycling system into the formal SWMS. According to this model, the recyclers' organizational degree ranges from low to high; while the socio-political context ranges from a repressive to a stimulating scenario. The technical aspect examines the appropriateness of the modern waste technologies used in waste collection, transportation and final disposal.

Jaffe and Nas (2004) have also suggested including the government and NGO when working towards the integration process. It was noted that when recyclers-by-trade presented a high level of organization, they had a higher chance of being integrated into the formal waste management sector, in particular, when there was political will and stimulation supporting this process. On the other hand, it was also noted that there was no direct link between social segregation and the success of the system.

Table 4. Integration success of informal recycling system into formal waste management associated with the interaction of the political context, technology employed, social setting and organizational aspects

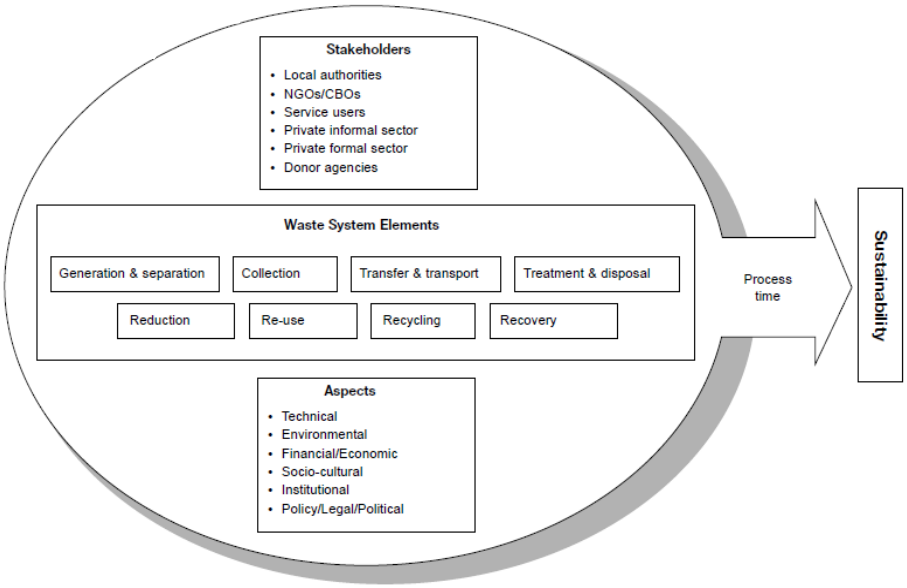
Model type	Organization (conducive to cooperatives)			Political context				Social segregation		Technology applied (collection/transportation/ sorting/disposal of waste)		Success factor
	Low	Med	Hi	Repression	Neglect	Collusion	Stimulation	Restricted to Social Status	Extended to Ethnicity	Appropriate	Inappropriate	
A			X				X	X			X	++
B			X			X		X	X		X	+
C		X			X			X		X		—
D	X			X				X	X	X		——

Jaffe and Nas (2004)

Although the hypothetical model has a novel approach contextualizing the informal recycling sector and providing a predictive success rate; the model itself falls short when applied to other scenarios that might present variables slightly different from the ones described in the four scenarios. It also falls short in explaining the scoring criterion used to calculate the effect of each variable and how this interaction determines the success rate.

According to Anschutz and van de Klundert (2001), the stakeholders to be considered when attempting to develop ISWM include: recyclers-by-trade, itinerant waste buyers, dealers, wholesalers, recycling enterprises and end-user industries. It is also required to have data regarding the waste generation and composition, the different neighbourhoods and their relevant socioeconomic characteristics; as well as all socio-cultural aspects of citizens and their willingness to co-operate and pay for waste service. Road and traffic conditions, elements of waste systems such as collection, transportation and disposal and the city's waste management activities are also required (Figure 4).

Figure 4. Integrated Sustainable Waste Management



Anschutz and van de Klundert (2001)

In addition, Anschutz and van de Klundert (2001), suggest that it is useful to identify the strengths, limitations, opportunities and threats of the various actors. A way of doing this is through conceptual mapping of the waste system, identifying what the activities that the informal and formal sectors are undertaking. For this performance evaluation they suggest the utilization of a SWOT assessment, which explores the opportunities, threats, strengths and weaknesses of the involved stakeholders.

In order to address the informal recycling role in waste management Muraleehdharan *et al.* (1996) designed a comprehensive model that would contribute to the planning process of waste managers. This comprehensive model was designed over a decade ago. However, it is still relevant to the current social, environmental and technical aspects that are required to be assessed in developing countries when an integration of the informal recycling sector into the formal SWMS is being considered. In order to achieve an inclusive SWMS that would integrate the informal recycling sector into the formal waste management sector, they developed the Critical Operational Research (COR) framework. This framework was designed as a policy analysis tool that would allow an open discussion between the various actors involved in waste management in Madras, India. Based on the framework, they proposed a Nonlinear Lexicographic Goal Programming (NLGP) model, which consisted of six objectives with their respective goals. The first four objectives pertained to the municipal entity and dealt with issues such as waste collection, environmental quality, budget spending, and vehicle usage. The next objective focused on the informal recycling sector and addressed the social factor. Another objective was related to private entities involved in waste management and incorporated the economic viability of processing facilities. They used actual measures pertaining the city's current SWMS and combined these six objectives (collection, employment of waste pickers, budget utilization, disposal, processing facilities, vehicle utilization) to create six scenarios, in order to analyze the effects of controllable targets on the performance of an inclusive system. The NLGP was resolved with a sequential non-linear goal programming method, which divided the problem into sub-problems. Subsequently, these sub-problems were resolved using the General Algebraic Modelling System.

The results showed that the amount of waste collected by the municipality's collection system, did not affect the employment level of informal recyclers. However, when the waste collection exceeded 80% of the waste produced, it reduced dramatically the employment level of recyclers-by-trade. It was also observed that if informal recyclers picked 100% of the recyclable materials without being part of the formal sector, it would save the municipality over Rs$200 million, compared to Rs$40 million if they were part of the formal waste management sector. This result contradicts the belief that the informal recycling sector reduces the efficiency and increases the operating costs for municipalities. In addition, the results also showed that the integration would reduce the number of informal recyclers employed to about 500-600 out of the 30 000 present in Madras, India (Muraleehdharan *et al.* 1996).

Chapter 5. Problem, Objectives and Methodology

5.1 Problem

The privatization of waste management services has become a tendency in developing countries. However, this privatization has not taken into consideration the social aspects associated with waste management, specifically with the informal recycling sector. The privatization has been oblivious to social inclusion solutions, which aim towards poverty eradication for recyclers-by-trade (CiViSOL, 2011).

Nitivattananon and Sembiring (2010) carried out a study in Bandung, Indonesia. In their paper they discussed the perception and attitudes of decision-makers and key stakeholders towards the participation of recyclers-by-trade in waste management. They stressed the difficulties and challenges of convincing politicians and authorities that the informal sector's role in waste management is not a liability, but to the contrary an asset.

In addition, due to the dependency of informal recyclers on local politics, the livelihood of these marginalized communities is constantly challenged. Changes in municipal politics can put at stake the logistic and governmental support of infrastructure, financial aid and capacity building given to informal recycling organizations (Gutberlet, 2008).

Colombia is a suitable case study, due to being a developing country that experiences environmental and social problems, as well as financial constraints regarding its waste management. Similar to the rest of the developing world, Colombia's recycling system is characterized by its informal and fragmented nature. This informal recycling sector in Colombia as in other developing countries is noted for the poverty and marginalized conditions of its recyclers-by-trade. In addition, the data provided by the District Secretariat of Planning of Bogotá, the Special Administrative Unit of Public Services of Bogotá (UAESP), rra (public law + social innovation) attorneys and consultants and the Mayor's Office of Santiago de Cali, together with CiViSOL foundation's support, made Colombia a good candidate for a case study.

According to the Mayor's Office of Santiago de Cali (2009), Colombia produces 25 079 tons of waste daily and only 13% is recycled of the total waste generated, out of which

recyclers-by-trade contribute 54%. As stated by CiViSOL (2011), part of the reason there is no source separation culture in Colombia is that cities do not have proper infrastructure, such as transfer stations dedicated to the separation of recyclables. Also, it is important to note that even though the current operators of waste management in Bogotá are responsible for performing the route of recyclable's collection — according to their legal contracts — they do not operate this route.

Rising public and NGO concern, especially by the CiViSOL Foundation has suggested the need to involve various stakeholders to set out scientific- and management-based alternatives to the current SWMS problems.

CiViSOL is a non for-profit organization that operates in Paris, New York and Barcelona as well as in the cities of Cali and Bogotá in Colombia. It focuses on policy-making to increase democratic participation and development prospects for poor and marginalized communities. This organization has contributed to the litigation process by Colombia's recyclers-by-trade. Its goal is to formally integrate them into the marketplace in order to assure their rights to survival and development. Also, it has contributed to this research by providing legal documents of the litigation process and by introducing key stakeholders from the informal recycling sector which have participated in the interviews performed in 2011 in Cali and Bogotá.

Considering the current state of Colombia's waste generation, the improper disposal methods and deficiency of waste collection in some municipalities, the lack of a formal recycling system and the lack of a recycling culture nationwide, coupled with the poverty condition of recyclers-by-trade, it would appear that a context-based solution is needed. Through this research, it is argued that an integral solution to Colombia's SWMS lies within an inclusive infrastructure that will incorporate the existing informal recycling system within the formal sector, benefiting the SWMS as a whole. Culture needs to be respected and accommodate to changes. There seems to be a need to develop a model —based on the world's examples, yet customized to the Colombian context— that considers the implementation of sustainable and inclusive SWMS goals.

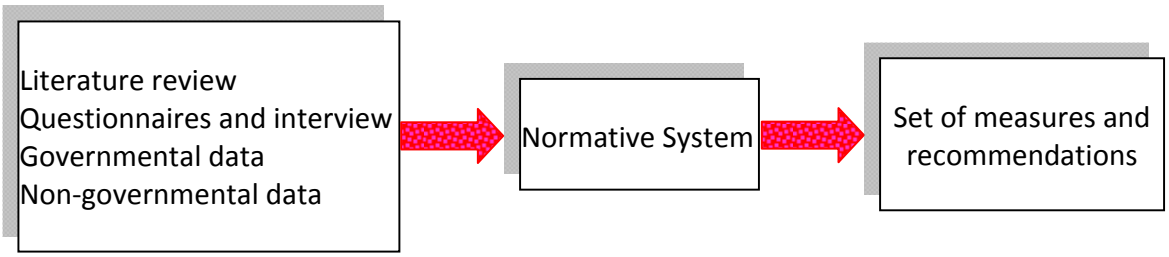
5.2 Objectives

Overall, the objective of this project has been to develop a strategy and plan for SWMS (reducing landfilling, enhancing recycling and improving the working conditions of organized recyclers-by-trade) in developing countries by:

1. modelling the experiences of other developing countries' SWMS that have increased the recycling efficiency and improved the livelihood and working conditions of recyclers-by-trade, and research into sustainable and inclusive SWMS
2. testing the model by applying it to knowledge gained in a case study of Colombia where the cities of Cali, Bogotá and Medellin have experienced problems in managing waste
3. contributing to the incipient research on the informal recycling sector and attempting to add valuable new knowledge on this topic since existing literature seems to fall short in describing the diversity of conditions for SISWMS

Specific stages in completing these objectives aim at developing an understanding of the environmental, social, cultural and financial issues. It is hypothesized that such a plan and strategy will enable objectives related to each of these issues to be achieved. In particular, social goals for informal recyclers are hypothesized to be able to be attained at the same time as environmental (recycling/landfilling) and financial goals.

5.3 Methodology



The methodology comprises three major steps. The first step consisted of synthesizing components identified in the literature demonstrating successful initiatives to make waste management sustainable and inclusive. This enabled the compilation of a list of criteria from which a preferred alternative for any developing-world application could be developed, based on the priorities expressed in their local values and attitudes. A description of the current solid waste management system in Colombia (its SWMS and informal recycling sector) was assembled in part from primary observations, which included questionnaires and an interview from key stakeholders, such as: recyclers-by-trade, dealers and the president of Bogotá's Recyclers Association. The description of Colombia's SWMS has also included official published (and unpublished) documents. The data were intended to match the criteria identified in the literature from other parts of the developing world.

Data needed to achieve understanding were:

1. Identify the socioeconomic characteristics (inferred from socioeconomic-strata) of informal recyclers and dealers to subsequently analyze their distribution pattern in the cities
2. Identify working conditions, organizational status, the current market prices of recyclable materials, treatment performed, transportation modes and their political awareness
3. Identify working conditions and operations' characteristics at the Alqueria Transfer Station, recycling capacity and staff size, selling prices of the recyclable materials, role division within the ARB organization, informal recycling routes and the perception and expectations regarding an inclusive SWMS in Bogotá

For this purpose, questionnaires for recyclers-by-trade and dealers in Cali were conducted, as well as an interview with the president of the Recyclers' Association of Bogotá (Asociacion de Recicladores de Bogotá (ARB)). During the questionnaire process carried out in this study, the difficulties associated with dangerous conditions were experienced. This was a limiting factor when conducting the questionnaires to recyclers-by-trade in the Calvario

neighbourhood, as according to the commander in chief of the police, it was recommended that the researcher should go with a team of four armed police officers.

The second step consisted of developing a normative system that supports the sustainable and inclusive solid waste management in developing countries, recognizing the various stakeholders, as well as the environmental, financial and social goals. The options for managing recurrent issues were itemized; *e.g.* different waste collection arrangements by characteristics of the waste (quantity, composition, socioeconomics and cultural aspects), options for mandated roles for the stakeholders, from collection and sorting to recycling and after use, as well as associations with vehicle options for transporting sorted household waste. The last step consisted in developing a set of measures and recommendations to assure the success of the normative system for a sustainable and inclusive solid waste management in Colombia.

Confidentiality was sustained throughout the research process. The only organization and respondent names that have been disclosed in this paper pertain to the Recyclers' Association of Bogotá and its president. The purpose of carrying out direct interviews was to assess which aspects need to be improved to achieve higher recycling rates, as well as formalize the informal recycling routes. It can also help to assess the applicability of reproducing this medium-size transfer station experience in other areas throughout the cities in Colombia. It also provided the opportunity to corroborate and enhance the data available from secondary sources. Table 5 illustrates the various data source used to build up the case study.

Table 5. Data Sources Regarding the Case Study

Source	Data	Method	Data concerns
Recyclers-by-trade in Cali	Socioeconomic information; working days; potentially recyclable materials (PRM) collected; place of collection; transportation type; treatment; prices of sale; organizational level; and knowledge of the policy advancements regarding the	104 questionnaires	It was not possible to perform these same questionnaires to recyclers in Bogotá, due to direct order from the ARB to discontinue the socioeconomic characterization study conducted in a joint venture between the UAESP and the Pontificia Universidad Javeriana of Bogotá. Due to time and financial constraints, the population was

	informal recycling sector		sampled, rather than being complete
Dealers in Cali	Socioeconomic information; PRM purchased; treatment; prices of purchase and sale; organizational level; knowledge of the policy advancements regarding the informal recycling sector	Four questionnaires	Due to time and money constraints, and safety concerns the population was selectively sampled, rather than being complete
President of Recyclers' Association of Bogotá (ARB)	Operational structure at the Alqueria, the working conditions of recyclers at the ARB, and the ARB's proposal regarding the monetary recognition for their service	- An interview - Document containing sale prices of recyclables - Four PDF documents regarding the Alqueria Transfer Station	Access to information regarding the informal routes of collection was denied. Details regarding the socioeconomic analysis were also denied.
Director, Graduate Program at Pontificia Universidad Javeriana of Bogotá	Anecdotal information of the results on the socio-demographic characterization of recyclers-by-trade in Bogotá	Meeting to discuss the thesis topic and direction	Opportunities of obtaining the results of the socio-demographic characterization of recyclers in Bogotá were denied after an employee from the UAESP, responsible for authorizing this study was dismissed from the position
rra	Summarized information regarding the litigation process of recyclers-by-trade in Colombia	Unpublished article regarding policy advancements	
CiViSOL	- Detailed information regarding the litigation process of recyclers-by-trade in Colombia - Introduction to key stakeholders belonging to the informal recycling sector in Colombia	Extraordinary Report Number 6 passed to the Constitutional Court of Colombia referencing the Sentence T-291 of 2009	
Mayor's Office of Santiago de Cali	Socio-demographic and socioeconomic characterization of the informal recycling sector in Cali and the organizational and working conditions of recyclers-by-trade in Cali	3 documents regarding the informal Recycling community of Cali	
Special Administrative Unit of Public Services (UAESP) of Bogotá	MSW composition and quantities according to the various income levels and localities and Doña Juana Landfill waste characterization	- Published document regarding the characterization and quantification of MSW in Bogotá - 2 excel documents	The sample size households of the final report was small due to the limited sampling size sample determined by a 90% confidence level, 17 households were analyzed per income level. Results were valid only as indications, and not as exact statements of the waste composition
District Secretariat of Planning of Bogotá	Provided appropriate records of Bogotá's income levels stratification	GIS shapefiles	

Chapter 6. Case Study

The following chapter provides a detailed description of Colombia's waste generation and composition and its current SWMS, with special focus on Bogotá. This is followed by a detailed explanation of the current recycling system in Colombia and the social aspects associated with it, as well as the policy development regarding recyclers-by-trade in Colombia.

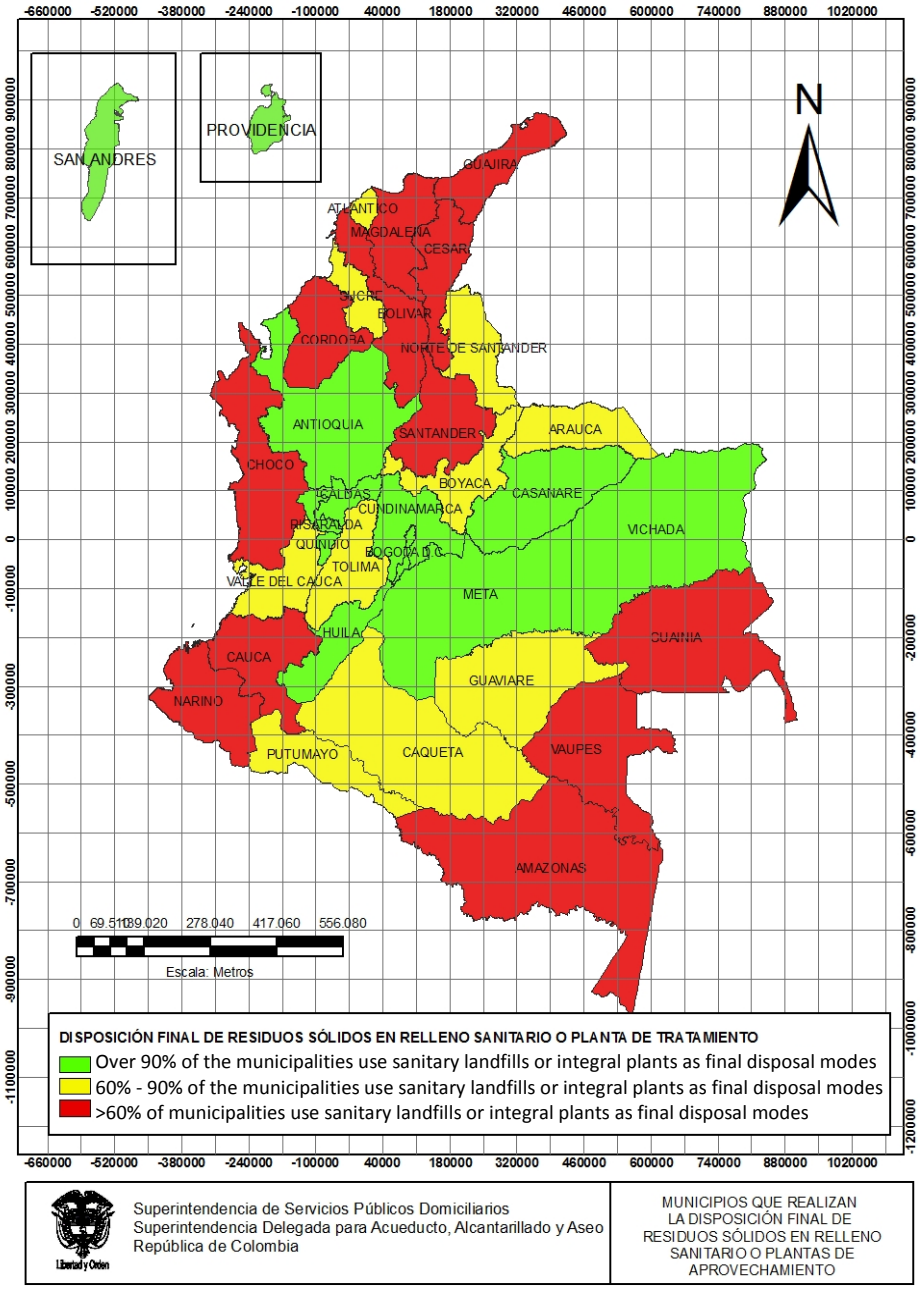
6.1 Colombia's Waste Generation and Composition and its Current SWMS, with Special Focus on Bogotá

Currently, Colombia produces 25 079 tons per day of solid waste. Bogotá is responsible for 23.48%, followed by Cali responsible for 8.0% and Medellin with slightly less. The per capita waste generation is 0.6 kg/per capita/day. However, it varies substantially among cities; while big cities like Bogotá produce 0.95 kg/per capita/day of waste and small cities produce 0.31kg/per capita/day (Mayor's Office of Santiago de Cali, 2009). If these values are compared to the estimates of waste generation according to the country's income level reported by Cointreau (2008), the average daily waste generation of Colombia is equal to a low- or middle-income country. Small cities in Colombia have a daily waste generation of low-income countries and big cities like Bogotá are equal to middle- or high-income countries.

According to the Mayor's Office of Santiago de Cali (2009), 96% of the urban areas provide waste collection and transportation services, whereas rural areas only have 1.6% coverage by area. There are 1 112 municipalities in Colombia, out of which 97.8% have available data regarding final disposal practices. Based on the Unique Information System of Public Services of Colombia (Sistema Unico de Informacion de Servicios Publicos (SUI)) (2009), 80.21% of the total waste produced is disposed of in sanitary landfills, 10.03% is disposed of in transition containment units, 7.56% is disposed in open dumps and 2.20% is disposed in other ways, such as uncontrolled dumping of waste directly into water bodies, burial sites or waste

burn-off sites. Figure 5 illustrates the percentage of municipalities within each department in Colombia that use sanitary landfills or integral plants as their final disposal methods.

Figure 5. Final Disposal Methods in the Departments of Colombia (SUI, 2009)



The Ministry of the Environment, Housing and Territorial Development (Ministerio de Ambiente, Vivienda, Desarrollo y Territorio (MAVDT)) passed Resolution 1390 in 2005, which prohibited municipalities from having open dumps and other inadequate final waste disposal methods. Subsequently, sanitary landfills were pointed out as the only system that could be recognized in the waste management household billings. In addition, Resolution 351 and 352 of 2005 determined the new billing system, which is oriented towards the desegregation of costs by activity and the acknowledgment of the costs of final waste disposal (General Secretariat of the Mayor's Office of Bogotá, 2005).

The implementation of the resolutions created in 2005 in municipalities lacking sanitary landfill, has been a slow transition. Such is the case of the city of Cali that closed Navarro Open Dump — which had operated since 1973 — in 2008 (Mayor's Office of Santiago de Cali, 2009). In addition, the municipality has made broken promises to Navarro's Dump waste pickers, regarding alternatives to their livelihood since the closure of the Dump in 2008. Until today, the municipality has ignored the Court's petition to implement social inclusiveness into the design of waste management as set out by the ad-hoc committee chosen by the Court (rra, 2010).

On the other hand, the MAVDT stipulated the guidelines for an Integral Solid Waste Management Plan (Plan de Gestion Integral de Residuos Solidos (PGIRS)), which is managed by one of the 33 autonomous regional corporations (General Secretariat of the Mayor's Office of Bogotá, 2002). Although 639 municipalities have already implemented the PGRIS, 42% have not proceeded with its implementation (SUI, 2006). In fact, the PGIRS does not take into consideration its institutional, financial or even technical viability.

The current municipal solid waste management systems in Colombia have not recognized recycling as an important and integral feature. This is reflected in the lack of the valorisation of the potentially recyclable materials. As a result of this, there is a lack of formal recycling, as well as a poor recycling culture and an almost nonexistent participation in source separation at the household level (Mayor's Office of Santiago de Cali, 2009).

According UAESP (2009), the perception of Bogotá's citizens in regards to source separation shows that: the majority (31%) does not think it is important; 25% indicate that they

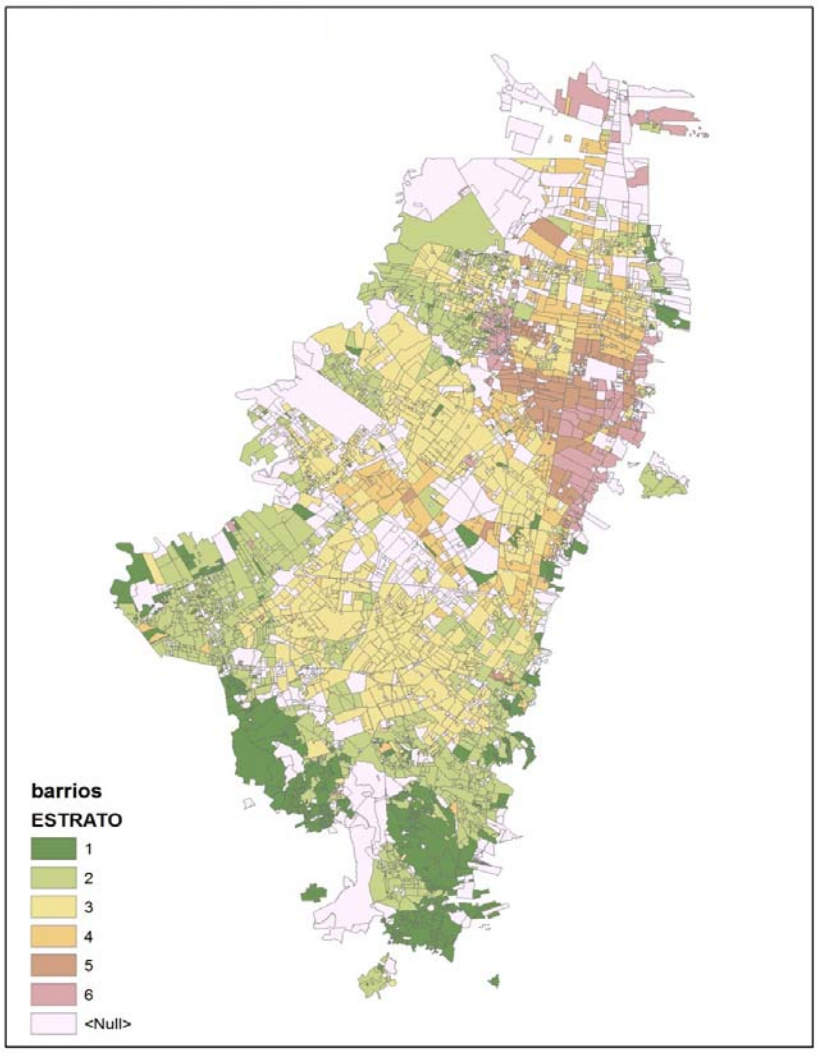
do not have the time or space to accumulate recyclable materials; 19% who complain the garbage collection truck mixes the waste; and 15% that believe they generate too little waste to have the need to recycle. The remaining population expresses that they have insufficient incentives for recycling or have only one garbage can at home. In addition, it has been noted that waste management decision-makers believe — based on their studies — that composting does not have a market and therefore, it is not a viable option (senior employee from UAESP of Bogotá. Interview via email. 22 September 2010).

Bogotá

The climate in Bogotá is cold and dry, with an average temperature of 14 °C and mist as a predominant phenomenon. The annual precipitation distribution is bimodal with maximum peaks in April and October and minimum peaks in January and July, with an average annual precipitation of 799 mm (DANE, 2005). Bogotá city is located 2 640 meters above sea level with an estimated 7 304 384 inhabitants and an annual population growth rate of 2.1% (IDEAM, 2000). For the purpose of billing and subsidizing public services such as waste management, the District Planning Secretariat of Bogotá has stratified the city in different income levels or strata ranging from one to six. According to this classification, income level 1 receives a subsidy of 50% in its waste management billing, while income level 2 receives a subsidy of 40% and income level 3 receives a subsidy of 15% (Figure 6) (Dane, 2009).

Six Areas of Exclusive Service (Areas de Servicio Exclusivo (ASE)) for curbside waste collection within Bogotá have been established. Each area includes different localities that contain various neighbourhoods. ASE 1 includes Usaquén and Suba localities. ASE 2 includes Fontibón and Engativá. ASE 3 includes Chapinero, Barrios Unidos, Teusaquillo, Mártires, Santa Fe and Candelaria localities. ASE 4 includes Puente Aranda, Tunjuelito and Ciudad Bolívar localities. ASE 5 includes Antonio Nariño, Rafael Uribe, Usme and San Cristóbal localities. ASE 6 includes Kennedy and Bosa localities (UAESP and CIIA, 2005).

Figure 6. Distribution Pattern by Income Level in Bogotá, Colombia



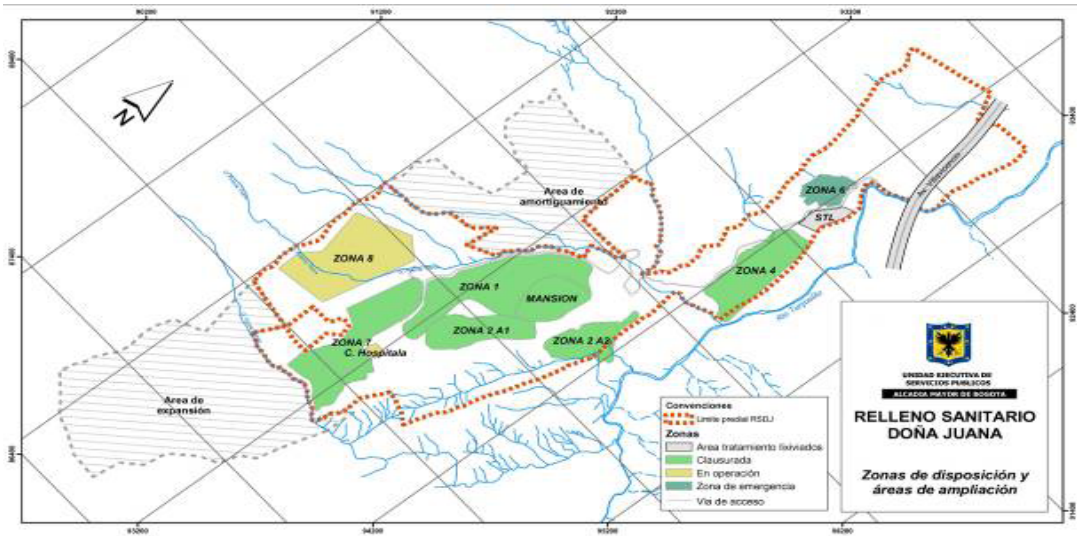
District Planning Secretariat of Bogotá (2010)

Although Bogotá has implemented a low-scale recycling project at the Alqueria Transfer Station, the prevailing recycling system in Bogotá, as in the rest of Colombia, is characterized by its unsystematic and fragmented nature, as well as the poverty and marginalized conditions of recyclers-by-trade CiViSOL (2011). The Alqueria Transfer station has been operating since 2006. It receives PRM from curbside Selective Micro Routes (Ruta de Recolección Selectiva (RRS)),

which operate once a week. A total of 73 RRS collect PRM of approximately 30% (663 078) of the total amount of users of waste management service in Bogotá, which are distributed in 16 localities covering 221 neighbourhoods (UAESP, 2009).

In regards to the final disposal of waste, Bogotá has a sanitary landfill called Doña Juana, which has been operating since 1988. It has an area of 456 hectares of which 40% is utilized as a landfill, where the waste is distributed among eight zones (Figure 7).

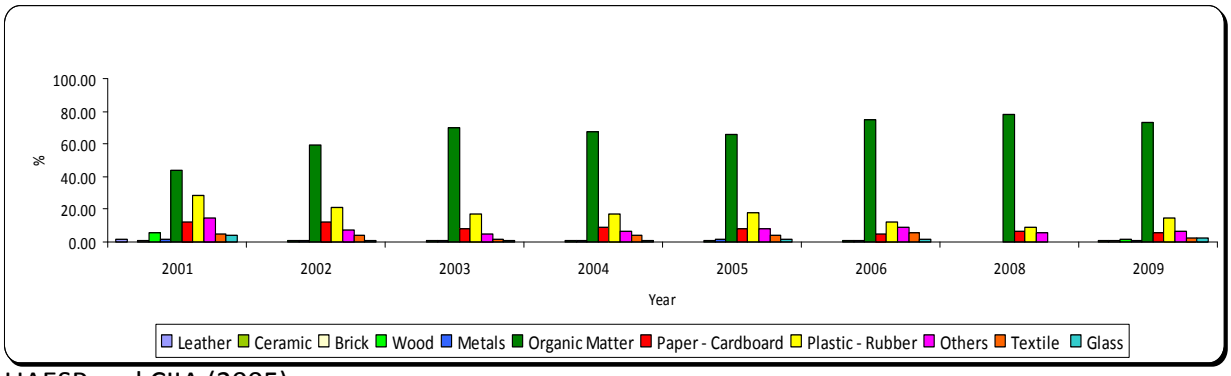
Figure 7. Doña Juana Sanitary Landfill and the Distribution of Waste by Zones



SCS Engineers (2007)

It receives 6 000 tons of waste daily, a total of 2.2 million tons of waste annually. Currently, it has approximately 26 000 000 tons of disposed waste, and its closure is projected for 2016 due to potential expansion of the landfill, with a total of 47 000 000 tons of disposed waste; otherwise, it would have been closed before. The composition of waste at the landfill is disaggregated the following way: clay (0.06%), bricks (0.11%), leather (0.33%), minerals (0.38%), cardboard (0.76%), wood (1.03%), metals (1.13%), glass (1.72%), textiles (4.45%) paper (8.92%), plastics and rubber (19.71%) and biodegradable (61.58%) (Figure 8) (SCS Engineers, 2007). If compared to the worldwide MSW composition values presented by Cointreau (2006), Bogotá presents a similar composition to the ones observed in low- and middle income countries.

Figure 8. Waste Characterization at Doña Juana Sanitary Landfill in Bogotá, Colombia



UAESP and CIIA (2005)

According to SCS Engineers (2007) the final coverage includes a layer of clay, a biosolid mix, dark earth and grass as the top layer. The landfill's bottom waterproofing includes the following layers: clay, texturized geomembrane, geotextile, ground limestone and gravel. Due to the continuous functioning schedule at Doña Juana Sanitary Landfill, a temporarily plastic sheet is used to cover waste which has not been disposed of in the discharge area or if it is in the process of final closure. The plastic used is a woven canvas covered in a polyethylene film that increases its impermeable properties. There is no recycling inside the landfill and the entire complex is enclosed. However, Doña Juana has a leachate treatment plant that has been operating since 2002 and includes physical, chemical and biological processes.

According to SCS Engineers (2007), the growth of disposed waste is expected to be 2.08% per year under the current conditions. They suggest that if implementing recycling policies in the following years —that do not take into consideration the informal recycling sector— the estimated annual growth is expected to behave as shown in table 6:

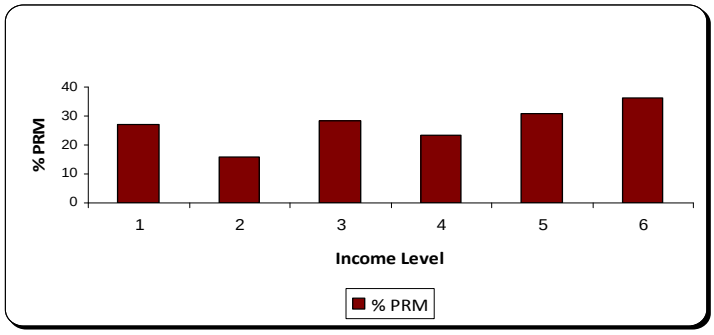
Table 6. Annual Expected Growth of the Disposed Waste (SCS Engineers, 2007)

Year	Linear Projection of Disposed Tons	Proportion of Material Recycled	Total Tons
2006	1 994 906		1 994 906
2007	2 035 625	1%	2 015 269
2008	2 076 343	2%	2 034 816
2009	2 117 061	3%	2 053 550
2010	2 157 780	4%	2 071 469
2011	2 198 498	5%	2 088 573
2012	2 239 216	6%	2 104 863
2013	2 279 935	7%	2 120 339
2014	2 320 653	8%	2 135 001
2015	2 361 371	9%	2 148 848
2016	2 402 090	10%	2 161 881

During the study on the quantification and characterization of PRM contained within the MSW generated in Bogotá, the percentage of PRM was expected to increase with income level. However, the percentage of PRM by income level at the landfill showed a different behaviour. Income level 1 exhibited a value higher than income levels 2, 3 and 4. Income level 2 exhibited the lowest value with 16.7% and income level 6 showed the highest value with 22.9% (UAESP and CIIA, 2005).

According to UAESP and CIIA (2005), the percentage of PRM analyzed in the sampled households did not show a clear relation with income level (Figure 9). Although, high values belonged to the highest income levels (income level 5 with 30.7% and income level 6 with 36.3%), in the other income levels there was no defined tendency. Income level 1 with 27.1% was quite similar to income level 4 with only 23.5%. The UAESP and CIIA (2005) have suggested that this could be due to the high variation observed in the quantities of waste collected per week among the different households. It was also suggested that it was due the fact that

Figure 9. Household % PRM by Income Level



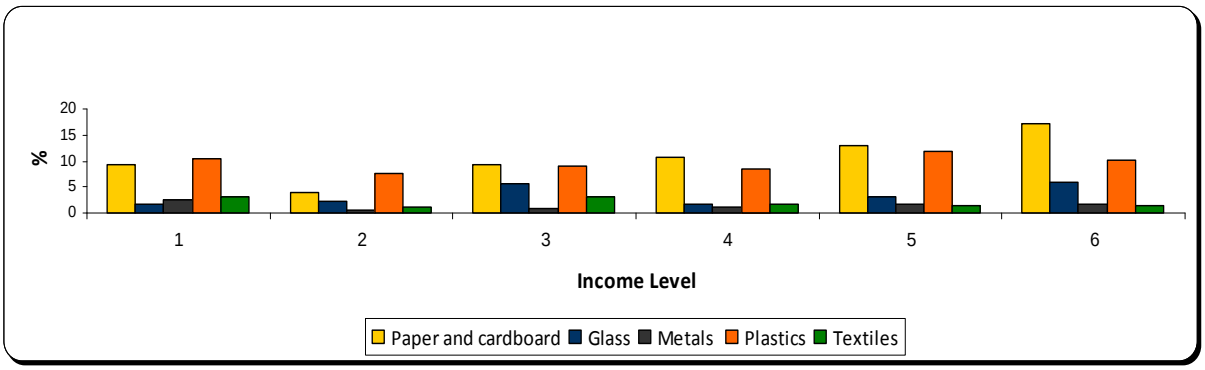
UAESP and CIIA (2005)

informal recyclers are not inclined to collect PRM in areas belonging to income level 1. Instead, they tend to collect recyclables in areas of higher income levels. Another possibility is the existence of an internal reuse chain among income levels, especially observed for textiles, which are passed from higher to lower income levels. However, due to the extent of this research, it was not possible to corroborate these hypotheses.

According to UAESP and CIIA (2005), the percentage of PRM found in the sampled households, showed higher values than the ones reported at the landfill —with 24% in households against 18% at landfill. This might also be indication the effects of informal recyclers' activities. However, again due to the extent of this research, it was not possible to corroborate this hypothesis.

According to UAESP and CIIA (2005), the composition of PRM at the household level reported is as follows: paper and cardboard 39%, plastics 37%, glass 13%, textiles 6% and metals 5%. These values differ from the ones reported at the landfill, where plastics were 45%, paper and cardboard 23%, textiles 15% and metals 6%. They observed that paper and cardboard showed a tendency to increase with income level. Glass followed the same pattern and metals and plastics also increased with income level, but their values were very close. On the other hand, textiles decreased with income level. However, income level 1 presented the highest value with 4.6%, while income levels 4, 5 and 6 were 1.9% (Figure 10).

Figure 10. Percentages of PRM by Income Level

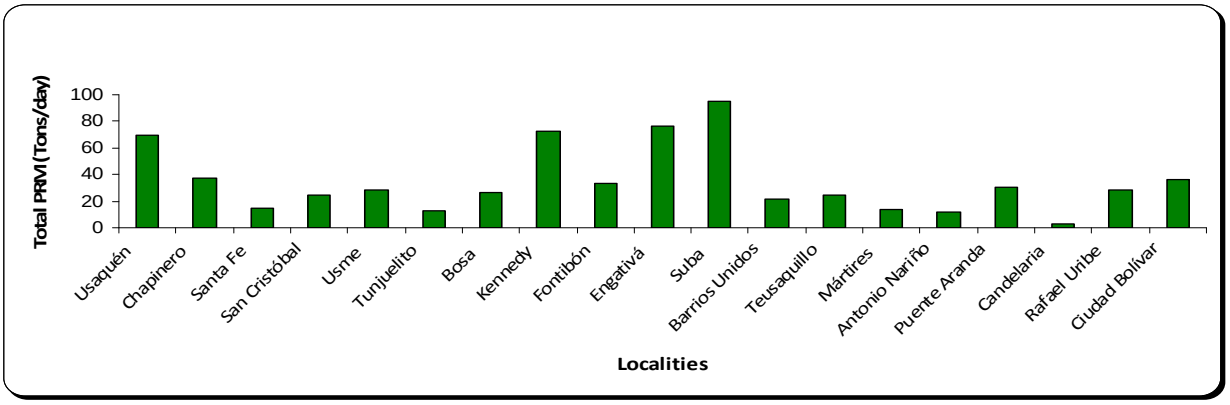


UAESP and CIIA (2005)

Preliminary investigations suggest that the per capita RSW generation exhibited a function of income level, where the highest income level presented the highest waste generation, which coincides with the pattern identified for other areas. In addition, the relation between family income and quantity of PRM showed that the quantity of PRM rises with increasing family income (UAESP and CIIA, 2005).

According UAESP and CIIA (2005), ASE 1 which includes Usaquen and Suba localities presented the highest generation of PRM. On the other hand, ASE 4 which includes Puente Aranda, Tunjuelito and Ciudad Bolivar localities presented the lowest contribution of PRM. Each locality is composed by various neighbourhoods belonging to different income levels (Figure 11).

Figure 11. Quantity of PRM by Locality



UAESP and CIIA (2005)

6.2 The Recycling System in Colombia and its Social Component

According to the Mayors' Office of Santiago de Cali, the current recycling rate in Colombia is as low as 13% out of the 25 079 tons of waste produced daily. Informal recyclers collect 7% of the total percentage recycled. Colombia is typical of developing countries in that it presents an informal recycling sector composed by dealers, wholesalers and recyclers-by-trade with itinerant waste buyers, street waste pickers and dump waste pickers. This informal sector is

dedicated to the recovery of potentially recyclable materials for their subsequent commercialization.

The informal recycling sector has existed for over 60 years in Colombia. At present it is estimated to involve 20 000 families, of which 30% belong to an organization and the remaining 70% work independently. According to the Mayor's Office of Santiago de Cali (2009) there are estimated 128 organizations of recyclers-by-trade associated with the ANR. However, the ANR approximation of the recyclers-by-trade community in Colombia is substantially higher. They have estimated that there are 50 000 families with a total of 300 000 individuals involved (ANR, 2010).

According to ANR (2008), it is difficult to establish the precise origins of the recyclers-by-trade in Colombia as it has not been documented. However, during the decade of the 1950s Colombia was mainly rural (70%) and going through a violent political episode caused by the confrontations between the liberal and conservative parties. This conflict resulted in the death of thousands of peasants, leaving widows and orphans. Not having other options, this population migrated to the cities creating a homeless and urban poor community. During this same period, Colombia's industry was very precarious and the lack of materials such as paper, metal and containers was prevalent. Under these circumstances, the urban poor found livelihood opportunities in waste collection (ANR, 2008).

According to Restrepo (2009), the violent political situation in Colombia along with the migration of peasants to the cities, continue to influence the composition of the informal recycling sector. This is the case of many displaced families that as a result of the last decade of violence have moved to cities like Medellín, resorting to waste picking for subsistence. On the other hand, according to Agudelo *et al.* (2007), the majority of recyclers-by-trade (46.4%) in Medellín have worked in this trade for over 10 years, followed by 3 to 5 years (24.7%), which is followed by 6 to 10 years (17.5%) and less than 1 year and up to 2 years (11.4%).

It was during the 1980s that the informal recycling community began to gain social acknowledgement. This response took place as a result of the closure of two open dumps in the cities of Medellin and Bogotá. The closure of these open dumps threatened the livelihoods of

600 to 800 families, which were dedicated to the recovery of recyclable materials. Subsequently, two cooperatives were created, becoming the first attempts of cooperativism in Colombia. Eventually, the ANR was founded in 1990 during the first National Meeting of Recyclers announced by the ARB (ANR, 2008).

During the 1990s, Bogotá's mayor recognized the ANR as a not-for-profit legal organization, which drove the ANR to establish regional representation. Such regional representation includes ARCON on the Atlantic Coast, FEDESURCO on the southwest, ARCESCO on Huila and Caqueta and ARR in the coffee-growing region. Since then, ANR has created links with various organizations and has continued to advance and reach thousands of recyclers across Colombia (Figure 12). Although, the ANR has made significant progress contributing to the consolidation of recyclers' organizations at the national, regional and local levels, the social and economic reality of recyclers is far from ideal (ANR, 2008).

Figure 12. Distribution of Regional Recyclers' Organizations Belonging to the ANR (ARB, 2011)

The Mayor's Office of Santiago de Cali (2009) has suggested that the lack of cohesiveness and higher organizational systems in Colombia are affecting these actors in two ways. On one hand, their capacity and efficiency in terms of the recycling rates achieved are being lowered. On the other hand, they are creating an uneven economic recycling chain where dealers and recycling industries gain the highest profits, while recyclers-by-trade continue to be in the bottom of the chain with the lowest earnings.

Gomez *et al*. (2008) carried out a study in Medellín assessing the aspects that affect the productivity of informal recyclers in that city, through the interview of 209 recyclers-by-trade. They found that the majority (37%) of

recyclers-by-trade perceived that under their current precarious working conditions, it was not possible to improve their earnings. On the other hand, 20% perceived that improving the selling prices of the collected recyclables could improve their income and living conditions.

The continuous development of big cities in Colombia such as Bogotá, Cali and Medellín presents many challenges. Among these, the current recycling system raises some concern, especially the social aspect associated with it. This social concern is due to the fact that in Colombia 10% of the urban poorest belong to the recyclers-by-trade community (Gomez *et al.* 2008). According to Agudelo *et al.* (2007), over 80% of recyclers-by-trade in Medellín have said that they work in this trade due to unemployment, while 11.3% due to tradition and 8.2% because they like it. Thus, recycling is not limited to only being a technical and environmental issue but also a social one. This is of special concern when cities' recycling goals increase and with it more professional, technical and formal attitudes towards recycling activities might be required, representing more challenges for the informal recycling sector in Colombia.

The capacity to transport recyclable materials, which also affects their productivity, varies according to the transportation availability for each recycler-by-trade. Depending on their earnings, the main modes of transportation in Colombia include a sack, hand-pulled cart, tricycle-pulled cart, horse-pulled cart and a motorized-pulled cart (Appendix A). The largest group of these (33.33%) transport between 41kg/day and 70kg/day, while a small percentage (13.4%) transports 71kg/day to 250kg/day (Mayor's Office of Santiago de Cali, 2009). These differences in the recycling capacity —due to their precarious conditions and limited capital— have resulted in an overall inefficient and inconsistent recycling system.

Gomez *et al.* (2008) performed a study regarding the aspects that influence the productivity of recyclers-by-trade in Medellín. They suggested that the most common mode of transportation in Medellín is the hand-pulled cart, which empty weights 50kg. Although this mode of transportation presents impacts, 63% of the recyclers-by-trade interviewed perceived it as a positive element that increases their productivity. These negative impacts are associated with the vibrations and the physical exhaustion it causes, as well as the mechanical and ergonomic risks.

Agudelo *et al.* (2007) had performed a study on the working and health conditions of recyclers-by-trade also in Medellín, through the interview of 97 recyclers-by-trade. They suggested that the hand-pulled cart requires great physical effort, especially from the arms, the torso and the legs. Due to having only two wheels, it prevents the use of potential energy. Another negative aspect is related to the wheels, which are made out of circular metallic plates covered with recycled rubber from car wheels. This design causes the wheels to lose their round shape, which subsequently causes a resistance in the motion and increases the vibration. Lifting and pulling the hand-pulled cart with the collected PRM that can weigh between 80 to 120kg, also represents an occupational risk.

The informal recycling sector presents overall similar aspects throughout Colombia, such as the composition of the recycling chain, transportation modes, poverty and marginalized conditions; as well as health risks associated with their working conditions and a higher percentage of unorganized recyclers-by-trade that work independently.

It is important to note that the number of informal recyclers in Bogotá differs according to the source. According to the General Secretariat of the Mayor's Office of Bogotá D.C. (2010), the community of recyclers-by-trade in Bogotá is estimated to be 8 479 individuals. However, an additional 10 027 individuals who are not considered recyclers-by-trade, depend on this activity for their subsistence. On the other hand, according to the president of the ARB, the community of recyclers-by-trade in Bogotá is estimated to be 18 000 individuals (President of ARB. Personal Interview. 22 March 2011).

The findings in the socio-economic study assessing Cali's informal recycling sector have suggested that this sector presents a low capacity to recover, accumulate and transform potentially recyclable materials. As a result, informal recyclers do not have the possibility to generate added-value from the collected materials and gain higher incomes. According to Gomez *et al.* (2008), the informal recyclers' community in Medellín lives in poverty conditions. This is due to the fact that the majority of this population (over 80%) base their income exclusively on waste picking. According to the Mayor's Office of Santiago de Cali (2009) "77.6% of the households of recyclers-by-trade in Cali gain less than the minimum wage a month

(COP$353 600 or USD $202.24 at the current exchange rate)". Similarly as stated by Agudelo *et al.* (2007) "in Medellín, 87% of informal recyclers have low salaries (less than 8 € per day that is equal to approximately USD $11.3 per day), which is insufficient to cover their basic necessities". According to Gomez *et al.* (2008) "almost 60% of the informal recyclers' community belong to socioeconomic strata 0, 1 and 2".

According to the Mayor's Office of Santiago de Cali (2009), private recycling companies have been introduced in recent years in the recycling market of Cali. These companies have developed infrastructure and the capacity to access waste from the most productive areas, which has displaced recyclers-by-trade. Subsequently, these new circumstances have deteriorated recyclers-by-trade's working conditions observed in longer working hours and less income. This is reflected in the statistics that show that 80% of informal recyclers have expressed their incapability in assuming all household expenses and their low access to credit, which is only 14.4%.

The average age of recyclers-by-trade for both sexes in Cali according to the Mayor's Office of Santiago de Cali (2009), is 38.6 years old. Men constitute 65.5% and women 34.5%. According to Agudelo *et al.* (2007), the gender distribution in Medellín is 66% male and 33% female. According to the General Secretariat of the Mayor's Office of Bogotá D.C. (2010), the gender distribution in Bogotá is 51.2% men and 48.8% women. The age range with the highest concentration of males is 18 to 40 years old (22.7%), followed by the range of 5 to 17 (20.9%), which is considered child labour. Similarly, women's highest concentration by age range is 18 to 40 (22.4%).

In regards to education levels, according to the Mayor's Office of Santiago de Cali (2009), 67% of recyclers-by-trade find themselves with only the primary level of education, whether completed or not. The main reasons for not continuing with their education include financial constraints and lack of interest in education.

According to the Mayor's Office of Santiago de Cali (2009), recyclers-by-trade work an average of 6 days per week. However, their working hours have increased from eight to nine hours per day, yet their earnings have not increased. On the other hand, according to Gomez *et*

al. (2008), recyclers-by-trade spend an average of 8.23 hours per day. This time is distributed in the following way: 1.32 hours are spent travelling to the specific location where they rent and store their transportation mode (e.g. hand-pulled cart), and then travelling to the place where they begin their route and finally travelling back to the storage place at the end of the day. They spend 6 hours recovering PRM, while spending an average of 37 minutes selecting the material and transporting it to the selling sites (dealers).

As stated by Gomez *et al.* (2008) the majority of recyclers-by-trade (76%) obtain PRM from the direct opening of garbage bags and cans put out for collection (Figure 13), 18% obtain PRM directly from waste generators, while only 4% find them properly separated. They also found that the most productive schedule for collecting PRM was from 6:00 am to 8:00 am (34%), followed by 4:00 am to 6:00 am (17%), then 8:00 am to 10:00 am (13%). In regards to the treatment given to PRM, 66% organize it, while 20% clean it and 10% leave it as is. Lastly, the productivity and income according to recyclers-by-trade's perception is mainly dependent on the quantity of the materials they collect (48%), followed by the capacity of the transportation mode (18%). The weather and the individual's capacity were both rated similarly (12%), followed by the competition for the material (9%).

Figure 13. Street Waste Pickers Collecting PRM (Courtesy of ARB, 2011)

According to Gomez *et al.* (2008), it was found that a high percentage of recyclers-by-trade (38%) perceived that the personalized delivery of PRM was considered the best way to increase their productivity, followed by collective agreements with waste producers (26%) and source separation (13%). The income of recyclers-by-trade was found to be directly proportional to the quantity of recovered PRM.

In regard to the value of the collected recyclable materials, copper has the highest commercial value per kilogram (average price of sale in Colombian pesos COP$5 200 which is equal to CAD$1 at the current exchange rate); however its recovery is low. Paper on the other hand has an average selling price of COP$360 per kilogram, and it registered the highest recovery rates by recyclers-by-trade. Glass presents the lowest selling value (Gomez *et al.* 2008). According to the General Secretariat of the Mayor's Office of Bogotá D.C. (2010), the most sold recyclable materials by recyclers-by-trade are cardboard and paper. The highest added value is found in plastics, cardboard and paper. In Bogotá, the highest concentration of dealers is found in the localities of Kennedy, Los Mártires, Bosa, Suba, Engativá and Puente Aranda. On the other hand, the highest concentration of dealers in Cali is found in El Calvario, Sucre, Fepicol, Mauela Beltran and Porvenir (Mayor's Office of Santiago de Cali, 2009).

6.3 Policy Development Regarding Recyclers-by-trade in Colombia Led by CiViSOL

The legal status of recyclers-by-trade in Colombia has vacillated over the past decade, presenting fluctuations regarding the legal status of their trade. These fluctuations have been mainly determined by the different municipalities that, by attempting to improve the waste management service only considering the environmental, technical and financial aspects of it, have excluded the participation of recyclers-by-trade.

According to the Mayor's Office of Santiago de Cali (2009), it has been noted that municipalities around Colombia perceive that a drastic change of roles regarding the various stakeholders involved in SWMS will occur in the medium-term. This change is associated with the control of waste by privatized big companies; which would gradually exclude recyclers-by-trade from their occupation.

Throughout this past decade, the informal recycling sector has received the support of voluntary lawyers, such as the CiViSOL Foundation. It is important to note that the legal and constitutional advancements made in Colombia have set a precedent. It is thanks to this precedent that the inclusive waste management alternatives are now possible. However, it is

also thanks to the results of scientific case studies —showcasing the environmental, financial and social benefits of inclusive waste management models— that have made the development of such inclusive policies possible.

Overall, CiViSOL has been working towards improving the living and working conditions of recyclers-by-trade through legal empowerment since 2003. So far, the foundation has contributed to the implementation of recyclers-by-trade's rights to their livelihood and their empowerment as "entrepreneurs of waste" (CiViSOL, 2011). According to CiViSOL (2011) "This is not a process of philanthropic nature or public social assistance. This is a reform to public policy and the configuration of spaces to allow systemic and autonomous inclusion in the public service of waste management".

According to rra (Public Law + Social Innovation) attorneys & consultants (2010), a New York and Bogotá-based law firm, the summary of the litigation history in Colombia regarding the informal recycling sector is as shown in Table 7. The following table illustrates the dates that certain laws which threatened the livelihood of recyclers-by-trade in Colombia were implemented. The table also shows the Supreme Court of Colombia's response which resulted from the voluntary legal intervention of CiViSOL foundation and other independent lawyers.

Although informal recyclers have now been legitimized, in practice their real integration to the SWMS has not yet been achieved. According to rra (2010), due to corruption surrounding the bidding for the recycling contract at Doña Juana Landfill in Bogotá, the participation of informal recyclers has not been determined. Broken promises have been made by the municipality to Navarro's Dump Waste Pickers in Cali, regarding alternatives to their livelihood since the closure of the Dump in 2008 and until today the municipality of Cali has not implemented the inclusive waste management ad-hoc committee designed.

Table 7. The Litigation History in Colombia Regarding the Informal Recycling Sector (rra, 2010)

Year	Situation and effects	Response
2002 **2003**	Informal recyclers were excluded from competing for one of the six waste collection and transportation contracts in Bogotá. This exclusion was based on the fact they are not equity-owned corporations. Instead, they are non-profit and solidarity-based organizations, such as co-operatives.	**Court Ruling T-724-2003** As a result of voluntary legal intervention, the Constitutional Court stated that the public biddings for waste management contracts could not exclude recyclers-by-trade's cooperatives from competing.
2002	**Article 28 of Decree 1713** Municipalities throughout Colombia were granted the property rights to waste once it was put out for collection. This decree prevented recyclers-by-trade from claiming an entitlement to collect recyclables.	**Article 28** was derogated by **Article 10 of Decree 1505** As a result of the voluntary legal intervention the Court expressed that after garbage bags and cans were discarded for collection, they were considered abandoned property. This allowed recyclers-by-trade's organizations to collect recyclables, as well as to compete in municipal waste collection and transportation contracts.
2003	The conditions for competing in waste management contracts issued by the municipality of Bogotá were designed in such a limiting way that it again excluded recyclers-by-trade's organizations from competing.	As a result of the voluntary legal intervention of, the Court requested effective actions for the inclusion of recyclers-by-trade organizations in future bidding contracts of waste management
2008 **2009**	**Law 1259 of 2008** Forbade not only the opening of garbage bags or cans put out for collection, but also the transportation of waste in non-motorized vehicles. Subsequently, this law threatened the trade that informal recyclers in Colombia engage in, as they belong to the urban poor and do not possess sites to extract waste or motorized vehicles to transport recyclables. Also, Navarro dump waste pickers (1200 individuals) in Cali were evicted when the dump was closed in 2008. This eviction was done without providing an alternative to their livelihood.	**Court Ruling T-291-2009** As a result of the legal intervention of CiViSOL, the Court stipulated that recyclers-by-trade's organizations must be included in future public bid processes associated with the cleanliness public service. In addition, under the right to equality stated in Article 13 of the Colombian Constitution of 1991, the Court pressured the municipalities to incorporate marginalized and discriminated groups in the administrative procurement processes. It also stipulated that public biddings for cleanliness contracts in Colombia must: (a) ensure participation of recyclers-by-trade's organizations (b) enable organized recyclers-by-trade to access to bidding processes and (c) guarantee that large-scale corporate bidders must operate contracts with recyclers-by-trade as organizations and not as individual employees. For this purpose, a scoring criterion was set to measure large-scale corporate bidders' efforts to operate waste management contracts with recyclers-by-trade's organizations. The Court recognized the rights to a livelihood, food, education and dignified housing and health of Navarro's dump waste pickers. Thus, it ordered the municipality of Cali to guarantee their fulfilment. To assure this, the Court requested an ad-hoc committee to design and implement an inclusive waste management policy for the city of Cali within the next six months.
2009	Recyclers-by-trade's livelihood remained illegal according to **Law 1259**.	**Ruling C-793 of 2009** The court consent to exceptionally not apply its relevant conditions by the competent authorities. This was due to human rights implications.

Chapter 7. Results and Discussion

7.1 Results

Questionnaires were conducted to 104 out of the 3200 recyclers-by-trade and to 4 out of 359 dealers in Cali. Although the sampled population of recyclers-by-trade is small and statistical rigour cannot be demonstrated, it does provide an idea of what the current issues for recyclers-by-trade in Cali are. Similarly, although the sampled population of dealers is really small and not statistically representative, it does give an idea of the prices paid for the collected PRM. It is also useful as a comparison with the prices of sale according to recyclers-by-trade. The questionnaires were done in a period of two weeks during the month of March 2011 and they were conducted in areas where there is a high concentration of dealer shops, such as el Calvario and Siloe neighbourhoods. Questionnaires were also conducted in the street during the waste collection days, as well as at two meetings of recyclers' organizations. The questionnaires are found in Appendix B. Table 8 illustrates some of the results obtained from the questionnaires conducted to recyclers-by-trade in Cali.

The interview conducted with the president of ARB is found in Appendix C. The interview provided clearer insight into the organizational structure and division of roles within a well established organization of recyclers in Colombia, as well as to have a better understanding of the operations and recycling capacity of the low-scale recycling system in the Alqueria Transfer Station. The interview also allowed an assessment of the applicability of reproducing this medium-size transfer station experience in other areas throughout the cities in Colombia, as well it provided useful data for comparing the prices of sale between Cali and Bogotá. In addition, it provided the opportunity to assess the ARB's perception and expectations regarding an inclusive SWMS in Bogotá.

Table 8. Results from the Questionnaires Conducted to Recyclers-by-trade in Cali, Colombia

Gender ratio	73% men	27% women
Socioeconomic strata	89% stratum 1	10% stratum 2
Period of time engaged in recycling	30% from 6 to 10 years and 17.31% from 11 to 15 years	35.6% over 16 years
Working days per week	41% work 3 days per week and 27% work 6 days per week	16% work 7 days per week
Sources of obtaining PRM	97% obtain PRM from garbage bags and cans	3% other sources (e.g. paper industry)
Transportation modes	74% use a hand-pulled cart (owned or rented)	14% use tricycle-pulled cart, 10% use sack and 2% other
Buyers of the PRM	98% sale directly to dealers	2% other
Treatment performed to PRM	96% only classify collected PRM	4% carry out other pre-processing activities to collected PRM
Degree of classification of plastics	55% do not classify and sale mixed plastic	38% classify plastic in plastic bags and containers and 7% classify plastic according to its production (extrusion- or injection-blow moulding)
Types of PRM collected	95% collect plastics, paper, cardboard and metals	77% also collect glass
Income Sources	75% is dedicated solely to informal recycling	25% present additional income source
Organizational level	67% belong to recyclers' organization	33% work Independent
Knowledge of Sentence T-291	70% do not poses knowledge regarding the legal advancements	30% poses some knowledge of the legal advancements

According to the findings of this study, the gender ratio, socioeconomic stratum, period of time engaged as recyclers, working days per week, income sources, organizational level, source of obtaining PRM, transportation modes used, buyers of the PRM collected, types of PRM collected, and the treatment performed to PRM prior to their sale, show a similar tendency to the data reported by the Mayor's Office of Santiago de Cali (2009), the General Secretariat of the Mayor's Office of Bogotá, Agudelo *et al.* (2007), and Gomez *et al.* (2008).

The alternative income sources reported by the respondents were the collection of debris, purchase and sale of metal scrap and construction for men, and house cleaning for women. According to the results drawn from the questionnaires conducted to recyclers-by-trade, it is observed that the majority (70%) is not informed regarding the policy advancements concerning the informal recycling sector, while 24% had somewhat of a vague idea about the policy advancements and only 6% knew what the sentence T-291 entailed. This has not been assessed before and no available data exist to compare these results with.

In summary, the values of sale of PRM can be observed in Table 9. As illustrated in this table, there are major differences between the lowest and highest prices of sale of PRM, which show inconsistencies in the prices, as well as a lack of a standardized valorization.

Table 9. Lowest and Highest Values of Sale of PRM Reported by Recyclers-by-trade in Cali

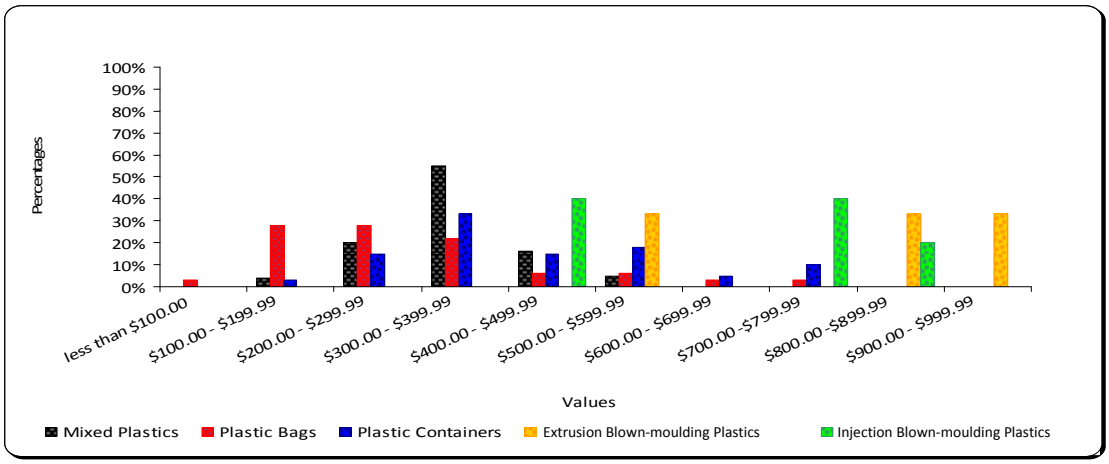
PRM	Lowest Price (COP)	Highest Price (COP)
Mixed plastics	$100.00/kg	$500.00/kg
Plastic bags	$50.00/kg	$700.00/kg
Plastic containers	$100.00/kg	$800.00/kg
Extrusion blown-moulding	$500.00/kg	$950.00/kg
Injection blown-moulding	$400.00/kg	$800.00/kg
Newspaper	$20.00/kg	$200.00/kg
Paper	$150.00/kg	$600.00/kg
Cardboard	$150.00/kg	$650.00/kg
Rubber	$100.00/kg	$800.00/kg
Liquor glass bottle	$50.00/kg	$200.00/kg
Glass bottle	$10.00/unit	$60.00/unit
Metal scrap	$100.00/kg	$600.00/kg
Mixed aluminum	$800.00/kg	$8 000.00/kg
Aluminum pots	$1 000.00/kg	$2 400.00/kg
Aluminum cans	$1 200.00/kg	$2 000.00/kg
Aluminum profile	$1 500.00/kg	$3 500.00/kg
Bronze	$800.00/kg	$11 000.00/kg
Copper	$6 000.00/kg	$17 000.00/kg

It was also noted that the majority (over 95%) of the respondents collect cardboard, paper, plastics and metals. However, metals especially bronze and copper are collected in lower

amounts. Due to its low commercial value and its heavy weight, glass is collected by a slightly lower percentage of respondents (77%). Rubber is only collected by 22% of the respondents and organic waste is only collected by 3%.

In regard to the classification of materials, plastics showed the highest degree of classification within its own material type. According to the results drawn from the questionnaires, 55% of the respondents do not classify plastics and they sell them mixed; while 38% classify plastics into two categories, such as plastic bags and containers. The remaining 7% sort plastics according to the production process it undergoes (injection- and extrusion-blown moulding). Figure 14 illustrates the selling prices of plastics according to the different categories. It is observed that the highest value of sale (per kilogram) of plastic is obtained with the category of extrusion-blown moulding, followed by injection-blown moulding, plastic containers and mixed plastic. The lowest value of sale corresponds to plastic bags.

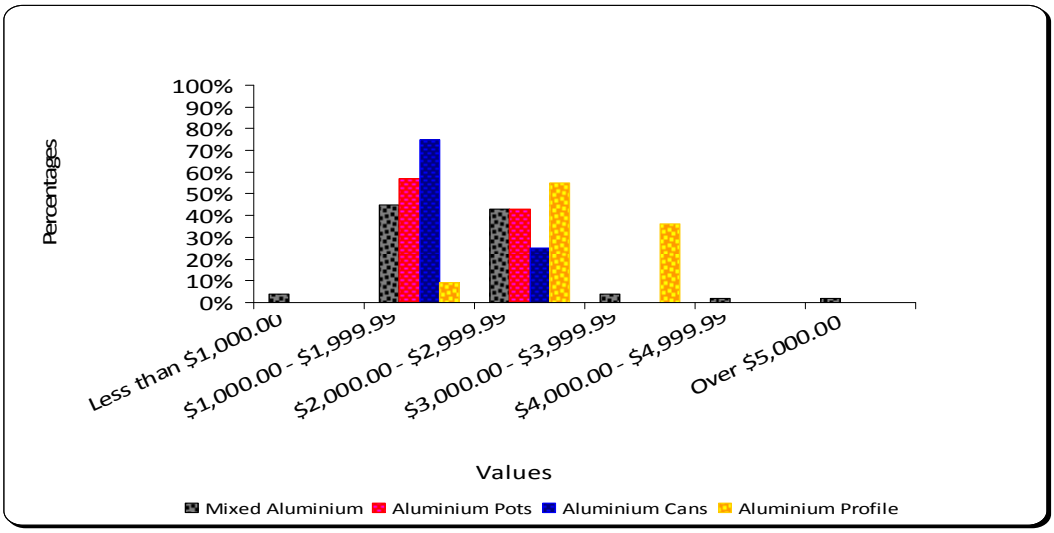
Figure 14. Value of Sale per Kilogram of Plastic by Category



According to the results from the questionnaires, the majority (82%) of the respondents do not sort aluminum and they sell it mixed. The remainder (18%) classify aluminum in three types: aluminum pots, cans and profile. The value of sale per kilogram by category of aluminum is shown in Figure 15. As illustrated by the figure, almost 90% of recyclers-by-trade sell the kilogram of mixed aluminum for a value ranging from COP$1 000.00 to $2 999.99. It also shows that the kilogram of aluminum pots and aluminum cans is sold (almost 60% and 80%

respectively) for a values ranging from COP$1 000.00 to $1 999.99. The majority of respondents (over 90%) sell aluminum profile for a value ranging from COP$2 000.00 to $3 999.99, which displays the highest value of sale.

Figure 15. Value of Sale per Kilogram of Aluminum by Category



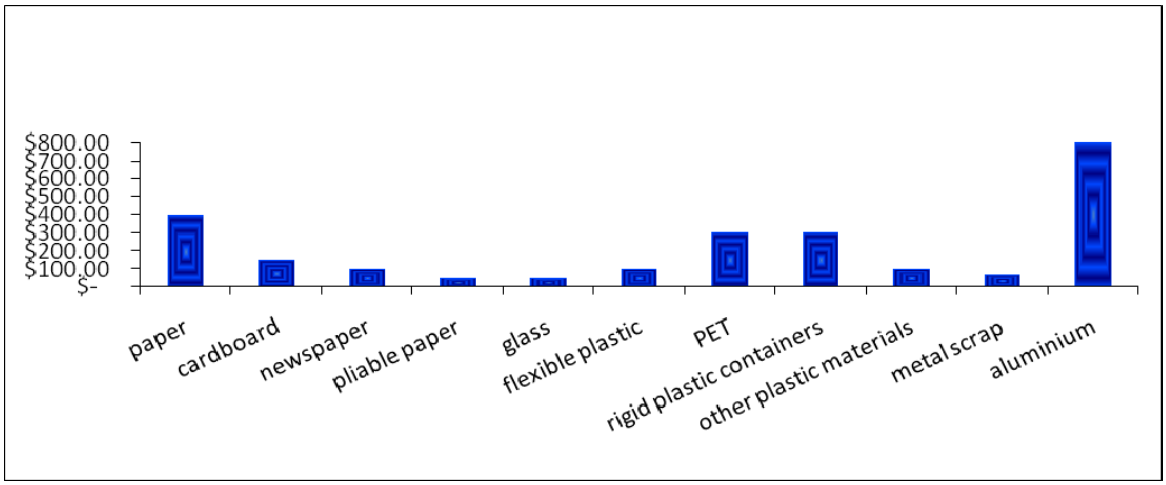
According to the results drawn from questionnaires conducted to dealers, all the respondents sell their purchased PRM to wholesalers. The majority (75%) only selects the purchased PRM, while the remaining (25%) also performs baling. In regard to their organizational status, the majority belong to an organization. All the respondents said they purchase from individual recyclers-by-trade plastics, paper, cardboard and metals. Table 10 illustrates the average prices of purchase and sale according to the dealers who participated in the questionnaires. Based on the results drawn from the questionnaires, cardboard displayed the lowest (10%) profit margin. Copper, aluminum pots and plastic bags exhibited a profit margin around 20%. Bronze, metal scrap, aluminum sheets and paper displayed a profit margin around 30%. Aluminum profile and mixed aluminum showed a profit margin around 40%. Mixed plastic, glass bottles and newspaper, exhibited over 60%, 70% and 90% profit margins, respectively. Plastic containers and rubber exhibited the highest profit margins with 100% and 120%, respectively.

Table 10. The Prices of Purchase and Sale of PRM According to Dealers

	Purchase price COP	Sale Price COP
Mixed plastic	$200.00/kg	$333.33/kg
Plastic bags	$150.00/kg	$200.00/kg
Plastic containers	$250.00/kg	$500.00/kg
Newspaper	$50.00/kg	$95.00/kg
Paper	$426.70/kg	$562.50/kg
Cardboard	$200.00/kg	$220.00/kg
Rubber	$250.00/kg	$550.00/kg
Glass	$50.00/unit	$85.00/unit
Copper	$10 000.00/kg	$11 833.33/kg
Bronze	$5 333.33/kg	$7 166.66/kg
Mixed aluminum	$1 900.00/kg	$2 650.00/kg
Aluminum profile	$2 200.00/kg	$3 000.00/kg
Aluminum pots	$2 000.00/kg	$2 400.00/kg
Aluminum sheets	$1 500.00/kg	$2 000.00/kg
Metal scrap	$300.00/kg	$392.50/kg

Figure 16, illustrates the prices of sale of the recyclable material portion of PRM at the Alqueria Transfer Station during the month of February of 2011. These recyclable materials include: paper, cardboard, newspaper, pliable paper, glass, flexible plastic, PET, rigid plastic containers (*tatuco*), other plastic materials (*pasta*), metal scrap and aluminum.

Figure 16. Value of Sale of Recyclable Materials at the Alqueria Transfer Station During the Month of February, 2011. (Courtesy of ARB, 2011)



It is possible to compare the different values of sale of recyclable materials by the three stakeholders (Table 11). These are the 104 interviewed recyclers-by-trade in Cali, the four interviewed dealers in Cali and the reported sale inventory for the month of February of 2011 of the Alqueria Transfer Station.

Table 11. Comparison of Value of Sale of Recyclable Materials

Material	Alqueria Transfer Station value of sale in Bogotá (COP)	Recyclers-by-trade in Cali value of sale (COP)	Dealers in Cali value of purchase (COP)
Paper	$400.00/kg	$432.53/kg	$426.70/kg
Cardboard	$150.00/kg	$208.69/kg	$200.00/kg
Newspaper	$100.00/kg	$77.44/kg	$50.00/kg
Glass	$50.00/unit	$47.24/unit	$50.00/unit
Flexible plastic (plastic bags)	$100.00/kg	$261.56/kg	$150.00/kg
PET	$300.00/kg	-	-
Rigid plastic containers	$300.00/kg	$401.28/kg	$250.00/kg
Other plastics	$100.00/kg	$312.86/kg	$200.00/kg
Metal scrap	$70.00/kg	$526.11/kg	$300.00/kg
Aluminum	$800.00/kg	$1 957.14/kg	$1 900.00/kg

As illustrated in Table 11, the value of sale of paper is slightly higher in Cali compared to Bogotá. This is confirmed both by the average sale value reported by recyclers-by-trade and the average purchase value reported by dealers. A similar situation is observed with the cardboard. Although the values of sale of flexible plastic, rigid plastic containers, other plastics, metal scrap and aluminum are higher in Cali compared to Bogotá, the values of purchase reported by the dealers are lower than the ones reported by recyclers-by-trade. In the case of newspaper, the values of sale are higher in Bogotá than in Cali. However, the value of sale of glass in Bogotá matches the purchase value of dealers in Cali, which are both lower than the average value of sale reported by recyclers-by-trade.

It is also interesting to note that the categorization of plastic varies according to the recyclers' knowledge. At the Alqueria Transfer Station in Bogotá plastics are classified in four types that include flexible plastic, PET, rigid plastic containers (*tatuco*), and other plastics

(*pasta*). On the other hand, in Cali plastics are classified four different types, which include plastic bags, plastic containers, extrusion moulding plastics and injection moulding plastics. Another difference is glass, which at the Alqueria does not have a categorization as the one observed in Cali with two kinds, namely glass bottles and glass liquor bottles.

An additional difference between the Alqueria and Cali is observed with metals. This is especially evident for the case of metal scrap and aluminum which have values of sale smaller in Bogotá compared to Cali. In addition, Cali presents a higher classification of aluminum, as well as the presence of other metals like bronze and copper. Better data may offer an explanation for these differences.

According the president of the ARB (2011), the current recycling rate in Bogotá is 1 200tons/day. The Alqueria is a medium-size transfer station with 100 workers, out of which 70 are permanent and the remaining operate only during the weekends. It has a loading area where it receives the collected PRM (Appendix D1). The PRM is set on long metal tables in a ventilated area, where it gets sorted out by uniformed recyclers-by-trade. This includes a one-piece uniform, back support belt, cap, dust respirator mask, boots and gloves. Next to the metal tables there are big cans for each type of recyclable material (Appendix D2). The sorted material is flattened, baled and weighted (Appendix D3). Due to occupational risk concerns, recyclers-by-trade at the transfer station do not lift anything heavier than 60kg; in which case they use a lifting jack. Then the sorted recyclable materials are set in designated areas according to the recyclable material type (Appendix D4).

It receives an average of 15tons/day of PRM, out of which only 65% are recyclable materials and 35% are rejected materials, which are also baled. However, in order for the Alqueria to be self-sustainable and cover all its operational and administrative costs, it requires 20tons/day of PRM —an amount only received during the month of December. These administrative costs include payroll of the administrator, the coordinator, the administrative assistant and the record-keeper, which reach almost COP$5 000 000. In regard to the current state of the cooperative system in Bogotá, she expressed that “there are only three cooperative companies of associated work, which pay their members’ health plan and social benefit”.

The informal recycling routes carried out by recyclers-by-trade are a core component of informal recycling. For the purpose of this research, it was considered as an important aspect that requires to be acknowledged when thinking of integrating this sector into the formal SWMS. The ARB together with a group of professionals has mapped the informal recycling collection routes performed by all the recyclers-by-trade in Bogotá. However, these data were not made available.

When inquiring about their present political agenda, the president of the ARB expressed that presently, they are concentrating their efforts into obtaining the monetary recognition for their service, in order to change the livelihood of recyclers-by-trade. For this purpose, the ARB has come up with a plan. According to the president of the ARB (2011) and the team of professionals that has been collaborating with the ARB, the city is currently paying to waste collection companies in Bogotá COP$145 000 per ton of waste collected, which leaves a profit margin of 46%.

According the president of the ARB (2011), the ARB's proposal consists of locating collection trucks in strategic zones in order to receive, weigh, and record the collected PRM of approximately 35 recyclers-by-trade. Then, the collection trucks would transport the PRM to the dealers' sites. Based on the hours of work of recyclers-by-trade and the transportation costs, they have estimated it will cost COP$385 000 per ton to operate this system.

According to the presidents of the ARB (2011) the value of sale per kilogram of collected PRM — without discriminating the type of material collected — by recyclers-by-trade is estimated to be COP$200. Subsequently, the deduction of this brings down the final cost of their proposed system to COP$185 000. In addition, the presidents of the ARB explained that there are savings of COP$90 000 in the transportation due to the surplus stretches in the collection circuits, which brings down the final cost of their proposed system to COP$95 000.

According to the president of the ARB (2011), the city recognizes the collection service of PRM COP$70/Kg. The ARB is proposing to divide this amount the following way: COP$56/kg should be allocated to recyclers-by-trade and the remaining COP$14/kg should be allocated to the transportation trucks who take the PRM to the dealers' sites.

7.2 Discussion

The hypothetical model proposed by Jaffe and Nas (2004) which analyzes the interactions in a political context, the technology employed in a given SWMS, the social setting and the organizational advancements of recyclers-by-trade, could give a glimpse into the success rate of achieving a Sustainable and Inclusive SWMS in Colombia. However, other aspects that are not included in this model such as the financial data, education, environmental and health issues are discussed subsequently.

In Jaffe and Nas (2004) model, the organizational level of recyclers-by-trade is the starting point that influences and determines the success level of their integration into the formal SWMS. According to their model (in Table 4 on page 49) Colombia has a combination of scenarios C and D, medium to low organizational level. These scenarios predict a low to very low success factor regarding the integration of the informal recycling sector into the formal SWMS. The organizational status of recyclers-by-trade in Colombia is still very incipient and not cohesive, as only 30% of the recyclers-by-trade belong to an organization. This positions Colombia in a low stage in recyclers-by-trade's organizational structure. Also, as described in the literature, successful experiences integrating the informal recycling sector into the formal SWMS, demonstrate that high organizational structure is essential for increasing recycling rates and improving the recyclers-by-trade's living conditions. Certainly there is room for improvement in this regard, especially when legally — according to Sentence T-291 of 2009 — the partnerships between large waste management corporations and recyclers-by-trade can only be done through their organizations and not as individuals.

Organizing recyclers-by-trade in cooperative systems in Colombia could potentially contribute to public recognition. Renaming the informal recycling sector positively could promote a change of their perception as an asset to SWMS, becoming the preferred agents in charge of the collection of recyclables. In addition, the provision of ID cards, uniforms and standardized transportation modes would create a recognizable image. It can also award them

with legal status and more stability, increase their self-esteem and influence their decision-making.

Having under consideration that the informal recycling sector has existed for over 60 years and currently it only exhibits a very low organizational status, might suggest that the ANR's efforts are not being sufficient in reaching out to the majority of recyclers-by-trade operating in Colombia. The ANR's efforts are also not enough in consolidating a cohesive organization system throughout Colombia, as well as informing recyclers-by-trade in regard to the legal advancements. Similar to the work carried so far by CiViSOL regarding the legal advancements, other NGOs could focus more in capacity building. It could be argued that the intervention of NGOs could contribute substantially to increasing the percentage of organized recyclers-by-trade, as well as creating a more unified organizational system. As described in previously, NGOs have played a crucial role organizing recyclers-by-trade into cooperatives in other developing countries. This is due to being familiar with the local conditions, having the capacity to develop interesting initiatives, providing business, legal and technical support, as well as obtaining funding.

Another important factor in consolidating the informal recycling sector in Colombia is its socioeconomic characterization, such as the one performed by the Mayor's Office of Cali. This socioeconomic characterization could include a registry of all cooperatives of recyclers-by-trade in order to legitimize them and to improve the management of a professional and integrated SWMS.

It could be argued that the informal recycling sector in Colombia has evolved from a repressive political context to a stimulating one. This recent stimulating political scenario is based on the Sentence T-291 of 2009. However, in practice this transition which involves various adjustments seems to be taking some time. Thus, a real integration is still to be proven. According to Jaffe and Nas (2004) model, this stimulating political context now present in Colombia increases the possibilities of having a higher success in the integration of recyclers-by-trade into the formal SWMS.

In regard to the social segregation of recyclers-by-trade in Colombia, this seems to be related specifically to their social status, as the majority of this community belongs to socioeconomic stratum 1. Their low socioeconomic stratum is associated with their low earnings, which are based exclusively on waste picking. This is confirmed by Gomez *et al.* (2008) in Medellin, where over 80% base their income exclusively on waste picking; as well as the fact that 80% of them in Cali have expressed their incapability in assuming all household expenses (Mayor's Office of Santiago de Cali, 2009). This scenario suggests that there is a direct relation between the income of recyclers-by-trade and the quantity of recovered PRM, thus their low collection capacity is also confirmed. It seems that recyclers-by-trade are the "working poor" who are unable to survive on this income, nor control their destiny to escape this cycle of poverty. Therefore, increasing their productivity is another aspect that has to be taken under consideration in order to increase overall recycling rate and as a result of this, improve their income and living conditions.

According to the Jaffe and Nas (2004) model, this social segregation is restricted to social status dictated by their low socioeconomic stratum in Colombia, and increases the possibilities of having a higher success in the integration of recyclers-by-trade into the formal SWMS in Colombia.

Currently, the country presents a curbside collection system of mixed waste. It also presents issues regarding its waste collection coverage, especially in the rural areas. Currently, almost 20% (5 0159 tons/day) of the total waste is disposed in a method different from the sanitary landfill, which was pointed out as the only method recognized. These different methods include transition containment units, open dumps and uncontrolled dumping of waste directly into water bodies, burial sites or waste burn-off sites. One of the main faults of Colombia's SWMS is the lack of an integral recycling system and the current low recycling rate of 13%. This is substantially lower compared to what appears in the literature for developing countries, where according to Cheeseman *et al.* (2006), the overall recycling rates are between 20% and 50%. Thus, the current reported technologies applied in Colombia's SWMS show that there is room for improvement.

This improvement is related in part to implementing a source-separated curbside collection system, which should focus on a sustainable and socially sound alternative. It is believed that implementing a source-separated curbside collection system such as the ones observed in the developed world, with expensive collecting trucks, high maintenance fees and gasoline requirements could represent costs that are not financially viable. Thus, it seems logical to rethink alternative systems for the collection of recyclables that could be financially viable, environmentally friendly and socially responsible. In addition, it could be argued that one of the most important aspects of recycling begins with source separation, which is currently almost nonexistent in Colombia. In the Colombian society where source separation is such an incipient practice, education would play an important role in creating awareness of its importance, as well as fundamental instructions on how to recycle. This educational campaign needs to target the various stakeholders from citizens and institutions to industrial and commercial settings. Further benefits of source separation would include the reduction of occupational health risks of recyclers-by-trade who would not need to recover PRM from mixed waste, increasing their collection efficiency.

Education regarding the ecological merits of recycling, and the prospect of collecting PRM where it has not been collected so far, is a vital component in the introduction of recycling in the current waste management system. However, other measures are also required. The current profit margin of 46% gained by the waste management companies operating in Bogotá, could affect the imperative to change as it is not as strong as it would be if there were a 100% profit margin or more. Thus, incentives such as taxes, fines and rewards could potentially increase the recognition and the needed structural changes in the *modus operandi* of people.

From an economic perspective, source separation could potentially increase if financial incentives exist. This financial incentive would promote source separation of waste producers. Considering that one of the highest recycling rates reported worldwide belonged to the Zabaleen community of itinerant waste buyers in Egypt, could suggest that this system might offer a viable alternative for the Colombian case. On the other hand, SWMS in Colombia is

required to increase the collection coverage both in cities and especially in rural areas, as well as assure that all the waste produced is disposed in sanitary landfills.

The current inefficient recycling practice is also related to the low productivity of recyclers-by-trade. This low productivity is associated with their transportation mode as it reduces not only the capacity of carrying high volumes of PRM, it also reduces the capacity to travel longer distances. This is observed with the reported data on Cali's recyclers-by-trade where the majority (33.33%) transport between 41kg/day and 70kg/day, while a small percentage (13.4%) transport 71kg/day and 250kg/day. Also, there are issues associated with the hand-pulled cart, which is the most common transportation mode. The deficiencies in Colombia's SWMS, as well as the inappropriate alternative of applying a recycling collection system typical of the ones seen in the developed world due to financial constraints and the social conditions associated to recyclers-by-trade, increase Colombia's success rate according to the hypothetical model proposed by Jaffe and Nas (2004).

Overall, according to the model designed by Jaffe and Nas (2004), Colombia is required to increase the organizational level of recyclers-by-trade in order to increase its success factor in creating sustainable and inclusive SWMS. On the other hand, the other aspects analyzed by them such as the political context, the social segregation and the current technologies used in the SWMS point out a high success rate. Therefore, it would be argued that the greatest efforts need to focus on capacity building of recyclers-by-trade organizations such as cooperatives, reaching greater numbers of informal recyclers throughout Colombia, and consolidating a more unified system.

It is suggested that by involving recyclers-by-trade in new service roles both in collection and recycling, as well as improving sorting activities by building transfer stations in strategic locations and assuring good communication among the partnerships between waste management corporations and recyclers-by-trade cooperatives, could potentially promote higher recycling rates.

The results of this study show that in Colombia, recyclers-by-trade's economic activities within SWMS are mainly dedicated to collection and separation activities of PRM prior to their

commercialization. Also, in the Colombian case this collection is not efficient as it is time consuming to recover PRM from mixed waste by opening garbage bags and cans put for collection. In addition, the recyclers-by-trade's standards of categorization of PRM are very simple. In most of the cases, the commercialization is done directly with dealers which act as the middlemen in the recycling chain. A simple and inconsistent categorization style is especially observed in plastics and metals such as aluminum. Therefore, it is suggested that organized recyclers-by-trade are trained to sort metals and plastics in standardized categories, such as PET (Polyethylene Terephthalate), HDPE (High Density Polyethylene) PS (Polystyrene), PVC (Polyvinyl Chloride), LDPE (Low Density Polyethylene) and PP (Polypropylene) for plastics.

Currently, the net income of recyclers-by-trade could be inferred, according to the president of the ARB (2011) estimation of the value of sale per kilogram of collected PRM which does not differentiate between the types of materials collected and the estimation of the capacity to transport PRM by recyclers-by-trade according to the Mayor's Office of Santiago de Cali (2009). According to these two estimations, 33.33% of recyclers-by-trade earn between COP$ 8 200 to COP$14 000; while 13.4% earn between COP$14 200 and COP$40 000 (considering the deduction of 50kg that the hand-pulled cart weighs).

Independent recyclers-by-trade, as well as the ARB members working at the Alqueria Transfer Station in Colombia, do not engage in pre-processing activities. It is also especially difficult for independent recyclers-by-trade that lack the infrastructure to have the capacity to accumulate large volumes that could potentially add value and increase their income. This scenario suggests the importance of establishing transfer stations like the Alqueria throughout the different cities in Colombia. A step further could be to include the performance of pre-processing activities carried out in these transfer stations, such as granulating of plastics that could be sold directly to recycling industries for example. These pre-processing activities can potentially add value to the commercialization of the collected recyclables, which would improve their income. This last aspect would actually follow the idea of involving recyclers-by-trade in new service roles, which could potentially raise financial, human and social capital.

Organized recyclers-by-trade would need to undergo professional training in order to use machinery for pre-processing activities such as hot-press technology and extruders.

The differences noted in selling prices of recycled materials between Cali and Bogotá suggests a lack of consistency. The most evident differentiation in the sale values between Alqueria and Cali is observed for metals like metal scrap and aluminum. Therefore, more consistency in the market prices should be considered in Colombia to assure transparency in transactions through limited government intervention. It is suggested that governmental participate by publishing the market prices of recyclables through mass media.

There are various environmental advantages of increasing recycling rates in Colombia and collecting the PRM by improved alternative environmentally-friendly modes of transportation, such as a tricycle-pulled cart. These advantages range from energy conservation, source conservation and prolongation of sanitary landfills in reducing greenhouse gas emissions. From a sustainability perspective, the environmental needs would not be met if the value to society is not sufficient for recyclers-by-trade to continue performing this service by being able to survive on their revenues. Thus, the demand of a monetary recognition for their service seems to be logical in order to improve their efficiency and their income. In the case of Colombia, as proposed by the ARB a recognition of COP$56/Kg would be suggested. In regard to their suggested amount, although it seems reasonable, further studies could be performed to assess this particular aspect. This is especially true if the value of their service becomes so lucrative or expensive that they become replaced by entrepreneurs and automation (as in developed countries).

Another aspect regarding the cost of the integration would be the financial savings to the different municipalities in Colombia, as has been observed in the literature. However, as observed in the literature, the integration could potentially reduce the number of recyclers-by-trade participating formally in SWMS. This is an important factor which would have to be assessed in the case of Colombia.

Due to the nature of the informal recycling system in Colombia, which is unregistered and unregulated, as well as the scarce research done on the topic, there is a lack of data. This

also applies to insufficient data that could enable the estimation of the current market for recyclables. Thus it is not possible to assess how income could be portioned across the families who do the work (by dividing the estimated market into the number of recyclers-by-trade), as well as for how many recyclers-by-trade this integration could benefit.

It is lastly argued that under the premises of environmental science and management: sustainability entails viable systems which rely on social commitment and responsible economics. It is also acknowledged that the recyclers-by-trade community in Colombia has shown an adaptive nature that has responded to the local economic conditions, providing an important service throughout the country. Thus, an alternative SWMS that considers, on one hand, the legal development with inclusive policies and social aspects, and on the other hand, the municipalities needs regarding the technical, financial and environmental aspects of waste management.

Chapter 8. Conclusions: A Normative System for the Inclusion of Recyclers-by-trade's Organizations in a Sustainable Solid Waste Management in Colombia

There is limited research done on recyclers-by-trade in the developing world due to the difficult conditions of carrying out research in these communities. Although recent attention has been paid by the Mayor's Office of Cali and independent researchers in Medellin, the scarcity of data still prevails in Colombia. This is especially evident in Bogotá, where the recyclers-by-trade community is the biggest and no socio-economic or demographic characterization exist.

It is believed that recycling in developing countries, such as Colombia, is not limited to only being a technical and environmental problem but also a social one. Due to this, it requires a solution that considers the financial, technical, environmental and social aspects of recycling in Colombia. The SWMS in Colombia has various limitations as demonstrated above and the current recycling system that is mainly carried out by the informal recycling sector is one of them.

On the other hand, the development of new technologies and the implementation of more rigorous policies aiming to achieve higher recycling goals might also represent a challenge to the recycling-by-trade community, especially those who are not organized. These changes can potentially challenge their traditional working structure, as the city's requirements will determine more professional and formal attitudes towards recycling activities. It is therefore, necessary to focus first on strengthening the informal recycling sector's organizational structure in Colombia. This way, the cities' waste management requirements could be fulfilled and the success rate of the integration could increase, along with recyclers-by-trade's income and living conditions. This process also needs to consider policy development, monetary incentives, and educational campaigns aiming at the reduction of waste generation and the participation of residents in source separation. Another important aspect that is required to be considered is increasing recyclers-by-trade productivity. As discussed previously, there is an urgent need to develop infrastructure, such as transfer stations and to improve their transportation mode, as well as provide training regarding the standardization of PRM's categorization.

Figure 17 is a conceptual diagram of the current recycling system in Colombia composed of waste generators, recyclers-by-trade, small to large-size dealers, and the recycling industry. Figure 17 also illustrates how the current recycling system is neither cohesive nor an integral feature of the current SWMS. Instead, the recycling system has an informal and fragmented nature that results in a low recycling rate. In addition, it shows how the diversity of transportation modes used by recyclers-by-trade determines the different productivity levels regarding the recovery of PRM. Last, it is possible to observe how this recycling system is likely unsustainable and missing out opportunities for meeting social and other goals.

Figure 17. The Current Recycling System in Colombia

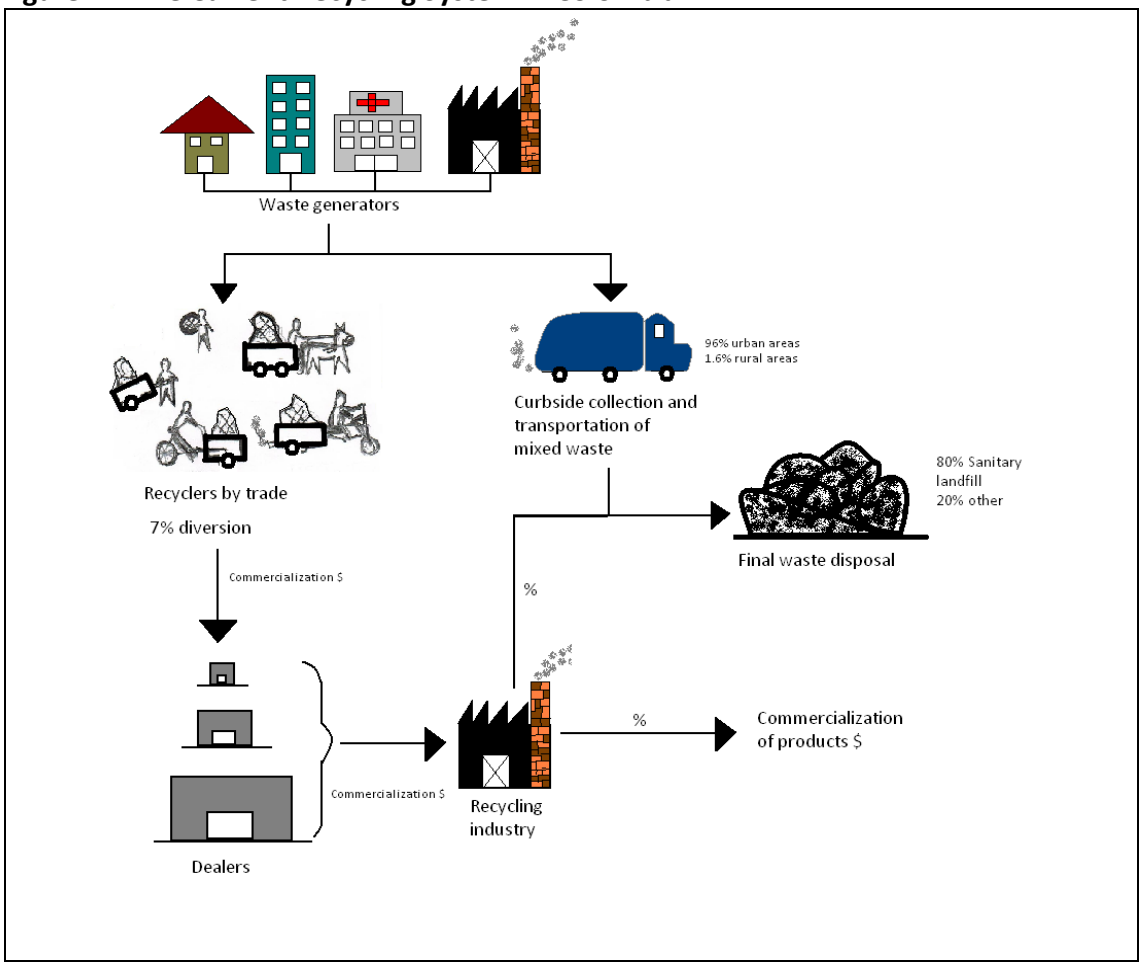
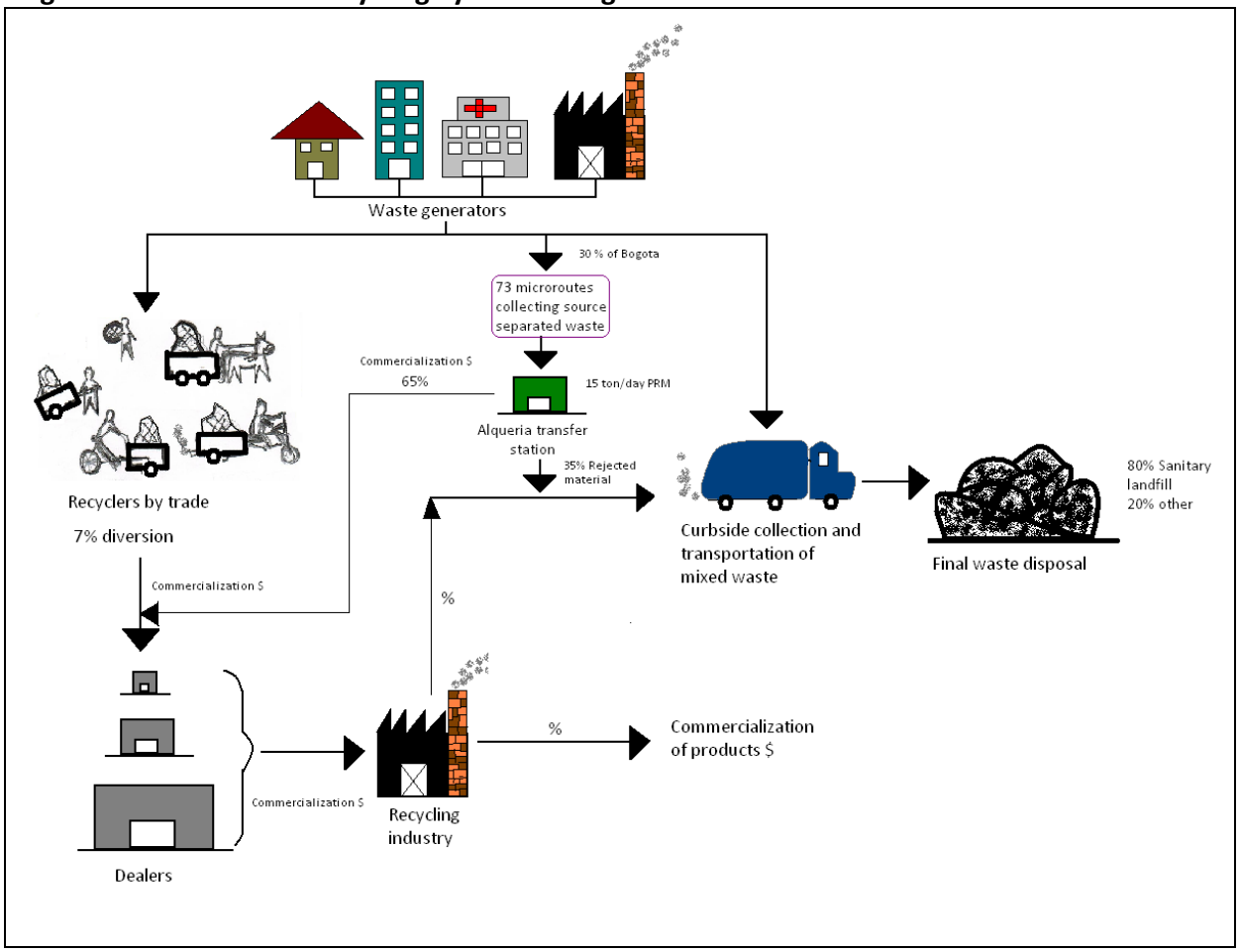


Figure 18 is a conceptual diagram of the current recycling system in Bogotá. It illustrates the addition of the Alqueria Transfer Station, where the recycling rate has increased along with the working and living conditions of the organized recyclers-by-trade involved. However, this pilot project is an isolated experience that has only been able to reach a limited amount of organized recyclers-by-trade, as well as a low portion of the city (30%). Figure 18 illustrates also shows how the diversity of transportation modes continues to determine different productivity levels regarding the recovery of PRM and how recyclers-by-trade are only involved with collecting and sorting activities. Thus, the reality of the informal recycling sector in the rest of Bogotá as in the rest of Colombia is characterized by a recycling system that is neither cohesive nor an integral feature of the current SWMS.

Figure 18. The Current Recycling System in Bogotá



The Proposed Normative System for the Inclusion of Recyclers-by-trade's Organizations in a Sustainable Solid Waste Management in Colombia

The focus of the model is the integration of the perspectives of the different stakeholders involved in SWMS, which is currently lacking. The inclusiveness applies to all if sustainability is to be achieved. If any player or aspect associated with the SWMS are sacrificed, then the puzzle is incomplete and its structure and functionality are lost. The different elements that constitute the normative system are aiming to address the pressing environmental problem related to Colombia's SWMS by considering the social, economic, political and technical aspects, as well as the various stakeholders associated with it. Figure 19 is a conceptual diagram showcasing the different dimensions and aspects that constitute the normative system. The conceptual diagram has a puzzle-like style which symbolizes the puzzle-like data that were used to build-up the case study.

Figure 19. The Different Dimensions and Aspects that Constitute the Normative System

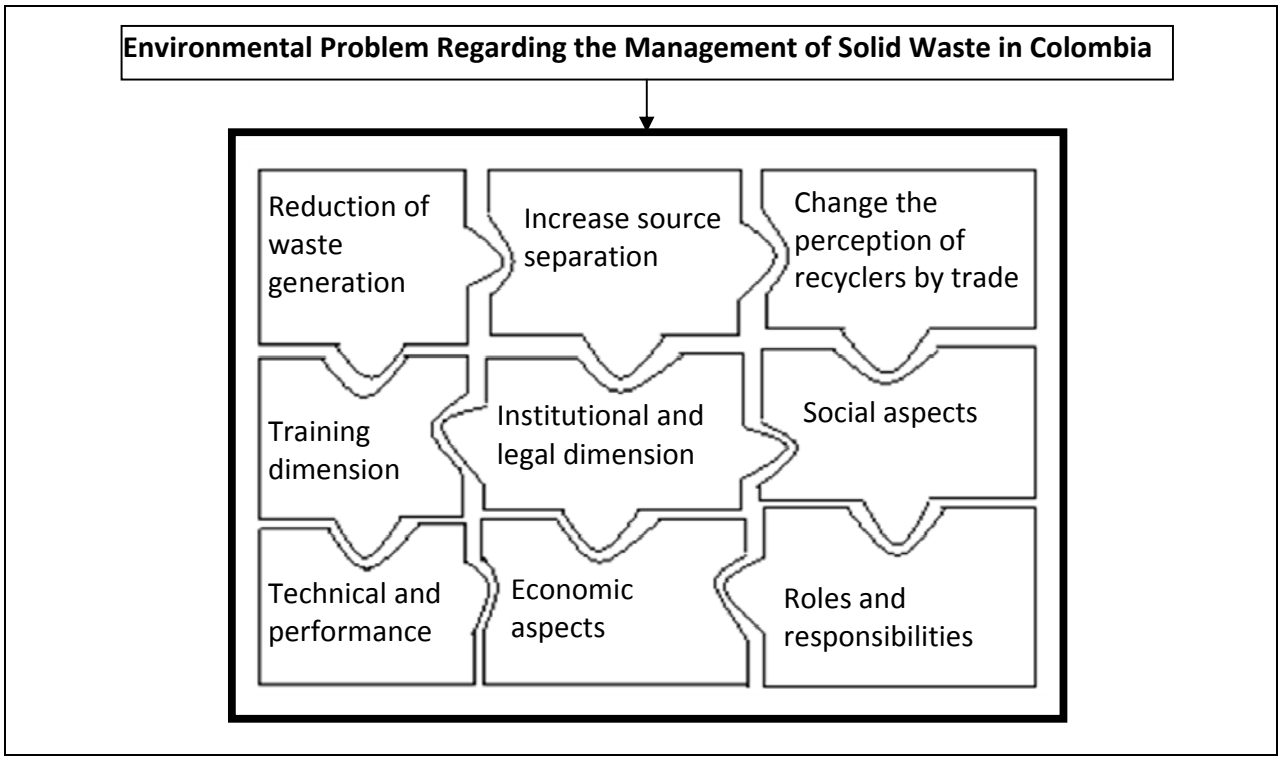


Figure 20 is a conceptual diagram illustrating the proposed normative system for the inclusion of recyclers-by-trade's organizations in a sustainable solid waste management in Colombia. The normative system proposes changes in the current SWMS of Colombia that could potentially: achieve higher recycling rates, increase the lifespan of its landfills, reduce greenhouse gas emissions, and be financially viable and socially sound. The normative system promotes a more cohesive recycling system supported by a higher organizational level of recyclers-by-trade's cooperatives. As illustrated in Figure 20, the proposed normative system focuses on the integration of organized recyclers-by-trade into the SWMS through contracts with waste management corporation. Each joint contract between a given municipality and the waste management corporation with one or more recyclers-by-trade's cooperatives would be in charge of a specific area of the city, such as one of the six ASE in Bogotá. This integration would support itself with the real enforcement of the Court Ruling T-291 of 2009.

As shown in Figure 20, waste management corporations would be in charge of the curbside collection of the non-recyclable portion of waste; while organized recyclers-by-trade would be in charge of the curbside collection of the PRM portion of waste. In addition, the informal recycling routes are required to be mapped and formalized and where needed improved.

Figure 20 also shows how the technical and performance aspects, as well as the division of roles need to be addressed. It illustrates that the transportation mode used by the waste management corporations continues to be garbage trucks; while organized recyclers-by-trade's transportation mode would undergo a standardization process. This standardization process would focus not only in achieving higher productivity levels regarding the recovery of PRM, but also addressing the environmental issues associated with the common motorized transportation modes. Thus, it is proposed that organized recyclers-by-trade use non-motorized vehicles which are environmentally friendly due to the reduction of greenhouse gas emissions. In addition, the design of this non-motorized vehicle would address the current issues related to the weight of the vehicle, the size and material of the wheels, and the transportation capacity which have been reported in the literature.

Figure 20. The Proposed Normative System for the Inclusion of Recyclers-by-trade's Organizations in a Sustainable Solid Waste Management in Colombia

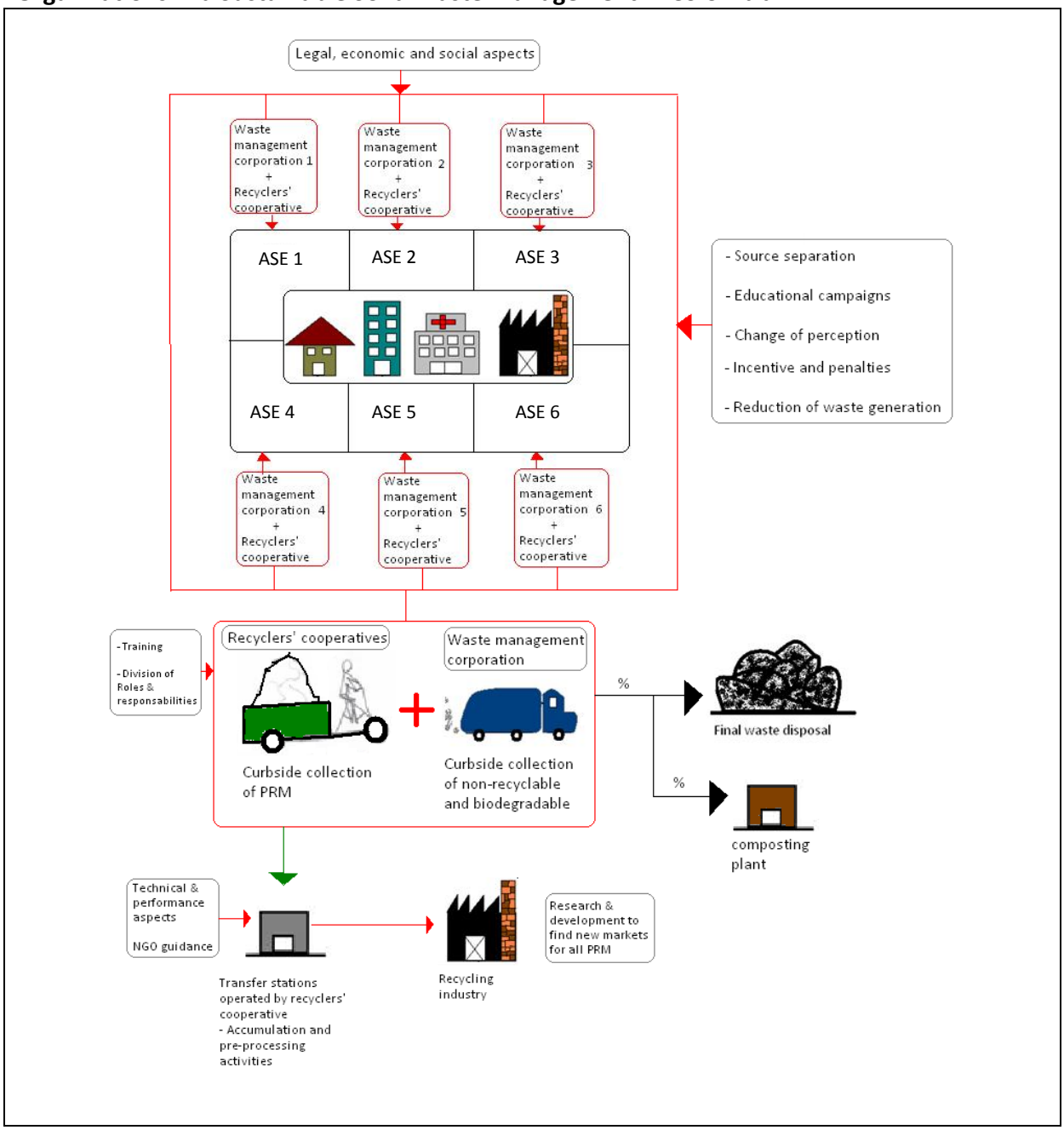


Figure 20 also illustrates how the legal, economic and social aspects are defining the system and determining its functionality. Also, the normative system is influenced by the addition of new practices such as source separation and reduction of waste generation, which

are currently lacking. Attention is also given to changing the negative perception associated with informal recyclers. The normative system promotes the perception of recyclers as an organizational asset to the SWMS in Colombia. Thus, educational and public awareness campaigns to promote all these new practices are a fundamental feature of the normative system. Another important aspect of the normative system is the training and capacity building of organized recyclers-by-trade. This also includes the establishment of transfer stations in strategic areas throughout the city. These transfer stations can potentially reduce the distance of transportation of PRM, as well as increase the sorting and accumulation capacity.

The normative system also points out the importance of further research and development to find new markets for all PRM which is currently lacking. In addition, through further training it is possible to involve organized recyclers-by-trade in additional recycling activities beyond collecting and sorting, such as pre-processing activities.

Below there is a detailed description of the different dimensions that constitute the normative system along with a set of measures and recommendations in order to assure the success of the normative system for a sustainable and inclusive solid waste management in Colombia.

Reduction of Waste Generation —Aiming Towards Zero Waste

One of the aspects addressed in the normative model refers to waste reduction. In order to reduce waste generation in Colombia, application of the preventive principle is recommended. This requires the conjunct work of: producers aiming to include cleaner production, responsible consumers, and the government as a regulator implementing incentives and sanctions. Also, manufacturers are required to assume the responsibility for the life cycle of the products produced; this falls under the Extended Producer Responsibility Policy that deals with the process of goods until the consumer is done using them. In addition, applying the Duales System Deutschland (DSD) practice consisting of labelling packaging materials in order to identify the recycling process it should undergo can potentially increase the efficiency of the recycling system (Chang *et al.* 2011). Further research is recommended in order to develop

products that use non-toxic compounds and that once recycled, conserve their high quality and usefulness called "upcycling" (Brungart and McDonough, 2002).

Increasing Source-separation

Increasing source-separation is an important feature addressed in the normative model for two main reasons. On one hand, the current lack of source-separation results in a low productivity due to the considerable amount of time that recyclers-by-trade spend on recovering PRM from mixed waste results. On the other hand, due to the recovering conditions, recyclers-by-trade are faced with a wide range of health and occupational risks. Thus, according to the results drawn from the questionnaires and the interview (2011), as well as the data reported by the Mayor's Office of Santiago de Cali (2009), the normative system suggests the implementation of source separation at the household level in order to increase the productivity of recyclers-by-trade and with it increase the recycling rate, as well as reduce the occupational and health risks. It is also recommended that educational campaigns be developed promoting recycling and showcasing the financial incentives at a national and local level, reaching the public through mass media to instil the information (Orccosupa, 2002; Chang *et al.* 2011). For this purpose, it is suggested that workshops be developed targeting various stakeholders (school, universities, residents, decision-makers, NGO and recyclers-by-trade associations) focused on providing guidelines on how to recycle (Armijo *et al.* 2002).

Perception of Recyclers-by-trade

Changing the public's current perception of recyclers-by-trade is also addressed in the normative system. It is suggested by the normative system to change the negative perception of recyclers-by-trade to a positive one. As reported by Medina (2000), it is recommended to start this perception change by renaming this informal recycling sector a positive name, such as "street beautifiers" or "eco-aides". The idea is that by renaming this sector, it is possible to showcase through mass media the financially viable, environmentally advantageous and socially sound service that they provide. In addition, as reported by Anschutz *et al.* (2006), it is

suggested to take under consideration the systems approach, in order to provide a more comprehensive outlook when dealing with the integration of organized recyclers-by-trade into the formal SWMS in Colombia. This is of special importance due to Court Ruling T-291, which stipulates that recyclers-by-trade must be recognized as economic actors that participate in the recycling portion of the waste management system as "entrepreneurs of waste" (CiViSOL, 2011).

Institutional and Legal Aspects

The institutional and legal aspects are the foundation of the normative system as it sets the parameters of a real integration of the informal recycling system into the formal SWMS in Colombia. As reported by CiViSOL (2011) and rra (2010), Court Ruling T-291-2009, stipulated that recyclers-by-trade's activities which fall under the public cleanliness category and waste management, must be included in future public biddings regarding waste management contracts. It is also stipulated that the contracts with the waste management corporations must take place with recyclers-by-trade's organizations and not as individual employees. In addition, Court Ruling T-291 included a scoring criterion that measures the efforts of inclusion made by the waste management corporations.

The normative model focuses on increasing recyclers-by-trade at an organizational level and strengthening of the existing ones, in order to assure a higher success rate of the integration of the informal recycling sector into the formal SWMS (Nitivattananon and Sembiring, 2010).

According to the results drawn from the questionnaires and interview, it is recommended that municipalities conduct further socioeconomic and socio-demographic characterization of the informal recycling sector in Bogotá and other cities in Colombia in order to understand the economics of the recycling system (Scheinberg *et al.* (2006). These results should be made available to the general public. In addition, it is recommended that Colombia implements a national registry of recyclers-by-trade's organizations (Baillie and Feinblatt, 2010). This registry would only include those recyclers-by-trade that are enthusiastic to be part

of the process of integration to the formal SWMS. This is mainly due to the fact that the collection of materials is only sufficient to a specific number of cooperatives (Anschutz *et al.* 2006). The registry should be updated periodically.

Another aspect that the normative system attempts to address is the terms of the contracts between the waste management corporations and recyclers-by-trade's organizations. It is suggested that the partnerships are required to share the utilities generated, but the percentage of utilities shared requires further studies assessing this aspect. In addition, it is recommended that the system include recyclers-by-trade's cooperatives in the first stages of the design and implementation of the sustainable and inclusive SWMS in the different cities throughout Colombia. This measure can contribute to assuring good communication and long-term commitment between recyclers-by-trade's cooperatives and waste management corporations (Questionnaires and interview, 2011).

The normative system also suggests assuring long-term commitment of the various stakeholders involved in SWMS, including the guidance of NGO, in order to guarantee long-term success (Lardinois and van de Klundert, 1995). In addition, it is recommended that the government is made responsible for publishing through mass media, the values of sale per kilogram and per unit of PRM to guarantee transparency in the transactions (Dikshit *et al.* 2006).

The current situation of the recycling market in Colombia exhibits a biased recovery of PRM by recyclers-by-trade due to demands for particular materials and rejects of others. Thus, the normative system recommends that further research and development efforts must focus on increasing the range of recovery of PRM, in order to expand the collection of PRM and avoid an inconsistent and deficient recycling system (Questionnaires and interview, 2011).

Roles and Responsibilities

The normative system also deals with the division of roles and responsibilities of each stakeholder. According to the normative system, it is recommended that recyclers-by-trade's cooperatives are in charge of collecting the PRM in a source-separated curbside system. It is

also suggested for the purpose of easier differentiation to placed PRM in white or transparent plastic bags the days scheduled for collection of recyclables.

The normative system also recommends following the Egyptian experience with the Zabaleen community of itinerant waste buyers, which have achieved one of the highest recycling rates reported worldwide (Cheeseman *et al.* 2006). Basically, it is suggested to apply the financial incentive of paying waste generators for their PRM in order to achieve higher source-separation and recycling rates.

According to the normative system, organized recyclers-by-trade are responsible for transporting the purchased PRM to the various transfer stations located strategically located throughout the cities. They will also be responsible of operating the transfer stations where high degree of sorting, accumulation and baling takes place (Questionnaires and interview, 2011). Further training down the road could potentially include the addition of pre-processing activities (Baillie and Feinblatt, 2010; Waste for Life, 2011).

According to the normative system, private waste companies are in charge of collecting the non-recyclable fraction of waste. These fractions of waste should be placed in separate black plastic bags — for differentiation purposes —the days scheduled for collection (Questionnaires and interview, 2011).

Based on the studies performed by Lardinois and van de Klundert (1995), the normative system recommends that NGOs are in charge of training the cooperative's members, developing initiatives and providing business, legal and technical support to the recyclers-by-trade's cooperative, as well as supervision at the transfer stations. This is due to the fact NGOs are acquainted with the local conditions. Based on the questionnaires and interview conducted (2011) part of training should focus on the standardization of the classification of PRM.

Economic Component

Based on the information gathered in the questionnaires and interview conducted (2011), it is recommended that the association between the private waste management corporation and recyclers-by-trade's cooperatives takes place during the first steps of the integration process,

including the bidding of contracts for waste management. It is also suggested by the normative system that due to the waste management contracts shared by the two parties, it is required to share the revenues generated; however, the percentage of revenues shared requires further studies assessing this aspect. On the other hand, the normative system suggests that recyclers-by-trade's organizations should be paid for the following: (1) the collection and transportation of recyclables COP$56/kg recognized by the city and for (2) the sale of recyclable materials (Questionnaires and interview, 2011).

Last, according to Anschutz *et al.* (2006), it is expected that the integration of the informal recycling sector into the formal SWMS could potentially reduce the number of recyclers-by-trade employed. Therefore, it is recommended that alternatives solutions are assessed throughout the integration processes, especially with children and the elderly involved.

Technical and Performance Aspects

Based on the study conducted by Muraleehdharan *et al.* (1996), the normative systems also recommends that in order to analyze the effects of controllable targets on the performance of the integration of the informal sector into the formal SWMS, further management-inquiry procedures be developed, such as the Nonlinear Lexicographic Goal Programming (NLGP) model.

The normative system also suggests the use of GIS software for mapping the improved "informal recycling routes" which can determine the recommended amount of recyclers-by-trade that could participate in each route. GIS software is also recommended for determining the strategic location of transfer stations throughout the cities (Calvo *et al.*2009). The design of the improved "informal recycling routes" will consider the results of the characterization of RSW carried out by the UAESP and CIIA (2005). This could potentially improve the recycling productivity and by increasing the number of recyclers-by-trade operating in areas with higher PRM like ASE 1 and fewer number of recyclers-by-trade in ASE 4 (UAESP and CIIA 2005).

Based on the questionnaires and interview conducted (2011), as well as the data reported by Gomez *et al.* (2008), the normative system recommends that organized recyclers-by-trade use a standardized and improved transportation mode (e.g. tricycle-pull carts). The idea is to maximize the performance of the transportation vehicle, and equipped it with a scale for purchase purposes.

Based on the study carried out by Araba *et al.* (2009), the normative system recommends the use of ID cards assigned to each member of the cooperative that would match the transportation mode of the corresponding member. Based on the interview conducted (2011), each cooperative should provide uniforms to its members. The uniforms should include pants, shirt, boots, hats, gloves, high-visibility vest in traffic, breathing masks and back support belt. These measures will help to reduce health and occupational risks (Cointreau, 2006).

Based on the study carried out by Gomez *et al.* (2008), the normative system suggests that medium-size transfer stations should be placed strategically throughout the city to guarantee a prudential distance from the transportation of PRM. To increase the performance at the transfer stations, it is recommended that they are equipped with scales, boxes for storage, compacting machines, grinders for waste processing and showers (Scheinberg *et al.* (2006); Armijo *et al.* (2002); (Baillie and Feinblatt, 2010).Based on the interview conducted (2011), the normative system also recommends that transfer stations should be managed by recyclers-by-trade under the supervision of designated NGOs.

Based on Anschutz *et al.* (2006), it is recommended that all transfer station meet air standards requirements to assure occupational and health safety. If needed, dust suppression and ventilation systems should be installed. Based on the questionnaires and interview conducted (2011), it is suggested that waste collection trucks transport the sorted and baled PRM to the recycling industries.

Training Aspects

Based on the questionnaires and interview conducted (2011), the normative system recommends that recyclers-by-trade receive training regarding the collection and purchase of

recyclables, the operation of transfer stations, as well as the standardization of the classification of PRM. It is also suggested that recyclers-by-trade with higher education levels are trained in basic computer knowledge, business management and accounting. Based on the study carried out by Cointreau (2006), it is also suggested to include training on occupational safety measures at transfer stations.

Social Aspects

Based on the interview conducted (2011), the normative systems recommends that the cooperative must represent the benefits of all its members providing legal support, representation and social benefits. It is also recommended that cooperatives have a representative board that is elected by its members and is aligned with the seven governing principles established by ICA (Rufino, 2002).

In addition, the normative system suggests the implementation of a set of educational campaigns targeting the informal recycling sector. These campaigns include: an educational campaign focusing on hygienic measures to prevent occupational risk caused by handling waste and a vaccination campaign for tetanus, rabies and hepatitis A and B (Cointreau, 2006; Baillie and Feinblatt (2010).

By implementing these recommendations in Colombia, it is anticipated that the SWMS would be inclusive and sustainable.

Appendices

Appendix A. Photographs of waste pickers and their different modes of transportation

A1. Street waste pickers with sack

A2. Street waste pickers with hand-pulled cart

A3. Street waste pickers with tricycle-pulled cart (ARB, 2011)

A4. Street waste pickers with horse-pulled cart

A5. Street waste pickers with Motorized-pulled cart (ARB, 2011)

Appendix B. Questionnaire for recyclers-by-trade and dealers Cali (March 2011)

1. Name
2. In which social strata do you live?
3. How long have you been dedicated to the recycling trade?
4. Where do you collect the PRM?
5. How do you transport the collected PRM?
6. What type of PRM do you collect? Do you specialize in one type?
7. Where do you take the collected PRM?
8. Do you perform any pre-processing treatment to the PRM you collect before selling them?

9. What is the selling price of the PRM? If a dealer: And what is the purchase price of the PRM?
10. Do you have alternative income besides the recycling trade?
11. Is there flexibility to change the role in the recycling chain? Why?
12. Do you belong to any recyclers-by-trade's organization?
13. There was a case in the Court regarding recyclers-by-trade. Do you know what did it deal with? Which rights were gained?

Appendix C. Interview with the President of ARB. Monday, March 22, 2011

1. Tell me about the history of the ARB
2. When did the Transfer Station la Alqueria (Centro de Acopio la Alqueria) began operations and how is the working environment structured, as well as the procedures?
3. How is the working dynamic of recyclers-by-trade at the ARB?
4. What types of benefits are available to recyclers-by-trade that belong to a cooperative or association?
5. What is the ARB's proposal regarding the monetary recognition for the transportation of PRM and how does the ARB view an inclusive solid waste management system in Bogotá?

Appendix D. Photographs of the recycling operation at the Alqueria Transfer Station

D1. Uniformed recyclers-by-trade at the sorting out PRM (ARB, 2011)

D2. Weighting and baling recyclable material (ARB, 2011)

D3. Unloading zone (ARB, 2011)

D4. Designated areas from left to right: flexible plastic, metal scrap and PET (ARB, 2011)

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