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WASTE MANAGEMENT AND INFORMAL SECTOR IN BRAZIL

**AN INTEGRATED PROPOSAL
BASED ON CAPACITY BUILDING AND
SOCIAL HOUSING DESIGN**

BRAZIL

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POLITECNICO DI MILANO | COOPERA(C)TION: KNOWLEDGE AND
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**Waste Management and Informal Sector in Brazil: an
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Social Housing Design**

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1. Introduction

This research project had as initial ambition unifying two fields of knowledge based on the assumption that there wouldn't be so many connections between them in the literature or in practical projects. In this sense, this thesis analyzes the possibility of improving the informal sector role in the waste management system, considering capacity building models focused on the creation of new businesses. Such models would explore the possibility of using waste for the production of materials for social housing.

Taking into account the points made above, this project has the general objective to analyze the performance of the informal sector in Brazil waste management system and the conjuncture of social housing in the country, identifying good local and international practices to analyze the current situation and envision potential future developments.

It was made the choice to not focus in a specific location, such as the city of São Paulo or even a neighborhood, yet it was considered at the beginning. On the contrary, the data and good practices identified revealed similar patterns, what have lead to consider Brazil as a whole for the case study.

The specific objectives are:

- To analyze the performance of cooperatives, understanding their economic, social and financial aspects, as well as identifying potential new business to be developed.
- To recognize the demand for social housing in Brazil.
- To identify local examples of cooperatives that already use the waste collected for the production of materials, identifying the level of training and industrial structure adopted.
- To research and analyze good manufacturing practices of materials made from solid waste, recognizing the context of differences in each and analyzing partnerships and structures necessary to its production.

Finally, it is important to say that the necessary requirements for technical certifications of building materials in Brazil will not be analyzed in this project, even being necessary for the stage of commercialization.

To achieve those objectives, the project presents in chapter two a review of related literature that conceptualizes the waste management system and the role of the informal sector, recognizing your default in the Global South. At chapter three this situation is summarized in Brazil. It also brings the context of social housing and the housing deficit in the country, in order to portray the demand for affordable housing in the context of this research project.

Chapter four presents the good practices in capacity building projects for the informal sector and in the production of building materials from waste in different contexts and with different typologies.

To support the content of each chapter interviews were made with actors with national presence, highlighting: CEMPRE (Business Commitment for Recycling), ANCAT (National Association of Teamsters and Pickers Recyclable Materials) and MNCR (National Movement of Waste Pickers), Sintronic and Coopermit.

Chapter five analyzes the current situation found, presenting: (i) the synthesis of the opinions of the interviewed stakeholders, summarizing what was identified as the basic pillars or conditions for capacity building projects in the informal sector, and (ii) possible models of capacity building projects in the cooperatives, based on existing chains with the private and public sector.

Those models are analyzed considering the possibility of using part of the collected waste for the production of new materials and / or products for the construction industry.

The second part of the chapter focuses on identifying strengths and weaknesses under the current scenario and present some opportunities identified in light of the main objective of this research.

2.Waste management and the Informal Sector

The literature that approaches the participation and influence of the informal sector in waste management systems of the Global South cities is considerably extensive. It is not intended in this research exhaust the different realities and dynamics found, their similarities and differences, or even get a stoppage of the definitions found in such research sources. On that account, this chapter aims to bring a basic frame of reference of the informal sector's activities in developing countries. This panorama plays the role of being an introduction to understand the Brazilian reality presented below.

A waste management system, according to UNEP – United Nations Environment Programme (2005), comprehends some basic elements, such as the establishment of policies and regulatons; the planning of the activities considering waste generation and its classifications; system of financing mechanisms in addition to their pricing; the existence of facilities and actors for the collection, separation, processing, treatment and final waste disposal; the capability to regulates the private sector performance and the ability to incorporate the informal sector, especially in developing countries.

It is important to highlight that not always this integration of the informal sector can be accomplished in a structured way in the waste management systems, albeit many researches point to the socioeconomic and environmental benefits that they can generate. This scenario becomes a reality mainly by noting the percentage of provision for housing waste collection and the recycling rates and material recovery systems. The majority of developing countries faces quite difficulties and challenges in providing facilities, infrastructure and services related to an efficient system (Gunsilius, 2012; Gupta, 2010).

Traditionally, a waste management system consists of waste generators (residential, business and commerce institutions, industrial actors and so on), public health and sanitation departments, environmental regulatory agencies, and private sector companies. Notwithstanding, two others actors coexist, either separately or integrated to the management system, according to UNEP (2005: p33):

- Informal sector workers and enterprises: in developing countries, individual workers and unregistered, small enterprises recover materials from the waste stream, either by segregated or specialized collection, by buying recyclable materials, or by picking through waste. These workers and enterprises clean and/or upgrade and sell the recovered materials, either to an intermediate processor, a broker, or a manufacturer. Informal sector workers sometimes manufacture new items using the recovered materials, making, for example, gaskets and shoe soles out of discarded tires.
- Non-governmental organizations: NGOs are yet another set of participants in the waste management field. NGOs often have a mission of improving the environment or the quality of life of poor or marginalized groups; as part of this mission, they may stimulate small-scale enterprises and other projects. Since waste materials represent, in many cases, the only growing resource stream, these organizations frequently base their efforts on extraction of certain materials not currently being recovered and processing them to add value and produce revenue. In Latin America, a number of composting projects were started this way.

Ezeah, Fazakerley and Roberts (2013: p 2512-2514) listed in a very didactic way the composition of the so-called waste informal sector, mentioning six categories of activities/actors usually found:

- Household waste collector: are individuals or groups of individuals that going door-to-door collecting recyclable wastes. The income generated for those individuals are not often related to a possible fee charged for the service but rather the revenue generated from selling those waste. These actors can work independently or organized through cooperatives or hired by companies.
- Street pickers: they gather secondary raw materials from mixed waste in markets, streets, garbage bins, drains and transfer stations in the cities, working an average of 10 hours per day and covering an area of 10-15 km. They might have a hand cart or carry the materials in sacks.

Photo 01.Strett waste picker



Source:Wiego¹

- Itinerant waste buyers: often go door-to-door households or institutions and commercial centers collecting, trading or purchasing recyclable items (cans, glass, plastic bottles, paperboard, furniture, and so on). Usually, this category is formed by individuals and involves small investments in order to purchase bicycles, hand carts or wheelbarrows.
- Municipal waste collection crew: usually are involved in the municipal solid waste activities, segregating the waste from the initial collection vehicles from the final disposal sites. They later sell the materials to scrap dealers. This type of activity is common in Thailand, Colombia, Mexico and Philippines.
- Dumpsite pickers: whenever a truck full of solid waste arrives at the open dump/ landfill the waste pickers pick out the useful material prior to it being covered. These materials are often deemed undesirable by other scavengers due to their poor quality (contaminated, damaged or soiled). This activity is mostly carried out by females, the elderly and children in a very vulnerable and risky condition. The items are sold to dealers located in the dumpsite.

¹Wiego, Waste Pickers. Available in <http://wiego.org/informal-economy/occupational-groups/waste-pickers>.

Photo 02. Dump pickers – Gramacho Dump (Rio de Janeiro/Brazil)



Source: Jornal do Brasil²

- Intermediate dealers: those are the primary and secondary dealers, small enterprises, junk shops, intermediate processors, brokers and wholesalers. This group plays an important role in the recycling of materials. Industry demands an adequate volume of quality materials from their supplies and will not buy materials from individual scavengers. As a result, middlemen purchase items from 'scavengers' and then sell them to small industries, traders, main dealers, large scale enterprises and/or exporters who finally sell the recyclables to the manufacturing industry (private sector).

It is quite clear that there is a vast complexity in the socioeconomic dynamics of these actors related to the collection and sale of recyclables / reusable waste. In order to improve the performance and operation conditions in the waste management system in cities, it is necessary to discuss how to integrate them and magnify the degree of formalization in its operations, diminishing the situation of social vulnerability in which the majority is.

² Available in: <http://www.jb.com.br/fotos-e-videos/galeria/2012/05/31/catadores-passam-ultimos-dias-no-lixao-de-gramacho-na-baixada/>

Photo 03. Traders at a dump (Nigeria)



Source: Ezeah et al³

Particularly dump and street waste pickers are exposed to risky living and extreme poverty. Their labor reality is highly unhealthy, with lack of basic sanitation services, health and education. On the other hand, women and children are a considerable portion of the population at the dumps. According to Gunsilius (2012, p.1), *“the departure point for informal sector integration was the endeavour to improve social inclusion and protection. This was initially and exclusively the work of civil rights activists, attempting to help the poorest of the poor. But there are also environmental and economic arguments for informal sector integration”*.

It is important to point out that the informal sector plays an important role in the urban waste management system in most cities of developing countries, since the sector can enhance greater capillarity and exercise selective collection function at a low cost. It has been attested that the existence of these actors increases the level of material recovering from the total volume of waste collected, resulting in environmental and economic benefits, feeding the entire chain of recycling and recovery of materials to be

³Ezeah et al. Waste management 33 (2013) 2509-2519, fig. 1b

later used by industries and saving landfill space (Gusilius, 2012; UNEP, 2005; Gupta, 2010; Ezeah et al, 2013).

Gupta (2010) and Ezeah et al (2013) mention that currently about 15 million person worldwide are part of the informal sector in the waste stream; 6 million in India alone; from 4 to 5 million in Latin America, of which approximately 1 million located in Brazil⁴. Considering this total, the extent to which the waste trading enterprises are registered (“formalized”) varies in developing regions: in Latin America and Asia, there is more formal registration than in Africa.

In recent decades, a number of projects were developed to gain official recognition for these enterprises, and to shelter their operations from disruption during waste system upgrading and modernization, such as:

- Awarding or arranging contracts between informal sector enterprises and the city or formal private sector collection companies.
- Organizing cooperatives.
- Providing equipment, facilities, supplies, clothing, gloves, and shoes, or even vehicles, to improve working conditions; and
- Designing new waste facilities for separation of the waste.

The UNEP indicates that the decreasing in waste generation occurs naturally in developing countries, considering their more favorable conditions for the materials reuse than in developed countries. Among some mentioned factors, it can lead to shortages or high prices for raw/ virgin materials, the low cost of labor employed in design reuse, and considerable market for used products made from recycled materials. Besides that, in some countries, certain types of waste would not be economically viable for reuse, such as dung and coconut shells, are used in energy production. Several projects have been developed in countries such as India, Vietnam, China and Brazil.

The informal collection and treatment network would shrink significantly over time, as the collectors enter into formal collection contracts with licensed recyclers. Also, in addition to offering an incentive to collectors, informal collectors must receive access to

⁴IADB, Regional Initiative for inclusive recycling. Available in <<http://www.iadb.org/en/topics/solid-waste/regional-initiative-for-the-inclusion-of-recyclers,4918.html>>

training and safety equipment in order to start operating under environmental, health and safety standards.

In recent decades, there has also been an expressive improvement in the organization of the informal sector and in its potential for cooperation and integration with governments and the private sector. According to Ezeah et al (2013, p. 2511), comparing Latin America to others regions of Global South, it is possible to find a higher level of the informal sector organization and its inclusion in the waste management system.

They are often organised into worker cooperatives or associations, which have combined into national movements in some countries (Bonner, 2008). A wide variety of stakeholders are involved, including activists, academics, waste picker organisations, NGOs, financial institutions, service providers, and federal, state, and local governments (Medina, 2008). Brazil for instance has one of the largest and best established national movements of waste pickers (Bonner, 2008). The organisation strives for collective recognition, legitimisation, self-empowerment and social inclusion, aiming to build a better and more dignified working life for its estimated 300,000–1 million Catadores(scavengers) who are involved in recycling activities (Gutberlet and Baeder, 2008). It is reported that Brazil alone has about 500 waste pickers' cooperatives (Medina, 2008).

On March 2008, a number of representatives from waste picker organisations, including cooperatives, associations, supportive NGOs, development agencies, governments and researchers, met in the city of Bogotá, Colombia, to attend a three world conference. WIEGO (Women in Informal Employment: Globalising and Organising) was an important enabler together with the waste picker organisations. It has consisted of the First World Conference of Waste Pickers, Third Latin American Conference of Waste Pickers, and the National Day of the Waste Picker in Colombia (Ezeah, 2013).

Another very important initiative is the WAW – Waste Pickers around the world. Launched in 2015, is the sum of several existing databases with information about waste picker organizations in Africa, Asia and Latin America. It was a multi-year process commissioned by WIEGO from 2009 to 2013. Below it can be seen the world map of waste pickers associations around the world:

Photo 04.WAW database map



Source: <http://globalrec.org/waw/waste-picker-organizations-map/#2/0.9/0.2>

These organisations also improve and facilitate the development of capacity building projects, waste pickers data collection and the development of projects with multilateral organisations, such as World Bank and Inter-American Development Bank (IDB).

It is very important to highlight that cooperatives are also a powerful social way of organizing the informal sector. This dynamic model will be explicitly considered in the chapter that presents the case of Brazil and the usual practices. The existence of cooperatives not only dignifies the work of waste pickers but also allows the provision of services - as formalized legal structure-to the local governments and the private sector (recycling industry and productive sector).

It also allows them to advocate as an organized group for better labor rights, such as the regulation of daily working hours, access to health and other basic services. Networking and collaborating with NGOs will add credibility to the role whilst opening channels of communication with the government, formal stakeholders, decision-makers, industry and the community (Ezeah, 2013).

Such formalization is very important for accessing financial resources (subsidies, grants and free-loan infrastructure) and facilities/ materials (equipments, tools, uniforms) that will enable operational efficiency and income generation of these workers.

The government and multilateral agencies will have the opportunity to more easily establish development programs, training and monitoring of these activities. Also, it will be

possible to analyze the situation from a financial point of view, since the revenues and costs will be formalized in accounting systems.

Additionally, it is essential that legislations should be put in place at federal, state and municipal levels as a way to legalising and regulating the operations of the sector and other stakeholders and enable those agreements, partnerships and even contracts between them and the public sector. The formalization and improvement of separation techniques and valuation of waste, training programs and capacity through cooperatives allows them to stand as formal workers in the waste management system. Also, allows them to increase your income in order to equalize themselves with the workers of the base industry and/ or services.

According to Ezeah et al (2013), Medina (2000) and Gusinlier (2012), since improved their level of organization and efficiency, cooperatives will be able to provide a various type of services, such as sweeping streets, pruning trees and bushes, weeding, and removing bulky objects and/or electrical waste and even improve the contracts and level of services provided for the municipalities. Furthermore, it can be possible to overcome some brokers, with the increase of the collected volumes, enlarging the percentage gain in waste sold.

3. Brazil Study Case: the cooperatives in the management system and the demand for low cost housing materials

This chapter seeks to analyse the Brazilian scenario in general, considering its regulatory framework and public policies at federal level, presenting some local examples when existing.

The field research was made during the month of September 2016 and focused on interviewing some actors that have national interface listed below:

- Sinctronics (electronics recycler which underlines the industrial point of view), accounting for its country manager Carlos Odhe and consultant João Carlos Redondo;
- ANCAT - National Association of Teamsters and Pickers Recyclable Materials;
- MNCR – National Movement of Waste Pickers (elucidating the point of view of the waste pickers), accounting for its communication coordinator Davi Amorim;
- Coopermit (it is the only cooperative specializing in electronics in Brazil), accounting for its president Alex Pereira;
- CEMPRE – Business Commitment for Recycling (is a Non-Governmental Organisation – NGO – that operates nationally on training and support to cooperatives in Brazil), accounting for its executive director André Vilhena.

Thus, the core issue in this chapter was to capture the different points of view, especially the private sector, waste pickers and also non-governmental organisations dealing with the training and advising of cooperatives. On the other hand, it is important to emphasize the challenge inherent in this study, due to the extensive universe of active players in the waste management system in Brazil.

In addition, through consultations with the United Nations University (Federico Magalini); Abinee - the Brazilian Association of Electronics (Ademir Brescasin); Ellen MacArthur Foundation (Luisa Santiago), it was possible to get indications of good international and national practices on both the training and empowerment of pickers, such as the use of waste for construction. This panorama is presented in the following chapter.

Therefore from the introduction given above, this chapter presents a brief framework of the current situation of the scavengers and the cooperatives in the waste management system.

Also brings an analysis of the Brazilian conjuncture about the provision of housing services of social interest.

This discussion begins with the contextualization of social housing programs in Brazil to clarify, briefly, what mechanisms exist nowadays for the provision of housing and what are their demand. To achieve the objectives of this research, this analysis aims to comprehend what potential a construction material that results from a recycling chain may interest at this housing service scenario. Against this background, the existing laws were consulted, such as available literature and the Housing Department of the city of Sao Paulo (Architect Julia Mantovani).

3.1 The informal sector in the Brazilian waste system

“Brasilia, March 11th, 2010. It was already 1:51 am when the Chamber of Representatives finally closed a debate that had been going on for 19 years. At that historic moment for the Brazilian environmental scene, politicians, advisers, industry leaders, environmentalists, and government, waste pickers and social organizations representatives watched the passing of the National Policy for Solid Waste. The Act 12305/2010 climaxed with the creation of a model feverishly debated on the halls of the Legislative Chamber during previous months. In play was the future for waste management in the country and its economic, environmental and social implications. The 140 proposals for revision to the original bill showed the complexity of knots to be undone in order to get to a consensus between different interests and points of view.

It was a real exercise of dialogue – a path that has reached the end of its main phase, but that goes on with search for mechanisms to put the new law into practice. When it prioritized the participation of cooperatives, the legislation reinforced a model of recycling that had been being built in the country for the past twenty years, with support of the business sphere. This proposal came with innovations. Among its advancements is the principle of “shared responsibility” between government, businesses and the population – that is, everyone must deal with the challenge of waste.” Source: Ano + 20, *The Recycling in the life of Brazilian*, CEMPRE (Brazilian Business Commitment for Recycling), 2012.

The National Policy for Solid Waste (PNRS) was enacted in December 2010. It was established targets for end dumpsites in all over the country, mandatory reverse logistic for some kinds of waste, such as packaging, lamps, electronics, tires, lubricant oils and agrottoxics packaging. Besides that, responsibilities of each actor were set up at national level in the waste management system, including the need for inclusion and strengthening of scavengers and waste cooperatives in the country. The law guides prioritization so that municipalities can implement selective collection with the participation of cooperatives, and also look after for the creation of financial and fiscal incentives to stimulate recycling.

Another important legal device was set up the Pro-Picker Program in 2010 by Decree 7405/2010. The program provides capacity building and technical assistance, incubation of the cooperatives, development of researches and studies, investment in the cooperative structures and facilities, access to credit and even development actions for new technologies and production arrangements. The decree also enables the signing of agreements, financial transfers agreements, cooperation agreements, partnership terms, adjustments or other mechanisms of collaboration with agencies or entities of the federal public administration, the states, the Federal District and the municipalities.

The Brazilian daily production waste is about 240 thousand tons, much of it improperly deposited in dumps. According to studies conducted by the Institute of Applied Economic Research (IPEA), there are 2,906 dumpsites in Brazil, distributed in 2,810 municipalities.

One of the goals set by The National Policy for Solid Waste was that all dumps should close their activities by the end of 2014. However, considering the several municipalities that face financial difficulties, the construction of landfills in addition to being a high investment, competes with several other needs of infrastructure and basic services, leading to failure to meet this goal. The informal sector in Brazil is formed by about 800,000 pickers. Of these, only 10% are organized in cooperatives. Most work in dumps around the country or acting as autonomous carters, according to National Movement of Waste Pickers (MNCR).

In 2001, UNICEF noted that more than 45,000 children were working in the dumps. Of this total, 22% had less than 14 years age. Although there is lack of updated data, it is possible to find news in the media about this same scenario in the still existing dumps.

The situation of the so-called informal sector in the waste management system in Brazil become more vehement considering that only 13% of the urban solid waste is sent recycled, according to Business Commitment for Recycling (CEMPRE).

In general terms, Brazil has a very inefficient and loss-making waste management system. The social vulnerability of much of the pickers is, above all, a welfare and human rights issue. On the other hand, its performance in the management of urban waste is essential to supply the needs of the selective collection service in the country.

Still, despite the low percentage of selective collection, Brazil stands out in the recycling industry, specifically the direct involvement of cooperatives in collection systems and the formation of a chain that directly involves the productive sector. The aluminum and cardboard are products with higher utilization rates higher on the country: 94% and 77%, respectively. Also, according to IPEA (2013) can be mentioned, with proper recycling percentage, steel cans (47%), paper originating office (43.7%) and long-life type packaging, used for milks for example (27%). The greater or lesser success of recyclable recycling percentage is directly linked to the cost of production of the virgin raw material as compared to the recycled material. For example, in the case of aluminum, it is possible to obtain a saving of 50%.

The municipal selective collection programs, however, represent only 2.4% of all solid waste collection services in Brazil. Exacerbating this scenario, it is emphasized that these services are offered in only 18% of Brazilian municipalities (in 1055 the total). In the other municipalities, the collection is still done irregularly, compressing and mixing all kinds of waste, which makes it difficult or even prevents the recycling process. The lack of separation of waste at the source makes it difficult and costly to waste chain. This reality makes many of the materials that could be recycled end up in landfills unnecessarily. In this sense, the pickers can play a key role as environmental agents when acting in collecting

door-to-door, improving awareness of the population in the daily process of a home collection.

Still, in accordance to IPEA (2013), the pickers collect 90% of all recycled material in the country: *"In this context, as stated Benvindo (2010: 71), 'there is no recycling without picker', regardless of its form organization "*.

CEMPRE⁵ data shows that from the already small number of municipalities that have selective collection programs, 80% are in the South and Southeast of the country, which are the most developed regions of Brazil. In practice, this figure serves only 31 of the 206 million Brazilians. In existing programs, around 44% (464 municipalities) have some form of support or partnership with cooperatives. The formalization of the participation of cooperatives varies from city to city, but in general there is investment of government resources in obtaining machinery, sorting sheds, water costs and electricity, availability of collection trucks (including fuel), training and investments in environmental education and dissemination of population to the program.

For all that has been mentioned and despite its key role in the country's waste management, the pickers have many difficulties with developing their direct citizenship and have ensured their economic survival. According to David Amorim, from MNCR, the pickers represent part of a population deeply vulnerable socially and in their living conditions. Their earnings are pegged to the sale of recyclable materials that are priced as commodities and subject to price fluctuations. Worsening this scenario, there is not an effective policy for waste recovery. There are no adequate incentives for the financial sustainability of the picker: the least valued and paid link in the waste stream but the most essential actor to the performance of recycling in the country.

Also according to David, although the cooperative is a model that has helped in the survival of pickers and improving their working conditions, there is no incentive policy to the formation of these organisations. Some of the main reasons: the recyclables are doubly taxed (in Brazil, the industrial product and the market one are taxed, as well as recyclable

⁵ Research ciclosoft 2016. Available at <cempre.org.br/ciclosoft/id/8>

materials that are sold) and tax withholdings in cooperatives are exactly the same as a traditional company, often invalidating their survival.

The implementation of a cooperative of pickers requires a set of basic conditions for transport, sorting, processing and commercialization of waste, as well as supporting its members. The average income of the pickers varies according to the region of the country and its activities in urban centers or peripheries. But the average is R\$ 1,000 to R\$ 1,500 per month (around 1 to 1.5 minimum wage), reaching only 300 reais in the poorest regions or three thousand reais in most health regions. On the other hand, it can be said that the fixed investment of a cooperative can range from \$ 55 thousand to 200 thousand reais according to its structure (CEMPRE and MNCR).

Thus, according to IPEA (2013), analyzing the current status of recycling cooperatives, with some exceptions, it can be concluded that it is a reality still fragile, and that this precarious work goes beyond the issues of labor rights. Even organizing to escape from economic exploitation, the picker remains vulnerable to it. There are few industries that purchase recyclable and, moreover, require large volumes to negotiate. In practice, large volumes are generally obtained only by scrap dealers, who own infrastructure and financial resources to work with the residue to add value (balance, press, trucks, crusher, shed, phone, and capital), taking advantage in negotiations with major buyers and the industries that use those materials.

The average cooperative adding value to the ultimate purchaser reaches 85%, with some products exceeding 100%. The highest value for the recycling of waste is the scrapper (intermediate), which imposes the price of recyclable products to cooperatives by market force. The industry, buying recyclable, benefits from saving energy and virgin raw materials, as well as labor for screening. The strengthening of relations between the private sector and cooperatives may be a solution, according to André Vilhena (CEMPRE) for the elimination of the brokers in the chain. Still, there are many difficulties in this direct connection to the business: fear of labor process, the requirements for the provision of services, the technical specifications in the supply of recycled raw material and the supplied volume are some of the barriers.

A study by IPEA (2013) points five links in the selective collection chain: segregation of waste at source, collection activities, sorting, processing and recycling. The collection of recyclables can basically be performed by pickers and private companies from outsourcing contracts undertaken by local authorities. At the stage of sorting and classification there is use of both manual activities and mechanized pressing and packing waste in the cooperatives. At this stage, scrap dealers and the intermediaries may also act.

In the processing step, specific procedures are applied to each material, which is then transformed into new input. The most common agents are the companies and a few more organized cooperatives. Recycling, which is the last stage, is characterized by the effective production of raw materials for industrial processes. Here, companies hold greater participation. The few cooperatives are inserted in some experiments as the production of tiles or broom and shafts, for example.

Historically, the first cooperative in Brazil is the Cooperative of Pickers of Paper, Paring and Recyclable Materials (Coopamare), founded in 1989, in the city of São Paulo. In 2001, The National Movement of Waste Pickers(MNCR) was created during the First National Congress of Recyclable Materials. At that time, more than 1,700 pickers gathered which resulted in the launch of the so-called *Brasilia Letter*, a document expressing the needs and demands of the category, as well as its principles of political action. The creation of MNCR was instrumental in the process of strengthening a collective identity of *pickers of recyclable material*, term by which these workers have come to recognize themselves nationally,officializing this category to the Ministry of Labor.

Currently, MNCR is considered the largest organisation defending the interests of the world pickers. It is important to notice that, over the years, the movement managed to extend their joints to other countries. In 2008, the first world congress of waste recyclers occurred in Bogotá - Colombia, gathering representatives from Latin America, Africa, Asia and Europe. In 2009, São Paulo hosted the 1st. International Meeting of Pickers, with representatives from Latin America and India. Despite the challenges, Brazil, aligned and combined with the work of other key players such as CEMPRE (founded in 1992), has been

well recognized in relation to the performance and integration of the informal sector in waste management system as well as for its ability to organization and articulation.

Photos 05 and 06. Selective collection in trucks and PEVs- collection points provided by the private sector



Source: CEMPRE, 2011

Photo 07. Screening area of cooperative



Source: CEMPRE, 2011

Photos 08 and 09. Press activities and paper shredding held in cooperatives



Source: CEMPRE, 2011

3.2 The demand for access to housing and the context of social housing programs in Brazil

The Brazilian popular architecture resulted from the simplicity that is the result of the materials generally available in the region; adaptability, since exogenous models just adapting to the medium as occurs, for example, Japanese and German immigrants; creativity or creation in the sense of formal imagination and use of building materials; and shape of the architecture, the result of techniques and construction materials, the multicellular evolution and deep respect for the traditions culturais group; and not the result of a party, as in classical architecture. (Weimer, 2005).

Currently, Brazil housing deficit is around 6,070,000.00 homes⁶, according to the latest survey(2014), conducted by the following institutions: Joao Pinheiro Foundation, in partnership with the Ministry of Cities; Inter-American Development Bank (IDB) and the United Nations Development Programme (UNDP).

This index(deficit) represents some factors: the number of poor households, family cohabitation (families who need new homes), excessive burden on rent (number of urban

⁶ In this sense, and to help understand the Brazilian scenario, is important to consider that Brazil has approximately 206 million inhabitants according to latest research from IBGE, the Brazilian Institute of Geography and Statistics, this year.

households with low family income) and increased density of rented homes. In a broad view of housing needs, the housing deficit is the immediate sense of the need to build new houses and sense of inadequate quality of life of residents. Therefore, the deficit does not make reference to the physical characteristics of the constructions⁷

In Brazil, access to housing is a right guaranteed by law. Briefly, the National Housing policy began in 1946 with the creation of the “Foundation of the Popular House”. Your action plan was overhauled in 1964 with the creation of the National Housing Bank, BNH. In 1986, the BNH was abolished and its duties were transferred to CaixaEconômica Federal⁸. Housing remained linked to the Ministry of Urban Development and Environment (MDU).

In 1987, the MDU was transformed into in the Ministry of Housing, Urban Development and Environment. With the Brazilian Constitution of 1988 there was the decentralization of the management of social housing programs for the state and municipalities. With high degree of investments, state and local governments have made development initiatives based on alternative models, highlighting the urbanization programs and slum regularization.

However, in 1994, even with the creation of the two programs Inhabit Brazil and Live Municipio, began the decline of investment in the Housing sector in the country, mainly marked by cost containment and weakening institutions. This situation improved in 2003 with the creation of the Ministry of Cities and the Council of Cities. The main milestones were: restructuring and strengthening of institutions, creation of new laws and consolidation of the social movement’s participation in the policies. One of the Council's actions is to ensure the execution of the law 10.257 of July 2001 - the City Statute, which establishes the social function of urban property, among others. In 2004, the National Housing Plan was approved: in addition to establishing rules and guidelines based on social inclusion, participatory and democratic management, it defined the functions of organs and institutions such as CaixaEconômica Federal as the main responsible for housing programs⁹.

⁷Anexo Nota Técnica, página 4, Deficit Habitacional no Brasil 2014

⁸Caixa Econômica Federal is a public bank.

⁹Ações Integradas de Urbanização de Assentamentos Precários Brasília, 2010, page 20.

This historic clarify the understanding of the changing nature of the latest reforms in the Brazilian legislation. Strengthening institutions managing the construction programs of social housing in Brazil allows housing assistance through mainly two actions: the construction of new housing and urbanization of slums.

Currently, one of the main government social housing programs is called Minha Casa Minha Vida. In this thesis, its rules and regulations won't be discussed. However, it is possible to define it as a program focused on the building of new social houses. In relation to the object of study of this thesis, the need for low cost materials is still a major challenge in the projects, despite the considerable achievement in terms of quality in recent years in this sector.

The Social Housing programs in Brazil currently have buildings with low and high impact. In Sao Paulo, for example, urban legislation has social interest zones where the occupation rate and the coefficient of utilization are the same as for residential buildings over ten floors. The possibility of construction of buildings with a high index of densification is interesting, especially in urban settings. However, on the assumption of a constructive element of low cost, high strength and likelihood of industrial production, the challenge presents very complex for the purposes of this thesis.

As mentioned, the Minha Casa Minha Vida program also develops low index densification projects. A challenge that can be perceived as an opportunity is on the main removal method, in residential care. In many cases, the decision is for payment of financial assistance. For example in this sense, recently an initiative has been observed, in relation to new solutions of materials for construction of social housing: a company in the city of Sao Paulo (which develops finished as dividers and liners) submitted to the Secretary of Housing a product that features lightweight and easy handling for construction of temporary housing.

Thus, currently, the possibility of developing low-cost materials for the construction of temporary settlements in Brazil is interesting, to promote the quality of housing supply in case of removal regardless of the reason for the removal: cases of construction works or cases of risk areas (such as areas with natural risks with slopes), for example.

Regarding the urbanization of slums, this is held in synthesis by diminishing risk factors, infrastructure implantation and implementation of basic and settlement services. It is important to clarify that in Brazil, as in other countries of the Global South, so a slum have access to services guaranteed by the government is necessary that the slum present consolidation features. To do so, are considered on the spot settlement time, the level of infrastructure and mainly safety conditions of buildings. On this last point, given the existing legal possibilities, it is possible to say that the solutions studied in this project meet the necessary requirements for residents of precarious housing can make improvements in their own dwellings , aiming at enhancing the living conditions of these people and the possibility of land regularization.

In this sense, in the following chapter it is intended to analyze what are the characteristics of the construction materials that use recycled content aiming to identify their possible use for self-construction.

Photo 10. Favela Ernesto Simoes (San Paolo, Brazil)



Source: Ana Luisa Barbosa

4. Good Practices identified: Brazil and the Global South initiatives

From the survey of the Brazilian reality, this chapter presents examples of good practices found:

- Regarding the empowerment and capacity building of the informal sector, from its organizational capacity in cooperatives and in particular in terms of partnerships and innovative projects signed with public and private sector;
- Taking into account the solutions in architecture using solid residues in building materials, to identify whether they are, low-cost solutions and if establish connections with the informal sector for provision of such waste.

The item 4.1 provides a summary of some projects that could be considered examples of capacity building in Brazil. These models assume the organization of the informal sector into cooperatives and their articulation with social movements, universities, public and private sector. In item 4.2, are pointed examples of the development of construction materials with recycling of solid waste. These examples are analyzed to identify the technical skill levels, complexity, types of waste that are used in the composition of those materials and the establishment of partnerships with the public, private and academic sectors. .

It is intended, at the end of the exhibition of these examples, intuitively draw some models that can meet the demand for low-cost products for the construction and present the characteristics required for its design.

4.1. Brazil Informal Sector: examples of Capacity Building

There are many interesting examples found in Brazil regarding the organization of scavengers in cooperatives. Good practices portrayed in this project aim to present the cooperatives that have improved their level of organization and have developed projects to increase their revenue.

The scenario of the informal sector in the Global South, from the literature review, teaches us that, in general, there are similar movements going on in other countries. Moreover, there is a high level of coordination and exchange of experiences among associative movements of scavengers around the world. This means a growing organization of these actors in productive structures, aiming to dignify their work and increase their incomes.

In this structure, the participation of the public sector and the third sector has fundamental importance to the informal sector, especially in the early stages, both in relation to the provision of training, structure and resources. On the other hand, there is also a great potential to work together with the private sector, either in reverse logistics chains or social innovation projects.

The identified cases where processing structures were created for the production of recycled raw materials or even new products are not focused on meeting the social housing demand. Here, it is important to clarify that this connection is not well delineated in Brazil.

The examples were classified into three types: partnerships with municipalities for selective collection programs, partnership projects with the private sector and organization networks.

4.1.1 Partnerships with municipalities for selective collection programs

The municipalities deal with challenges to improve their collection systems, especially regarding the selective collection. Two causes are the main ones: the obligation of the National Policy on Solid Waste in determining that the dumps were extinct by 2014, but also by the need to have a more efficient use of landfills.

The alternative of municipalities to hire cooperatives without bidding, through agreements or payment for environmental services, highlighted several examples of partnerships in the implementation of selective collection programs, such as in São Paulo (SP), Belém (PA), Salvador (BA), Brasília (DF), Itaúna (MG), Londrina (PR), Itú (SP) Ourinhos (SP), among others.

Through such agreements, cooperatives begin to make the selective collection on trucks, perform screening activities, pressing, weighing and sale of recyclables. The goal is to improve the financial sustainability of cooperatives and, on the other hand, increase the collection of recyclables by the municipalities. In these agreements, in general, the city gives the physical space and trucks for the collection, in addition to supporting expenses such as water, electricity, or safety equipment.

Despite being a model with subsidies, there are savings to the government, compared to the concession agreements that are usually carried out with companies for that purpose. In addition, through the selective collection programs, there is a decrease in the volume of waste going to landfills, when run efficiently.

However, there are cases where the financial equation does not close and the average income of the cooperative ends up falling. According to CEMPRE (2012), it was the situation of Natal (RN), with the transfer of people working in dumps for sorting plant. Without training and proper administration, the average income of workers has plummeted to less than a minimum wage.

The collection by trucks donated by the City Hall has started to increase the volume of waste and improve their separation. However, administrative barriers did the number of trucks dropped from 16 to four. After action of the prosecution, which forced the city to return to the selective collection program in the city, the collection of recyclable waste started to be made entirely by the cooperatives, paid by contract to provide environmental services.

In this model, the City Hall pays to collectors the value that saves for not sending the waste into the landfill (around R\$ 150 per ton). This system has extended the geographical coverage to 70%, with the increase of waste collected from 40 to 300 tons per month. The average income of cooperative members reached a level of R\$ 850 per month, about a minimum wage.

In the case of Londrina (PR), the contract with the City Hall also involves pay per ton collected, plus the cost of transportation and disposal of the sorting center spaces. There is

also an additional amount to cover the INSS collection costs (tax for public welfare) for the workers.

However, in the case of São Paulo (SP), despite the existence of the selective collection program since 2007 and the integration of 23 cooperatives to the system, there is criticism about the effectiveness of the program and the real profits to the waste pickers. Selective collection is carried out by private companies (Loga and Ecourbis) or through Voluntary Delivery Points - VDP's. Contracts with these companies are service concessions for up to 20 years. According to Davi (MNCR), compactor trucks are used, which makes the subsequent screening and recovery of materials more difficult. Moreover, there is no environmental education and information on how to properly dispose recyclables to the population. The result is the low quality of the waste and a high reject content that reaches the 31 city screening centres, which employ about 1100 people.

The monthly income generated to the cooperative members from the material sent to cooperatives is far short of what could be, in case of a higher quality collection made at the source (home collection). The city of São Paulo generates around 20 thousand tons of waste per day, of which 12,000 are from household waste. Despite all the efforts, according to Bastos, Pinto, Souza (2010): "It is collected and recycled 7% of the waste discarded every day. For a city with the size of São Paulo, one can consider that is a small amount, since the remaining 93% are destined for landfill, along with the regular trash, or worse, discarded in nature (SOUZA, 2000)".

In the opinion of MNCR, the inclusion of scavengers in collecting door-to-door could bring a major improvement to the system, reducing costs and increasing the quality of what could be recovered and improve recycling rates, since the waste picker can and should be above all an environmental education agent with the population. This is the case of the municipality of Itaúna, State of Minas Gerais, shown below as a good example of public partnership with cooperatives.

- **Selective collection program of Itauna(MG):**

In this municipality, the Coopert was established in 1998 and was managing to gradually gather all pickers who used to work in the city dump. With the strengthening of the relationship with the City Hall and the social assistance agencies in the state of Minas Gerais, the volume for the cooperative grew until the entire selective collection in the city.

According to Von der Heiten (2007), the City Hall donated the equipment to the cooperative, and gave the physical space. After sorting and pressing, these materials are sold to various buyers. Plastic, for example, goes to another recycling cooperative, in Belo Horizonte, called Asmare, which according to Ethos Institute and Avina (2007) has plastic processing pilot project for return to the industry.

In the case of Itauna, the cooperative members play a key role in environmental education of the population. The average separation of waste reaches 70%. The work is so successful that the average income of laborers reaches R\$ 3,200, according to the Tempo¹⁰ newspaper. Before the service be hired by the city, the average income did not exceed R \$ 980

The City Hall saves R\$ 130,000 monthly and there are plans to extend the collection to the portion of the wet waste, to increase the separation of recyclables and start composting projects with organic waste.

It is noticeable that the integration of cooperatives to municipal waste system should have a careful analysis to actually achieve the best range financial equation for both the public accounts, and the generation of revenue for the cooperatives. Recognizing the collector as an environmental education agent is another key point in the studied examples, since it allows him to be seen as an information link for the population, improving the quality in the collection of waste.

¹⁰Available in: <<http://www.otempo.com.br/cidades/catadores-em-ita%C3%BAna-faturam-sal%C3%A1rio-mensal-de-r-3-200-1.923374>>

Photos 11 and 12. Truck of selective collection and inauguration of the new cooperative's headquarters



Source: Coopert¹¹



Source: Insea¹²

4.1.2 Partnerships productive industry – cooperatives

Furthermore, it is possible to identify projects that are carried out directly with the private sector. According to the Ethos Institute and Avina (2007), there are generally two types of links identified between cooperatives and private sector. The first is one in which companies hire cooperatives to collect recyclables in exchange of these materials, as the case of BelgoMineira that provide recyclable waste from your site in exchange for management (collection, sorting, pressing and consolidation of waste to recycling). In addition, the company pays Asmare cooperative in Belo Horizonte by the provided collection services. The model has expanded to other companies in the region.

The second type involves the investment in training projects and infrastructure to improve the functioning of cooperatives, such as Petrobras and other medium and large companies that help in the acquisition of presses, scales and security equipment for the

¹¹Available in:

<https://www.facebook.com/262027087239262/photos/a.262540330521271.55154.262027087239262/262540897187881/?type=3&theater>

¹²Available in: <<http://www.insea.org.br/coopert-tem-nova-casa/>>

cooperatives. In these cases, there is also the forwarding of recyclable volumes generated in their operations to these cooperatives.

The "Glass is Good" project is a good example of this partnership. Developed by Diageo company, seeks to increase glass recycling percentage in Brazil (currently 47%), and avoid the empty containers of its products are used for adulteration of drinks.

Partnerships with bars and restaurants in the cities of São Paulo and Recife ensure that glass containers are separated and delivered to cooperatives. These, through the project incentive, receive glass processing structures, transforming it into homogeneous pieces to be sent to Owens-Illinois, the largest glass manufacturer in the world and supplier of glass packaging for Diageo.

The company buys volumes of cooperatives and saves energy in the transformation of the recycled material for reintroduction. Compared to the usual transformation process of virgin raw materials, the economy is a third less heat.

There are still efforts by non-governmental organizations to bring the industry of recyclables waste and cooperatives. By buying in large volumes, there must be efficiency in collecting, sorting and increase the volume to send to these companies. Besides the organization of cooperatives to negotiate large volumes with the industry, some examples of agreements for low volumes can be cited: Companhia Industrial glasses and Frompet in Recife, which provide equipment and training for the cooperatives, prioritize the purchase of recyclables collected by them.

Furthermore, there are interesting cases through retail participation, offering voluntary delivery points to be managed by cooperatives or directing the packaging collected in their establishments for the cooperatives.

4.1.3 Cooperative Networks: processing infrastructure

In Brazil, there are some cooperatives that have established processing facilities in its operations. This was possible through support to government programs, multilateral or corporate training or through own resources. Most of them works with solutions for the

plastics, like the pet flakes production, or the production of buckets, bottles, clothesline rope and brooms. There are also those who work with the cooking oil to produce biodiesel.

At this point, it is not possible to identify a more strategic production to meet social objectives or market niches. What can be seen is the use of residues which are not so highly valued in the chain, or even materials that transformed have more value to its sale as a residue, as is the case of some plastics. Below are some examples of this:

- **Coopecent ABC – São Paulo:**

The Coopecent ABC is the result of the union of three cooperatives in the region, Cooperma (Mauá), Cooperpires (RibeirãoPires) and Cooperlimpa (Diadema). It was created from the identification of unification needs of volumes collected by the cooperatives for direct selling industry, cutting brookers and increasing the revenue generated.

The institution had the support of the GEA Institute and Petrobras resources, through the Petrobras Development & Citizenship Program. One of the organization's goals is also to increase the number of members and the involvement of more cooperatives, improve the quality of work and increasing the selective collection of the region.

One of the cooperative's revenue sources is the production of poles and brooms from PET plastic bottles, setting up trade agreements even to local supermarket chains (MNCR).

Photos 13 and 14. Broom and clothesline made of pet plastic



Source: Coopecent¹³

¹³ Available in <http://www.coopcentabc.org.br/>

- **Cooperativa CORESO – Rede Catavida Sorocaba (São Paulo):**

The CORESO - Sorocaba Recycling Cooperative was established in 1999 and currently has over 80 members and is part of Catavida Network, which brings together several cooperatives of 12 municipalities. This reality was made possible by the support of non-governmental organizations such as the CEADEC - Centre for Studies and Development Support, Employment and Citizenship.

In 2011, the plastic processing site was inaugurated, from an investment of R\$ 700,000, from partnerships with Petrobras (purchase of equipment and construction of infrastructure), BNDES - National Bank for Economic and Social Development (installation of power transformers), Metalworkers Union of Sorocaba and Region (electrical installations) and City Hall of Sorocaba (donation of space).

The cooperative's polymers division works with the Polyethylene Polymer (PP) and Polypropylene (PE), recycling margarine tubs, ice cream, covers, packaging of detergents, shampoos, among others. The processing involves washing steps, grinding and drying; then passes to the extruder and processing of polymers in granules for commercialization to industries. Still, there is their own production line: pipes and sewage pipes for construction and PE polymers (polypropylene) transformed into hoses for irrigation in agriculture.

Currently, 110 tons per month of plastic are processed, from partnerships with other cooperatives in the region for consolidation of volumes.

In 2016, the CORESO was visited by scholars and entrepreneurs from Canada, Kenya, Argentina, South Africa, Sweden and Nicaragua, as part of a project developed in conjunction with the University of Victoria, Canada and Federal University of ABC to promote caring and inclusive economy.

Photos 15 and 16. Kenya visitors knowing the processing of plastic and selective collection trucks of CORESO



Source: Luiz Setti¹⁴ e CORESO

- **Rede CataBahia – Bahia**

The Catabahia network was started during the First Meeting of Scavengers of Recyclable Materials of the State of Bahia in 2004, with the support of MNCR. The project of uniting the cooperatives in the region was consolidated from the support of non-governmental organizations, and the sponsorship of stakeholders: Petrobras, the European Union and Bank of Brazil Foundation, through the CataAção¹⁵ (“Collect Action”) program. Its strategic objective is the social and economic inclusion of collectors in the state of Bahia and direct sales for the recycling industry (FundaciónAvina, 2013).

Currently, Catabahia is considered a Solidarity Network of Collection and Recyclable Materials Trading between various cooperatives in the state of Bahia. More than 1,000 collectors are benefited and are organized into the following cooperatives: Collectors of Ecological Canabrava agents - CAEC (Salvador city), COOPERBRAVA (Salvador city), CAELF

¹⁴Available in <http://www.jornalcruzeiro.com.br/materia/695214/estrangeiros-conhecem-reciclagem-da-coresoe> e <http://www.jornalcruzeiro.com.br/materia/400706/coresoe-e-pioneira-na-reciclagem>

¹⁵According to FundaciónAvina (2013, p. 5): “The program is the result of a partnership between the National Movement of Recyclable Materials (MNCR), the Inter-American Development Bank, through the Multilateral Investment Fund (IDB / MIF) and the Department of Water and Sanitation, the Ministry of Social Development and Fight against Hunger (MDS), FundaciónAvina, Coca-Cola Brazil and the Interchurch Organization for Development Cooperation (ICCO)”.

(Lauro de Freitas city), CORAL (Alagoinhas city) RECICLA CONQUISTA (Vitória da Conquista city) VERDECOOP (Entre Rios city), COOPERJE (Jequié city) ITAIRÓ (Itapetinga and Itororó cities) and COOBAFS (Feira de Santana city).

According to FundaciónAvina (2013), through the CataAção project, some processing structures were implanted adding economic value to the waste and generating more revenue for cooperatives. It was developed a plastic processing structure, aiming at the production of bleach (with plastic bottles as a product of this process), a cooking oil processing unit (filtering, crushing and storage of oils and fats) for the production of soap and even a biodiesel production plant to supply fuel to the cooperatives trucks. A cutting machine for producing cartons was obtained, enabling the production of new boxes.

Photos 17 and 18. Cutting machine for cardboard boxes and announcement model of bleach



Source: FundacionAvina, 2013¹⁶



4.2 Good practices in the use of recycling materials for low-cost construction

It was possible to identify, during the research, that there are two distinct processes of solid waste reuse in construction: one produces a local impact, while the other has a production process on an industrial scale.

¹⁶ Available in <http://www.pasocierto.com/assets/dd6.passo5-rede-cata-bahia.pdf>

The first process is related to the construction of housing and public use equipment in contexts where, generally, not yet there is a solid waste collection system. Participatory processes are developed from the initiative of non-governmental organizations with partnerships between designers and local community seeking solutions for the reuse or recycling of the local solid waste for housing construction.

The second type of process is also related to low-cost construction. The difference is that in these cases the main goal is to produce construction elements from recycled materials, not the constructions. The solutions run mainly from the academic sector and industry, and result in an industrial process.

Within a range of complexity, the first examples result in the construction of houses with reuse of local solid waste, bringing the possibility of generating social and economic impact. Here the local community, through a participatory process, become aware of the environmental issue and develop an interest in the formation of cooperatives.

In the second situation, the result is a constructive product easy to handle, with characteristics of replicability and the possibility of production on a large scale at low cost. It is interesting for scenarios that already have some capillarity in solid waste collection system.

Both examples require different levels of complexity as technical training for product development and structure to the production process. The training and structure, perceived as indicators, can be classified as high, medium and low.

Regarding the technical training, it is considered low when the technique used is easy to reproduce. Medium, when there is need for some kind of training. High when some advanced technical formation is necessary.

In relation to structure for the production of the material, it is considered low when the product can be performed in the construction site. Medium when is needed to its production a specific facility, but with use of simple machinery. When the classification is high, it is necessary a larger structure, with high capacity equipments.

The following examples can be found in Ghana, Cambodia, India, Paraguay, Mexico and Colombia. Some cases presented not have sufficient information, however, still are considered important as an example for future in-depth research.

4.2.1 Solutions with local impact

- **Ghana's house**

Anna Webster, a fourth-year student of London Metropolitan University's School of Architecture, created the design as part of a competition that invited proposals to build a single-family home in the Ashanti, Ghana. The competition was organized by the Nka Foundation, a non-profit organisation whose mission is to promote humanitarian efforts through the use of the arts¹⁷.

As in Ashanti, most communities in remote locations do not have a collection system of solid waste. Besides the application of local techniques for the construction of edification, as the compacted mud, Webster proposed reuse of plastic bags - typically used by the locals to transport drinking water - for the construction of the roof and windows.

Photos 19 e 20. Ghana's house and window detail



Source: <http://inhabitat.com/this-home-in-rural-ghana-was-built-from-rammed-earth-and-recycled-plastic/>

¹⁷ Available in: <http://www.dezeen.com/2015/06/28/nkabom-house-prototypical-ghana-home-mud-waste-plastic-anna-webster-abetenim-arts-village/>>

Materials: Plastic bags used for dispensing drinking water

Location: Ghana

Application: Window blinds equipped with, mesh bars translucent panels for facades and which form part of the roof

Level technical training to difficulty: low

Level of complexity for production: low

- **Building with bottles**

HUSK Cambodia is a non-governmental organization focused on promoting the development of villages in the province of Siem Reap Cambodia. In an attempt to solve the problem of solid residue in the region, the NGO has developed a solution for construction of walls with plastic bottles reuse, in partnership with the proposal of the group "Pura vida".

Instead of using traditional brick, there is the use of wire, plastic bottles filled with clean and inorganic waste, and plastic bags. According to the NGO, more than 100,000 bottles were used for the construction of a medical center, three classrooms, a workshop and a sanitary.

This same solution in construction is also used in the project for KoukKhleang Youth Center, conducted by Komitu group (NooraAaltonen, SiskoHovila, TuuliKassi, Elina Koivisto, Maiju Suomi, InariVirkkala): "The bottles can be filled into any kind of frame, most often concrete or wood. If the frame is concrete, one should leave metal "hooks" for attaching the iron chicken net to hold the bottles in place. If this had been done while casting the concrete in KKYC, the wooden frame, which actually turned out to be quite expensive as wood is so scarce in Cambodia, would not have been needed.

After building the wooden frame and attaching the net from the bottom, one can start filling the frame with bottles. A good amount of bottles is 2 side by side per wall. In order to save cement in plastering one should then fill the gaps between bottles with pieces of plastic. The bottles are simply tied together with iron wire, which makes the best result when added to each layer.

Photos 21 and 22. Instructions for construction of walls with plastic bottles and bottles collected by the children

Building a bottle wall

Bottles

Students and volunteers stuff the plastic bottles with plastic bags and other insulating trash. More bags fill in the gaps between bottles.



Chicken wire

The bottles were bound between layers of chicken wire, which are attached to a metal frame.

Concrete

Up to three layers of cement mixed with sand were applied to the outside of the bottles, with orange paint adding the finishing touch.

ERIC BAKER/THE OREGONIAN



Source: <http://www.huskcambodia.org/>

It would have been great to collect all the bottles in KoukKhleang but as Inari's time in Cambodia was so short, we needed to buy our bottles from Siem Reap. What made us happy was that local kids picked up the idea and wanted to collect few bottles for the center. Here are some pictures of them proudly receiving their awards of 300 riel per bottle."

Photo 23. Detail of the construction of the wall KoukKhleang Youth Center



Source¹⁸: KomituArchitects et al

¹⁸Available in: <http://www.komituarchitects.org/>

Photos 24 and 25. The KoukKhleang Center and call to contribute with the gathering of plastic bottles.



Source¹⁹: KomituArchitects et al

Materials: reused plastic bottles
Location: Cambodia
Application: building walls
Level technical training to difficulty: medium
Level of complexity for production: low

- **Pani Community**

The educational building in the north of Rajarhat, designed by SchilderScholte Architects, used materials and techniques constructive from a maximum radius of 15 miles from land. In the research, it was not possible to find constructive methods used for the reuse of materials. But beyond the use of bamboo on the roof and walls, bricks molded by hand, wooden hoses and mortar location, the project reuses steel and cardboard found in the region.

"The concept was to combine and optimize local techniques also local materials. For this, the strategy was to participate in the development and modernization of local building processes without breaking with the 'know how' of the population".²⁰

Photos 26, 27 e 28. The Pani Community

¹⁹Available in: <http://www.komituarchitects.org/>

²⁰Available in: <http://www.archdaily.com.br/br/766431/centro-comunitario-pani-schilderscholte-architects>



Source: <http://www.archdaily.com.br/br/766431/centro-comunitario-pani-schilderscholte-architects>

Materials: reuse of metal and steel

Location: India

- **Loofahs's house.**

A specific material was developed from recycled plastic and agricultural fibers, in order to suppress the use of materials demand with characteristics similar to wood. In a context where forest areas were reduced considerably, coupled with the housing deficit in the country, Elsa Zaldivar, in partnership with industrial engineer Peter Padros developed this material: " The region around Caaguazú has experienced severe deforestation for morethan four decades, and the area's economy has declined considerably due to a collapse in cotton and an increase in cultivation of soya, a crop that has contaminated the soil and forced families to leave their land. To help the local economy, Elsa had previously worked with a group of women in Caaguazú to growloofah and use it as a source of income.(...)But they also had wastes. About a third of the plants grown were of inferior quality and could Not be exported, and then 30% of a good loofah is trimmed off. All of these scraps ended up going to the landfill." ²¹

²¹Available in: <http://inhabitat.com/sustainable-and-recycable-housing-made-from-loofahs/>

The idea of using the ground plastic arose from the difficulty of finding a product that could work as a league of agricultural fibers economically. The structure for producing panel is consisted of: a melter, mixer, an extruder and a cutter whose amount of material may vary and fillers, besides variations in degrees of flexibility, weight and quality of the isolation. Having careful in choosing the type of plastic, the panel can still be crushed, melted and be formed into new panels after use.

The Elsa's hope is that this building material will allow families to easily and quickly construct simple homes in 3 to 4 days at minimal costs. Urban residents will also be able to use these panels for construction: "We want to find sustainable housing alternatives for the poor, while also discovering new markets for their agricultural products, particularly the loofah. This is a perfect combination."

Photos 29 and 30. House made with loofah panel



Source: <http://inhabitat.com/sustainable-and-recycable-housing-made-from-loofahs/>

Photo 31. Harvesting loofahs



Source: <http://inhabitat.com/sustainable-and-recycable-housing-made-from-loofahs/>

Materials: recycled plastic and agricultural aggregate

Location: Paraguay

Application: walls

Level technical training to difficulty: medium

Level of complexity for production: medium

4.2.2 Solutions applicable in an industrial process

- **EcoDomum**

Carlos Daniel Gonzalez founded EcoDomum in 2013, in order to build durable homes with affordable prices, by using recyclable plastic. In this sense, the company produces panels of recyclable plastic. Gonzalez said that "Mexico ranks as the 12th largest plastics consumer in the world, consuming over 5 million tons of plastic each year."

The project started with the initiative of solving environmental and social issues, "Puebla, where EcoDomum is headquartered, is one of the poorest states in Mexico with 64 percent of the population living in poverty. According to González, this often means people in his neighborhood lack the basic needs of food and housing."

The company carries out the collection of plastic in the region and separates those that melt without emitting harmful gases. After, the plastic is cut inside a specific machine. This material passes through an oven at 350 degrees Celsius (over 600 degrees Fahrenheit) for half an hour to achieve their fusion. Then it is compressed by a hydraulic machinery.

Each panel is about 2.43 meters long, 1.22 wide and 2.5 cm of thickness. Turning 5.5 tons of plastic waste, EcoDomum produces 120 panels per day. Of these, 80 are used to build a family unit home with two bedrooms, a bathroom, a living room and a kitchen.

Photos 32 and 33. EcoDomum plastic panel



Source: <https://unreasonable.is/ecodomum-story/>

Photo 34. An EcoDomumprototype house



Source: <https://unreasonable.is/ecodomum-story/>

Materials: recycled plastic

Location: Mexico

Aplicattion: walls

Level technical training to difficulty: medium

Level of complexity for production: low

- **Low cost bricks**

The paper recycling plants contribute 30% to the total pulp and paper segment in India. With average efficiency of 85%, 5% of waste (RPMW) is produced annually. The professors Rahul Ralegaonkar and Sachin Mandavgane of the Visvesvaraya National Institute of Technology India (VNIT) developed a brick from that material. The brick is composed of 90% ground recycled paper (RPMW) and 10% of cement by means of a mechanical mixture is pressed into molds and then the brick is dried in the sun. Besides the positive environmental impact, cost half the product of the traditional brick, in addition to being lighter. "Such inexpensive bricks would come as a great benefit to the Indian construction market, which has a 30% deficit in supply. The team is presently working on a waterproof coating for the bricks (so they can be used on housing exteriors) and determining the material's efficacy in earthquake prone areas."

Photos 35 and 36. Laboratory production and sample brick



Source: <http://inhabitat.com/researchers-in-india-create-low-cost-bricks-from-recycled-paper-mill-waste/>

Materials: paper fibers

Location: India

Application: walls

Level technical training to difficulty: medium

Level of complexity for production: low

- Block ARMO

Photo 37. Sample brick



Source: <https://armo-system.com/tecnologia/sillar-armo/>

Created by Juan Manuel Reyes of Armed Omega and the architect Jorge Capistran, Block ARMO stands out for building system developed. The product design provides a reduction of fifty percent of the construction time and does not require the use of binder mixtures. Regarding the use of recycled materials, it was possible to find the information of the use of recycled wood in the constitution, besides the hydraulic cement. Note that this information does not this clear on the company website. Its dimensions are 16x20x40 cm, with resistance to compression 60kg / cm². Are necessary twenty-six pieces for each square meter, with 6.5kg weight each. The goal of its creators is to meet the existing demand for decent dwellings, facilitating self system at different scales and requirements.

Materials: wood

Location: Mexico

Aplicação: wall buildings

Level technical training to difficulty: medium

Level of complexity for production: medium

- **Conceptos Plasticos**

Conceptos Plasticos is a company founded by the architect Oscar Andrés Méndez. Plastic and rubber waste are melted by an industrial process and are then injected into molds for production of plastic blocks. These blocks function as pieces of Lego, an alternative construction system for temporary and permanent housing. It enables communities to play an active role in building their own homes. A family house can be built in up to five days. Due to the use of additives, the materials are resistant to fire and plastic presence, the buildings are also resistant to earthquakes.

Photo 38. A Conceptos Plasticos prototype house



Source: <http://conceptosplasticos.com/>

Materials: recycled plastic and rubber waste

Location: Colombia

Aplicattion: walls

Level technical training to difficulty: high

Level of complexity for production: high

Therefore, plastic bags and plastic bottles (PET) are materials showing reusability in construction, from the outstanding examples. Regarding the stage of production of building elements, the recycled materials are: plastics, paper fibers and wood.

Table 01. Summary of the good practices in the internacional context

NAME	PRODUCT	RECYCLED OR REUSED MATERIAL	APPLICATION	LEVEL TECHNICAL TRAINING TO DIFFICULTY	LEVEL OF COMPLEXITY FOR PRODUCTION	LOCATION
Ghana's house		Plastic bags used	window and roof	low	low	Ghana
Building with bottles		reused plastic bottles	building walls	medium	low	Cambodia
Pani Community		reuse of metal and steel				India
Loofahs's house	panel	recycled plastic and agricultural aggregate	walls	medium	medium	Paraguay
EcoDomum	panel	recycled plastic	walls	medium	low	Mexico
Low cost bricks	brick	paper fibers	walls	medium	low	India
Block ARMO	brick	wood	walls	medium	medium	Mexico
Conceptos Plasticos	brick	plastic	walls	high	high	Colombia

Importantly, the use of plastic in most constructions, probably due to the fact that the plastic present chemical properties of alloy (link), such as the example of loofahs's house. Besides the plastic, the characteristic that unites the two examples is that both fiber present in the composition.

On the opportunities, it is noted that currently there is a new sector of civil construction, especially in Latin America, interested in not only reduce costs and work time, but also solve the problem of access to Housing.

The most likely products of industrialization are those that provide quality in self. Being efficient, it is interesting to the problem of access housing and to contexts with natural disasters such as floods and earthquakes. .

Companies such as ARMO, in Mexico, and ConceptosPlasticos, in Colombia, have been organized to serve customers as non-governmental organizations and governments.

In terms of business, it is interesting to note that the products of these companies follow almost the same rules: efficiency planning, energetic economy, execution time, adaptability, high durability, seismic resistance, capacity for absorption of noise and fire resistance.

Beyond that, the sectors interested in solving the waste issue left over from a recycling loop that is already closed, should be highlighted. It is the case of the block created by professors Ralegaonkar Rahul and Sachin Mandavgane in India.

4.2.3 Good practices of low cost construction material from recycled waste in Brazil

In Brazil, unlike international examples, we did not find examples of the use of recycled materials for the construction of equipment's or social Housing in places with no waste management system, such as the examples cited in Africa and Asia. And despite neither the housing deficit, nor we find examples of structured companies who are developing products focused on answering this demand, as the examples identified in Latin America.

Despite the intention to meet the demand for low-cost materials, Brazilian examples stand out mainly by the production focused on diminishing the environmental impacts caused by solid waste issue.

- **ISOPET**

The Isopet block results from student's project from the Construction Technology course of the Federal Center of Technological Education of Paraná (CEFET). Blocks are developed in concrete with EPS (Styrofoam) recycled with plastic bottles positioned horizontally or vertically. Besides the recycling, the material shows characteristics for rationalization of the construction process.

Its male side fitting and female system generates an interlock, eliminating the use of mortar, with exception of the first row, in addition to being light. They have channels that

replace the molds in molding lintels, counter lintels and lashing straps. The block also has good qualities thermo-acoustic and fire resistance. About the production process, the raw material of the block is obtained by mixing the cement with recycled polystyrene in a cement mixer.

Photos 39 and 40. Sample brick



Source: <http://www.artigos.com/artigos-academicos/2253-isopet-a-tecnologia-do-concreto-aliada-ao-meio-ambiente>

Materials: recycled polystyrene and PET bottle reused

Location: Brazil

Aplicattion: walls

Level technical training to difficulty: medium

Level of complexity for production: low

- **Ecologic Brick**

The example in brick illustration done by the master in Technology Luiz Fernando CarvalhoBadejo, in the city of Rio de Janeiro, is made of 40% of organic waste (mainly the cotton coming from the paper currency) and 60% cement. The production of brick in large scale is only possible by applying a product that inhibits the proliferation of bacteria.

In fact, according to the creator, the mixture can be made from any solid waste, regardless of being organic or inorganic. "By sewage waste may be employed obviously from a basic treatment which gives the grains one envelopment , which makes every grain almost equal to each other, homogenous with regard to coating in which, besides acting as a catalyst for hydraulic cement used in the mass stabilization, also sanitizes as to be alkaline

inhibits bacterial growth. (...) I have done with bricks to waste with many heavy metals, and due to enveloping, no longer identified in chemical tests to this end, tests produced in the laboratories of the Mint of Brazil. The same goes for waste Construction”²².

In a waste screening process that comes from landfills and dumps, where usually the materials such as glass, plastics and metals that will be reinserted in the productive system are separated, the earthy residue that remains of this process may be the main brick component.

In one of his experiments, Badejo used organic fertilizer produced by a company that collects organic waste from a supermarket chain. "Great stuff, because there is no mixing with glass and plastics or metals as is routinely the case in the compost produced by COMLURB - Company of Urban Cleaning of the City of Rio de Janeiro". Regardless of the type of residue used in brick production, it is always necessary to break the grains in diameters from 1mm maximums. The other steps are the same for the soil-cement brick production.

Photos 41 and 42. Sample brick



Source: <http://redeglobo.globo.com/como-sera/hoje-e-dia-de/noticia/2014/08/hoje-e-dia-de-obra-conheca-ciencia-que-ha-por-tras-do-tema.html>

Materials: organic residue

Location: Brazil

Aplicattion: walls

Level technical training to difficulty: low

Level of complexity for production: low

²²Contact by email.

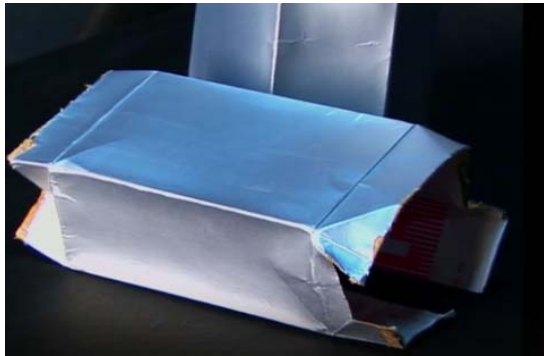
- **Corrugated tile in TetraPak.**

Created by empresariolvanildoRezende, Eco-Logica is a Brazilian company located in Brasilia. Transforms TetraPak packaging (EOL) on tiles and plates. The corrugated sheets, being a cheap alternative in Brazil, met, initially, demand for low-income consumers. Currently, also meet architects.

The separation technology of materials of long-life packaging (20% plastic, 5% aluminum and 75% paper) and manufacturing tiles was developed by the Institute for Technological Research (IPT), University of São Paulo (USP) and it is known as plasma technology. Currently, there are 30 factories as the Eco-Logic across the country. Together, they produce about 100,000 tiles / month.

Each tile has 2.20 x 0.90m, not harm the health of workers involved in production, has half the weight and is 80% cooler than the traditional asbestos tile, and is 100% reusable. The product is the result of partnerships with various sectors: Sebrae (Brazilian Service of Support to Micro and Small Enterprises), Eco-Logica, a supermarket chain, Vitoria Cooperative of Belem and the company TetraPak.

Photos 43 and 44. TetraPak packaging and corrugated tile made with packaging Tetrapak



Source: <https://www.youtube.com/watch?v=IZHJ-oGOeaw>

Materials: packaging TetraPak Location: Brazil Application: coverages Aplicattion: walls Level technical training to difficulty: low Level of complexity for production: low

So, from what it was possible to research, we can point out that, currently, Brazil presents solutions for the production of construction materials from low cost through the Styrofoam recycling, organic waste and TetraPak packaging.

Table 02. Summary of good practices in Brazil

NAME	PRODUCT	RECYCLED OR REUSED MATERIAL	APPLICATION	LEVEL TECHNICAL TRAINING TO DIFFICULTY	LEVEL OF COMPLEXITY FOR PRODUCTION
Isopet	brick	recycled polystyrene and PET bottle reused	walls	medium	low
Ecologic Brick	brick	organic residue	walls	low	low
Corrugated tile in TetraPak	corrugated tile	packaging TetraPak	coverages	low	low

On the other hand, these studies do not necessarily correspond to material reuse of demand in the chain that identify with private initiatives and cooperatives. From the interviews, we can say that the plastic, the cardboard, the aluminum, the metal and the steel are the materials in Brazil more likely to return to the recycling chain. This probability is greater because it is industry interest.

The challenge lies precisely in packages that feature a mix of materials in the composition. This complicates the sorting, such as the packaging of milk "Shefa" that it is a plastic bottle with aluminum inside. Or the case of materials which do not present the technology for recycling generally called flexible packaging, and which are used for packaging snack foods, and many materials present in the composition (PE film, PP, BOPP metallized films).

Photos 45 and 46. Packaging of milk Shefa and packaging of snack foods



Source: images from internet LeiteShefa and embalagem de salgadinho.

Considering the good practices and opportunities, it is interesting to point out an example found in the private sector, conducted by Sintronics. In the electronics recycling process (disassembly, sorting and return of raw material for the industry), some materials did not find any solution of reintroduction. The company currently recycles 95% of all materials coming up to her, among these 95%, beyond what is reintroduced as raw material, there is the production of a plastic timber developed by own company that are used to build cabinets and pallets.

The plastic timber is made of plastic bag (polyethylene, polypropylene - which is an easy material recycling) and plastics that do not allow the identification of the composition. Screws, wires and glued Metal labels work as aggregates for the resistance of the material. Finally, the toner powder that is black is added and provide the dark color of the material.

The material is provided by the company, but the production of timber is outsourced. The supplier develops a paste that can be shaped and produce varied dimensions in bar.

Photos 47 and 48. Pallet made of plastic timber



Source: Ana Luisa Barbosa

5. Analysis of the Brazil Study Case

After presenting examples of capacity building projects in cooperatives, as so Brazilian and international examples of low cost building materials from waste, this chapter seeks to portray the perceptions of stakeholders interviewed about such practices and draw strengths and weaknesses of the current scenario, to understand what opportunities can be identified to reach of the objective of the research.

5.1. Stakeholders perception

As mentioned in Chapter 2, respondents act nationally and represent different points of view, although not represent, of course, the perception of all involved in the waste management system of Brazil.

However, their complementarity brings relevance to the systematization of perceptions. Thus, it is possible to draw a perceptual profile of: (i) the role of cooperatives and their strengthening from new business models and (ii) the possibility of reuse of the waste collected for low-cost building materials

Regarding the respondents, it is necessary to characterize them as to their positions: Sinctronics represents the interests of the private sector and is a high-quality recycling company, born as an electronics industry initiative; MNCR (National Movement of Waste Pickers) represents the interests of waste pickers and cooperatives and CEMPRES (Business Commitment for Recycling) represent the NGOs. Bellow, it is possible to find a summary of the points discussed by each.

- Sinctronics:

This actor recognizes the importance of thinking about integration models with the waste pickers, mainly because of the potential of capillarity that they have in reverse

logistics chains, increasing efficiency and collection rates. However, point out as fundamental conditions:

- Organisation of the scavengers in cooperatives, to minimize the risks of labour processes and meet the basic criteria's of the industry in order to formalize legally such service relations;
- Investments in training and development of the waste pickers for the adoption of industrial health and safety standards in order to reduce occupational risks and insalubrity issues and also to improve efficiency of sorting processes, consolidation and material identification techniques.

In this relationship, the industry is particularly interested that the cooperatives provide the materials or EOL products that feed the production of recycled raw material. By establishing this relation, the cooperative acts as a service provider to the industry.

In this process, the materials recycling loop is closed, as a stream. The exploitation of materials resulting from this process (which currently are not eligible for re-introduction) would be very advantageous. In the specific case of Sinctronics, the company developed the plastic timber with unusable waste. This type of wood is produced in various dimensions of bars and plates for the production of pallets and cabinets for the own company. Tests could be performed for this material enable its commercialization. Another alternative would be that cooperatives receive the plastic timber in its final product form for selling, generating additional revenue.

- CEMPRE:

CEMPRE, as an NGO founded in 1992 to support training and capacity building of cooperatives, presents views focusing on social aspects. For the proposal of a model that considers ideal in forming cooperatives, Andre suggests the definition of a baseline, the closure of all dump sites in Brazil. It then suggests a series of actions to form cooperatives, involving support for training as well as a key support from the Government to provide initial conditions for its operation.

Andre also confirmed that, currently, most cooperatives develop a pre-processing work: collection, sorting and pressing (consolidation of waste for subsequent sale). Only in some cases, one comes to the grinding step. Still, it says that there are possibilities to have more complex structures, but much will depend on the level of organization and the ability to get support and funding.

About the relationship with the private sector, Andre suggests that the company interested in a specific material should establish direct purchasing relationships with cooperatives, limiting the role of intermediaries.

- MNCR (National Movement of Waste Pickers):

The vulnerability of the conditions of waste pickers was appointed by Davi, regarding the main causes: (i) the Brazilian economic crisis, generating a drop of recyclables prices; (ii) the lack of an efficient and integrated waste recovery policy; (iii) the level of the informality and (iv) taxes paid by cooperatives.

In resemblance to what was portrayed by CEMPRE, Davi points out the importance of the partnership of local governments with the cooperative for improving the efficiency of collections based on the ability of the waste pickers to serve as an environmental agent: *"We believe that this service must be paid. Because it is a service that is saving public resources, saving natural resources and creates a micro economy in the suburbs, creating jobs."*

Thus, suggests model agreements with the municipalities in which cooperatives can also be paid for the environmental services they provide. They are called payments for environmental services. In practice, the cooperative can reduce possible negative impacts and public spending that end up being generated with improper disposal of waste to landfill.

As comments: *"It is an interesting policy, for example, to recover such waste with less value in the market. It is clear that if the material has a lower market value, it has a higher value in relation to environmental protection."*

Another organizational model highlighted by Davi intensifies the relationship between cooperatives and industry, standardizing materials, and eventually generating new products to benefit the collectors. According to Davi, the lack of structure of cooperatives is a challenge to meet industry.

In this sense, he emphasized the concept of "network" in which cooperatives unite to consolidate their volumes and sell directly to the industry together. *"The relationship with industry exists only when there is a great demand for materials. Alone, cooperative cannot have a sufficient volume to sell directly to the industry that buys large quantities. A network model can do this, unite cooperatives and standardize in a way that the industry can use"*. Thus, from this network, the materials processing centres can be created.

All these models of partnerships are described in Chapter 4, in which the current Brazilian examples of capacity building were resumed. Regardless of the viewpoint of each agent, they all agreed that the gap between industry and cooperatives is an issue and must be faced with the reduction of intermediaries in the process. Such intermediaries, as well as weaken the capillary potential of cooperatives, negatively impact on the final value of the material the collector receives.

Below diagrams represent the basic terms of capacity building identified by the actors and possible models applied to the Brazilian reality:

Figure 01. Basic capacity building conditions and possible models

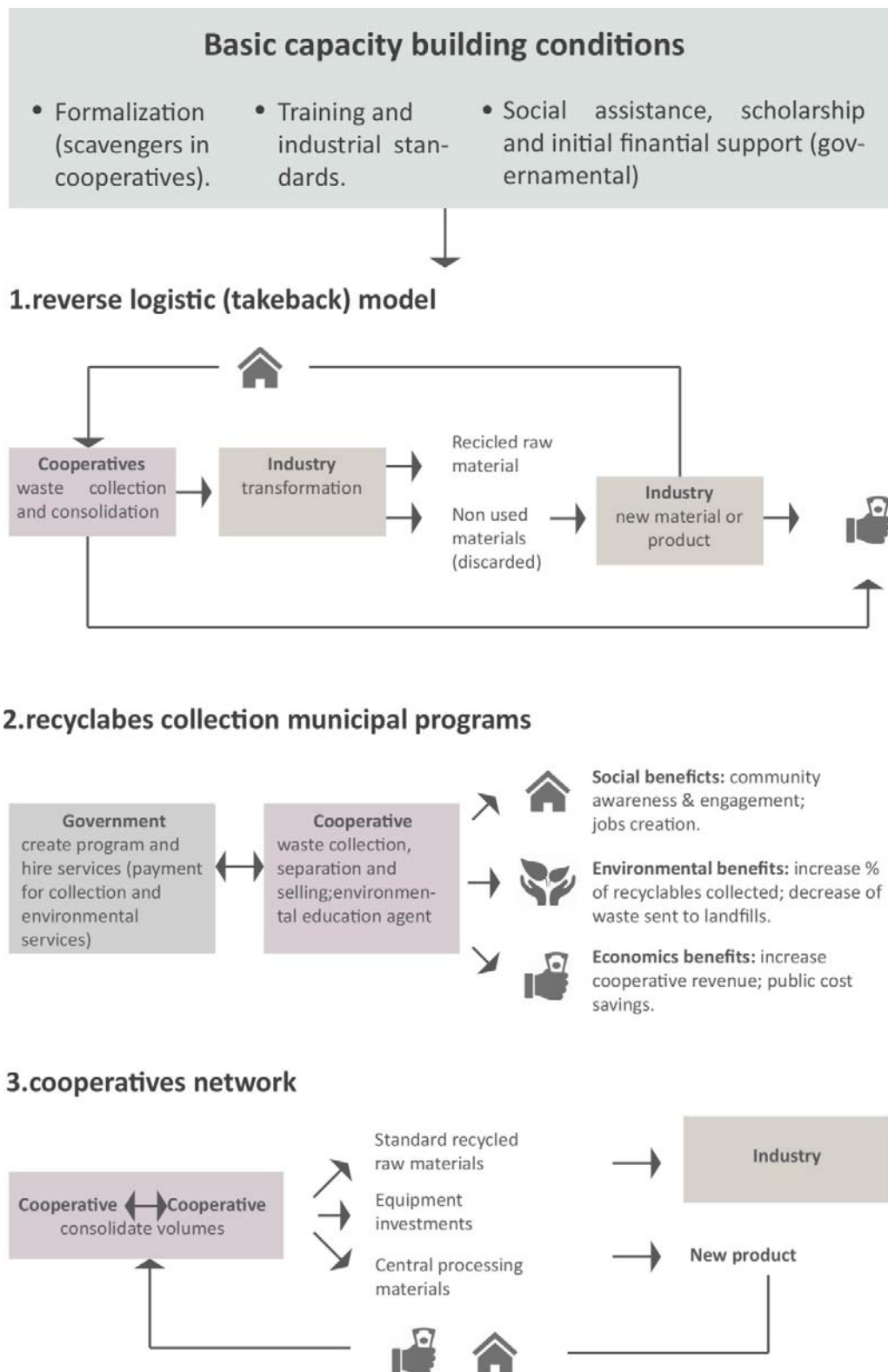


Figure 1 allows portray some models that enhance the longevity of cooperatives in systems and its ability to generate revenue. The first model considers the possibility of inclusion of cooperatives in the reverse logistics chain, providing collection services and consolidation of these materials due to its capillarity in the country.

In this model, the industry receives such materials, transforms them into recycled raw material for reintegration into the production process. Still, a percentage of the waste cannot be reintroduced, enabling its use for the design of new materials or the creation of new types of products to enhance the income of cooperatives.

This model will be detailed in item 5.2 on the development of opportunities related to materials design for low-cost construction.

The second model covers, in a way, an initiative that is already undergoing expansion in the country. The main feature is the hiring of cooperatives to operate municipal selective collection programs, with compensation for the collection itself and payment for environmental services. This expand the vision that waste pickers are only service providers; rather they start to be recognized as an environmental education agent in the system. The experiments demonstrate greater efficiency in selective collection and increased recycling rates when cooperatives are inserted into the system.

The last model, the network model, also can be found in the country. Capacity building programs allow the union of cooperatives to consolidate the collected volumes and sell them directly to the industry, increasing its gains without brokers. In this sense, investing more in the purchase of equipment can provide materials with higher added value through the processing of materials and its transformation into recycled raw material.

Also, there is the possibility of generating new products to be marketed, although this alternative occurs to a lesser extent in the country. At this stage, it is also possible to envision design interventions in the use of materials in construction.

5.2. Strengths, weaknesses and possible opportunities for development

The table below shows the main strengths and weaknesses found during the research. Such surveys are portrayed considering the research objectives: the analysis of the role of the informal sector in waste management system; the opportunities of capacity building for its strengthening; and the possibility of using waste collected by these actors for the design and production of low-cost materials for public housing.

Table 03. Strengths and weaknesses

STRENGTHS	WEAKNESSES
High level of organization and influence of the informal sector (representative social organizations and cooperativism)	High % of scavengers working in dumps or in autonomous way (not organized)
National legal framework addressing integration of the informal sector in the system and goals for ending the dumps	Lack of strong policy and incentives for the recycling chain and activities
Several capacity building projects being developed by NGO's, public and private sector	High financial vulnerability of the cooperatives due to recyclables price oscillation
Increasing partnerships with cooperatives for operating the municipal recyclable waste collection programs	High dependency of governmental support (subsidies and financial support) and low access to formal credit
Private sector willingness for establishing direct agreements of services and projects with the cooperatives	The existence of brokers (loss of revenue for the cooperatives)
High demand for low cost housing and consolidation of informal settlements (use of materials)	The competition for the use of recycled plastic (construction products versus other industry uses)
Some Brazilian examples of projects that use recyclables for housing materials (Ecologic Brick, Ecologica) ²³	Relatively low adoption of better remuneration models for the cooperatives in the municipal waste collection (payment for environmental services)
The designed products that presented a higher level of scalability were integrated with the waste management system	Inexistence of Brazilian projects that integrate the design and production of housing construction materials with the demands for social housing
Some Brazilian examples of cooperatives networks that are already producing recycled raw materials and/or new products	

²³See item 4.2.

The self-organizing capacity of the informal sector in Brazil, as well as their ability to influence public policy can be assumed as very strong points. Even though only 10% of scavengers are organized in cooperatives, the role of social movements, the third sector and the government has been instrumental in the increase of this index. Still, the existence of garbage dumps, even after the target set by the federal government in 2010, contributes to the existence of a situation of social vulnerability of these groups, especially regarding women and children.

Considering the legal and institutional point of view, Brazil adopted its National Policy on Solid Waste after nearly 20 years of intense discussions with the various actors. Formally, this tool considers the provision of the need for scavenger integration in the waste management and reverses logistics systems, especially by governments.

As seen previously, the basic conditions for the strengthening of cooperatives in the system have been identified and, in a way, these conditions are already planned, both in terms of public policies, and at the level of governmental programs. It is also understood and supported by the work of the third sector and private sector.

The first condition is the organization of collectors in cooperatives, which results in the second condition: the government and third sector support in the provision of social services (often scavengers are homeless, ex-convicts or people at risk), training and financial support (in the creation of the legal entity, provision of basic equipment of work safety, machinery, physical space, and so on).

The third basic condition is the need for training of cooperative members for the adoption of industrial health and safety standards, and improvement of processes. Based on this, there was the flowering of many cooperative training projects and support for the growth of its business and revenue.

From the scope of these conditions, the construction of more sophisticated models of capacity building is feasible, as shown in the previous item. They can be integrated models of reverse logistics, maximizing the performance of cooperatives in municipal selective collection programs, as well as the formation of cooperative networks to gain volume and production capacity.

It is important to note that there is an increase in the number of municipalities that have included cooperatives in their selective collection programs. On the other hand, the cooperatives dependence on the financial support of municipalities is a challenge that must be overcome so that more adequate financial models can be adopted. And not least, local governments need to recognize the important role that collectors have in environmental education.

The models and identified examples seek to lessen the existence of brokers in the waste chain as well as maximize their value, to generate more revenue. This assumes that cooperatives have to be organized in networks considering their average size (between 20 and 80 cooperative members), as in the cases of Coopecent, Catavida and Catabahia. Thus, it is possible to consolidate their volumes and create central processing materials.

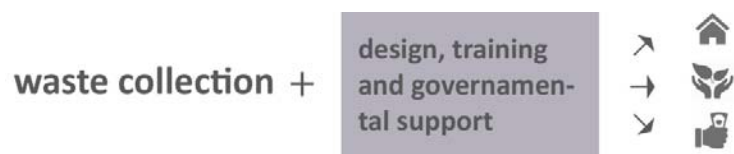
There are still, however, a greater potential for partnerships with the industrial sector, especially in reverse logistics chains and the industrial sector processing (models 1 and 3, item 5.1). The possibility of using the waste discarded from the manufacturing process or direct the recycled raw material for the manufacture of higher value-added materials and even more sophisticated products from the design point of view is a verified gap in Brazilian examples of capacity building.

Linking these points to the design examples studied, it is highlighted the potential that exists in directing these materials for the production of products to meet the low-cost housing demands in Brazil.

Even with an adequate legislation for the attendance of social housing needs in Brazil and a considerable housing deficit, there are no examples found in the public programs that use low cost building materials produced from recycled waste.

The initiatives found internationally, developed by the academia, private sector and local communities can be replicated in Brazil. This replication can be improved by including cooperatives in the production chain and increasing the waste volumes collected for that end. And this, especially when considered the industrial examples brought in chapter 4, where there is potential for scalability.

Figure 02. Scheme to improve the waste collection system for production of new materials



Still, it is possible to find in Brazil companies dedicated to transform waste in materials for low-cost construction. The Brazilian company that have developed tiles with TetraPak waste is a result from the private sector and cooperatives partnership, with the support of SEBRAE - Brazilian Support Service for Micro and Small Enterprises²⁴. This is an example of how flourishing is the possibility of using existing waste chains for generating materials for social housing in the country.

It was possible to identify, from the analysis of practices in architecture, that the plastic is the residue more reused in the production of construction materials. This reality is a challenge because plastic has a high value in the recycling chain: it is generated the plastic granule, which returns to the industries.

But taking as an example the company Conceptos Plasticos explored in chapter 4, it is possible to think directing part of this plastic collected by the cooperatives for the use of building materials. The company has a product very efficient for housing, with an easy interlocking system that allows saving time in the construction with low technical requirements. The product is also certified against fire and is sold for NGOs and the public sector. If we consider that Brazil only recycle 13% of its waste, plastic can still be a viable source for this type of project:

Figure 03. Possible production line for NGO s and government demands



²⁴Sebrae is a private non-profit entity.

Additionally there are initiatives in academia (the blocks developed by Professors Rahul Ralegaonkar and Sachin Mandavgane of the Visvesvaraya National Institute of Technology in India, and the master in Technology Luiz Fernando Badejo Carvalho, in Brazil), private sector (Sintronics and Eco-logic) and even in cooperatives that generate income through the production of brooms and clothesline from pet plastic.

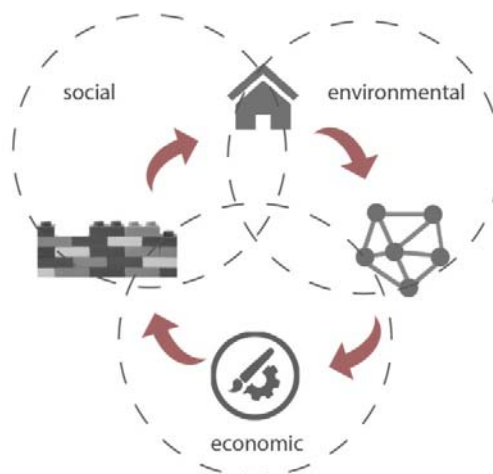
Figure 04. Necessary inputs for the production of efficient materials



Despite those products be developed considering mainly issues related to waste, if we add inputs for the production of housing materials we may have as a result products that address environmental, social and economic issues as shown in the above diagram.

The using of the Block of Badejo, combined with the integration of design quality, can achieve a low-cost construction material, with potential for scalability and considerable environmental impact. Uniting this with the capacity building projects can potentiate the sustainability results (below diagram).

Figure 05. A circular collaboration system



6. Conclusions

The Brazilian context is favorable for the production of low-cost materials from recyclable waste, by the demand of the waste management system in Brazil, either by the housing deficit number.

Considering the good practices in architecture, it is possible to highlight the materials planned for temporary housing that facilitate selfbuilding. These materials guarantee high potential utility and value to its users, generating a positive impact on social, environmental and economic spheres. Therefore, improving the living conditions and polishing the social vulnerability of the inhabitants.

On the other hand, an in-depth study is needed on the architectural practice of building systems that meet the characteristics that this type of product demands. Yet another important step would be to analyze the Brazilian legislation in what refers to the current technical standards for production materials in construction.

Considering the informal sector, the high level of organization of cooperatives and good self-organization practices in networks should be perceived as great potential for the above mentioned. The cooperativenetworksallowtheconsolidation ofwastevolumes and the creation of central materials processing structures, either for the production of recycled raw materials and the development of new products.

This capacity building model – the creation of cooperatives networks – seems to be the one more advanced among the others explored in chapter five. If we consider the investments already done by them in processing infrastructure, makes sense to invest in projects for researching and designining products for social housing. That can be a viable path for enabling new business models.

But undoubtedly, there is a need to understand in more depth on the existing processing structures and the level of technical training which is demanded in such projects development. In addition, it is necessary to comprehend the model of financial viability (costs, the use of materials and potential revenue), as well as analyze the possible distribution and commercialization models (small retailers, direct sales, partnerships with construction companies, and so on).

The potential to develop projects with the private sector, in the different reverse logistics chains, has high strength, considering the growing interest of the industry to increase the collection of their products and packaging End-Of-Life (EOL).

There are advances in the reintroduction of those EOL products and packaging as raw material for manufacturing new ones. But in the examples studied, there is a waste disposal rate in this process. That non used percentage of waste could be directed to the production of building materials for low-income housing - from the development of partnerships with the third sector, architects, among others actors.

Finally, it is possible to assume that there is a huge potential untapped, which falls on the joint efforts (or links) between: (i) the organization and empowerment of the informal sector in the waste streams and (ii) the researches and projects for residue utilization in social housing. These links need to be strengthened and explored by spreading this possibility among all the actors in the system, private and public sector, cooperatives, designers and architects. With that there is a possibility that the current capacity building models being already explored by the cooperatives can be upgraded.

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