

**DEVELOPMENT OF A SOCIAL IMPACT ASSESSMENT
METHODOLOGY FOR RECYCLING SYSTEMS IN LOW INCOME
COUNTRIES**

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**SANDRA ROXANA
APARCANA ROBLES**

Matrikelnummer 0941180

Institut für Abfallwirtschaft
Institutsvorstand: Univ.-Prof. Dipl.-Ing. Dr. Marion Huber-Humer

**Department Wasser - Atmosphäre – Umwelt (WAU)
UNIVERSITÄT FÜR BODENKULTUR
Wien, Juni 2013**

GutachterInnen:

Univ.-Prof. Dipl.-Ing. Dr. Marion Huber-Humer
Institut für Abfallwirtschaft, Universität für Bodenkultur, Vienna

Ao.Univ.Prof. Dipl.-Ing. Dr.nat.techn. Werner Zollitsch
Institut für Nutztierwissenschaften, Universität für Bodenkultur, Vienna

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Abstract

Informal recycling is one of the most significant activities within waste management systems in low income countries. The main aspect of a number of recently implemented waste management systems has been to organise the informal recycling sector and to integrate it as a formal stakeholder. These formalisation approaches are expected to eliminate not only the poor economic situation of informal recyclers but also their common social problems e.g. social rejection, lack of education and inappropriate health and working conditions. However the effectively elimination of social problems related to the informal sector has not been precisely measured and evaluated. A lack of methodology to assess social impacts persists, as does the comparison of different formalisation approaches.

This work aims to develop a methodology for assessing the contribution of formalisation approaches in terms of social impacts. A further goal is to determine the feasibility of applying this methodology by identifying and measuring the social impacts of three case studies in Peru.

A review of literature was carried out in order to describe the current situation of waste management systems in low income countries and to evaluate some existing social impact assessment approaches including sLCA. For the social impact assessment this study proposes an approach based oriented towards the Social Life Cycle Assessment methodology (sLCA) considering 3 social impact categories, 9 social subcategories and 26 semi-quantitative indicators for the social. The methodology was tested on three Peruvian case studies with two different formalisation approaches thereby confirming or rebutting the expectations and forecasts of organisations (NGOs, Local Authorities, Ministries & Business) involved in the implementation.

It can be concluded that although sLCA was originally used to analyse the environmental impacts of products, it is feasible to adapt it for the social assessment of recycling systems based on formalisation of the informal sector in low income countries. The impact categories and subcategories identified represent the social problems of informal recyclers. The comparison of current social impacts between different formalisation approaches using this methodology is also viable. A further conclusion is that it is feasible to measure the social impacts of formalisation approaches using the selected indicators and characterisation procedure.

Keywords

Keywords: Low income countries, informal sector, recycling, social impacts, social life cycle assessment

Publications in context with this study

Reviewed publications

- Aparcana S, Salhofer S (2013). Application of a methodology for the social life cycle assessment of recycling systems in low income countries: three Peruvian case studies. *International Journal of Life Cycle Assessment*. DOI 10.1007/s11367-013-0559-3 (online)
- Aparcana S, Salhofer S (2013) Development of a social impact assessment methodology for recycling systems in low-income countries. *International Journal of Life Cycle Assessment*. DOI: 10.1007/s11367-013-0546-8 (online).
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Not reviewed publications

- Aparcana S. (2012) Social assessment of sustainable waste management strategies in developing countries with focus on the informal sector: case studies from Peru. 2. Wissenschaftskongress Abfall- und Ressourcenwirtschaft. Deutsche Gesellschaft für Abfallwirtschaft (DGAW). 29 – 30 März 2012. Rostock. Deutschland
- Aparcana S, Salhofer S, Linzner R (2011) Material flow analysis of formal and informal household waste recycling systems in developing countries. Case studies from Peru. Executive summaries. Thirteenth International Waste Management and Landfill Symposium (3 – 7 October 2011, S. Margherita di Pula - Cagliari, Sardinien, Italien). Full paper on CD.
- Aparcana S (2011) Strategien zur nachhaltigen Abfallwirtschaft in Entwicklungsländern mit Schwerpunkt im informellen Sektor am Beispiel zwei Fallstudien in Lima, Peru. I. Wissenschaftskongress Abfall- und Ressourcenwirtschaft. Deutsche Gesellschaft für Abfallwirtschaft (DGAW). März 2011. Straubing. Deutschland
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1. Introduction and scope of the work

The informal sector plays an important role in waste management systems in developing countries. Informal recyclers are individuals or groups that carry out various activities within the waste management system (collection, processing, recycling, commercialisation, etc.) without formal assignment. The informal sector focuses mainly on recycling and therefore contributes significantly to the recycling rate of many cities in developing and emerging countries. In Lima and Callao (Peru) for example about 19.7 % of the municipal waste is recycled by the informal sector, while the overall recycling rate (formal and informal) is 20 % (Scheinberg et al. 2010).

The informal sector carries out recycling activities under inappropriate conditions that often endanger health and safety of the people working in this sector and their families (recycling activities on streets, dumps, etc.). Often children, pregnant women, elderly and other people who have no opportunity to work in the formal sector find work in the informal sector (Wilson et al. 2006). In most cases the economic contribution of this sector to the waste management systems, its environmental and social benefits are not recognised by the stakeholders of the formal sector. For this reason, the informal activities are considered as negative. In many developing countries the informal sector is rejected and policies to eliminate the informal recycling activities are implemented (Medina 2000).

Some cities have identified the need to recognise the contribution of the informal sector and its inclusion in formal waste management systems as an effective strategy. For this reason over the last years some formalisation approaches were implemented with the aim to organise the recyclers, to improve their working conditions and economic situation. The formalisation approaches are often implemented through the initiative of local recyclers, municipal authorities and non – government organisations (NGO). These approaches have similar frameworks but also some important differences regarding their financing, political and legal support, value chain and stakeholders involved in the recycling activities. The formalisation is expected to eliminate not only the poor economic situation of informal recyclers but also their common social problems e.g. social rejection, lack of education and inappropriate health and working conditions. However the effectively elimination of social problems related to the informal sector has not been precisely measured and evaluated. A lack of methodology to assess social impacts persists, as does the comparison of different formalisation approaches.

This study aims to develop a methodological procedure oriented towards the Social Life cycle Assessment methodology (sLCA) for assessing the contribution of formalised recycling systems in low income countries in terms of social impacts, in comparison with informal systems. A further goal is to determine the feasibility of applying this methodology by identifying and measuring the social impacts of three Peruvian recycling systems based on two formalisation approaches, thereby confirming or rebutting the expectations and forecasts of organisations (NGOs, Local Authorities, Ministries & Business) involved in the implementation.

First a review of literature was done in order to identify existing formalisation approaches. The similarities in the initial situation of the recycling system before the formalisation, the role of the informal sector, the applied formalisation measures, the economic and social impacts were described and analysed. Secondly a literature investigation was carried out in order to evaluate some existing social impact assessment approaches. This phase focused on the development of the social life cycle assessment approach, the analysed social aspects, proposed indicators and characterisation models. The final part of this study was the application of the methodology to three Peruvian recycling systems which had been formalised using two different approaches. One approach utilizes cooperation with recyclers' associations and the second one, operated by the municipality uses formalised recyclers as employees. Interviews were conducted with local recycling system stakeholders in order to collect data to assess fulfilment of the social criteria. 3 social impact categories and 9 subcategories were analysed using 26 indicators. The new methodological approach developed in this study and the application on the three Peruvian case studies are described in the two articles attached to this paper.

In chapter 2 a research of literature is presented. Some background information about waste management systems in low income countries, a description of the current problematic of the informal recycling sector and general features of formalisation approaches implemented in low income countries are shown.

In chapter 3 a literature revision about the existing approaches of social impact assessment as part of sustainability assessment is presented and discussed.

Chapter 4 describes the current stand of the Social Impact Assessment methodology (sLCA) and includes further development of this methodology done by different authors. Diverse procedures for selecting social impacts categories, subcategories, indicators and characterisation approaches are presented in this chapter. Also some examples of the application of the sLCA methodology to several products are described.

The chapter 5 presents the three Peruvian case studies to be assessed with the developed methodology. The results of the three case studies are compared and discussed

Chapter 6 presents the conclusions and the major outcomes of this work

Chapter 7 presents the limitations of the study and further research challenges

2. Waste management in low income countries

2.1 General description

Low income countries have some similarities regarding their socio – economic conditions. In these countries waste management systems are often not efficient and operate to low standards (Wilson et al. 2006). Scheinberg et al. (2006) define waste management systems in low income countries as a “pre-modernised system based on a single disposal technology (dumping or landfilling). The waste management system is managed by a single major stakeholder: the local government sometimes supplemented by private waste collectors. Other actors – like recyclers – operate at the margins, and have the status of informal sector”.

The deficiencies of waste management systems in low income countries can be demonstrated by their low national coverage rates. Gamarra and Salhofer (2007) give some examples of coverage rates in Latin America (in Peru 74%, Mexico 70%, and Uruguay 71%) in terms of % municipal waste collected and compare them with the coverage rates in Central Eastern Europe and Central Europe, which are nearly 100%. Regarding the final waste disposal the authors specified the use of controlled dumps, uncontrolled dumps and sanitary landfills as the most commonly used disposal systems in Latin America. The presence of informal recycling is identified at uncontrolled and controlled dumps. This situation along with the deficient collection rates allows the participation of the informal recycling under inadequate and uncontrolled conditions. Figure 1 presents, as an example, a flow diagram of a common waste management system in Peru including informal recycling. The material flow corresponding to recyclable waste (plastic, glass, metal, paper and cardboard) and mixed waste (organic waste, recyclable waste materials and residual waste) is represented in figure 1.

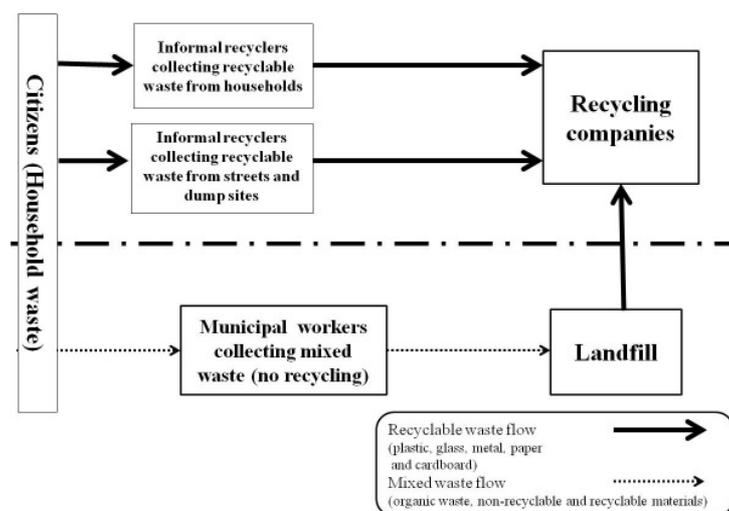


Figure 1 Example of a typical waste management system in low income countries

2.2 Informal recycling sector

The informal recycling in waste management comprises individuals or groups that have no access to the formal recycling activities. They extract recyclable materials from dumping places, from street bins, communal collection sites, etc. and they sell them in order to enhance their livelihoods (Scheinberg et al. 2006). Frequently; children, pregnant women, the elderly and socially excluded groups work in this sector. These persons are known by many names depending on the local language but they are usually known as scavengers, waste pickers or rag pickers (Medina 2000; Wilson et al. 2006). Further authors prefer to name them “recyclers” (Gutberlet 2011) as a form of recognising their recycling activities and their contribution to the recycling market in low income countries. For this work it has been decided to use “recycler”.

The classification done by Medina (2000) has been quoted many times as model classification of informal recycling patterns. The itinerant waste buyers, which go from door to door and collect and buy recyclable materials, the street waste pickers, who recover recyclable materials from mixed waste on the streets, municipal waste collection crew: recovering of recyclable waste during the waste transport to disposal sites and finally the waste picking at dumping places.

Several studies about the informal recycling sector indicate the importance of this categorisation and they remark the connection of higher added value of recyclable materials with better organised recyclers (see figure 2). This has an important influence on their incomes (Medina 2000; Wilson et al. 2006; Scheinberg et al. 2006; Gutberlet et al. 2012). In reference to the added value chain of recycling the authors report the existence of others formal and informal stakeholders (middle dealers, waste recycling companies, etc.). Normally the middle dealers buy the collected recyclable materials from the informal recyclers and sell the materials to the waste recycling or waste processing companies (Wilson et al. 2006). They exploit the informal recyclers and pay them very low prices for the materials. This situation results in an exploitation cycle, which does not allow the informal recyclers getting out of poverty.

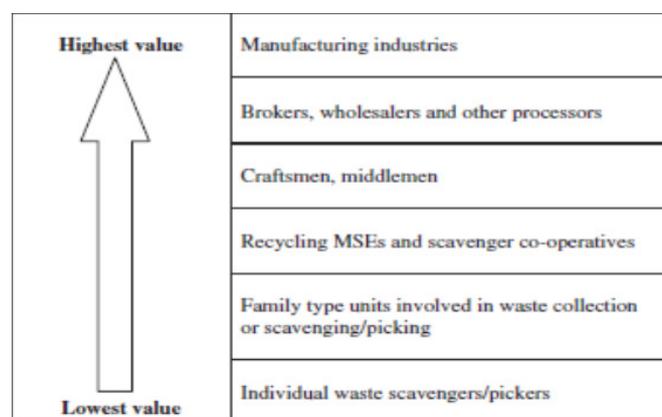


Figure 2 Hierarchy of informal sector recycling (Wilson et al. 2006)

The recycling carried out by informal recyclers contributes significantly to the recycling rates in low income countries. Table 1 shows some examples of their contribution (UN – HABITAT 2010; Wilson et al. 2009 and Scheinberg et al. 2010).

Country	City	% Recycling (formal /informal Sector)
Egypt	Cairo	85% (11% / 74%)
The Philippines	Manila	25% (2%/23%)
India	Delhi	34% (7%/27%)
The Philippines	Quezon City	39% (8%/31%)
Peru	Lima	20% (0.3%/19.7%)

Table 1 Examples of the contribution of the informal sector in recycling rates in low income countries

This positive contribution is reflected through their economical contribution to the formal sector. Wilson et al. (2006) point out the cost reduction of formal waste management systems as a direct consequence of the informal recycling. The amounts of collected waste are reduced, resulting in less money and collection time and transport. Also the landfilling is optimised through the reduction of volume use.

For example, for Mumbai (India) it was estimated that the cost of the waste system without integration of the informal sector was around 44 USD / ton of waste, however in cooperation with the informal sector the cost of the waste system amounts to 35 USD per ton of waste (Rathi 2006). The same case is displayed in Londrina, Brazil, where due to the integration of informal recyclers to the formal waste management system the cost of waste collection decreased from 42 USD per ton collected waste in 2001 to 24 USD per ton collected waste in 2003. Regarding the social aspect, several studies have identified the same problems: child labour, truancy in schools, incomplete school education for adults and poor working conditions (Medina 2000; Wilson et al. 2006; Scheinberg et al. 2006 and ILO 2004). Despite the several disadvantages and poor working and living conditions of informal recyclers, it should be pointed out that the informal recycling represents for many individuals the possibility to get an income in a society without a chance of improvement for them.

With respect to social issues, several studies have identified the same problems: child labour, truancy in schools, incomplete school education for adults, poor working conditions and social rejection (Medina

2000; Wilson et al. 2006; Scheinberg et al. 2006 and ILO 2004). The informal recyclers, which are in at the bottom of the waste value chain, perform their activities under poor working conditions which represent a high risk to their health and living conditions. Multiple studies have shown the presence of diseases related to working with waste (Medina, 2000; Cointreau 2006; Wilson et al. 2006 and Zurbrügg and Schertenleib 1998). Also children are involved in various stages of the waste picking process. The most well-known involvement is on dumpsites, where they work with their families or in groups. They can also be found picking in the streets. Children work also often at home. While their parents pick waste in the streets or collect it from households, children (and women) often sort the mixed waste at home so that it can be sold. Both boys and girls can be found scavenging, but girls are much less involved in street picking. The age of child ranges from 4-5 years to 18 years (ILO 2004).

Children working in informal recycling can contribute a considerable share of the family income. Their income varies from 10 to 50% of an adult's income, which makes it difficult to convince their parents to let the children go to school. A study of ILO (2004) reports some examples of income share of child scavengers in Kolkatta, Cambodia, Egypt, Philippines and Tanzania. In these countries children can earn between 30 – 50% of a family income or 50% of an adult's income (1 USD /day). Also children provide unpaid labour, which saves the family the cost of hiring someone from outside (girls mainly).

The same study of ILO (2004) assert that main reasons for child labour in informal recycling are poverty of the family that needs the additional income, parents are not able to provide for income (because of a background of violence, gambling, alcoholism, disabilities), lack of skills/low education, lack of other income opportunities, lack of available and accessible schools, high costs of school fees and/or school supplies such as uniforms, school materials, meals, education is not relevant, of low quality, education is not considered important in the culture of the parents, scavenging is a way of life/Landfill is the medium of life/Lack of vision of an alternative future; day care is expensive/parents do not have another place to leave their children/absence of safety nets in communities.

Further main social issue of informal recyclers is health. Handling waste can cause many health problems because of its nature e.g., toxicity, allergenic and infectious components but also can cause work injuries (e.g. presence of sharp objects). Children are particularly vulnerable to toxins because they ingest more water, food, and air per unit of body weight; their metabolic pathways are less developed to detoxify and excrete toxins; and any disruption during their growth years can easily disrupt development of their organ, nervous, immune, endocrine and reproductive systems. (Landrigan 1998 cited by Cointreau 2006)

In developing countries, the health-related problems of handling of waste still need to be addressed. Informal recycler face a labour-intensive collection, poor or no work protection, work with mixed waste, presence of insects and diseases vectors, high risk of injury, open waste burning, lifting heavy loads, pollution, etc. Informal recyclers work informally at open dumps, typically living adjacent to the dumpsite in poor housing conditions, with minimal basic infrastructure for clean water and sanitation.

Wastes sorting and recycling activities are typically conducted manually in micro and small-scale enterprises, with minimal washing and baling equipment and virtually no dust control or worker protection (Cointreau 2006). Besides the described social problems of informal recycling there exists another main social problem: social rejection. In many developing countries, informal recyclers have a different socio-cultural background than the majority of the population. It can be stated that their socio-economic status is usually very low; the general population as well as the authorities often are hostile (Medina 2000). People involved in collecting, transporting and recycling generally suffer a social stigma of being associated with waste.

Because their activities commonly affect their appearance, informal recyclers are often subject of harassment from officials, exploited by middlemen and are despised by the society. This situation affects their self-confidence and of their families. A study of UNESCO (2001) cited by Nas and Jaffe (2004) show that this attitude of self-hatred has even been adopted by scavengers themselves... "Comparative research and experiences have shown that the scavengers consider themselves as a sort of social category associated with "sub-human characteristics". Low education levels and unhealthy working conditions in combination with their popular status lead to a negative self-perception and a lack of self-confidence (Nas and Jaffe 2004).

Gunsilius et al. (2011) assert even that their living and working environments overlap affecting not only their health but also increasing the disrespect and neglect from neighbours and enforcing their exclusion. They hardly find citizens who esteem and appreciate their work, or partners at the political and legal levels who defend their interests. Medina (2000) even reported violence episodes against informal recyclers in Colombia. The author states that even though informal recyclers are not always the poorest of the poor, their occupation is generally considerate the lowest status in society. Outcasts and marginal groups, such as religion minorities, gypsies and migrants have performed waste collection and recycling activities in developing countries. In other countries, such as Egypt, recycler communities are groups of rural migrants and religion minorities who adopt scavenging as a way to survive in the city and end up specializing in this sector (Wilson et al. 2006).

Aside from the day-to-day bad treatment that informal recyclers experience, their low status can deter them from climbing the social status. NGOs and even governments strive for recognition of recyclers. One way of tackling the low status of recyclers is through their formalisation and inclusion in the formal waste management system. Besides raising income, this form of development can give recyclers a certain status; they are recognised as a formal part of the waste management system that is beneficial to the whole population and their self-esteem grows with self-reliance. The terms "small businessmen", associated or organised recycler" or "micro-entrepreneur" sound more respectful than "rag pickers" or "scavengers".

2.3 Formalisation strategies

Political trends together with socioeconomic and environmental problems related to inefficient waste management have led to several low income countries attempts to bring their systems up to European or American standards (Scheinberg et al. 2006). This modernisation is characterised by a transformation to complex integrated systems with multiple formal stakeholders, a wide diversity of technical operations and the expulsion or rejection of the informal sector (Scheinberg et al.2006). Despite these innovations, some cities have identified the need to recognise the contribution of the informal sector and its inclusion in formal waste management systems as an effective strategy.

For this reason over the last years several formalisation approaches have been implemented in order to improve the waste management systems. Various authors have written about the tendencies of the formalisation approaches in low income countries. Medina (2000) describes some public policies that are based on a negative perception of informal recycling and try to encourage informal recyclers to engage in other occupations in order to reduce their informal activities (Medina 2000). The idea of eliminating social and public health problems through the eradication of informal recycling activities is a widely extended tendency.

Repression and neglect are some of these tendencies. In the first one the informal recycling is seen as an inhuman activity and as a shame for the city. In this case the recycling activities are banned and declared as illegal, some examples of this repression in Colombia, India, and Philippine. Neglecting are characterised mainly through indifference of the authorities towards the informal recyclers and their situation. Neither help nor persecuting occurs (Medina 2000).

Due to their increasing economies the cities in low income countries have over the time problems with the increasing amount of waste and the difficulties of their treatment and disposal. Local and regional governments have recognised the economic, social, and environmental contribution of the informal recycling to the formal waste management systems as an effective strategy. The governments have started to change their previous attitude of opposition, indifference or tolerance, to one of active support (Wilson et al. 2006). As an alternative to the already described public policies several initiatives to formalise the informal recyclers and integrate them into the formal waste management system have been formulated and implemented.

The formalisation approaches are mainly based on the encouragement of the recyclers' activities. They focus on the recognition of environmental, social and economic benefits of informal recycling. The authorities support the formalisation of recycling activities under the constitution of recyclers associations and micro and small recycling enterprises (MSEs). Often the cooperation scheme is based on formation of public – private partnerships (PPP), collection and recycling contracts with recyclers, etc. Some examples of this formalisation experiences are in Egypt and Brazil (Medina 2000 and Wilson et al. 2006).

Some authors have identified different formalisation approaches that are frequently implemented in low income countries. Scheinberg et al. (2006) the rights-based approach as a traditional formalisation schema frequently implemented in low income countries. This approach points towards creating more political room for empowering the recyclers and stimulating their participation in the political decision making process in the waste management system. The authors point out that although this approach sees the recyclers not as a social problem or as a weak social group, it still does not recognise the economic contribution of the recyclers. Despite acknowledging their social and political role, there is a lack of understanding their whole contribution in the waste management system (Scheinberg et al. 2010).

Some cities where this approach was implemented are the cases of India, The Philippines, Brazil and Peru. The case of the Philippines highlights a significant increase in the informal waste recycling rate through the last ten years. The recycling rate from recyclers increased from 4% (total recycling rate 6%) in 1997 to 16% (total recycling rate 25%) in 2006 (Wilson et al. 2009). This increase has been achieved through a formalisation program for informal recyclers and informal middle dealers in the formal waste management system. This program was initiated by the NGO Council of Women Balikatan Movement in the 80s. This program operates mainly in the metropolitan area of Manila. Bennagen et al. (2002) report that the program has 17 cooperatives located in 17 municipalities of the metropolitan area of Manila, 572 middle dealers and 1.000 formalised recyclers. The program promotes the waste segregation at source, minimisation of waste disposal in rivers and streets, reduction of the landfills' volume and the improvement of economic and social conditions for the recyclers. Prior to the program, the activities of the informal recyclers were rejected by the citizens and authorities. The recyclers' income was low and the living conditions were far below average (UN - HABITAT 1998). The figure 3 shows the system procedure:

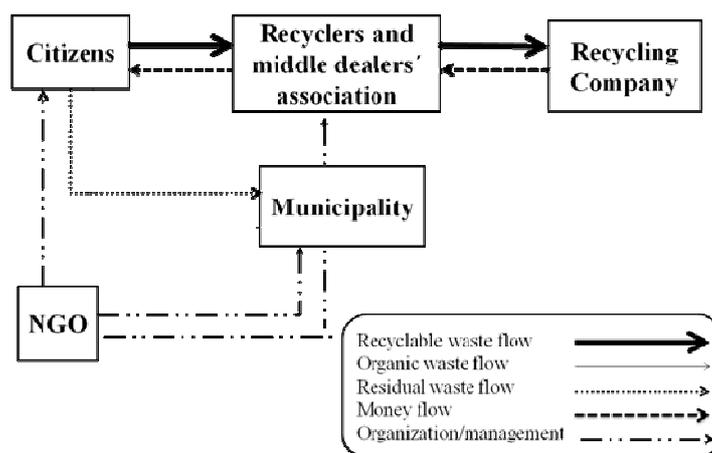


Figure 3 Formalisation system in Manila

The formalised recyclers organised in associations visit the households, buy the recyclable materials (paper, cardboard, plastics, metals and glass) and sell them to the formalised middle dealers. After that, the middle dealers sell the materials to the production factories as final users. Some of the socio economic benefits of the program are the increasing of incomes for the formalised recyclers and middle dealers. The program provides stable and decent livelihoods for the recyclers. Through the program the formalised recyclers and middle dealers are recognised as economically active stakeholders and no longer considered as a social problem.

In Peru, one of the best known cases of formalisation is located in the city of San Vicente de Cañete in Lima. In 2007 the municipality with the technical support of the NGO IPES and the financial support of a recycling company implemented a separate collection and recycling system based on the cooperation with recyclers. According to the United Nation Human Settlements Program (UN – HABITAT, 2010) 7 formalised recyclers, 4 of them women and 3 men are working at this program. The figure 4 shows a flow chart of this system.

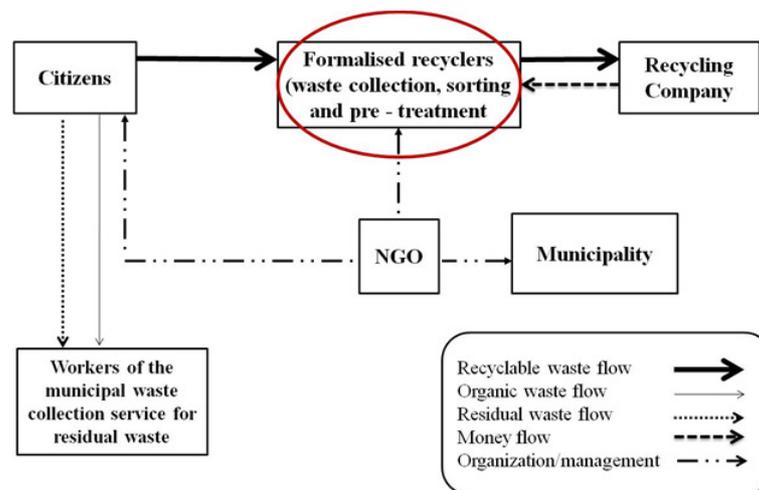


Figure 4 formalised recycling system in San Vicente de Cañete

Each recycler has a specific geographical sector with a number of households to be served. The formalised recyclers collect glass, paper, cardboard and plastics from households without any payment to the citizens. They transport the separated waste with tricycles and subsequently perform a more accurate manual separation in sorting centres with the intention of selling them. The recyclers, with the support of the municipality, are responsible for increasing the collection rate (currently 15% of the total households in Cañete) and also for the encouragement of new residents to participate in the recycling system. The recyclers' income depends on the amount of sold material which depends on the number of participating residents. As a result they have increased their average income from 44 USD/month to about 178 USD/month over the last 3 years. This means an increase about 4 times higher in comparison with the

situation before the program implementation. Some social measures are the awareness raising and identification of the population with the recyclers work, vaccination campaigns, and access of the recyclers to health prevention and health insurance programs and the improvement of their work equipment.

As last case study categorised under the the rights-based approach of Scheinberg et al. (2006) is the case of Joao Pessoa, Brazil. Here a pilot project was initiated through an initiative of the municipal cleaning company in 2000. The stakeholders involved in the project were: the municipal cleaning company, two NGOs, the citizens and the recyclers, who founded an association with 500 members. Before the project, usually the waste was collected, transported and disposed at dumps (Pimentel and Countinho 2005). The goals of the pilot project were to close down illegal dumps, to take into operation a modern landfill, to implement separate waste collection, to organise the recyclers and the elimination of child labour. For the achievement of these goals measures like awareness programs for the citizens, training for the recyclers, adult education programs for promoting the integration of recyclers, purchase of tools and equipment, construction of sorting and sale centres for the recycled materials were implemented (UN - HABITAT 2004). The system is described in the figure 5.

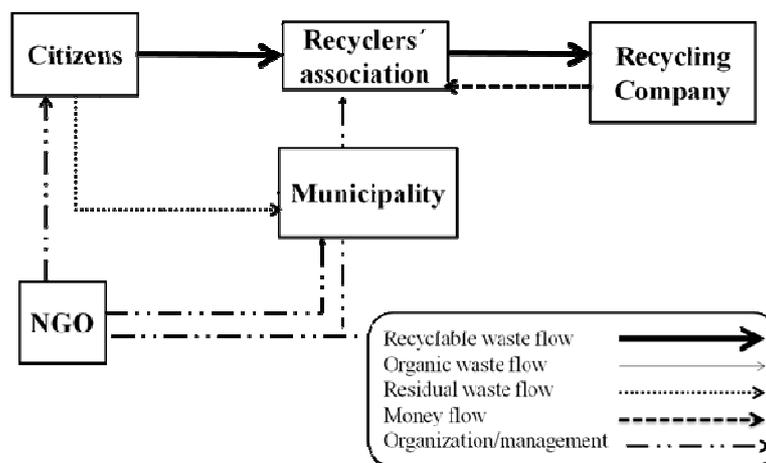


Figure 5 Formalisation system in Joao Pessoa (Brazil)

In order to eliminate child labour, a scholarship program was developed. The aim was to assign certain money amount to the families to send their children to school instead of working at the landfill. In addition kindergartens and support programs for newly born children were established (UN - HABITAT 2004).

Pimentel and Countinho (2005) calculated the cost/benefit ratio of the implemented recycling strategy in Joao Pessoa through an economic analysis. As benefits were considered: income from the sale of recycled materials, savings from the reduction of waste disposal, savings through the reduction of energy consumption due to the use of recycled materials instead of raw materials and as costs were considered:

social taxes, water, energy, cleaning products, transportation, maintenance, accounting, etc. This ratio was obtained based on the division between benefits (B) and costs (C). The evaluated system can be considered viable if the value of B/C is higher than one (Pimentel and Countinho 2005). It was found out that the B/C ratio for the entire recycling system was very positive, namely 1.77. Under consideration only of the benefits and costs for the recyclers the B/C relation was 1.27 which means, that the benefits for them were 27% higher than the costs (Pimentel and Countinho 2005). With this economic analysis, the economic viability of the project under the condition of a separate waste collection was probed.

Gutberlet (2012) identifies a different formalisation approach and defines it as participatory sustainable waste management (PSWM) consisting in “solid waste recovery, reuse and recycling practices with organised and empowered recycling cooperatives supported with public policies, embedded in solidarity economy, targeting social equity and environmental sustainability”. This formalisation model has as target the implementation of public waste management policies under consideration of environmental social and economic aspects. Livelihood, income generation, human development and environmental protection are basic aspects of this approach. It is based on the achievement of collective goals and results aiming the common economic development, the formulation of democratic policy making of waste management and participatory management, where the stakeholders involved in the waste management system make decisions for their common good (Gutberlet 2012). The author mentions a successful implementation of this approach in some Brazilian Cities (Diadema, Londrina, Sao Paulo).

Londrina’s case is interesting in relation to the recycling efficiency as well as the operation of a selective waste collection system based on the cooperation between formalised recyclers and the municipality. Londrina is a city of Parana, Brazil and it has a population of approximately 500,000 inhabitants. Londrina runs a recycling system that serves 90% of its population (Gutberlet 2011). The recycling system of the city started in 1996. At that time the system was managed by the municipality and only 10,000 families were served. The material was collected and transported to a sorting centre. Through this system barely about 1% of the total waste generated in the city was recycled (Terraza and Sturzenegger 2010).

Since 2001 the municipal system changed by giving way to the participation of informal recyclers into the formal waste management system. This new waste management concept implemented a remuneration system for the separate waste collection done by the recyclers based on the served area and not on the mass (tons) of collected total waste (Terraza and Sturzenegger 2010). By time different associations of ex - informal recyclers from dumps were established. In 2009 the existence of 33 associations representing 400 recyclers – with a female participation of 80% - was reported (Terraza and Sturzenegger 2010).

In 2011 this participation increased to 500 formalised recyclers producing 274 t of recycled materials/month (Gutberlet 2011). The recycling program recovers about 27% of the household waste with 4% of rejected material. In order to strengthen the bargaining position of the recyclers’ associations and to achieve better material sale prices, a main storage and sales centre was created. With this measure higher

sales prices have been achieved by reducing the middle dealers' activities (Terraça and Sturzenegger 2010).

The average income for a formalised recycler reaches about 230 USD/month (Terraça and Sturzenegger 2010). Gutberlet (2011) mentions three income sources for the recyclers involved in this recycling system: a payment from the municipality for recycled material that is not landfilled (36 USD/tonne), a second income source from the separate collection service (16,850 USD/month). This remuneration modality is calculated based on collection service and no longer based on the collected mass of total waste. The third income source for the formalised recyclers is the sale of recycled material at the main storage and sales centre. The prices achieved by this centre are between 70% and 275% higher than those achieved by the association by selling their materials independently to middlemen (Terraça and Sturzenegger 2010).

Finally from an economic point of view the cost for the residual waste collection has been reduced due to the increasing of the separate collected waste volumes (Gomes do Reis et al. 2005). The reduction was in this case from 42 USD per tonne collected waste in 2001 to 24 USD per ton collected waste in 2003.

This recycling program in Londrina has brought not only environmental and economic benefits but also positive social impacts. Some environmental benefits are the reduction of landfill volume, resources recovery through the recycling, etc. The positive social impacts get visible as improvement of the living and working conditions for recyclers, achievement of their economic stability and empowerment by means of the creation of associations, the recognition and support of their activities by the population and local authorities.

Diadema is another city where participative recycling was implemented. The city is located in the region of São Paulo, Brazil (Gutberlet 2011) and currently it has about 386,000 inhabitants (Municipality of Diadema 2011). In 2004 in the framework of the Municipal Law No. 2336/04 "Policy for Sustainable Municipal Waste Management" the municipal government of Diadema implemented a separate collection and recycling program. Due to this program the cooperation between the municipality of Diadema and the formalised recyclers was established. These recyclers' associations are defined as self-governing local associations responsible for separate collection of recyclables materials from the households and from other participating institutions (e.g. public or private companies, schools, etc.). The figure 6 describes the formalisation system in Londrina and Diadema:

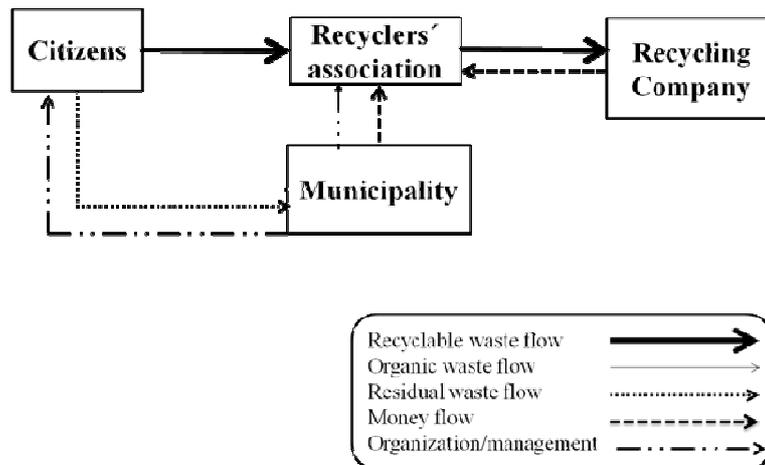


Figure 6 Formalisation system in Londrina and Diadema

The recyclers are responsible for carrying out the collection service and waste recycling in Diadema. According to the municipal law No. 2336 / 04 art. 12 this program assigns a payment from the municipality for the recyclers per ton of waste that is not disposed in the landfill. Related to this payment Gutberlet (2011) mentions that the recyclers received 21 USD per tonne of non-disposed material in 2008. In addition to these revenues the recyclers can sell the recycled materials directly to the industry (Gutberlet 2011).

The associated recyclers have access to six sorting and sales centres. The recyclers collect materials door-to-door and they transport them to these centres. There the collected materials are weighed and sorted (Yates and Gutberlet 2011). In 2007 were generated 2,705 tonnes/month of inorganic household waste and through the program approximately 44 tonnes/month were recycled (Gutberlet 2011). In 2009 the amount of recyclers working for the program increased from 46 to 66 and the volume of collected material was about 100 tonnes/month (Municipality of Diadema 2011).

One more case where recyclers were formalised following a participative approach is Mumbai, India. In 1997 an initiative of the central Indian government, the municipality of Mumbai ("Municipal Corporation of Greater Mumbai" - MCGM) and the United Nations Centre for Human Settlements for establishing a decentralized management system under the name "Advanced Locality Management" was implemented. The aim was organizing various aspects of the local development and carrying out the local public services. This decentralized management system is based on a close cooperation between the community based organisations (CBOs), NGOs, and the MCGM.

In this system the citizens separate their waste into two parts: the dry fraction (recyclable), and wet fraction (organic waste). The formalised recyclers, who were trained by the NGOs collect both fractions, the wet one is composted and the dry fraction is sold to the recycling market. The MCGM takes over the installation of composting plants in the associated counties. Under this management scheme the NGOs

play an important role regarding the organisation and the technical training of the recyclers in order to secure a proper composting and waste collection. In 2006 there were 360 decentralized management systems with about 0.2 million people and 69 tonnes waste/day were also produced. In addition, 283 composting facilities were operating under this scheme (Rathi 2006). Also the role of women became significant in form of their leading participation by the CBOs. 35% of the CBOs in Mumbai are headed by women (Redkar 2005 cited by Mahadevia et al. 2005). The figure 7 shows the operation of the formalisation system in Mumbai.

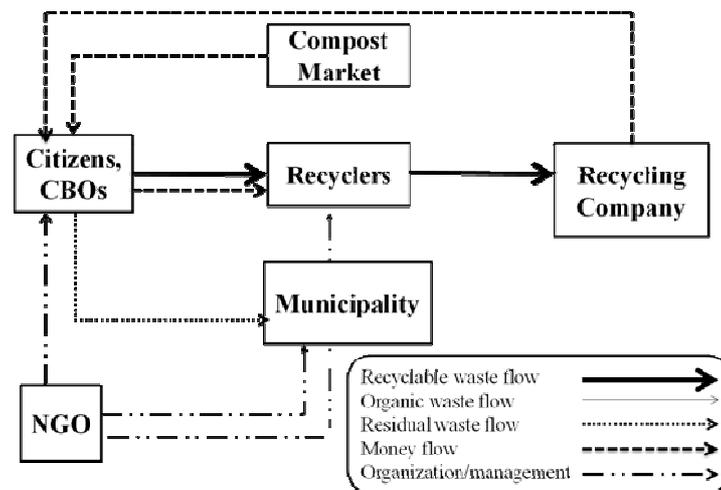


Figure 7 Formalisation system in Mumbai

Some positive effects named by Rathi (2006) are the value creation from recycled materials and compost, better living standards for the recyclers, clean and healthy environment and the reduction of waste management costs (from 44 to 35 USD/tonnes of waste after the implementation of the recycling system). Besides the economic benefits also social benefits exist for the recyclers e.g. better health and insurance services, which were promoted by some NGOs (Mahadevia et al. 2005).

Recently Velis et al. (2012) conducted a study for analysing different formalisation models that are being implemented during the last years. Wilson et al. (2012) identify and categorise possible approaches to promote integration of informal recyclers into three levels of interventions: measures affecting the informal recyclers and their role in the waste management system, measures affecting the materials and value chain (e.g. increasing quality of recycled materials or recycling rates) and measures affecting the social interface, promoting legal recognition, public engagement, promoting acceptance and equality. Wilson et al. (2012) allocate these three levels of intervention into a fourth level, which encompasses the whole system: Organisation and empowerment (enabling and underpinning aspects). The authors developed a visualisation tool “Integration radar – InterRa” for illustrating the degree to which a planned

or existing intervention considers each of the four categories. This tool allows a quick overview of the focus of formalisation approaches and enables comparisons between different cases. However, the tool does not claim to be able to measure the sustainability or to predict the long-term viability of a planned intervention. The authors prove the applicability of this tool by its application to 10 case studies. The cities of Manila (the Philippines) and Londrina (Brazil) were two of the cities evaluated by this tool. The tool evaluates both formalisation cases giving them a better profile considering balance at the four levels of interventions.

3. Social impact assessment as a part of a sustainability assessment

To establish sustainability, environmental, economic, and social issues should be taken into consideration and brought together (Klang et al. 2003; Ness et al. 2007 and Klöpffer and Ciroth 2011). Because individual methodologies for environmental, economic and social impact assessment are usually inadequate to represent the overall sustainability of a complex system, the integration of these methodologies has been increasingly applied as a useful method of analysing complex multidimensional issues e.g. use of indicators and their combined interpretation (Klang et al. 2003), qualitative evaluations (Chung and Lo 2003) and multi-criteria methods (Brouwer et al. 2004).

Many of the methodologies for assessing current or future environmental and economic impacts of products, value chains or policies are known and are widely applied e.g. Environmental Life Cycle Assessment, Environmental Impact Assessment, Life Cycle Costing, Economy-Wide Material Flow Analysis, Indicators and Index etc. (Ness et al. 2007). Regarding the social aspects there is neither a standardised methodology that indicates clearly the social impacts to be assessed nor their characterisation and interpretation. However various efforts have been done for measuring and interpreting social aspects and different methodological approaches have been developed in order to assess social impacts and to include them as a part of sustainability assessment. The studies performed by Brouwer et al. 2004; Klang et al. 2003, Kijak et al. 2004, Chung and Lo 2003 and Labuschagnel and Brentl (2006) are some examples of these efforts. In these studies the authors applied different approaches to choose the social aspect to be analysed and used qualitative, semi quantitative and quantitative aggregation procedures for the social assessment and interpretation of results.

Brouwer et al. (2004) performed a sustainability assessment combining different environmental, economic and social impact assessment procedures in order to support decision-making in the context of flood control policy in the Netherlands. The results from the ecological, economic and social impact assessment are evaluated in an integrated way through cost-benefit analysis (CBA) and multi-criteria analysis (MCA). In this study, the social impact assessment of the proposed policies is based on available literature and expert judgement regarding the effect of the proposed measures on the stakeholders involved

(stakeholder analysis), and the stakeholder perception of the proposed measures. The main stakeholders in the area expected to be affected by the proposed measures were inhabitants, farmers, nature conservation organisations, water supply companies and the recreation sector. This approach for social impact assessment considered the following social criteria: impact on functions performed in the area (area's multi-functionality), stakeholder and public perception of landscape change, stakeholder and public perception of risk, communication efforts, and possibilities to participate in the decision-making process. The evaluation of these social criteria was done based on a qualitative judgment of social experts and applying qualitative scores (+, -).

The methodological approach developed by Klang et al. (2003) proposed a social impact assessment based on a set of indicators for evaluating the contribution of waste management systems to a sustainable development. These indicators were developed through discussions with stakeholders. From these, a smaller number of applicable indicators were chosen, based on their relevance to sustainable development and the possibility of obtaining reliable data. The model was tested in a case-study, where groups of long-term unemployed people were offered both education on environmental issues and practical work with the recovery and recycling of building and demolition waste as a form of vocational development. The social data was collected through questionnaires regarding both the physical and psycho-social working environment. These questionnaires were given to all the workers participating in the study. They were asked to give their own subjective assessment of eight different aspects of the psycho-social working conditions on a scale from 1 to 5. All the workers were also asked to assess the physical and ergonomic working conditions in 10 different activities, by rating them on a four-level scale from "highly unsatisfactory" to "very satisfactory" (Klang et al. 2003). Also the percentage of workers that consider continuing working in the field of recycling of building and demolition waste and the percentage of worker that continue on to further education about waste recycling of building demolition was determined as additional social aspects.

The study of Kijak et al. (2004) developed a decision support framework for the evaluation of scenarios for the integrated management of municipal solid waste within a local government area. The framework integrates life-cycle assessment (LCA) with desktop social impact assessment and full cost accounting (FCA). The integration follows the structured approach of the pressure-state-response (PSR) model suggested by the Organisation for Economic Cooperation and Development (OECD). The framework primarily focuses on decision analysis and interpretation processes, then multi attribute utility theory (MAUT) was used to assist with the integration of qualitative and quantitative information. The developed approach was tested in the state of Queensland, Australia In order probe the viability of methodology. The social impacts were determined through a survey applied to a representative group of stakeholders (representing waste managers and planners from local and state government, industry, consultancy and academia) to identify potential problems and to refine the scope and complexity of the survey. Eight social

impact categories were identified: impact on visual amenity, odour, noise, traffic increase, dust, impact on public health (e.g., disease transmission via disease vectors), impact on property value and stigma perceived by affected community.

The stakeholders evaluated each waste management activity of the city (home composting, waste recycling, waste treatment and waste disposal) in relation to the eight social impact categories using a score system of 1 to 5 (very low to very high).

Another study for evaluating sustainability in solid waste management is the work of Chung and Lo (2003), which defined assessment criteria for sustainability in solid waste management and applied them to the Chinese city/Hong Kong. Following a literature review, four evaluative criteria are derived: environmental desirability, economic optimisation, social acceptability and equity and administrative diligence. These four criteria were evaluated qualitatively and are then applied in the context of Hong Kong for the evaluation of the management performance of construction and demolition waste, clinical waste and chemical waste. For the social assessment was discussed how receptive and supportive the stakeholders are to the waste management options and this evaluation was interpreted regarding social acceptability and equity. As stakeholders were considered the residents, advisory non-government bodies, the industry supplying the goods or services related to the decision outcome and local community.

One interesting example of a quantitative approach is the study of Labuschagnel and Brentl (2006). This approach developed a methodology to assess the social sustainability of projects and technologies in the process industry by calculating social impact indicators (SII), defining the social criteria to be considered and measured as well as the characterisation procedure. For the SII the authors apply the procedure of Environmental Resource Impact Indicators (RIIs) and demonstrate the practicability of the SII approach in the context of the process industry in South Africa.

First the authors selected the social impacts to be assessed based on a desk study about the social issues most commonly present in South African process industry. The four social impacts categories (or social impact indicators – SII) are defined as “areas of protection”, which are further classified into 21 “midpoint” categories. The difference between area of protection and midpoints categories refers to their location in the impact pathway. For example, job creation is normally not considered a goal in itself but, through contributing to the family income and subsequent poverty reduction, it may improve the family's health conditions, which may be considered as an end goal. In this example, job creation could be considered a midpoint category, and health as area of protection. Both are in principle linked by an impact pathway describing their cause-effect relationship, but this relationship is often difficult to express (Jørgensen et al. 2008). The social impacts categories identified by Labuschagnel and Brentl (2006) are presented in the table 2.

Social Impact Indicators (SIIs) or areas of protection	Midpoint category
Internal human resources	Permanent internal employment positions
	Internal Health and Safety situation
	Knowledge level / Career development
	Internal Research and Development capacity
External Population	Comfort level / Nuisances
	Perceived aesthetics
	Local employment
	Local population migration
	Access to health facilities
	Access to education
	Availability of acceptable housing
	Availability of water services
	Availability of energy services
	Availability of waste services
	Pressure on public transport services
	Pressure on the transport network / People and goods movement
	Access to regulatory and public services
Stakeholder Participation	Change in relationships with stakeholders
Macro-Social Performance	External value of purchases / supply chain value/Nature of Purchases
	Migration of clients / Changes in the product value chain/Nature of Sales
	Improvement of socio-environmental services

**Table 2 Areas of protection and midpoints categories
(Labuschagnet and Brentl 2006)**

After the desktop identification of these impact categories personal interviews with a total of 23 project management experts in the process industry in South Africa were held in order to establish the suitability of these social criteria as well as their relevance in terms of sustainable business practices. To continue with the assessment the authors developed and tested a method for a social assessment based on quantitative indicators. For that they proposed the application of the Resource Impact Indicator (RII) approach. The environmental RII approach considers the current and target ambient state or ecological footprint through a conventional distance-to-target normalization and weighting calculation procedure (Brent and Labuschagne 2004 cited by Labuschagne and Bren, 2006).

The four main social criteria are considered as areas of protection (AoP). Here the Social Impact Indicator (SII) is calculated through the summation of all impact pathways of all categorised social interventions (in terms of midpoint indicators) of an evaluated life cycle system.

$$SII_g = \sum_c \sum_x Q_x . C_c . N_c . S_c$$

Where:

Q_x = Quantifiable social intervention (X) of a life cycle system in a midpoint impact category, i.e. project or technology specific information with regards to social impacts

C_c = Characterisation factor for an impact category (of intervention X) within the pathway. As a first approximation no characterisation factors are assumed and social LCI constituents are considered separately.

N_c = Normalisation factor for the impact category based on the social objectives in the region of assessment, i.e. the inverse of the target state of the impact category. The information is obtained from social footprint data in the region of the assessment.

And,

$$S_c = C_s / T_s$$

S_c : Significance (or relative importance) of the impact category in a social group based on the distance-to-target method, i.e. current social state divided by the target social state (Labuschagne and Brent 2006)

In order to determine and collect the data to express the mid-point categories three methods were applied: the subjective evaluation of the probability of occurrence, of the projected frequency of the occurrence, and the potential intensity of a social issue (risk assessment approach) the assessment of costs and direct measurements in society (quantitative evaluation approach) and subjective scales and associated guidelines (project related documentation and interviews) (Labuschagne and Brent 2006). After this development the authors applied it to three case studies in order to determine the current feasibility in terms of data availability. All case studies were set in South Africa and the information was obtained interviews with members of the respective project teams as well as from diverse official studies and databases in South Africa (e.g. municipalities, national statistics, research councils, etc.).

Common methodological aspects of these studies are the data collection procedures and data sources considered for the study: desk studies, local social reports, the opinions of social experts and interviews with local stakeholders (citizens, companies, local authorities, etc.). These studies proposed the application of scores e.g. + or - (Brouwer et al. 2004), 1 to 5 (Klang et al. 2003; Kijak et al. 2004) and the interpretation of results are performed based on the comparison with international or local social regulations e.g. Klang et al. 2003 for the social evaluation of management of demolition waste. Some examples of social aspects evaluated are the perceptions of citizens in relation to landscape changes , communication (Brouwer et al. 2004), physical and psychological working conditions for the workers in demolition recycling alternatives (Klang et al. 2003), odours and noise emissions, dust, impact on the public health, etc. (Kijak et al. 2004).

An interesting exception is the quantitative approach of Labuschagnel and Brentl (2006). For the social inventory this approach does not consider any subjective evaluation (as other approaches based on qualitative analysis or semi quantitative scores). This intend to quantify social impacts seems to fail, since the authors assert that without social data readily available, the number of mid-point categories that can be evaluated are minimal, resulting in an incomplete social picture. The authors also conclude that a quantitative social impact assessment method cannot be applied for project and technology life cycle management purposes in industry.

4. Social Life Cycle Assessment Methodology (sLCA) – state of the art

4.1 Definition

In 2009 the UNEP/SETAC Life Cycle Initiative developed the Social Life Cycle Assessment methodology to assess impacts of products during their life cycle. The sLCA complements the ELCA and can be used on its own or in combination with the E – LCA (UNEP, 2009). The guidelines for the social life cycle assessment of products (UNEP, 2009) emphasizes the need for a clear definition of the aims, the scope, the identification of stakeholders of the product value chain, their role and their social interactions. The figure 8 presents a diagram of a sLCA process.

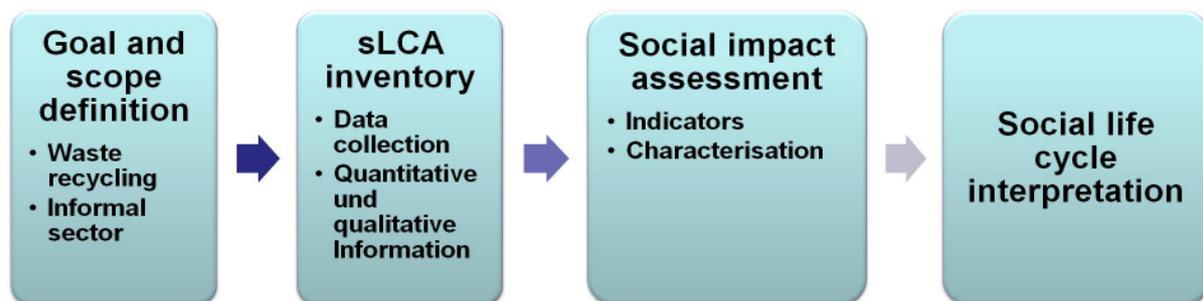


Figure 8 Social Life Cycle Assessment

There are no standardised social aspects to be analysed but this guideline proposes a list of social impact categories and subcategories to be considered according to international social conventions (e.g. ILO) and the stakeholders involved in a production system (see table 3) . However, the social aspects to be evaluated are constantly changing depending on the system and the stakeholders involved. Regarding to this point Dreyer et al. (2006) describes two variants for choosing the social impacts to be assessed: the "bottom - up" and "Top - Down" focus. In the first variant, the social aspects and the parameters for their assessment are defined based on the company interests and context. In this case the companies should be responsible only for the social impacts that they can influence. In the second variant of "Top – down" the

evaluation parameters for the social impact categories are chosen based on the interests of the society. The "top - down" approach was chosen by the method developed by Dreyer et al (2006) to define the relevant issues concerning the identification of the social impact categories in a sLCA. The authors considered the international agreements in order to develop international accepted social impacts categories.

Below the sLCA methodology will be described following the four assessment phases proposed by UNEP (2009) (see figure 8). Also further developments and methodological contributions from other studies associated these four steps will be described

4.2 Goal and scope definition

By this phase of the sLCA it is important to define the purpose of the analysis: the goal of the study will ensure the fulfillment of the final application of the study e.g. learning and identifying social hotspots, reducing social risks through product development or substitution in the supply chain, development of public policies, etc. (UNEP 2009). Jørgensen et al. (2008) mention two possible main goals of a sLCA: the comparison of products, production processes or companies and the identification of improvement potential of products or processes.

The scope definition is the identification and determination of depth and breadth of the sLCA study (UNEP 2009). For that purpose Jørgensen et al. (2008) assert that the sLCA and its limits should be defined in function of the stakeholders within a process chain or product system (made of several process chains) and not in function of the process itself. In contrast to the environmental impacts related to the production processes the social impacts have no cause–effect link with the processes self, but with the social conduct of the companies that perform these processes (see figure 9) (Dreyer et al. 2006, 2010 and Jørgensen et al. 2008). In other words, the social impacts are caused by the company’s actions regarding the social aspects.



Figure 9 Impact pathway model of the social LCA framework (Dreyer et al. 2010)

4.3 Social life cycle inventory - Data collection

The UNEP (2009) mentions desktop research and interviews with the stakeholders involved into the system as methods for the data collection. UNEP (2009) recommends the comparison of the information

given by the stakeholders in order to balance the variation of the information. The information given by each stakeholder about a certain social aspect could be different from others because of their different subjective perception regarding social, political and culture issues. Jørgensen et al. (2008) assert that the social impacts are caused by the social behaviour of the companies at the local level. The data collection must be related to this local level and to the stakeholders within the evaluated system.

4.4 Life cycle impact assessment

4.4.1 Social impact categories and impact subcategories

The social impacts are defined as consequence of social interactions within a productive system, i.e. production, use, and end of life management (UNEP 2009). Further studies (Klang et al. 2003; Brouwer et al. 2004; Kijak et al. 2004) also define the social impacts based on a stakeholders 'analysis and their social issues. The social impacts can be grouped in social impact categories. There are defined as "logical groupings of sLCA results, related to certain social issues of interest to stakeholders and decision makers" (UNEP 2009). These social impact categories are subdivided into social impact subcategories, which represent the relevant social features to be assess within an impact category.

The social categories and subcategories should be determined and classified in function of the social issues that affected the stakeholders and they should reflect internationally as well as local recognised social standards (UNEP 2009; Dreyer et al. 2006; Jørgensen et al. 2008 and Spillemaeckers et al. 2001). Mainly the focus of the impact categories and subcategories analysed by these studies are labour rights and working conditions: child labour, forced labour, discrimination, freedom for association and collective bargaining, equal remuneration, wages, working hours, health and safety and social security and contracts. Additionally UNEP (2009) recommends the evaluation of further social aspects, that can also affect others stakeholders of the value chain e.g. cultural heritage or contribution to economic development (for local community and society).

As already mentioned despite the recommendations of the UNEP guidelines and other studies currently there are no standardised social categories and subcategories to be assessed. Basically the social categories and subcategories to be evaluated depend directly on the system, local social issues and the stakeholders involved in it. The UNEP suggests two types of classification for the social impact subcategories within the social categories: based on the stakeholders and based on the impacts. Both classification types are complementary and not contradictory. The UNEP recommends considering the international social standards (e.g. the universal declaration for human rights, the UN declaration on economic, social and cultural rights - ECOSOC, etc.). Further studies (Jørgensen et al. 2008; Dreyer et al. 2006 and Spillemaeckers et al. 2001) propos also the definition of impact categories and subcategories based on the international social agreements. The table 3 shows some examples of the social impact categories and stakeholder categories proposed by UNEP (2009).

Stakeholder	Subcategories
Workers	Freedom of Association and Collective Bargaining
	Child Labour
	Fair Salary
	Working Hours
	Forced Labour
	Equal opportunities/Discrimination
	Health and Safety
	Social Benefits/Social Security
Consumer	Health & Safety
	Feedback Mechanism
	Consumer Privacy
	Transparency
	End of life responsibility
Local community	Access to material resources
	Access to immaterial resources
	Delocalization and Migration
	Cultural Heritage
	Safe & healthy living conditions
	Respect of indigenous rights
	Community engagement
	Local employment
	Secure living conditions
Society	Public commitments to sustainability issues
	Contribution to economic development
	Prevention & mitigation of armed conflicts
	Technology development
	Corruption
Value chain actors	Fair competition
	Promoting social responsibility
	Supplier relationships
	Respect of intellectual property rights

**Table 3 Stakeholder and impact categories according
UNEP (2009)**

4.4.2 Indicators

Regarding the indicators the UNEP (2009) mentioned the use of quantitative, qualitative, and semi - quantitative indicators. The last one is defined as a numerical description of qualitative information by using different scoring systems. In the methodological sheets of the UNEP guideline (2009) the use of these three types of indicators is proposed. Jørgensen et al. (2008) indicates two important criteria for the development of indicators. The first criterion is the qualitative, quantitative or semi quantitative indicator character and the second criterion is the direct or indirect effect measurement using the indicators. Regarding the semi quantitative indicators, the authors indicate the use of scoring methods to measure them. These indicators are especially used to measure and describe the systems with complex social phenomena through simple physical units.

The second criterion for the formulation of indicators is their determination for a direct or indirect measurement of the phenomena that cause the social impact. Direct indicators are a traditional quantitative and one - dimensional representation of a social impact (Jørgensen et al. 2008 and Dreyer et al. 2006). One example is the frequently used indicator “number of employees under 15 years old” (Dreyer et al.

2010). This indicator measures child labour. However, further aspects pertaining to local context or special situations like the social responsibility of a company are not considered. The authors define indirect indicators as those based on preventive social measures. These indicators aim to assess the preventive management effort of a company rather than the reported impacts (Jørgensen et al. 2008). Dreyer et al. (2006) explained an example related to the working safety, where the safety at the working place not always has a connection with the frequency of accidents in the workplace. A low number of accidents could show a very efficient management, but it could also be a very inefficient data collection (if the accidents are not registered) However, the "safety" not only could be evaluated by statistical data-based indicators, but also it can be evaluated based on the use of management measures, which the company implements to reduce accidents and to improve the working conditions (e.g. One example of these indicators can be the presence of management measures to ensure training for workers in relation to safety and occupational work, instructions for the safe use of machines, etc. (Dreyer et al. 2010).

4.4.3 Characterisation

The assessment of the impact categories and their impact sub categories are made on a basis of an "cause-effect" impact pathway (Dreyer et al. 2006). Currently there is no international consensus about the characterisation method for the social impacts and the modelling method for "cause - effect" pathways (see figure 10). Regarding this aspect UNEP (2009) defines the characterisation as the transformation of the data collected in the life cycle inventory into common units and its aggregation within the same impact category. For the case of sLCA the characterisation is not always a numerical procedure but it can be only a qualitative expression of the data inventory. UNEP (2009) assert that a scoring system can be also used in order to evaluate and interpret the social data (quantitative or qualitative). By comparing the social data with performance reference points (social standards or regulations) and by assigning scores according the fulfillment of these reference points the social impacts can be estimated and better understood (UNEP 2009). Similar to that, Spillemaeckers et al. (2001) proposes a characterisation scheme at subcategories level. This approach is mainly oriented to the human working rights and it uses semi quantitative indicators to assess their compliance. The scores 1 and 0 are assigned corresponding the fulfillment or non-fulfillment of the social criteria (international or local social conventions). Then the weighted average of the scores for each subcategory of impact is calculated. The authors do not specify a procedure for characterisation to impact categories (human working rights and working conditions).

A further development of a characterization approach was proposed by Dreyer et al. (2010). The authors developed a methodology for the characterisation of the impact categories in the context of a sLCA. Based on the "top - down" approach the impact categories regarding the labour rights and their indicators were proposed. It was oriented on a preventive approach which seeks measuring the risk of the evaluated company of no meeting the compliance criteria for the evaluated social aspects. The authors suggest a

characterisation model that assigns a score depending on the level of compliance of the social criteria. In this method different adjustment factors are applied depending on the social context of the company (geographical location, legal framework, etc.).

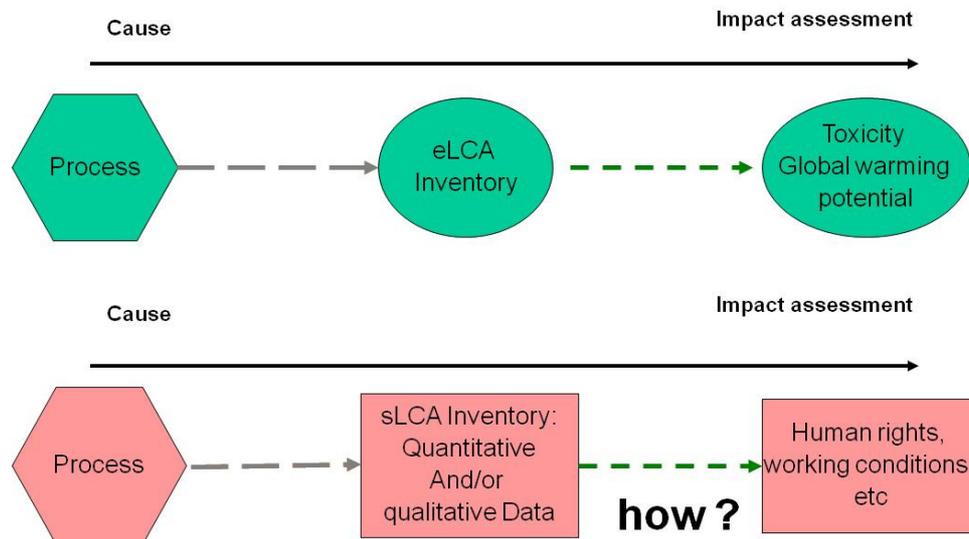


Figure 10 Cause – effect impact pathway
How to do the characterization and interpretation of social impacts?

4.4.4 Life cycle interpretation

With exception of the UNEP guidelines no studies about defined procedures for the life cycle interpretation step were found. UNEP (2009) proposes for this sLCA phase the following steps:

- Identification of significant social findings (social hotspots, not expected positive or negative social impacts, etc.) and critical methodological choices that cause important consequences for the study.
- Evaluation of the study: critical review of the study, of its transparency and verifiability.
- Conclusions, recommendations and reporting.
- The participation of stakeholders: it means the reporting of the participation of the stakeholders in the study.

4.5 Application of sLCA for social impact assessment of products

In the last years and especially since the sLCA UNEP guideline was developed, several studies are applying the sLCA for the social impact assessment of products in order to analyse the feasibility of this

method and to develop social indicators and different approaches for the characterisation and interpretation of social impacts. Below some examples of these further developments are described.

Ekener-Petersen and Finnveden (2012) applied the sLCA for the identification of social hotspots of laptop computers. The aim was first to identify social hotspots of the laptop and to test and evaluate the methodology. The case study was based on the sLCA methodology described in the Guidelines for sLCA (UNEP, 2009) and included the product system from ‘cradle to grave’ as well as the impacts on all relevant stakeholders. The authors focused on a simplified list of materials and used mainly country-specific data. The functional unit in the study was a laptop with generalised features and with a typical product system for such a computer. The case study included the product system from ‘cradle to grave’ and the impacts on all relevant stakeholders as suggested by the Guidelines. The following production phases were considered: resource extraction, refining and processing of raw materials, manufacturing and assembly (including manufacturing of components, assembly of complex components and final assembly), marketing and sales, use (i.e. customer relations), recycling and disposal.

Since this was a generic study, the authors mainly collected national data. The need for data was defined first by identifying the countries most involved in each phase and only a very little sector-specific information was inventoried. The data were collected from the sources suggested in the methodological sheets of the UNEP Guidelines. The table 4 shows the stakeholders and impact subcategories analysed in this study:

Stakeholder	Impact subcategories
Worker	Freedom of association; Collective bargaining
	Child labour
	Fair salary
	Working hours
	Forced labour
	Equal opportunities /discrimination
	Health and safety
	Social benefits/social security
Consumer	Health and safety
	Feedback mechanism
	Consumer privacy
	Transparency
	End of life responsibility
Local community	Access to material resources
	Access to immaterial resources
	Delocalisation; Migration
	Cultural heritage
	Safe and healthy living conditions
	Respect for indigenous rights
	Community engagement
	Local employment
Secure living conditions	

Society	Public commitment to sustainability issues
	Contribution to economic development
	Prevention and mitigation of armed conflicts
	Technology development
	Corruption
Value chain actors	Fair competition
	Promoting social responsibility
	Supplier relationships
	Respect for intellectual property rights

Table 4 Stakeholders, subcategories and phases examined in the study (Ekener-Petersen and Finnveden, 2012)

The hotspots were identified by combining two actions in the data collection. Firstly, the countries were divided into groups with very large activity, medium activity and moderate activity. This is the vertical orientation in a spreadsheet used and indicates the countries with most stakeholders potentially affected. Secondly, the countries with values in the high end of the range of possible values for each specific indicator were highlighted. This was the horizontal orientation in the spreadsheet used. To do this, the authors identified the world minimum and maximum values on the indicator. Countries which combine a large activity and also high and medium values in the evaluated social aspects were identified as hotspots. After the assessment the authors concluded it is possible to conduct a simplified sLCA, using the guidelines UNEP (2009), on a generic complex product. Although there were some challenges, for example in data collection, the authors were able to obtain results which revealed some hotspots, some hot countries and some hot issues, all indicating a risk of negative social impacts in the product system of a laptop. The study identified workers and the local community as the stakeholders most at risk of negative social impacts, with social benefits/social security, working hours, and freedom of association as important issues.

The paper of Kruse et al. (2009) develop a suite of socioeconomic indicators that complement the LCA methodology and provides a comprehensive approach for assessing the cradle-to-grave sustainability of a product or process. The feasibility of this approach is analysed by applying to salmon production systems. The methodology proposed in this study combines top-down and bottom-up approach and that serves as the basis for development of the set of socioeconomic indicators presented in the study. The top-down approach ensures that the indicators define and measure impacts that have a high societal value.

To the extent possible, indicators are based on various international conventions, agreements, and guidelines (such as the International Labour Organisation (ILO), United Nations Global Compact, The Universal Declaration of Human Rights, Corporate Social Responsibility Europe, Global Reporting Initiative. The bottom-up approach identifies indicators based on industry or stakeholder interests and/or data availability. Socioeconomic impacts have the potential to vary between industries due to the nature of the process or product with which a given industry is involved. Any set of socioeconomic indicators used

as a complement to LCA should be able to adequately address industry specific impacts (Kruse et al. 2009).

Two types of socioeconomic indicators were used: additive indicators and descriptive indicators. The authors define additive indicators as indicators that can be measured quantitatively and can relate to the functional unit (i.e., they are additive through the chain). Descriptive indicators are defined as indicators that fail to meet the additive indicator criteria and they are neither strictly quantitative nor additive along the chain but they can represent different social aspects that are not always quantifiable. Consequently, descriptive indicators meet the following criteria: they can be either quantitatively or qualitatively described and/or measured at each point in the chain and they cannot be related to the functional unit (i.e., cannot be added through the chain) (Kruse et al. 2009). Tables 5 and 6 show the indicators applied by the authors:

Additive	Indicators definitions
Production costs	The cost to produce one functional unit (fu)
Labour costs	The labour cost to produce one fu
Gendered labour cost	Labour cost broken out by male/female
Migrant labour cost	Labour cost broken out by migrant/non-migrant
Value – added	The dollar value added per fu
Person hours of production	The total person hours required to produce one fu
Gendered person hours	Person hours broken out by male/female
Migrant person hours	Person hours broken out by migrant/non-migrant
Deaths/accidents	The loss of life/injury on the job per fu

Table 5 Additive indicators
(Kruse et al. 2009)

Descriptive general	Descriptive general
Fair wage	A wage adequate for a person to survive on
Employment benefits	The existence of and/or type of benefits
Hours worked per week	The number of hours worked per week by an average worker
Forced labour	The existence of compelled labour
Discrimination/gender	The breakdown of employees by gender
Right to organize	A right to freedom of association and collective bargaining
Age distribution of workers	The breakdown of employees by age
Minimum age of workers	A proxy for child labour
Access to bathroom/potable water	A proxy for working conditions
Industry concentration	The number of companies at each step in the value chain
Distance traveled	The distance between the different activities in the value chain

Table 6 descriptive indicators and their definition
(Kruse et al. 2009)

Foolmaun and Ramjeeawon (2012) developed a semi quantitative methodological approach for the comparative life cycle assessment and social life cycle assessment of used polyethylene terephthalate (PET)

bottles in Mauritius. The authors investigated and compared the environmental and social impacts of four selected disposal alternatives of used PET bottles. Four disposal alternatives (100 % landfilling, 75 % incineration with energy recovery + 25 % landfilling, 40 % flake production (partial recycling) + 60 % landfilling and 75 % flake production + 25 % landfilling, were analysed..

Three stakeholder categories (worker, society and local community) and eight sub-category indicators (child labour, fair salary, forced labour, health and safety, social benefit/social security, discrimination, contribution to economic development and community engagement) were identified to be relevant to the study. The table 7 presents the impact categories and indicators selected for this assessment.

Stakeholder Categories	Sub category indicators	Indicator	
Workers	Child labour	Percentage of child labour in organisation	
	Fair salary	Satisfaction in wages paid by organisation	
	Forced labour	Whether workers are forced to work	
	Health and safety		Awareness on health and safety issues
			Awareness of steps/protocol to follow in case of emergency/accidents
			Percentage of accident/injury in the organisation
		Use of protective equipment	
Society	Contribution to economic development	Number of jobs created	
Local community	Community engagement	Percentage of corporate social responsibility fund spent on community projects	

Table 7 Stakeholder and impact subcategories (Foolmaun and Ramjeeawon, 2012)

In reference to aggregation and interpretation of the social inventory data the authors developed a new method. The data was obtained through surveys for the workers involving yes or no type questions. The authors converted qualitative inventory data and aggregated it using a score system with two steps: conversion of inventory results (indicators) into percentages e.g. the number of workers answering yes to wage satisfaction in the survey is converted into a percentage (e.g. 55% are satisfied with their wage) and assigned scores from 0 (very bad) to 4 (very good) to indicators and subcategories (e.g. a score 2 corresponds to 55%). For sub-categories with more than one indicator, similar scores ranging from 0 to 4 were used for each indicator. The score for the subcategory was the average of their indicator scores. The authors applied the same weight for all subcategories and their indicators as with the other approaches described (Foolmaun and Ramjeeawon 2012). The authors concluded that the scenario (75 % flake production and 25 % landfilling) showed least social and environmental impact than the other alternatives evaluated and confirmed the feasibility of using this approach for the characterisation of social impacts.

5. Social impact assessment of three Peruvian case studies

The methodological approach developed in this study was tested by analysing the recycling systems of three Peruvian cities: San Vicente de Cañete, the Colca valley and Santiago de Surco in September 2011. Through the methodology developed in this study, the social impacts related to the social impact categories of human rights, working conditions and socioeconomic repercussions as well as the potential for social improvement were identified, measured and compared among the case studies. Three impact categories subdivided into 9 social impact subcategories were assessed through the application of 26 semi – quantitative indicators. The methodological approach developed in this study as well as its application on three Peruvian case studies is presented and described with more detail in the papers attached.

6. Conclusions

It is concluded that although originally sLCA is used for the analysis of products and production processes, it is feasible to use it for the evaluation of waste management systems. By applying this methodological framework based on sLCA it is possible to measure qualitative social impacts that previously were only assumed. The semi quantitative indicators and the applied score system can be satisfactorily used for translating social qualitative information into numbers aiming to measure complex social phenomena that cannot be direct expressed in physical units. The social weak aspects/hot spots of a recycling system can be identified and understood. The characterisation approach proposed in this approach allows to understand and to interpret the social impacts while the possibility of a subjective evaluation is reduced. It is also concluded that the availability and reliability of the data from the local stakeholders linked to the waste management system is of vital importance for the values assignment of the indicators and thus for the results of the evaluation.

Regarding the social impacts of formalisation approaches, the one based on cooperation with recyclers' associations shows positive social impacts in the subcategories freedom of association and collective bargaining, psychological working conditions, while the formalisation approach operated by the municipality shows positive social impacts in the subcategories working hours and minimum and fair wages. With relation to psychological working conditions it seems to be that low payments and longer working hours for recyclers do not affect their work satisfaction negatively. Reason for that could be the positive feedback given to recyclers by the citizens about their recycling activities and the direct contact between them. With this positive feedback the recyclers' work satisfaction increases and their feeling to be cherished are reinforced. The assessment displays similar results for both approaches regarding child labour. Negative social impacts for discrimination, recognised employment relationships and fulfilment of

social benefits, physical working conditions and education were identified for both formalisation approaches. These aspects need to be improved by both formalisation approaches. The social impact assessment indicates the need of improving the payment modality in the formalisation based cooperation with recyclers. The aim is to reduce or to eliminate the negative influence of price and waste amounts fluctuations. Unfavourable fluctuations endanger the chance for recyclers of getting fair and sustainable incomes and additionally have negative impacts on the working time causing bad working conditions. A fixed payment considerably reduces these problems.

7. Limitations of the study and further research challenges

One limitation of the study is that the methodology measures current social impacts caused by recycling systems in operation. Its application for assessing potential social impacts of future scenarios is difficult. Several social factors like regulations, tendencies, perception about satisfaction, quality of life, etc. can change and cannot be precisely forecasted. To determine potential future social impacts a preventive approach oriented to the assessment of management strategies (social responsibility policy, occupational health, etc.) could be used. The present study is limited to compare different models of formalisation after their implementation and did not analyse social impacts before the formalisation. It is recommended to test the feasibility of this methodology for comparing social impacts before and after the implementation of the formalisation. Further limitation of the study is the assessment of formalised recycling systems in low income countries with similar social context as the three Peruvian case studies. Using this approach, the relevant social impacts of recycling systems in countries with different social context would not be representative. In order to apply this approach in other countries the methodology should be adjusted to their local or national social context.

Finally there is a research demand of analysing social impacts of formalisation approaches, different than those implemented in the Peruvian case studies. Also the influence of different social contexts should be researched. The possibility of including other stakeholder categories besides from the workers in the social impact assessment (such as citizens, recycling companies, etc.) should be object of future research.

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Annexes

Paper 1

Aparcana S, Salhofer S (2013). Application of a methodology for the social life cycle assessment of recycling systems in low income countries: three Peruvian case studies. Int J Life Cycle Assess. DOI 10.1007/s11367-013-0559-3

Application of a methodology for the social life cycle assessment of recycling systems in low income countries: three Peruvian case studies

Sandra Aparcana · Stefan Salhofer

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Abstract

Purpose In a previous phase of this work, a methodology oriented towards social Life Cycle Assessment (sLCA) was developed to assess the social impact of formalised recycling systems in low income countries. To support this, a literature review of social impact assessment methodologies was carried out incorporating the social issues of both the informal and the implemented, formal recycling approaches. The goal of this study is to determine the feasibility of applying this methodology by assessing the current social impacts of three Peruvian recycling systems based on two formalisation approaches. A further goal is to identify and measure the social impacts of the formalisation procedures, thereby confirming or rebutting the expectations and forecasts of organisations (NGOs, Local Authorities, Ministries & Business) involved in the implementation.

Methods The methodology developed was applied to three Peruvian recycling systems which had been formalised using two different approaches. One approach utilizes cooperation with recyclers' associations and the second one, operated by the municipality uses formalised recyclers as employees. Interviews were conducted with local recycling system stakeholders in order to collect data to assess fulfilment of the social criteria. Three impact categories and 9 subcategories were analysed using 26 indicators. To transform the qualitative information into numerical values, a score system 1 or 0 for the fulfilment or non-fulfilment of

social criteria was applied. After obtaining the indicators' average scores, further characterisation by social impact subcategory was effected. The final scores for the subcategories show the fulfilment or otherwise of all social criteria related to the subcategory.

Results and discussion The assessment substantiates similar negative impacts of both formalisation approaches for the social subcategories discrimination, recognised employment relationships and fulfilment of social benefit, physical working conditions and education. The formalisation based on cooperation with recyclers' associations reveals a positive social impact for freedom of association and collective bargaining, psychological working conditions and social acceptance whereas the method operated by the municipality scores better for working time and minimum, fair incomes. Regarding the methodology, no difficulties were detected in applying the indicators.

Conclusions It can be concluded that although sLCA was originally used to analyse products and production processes, it is feasible to adapt it for the social assessment of recycling systems based on formalisation of the informal sector in low income countries. A comparison of current social impacts between different formalisation approaches using this methodology is also viable. A further conclusion is that it is feasible to measure the social impacts of formalisation approaches using the selected indicators and characterisation procedure. Social issues such as anti-discrimination policies, employment terms, payment of social benefits, preventive policies, occupational and health training and adult education can be improved following the evaluation.

Responsible editor: Andreas Jørgensen

S. Aparcana (✉) · S. Salhofer
Institute of Waste Management, University of Natural Resources and Life Sciences, Muthgasse 107,
1190 Vienna, Austria
e-mail: sandra.aparcana@boku.ac.at

Keywords Developing countries · Formalisation · Recycling · Social impacts · Social indicators · Social life cycle assessment

1 Introduction

The informal sector plays an important role in waste management systems in developing countries. It focuses mainly on recycling and therefore contributes significantly to the waste management of middle and low income countries. As a result, several cities in these countries have begun to recognise the economic, environmental and social contribution of the informal sector to waste management systems. Various cities in India, Peru, Brazil, the Philippines and Colombia have developed their recycling systems by formalising the informal sector and accommodating it in a waste management system (Rathi 2006; UN-HABITAT 2010; Gutberlet 2011; Wilson et al. 2009 and Medina 2000). Additionally, in some countries, e.g. Brazil, Colombia (Gutberlet 2011; Terraza and Sturzenegger 2010) and Peru (Peruvian 2009) national waste management legislation and waste management strategies have been implemented, aimed at a structured integration of informal recyclers into formal waste management activities.

On the other hand, common social problems within this sector still exist, for example inappropriate working conditions, child labour, discrimination, social rejection, etc. Frequently, it is children, pregnant women and socially excluded groups who work in informal recycling. Local and regional waste policies as well as non-profit organisations point to the implementation of formalisation approaches as an attempt to reduce or eliminate these social problems. Promoters of formalisation (NGOs, municipalities, government) assume that such problems stem from informal recycling and thereby expect formalisation to yield positive social impacts. These social impacts, however, have been not precisely measured and evaluated.

In a previous part of this research, a methodological approach for the social impacts assessment of recycling systems with formalisation approaches was developed, based on the social life cycle assessment methodology (sLCA) (SETAC Life Cycle Initiative 2009). The assessment of social impacts is a part of sustainability assessment, i.e. to consider environmental, economic and social impacts. While the first two have been established for years, no standard approach has yet been established for the social impacts addressed herein. The development of a methodological sLCA approach for recycling systems complements the sustainability assessment (together with Environmental Life Cycle Assessment and Life Cycle Costing). Hunkeler (2006) concludes that "...societal life cycle assessment provides a means to investigate how policy and policy makers can be linked to sustainable development..." and "...the goal of societal life cycle assessment is not to make decisions, but rather to point out tradeoffs to decision- or policy makers...". The sLCA UNEP guidelines of SETAC Life Cycle Initiative (2009) states that "... sLCA provides information on social and socioeconomic aspects for decision

making, instigating dialogue on the social and socioeconomic aspects...". The methodology in this paper intends more to analyse the specific situation of formalisation approaches than to support the direct decision making process.

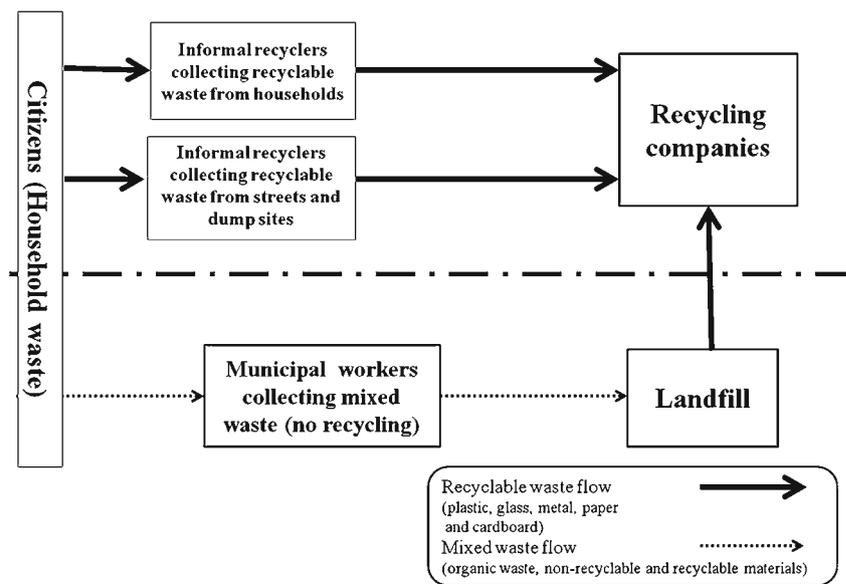
The present paper shows the application of this methodology in three Peruvian cities with recycling systems based on two different formalisation approaches. The feasibility of applying this methodology to evaluate social aspects is analysed. The relevance of social impact categories, sub-categories, and indicators including their characterisation procedure are discussed. Similarities and differences regarding the social impacts, social weaknesses and the circumstances causing these results are compared and analysed. This study attempts to point out, what kind of social impacts exist by each formalisation approach. This in turn will provide more information regarding the fulfilment of the expectations held by decision makers.

2 Waste management and informal recycling in low income countries

Low income countries have some similarities regarding their socioeconomic conditions. In these countries, waste management systems are often not efficient and operate at low standards (Wilson et al. 2006). Scheinberg et al. (2006) defines waste management systems in low income countries as a "pre-modernised system based on a single disposal technology (dumping or landfilling). The waste management system is managed by a single major stakeholder: the local government sometimes supplemented by private waste collectors. Other actors—like recyclers—operate at the margins, and have the status of informal sector".

The shortcomings of waste management systems in low income countries can be demonstrated by the low national coverage rates. Gamarra and Salhofer (2007) submit examples of waste collection rates in Latin America (in Peru 74 %, Mexico 70 %, and Uruguay 71 % in terms of % waste collected) and compare them with the waste collection rates of Central Eastern Europe and Central Europe, which are nearly 100 %. The authors specify the use of controlled dumps, uncontrolled dumps and sanitary landfills as the most commonly used end disposal systems in Latin America. The presence of informal recycling is identified by uncontrolled and controlled dumps. This situation, along with the deficient collection rates, allows the participation of the informal recycling under inadequate and uncontrolled conditions. Figure 1 presents a flow diagram of a common waste management system in Peru including informal recycling, as an example. The material flow corresponding to recyclable waste (plastic, glass, metal, paper and cardboard) and residual waste (organic waste, non-recyclable waste materials, etc.) are indicated.

Fig. 1 Example of a typical waste management system in low income countries



Informal recycling comprises individuals or groups that have no access to formal recycling activities. They are referred to by many names depending on the local language but they are usually known as scavengers, waste pickers or rag pickers (Medina 2000). Other authors prefer to designate them “recyclers” (Gutberlet 2011) in recognition of their recycling activities and their contribution to the recycling market in low income countries. For this work, “recycler” has been adopted.

Recyclers extract recyclable materials (plastic, glass, metal, paper and cardboard) from dumping places, street bins, communal collection sites, etc. and sell the goods in order to improve their livelihoods (Scheinberg et al. 2006). They perform their activities under poor working conditions which represent a high risk to their health and living conditions. Numerous studies have shown the presence of diseases related to working with waste (Medina 2000; Wilson et al. 2006; Zurbrügg and Schertenleib 1998). Further studies have identified other social problems: child labour, truancy in schools, incomplete school education for adults and poor working conditions (Medina 2000; Wilson et al. 2006; Scheinberg et al. 2006; International Labour 2004).

3 Formalisation approaches

Political trends and socioeconomic and environmental problems related to inefficient waste management have led to several low income countries attempts to modernise their systems in order to bring them up to European or American waste management standards (Scheinberg et al. 2006). This modernisation is characterised by the transformation to complex integrated systems, with multiple formal stakeholders, a wide diversity of technical operations and the expulsion or rejection of the informal sector (Scheinberg et al. 2006). Despite the “modernisation”

some cities have identified the need to recognise the contribution of the informal sector and its inclusion in formal waste management systems as an effective strategy. As a consequence, several formalisation approaches have been implemented in recent years, in order to improve waste management systems and to reduce the social problems of informal recyclers.

Medina (2000) describes some public policies that try to encourage informal recyclers to engage in other occupations in order to reduce their informal activities (Medina 2000). Scheinberg et al. (2006) indicate that this approach fails to recognise that leaving their recycling activities would precipitate a reduction in their incomes to below the minimum amount in these countries (Arroyo et al. 1998 cited by Scheinberg et al. 2006).

Further studies about formalisation in low income countries describe as main features the creation and support of recyclers’ associations, their inclusion in formal waste collection, the creation of a legal framework to support their integration (Peru and Brazil), the improvement of working conditions, the improvement of income through cooperation contracts with local authorities, the elimination of child labour, educational programmes, diversification of services, etc. Strategies implemented in the Philippines, India, Colombia, Mexico, Brazil and Peru are based on these measures (Wilson et al. 2009; Rathi 2006; Medina 2000; Gutberlet 2011; Scheinberg et al. 2010). Figure 2 shows a flow chart of a commonly implemented formalisation approaches in low income countries.

4 Peruvian case studies

The Peruvian waste management system is regulated by the Peruvian Environmental Law and Peruvian Waste General

households without paying for them. They then transport the collected waste by tricycle and subsequently perform a more thorough, manual sift at tables in sorting centres. After this separation the recyclable materials are sold on the local recycling market. With this approach, the income of the recyclers depends not only on the price and quantity of materials sold, but also on the number of participating citizens. Measures were taken in order to improve the working conditions of the recyclers, i.e. campaigns to raise the awareness and identification of the population with the recyclers, vaccination campaigns, and recyclers' access to health prevention and working equipment.

In contrast, the city of Santiago de Surco has a recycling system operated entirely by the municipality. As the only stakeholder, the municipality has employed the recyclers as formal workers at the municipal recycling plant. The workers collect recyclable materials (glass, paper, cardboard, metal and plastics) door to door without paying any revenue to the households. The collected waste is transported with waste collection trucks and the material is taken in by other workers at the municipal recycling plant. They separate more accurately than by using a sorting system with conveyor belts. The workers receive a fixed income independent of the amounts of materials sold. The entire system is financed by the municipality. Access to adequate working equipment and to health and social insurance are some of the measures for improving the working conditions of the municipal workers. Table 1 provides general information about the three case studies representing the two formalisation approaches. Figure 2 (a typical formalisation approach based on cooperation with recyclers' associations) shows the recycling systems in Colca Valley and San Vicente de Cañete and Fig. 3 the flow chart of the recycling systems in Santiago de Surco.

5 Methodology for social impact assessment of recycling systems based on formalisation approaches

The methodological approach was developed in a previous phase of this work (Aparcana and Salhofer 2013). This methodology is based on the sLCA framework developed by SETAC Life Cycle Initiative (2009). The terms in this paper correspond with definitions in the UNEP-SETAC Guidelines.

The procedure developed has been tested by applying it for the social assessment of three Peruvian recycling systems. One goal is the determination of current social impacts related to formalised recyclers involved in recycling systems with formalisation approaches. A further goal is to identify and measure the social impacts of the formalisation approaches themselves; thereby confirming, or refuting those impacts expected/forecast by organisations (NGOs, Local Authorities, Ministries & Business) involved in the implementation of the systems.

The structure of waste management systems in low income countries work similarly, having the same stages from waste collection to recycling and final disposal. The stakeholders involved in these activities are also similar: recyclers, municipalities, citizens, recycling companies (see Fig. 1). Taking that into account, this study considers a waste management system as a process formed of several phases, where the recyclers are affected to various degrees regarding their working conditions, health and human rights (see chapter 2 and chapter 3). Different formalisation approaches have different social impacts but all relate to the same social issues. This study assesses the social impacts of formalisation approaches on formalised recyclers.

Through this methodology, the social impacts related to the social impact categories of human rights, working conditions and socioeconomic repercussions as well as the potential for social improvement were identified, measured and compared among the case studies. These three impact categories are subdivided into 9 social impact subcategories, which are analysed through 26 semi-quantitative indicators.

The life cycle inventory for the three case studies was accomplished through interviews with the main stakeholders involved in the formalisation approaches (municipalities, recyclers' associations and NGOs) in September 2011. These interviews not only provided information about the social impacts, but also about the context thereof. The stakeholders interviewed could furnish details related to the context of recycling systems that were pertinent to the assessment results.

A check list of 56 open and closed ended questions used to collect the relevant information for the assessment of the social impact categories and their subcategories. The same check list was applied to all stakeholders with exception of the data collection for the subcategory psychological working conditions. In this case, the interviews were carried out only with the formalised recyclers. They could deliver more direct and reliable information regarding this impact subcategory, because it is mainly related to their work satisfaction level.

Currently, there is no consensus about the characterisation method for the social impacts. The UNEP-SETAC Life Cycle Initiative (2009) asserts that a scoring system can be used in order to evaluate and interpret the social data. Studies about different approaches for social impact assessment propose the application of scores, e.g. + or - (Brouwer and Van Ek 2004), 1 to 5 (Klang et al. 2003; Kijak and Moy 2004) and the interpretation of results are based on a comparison with international or local social regulations, e.g. Klang et al. 2003 for the social evaluation of management of demolition waste. Dreyer et al. (2010) developed a characterisation methodology oriented towards a preventive approach that assesses social management measures and also uses an elaborated scoring system. The method proposed by Cirotto and Franze (2011) calls for expert judgement for a

Table 1 Case studies description

City	Formalisation approach	Stakeholders	Collection rate of recycling system (% of household participating in the recycling system)	Collected materials	Number of workers	Hiring strategy	Income	Presence of informal recyclers outside the assessed recycling system
San Vicente de Cañete Colca Valley	Cooperation with recyclers' associations	NGO, formalised recyclers and municipality	15 % 10 %	Glass, plastics, paper and cardboard and metals	6 14	Cooperation agreement among the municipality and association of recyclers permitting the access to households and the collection of recyclable materials	Variable income based on the amounts of recyclable material sold	Yes (unknown quantity)
Santiago de Surco	Operated by the municipality with recyclers as formal workers	Municipality and recyclers at the recycling plant	38 %		35 (at the recycling plant)	Recyclers at the recycling plant have working contracts as formal employees with the municipality	fixed income	

subjective score assignment of 1 to 5 and for the interpretation of social impacts.

Spillemaeckers et al. (2001) develop a characterisation approach based on semi-quantitative indicators and the application of the scores 1 and 0 corresponding the fulfilment or non-fulfilment of the social criteria (international or local social conventions). The average of the scores for each impact subcategory is then calculated. This approach is also angled towards the assessment of human rights and working conditions. In a similar vein, Spillemaeckers et al. (2001) and Foolmaun and Ramjeeawon (2013) developed an sLCA approach for used PET bottles, where the data was obtained through surveys involving yes or no type questions. The authors converted qualitative inventory data and aggregated it using a score system with two steps: conversion of inventory results (indicators) into percentages, e.g. the number of workers answering yes to wage satisfaction in the survey is converted into a percentage (e.g. 55 % are satisfied with their wage) and assigned scores from 0 (very bad) to 4 (very good) to indicators and subcategories (e.g. a score 2 corresponds to 55 %). For sub-categories with more than one indicator, similar scores ranging from 0 to 4 were used for each indicator. The score for the subcategory was the average of their indicator scores Foolmaun and Ramjeeawon (2013). The authors applied the same weight for all sub-categories and their indicators as with the other approaches described.

The characterisation procedure for this methodology proposes the application of a score system for each indicator and assigns the values 1 and 0 for the fulfilment or non-fulfilment of the social compliance criteria. The answers given by each stakeholder interviewed have been converted into these values. Because several stakeholders were interviewed, the average score for each indicator was calculated.

$$\frac{\sum_{i=0}^n Si}{n}$$

Eq. 1: calculation of average score

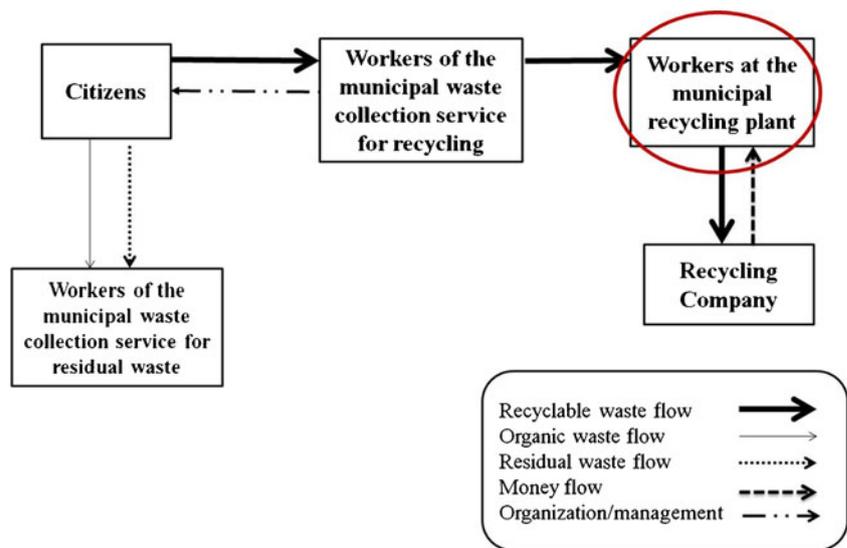
Si = Score for indicator i given by the stakeholder i

n = number of interviewed stakeholders

The result is an average, decimal score between 0 and 1 for each indicator (26 in total). The average score calculated for each indicator represents the proportion of stakeholders (as a percentage) affirming fulfilment of the social criterion. At least 50 % of the stakeholders interviewed (0.5 average score) have to report the fulfilment of the social criterion in order to consider this result reliable. In this case, the social criterion is considered fulfilled and the average score is rounded up to 1.

When the average score is less than 0.5, it signifies that less than 50 % of the interviewees reported fulfilment of the evaluated criterion and the score is rounded down to 0.

Fig. 3 Flow chart recycling system with formalisation in Santiago de Surco



As mentioned above, only recyclers were interviewed regarding the indicators for the impact subcategory psychological working condition. The score assignment and fulfilment criteria were defined differently for the indicators of both impact subcategories. A scale of 1 (very bad), 2 (bad), 3 (medium), 4 (good) and 5 (very good) denoted degrees of satisfaction. In order to transform the scores obtained to a scale similar to that of the indicators in other subcategories (0 or 1), the following values were also assigned: 0, 0.25, 0.5, 0.75 and 1 for the scale 1, 2, 3, 4 and 5, respectively. An average of the scores given by the recyclers has been calculated. An average score higher than “medium” (0.5) connotes fulfilment of the social criterion for the indicator and it receives the final score “1”. An average score lower than or equal to 0.5 means non-fulfilment of the social criterion and the final score “0” is assigned. The reason for applying a different scale for the impact subcategory psychological working conditions was the subjective evaluation of the recyclers about their own satisfaction levels. It was difficult for them to categorise their satisfaction feelings in only 2 levels “yes, I am satisfied” (score 1) and “no, I am not satisfied” (0). In the case of the data collection for the other social subcategories, the information is fact based (e.g. use of uniforms, presence of training programmes, etc.) and fulfilment can be evaluated with “yes, there is..., yes, we have it” or “no, we do not have it... no, there is not”. However, for the psychological working conditions, the recyclers understood the 1 to 5 scale better and showed more willingness to elaborate on their answers.

After obtaining the average scores of the 26 indicators the score for each subcategory was calculated and interpreted as follows: when all the indicators within a subcategory obtain the score “1”, the subcategory obtains the overall evaluation “1” meaning the fulfilment of all the social criteria for the subcategory. In the case that one or more indicators within a subcategory receive “0”, the subcategory also obtains the

overall evaluation of “0” meaning the non-fulfilment of the social criteria related to the subcategory. The reason for this interpretation is that each indicator within a subcategory represents a basic social aspect to be fulfilled in accordance with social regulations. In order to obtain a positive subcategory evaluation all of the indicators within it have to be evaluated with “1”. The principle of choosing severe evaluation criteria for the results at subcategory level was also applied by Ekener-Petersen and Finnveden (2013).

It is important to mention that although this evaluation is based on scores, these results are not relevant as numeric values. The aim is to show the differences between the case studies in terms of their social aspects. The results indicate which aspects of a formalisation approach are favourable or not.

6 Results and discussion

6.1 Characterisation results

Table 2 shows the results of the social impact assessment for the indicator and subcategory levels respectively. The three recycling systems correspond to formalisation approaches described in chapter 2.

6.2 Indicators relevance and applicability of the characterisation procedure

Previous studies mention the use of direct and indirect indicators to measure the phenomenon that cause a social impact. Direct indicators are defined as traditional, quantitative and one-dimensional representations of a social impact, e.g. “number of employees under 15 years old” (Jørgensen et al. 2008; Dreyer et al. 2006). Indirect indicators aim to assess the preventive management efforts of the

Table 2 Results of the social assessment at indicators and sub category level

Social impact category	Social impact subcategory	Indicator	Results at indicator level		Results at sub category level		
			Formalisation approach (operated by the municipality)	Formalisation approach (cooperation with recyclers' associations)	Formalisation approach (operated by the municipality)	Formalisation approach (cooperation with recyclers' associations)	
							Recycling system Santiago de Surco
Human rights	Child labour	No child labour	1	1	1	1	
		Formal policy against discrimination	0	0	0	0	
		No income differences between women and men	1	1	1	1	
	Freedom for association and collective bargaining	Presence of collective bargaining	0	1	0	1	
		Working hours	1	0	1	0	
	Working Conditions	Minimum income, faire income	Fulfillment of overtime agreed in working contracts	1	0	1	0
			Average income according to legal framework	1	0	1	0
		Absence of non-agreed wage deductions	1	1	1	1	
		Regular payment for the workers	1	1	1	1	
		Minimum income according to legal framework	1	0	0	0	
Existence of legal working contracts for all workers		1	1	1	0		
Access to legal social benefits		0	0	0	0		
Recognised employment relationships and fulfilment of legal social benefits	Physical working conditions	Access to further social support programmes for workers	0	0	0	0	
		Absence of work accidents	0	1	0	0	
	Formal policy about occupational health and safety	0	0	0	0		
	Vaccination for workers	1	1	1	1		
	Training programmes for workers regarding occupational health and safety	0	0	0	0		
	Access to preventive health care programme for workers	0	1	1	1		
	Presence of medical equipment at the working place for the workers' use	1	0	1	1		
	Absence of diseases related to waste handling	0	0	1	1		
	Appropriate working equipment	1	1	1	1		
	Willingness to continue working in the same company or sector	0	1	1	0		
Psychological working conditions	Work satisfaction	0	1	1	1		
		1	1	1	1		

Table 2 (continued)

Social impact category	Social impact subcategory	Indicator	Results at indicator level		Results at sub category level	
			Formalisation approach (operated by the municipality)	Formalisation approach (cooperation with recyclers' associations)	Formalisation approach (operated by the municipality)	Formalisation approach (cooperation with recyclers' associations)
Socioeconomic repercussions	Education	Willingness to be trained regarding the work activities	1	1	0	0
		Educational level of children from recyclers' families	1	1	1	0
		No school absence of children from recyclers' families	1	1	1	1
		Existence of educational programmes for self-development	0	0	0	0
			Formalisation approach (operated by the municipality)	Formalisation approach (cooperation with recyclers' associations)	Formalisation approach (operated by the municipality)	Formalisation approach (cooperation with recyclers' associations)
			Recycling system Santiago de Surco	Recycling system San Vicente de Cañete	Recycling system Santiago de Surco	Recycling systems San Vicente de Cañete and Colca Valley

company rather than the reported impacts (Jørgensen et al. 2008); e.g. presence of management measures ensuring the training of workers in relation of safety and occupational work, instructions for the safe use of machines, etc. (Dreyer et al. 2010).

As previously asserted, some social impacts can be better evaluated by using indirect indicators, which are based on preventive social policies. The findings of this study support this perspective for the assessment of working conditions. The absence of a formal policy to ensure appropriate health and security at work seems to negatively affect further social aspects like work accidents and cases of disease caused by the contact with waste. A social assessment employing indirect indicators can complement one made using direct indicators by showing more clearly the weaknesses of a formalisation approach. Indirect indicators are able to detect possible flaws based on the presence or absence of preventive social policies without analysing information given directly by the stakeholders.

Regarding the semi-quantitative characteristic of the indicators, diverse studies (Jørgensen et al. 2008; Spillemaeckers et al. 2001, UNEP-SETAC Life Cycle Initiative 2009 and Dreyer et al. 2006) verify the ability of these indicators to measure and describe qualitative information through numerical units. As a result of this study it can be asserted that social impacts on formalised recyclers can be expressed by applying score systems. The data collected through interviews with the stakeholders of recycling systems can be easily transformed into numerical information. That allows the characterisation and the direct comparison of social impacts between recycling systems. It also allows the clear identification of their social weaknesses, similarities and differences.

No difficulties were encountered during the data collection steps, characterisation and comparison of results. The information collected through the interviews about the fulfilment of social criteria was transformed into scores. The calculation of indicators' average scores, rounding up and down, and interpretation was easily accomplished, and reflects both positive and negative social impacts of the assessed recycling systems.

6.3 Social impact interpretation of the case studies

The methodology developed was tested in two different formalisation approaches implemented in three Peruvian recycling systems. The aim was to determine the feasibility and applicability of this methodology for assessing the contribution of formalised recycling systems in terms of social impacts, compared to recycling systems based on informal recyclers. In chapters 2 and 3, the social problems of informal recyclers in low income countries were described. Substandard working conditions, discrimination, child labour, poverty, poor health conditions, lack of

education, and low work satisfaction are some of the social problems commonly identified. The two formalisation approaches were analysed and compared, in order to determine their differences regarding social impacts. For this study, it is assumed that a recycling system without formalisation (based on informal recyclers) does not fulfil any of the social criteria of this methodology and scores 0.

In order to perform this assessment, the functional unit is defined as the amount of household recyclable waste collected by one house during 1 year. Based on the Peruvian national average waste generation rate and waste composition rate (see MINAM Ministry of Environment 2011), the functional unit amounts to 60 kg/inhabitant-year of collected recyclable household waste.

In low income countries, the collection of recyclable waste can be carried out by the municipality, informal recyclers or formalised recyclers. The definition of a functional unit allows the application of the methodology to different recycling systems. The recycling activities that are considered for the analysis are the recyclable waste collection and manual pre processing.

6.4 Human working rights

The results of this study reveal that both formalisation approaches did not show any differences regarding their social impacts for the social subcategories child labour and discrimination. Both were positively and negatively evaluated, respectively. An explanation for this result might be that Peruvian social regulations for the formal labour market strictly limit the working activities of those less than 18 years old. The formalisation approaches assessed have sought to fulfil this legal social criterion. With regard to the subcategory discrimination, both formalisation approaches obtained a negative evaluation. Although they showed no differences between women's and men's incomes (meaning fulfilment of the indicator), they acquired a negative evaluation because of the absence of formal policies to ensure equal opportunities and rights.

In respect of freedom of association and collective bargaining, the formalisation approach based on cooperation with recyclers' associations fulfilled the social criterion and received a positive evaluation. In stark contrast, the formalisation approach operated by the municipality did not fulfil the social criterion and scored negatively. The main reason for this result is the absence of periodic or scheduled meetings between the municipality and the recyclers (workers at the municipal recycling plant) as an organised group. No coordination or negotiation activities were reported during the interviews. In the case of the formalisation approach based on cooperation with recyclers' associations, consultations between recyclers and other stakeholders were mentioned as a regularly activity.

6.5 Working conditions

For both formalisation approaches, the assessment did not reveal important differences in the following subcategories: recognised employment relationships and fulfilment of legal social benefits and physical working conditions. In relation to the first, although both approaches have legal employment contracts with the recyclers, they obtained a negative evaluation for this subcategory. The reason is that none of them give the recyclers full access to legal social security and social benefits such as retirement pension or family health programmes. In the case of the formalisation approach operated by the municipality, this can be explained by the short term contracts given to some of the recyclers. This type of working contract does not allow full access to social security programmes. The formalisation approach based on cooperation with recyclers' associations works on the basis of participation agreements between them and the municipality. The associations and their members assume responsibility for their subscription to social programmes but they are not compelled to fulfil this duty and they are not scrutinised by the municipality or any other authority. They apparently have no awareness of the importance of securing these social benefits and do not sign up for them.

Neither formalisation approach fulfilled of all social indicators within the subcategory physical working conditions. An interesting exception is the result from the indicator: access of workers to preventive health programmes. Here, the formalisation approach based on cooperation with recyclers' associations gained a positive evaluation in contrast to the formalisation approach operated by the municipality, which was negative. In the first example the study detected meaningful support from NGOs working for the implementation of the formalisation, in providing recyclers with access to health prevention programmes (access to private health insurance with funding from the sale of recyclable materials or government health programmes for people in extreme poverty, etc.). It seems that the NGOs take the recyclers' need for these programmes strongly into account. In the case of the formalisation approach operated by the municipality, not all workers have access to health programmes. An explanation is the presence of short term contracts, which do not cover the costs of health programmes for the workers, who themselves are not able to assume these costs.

It should be mentioned that absence of a formal policy for occupational health and safety could have a negative effect on working conditions in the two formalisation approaches. This lack of preventive policies is manifested in the case studies evaluated by the incidence of work accidents and diseases caused by contact with waste. This finding supports the assertion that the implementation of preventive measures and social policies can ensure a positive social impact of the

formalisation approaches regarding physical working conditions.

Significant differences were identified for the subcategories working hours, minimum and fair incomes and psychological working conditions. During the interviews it was noted that no overtime was paid to recyclers in the formalisation approach based on cooperation with recyclers' associations. Although working times were initially agreed and essentially fixed, the recyclers currently work longer hours. For this reason the formalisation approach was negatively evaluated. The recyclers' income depends directly on the market prices and the amount of recyclable materials collected and sold. Price or quantity downturns mean the recyclers have to work longer to reach an adequate income. In contrast to this situation, it was observed that the recyclers from the system operated by the municipality usually work the hours agreed in their working contracts. The reason for that is their fixed payment, which does not depend on the market prices or amounts of waste material. The recyclers' income is not influenced by negative conditions (market or collected waste amounts).

The results described in the social subcategory working time have a strong correlation with the following impact subcategory: minimum income and fair income. In this subcategory, the formalisation approach operated by the municipality showed also better results than the formalisation approach based on cooperation with recyclers' associations. The first received positive evaluations for the four indicators within this subcategory. The second, however, was negative evaluated on the indicators related to average and minimum income. This result can be explained by the fact that associated recyclers often face sharp fluctuations in prices and recyclable waste amounts (sometimes citizens do not separate their wastes or do not give them to the recyclers). This reduces their incomes which then do not reach the legal minimum or average wage. In the case of the formalisation approach operated by the municipality, incomes are fixed and are not influenced by such fluctuations.

It is interesting to note the results obtained for the social subcategory psychological working conditions. Although the recyclers at the municipal recycling plant receive higher incomes, reaching the legal minimum and the average incomes for the sector, the overall evaluation for this subcategory was negative. Less work satisfaction was found and less willingness to continue working in the same recycling activities than in the case of the formalisation approach based on cooperation with recyclers' associations. A possible explanation for this might be that the associated recyclers are happy with the improvement of their working conditions in comparison with their previous working situation (working at waste dumps and on the street). Additionally, the associated recyclers, who also perform the door-to-door collection, reported satisfaction in the

recognition of their work by residents and other stakeholders, their contribution to environment protection and their feeling of having a share in a better world.

In contrast with the recyclers from the formalisation approach based on cooperation with recyclers' associations, the recyclers from the formalisation approach operated by the municipality do not have any contact with the members of the public during their work. No direct feedback from citizens about the recognition of their recycling activities exists. For this reason, they are not psychologically motivated to contribute to environmental improvement. This would also negatively influence work satisfaction.

6.6 Socioeconomic repercussions

One subcategory was evaluated within this social category: education. Both formalisation approaches received negative evaluations in the subcategory access to education. This was caused by the lack of adult training for the recyclers, meaning the absence of adult education programmes for supporting or encouraging self-development. The promotion of self-development is important not only because of its positive impact on work satisfaction but also because of the possibility of improving the recycling business and of increasing access to new economic sources through gaining useful knowledge. Regarding the indicators educational level and no school absence of children of recyclers' families, both formalisation approaches were positive evaluated.

A limitation of this study was the evaluation based only on the reliability of the stakeholders' answers. A way to balance the answers given by individual stakeholders was the application of a score system and the calculation of average scores. It is recommended using and including local reports or studies in the evaluation where possible. The information from these documents would counterbalance the reliability of stakeholders' answers. For the social assessment, the inclusion of more management indicators is recommended. They should be based on preventive social policies in order to more accurately evaluate the current social impacts of a recycling system.

7 Conclusions and recommendations

It is concluded from this study that although the sLCA is normally used for the assessment of products and production chains, it is feasible to apply this methodology to the social assessment and comparison of recycling systems based on formalisation approaches. The adopted indicators and the characterisation procedures facilitate the assessment and interpretation of the selected impact categories and subcategories. In relation to the indicators, it can be concluded that the use of indirect indicators based on preventive social

policies is feasible for assessing current social impacts of recycling systems. It is also concluded that the social weaknesses of formalisation approaches as well as their positive aspects can be identified through the application of semi-quantitative indicators.

Regarding the social impacts of formalisation approaches, the one based on cooperation with recyclers' associations achieves positive social impacts in the subcategories freedom of association and collective bargaining, psychological working conditions, while the formalisation approach operated by the municipality shows positive social impacts in the subcategories working hours and minimum and fair wages. The assessment displays similar results for both approaches regarding child labour. Negative social impacts for discrimination, recognised employment relationships and fulfilment of social benefits, physical working conditions and education were identified for both formalisation approaches. These aspects need to be improved by both formalisation approaches.

Regarding the income of recyclers, the study shows the need to stabilise payments in the formalisation approach based on cooperation with recyclers' associations, the aim being the reduction of negative influences of price and waste amount fluctuations.

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Paper 2

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Development of a social impact assessment methodology for recycling systems in low-income countries

Sandra Aparcana · Stefan Salhofer

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Abstract

Purpose Informal recycling is one of the most significant activities within waste management systems in low-income countries. The main aspect of a number of recently implemented waste management systems has been to organise the informal recycling sector. The implementation of formalisation is expected to eliminate social problems related to the informal sector, but this has not been precisely measured and evaluated. A lack of methodology to assess social impacts persists, as does the comparison of different formalisation approaches. The goal of this work is to develop a methodological procedure for assessing the contribution of formalised recycling systems in low-income countries in terms of social impacts, in comparison with informal systems.

Methods Some existing social assessment approaches were evaluated by a review of literature. This investigation focuses on the development of the social life cycle assessment approach, the analysed social aspects, proposed indicators and characterisation models within this framework.

Results and discussion This study proposes an approach for the social assessment of recycling systems based on formalisation approaches in low-income countries oriented towards the social life cycle assessment methodology (sLCA). The approach developed considers 3 social impact categories, 9 social subcategories and 26 semi-quantitative indicators for the assessment of the social impacts on formalised recyclers. It includes a characterisation procedure that takes into consideration the application of a score

system and the calculation of average scores at both the indicator and subcategory levels.

Conclusions This research shows that it would be feasible to apply a sLCA-based methodology to evaluate recycling systems based on formalisation of the informal sector. The impact categories and subcategories identified represent the social problems of informal recyclers. The 26 semi-quantitative indicators and the proposed characterisation approach attempt to measure the social impacts that currently are only qualitatively assumed. The applicability and validation of the indicators and characterisation procedure will be determined by further research. The methodology developed will be tested using data from three recycling systems in Peruvian cities.

Keywords Formalisation · Low-income countries · Recyclers · Recycling system · Social life cycle assessment

1 Introduction

The informal sector plays an important role in waste management systems in low-income countries. This sector is defined as individuals or groups that carry out various activities within the waste management system (collection, recycling, treatment and disposal) without formal assignment. It focuses mainly on recycling and contributes significantly to the waste management of low- and middle-income countries. Several cities in low-income countries have identified the need to recognise the economic, environmental and social contribution of the informal recycling sector to waste management systems. Some cities in India, Peru, Brazil, the Philippines and Colombia have developed their recycling systems by the formalisation and inclusion of the informal sector (Rathi 2006; UN-HABITAT 2010; Gutberlet 2011; Wilson et al. 2009; Medina 2000).

Responsible editor: Thomas Swarr

S. Aparcana (✉) · S. Salhofer
Institute of Waste Management, University of Natural Resources
and Life Sciences, Muthgasse 107,
1190 Vienna, Austria
e-mail: sandra.aparcana@boku.ac.at

The most common social problems of informal recycling are inappropriate working conditions which endanger health and safety, social rejection, exploitation and poverty. Customarily, socially disadvantaged individuals or groups work in informal recycling (e.g. children, pregnant women and the elderly). It is assumed that formalisation leads to the reduction or elimination of such problems, although this has not been precisely measured and evaluated. A methodology for assessing the social impacts of formalisation within waste recycling systems in low-income countries has not been developed.

In contrast, there are several methodological proposals for assessing the social impacts of products and production chains using a variety of characterisation procedures that gauge the various social aspects of those products. One of them is the social life cycle assessment methodology (sLCA) notwithstanding its procedures, and characterisation methods of impact categories and subcategories are still under development.

The goal of this work is to develop a methodological procedure for assessing the contribution in low-income countries of formalised recycling systems, in terms of social impacts, compared to recycling systems using informal recyclers. In order to develop this methodology, research of the existing methodologies for social impact assessment including several experiences with the sLCA was carried out. The intention was to identify similarities and differences regarding the social impacts, their definition and interpretation. Further aspects such as characterisation approaches, definition and type of indicators, and data collection have also been analysed for their suitability of application for the social assessment of formalisation approaches in recycling systems. This methodology seeks to follow and to adapt the steps defined in the UNEP–SETAC guidelines for sLCA (2009) and to apply them to the social assessment of formalised recycling systems in low-income countries. The applicability and the relevance of the methodology developed will be tested on three Peruvian case studies with different formalisation approaches.

2 Waste management in low-income countries

Low-income countries have some similarities regarding their socio-economic conditions. In these countries, waste management systems are often not efficient and operate to low standards (Wilson et al. 2006). Scheinberg et al. (2006) define waste management systems in low-income countries as a “pre-modernised system based on a single disposal technology (dumping or landfilling). The waste management system is managed by a single major stakeholder: the local government sometimes supplemented by private waste collectors. Other actors—like recyclers—operate at the margins, and have the status of informal sector”.

The deficiencies of waste management systems in low-income countries can be demonstrated by their low national coverage rates. Gamarra and Salhofer (2007) give some examples of waste collection rates in Latin America (in Peru 74 %, Mexico 70 % and Uruguay 71 % in terms of percent waste collected) and compare them with the waste collection rates in Central Eastern Europe and Central Europe, which are nearly 100 %. Regarding the final waste disposal, the authors specified the use of controlled dumps, uncontrolled dumps and sanitary landfills as the most commonly used disposal systems in Latin America. The presence of informal recycling is identified at uncontrolled and controlled dumps. This situation along with the deficient collection rates allows the participation of the informal recycling under inadequate and uncontrolled conditions. Figure 1 presents, as an example, a flow diagram of a common waste management system in Peru including informal recycling. The material flow corresponding to recyclable waste (plastic, glass, metal, paper and cardboard) and mixed waste (organic waste, non-recyclable waste materials and recyclable waste materials) is represented in this figure.

3 Informal recycling and formalisation approaches

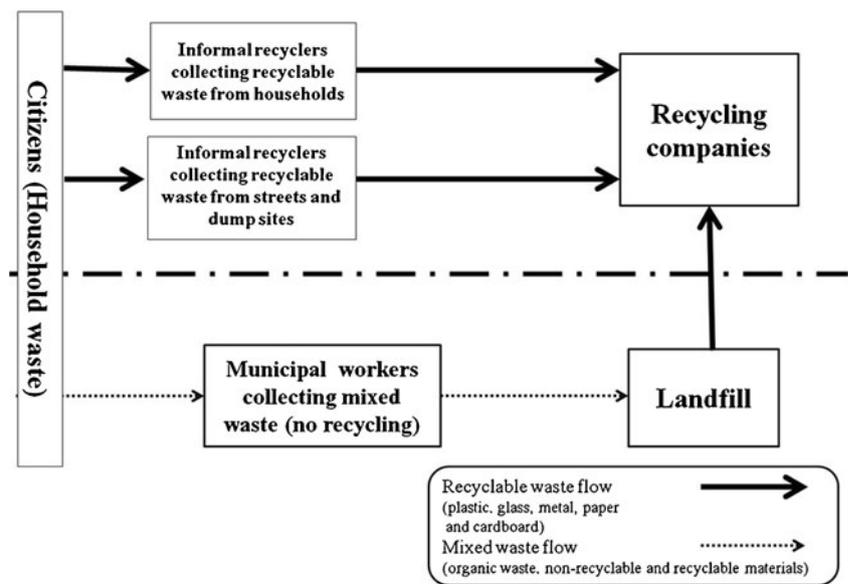
3.1 Informal recycling

The informal sector in waste management comprises individuals or groups that have no access to formal recycling activities. Such people are referred to by many names depending on the local language, but they are usually known as scavengers, waste pickers or rag pickers (Medina 2000). Other authors prefer to name them “recyclers” (Gutberlet 2011) as a form of recognition of their recycling activities and their contribution to the recycling market in low-income countries. For this work, it has been decided to use “recycler”.

They extract recyclable materials from dumping places, from street bins, communal collection sites, etc. and they sell them in order to enhance their livelihoods (Scheinberg et al. 2006). They perform their activities under poor working conditions which represent a high risk to their health. Numerous studies have shown the presence of diseases connected with waste working (Medina 2000; Countreau 2006; Wilson et al. 2006; Zurbrügg and Schertenleib 1998). Informal recycling contributes significantly to the recycling rates in low-income countries. Table 1 shows some examples of their contribution (UN–HABITAT 2010; Wilson et al. 2009; Scheinberg et al. 2010).

This is reflected by their economic contribution to the formal sector. For example, in Mumbai (India), it was estimated that the cost of the waste system without the informal sector was around USD 44 per ton of waste; however, in cooperation with the informal sector the cost amounts to

Fig. 1 Example of a typical waste management system in low-income countries



USD 35 per ton (Rathi 2006). The same has been noted in Londrina, Brazil, where the integration of informal recyclers in the formal waste management system has cut the cost of waste collection from USD 42 per ton in 2001 to USD 24 in 2003. With respect to social issues, several studies have identified the same problems: child labour, truancy in schools, incomplete school education for adults and poor working conditions (Medina 2000; Wilson et al. 2006; Scheinberg et al. 2006; International Labour 2004).

3.2 Formalisation approaches

Political trends together with socio-economic and environmental problems related to inefficient waste management have led to several low-income countries attempts to bring their systems up to European or American standards (Scheinberg et al. 2006). This modernisation is characterised by a transformation to complex integrated systems with multiple formal stakeholders, a wide diversity of technical operations and the expulsion or rejection of the informal sector (Scheinberg et al. 2006). Despite these innovations, some cities have identified the need to recognise the contribution of the informal sector

Table 1 Examples of the contribution of the informal sector in recycling rates in low-income countries

Country	City	% recycling (formal/informal sector)
Egypt	Cairo	85 (11/74 %)
The Philippines	Manila	25 (2/23 %)
India	Delhi	34 (7/27 %)
The Philippines	Quezon City	39 (8/31 %)
Peru	Lima	20 (0.3/19.7 %)

and its inclusion in formal waste management systems as an effective strategy. As a consequence, some formalisation approaches have been implemented in recent years in order to improve the waste management systems. Various authors have written about the tendencies of the formalisation approaches in low-income countries. Medina (2000) describes some public policies that are based on a negative perception of informal recycling and try to encourage informal recyclers to engage in other occupations in order to reduce their informal activities (Medina 2000). Scheinberg et al. (2006) indicate that this approach fails to recognise that leaving their recycling activities would precipitate a reduction of their incomes to below the minimum level in these countries (Arroyo et al. 1998 cited by Scheinberg et al. 2006).

Alternative formalisation approaches prefer to encourage recyclers' activities. They focus on recognition of the environmental, social and economic benefits of informal recycling. Under this system, authorities support the formalisation of recycling activities, promoting the formation of recycling associations. Commonly, the cooperation scheme is based on the formation of public-private partnerships, collection and recycling contracts with recyclers, etc. (Medina 2000).

Further studies about formalisation in low-income countries describe as main features the creation and support of recyclers' associations, their inclusion in formal waste collection, the creation of a legal framework to support their integration (Peru and Brazil), the improvement of working conditions, betterment of incomes through cooperation contracts with local authorities, the elimination of child labour, educational programmes, diversification of services, etc. Strategies implemented in the Philippines, India, Colombia, Mexico, Brazil and Peru are based on these measures (Wilson et al. 2009; Rathi 2006; Medina 2000; Gutberlet 2011; Scheinberg et al. 2010).

4 Social impact assessment as a part of a sustainability assessment

To establish sustainability, environmental, economic and social issues should be taken into consideration and brought together (Klang et al. 2003; Ness et al. 2007; Klöpffer and Citroth 2011). Currently, there are several techniques for assessing the social impacts within a system. The studies performed by Brouwer and Van Ek (2004), Klang et al. (2003) and Kijak and Moy (2004) are examples of these approaches. They aimed to carry out sustainability assessments, applying different procedures for the social analysis. Common methodological aspects of these studies are the data collection procedures and data sources considered for the study: local social reports, the opinions of social experts and interviews with local stakeholders (citizens, companies, local authorities, etc.). These studies proposed the application of scores, e.g. + or – (Brouwer and Van Ek 2004), 1 to 5 (Klang et al. 2003; Kijak and Moy 2004) and the interpretation of results are performed based on the comparison with international or local social regulations, e.g. (Klang et al. 2003) for the social evaluation of management of demolition waste. Some examples of social aspects already evaluated are the perceptions of citizens in relation to landscape changes, communication (Brouwer and Van Ek 2004), physical and psychological working conditions for the workers in demolition recycling alternatives (Klang et al. 2003), odours and noise emissions, dust, impact on the public health, etc. (Kijak and Moy 2004).

In 2009, the UNEP/SETAC Life Cycle Initiative developed the social life cycle assessment methodology to assess impacts of products during their life cycle. The sLCA uses predominantly semi-quantitative indicators and proposes a list of social impact categories and subcategories to be considered according to international social conventions (e.g. ILO) and the stakeholders involved in a production system. However, the social aspects to be evaluated are constantly changing depending on the system and the stakeholders involved.

5 Development of a social impact assessment methodology for recycling systems in low-income countries

In order to perform a social impact assessment of recycling systems, a methodology was proposed based on different social impact assessment methodologies (including sLCA) and several case studies about the application of these approaches. The methodology follows the four sLCA steps and seeks to adapt them to recycling systems with commonly implemented formalisation approaches. Figure 2 shows a flow chart of commonly implemented formalisation

approaches in low-income countries. In a further paper, the proposed methodology will be tested in three Peruvian recycling systems.

5.1 Goal and scope

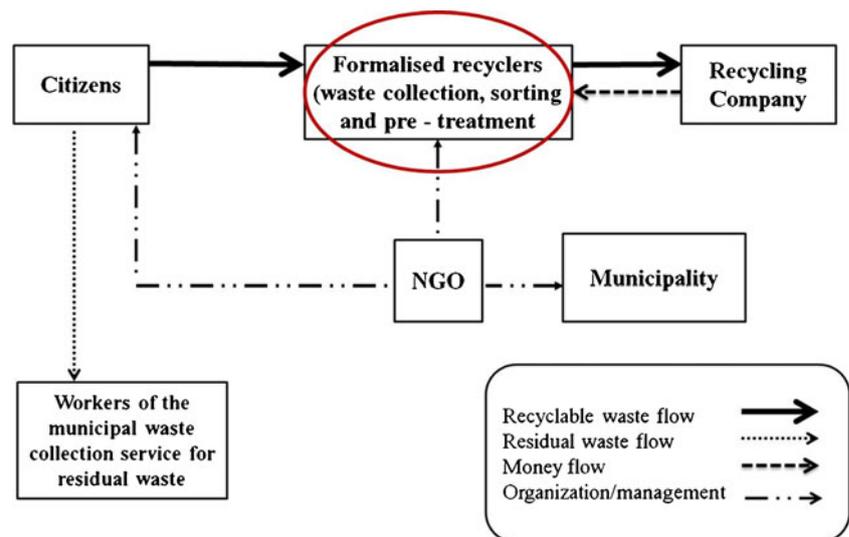
According to UNEP (2009), it is important to delineate the goal and scope in order to define the purpose of the analysis. It will ensure the fulfilment of the final application of the study. Jørgensen et al. (2008) mention two possible main goals of a sLCA: the comparison of products, production processes or companies and the identification of the improvement potential of products or processes.

The goal of this study is the assessment of recycling systems based on formalisation in terms of social impacts, in comparison to informal recycling systems in low-income countries. Formalisation approaches in recycling systems are mainly designed and implemented with the aim of reducing or eliminating the social problems that affect informal recyclers. The related social problems that often occur are in the areas of labour rights, working conditions and educational issues. This assessment attempts to objectively identify and measure the social impacts of frequently implemented formalisation approaches on the formalised recyclers compared to informal recycling systems. In order to perform this assessment, the functional unit is defined as the amount of household recyclable waste collected by one house during 1 year. Using the Peruvian national average waste generation rate and waste composition rate (MINAM. Ministry of Environment 2011), the functional unit is deemed to be 60 kg/inhabitant-year of collected recyclable household waste.

In low-income countries, the collection of recyclable waste can be carried out by the municipality, informal recyclers or formalised recyclers. Defining the functional unit allows for the methodology to be applied to different recycling systems. The recycling activities that are considered for analysis are recyclable waste collection and manual pre processing.

Other stakeholders are linked to recycling systems based on formalisation (e.g. citizens, recycling companies, waste disposal companies, informal recyclers beyond the formalised system, etc.). They can often be socially affected by the implementation of formalisation in relation to, e.g. environmental education and raising awareness, satisfaction about environmental amelioration, job creation, socio-economic impacts caused by the limited access to recyclable materials (for informal recyclers not included in the formalisation measures), etc. However, as the focus of this study is the social impact of formalisation on recyclers, only impacts related to that particular group will be considered. It should be pointed out that this methodology for social impact assessment contemplates only the social impacts occurring

Fig. 2 Formalisation approach based on cooperation with recyclers' associations



as a result of the implementation and actual operation of formalisation. This methodology is not oriented to a preventive approach and does not analyse potential social impacts caused by planned or unimplemented formalisation process.

5.1.1 Impacts categories and subcategories

Social impacts are defined as the consequences of social interactions within a production system (production, use, final disposal) (UNEP 2009). Further studies (Klang et al. 2003; Brouwer and Van Ek 2004; Kijak and Moy 2004) describe social impacts based on an analysis of the stakeholders involved in each process and their relevant social actions. Social impacts can be grouped in categories which can be further subdivided into subcategories, representing the applicable social features to be assessed.

As mentioned above, informal recyclers carry out their activities under inappropriate conditions that often endanger their health and safety. They experience discrimination, poor working conditions, a low level of education, poverty and are sometimes even considered criminals. Their children are often involved in various stages of the picking process (mostly in dumpsites or at home). Children from families of recyclers contribute significantly to the family income (income varies from 10 to 50 % of an adult's income), and for this reason, it is difficult to convince their parents to allow the children go to school (International Labour 2004). Informal recyclers, who are frequently non-organised individuals, survive under very difficult social and physical environments. They are paid a pittance by the middlemen, who have a stronger negotiating position (Medina 2000; Wilson et al. 2006). Regarding health conditions, Medina (2000), Wilson et al. (2006) and Zurbrügg and Schertenleib (1998) have reported the presence of diseases related to contact with waste.

In reference to psychological working conditions, Scheinberg et al. (2006), Medina (2000) and Cozzensa et al. (2006) report

low job satisfaction and other negative psychological impacts because of the lack of employment security, lower social status, dangerous work places, unsatisfactory working conditions, irregular working hours and isolation, etc.

In order to measure the social effects of formalisation approaches, the social impact categories and subcategories in this study were chosen from a review of literature on the social problems of informal recyclers in low-income countries, and previous studies related to social assessment in general. The social impact categories that represent the social problems of recyclers were identified as human rights, working conditions and socio-economic repercussions.

It should be mentioned that the selected categories and subcategories relating to workers were also applied by others' social assessments on products (Manhart and Griebhammer 2006). Within the selected social impact categories, there are nine subcategories, which describe more precisely these social issues. Table 2 shows the social impact categories and subcategories to be assessed.

5.1.2 Social indicators

UNEP (2009) and Jørgensen et al. (2008) discuss the use of quantitative, qualitative and semi-quantitative indicators. The last is defined as a numerical description of qualitative information by using different scoring systems. The second criterion for the formulation of indicators is their direct or indirect measurement of the phenomena that cause the social impact. Direct indicators are a traditional quantitative and one-dimensional representation of a social impact (Jørgensen et al. 2008; Dreyer et al. 2006). One example is the frequently used indicator "number of employees under 15 years old" (Dreyer et al. 2010). This indicator measures child labour. However, further aspects pertaining to local context or special situations like the social responsibility of a company are not considered.

Table 2 Social impact categories, subcategories and indicators for sLCA for recycling systems

Impact category	Impact subcategory	Indicator
Human rights	Child labour	No child labour
	Discrimination	Formal policy against discrimination No income differences between women and men
Working conditions	Freedom of association and collective bargaining	Presence of collective bargaining
	Working hours	Fulfilment of overtime agreed in working contracts
	Minimum income, fair income	Average income according to legal framework
		Absence of non-agreed income deductions
	Recognised employment relationships and fulfilment of legal social benefits	Regular payment for the workers
		Minimum income according to legal framework
		Existence of legal working contracts for all workers
		Access to legal social benefits
	Physical working conditions (health, security, working equipment)	Access to further social support programmes for workers
		Absence of work accidents
Formal policy about occupational health and safety		
Vaccination for workers		
Training programmes for workers regarding occupational health and safety		
Access to preventive health care programme for workers		
Presence of medical equipment at the working place for the workers' use		
Absence of diseases related to waste handling		
Appropriate working equipment		
Psychological working conditions		Willingness to continue working in the same company or sector
	Work satisfaction	
Socio-economic repercussions	Education	Willingness to be trained regarding the work activities
		Educational level of children from families of recyclers
		No school absence of children from families of recyclers
		Existence of educational programmes for self-development

The authors define indirect indicators as those based on preventive social measures. These indicators aim to assess the preventive management effort of a company rather than the reported impacts (Jørgensen et al. 2008). One example of these indicators can be the presence of management measures to ensure training for workers in relation to safety and occupational work, instructions for the safe use of machines, etc. (Dreyer et al. 2010).

This study defines 26 semi-quantitative indicators for the assessment of social impact subcategories. Among these, three indirect indicators are proposed. They are related to prevention policies regarding discrimination, occupational health and safety and training programmes. An attempt has been made to combine the use of direct and indirect indicators in order to more accurately detect the risk of threats to or negative effects on the social issues. Table 2 shows the selected social categories, subcategories and the indicators adopted.

Through research about the situation of informal recyclers in low-income countries, the most common social

problems affecting them were identified. As already described the social impact categories and subcategories as well as their indicators were proposed according this information. One common human rights concern in informal recycling is the presence of children working as informal recyclers at dumps and on the streets. They help their families by picking materials or sorting at home (International Labour 2004). Formalisation approaches seek to eliminate child labour. In order to measure the social performance of this issue, the indicator “no child labour” was defined. Further studies report the presence of discrimination particularly impinging upon gender, religion, social rejection, physical disability, etc. (Medina 2000; Wilson et al. 2006). Some of these forms of discrimination are somewhat typical for the country or region. The formalisation approaches implemented in low-income countries have a task of reducing or eliminating the factors which cause discrimination. Gender discrimination often manifests itself in lower incomes for women. A lack of strength, care children at home, pregnancy, etc. means women collect

lower waste amounts than men and they are not able to earn enough. Diverse formalisation approaches with special measures to deal with this topic were implemented in, e.g. The Philippines, India, Colombia and Brazil (Wilson et al. 2009; Mahadevia et al. 2005; Terraza and Sturzenegger 2010). The indicator “no income differences between women and men” was defined in order to identify the positive or negative performance of the formalisation approaches in relation to this matter. The indicator “formal policy against discrimination” also seeks to measure indirectly the risk or probability of discrimination within the formalised recycling activities.

Organising informal recycling has important consequences for income generation, working conditions and social status (Wilson et al. 2006). Several formalisation approaches are based on the organisation of recyclers and creation of recyclers’ associations. Wilson et al. (2000), Wilson et al. (2006) and further studies assert that this factor is essential for successful formalisation. The positive effects reportedly emanating from this measure are increased income, cooperation contracts between the recyclers and other stakeholders, diversification of services and the empowerment of recyclers. These experiences have led to the indicator “presence of collective bargaining and associations” to be chosen. The presence of active collective bargaining and associations validates a positive performance in reference to this impact subcategory.

Informal recyclers are notably vulnerable to long working hours, low incomes, unfair payments for the materials that they recover and sell to middlemen, and both variability and insecurity in their daily income. Formalisation approaches seek to eliminate this predicament by ensuring fair incomes in line with the legal minimum in the country, fair prices for recyclable material (fair trade of material from recyclers’ associations to recycling companies), etc. Furthermore, cooperation contracts between the authorities and formalised recyclers are signed in order to ensure the collection service and stabilise incomes for the recyclers. Some examples are described by Gutberlet (2011) in relation to the formalisation implemented in Londrina and Diadema, Brazil. The indicators chosen for the subcategories working hours and minimum, fair income try to determine if the formalisation approaches implemented fulfil their respective goals.

The target of formalisation approaches is to organise informal recyclers and to legalise their situation and their activities. Several studies on the general situation of informal recyclers in low-income countries report their illegal status, the failure to recognise their work, precarious daily incomes, expulsion from waste areas or a prohibition on gathering waste and a lack of access to social benefits, e.g. social security, insured pension plan, etc. (Scheinberg et al. 2006; Wilson et al. 2006; Medina 2000). Often, the formalisation approaches seek to mitigate these problems by

legalising their activities through cooperation contracts or public–private partnerships between the recyclers’ associations and local authorities or private stakeholders (Scheinberg et al. 2006). Recognised, legal business relationships are created, opening access to social support programmes and legal social benefits.

This methodology proposes indicators for legal work contracts, access to social benefits and social support programmes in order to evaluate whether the objectives of legitimising working activities and the creation of access to social support have been achieved.

Multiple studies about the general situation of informal recyclers in low-income countries report poor working conditions as a main problem. Informal recyclers work in hazardous conditions. They move waste around, searching for material, and are exposed to disease vectors, animals, infectious agents, injuries, etc. Formalisation approaches normally include several measures for the improvement of physical working conditions: accident prevention training programmes, occupational health policies, the implementation of preventive health care programmes including vaccination, work equipment, etc. This methodology seeks to determine the fulfilment or otherwise of the requirements that improve the quality of working conditions for recyclers involved in formalisation approaches. Two indicators are indirect and are based on preventive management measures (a policy regarding occupational health and safety, and training programmes about occupational health). The other indicators are directly related to current aspects of appropriate physical working conditions. For example, the presence of basic medical equipment in the working place which facilitates an adequately rapid response to work accidents as learned in the training programmes.

Concerning psychological working conditions, several studies assert that waste picking is related to low job satisfaction and further negative psychological impacts on informal recyclers because of the lack of employment security, lower social status, dangerous work places and working conditions, irregular hours and isolation, etc. (Scheinberg et al. 2006; Medina 2000; Cozzensa et al. 2006).

In order to measure the psychological working conditions, Klang et al. (2003) researched this point using workers at demolition waste recycling plants. The authors evaluated the percentage of workers that would considering remaining within the field and their willingness to continue with further training related to their work. Jørgensen et al. (2008) report the frequent use of psychological working conditions evaluations in terms of job satisfaction.

The primary goal of formalisation approaches is the improvement of working conditions. Stress and psychologically negative situations at work should be eliminated through formalisation. The organisation of recyclers and stimulation of their participation as formal stakeholders,

etc. strengthens their rights and social status. In this paper, the methodology proposed for the evaluation of work satisfaction is the willingness to receive job training and to continue working in the field. It is intended to measure the satisfaction level of the formalised recyclers only in relation to their recycling activities. Happiness or satisfaction in other areas of their lives is not evaluated.

For the assessment of the impact category socio-economic repercussions and the corresponding impact subcategory education, three indicators are proposed. As previously described various studies have reported child exploitation in waste picking activities in low-income countries (International Labour 2004; Medina 2000; Scheinberg et al. 2006; Wilson et al. 2006). Children work at dumps, on streets and also at home helping the parents to with the daily income. This makes it difficult to convince their parents to let the children go to school. Formalisation approaches strive to promote the presence of children of recyclers in schools. The purpose of the indicators proposed is to measure the performance of formalisation approaches in relation to school absence and the educational standard of children of recyclers which should be at the national average school level according to age group.

A further objective of formalisation approaches is to promote adult educational programmes for recyclers in order to support their self-development and social status. Informal recyclers often have a poor education and they do not have the chance to complete it (Wilson et al. 2006; Medina 2000). Several cities like Joao Pessoa in Brazil (Pimentel and Coutinho 2005) have implemented educational programmes as a part of a formalisation process (Scheinberg et al. 2006). The proposed methodology tries to determine whether this aspect in the evaluation of formalisation approaches has been fulfilled or not.

5.2 Social life cycle inventory

UNEP (2009) mentions as data collection methods both desktop research and local data collection through interviews with stakeholders involved into the system. In order to obtain balance, a comparison of the information given by the stakeholders is preferred. Jørgensen et al. (2008) support using local data and recommend that the data collection must be related to this local level and to the stakeholders within the evaluated system.

For recycling systems based on formalisation approaches, the major stakeholders involved in the implementation and operation of the formalisation will be interviewed (e.g. municipalities, recyclers, NGOs, etc.). As previously mentioned, there are other stakeholders within a recycling system (e.g. citizens, recycling companies, etc.). Since the data needed for the assessment are related to specific aspects about the implementation and functioning of the formalisation, the stakeholders to be interviewed are those who are directly involved in it.

A checklist of 56 closed and open-ended questions has been developed in order to collect the relevant information for the social assessment. They aim to obtain precise and logical answers in order to make a score assignment 1 or 0 (compliance or non-compliance of social criteria) possible. The same check list will be applied to all stakeholders with the exception of the subcategory psychological working conditions. In this case, the interviews will only be carried out with the formalised recyclers and workers at the recycling plant.

5.3 Life cycle impact assessment

5.3.1 Characterisation

Currently there is no international consensus on a characterisation method for social impacts. UNEP (2009) asserts that a scoring system can also be used in order to evaluate and interpret the social data. Dreyer et al. (2010) developed a methodology oriented towards a preventive approach that assesses social management measures and uses an elaborated scoring system. Spillemaeckers et al. (2001) developed a characterisation approach based on semi-quantitative indicators and the application of the scores 1 and 0 representing fulfilment or non-fulfilment of the social criteria (international or local social conventions). The average of the scores for each impact subcategory can subsequently be calculated. This approach concentrates on the assessment of human rights and working conditions and does not consider the social context of the company.

The characterisation procedure for this methodology proposes the application of a score system for each indicator and assigns the values 1 and 0, respectively, for the fulfilment or non-fulfilment of the social compliance criteria. The answers given by each stakeholder interviewed regarding fulfilment will be transformed into these values. Because several stakeholders will be interviewed, the average score for each indicator can be calculated.

$$\frac{\sum_{i=0}^n S_i}{n}$$

5.3.2 Equation calculation of average score

S_i = Score for indicator i given by the stakeholder i
 n = number of stakeholders interviewed

The result for each of the 26 indicators will be an average decimal score between 0 and 1. The average score calculated for each indicator represents the proportion of stakeholders affirming fulfilment of the social criterion. To interpret these average decimal scores, the following fulfilment criterion is applied: an average score of less than 0.5 denotes that the criterion for the positive evaluation of the indicator was not fulfilled and the score is rounded down to 0. In the

case that the average score reaches 0.5 or higher, the criterion for the positive evaluation of the indicator is fulfilled. The average score is then rounded up to 1. The reason for this interpretation is that at least 50 % of the interviewees (score 0.5) have to report the fulfilment of the social criterion.

Regarding the indicators for the impact subcategory psychological working condition, the only stakeholders to be interviewed are the recyclers. Score assignment and fulfilment criteria have been defined differently for the indicators of both impact subcategories. A scale of 1 (very bad), 2 (bad), 3 (medium), 4 (good) and 5 (very good) will be used by the recyclers to signify degrees of satisfaction. In order to transform the scores obtained to a similar scale to the one used by the indicators in other subcategories (0 or 1), the values of 0, 0.25, 0.5, 0.75 and 1 for the scale 1, 2, 3, 4 and 5 will be assigned, respectively. When the average scores given by the recyclers are calculated, a number higher than “medium” (0.5) means the fulfilment of the social criterion for the indicator and it receives the final score “1”. An average score lower or equal than 0.5 means non-fulfilment of the social criterion and the final score “0” is designated.

After obtaining the average scores of the 26 indicators, the score for each subcategory will be calculated and interpreted as follows: when all indicators within a subcategory obtain the score “1”, the subcategory obtains the overall evaluation “1” meaning the fulfilment of all the social criteria for the subcategory. In the case that one or more indicators within a subcategory receive “0”, the subcategory obtains the overall evaluation as “0” meaning the non-fulfilment of the social criteria related to the subcategory. Each indicator within a subcategory represents a basic social aspect to be fulfilled in accordance with social regulations. In order to achieve a positive result, all subcategory indicators have to be evaluated with “1”. It is important to mention that although this evaluation is based on scores, these results are not relevant as numeric values. The aim is to show the differences between the case studies in terms of their social aspects. The results indicate which aspects of a formalisation strategy are favourable or not.

6 Conclusions

This methodology was proposed to identify and measure social impacts caused by the implementation of formalisation approaches in recycling systems in low-income countries. Currently, different social impact assessment methodologies analysing products and productions chains have been established but no methodological approach exists for recycling systems. It can be concluded that impact categories related to the main social problems of informal recyclers have been identified. More detailed issues are addressed by the impact

subcategories and indicators as defined in this paper. By defining the functional unit as “60 kg/inhabitant-year of collected recyclable household waste”, it would be possible to assess social impacts before and after the implementation of formalisation approaches. This methodology focuses on the social impacts on recyclers, who perform the same service but under different conditions.

At the same time, this methodology measures social impacts caused by recycling systems after their implementation. Its application for assessing future scenarios is contentious. Several social factors such as regulations, tendencies, perceptions of satisfaction, quality of life, etc. can change and cannot be precisely predicted. The applicability of this methodology and its validation will be tested through further research in three Peruvian cities with different recycling systems.

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Paper 3

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Social assessment of recycling systems – Peruvian case studies

1 Sandra Aparcana MSc

PhD student, Institute of Waste Management, University of Natural Resources and Life Sciences, Vienna, Austria

2 Roland Linzner MSc

Research associate, Institute of Waste Management, Department Water – Atmosphere – Environment, University of Natural Resources and Life Sciences, Vienna, Austria

3 Stefan Salhofer PhD, Dipl Ing

Associate professor, Waste Logistics, Institute of Waste Management, University of Natural Resources and Life Sciences, Vienna, Austria



Several formalisation approaches of informal recycling have been implemented in developing countries, aiming at its integration into formal recycling systems. These strategies are often implemented through the initiative of local recyclers and non-government organisations. The aim is to tackle not only the poor economic situation but also common social problems of the informal recycling sector, such as social rejection, lack of education and inappropriate health and working conditions. Nevertheless, the expected positive social impacts are not precisely assessed or measured. This paper aims to develop a methodological approach based on the social life cycle assessment methodology for the assessment of recycling systems in developing countries with implemented formalisation measures. A field study in three Peruvian cities shows the feasibility of applying this methodology for assessing recycling systems. The case studies displayed negative performances regarding the indicators of discrimination, recognised employment relationships, and fulfilment of social benefits, physical working conditions and access to education. Regarding freedom of association, psychological working conditions and social acceptance, the city with formalisation of (formerly informal) recyclers obtained better evaluations whereas the city without formalisation was better evaluated in terms of working time and minimum and fair wages.

1. Introduction

The informal sector plays an important role in waste management systems in developing countries. It is defined as individuals or groups (mostly socially and economically disadvantaged people) who carry out various activities within the waste management system (collection, recycling, treatment and disposal). The informal sector focuses mainly on the collection of recyclable materials and therefore contributes significantly to the recycling rates of many cities in developing and emerging countries. For example, in Lima and Callao (Peru), about 19.7% of the municipal waste is recycled by the informal sector and only about 0.3% is recycled by the formal sector (Scheinberg *et al.*, 2010). The informal sector carries out recycling activities under inappropriate conditions that often endanger the health and safety of the people working in this sector. The sector consists of children, pregnant women, elderly and other people who have no opportunity to work in the

formal sector and therefore find work in the informal sector (Wilson *et al.*, 2006). In most cases the economic contribution of this sector to formal waste management systems, and its environmental and social benefits, are not recognised. For this reason, these informal activities are frequently perceived in a negative way. In many developing countries the informal sector is rejected and policies to eliminate informal recycling activities are implemented (Medina, 2000). As a solution, ‘modernisation’ measures are frequently proposed involving the application of the best available technologies that come from industrialised countries. Regrettably, these approaches do not consider the integration of the informal sector, and cause more problems than solutions (Wilson *et al.*, 2006).

Despite these ‘modernisation’ trends and because of the positive environmental and economic contributions of this sector, some cities have identified the need to recognise the contribution of

the informal sector and include it in formal recycling systems as an effective strategy. For this reason over recent years formalisation strategies are being implemented through the initiative of non-government organisations (NGOs) in cooperation with informal recyclers to improve and secure their economic situation and to eliminate or reduce social problems linked to their activities (child labour, inappropriate working conditions, lack of education, and so on). In some cities, for example in India, Peru, Brazil, the Philippines and Colombia, formalisation strategies based on the cooperation of NGOs, recyclers and local authorities have been implemented (Gutberlet, 2011; Medina, 2000; Rathi, 2006; UN-Habitat, 2010; Wilson *et al.*, 2009).

With the implementation of this formalisation, a reduction or elimination of the associated social problems is expected. However, these positive social impacts are mainly assumed and are often not precisely assessed. In order to analyse and evaluate the formalisation strategies in relation to their contribution to social sustainability of recycling systems in developing countries, the present research has developed an approach based on the social life cycle assessment (sLCA) methodology. A literature review on the current status of social impact assessment methods including sLCA was performed with the intent of proposing this methodology. Based on a literature research the developed methodology considers the assessment of three social impact categories that are strongly related to the recyclers: human rights, working conditions and society. These are also subdivided into ten social impact subcategories and measured through 27 semi-quantitative indicators. Some examples of these indicators are the non-existence of working children (child labour), the absence of unjustified wage reductions and full access to health care programmes.

The methodological approach was tested in three Peruvian case studies. Two case studies relate to cities with recycling systems based on the inclusion of formalised recyclers (model based on formalisation) and the third case looks at a conventional recycling system entirely operated by the municipality, without integration of recyclers (model without formalisation). The information was collected through interviews with local stakeholders linked to these recycling systems. The tested impact categories, subcategories, indicators and characterisation procedures are analysed regarding their feasibility of application for the social assessment of recycling systems.

2. Methodology research: social life cycle assessment

2.1 Definition

In the guidelines of the United Nations Environment Programme (UNEP) the sLCA is defined as a methodology to assess the social or socio-economic aspects of products and

their potential positive or negative impacts through their life cycle. It complements the environmental life cycle assessment and can be used on its own or in combination with it (UNEP-SETAC Life Cycle Initiative, 2009). The guidelines for the sLCA of products (UNEP-SETAC Life Cycle Initiative, 2009) emphasises the need for a clear definition of the aims, the scope, the identification of stakeholders of the product chain value, their role and their social interactions. On the other hand it is pointed out that there is no standardised list of social aspects to be considered. The assessed social aspects can be different depending on the product or production process and the stakeholders linked to them. According to Jørgensen *et al.* (2008) and Dreyer *et al.* (2006) the social impacts have no causal link with the product or production process, unlike the environmental impacts directly caused by the production processes. The possible cause of the social impacts is the social conduct of the companies that perform the production processes.

2.2 Impact categories and subcategories

Several studies (Brouwer and Van Ek, 2004; Kijak and Moy, 2004; Klang *et al.*, 2003) define the social impacts based on analysis of stakeholders involved in each process and their relevant social actions. The UNEP-SETAC Life Cycle Initiative (2009) indicates the same, and that the social categories and their subcategories should also reflect the internationally recognised social standards. Several authors (Dreyer *et al.*, 2006; Flyskö *et al.*, 2008; Jørgensen *et al.*, 2008; Spillemaeckers *et al.*, 2001) propose the social impact categories and subcategories according to the human rights and working conditions presented by the International Labour Organisation (ILO) conventions. They also recommend considering further international social standards (e.g. the universal declaration of human rights, the United Nations declaration on economic, social and cultural rights, and so on).

2.3 Indicators

With regard to the indicators, UNEP-SETAC Life Cycle Initiative (2009) distinguishes the use of quantitative, qualitative and semi-quantitative indicators. The last of these is defined as a numerical description of qualitative information by using different scoring systems. They are capable of measuring and describing socially complex phenomena through simple physical units by using scoring systems. Jørgensen *et al.* (2008) and Dreyer *et al.* (2006) additionally indicate a second criterion for the development of indicators, which is the direct or indirect measurement of the social phenomenon that causes the impact.

These authors define a direct indicator as the traditional quantitative and one-dimensional representation of a social impact. It is assumed that social impacts can be directly quantified through one-dimensional units. One example is the

Q2 frequently used indicator ‘number of employees under 15 years old’ (Dreyer *et al.*, 2010ab). This indicator measures child labour using the number of working children. However, further aspects that depend on local context or special situations, like the social responsibility of a company through the inclusion of children to a working life and letting them gain working skills according to their age, are not considered.

The authors define indirect indicators as those based on preventive social measures. These indicators aim to assess the management effort of the company rather than the reported impacts (Jørgensen *et al.*, 2008). They analyse the risk of negative impacts and the effectiveness of the management system. Dreyer *et al.* (2006) explained an example related to the working safety, where safety at the workplace does not always have any connection with the frequency of accidents in the workplace. It is asserted that safety can not only be evaluated by statistical data-based indicators, but also through the use of indirect indicators, which the company may implement to reduce accidents/risks and to improve working conditions. Some examples of these indicators can be the presence of management measures ensuring the training of workers in relation to safety and occupational work, instructions on the safe use of machines and so on (Dreyer *et al.*, 2010ab).

2.4 Characterisation and aggregation

Q3 In general in life cycle assessment studies the impact assessment is performed based on a ‘cause–effect’ impact pathway (Dreyer *et al.*, 2006). Currently there is no international consensus about the characterisation method for social impacts and the modelling method for such ‘cause–effect’ pathways. Dreyer *et al.* (2010ab) developed a methodology for the characterisation of impact categories in the context of a sLCA. This methodology is oriented on a preventive approach that assesses social management measures and seeks to determine the potential social impacts caused by a company in the life cycle of a product. A further important aspect of this characterisation approach is the consideration of the social context where the company operates. The social context involves the actual situation regarding frequency and severity of labour rights violations according to the different geographic locations and industries (Dreyer *et al.*, 2010ab).

Q4 Another methodological approach for the characterisation was developed by Spillemaeckers *et al.* (2001). The author proposes a methodology to assess actual social impacts and develop a characterisation approach using mainly direct semi-quantitative indicators. Scores regarding the compliance or non-compliance of social criteria are assigned (1 for compliance and 0 for non-compliance). This approach is also oriented to the assessment of human rights and working conditions and does not consider the social context of the company.

3. Description of case studies and data collection

The study conducted to test the developed methodology was conducted in three Peruvian cities: San Vicente de Cañete, the Colca valley and Santiago de Surco. San Vicente de Cañete is located on the central coast of Peru, 140 km south of Lima city (capital of Peru). The district is close to the Pacific Ocean and is also part of the watershed of the Cañete river. It has a flat topography and its altitude varies from 0 to 185 m. San Vicente de Cañete has a climate with temperatures between 14°C and 28°C. The district has an estimated population of 48 892 people with a population growth rate of 2.7% for the year 2008 (UN–Habitat, 2010). The city has a recycling system based on the formalisation of informal recyclers. This system was developed through the initiative of the local NGO IPES and formalised recyclers.

Q6 The second case study with a recycling system based on formalisation is the Colca valley, located on the Caylloma province, 150 km from Arequipa city, Peru at an altitude in the range of 3000–5000 m above sea level. The valley is 100 km long and the temperature varies between 0 and 20°C (see <http://www.colcaperu.gob.pe/>). The Colca has 19 districts and five of them (Callalli, Yanque, Lari, Madrigal and Chivay) are involved in the recycling system based on formalisation. These five districts combined have 11 647 inhabitants (DESCO, D. Poma, coordinator of Colca valley recycling project, personal communication, 2011). In this case the initiative to create a recycling system based on formalisation of recyclers came from the local NGO DESCO. The NGO worked with informal recyclers in order to formalise them by forming recyclers’ associations.

Q7 The third case study is Santiago de Surco, located at the occidental centre of Lima, Peru, 68 m above sea level. It has an area of about 42 m² and a climate with temperatures varying between 15°C in winter and 27°C in summer. Surco has a population of 272 690 people with a population growth rate 2.8% (see <http://www.munisurco.gob.pe/distrito/distrito.htm>). In this city the recycling system operates exclusively under the management of the municipality, without the participation of recyclers found in the other two case studies. The recycling system was implemented exclusively through the funding and support of the municipality.

The recycling model based on formalisation of recyclers (case studies of Colca valley and San Vicente de Cañete) has as stakeholders the municipality, a NGO and the recyclers’ association (formerly informal recyclers), who cooperate towards the implementation of the system. Whereas the NGO develops and finances the project implementation, the municipality authorises the access of the recyclers to households and permits the formal collection of recyclable materials. The formalised

recyclers collect recyclable materials from households for free and perform a more accurate manual separation in sorting centres in order to sell the recyclable materials on the local recycling market. Under this model the income of the recyclers depends entirely on the price and quantity of material sold, and on the number of participating citizens. Some social measures include awareness-raising campaigns, so that the population identifies with the recyclers, vaccination campaigns, access of recyclers to preventative health measures and improvement of work equipment.

Q8

In contrast to this, the conventional recycling system (case study Surco) is operated exclusively by the municipality (without participation of recyclers). The waste collection is conducted door to door using waste collection vehicles and the exact separation is done at a recycling plant by using a sorting system with simple technology. The workers receive a fixed income that does not depend on the amounts of materials sold. Social measures in this model are mainly related to the improvement of working conditions and to the access to health and social

insurance. Table 1 provides general information about the three case studies that represent these recycling models.

4. Results and discussion

4.1 Development of a methodology for social assessment of recycling systems

The formalisation strategies are designed and implemented with the purpose of reducing or eliminating the social problems that affect informal recyclers. Social problems very often occur in the areas of labour rights, working conditions, educational issues and social inclusion. The aim of the present work is the development of a methodology for assessing the social impacts of these formalisation strategies.

Many other stakeholders are linked to recycling systems with formalisation strategies (e.g. citizens, recycling companies, waste disposal companies, informal recyclers who are not included in the implemented formalisation, etc.). They can often be affected by the implementation of formalisation

City	Recycling model	Stakeholders	Collection rate of recycling system	Collected materials	Number of workers	Hiring strategy	Income	Presence of informal recyclers outside the assessed recycling system
Cañete (Lima)	Based on formalisation of recyclers	NGO, formalised recyclers and municipality	15%	Glass, plastics, paper, cardboard and metals	6	Cooperation agreement between the municipality and association of recyclers permitting access to households and collection of recyclable materials	Variable income based on the amounts of sold recyclable material	Yes (unknown quantity)
Colca (Arequipa)			10%		14			
Surco (Lima)	Conventional system (operated by the municipality without participation of recyclers)	Municipality and formal workers at the recycling plant	38%		35 (at the recycling plant)	Workers at the recycling plant have working contracts as formal employees with the municipality	Fixed income	

Table 1. Case studies: detailed information about the assessed recycling systems

measures in aspects related to environmental education and awareness raising, satisfaction related to contribution to the environment (e.g. citizens), job creation potential (in disposal companies through a cooperation with formalised recyclers), socio-economic impacts caused by the decrease of recyclable materials to be collected or the access limitation to these materials (for informal recyclers who are not included in the formalisation measures) and so on. However, this study focuses solely on the social impacts of formalisation strategies on formalised recyclers. It should be pointed out that this methodology considers only actual social impacts and does not analyse potential social impacts caused by formalisation strategies not yet implemented or still in planning.

4.1.1 Social impact categories and subcategories

Several studies on sLCA and other methods for social impact assessment of products and production chains (Dreyer *et al.*, 2006; Flyskö *et al.*, 2008; Jørgensen *et al.*, 2008; Spillemaeckers *et al.*, 2001; UNEP–SETAC Life Cycle Initiative, 2009) take into account social impact categories based on international social conventions (e.g. International Labour Organisation (ILO) conventions) and local legal framework. A recycling system is not a production company and other stakeholders are involved within the system (e.g. recyclers, NGOs, associations, municipalities and so on). Nevertheless, social impacts in recycling systems very often also occur in the area of human and labour rights (e.g. child labour, discrimination, poor working conditions, exploitation, poor education opportunities). For this reason, determination of the social impact categories and subcategories through the case studies is oriented towards issues relating to human and labour rights conventions and educational opportunities. Table 2 shows the selected social impact categories and subcategories to be assessed.

4.1.2 Indicators

Based on the indicators suggested by previous studies 27 semi-quantitative indicators are proposed for this methodology (see Table 2). The indicators are developed according to the impact categories that affect the formalised recyclers. Among the semi-quantitative indicators, three indirect indicators can be identified. They are related to prevention policies regarding discrimination, occupational health and safety and training programmes. An attempt is made to combine the use of direct and indirect indicators in order to detect more accurately the risk of social issues that are threatening or have a negative effect.

4.1.3 Characterisation approach

The proposed characterisation methodology is based mainly on the approach suggested by Spillemaeckers *et al.* (2001). The developed methodology proposes the application of a score system and assigns the following numerical values: 1 for the

fulfilment and 0 for the non-fulfilment of the social criteria. The methodology developed in this work does not include the social context, like the methodology proposed by Dreyer *et al.* (2010ab), and does not consider any compliance degrees; therefore the result of each indicator will be either 1 or 0. The answers given by each interviewed stakeholder are transformed into these values. After the assignment of score values, the average score for each indicator should be calculated (Equation 1). This is determined by summing the scores given by each stakeholder and dividing the sum by the number of stakeholders interviewed

$$1. \quad \frac{\sum_{i=0}^n S_i}{n}$$

where S_i is the score of indicator i and n is the number of interviewed stakeholders.

This calculation is done for each indicator (27 average scores corresponding to 27 indicators). As a result, decimal numbers between 0 and 1 will be obtained for each indicator. The average score calculated for each indicator represents the stakeholders' proportion that affirmed the fulfilment of the social criterion. In order to interpret these decimal average scores the following fulfilment criterion is applied: when the average score is less than 0.5, it means that the criterion for the positive evaluation of the indicator was not fulfilled and the average score for the evaluated indicator is rounded down to 0. In the case where the average score reaches 0.5 or higher, the criterion for the positive evaluation of the indicator is fulfilled. The average score is rounded up to 1. The reason for this interpretation is that at least 50% of the interviewed stakeholders (at least 0.5) have to report the fulfilment of the social criteria.

Regarding the indicators for the impact subcategories 'psychological working conditions' and 'social inclusion', the only interviewed stakeholders are the recyclers. The score assignment and fulfilment criteria are defined differently for the indicators of both impact subcategories. A scale of 1 (very bad), 2 (bad), 3 (medium), 4 (good) and 5 (very good) will be used by the recyclers in order to assign degrees of satisfaction and social acceptance. In order to transform the scores obtained to a similar scale as is used by the indicators in other subcategories (0 or 1), the following values were also assigned: 0, 0.25, 0.5, 0.75 and 1 for the scale 1, 2, 3, 4 and 5 respectively. The average of the scores given by the recyclers is calculated. An average score higher than 'medium' (0.5) means the fulfilment of the social criterion for the indicator of work satisfaction and it receives the final score of '1'. An average score lower than or equal to 0.5 means non-fulfilment of the social criterion and the final score '0' is assigned.

Q9

After obtaining the average scores of the 27 indicators, the score for each subcategory is calculated and interpreted as follows: when all indicators within a subcategory obtain the score ‘1’, the subcategory obtains the overall evaluation ‘1’, meaning the fulfilment of all the social criteria for the subcategory. In the case where one or more indicators within a subcategory receive ‘0’, then the subcategory also obtains the overall evaluation of ‘0’, meaning the non-fulfilment of the social criteria of the subcategory. Each indicator within a subcategory represents a basic social aspect to be fulfilled in accordance with social regulations. In order to obtain a positive evaluation of the subcategory, all indicators have to be evaluated with ‘1’.

The methodology considers that the indicators are equally important and no weighting system is applied for the score calculation. However, when using this methodology for a real decision-making process the application of a weighting step depends on the involved stakeholders and their criteria for establishing priority about the social aspects to be assessed. It is important to mention that although this evaluation is based on scores, these results are not relevant as numerical values. The aim is to show the differences between the case studies in terms of their social aspects. The results indicate which aspects of a formalisation strategy are favourable and which are not.

Impact category	Impact subcategory	Indicator	
Human rights	Child labour	No child labour	
	Discrimination	Formal policy against discrimination No wage differences between women and men	
Working conditions	Freedom of association and collective bargaining	Presence of collective bargaining	
	Working hours	Fulfilment of overtime agreed in working contracts	
	Minimum wages, fair wages	Average wage according to legal framework Absence of non-agreed wage deductions Regular payment for the workers Minimum wage according to legal framework	
	Recognised employment relationships and fulfilment of legal social benefits	Existence of legal working contracts for all workers Access to legal social benefits Access to further social support programs for workers	
	Physical working conditions (health, security, working equipment)	Absence of work accidents Formal policy about occupational health and safety Vaccination for workers Training programmes for workers regarding occupational health and safety Access to preventive health care programme for workers Presence of medical equipment at the workplace for the workers' use Absence of diseases related to waste handling Appropriate working equipment	
	Psychological working conditions	Willingness to continue working in the same company or sector Work satisfaction Willingness to be trained in relation to work activities	
	Society	Accessibility to education	Educational level of children from recyclers' families No school absence of children from recyclers' families Existence of educational programmes for self-development
		Social acceptance/social inclusion	Perception and acceptance of the recycling activities by citizens

Table 2. Social impact categories, subcategories and proposed indicators for sLCA for recycling systems

4.1.4 Data collection

Regarding the data collection for assessing the social impacts, this field study took into consideration the recommendations of previous studies and considered interviews with involved stakeholders as the main local information sources. For the two case studies with recycling systems based on formalisation, interviews with the municipalities, recyclers and NGOs were conducted. In the case of the conventional recycling system (operated only by the municipality and without participation of recyclers), only the stakeholders municipality and workers at the recycling plant were interviewed. In this case there is no project developer.

A checklist of 56 closed-ended and open-ended questions was applied in order to collect the relevant information for the assessment of the social impact categories and their subcategories. The purpose was to obtain precise and logical answers regarding the social impact of the formalisation measures to make possible the assignment of the scores 1 or 0 (compliance or non-compliance with social criteria). The same checklist was applied for the interviews with all stakeholders, with the exception of the data collection for the subcategories ‘psychological working conditions’ and ‘acceptance and social inclusion’.

For psychological working conditions, the interviews were carried out only with the formalised recyclers (system based on formalisation) and workers at the recycling plant (conventional system). They are considered to be the most reliable source of information regarding work satisfaction and further indicators of this subcategory. With regard to acceptance and social inclusion, only the recyclers from the two cities with

recycling systems based on formalisation were interviewed, not the workers from the conventional recycling system. The data collection for the indicator ‘perception and acceptance of the recycling activities by citizens’ was based on the impression of the recyclers regarding the degree of acceptance or rejection by the citizens with respect to their recycling activities in the city. The formalised recyclers carry out the collection door to door and receive feedback from the citizens about their acceptance.

By contrast, the workers from the conventional system work only at the recycling plant and have no direct contact with citizens during door to door collection. The question related to acceptance and social inclusion was not addressed to the workers in the conventional recycling system. Because of the lack of time and resources, no direct interviews with citizens were performed.

4.2 Social assessment of the three recycling systems

Table 3 shows the results of the social assessment for the three case studies. The assessment displays similar negative performances of the two recycling models regarding the social subcategories ‘physical working conditions’, ‘recognised employment relationships and fulfilment of social benefits’, ‘discrimination’ and ‘access to education’. Although both models (represented by the three cities) show an improvement of working conditions compared with the situation before the implementation of the formalisation measures (poor health and working condition, waste picking on the streets and dumps, social rejection, informal work and so on), not all fulfilment criteria for appropriate working conditions were achieved.

Social impact categories	Social impact subcategories	Conventional model Surco	Model based on formalisation	
			Cañete	Colca
Human rights	Child labour	1	1	1
	Discrimination	0	0	0
	Freedom of association and collective bargaining	0	1	1
Working conditions	Fair wage, minimum wage	1	0	0
	Working hours	1	0	0
	Recognised employment relationships and fulfilment of legal social benefits	0	0	0
	Physical working conditions	0	0	0
	Psychological working conditions	0	1	1
Society	Accessibility to education	0	0	0
	Acceptance and social inclusion	Not determined	1	1

Table 3. Social assessment of formalisation strategies in recycling systems

None of the assessed case studies offers full access to legal social benefits (e.g. retirement pension, preventive health measures for the workers' families) and therefore they are negatively evaluated. The same situation occurs in relation to discrimination, where none of the case studies has implemented a preventive policy against discrimination. None of the evaluated case studies provides educational programmes for the workers. Their social performance is therefore also negative in relation to this aspect.

Regarding positive social performance, the conventional recycling model was better evaluated for both working time and minimum and fair wages, whereas the recycling model based on recyclers' formalisation obtained better evaluations in relation to 'psychological working conditions' (high work satisfaction level), 'freedom of association and collective bargaining' and 'acceptance and social inclusion'.

With reference to 'acceptance and social inclusion', the evaluation was performed through the perception of the recyclers about the acceptance level of the citizens with regarding to their recycling activities. The more positive is the feedback of citizens in relation to these recycling activities, the better the recyclers feel about their role within the society. They feel accepted as an important and meaningful part of their social milieu.

Owing to the work place situation of the workers in the conventional recycling systems (at the recycling plant), they do not carry out waste collection and the kind of contact with citizens experienced by the formalised recyclers is missing. Therefore, social acceptance was not evaluated for the conventional recycling system. The questions on the checklist related to this subcategory were not asked and no data relating to this issue were collected.

Some characteristics of recycling systems differ from each other, so it is not always possible to apply the same data collection procedure. During the interviews it was discovered that data collection through the workers' perception about acceptance and feedback given by citizens (conventional recycling system) was not possible. It can be stated that data collection related to acceptance and social inclusion for the conventional recycling system could be carried out through direct interviews or surveys of the citizens. However, using different data collection procedures would make it difficult to compare the results of social performances and therefore to compare the different recycling systems. The same data collection procedure should be applied throughout.

When comparing recycling systems where there is direct contact between recyclers and citizens (e.g. during door-to-door waste collection), it is possible to perform data collection on

social inclusion through interviews with the recyclers. For recycling systems with different characteristics, however, it is recommended that citizens involved with the recycling systems themselves are surveyed.

For the other indicators proposed in this methodology, no difficulties in data collection or comparing results were experienced.

5. Limitations of the study

A limitation of this investigation was related to the evaluation of the acceptance/social inclusion for the conventional recycling model. As previously mentioned, this was not evaluated because of the absence of contact between the workers from the recycling plant and the citizens during the recycling activities. Therefore no questions regarding this issue were posed and the indicator for social inclusion was not evaluated.

For further applications of this method, interviews with the citizens themselves should be performed in order to measure directly their acceptance level regarding the recycling activities of recyclers. Although the perception of recyclers about the acceptance of recycling activities by the citizens could be a reliable data source, it is not applicable to all recycling systems.

A further limitation was evaluation based only on the reliability of the stakeholders' answers. The adopted way to balance the answers given by each stakeholder was the application of a score system and calculation of an average score. As far as possible, it is recommended to use and include local reports or studies in the evaluation. The information from these documents would provide a better balance to the reliability of the stakeholders' answers. For social assessment, it is recommended that more management indicators should be included. These should be based on preventive social policies in order to evaluate more accurately the current social performance of a recycling system.

6. Conclusions and recommendations

The present study concludes that it is possible to use a methodology based on sLCA for the social assessment of recycling systems. The developed methodology is oriented to measure the existing social impacts caused by recycling systems in operation. Its application for assessing potential social impacts of future scenarios is difficult. Several social factors such as context, regulations, tendencies, perception about satisfaction, quality of life, and so on, can change and cannot be precisely predicted. Further research studies might investigate potential social impacts by using an approach oriented to preventive management strategies (social responsibility policy, occupational health, etc.). It is concluded that the availability and reliability of local data is vitally important in values assignment

of the indicators and thus for the results of the evaluation. The present study has shown that direct semi-quantitative indicators can be satisfactorily used to measure the social performance of a recycling system. Their use in combination with indirect indicators is also feasible for assessing current social performance of recycling systems.

In relation to the data collection for determining social inclusion, it is concluded that in order to compare different recycling systems, the same data collection procedure should be applied – by which is meant using the same data sources, interview procedures and questions.

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Paper 4

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SOCIAL ASSESSMENT OF SUSTAINABLE WASTE MANAGEMENT STRATEGIES IN DEVELOPING COUNTRIES WITH FOCUS ON THE INFORMAL SECTOR. CASE STUDIES FROM PERU

Abstract: *Informal recycling is one of the most significant activities within waste management systems in developing countries. In the last years some of the recently implemented waste management systems have the formalization of the informal sector as main aspect. The goal of this work is the social assessment of sustainable waste recycling strategies with a focus on the formalization of the informal sector. With this aim an approach oriented towards the sLCA Methodology (Social Life Cycle Assessment) was developed. The developed methodology was tested using data from three Peruvian case studies, two recycling systems with formalization of recyclers and one conventional recycling system. The assessment displays similar negative performances of the two recycling models regarding the social sub-categories physical working conditions, recognized employment relationships and fulfillment of social benefit, discrimination and access to education. The recycling model based on recyclers' formalization shows a better social performance for psychological working conditions, freedom for association and collective bargaining and social acceptance while the conventional recycling model was better evaluated for working time and minimum and faire wages.*

1. INTRODUCTION

THE INFORMAL SECTOR PLAYS AN IMPORTANT ROLE IN WASTE MANAGEMENT SYSTEMS IN DEVELOPING COUNTRIES. INFORMAL RECYCLERS ARE INDIVIDUALS OR GROUPS THAT CARRY OUT VARIOUS WASTE MANAGEMENT SYSTEMS (COLLECTION, RECYCLING, COMMERCIALIZATION, ETC.) WITH NO ASSIGNMENT. THE INFORMAL SECTOR FOCUSES MAINLY ON RECYCLING AND THEREFORE CONTRIBUTES SIGNIFICANTLY TO THE RECYCLING RATE OF MANY CITIES IN DEVELOPING AND EMERGING COUNTRIES. LIMA AND CALLAO (PERU) FOR EXAMPLE 19.7% OF THE MUNICIPAL WASTE IS RECYCLED BY THE INFORMAL SECTOR, WHILE THE OVERALL RECYCLING RATE (FORMAL AND INFORMAL) IS 20% (SCHEINBERG 2008). COMMON SOCIAL PROBLEMS OF THIS SECTOR ARE FOR EXAMPLE THE INAPPROPRIATE WORKING CONDITIONS THAT ENDANGER HEALTH AND SAFETY. ALSO, FREQUENTLY CHILDREN, PREGNANT WOMEN, THE ELDERLY AND OTHER PEOPLE WHO HAVE NO OPPORTUNITY TO WORK IN THE FORMAL SECTOR WORK IN THE INFORMAL SECTOR. WITH THE IMPLEMENTATION OF FORMALIZATION STRATEGIES THE REDUCTION OR ELIMINATION OF THESE SOCIAL PROBLEMS ARE EXPECTED. HOWEVER THESE POSITIVE SOCIAL IMPACTS ARE NOT ASSUMED AND HAVE NOT BEEN PRECISELY MEASURED AND EVALUATED. THE STRATEGIES FOR THE FORMALIZATION OF RECYCLERS' INTEGRATION INTO THE WASTE MANAGEMENT SYSTEM ARE EXPECTED TO BE SUSTAINABLE AND TO IMPROVE THE SOCIAL CONDITIONS; NEVERTHELESS THESE SOCIAL EFFECTS HAVE NOT BEEN VERIFIED.

THE GOAL OF THIS WORK IS THE SOCIAL ASSESSMENT OF SUSTAINABLE WASTE RECYCLING STRATEGIES USING THREE PERUVIAN CASE STUDIES AS EXAMPLE. IN ORDER TO ANALYZE AND EVALUATE THE FORMALIZATION STRATEGIES IN RELATION TO THEIR CONTRIBUTION TO THE SOCIAL SUSTAINABILITY A METHOD APPROACH ORIENTED TOWARDS THE SLCA METHODOLOGY (SOCIAL LIFE CYCLE ASSESSMENT) WAS DEVELOPED. FURTHERMORE THE PROPOSED METHODOLOGICAL FRAMEWORK FOR SOCIAL ASSESSMENT WAS TESTED THROUGH ITS APPLICATION ON THE THREE CASE STUDIES.

2. INFORMAL RECYCLING ACTIVITIES IN DEVELOPING COUNTRIES

AS A RESULT OF A PREVIOUS LITERATURE STUDY ABOUT THE DIFFERENT FORMALIZATION MEASURES IMPLEMENTED IN DEVELOPING COUNTRIES, SEVERAL SIMILARITIES WERE IDENTIFIED IN RELATION TO DIFFERENT ASPECTS. CHILD LABOR, TRUANCY IN SCHOOLS, INCOMPLETE SCHOOL EDUCATION OF ADULTS AND POOR WORKING CONDITIONS WERE IDENTIFIED AS TYPICAL SOCIAL PROBLEMS OF THIS SECTOR. SOME OF THE MOST COMMONLY IMPLEMENTED FORMALIZATION MEASURES IN DEVELOPING COUNTRIES ARE THE CREATION OF THE SUPPORT OF RECYCLERS' ASSOCIATIONS IN ORDER TO INCLUDE THEM INTO THE WASTE RECYCLING SECTOR, THE IMPROVEMENT OF THEIR WORKING CONDITIONS, THE INCREASE OF THEIR WAGES, THE PROHIBITION OF CHILD LABOR, ETC. EXAMPLES IN MEXICO, PHILIPPINES, INDIA, BRAZIL, COLOMBIA AND PERU ARE GIVEN ON THIS APPROACH.

FURTHER MEASURES ARE THE DIVERSIFICATION OF THE ACTIVITIES OFFERED BY THE RECYCLERS, THE ESTABLISHMENT OF A LEGAL FRAMEWORK TO PROMOTE THE FORMALIZATION OF THE INFORMAL SECTOR, THE IMPLEMENTATION OF AND AWARENESS PROGRAMS FOR THE POPULATION REGARDING THE SEPARATION AT SOURCE AND ECONOMIC IMPROVEMENTS SUCH AS HEALTH CARE, CHILD CARE, EDUCATION, THE CREATION OF FUNDING FUNDS FOR THE RECYCLERS, ETC.

3. SOCIAL LIFE CYCLE ASSESSMENT – STAND OF THE METHODOLOGY

SOCIAL LIFE CYCLE ASSESSMENT (SLCA) IS DEFINED AS A METHODOLOGY TO ASSESS THE SOCIAL AND SOCIO-ECONOMIC ASPECTS OF PRODUCTS ALONG THEIR LIFE CYCLE. THE SLCA COMPLEMENTS THE ENVIRONMENTAL LIFE CYCLE ASSESSMENT (ELCA) AND CAN BE USED ON ITS OWN OR IN COMBINATION WITH THE ELCA (UNEP, 2009). THE SOCIAL IMPACTS ARE MAINLY PRODUCED DUE TO THE ACTIVITIES OF THE STAKEHOLDERS WITHIN A SYSTEM. UNEP (2009) INDICATES THAT THE SOCIAL IMPACTS CATEGORIES AND THEIR SUBCATEGORIES SHOULD BE DETERMINED AND CLASSIFIED IN FUNCTION OF THE SOCIAL IMPACTS THAT AFFECT THE STAKEHOLDERS AND THEY SHOULD REFLECT THE INTERNATIONALLY RECOGNIZED STANDARDS. DREYER ET AL. (2006), JÖRGERSEN ET AL. (2008), FLYSKÖ ET AL. (2008), SPILLEMAECKER ET AL. (2001) PROPOSE THE SOCIAL IMPACT CATEGORIES AND SUBCATEGORIES IN RELATION TO THE WORKER'S RIGHTS AND WORKING CONDITIONS BASED ON THE ILO (INTERNATIONAL LABOR ORGANIZATION) CONVENTIONS. THEY ALSO RECOMMEND CONSIDERING FURTHER INTERNATIONAL SOCIAL STANDARDS SUCH AS THE UNIVERSAL DECLARATION OF HUMAN RIGHTS, THE UN DECLARATION ON ECONOMIC, SOCIAL AND CULTURAL RIGHTS, ETC.). THERE IS NO INTERNATIONAL CONSENSUS ON THE CATEGORIES OF SOCIAL IMPACTS AND THEIR SOCIAL CATEGORIES AND SUBCATEGORIES.

REGARDING INDICATORS, UNEP (2009) DISTINGUISHES THE USE OF QUANTITATIVE, QUALITATIVE AND SEMI-QUANTITATIVE INDICATORS. THE LAST ONE IS DEFINED AS A NUMERICAL DESCRIPTION OF SOCIAL IMPACT INFORMATION BY USING DIFFERENT SCORING SYSTEMS. CURRENTLY THERE IS NO INTERNATIONAL CONSENSUS FOR THE CHARACTERIZATION METHOD OF SOCIAL IMPACTS. DREYER ET AL. (2010) DEVELOPED A NEW METHODOLOGY BASED ON A PREVENTIVE APPROACH. IT TRIES TO MEASURE THE SOCIAL PERFORMANCE OF A COMPANY IN TERMS OF THE PROBABILITY OF NOT MEETING THE COMPLIANCE CRITERIA FOR DIFFERENT ASPECTS. SPILLEMAECKER ET AL. (2001) PROPOSE ANOTHER SCHEME FOR THE CHARACTERIZATION OF SOCIAL IMPACTS USING MAINLY SEMI-QUANTITATIVE INDICATORS AND ASSIGN THEM A SCORE REGARDING THE LEVEL OF COMPLIANCE OR NON COMPLIANCE OF SOCIAL CRITERIA.

4. DEVELOPING A METHODOLOGICAL FRAMEWORK FOR SOCIAL ASSESSMENT

THE PROPOSED METHODOLOGY IS BASED ON SLCA FOR THE ANALYSIS OF WASTE MANAGEMENT SYSTEMS; THE ANALYSIS IS LIMITED TO THE RECYCLING ACTIVITIES WITH MAIN FOCUS ON FORMALIZATION AND THE SOCIAL IMPACTS ON THE RECYCLERS, WHICH ARE DIRECTLY AFFECTED BY THESE MEASURES.

THE STUDIES ABOUT THE SLCA TAKE INTO ACCOUNT THE SOCIAL IMPACT CATEGORIES THAT ARE RELEVANT FROM AN INTERNATIONAL POINT OF VIEW. FOR THIS APPROACH IT IS NECESSARY TO CONSIDER THAT IN A WASTE MANAGEMENT SYSTEM THE SOCIAL IMPACTS OFTEN OCCUR IN THE AREA OF HUMAN RIGHTS (CHILD LABOR, DISCRIMINATION, POOR WORKING CONDITIONS, ETC.). FOR THIS REASON THE DETERMINATION OF THE SOCIAL IMPACT CATEGORIES AND SUBCATEGORIES FOR THE CASE STUDY IS ORIENTED ALSO ON THE LABOR RIGHTS CONVENTIONS AND EDUCATIONAL OPPORTUNITIES ISSUES.

WITH REFERENCE TO THE INDICATORS AND THEIR SCORING SYSTEM F27 SEMI-QUANTITATIVE INDICATORS WERE DEVELOPED. SOME EXAMPLES OF INDICATORS (NONEXISTENCE OF WORKING CHILDREN), MINIMUM WAGES (THE ABSENCE OF REDUCTIONS), AND PHYSICAL WORKING CONDITIONS (ALL EMPLOYEES HAVE ACCESS PROGRAMS). FOR MEASURING THEM THE QUALIFICATION SCHEME "FULFILLED/ NOT IN ORDER" INDICATE THE COMPLIANCE-COMPLIANCE SOCIAL CRITERIA FOLLOWING SCORE PUNTAJES IS ASSIGNED: 1 (FULFILLED) AND 0 (NOT FULFILLED). THE CHARACTER INVOLVES THE CALCULATION OF THE AVERAGE SCORE OF THE STAKEHOLDER WHO WAS INTERVIEWED:

$$\frac{\sum_{i=1}^n S_i}{n}$$

SI = SCORE OF INDICATOR I

N = NUMBER OF INTERVIEWED STAKEHOLDERS

THE EVALUATION COMPARES THE CURRENT SOCIAL PERFORMANCE OF THE (MINIMUM COMPLIANCE CRITERIA ACCORDING TO THE INTERNATIONAL AND LOCAL THE DATA COLLECTION THIS METHODOLOGY USES SITE SPECIFIC INTERVIEWS WITH STAKEHOLDERS: THE MUNICIPAL RECYCLERS ASSOCIATIONS AND THE PROJECT DEVELOPERS. SHOULD BE NOTED THAT THESE RESULTS ARE NOT RELEVANT AS NUMERIC VALUE DIFFERENCES BETWEEN THE CASE STUDIES IN TECHNICAL ASPECTS AND TO INDICATE ASPECTS OF A STRATEGY ARE POSITIVE OR NOT. THE PROPOSED METHODOLOGY APPLIED FOR THE SOCIAL ASSESSMENT OF THREE PERUVIAN CASE STUDIES. THE RESULTS OF THE SOCIAL ASSESSMENT FLOW.

5. CASE STUDIES

THREE PERUVIAN COMMUNITIES WERE IDENTIFIED AS CASE STUDIES. TWO COMMUNITY RECYCLING SYSTEM WITH FORMALIZATION OF THE INFORMAL RECYCLERS WHO OPERATES A CONVENTIONAL WASTE MANAGEMENT SYSTEM. SYSTEM WITH FORMALIZATION WORK THROUGH THE COOPERATION OF THE MUNICIPALITY, THE PROJECT SUPPORTED BY RECYCLERS' ASSOCIATION. THE FORMALIZED RECYCLERS COLLECT FOR FREE METALS AND PLASTICS FROM THE HOUSEHOLDS. THEN THE SEPARATED WASTE SUBSEQUENTLY PERFORM A MORE ACCURATE MANUAL SEPARATION IN SORTING AND SELL THE MATERIALS. THE INCOME OF WASTE PICKERS DEPENDS ON THE PRICE OF MATERIAL AND THUS ALSO ON THE NUMBERING RESIDENTS. SOME SOCIAL MEASURES LIKE AWARENESS RAISING CAMPAIGNS AND IDENTIFICATION OF THE POPULATION WITH VACCINATION CAMPAIGNS, AND ACCESS OF THE WASTE PICKERS TO HEALTH IMPROVEMENT OF THE WORK EQUIPMENT.

THE CONVENTIONAL RECYCLING SYSTEM IS OPERATED EXCLUSIVELY BY THE INFORMAL RECYCLERS. THE FORMALIZATION OF RECYCLERS WASTE COLLECTION IS DONE WITH WASTE COLLECTORS. THE EXACT SEPARATION IS DONE BY USING A SORTING SYSTEM WITH. SIMILAR TO THE OTHER RECYCLING SYSTEM THE MAIN COLLECTED AND RECYCLED MATERIALS ARE PAPER AND CARDBOARD, AND METALS. THE WORKED INCOME. THE IDENTIFIED POSITIVE EFFECTS OF THE SYSTEM ARE MAINLY RELATED TO THE IMPROVING CONDITIONS AND TO THE ACHIEVING HEALTH AND SOCIAL INSURANCE.

6. RESULTS

THE FOLLOWING TABLE SHOWS THE RESULTS OF THE SOCIAL ASSESSMENT OF THE THREE CASE STUDIES

TAB. 1 FINAL SCORES FOR SOCIAL ASSESSMENT

SOCIAL IMPACT CATEGORIES	SOCIAL IMPACT SUBCATEGORIES	CONVENTIONAL RECYCLING MODEL	RECYCLING MODEL BASED ON FORMALIZATION OF RECYCLERS	
			CASE STUDY 1	CASE STUDY 2
HUMAN WORKING RIGHTS	CHILD LABOR	1	1	1
	DISCRIMINATION	0	0	0
	FREEDOM OF ASSOCIATION AND COLLECTIVE BARGAINING	1	1	1
WORKING CONDITIONS	FAIR WAGE, MINIMUM WAGE	1	0	0
	WORKING HOURS	1	0	0
	RECOGNIZED EMPLOYMENT RELATIONSHIPS AND FULFILLMENT OF LEGAL SOCIAL BENEFITS	0	0	0
	PHYSICAL WORKING CONDITIONS (HEALTH, SECURITY, WORKING EQUIPMENT)	0	0	0
	PSYCHOLOGICAL WORKING CONDITIONS (WORK SATISFACTION, WILLINGNESS TO WORK IN THE COMPANY)	0	1	1
SOCIETY	ACCESSIBILITY TO EDUCATION	0	0	0
	ACCEPTANCE AND SOCIAL INCLUSION	0	1	1

6. CONCLUSIONS

IT IS CONCLUDED THAT ALTHOUGH ORIGINALLY SLCA IS USED FOR THE ANALYSIS OF PRODUCTION PROCESSES, IT IS FEASIBLE TO USE IT FOR THE EVALUATION OF WASTE MANAGEMENT SYSTEMS. BY APPLYING THIS METHODOLOGICAL FRAMEWORK BASED ON SLCA IT IS POSSIBLE TO MEASURE QUALITATIVE SOCIAL IMPACTS THAT PREVIOUSLY WERE ONLY ASSUMED. THE SEMI QUANTITATIVE INDICATORS AND THE APPLIED SCORE SYSTEM CAN BE SATISFACTORILY USED FOR TRANSLATING QUALITATIVE INFORMATION INTO NUMBERS AIMING TO MEASURE COMPLEX SOCIAL PHENOMENA WHICH CANNOT BE DIRECTLY EXPRESSED IN PHYSICAL UNITS. THE SOCIAL WEAK ASPECTS/HOT SPOTS OF THE RECYCLING SYSTEM CAN BE IDENTIFIED AND UNDERSTOOD.

IN REFERENCE TO THE CHARACTERIZATION APPROACH OF SOCIAL SUBCATEGORIES IT ALLOWS FOR A BETTER UNDERSTANDING AND INTERPRETATION OF RESULTS WHILE THE POSSIBILITY OF A SUBJECTIVE EVALUATION IS REDUCED. IT IS ALSO CONCLUDED THAT THE AVAILABILITY AND RELIABILITY OF THE DATA PROVIDED BY THE STAKEHOLDERS LINKED TO THE WASTE MANAGEMENT SYSTEM IS OF VITAL IMPORTANCE FOR THE CORRECT ASSIGNMENT OF THE INDICATORS AND THUS FOR THE RESULTS OF THE EVALUATION.

THROUGH THIS WORK IT CAN BE ASSERTED THAT BOTH RECYCLING MODELS NEED TO BE IMPROVED. POLICIES AGAINST DISCRIMINATION, RECOGNIZED EMPLOYMENT RELATIONSHIPS AND FULFILLMENT OF LEGAL SOCIAL BENEFITS, PHYSICAL WORKING CONDITIONS (POLICIES AND TRAINING REGARDING HEALTH MEASURES) AND ADULT EDUCATION PROGRAMS. WITH RELATION TO PSYCHOLOGICAL WORKING CONDITIONS AND SOCIAL INCLUSION IT SEEMS TO BE THAT LOW PAYMENTS AND LONGER WORKING HOURS FOR RECYCLERS DO NOT AFFECT THEM NEGATIVELY. REASON FOR THAT ARE THE POSITIVE FEEDBACKS FROM RECYCLERS BY THE CITIZENS ABOUT THE RECYCLING ACTIVITIES AND THE DIRECT CONTACT WITH THEM. WITH THIS POSITIVE FEEDBACK THE RECYCLERS' WORK SATISFACTION INCREASES AND THEIR BELONGING TO THEIR SOCIETY IS REINFORCED.

THIS STUDY INDICATES THE NEED OF IMPROVING THE PAYMENT MODALITY IN THE FORMALIZATION OF THE RECYCLING MODEL. THE AIM IS TO REDUCE OR TO ELIMINATE THE NEGATIVE INFLUENCE OF WASTE AMOUNTS FLUCTUATIONS. UNFAVORABLE FLUCTUATIONS ENDANGER THE CHANCE FOR GETTING FAIR AND SUSTAINABLE INCOMES AND ADDITIONALLY HAVE NEGATIVE IMPACTS ON THE ENVIRONMENT CAUSING BAD WORKING CONDITIONS. A FIXED PAYMENT CONSIDERABLY REDUCES THESE

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KONTAKT

Autor: MSc. Dipl. Ing. Sandra Aparcana, PhD Student

Co – autor: ao. Univ.Prof. Dipl.-Ing. Dr. Stefan Salhofer

INSTITUTE OF WASTE MANAGEMENT

UNIVERSITY OF NATURAL RESOURCES AND LIFE SCIENCE, VIENNA, AUSTRIA

TEL.-NR.+43 (0)1 318 99 00, E-MAIL: SANDRA.APARCANA@BOKU.AC.AT

HOMEPAGE [HTTP://WWW.WAU.BOKU.AC.AT/ABF.HTML](http://www.wau.boku.ac.at/abf.html)

Paper 5

Aparcana S., Salhofer S., Linzner R. (2011) Material flow analysis of formal and informal household waste recycling systems in developing countries. Case studies from Peru. Executive summaries. Thirteenth International Waste Management and Landfill Symposium (3 – 7 October 2011, S. Margherita di Pula - Cagliari, Sardinien, Italien).

MATERIAL FLOW ANALYSIS OF FORMAL AND INFORMAL HOUSEHOLD WASTE RECYCLING SYSTEMS IN DEVELOPING COUNTRIES. CASE STUDIES FROM PERU

S. APARCANA*, R. LINZNER* AND S.SALHOFER*

**Institute of Waste Management, University of Natural Resources and Life Sciences, Vienna, Austria*

SUMMARY: Informal recycling is one of the most significant activities within the waste management systems in developing countries. A trend of the last years is the formalization of the informal sector and its inclusion into the system as a formal stakeholder. Currently, the economic and environmental effects of the implemented formalization strategies have been identified as positiv. Lacking an adequate methodology however the assessment of social impacts has not reached the same level. The goal of this study is to propose a methodology in order to identify, measure and analyze the social impacts of the different formalization strategies of waste pickers. The proposed methodology is oriented to the social Life Cycle Assessment and to the use of social indicators linked to the waste pickers.

1. INTRODUCTION

The informal sector plays an important role in waste management systems in developing countries. It is defined as the individuals (waste pickers) or groups that carry out various activities within the waste management system (collection, recycling, treatment and disposal) without formal assignement. The informal sector focuses mainly on recycling and therefore contributes significantly to the recycling rate of many cities in developing and emerging countries. In Lima and Callao (Peru) for example 31% of the total municipal waste is recycled by the informal sector, while the overall recycling rate (formal and informal) is 31.4%¹.

The informal sector carries out the recycling activities under inappropriate conditions that endanger the health and safety of the people working in this sector and their families (recycling activities on the streets, dumps, etc.). Often children, pregnant women, the elderly and other people who have no opportunity to work in the formal sector work in the informal sector. The economic contribution of this sector to the waste management systems and the environmental and social benefits of the informal recycling are not recognized by the stakeholders of the formal sector. For this reason, the informal activities are considered as negative. In many developing countries the informal sector is rejected and policies to eliminate the informal recycling activities are implemented.

¹ IPES, WASTE. 2006. City Report: Lima "Aspectos económicos del sector informal de los residuos sólidos en Lima y Callao"

Despite these trends, some cities have identified the need to recognize the contribution of the informal sector and its inclusion in the formal waste management systems as an effective strategy. For this reason over the last years some formalization strategies were implemented to organize the waste pickers and to improve their working conditions also to increase their wages, to eliminate the child labor and other socio-economic improvements. Some cities in India, Colombia, Mexico, Brazil, Chile and Peru have implemented such strategies.

The social impacts of the formalization strategies cannot be directly measured, they are only assumed. In order to analyse the formalisation strategies in relation to their contribution to sustainability an approach based on sLCA Methodology (Social Life Cycle Assessment) was chosen. The present work aims to develop a methodological framework to apply sLCA for the analysis of waste management systems. Using sLCA methodology the social impacts of the formalisation strategies as well as the positive contributions to the social situation of the waste pickers will be analysed. In a further phase of this study a field research on two case studies in Peru (Cañete and Surco) will be carry out with the aim to collect information from the stakeholders and local sources and to use it for measuring and evaluating the social impacts of formalization strategies using the proposed methodology and the indicators previously defined.

2. THE INFORMAL SECTOR AND THE RECYCLING ACTIVITIES IN DEVELOPING COUNTRIES

As a result of a literature study about the different formalization strategies that have been implemented in developing countries, several similarities in the initial situation of the waste management system, the role of the informal sector, the applied integration measures, the effect on the recycling rates and the economic and social impacts were identified.

From an economic point of view, the lack of recognition of the contribution of the informal sector in the waste system should be mentioned. For example, for Mumbai (India)¹ it was estimated that the cost of the waste system without integration of the informal sector was around 44 USD / ton of waste, however in cooperation with the informal sector the cost of the waste system amounts to 35 USD per ton of waste. Regarding the social aspect the same problems were identified: child labor, truancy in schools, incomplete school education for adults and poor working conditions. The most commonly implemented strategies are the creation and support of associations of waste pickers in order to include them in the waste collection programs, the improvement of their working conditions, the increase of their wages, the elimination of the child labor, etc. Examples in Mexico, Philippines, India, Brazil, Colombia and Peru are based on this approach.

Further measures are the diversification of the activities offered by the waste pickers, the creation of a legal framework to promote the formalization of the informal sector and their associations (Peru²), the communication and awareness programs for the population regarding the separate waste collection systems, social and economic improvements such as health care, child care, education, the creation of financing funds for the waste pickers and their associations, etc. (in Peru, the Philippines, and Brazil).

¹ Rathi S. (2006)

² Gesetz N° 29419

3. SOCIAL LIFE CYCLE ASSESSMENT APPROACH

3.1 Social Life Cycle Assessment

The sLCA is defined as a methodology to assess the social or socio-economic aspects of products and their potential positive or negative along their life cycle. The sLCA complements the eLCA (environmental Life Cycle Assessment) and can be used on its own or in combination with the eLCA (UNEP, 2009). Actually, no international standards for social aspects have been established.. Jorgensen et al (2008) indicate that the sLCA normally focuses on two main goals: the comparison of products, processes or business and the identification of their potential of social improvements. Dreyer et al (2006) describes two variants in terms of the sLCA focus: the "bottom - up" and "top - down ". In the first variant, the social aspects and the parameters for their assessment are defined based on the company interests and context. In the second variant of "top – down" the evaluation parameters for the social impact categories are chosen based on the interests of the society. The "top - down" approach was chosen by the method developed by Dreyer et al. (2006) to define the relevant issues concerning the identification of the social impact categories in a sLCA.

3.2 Impacts categories and subcategories

The social impacts are mainly produced due to the activities of the stakeholders within a system. The UNEP (2009) indicates that the social impacts categories and their subcategories should be determined and classified in function of the social issues that affect the stakeholders and they should reflect the internationally recognized social standards. Actually there is no international consensus on the categories of stakeholders and their social categories and subcategories.

Further studies (Klang et al., 2003; Bouwer et al., 2004; Kijak et al., 2004) identified the social impacts also based on a stakeholders analysis. The UNEP (2009), Jorgensen et al (2008), Dreyer et al. (2006), Spillemaeckers et al (2001) recommends to consider also the international social standards (eg the universal declaration for human rights, the UN declaration on economic, social and cultural rights - ECOSOC, etc.) to define the impact categories and subcategories.

3.3 Indicators

Regarding indicators, the UNEP (2009) distinguishes the use of quantitative, qualitative, and semi quantitative indicators. The last one is defined as a numerical description of qualitative information by using different scoring systems. Jorgensen et al. (2008) indicate two important criteria for the development of indicators. The first criterion is the qualitative, quantitative or semi quantitative indicator character and the second one is their determination to a direct or indirect measurement of the phenomena that cause the social impact. A low number of accidents could show a good social performance, but it could also reflect inefficient data collection (if the accidents are not registered) However, the aspect of "safety" can be evaluated by statistical data-based indicators, but also it can be evaluated based on the use of management indicators, which the company implements to reduce accidents and to improve the working conditions (Dreyer et al., 2006).

3.4 Characterization

The assessment of the impact categories and their subcategories is performed based on a "cause-effect" impact pathway (Dreyer, 2006). Currently there is no international consensus for the characterization method of social impacts and the modeling method their "cause - effect"

pathways. Dreyer et al. (2010) developed a methodology for the characterization of the impact based on a preventive approach which seeks to measure the social performance of a company in terms of the risk that the company does not meet the compliance criteria for the social aspects.

Spillemaeckers et al (2001) proposes another scheme for the characterization from the indicators to impact subcategories. This approach uses mainly semi quantitative indicators and assigns them a score regarding the compliance of the social criteria. For each sub category the weighted average of the scores is calculated.

4. CASE STUDIES

Two Peruvian communities were identified as case studies. One community has implemented formalization of the waste pickers while the other community operates a conventional waste management system. In both communities the amounts of collected recyclables were analyzed with the aim to identify and to measure the waste material flows and to estimate based on material flows the contribution of the formalized informal sector from a quantitative point of view.

The first case study is San Vicente de Cañete, Peru. Here the municipality with the technical support of the NGO IPES and the financial support of a private recycling company implemented a separate collection and recycling system based on the cooperation with the waste pickers. The formalized waste pickers collect glass, paper, cardboard and plastics from the households for free. They transport the separated waste with tricycles and subsequently perform a more accurate manual separation in sorting centers with the aim to sell the materials. The waste pickers with the support of the municipality are responsible for the increase of the coverage of the recycling program (today 15% of the total households in Cañete). The income of waste pickers depends on the quantity of sold material and thus also on the number of participating residents.

Diversification measures of the services within the program are the improvement of parks and gardens and the elimination of informal dumps. Some social measures are awareness raising campaigns and identification of the population with the waste pickers work, vaccination campaigns, access of the waste pickers to health prevention and health insurance programs and the improvement of the work equipment.

The second case study is the recycling system of the municipality of Surco in Lima, Peru. This recycling system is operated exclusively by the municipality (without integration of waste pickers). The waste collection is done with waste collection vehicles and the exact separation is done by using a sorting system with simple technology. Similar to Cañete, the main collected and recycled materials are glass, plastics, paper and cardboard, and metals. Currently the recycling program covers 38% of the total households. The employees on the collection and sorting activities get a fixed income. The identified positive effects of the system are mainly related to the improvement of working conditions and to the access to health and social insurance.

5. METHODOLOGICAL FRAMEWORK

5.1 Analysis of the recycled waste material

The waste material flows were determined by reviewing the internal documents about the collected materials and the recycled material that were sold. To determine the recycling rates, the quantities of each type of sold recycled material (glas, paper and cardboard, plastics, metal, etc.)

were compared with the potential of recyclables produced in the households. The recycling potential in the households was calculated based on the waste composition, the number of inhabitants and the waste generation rate.

5.2 sLCA for the social waste management assessment

The proposed methodology is based on sLCA. Currently sLCA is used for the analysis of social impacts for products, however in this work this method will be used for the analysis of waste management systems; the analysis is limited to the recycling activities with the main focus on the formalization strategies and the social impacts on the informal waste pickers, which are directly affected by these measures.

The studies about the sLCA take into account the social impact categories that are important from the international point of view. The UNEP (2009), Dreyer et al (2006), Jörgersen et al (2008), Flyskö et al (2008), Spillemaeckers et al (2001) proposed the impact categories and subcategories on the basis of the ILO (International Labor Organization) conventions about the worker's rights issues and the working conditions. For this approach it is necessary to consider that a waste management system is not a company. Different stakeholders are involved here: waste pickers, NGOs, associations, municipalities, etc. Nevertheless, the social impacts also occur very often in the area of human working rights (child labor, discrimination, poor working conditions, exploitation, etc.). For this reason, the determination of the social impact categories and subcategories for the case studies is oriented also on the labor rights conventions and educational opportunities issues.

With reference to the indicators and their scoring system three types of indicators were developed in previous studies applying the sLCA: quantitative, semi quantitative and qualitative indicators. The UNEP proposed a list of indicators, for which no scoring system and no characterization approach were specified. Spillemaeckers (2001) developed a semi quantitative approach with the aim to define a sustainability label for chain management by companies. Dreyer (2009) proposed for the evaluation of a company's social performance also a list of semi quantitative indicators similar to those reported by UNEP (2009) and Spillemaeckers (2001), except that they have a preventive management approach. For the methodology in this study the use of semi quantitative indicators is proposed and for measuring the compliance of the criteria the scheme "fulfilled/ not fulfilled" will be used and the followed score punctuation is assigned: 1 (fulfilled) and 0 (not fulfilled).

Regarding the collection of data needed to assess the indicators' compliance UNEP (2009) and Dreyer et al (2010) proposed the study of internal reports about the social performance of companies, the interviews with the workers, the managers and others stakeholders. As sources of information this methodology proposes the use of site specific data sources like interviews with stakeholders and the literature review related to the case studies. For the collection data to analyse the case studies in Peru, interviews with the following stakeholders will be conducted: the municipality, the waste pickers' associations and the project developers. If required also interviews with other stakeholders such as the local universities, research institutes, recycling companies, local authority, etc. will be conducted.

6. RESULTS AND DISCUSSION

6.1 Waste recycling rates

In a waste material flow analysis, the recycling rates of each recycled waste material and the overall recycling rate in Cañete (with formalization of the waste pickers) and the recycling rate of Surco (without the integration of waste pickers) were estimated and compared. The quantities of each type of sold recycled material were compared with the potential of recyclables produced in the households.

Table 1 Recycling rates of the recycled waste materials

	Paper and cardboard (%)	Other plastic materials* (%)	Plastic films (%)	Glas (%)	Non ferrous metals (%)	Ferrous metals (%)	Overall recycling rate (%)
Cañete	47	43	2	76	17	43	34
Surco	7	14	2,5	25	0,5	1	9

* Plastic toys, plastic bottles, plastic cans and other plastics

Although the recycling program in Cañete has a lower coverage (share of household participating) than the recycling system in Surco, higher recycling rates have been identified in the first system. Some of the economic and social benefits that will be analysed in a second phase of the research are the increase of the income of the formalized waste pickers (about 4 times higher), the possibility of a continuous economic improvement and the improvement of the working conditions.

6.2 Social life cycle framework

6.2.1 Impacts categories and subcategories

The proposed methodology for the social impact assessment of waste management systems has a multi-criteria approach and it is based on the use of several indicators and a scoring system. For the social assessment of the case studies only the social impacts in relation to the waste pickers are considered. Based on a literature review the social impacts categories and subcategories were identified and their associated indicators developed (see table 2).

Table 2 social categories and subcategories for waste pickers

Social impact categories	Social impact subcategories
Human working Rights	Child labor
	Discrimination
	Freedom of association and collective bargaining
Working conditions	Fair Wage, minimum wage
	Working hours
	Social benefits, social security
	Physical working conditions (health, security, working equipment)
	Psychological working conditions (communication, harassment, worker contracts)
Society	Accessibility to education

6.2.2 Indicators, scoring system and characterization

For this study 24 semi quantitative indicators were developed. Some examples of indicators for are: for child labor (non existence of working children), for minimum wages (the absences of unjustified wage reductions, all employees have access to health care programs). Concerning the scoring system the following numerical values were assigned: 1 to the compliance and 0 to the non compliance of the evaluation criteria. Degrees of compliance are not considered for this method, therefore the result of each indicator will be either 1 or 0. The evaluation will compare the current social performance of the case studies with the minimum compliance criteria according to the international and local standards.

The characterization will be performed only from the indicators to the impact subcategories. To aggregate different subcategories would need to consider them equally important or otherwise it would be necessary to apply a weighting system. In the case of the weighting application it should be determined through interviews with local experts, sociologists and stakeholders. That is by nature a very qualitative procedure and it may affect the impartiality of the assessment. For example: to consider that the impact subcategory “child labor” is as important as the right to “the freedom of association and collective bargain” is questionable due to qualitative local ethical, cultural, legal reasons, etc. An additional reason to perform the characterization only to subcategories is that the results of the assessment can be understood with more detailed than an overall result for each impact category. The characterization procedure involves the calculation of the average score by the sum of the scores given by each stakeholder who was interviewed and dividing the sum by the number of stakeholders interviewed.

$$\frac{\sum_{i=0}^n S_i}{n}$$

S_i = Score of indicator i

n = number of interviewed stakeholders

This calculation is done for each indicator. For the subcategories with more than one indicator a second average score within this subcategory is recalculated. It should be noted that these results are not relevant as numeric values. The aim is to show the differences between the case studies in terms of their social aspects and to indicate which aspects of a strategy are positive or not. As mentioned, in a further phase of the research the proposed framework will be applied to measure and evaluate the social impacts of two case studies in Peru.

5. CONCLUSIONS

It is concluded that although originally sLCA has been used for the analysis of products and there are no standardized indicators or characterization methods, it is feasible to apply this approach for the evaluation of the waste management system. By applying the 24 indicators proposed in this framework and their characterization procedure it would be possible to measure the qualitative social impacts that previously were only assumed. The characterization of social subcategories allows a clearer understanding and interpretation of results while the possibility of a subjective evaluation regarding the importance between social impact subcategories is reduced. It is also concluded that the availability and reliability of the data from the local stakeholders linked to the waste management system is of vital importance for the values assignment of the indicators and thus for the results of the evaluation. In a further phase of this study the applicability of the methodology will be tested on the cases studies.

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Paper 6

**Aparcana S. (2011) Strategien zur nachhaltigen Abfallwirtschaft
in Entwicklungsländern mit Schwerpunkt im informellen Sektor
am Beispiel zwei Fallstudien in Lima, Peru. I.**

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Strategien zur nachhaltigen Abfallwirtschaft in Entwicklungsländern mit Schwerpunkt im informellen Sektor am Beispiel zweier Fallstudien in Lima, Peru

Der informelle Sektor spielt in den Abfallwirtschaftssystemen von Entwicklungsländern eine wichtige Rolle. Um Stellenwert und Auswirkungen dieser Aktivitäten zu identifizieren wurde eine Literaturrecherche über die Erfahrungen mit der Integration des informellen Sektors durchgeführt. Es wurden Informationen über verschiedene implementierte Programme in Asien und Lateinamerika gesammelt. Als Ergebnis wurden viele Gemeinsamkeiten hinsichtlich der Ausgangssituation, der Rolle des informellen Sektors im Abfallsystem, den angewandten Integrationsmaßnahmen sowie der ökonomischen und sozialen Auswirkungen identifiziert.

Aus **ökonomischer Sicht** ist die fehlende Anerkennung des Beitrags des informellen Sektors für das Abfallsystem zu nennen. Beispielsweise wurde für Mumbai (Indien) abgeschätzt, dass die Kosten des Abfallsystems ohne Integration des informellen Sektors bei 44 USD/Tonne Abfall, bei Kooperation mit dem informellen Sektor jedoch bei 35 USD per Tonne Abfall liegen. In Verbindung mit dem genannten Aspekt steht die fehlende Anerkennung des informellen Sektors als Basis der gesamten Struktur des Recyclingsystems. Aus **sozialer Sicht** gibt es in allen Fallstudien ähnliche Probleme: Kinderarbeit, Abwesenheit in den Schulen, unvollständige Schulbindung bei Erwachsenen und schlechte Arbeitsbedingungen. Aus **ökologischer Sicht** sind die Boden-, Luft- und Wasserverschmutzung wegen der unangemessenen Abfallentsorgung und der fehlenden Abfallbehandlung vor der Deponierung die häufigsten Probleme.

Hinsichtlich der implementierten Strategien wird am häufigsten die Gründung und Förderung von **Assoziationen** von informellen Abfallsammlern (IAS) sowie ihre Aufnahme in Abfallprogramme als der Schwerpunkt der Integrationsstrategien beobachtet. Implementierte Strategien in Mexico, Philippinen, Indien, Brasilien, Kolumbien und Peru basieren auf diesem Ansatz. Eine Ausnahme stellt eine case study aus Haidian (China) dar, wo die IAS nicht organisiert sind, sondern als freie Mitarbeiter der Recyclingunternehmen arbeiten.

Am Beispiel Mexicos, Indiens, der Philippinen und Chinas werden die Vorteile der von den IWBs (**Itinerant Waste Buyers**)¹ als Sonderfall der IAS durchgeführten Recyclingaktivitäten gezeigt. Normalerweise kaufen die IWBs die wiederverwendbaren Materialien wie z.B. Glas, Metall, Aluminium, Papier und Pappe, alte Geräte etc. an die sich eine höher Sortierungsreinheit auszeichnen; bei den beteiligten Haushalten entsteht ein Einkommen, welches die getrennte Sammlung im Haushalt fördert. In den genannten Beispielen werden solche Recyclingaktivitäten von der Gemeinde unterstützt außer bei der Fallstudie Chinas, wo das System ausschließlich nach der Marktregel von Angebot und Nachfrage funktioniert.

¹ Wilson et al. (2009) "Building recycling rates through the informal sector" beschreibt das typische informelle Recyclingsystem in den Entwicklungsländern: Itinerant waste buyers (IWB), street waste pickers, municipal waste collection crew und waste pickers from dumps. Die IWB sind Abfallkäufer, die sie Haushalte besuchen und die verschiedene wiederverwendbare Stoffe (Altgeräte, Altmöbel, etc.) kaufen.

Ein anderer gemeinsamer Hauptaspekt der Fallstudien ist die **Diversifizierung** der Aktivitäten der IAS. Diese Diversifizierung wird als wichtiger Erfolgsfaktor einer Formalisierungsstrategie angesehen. Länder wie Kolumbien (Bogota und Medellin) sowie die Philippinen und Mexico implementierten diesen Aspekt als einen wichtigen Teil ihrer Strategien zur Weiterentwicklung des ehemaligen informellen Sektors. Dabei können folgende Rahmenbedingungen als maßgeblich angesehen werden:

- Schaffung eines gesetzlichen Rahmens zur Förderung des informellen Sektors und die Gründung der Assoziationen. Beispiel Lima: In Peru trat 2009 ein Gesetz zur Integration des informellen Sektors in Kraft. Dieses Gesetz ist das erste in Lateinamerika zur Formalisierung der der informellen Recyclingaktivitäten
- Kommunikations- und Sensibilisierungsprogramme für die Bevölkerung hinsichtlich der Implementierung von Systemen zur getrennten Abfallsammlung
- Soziale Maßnahmen wie Sozialbeihilfe, Gesundheitsvorsorge, Kinderbetreuung, Ausbildung, usw. Beispiel Joao Pessoa (Brasilien): hier wurden Kinderbetreuung und Ausbildungsprogrammen für die ehemaligen IAS umgesetzt.
- Maßnahmen zur Stärkung der Verhandlungsposition des informellen Sektors wie der Bau von Einrichtungen zur Sortierung und Aufbereitung von Altstoffe, Aufkaufzentren, Schaffung von Eigenkapital durch Finanzierungsmittel (Mikrokredite z.B. in Peru, Philippinen, Brasilien), usw.

Für einen Vergleich von dem konventionellen System mit dem System mit Formalisierung wurde in einer zweiten Phase der Arbeit eine **Feldforschung** bei zwei Gemeinden in Peru durchgeführt. In diesem Rahmen wurden die zum Recycling erfassten Abfallmengen untersucht, um den Beitrag formalisierter informeller Abfallsysteme besser abschätzen zu können.

Im Jahr 2007 implementierte die Gemeinde **San Vicente de Cañete**, in Lima, Peru mit Hilfe der NGO IPES und mit der finanziellen Unterstützung eines privaten Recyclingunternehmens ein getrenntes Sammel- und Recyclingsystem auf Basis der Zusammenarbeit mit den formalisierten IAS. Damals wurden die IAS gemäß ihrer Tätigkeiten und Arbeitsorte identifiziert und quantifiziert (Street Waste Pickers, Waste Pickers from Dumps, usw.). Es wurden die Recyclingwege und ihre Akteure in jeder Stufe des Abfallsystems identifiziert. Abfallströme und Mengen des ehemaligen Entsorgungssystems wurden auch auf allen Stufen kalkuliert. Auf Basis der erfassten Informationen wurde das Recyclingsystem geplant. Im Programm werden vor allem Glass, Kunststoffe, Metalle, Papier und Karton drei Mal pro Woche gemeinsam erfasst und die formalisierten IAS holen diese Altstoffe bei den Haushalten ab Die Abfallsammlung wird mittels Dreiräder durchgeführt und die Sortierung der Altstoffe wird manuell in Sortierungs- und Aufbereitungseinrichtungen gemacht. Jeder formalisierte IAS hat einen bestimmten Bezirkssektor mit einer Anzahl von Haushalten. Die formalisierten IAS bekommen die Altstoffe gratis; das bedeutet, es entsteht für die Haushalte kein Einkommen wie im Fall der IWB.

Entsprechend den teilnehmenden Einwohnern (aktueller Anschlussgrad des Systems: 15%), der Abfallmengen, der Preise und dem potenziellen Einkommen wurde die Aufnahmekapazität des geplanten Recyclingsystems hinsichtlich der Anzahl von IAS, die im Recyclingprogramm als formellen Mitarbeiter aufgenommen werden konnten, bestimmt. Derzeit sind die formalisierten IAS und teilweise auch die Gemeinde für die Steigerung des

Anschlussgrads, und damit für die Aufnahme neuer Einwohner, verantwortlich. Die Einkommen der formalisierten Abfallsammler sind abhängig von den verkauften Altstoffmengen und damit auch von der Anzahl der teilnehmenden Einwohner. Zur Diversifizierung der Dienstleistungen wird auch die Verschönerung von Parks und Gärten und die Entfernung von informellen Müllhalden angeboten. Als soziale Maßnahmen sind die Sensibilisierung und Identifizierung der Einwohner in Bezug auf die Mitarbeiter, Impfkampagnen, der Zugang der formalisierten Abfallsammler zum staatlichen integralen Gesundheitsversicherungssystem und die Verbesserung der Ausrüstung zu nennen.

Bei der zweiten Fallstudie handelt es sich um das Sammel- und Recyclingsystem in der Gemeinde **Surco, Lima**. Das System funktioniert seit dem Jahr 2000 und wird von der Gemeinde geleitet und finanziert. Derzeit nehmen nicht nur die Haushalte, sondern auch einige Schulen, Universitäten, Supermärkte und Einkaufszentren an dem Programm teil. Das Recyclingprogramm sieht die gemeinsame Erfassung von Glas, Papier, Karton, Kunststoffen, Tetrapak und Metallen (Dosen) vor. Für die Abholung von der Tür der Haushalte werden Motorfahrzeuge genutzt. Die Sortierung wird in einer manuellen Sortierungsanlage mit Hilfe einfacher Förderbänder durchgeführt. Derzeit beläuft sich der Anschlussgrad auf 38% der gesamten Einwohner und seine Erhöhung wird von der Gemeinde und im Gegensatz zur Gemeinde Cañete nicht von den Mitarbeitern vorangetrieben, die ein fixes Einkommen beziehen. Das Programm sieht keine Maßnahmen zur Belohnung der teilnehmenden Einwohner vor, aber die Einwohner werden ständig über die Vorteile des Recyclingsystems und der Abfalltrennung unterrichtet und somit dafür sensibilisiert. Die identifizierten positiven Auswirkungen des Systems beziehen sich hauptsächlich auf die Verbesserung der Arbeitsbedingungen und auf den Zugang zu den Gesundheits- und Sozialversicherungen, die durch die aktuellen gesetzlichen Arbeitsrechtsvorschriften festgelegt werden

Obwohl das Recyclingprogramm mit der Integration der IAS in Cañete einen geringeren Anschlussgrad als das von der Gemeinde geleitete Recyclingsystem in Surco hat, wurden im ersten Fall höhere **Recyclingraten** festgestellt. Die Recyclingraten wurden aus den recycelten Altstoffmengen und der anfallenden gesamten Altstoffmenge und der gesamten Abfallmenge in den Haushalten abgeschätzt. Die Erhöhung des monatlichen Einkommens der formalisierten IAS (ca. 4-mal höher), die Möglichkeit einer Einkommenserhöhung basierend auf der Erhöhung des Anschlussgrads und des Altstoffverkaufs, die Verbesserung der Arbeitsbedingungen und die Sicherung der Arbeitsplätze sind einige der im Zuge der Feldforschung identifizierten **ökonomischen und sozialen Vorteile** des Recyclingsystems mit der Integration der IAS im formellen Sektor.

Paper 7

**Aparcana S. (2010) Strategien zur nachhaltigen Abfallwirtschaft in
Entwicklungsländern mit Schwerpunkt im informellen Sektor.
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Strategien zur nachhaltigen Abfallwirtschaft in Entwicklungsländern mit Schwerpunkt im informellen Sektor

1. Autor: Dipl. Ing. MSc. Sandra Aparcana Robles

Institution: Institut für Abfallwirtschaft, Universität für Bodenkultur, Wien

1 Einführung

Der informelle Sektor spielt eine wichtige Rolle in den Abfallwirtschaftssystemen in Entwicklungsländern. Um Stellenwert und Auswirkungen dieser Aktivitäten zu identifizieren wurde eine Literaturrecherche über die Erfahrungen mit der Integration des informellen Sektors in Entwicklungsländern durchgeführt. Es wurden Informationen über verschiedene implementierte Programme in Asien (China, Philippinen und Indien) und Lateinamerika (Peru, Kolumbien, Mexico und Brasilien) gesammelt. Als Ergebnis wurden viele Gemeinsamkeiten hinsichtlich der Ausgangssituation, der Rolle des informellen Sektors im Abfallsystem, der angewandten Integrationsmaßnahmen sowie der ökonomischen und sozialen Auswirkungen identifiziert.

Die analysierten Berichte stellten hauptsächlich die derzeitige Situation der Abfallwirtschaft und die Rolle aller Akteure im informellen und formellen Sektor dar. Fokus war die Rolle des informellen Sektors, besonders jene der Waste Pickers. Es wurden die Vorteile und Nachteile des informellen Recycling umfangreich beschrieben und als übliche angewandte Lösungen wurden verschiedene Strategien und Maßnahmen zur Integration der Waste Pickers in den formellen Sektor des Abfallsystems identifiziert sowie ihre Wirkung analysiert.

2 Beschreibung

Zurzeit übernehmen die formellen Entsorgungsunternehmen Sammlung, Transport und Deponierung der gemischten Abfälle; gleichzeitig beteiligen sich auch die informellen Waste Pickers (IWBs, Street Waste Pickers, Dumps Waste Pickers, etc) an allen Aktivitäten des Systems. In Lima arbeiten noch zusätzlich Waste Pickers in Umladestationen. Es gibt auch Waste Pickers, die die gemischten Abfälle in armen Bezirken sammeln. Sie trennen die Wertstoffe und bringen den nicht verwendbaren Abfallanteil auf illegale Müllhalden oder auf die Straße.

Aus ökonomischer Sicht ist die fehlende Anerkennung des Beitrags des informellen Sektors für das Abfallsystem zu nennen. Beispielsweise wurde für Mumbai, Indien (Rathi, 2006) abgeschätzt, dass die Kosten des Abfallsystems ohne Integration des informellen Sektors bei 44 USD/Tonne Abfall, bei Kooperation mit dem informellen Sektor jedoch bei 35 USD pro Tonne Abfall liegen. Ein anderes Beispiel ist das in Joao Pessoa implementierte System (Pimentel et al. 2005); bei dem mittels einer ökonomischen Analyse der Abfallwertschöpfungskette ein Kosten-Nutzen-Verhältnis von 1,77 festgestellt wurde. Das bedeutet, dass Erlösen in Höhe von 177 Einheiten Kosten in Höhe von 100 Einheiten gegenüber stehen.

In Verbindung mit dem ökonomischen Aspekt steht die fehlende Anerkennung des informellen Sektors als Basis der gesamten Struktur des Recyclingsystems. Aus sozialer Sicht gibt es in allen Fallstudien dieselben Probleme: Kinderarbeit, Abwesenheit in den Schulen, unzureichende Schulbindung bei Erwachsenen und schlechte

Arbeitsbedingungen. Aus ökologischer Sicht sind die Boden, Luft- und Wasserverschmutzung wegen der unangemessenen Abfallentsorgung und der fehlenden Abfallbehandlung vor der Deponierung die häufigsten Probleme.

Die Studien analysieren die derzeitige Abfallproblematik in Entwicklungsländern in Lateinamerika, Asien und Afrika. Sie fokussieren sich dabei auf den informellen Recyclingsektor, auf dessen Funktionsweise, auf die mit diesem Sektor verbundenen Akteure und ihre Rolle sowie, auf ihre Wirkung auf das Abfallsystem auf ökonomischer, ökologischer und sozialer Ebene. Es wird in allen Studien festgehalten, dass der Schwerpunkt einer Integrationsstrategie bezüglich der Waste Pickers und zur Entwicklung eines nachhaltigen Abfallsystems die Assoziation und Organisation der Waste Pickers sowie ihre Aufnahme in getrennte Abfallsammelprogramme wäre. Wilson et al. (2009), Ojeda et al (2002), Medina (2000), Rathi (2006) und Pimentel et al (2005) beschreiben die Integration der Waste Pickers mithilfe verschiedener Maßnahmen, wie zB Gründung von Assoziationen, Einstellung der Waste Pickers als Mitarbeiter für private Abfallentsorgungs- oder Recyclingunternehmen, Einstellung als Mitarbeiter der Kommune, usw. Eine Ausnahme stellt der Fall Haidians in China dar (Wang et al 2008), dort sind die Waste Pickers nicht organisiert, sie arbeiten aber als freie Mitarbeiter der Recyclingunternehmen.

Ein anderer in allen Berichten genannter Hauptaspekt ist die Diversifizierung der Waste Picker-Aktivitäten in Bezug auf die Abfallservices. Autoren wie Wilson et al (2009), Scheinberg (2006), Ojeda, et al (2002) und Medina (2000) heben die Diversifizierung der Abfalldienstleistungen der Waste Pickers als einen wichtigen Erfolgsfaktor einer Formalisierungsstrategie hervor. In Lima arbeiten zum Beispiel auch Waste Pickers, die die informelle Sammlung plus Transport gemischter Abfälle übernehmen sowie Waste Pickers, die in weiteren Abfalleinrichtungen, wie z.B. Umladestationen, tätig sind. Die Autoren nennen als bedeutende Strategien die Berücksichtigung der Recyclingarbeiten und den Bau von Recyclingeinrichtungen innerhalb der Umladestationen, damit die Waste Pickers unter angemessenen Arbeitsbedingungen arbeiten können und dabei den Umladeprozess nicht stören (Wilson et al 2006 u. 2009; Scheinberg 2006). Auch in Kolumbien (Bogota und Medellin) wurde dieser Diversifizierungsaspekt als ein wichtiger Teil zur Weiterentwicklung ihrer Strategien implementiert (Waste Pickers Assoziation Bogotas und Medellins).

In den von Ojeda et al (2002), Wilson et al (2009) und Wang et al (2008) durchgeführten Analysen werden auch die Vorteile der von den IWBs¹ durchgeführten Recyclingaktivitäten genannt. Die Sammlung von sauberen Stoffen mit besserer Qualität wird gefördert, wodurch auch eine bessere Abfalltrennung in Haushalten geschaffen wird. Normalerweise kaufen die IWBs die getrennten und sauberen wiederverwendbaren Materialien wie z.B. Glas, Metall, Aluminium, Papier und Pappe, alte Geräte etc. an. In den Studien wird von erfolgreichen Erfahrungen mit diesen Recyclingschemata auf den Philippinen, in Indien (Wilson et al 2006) und China (Wilson et al 2006 und Wang et al 2008) berichtet. Im Fall Chinas (Wang et al 2008) funktioniert das gesamte getrennte Abfallsammlungssystem auf Basis der Einkäufe bei den Haushalten, d.h. das System funktioniert dank der Marktregel von Angebot und Nachfrage. Es gibt keine finanzielle Unterstützung durch den Staat. Obwohl dieses System erfolgreich ist, empfehlen die Autoren die Ergänzung des Schemas mit anderen Unterstützungsprogrammen, wie z.B. die Schaffung eines gesetzlichen Rahmens zur Förderung der IWBS-Aktivitäten, die Schaffung von Kommunikations- und Sensibilisierungsprogrammen für die Bevölkerung und die Akteure, die Errichtung von Sozialbeihilfeprogrammen, die Setzung von Maßnahmen für den Umweltschutz

¹ Itinerant Waste Buyers

betreffend die nicht recycelten Stoffe, die Förderung der Gründung von Waste Pickers Assoziationen, usw. Weitere von den Autoren empfohlene Maßnahmen sind z.B. die Aufteilung jedes Aufkaufzentrums in Sammlungszone, die Zuweisung der Zonen zu den Waste Pickers, die Feststellung der Einwohneranzahl pro Zone und des Anteils der von den Waste Pickers abgelehnten Stoffe. Dies sind wichtige Faktoren für die gerechte Festlegung des Gewinns der Mitarbeiter, insbes. wenn sie keine fixen Löhne bekommen sondern ihr Einkommen aus dem Verkauf der recycelten Stoffe beziehen (Wang et al 2008).

Die zur Ergänzung einer Abfallstrategie genannten Maßnahmen werden in allen Studien zitiert, analysiert und empfohlen. Die Erfahrungen auf den Philippinen, in Brasilien, Indien, Villa María del Triunfo und Villa el Salvador (Peru) zeigen, dass alle Integrationsstrategien der Waste Pickers zusammen mit Sozialbeihilfeprogrammen, Gesundheitsvorsorgeprogrammen, Ausbildungsprogrammen, der Gründung von Schulen, Sensibilisierungs- und Kommunikationsaktivitäten, der Förderung der persönlichen Entwicklung, sowie der Schaffung von Kinderbetreuungseinrichtungen etc. umgesetzt werden sollten. Ein anderer gemeinsamer Punkt, der nicht vergessen werden sollte, ist der positive ökonomische, ökologische und soziale Beitrag des informellen Sektors. Aus diesem Grund sollten die Waste Pickers als ökonomische Akteure des Abfallsystems und nicht nur als „arme Randgruppen“ betrachtet werden. Maßnahmen zur Verstärkung ihrer Position (durch die Erhöhung des Verkaufsvolumens, Aufbau von Aufkaufzentren, Eigenkapital) und andere Maßnahmen zur ökonomischen Entwicklung der Waste Pickers müssen daher gesetzt werden (Beispiele: Philippinen, China, Brasil, Indien und Kolumbien).

In der nächsten Phase der Doktorarbeit wird eine Feldforschung in Lima, Peru, durchgeführt werden, mit dem Ziel, die sozialen Auswirkungen der in verschiedenen Bezirken angewandten Formalisierungsstrategien vor Ort zu identifizieren und zu bewerten. Für die Analyse und Bewertung der entwickelten Strategien hinsichtlich ihres Beitrags zur Nachhaltigkeit soll die Methode des SLCA (soziale Life Cycle Assessment) angewendet werden.

Die Methode der SLCA ist noch in Entwicklung, standardisierte Vorgehensweisen (Charakterisierungs- und Aggregationsverfahren, Indikatoren, usw.) sind derzeit nicht verfügbar. Ziel der Arbeit ist es auch, einen Ansatz für die Anwendung der sozialen LCA auf abfallwirtschaftliche Systeme zu entwickeln. Mit der Methode der SLCA sollen die sozialen Auswirkungen des Abfallsystems sowie der positive Beitrag oder der Schaden für die soziale Nachhaltigkeit der im Abfallsystem involvierten Akteure bewertet werden.

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