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Putting solid household waste to sustainable use: a case study in the city of Rio de Janeiro, Brazil

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Abstract

The management of solid residues has, in recent decades, been a source of concern for public administrators the world over. Experiments in the sustainable use of such residues are highly relevant in social and environmental terms, stimulating widespread interest and debate, with considerable research going into sustainability projects. In many areas, however, adequate public funding for sustainable-use projects is hard to come by. One of the major reasons for this is that public authorities, particularly in times of financial constraints, are reluctant to invest in undertakings in which the economic returns are difficult to quantify. Official scrutiny of the expenditures of public authorities is also normally heavily influenced by cost-benefit analyses. The specific objective of this article is to show that putting solid domestic residue (household solid waste) to sustainable use is capable of generating economic returns, as well as environmental benefits for society as a whole. These economic returns can be set out in financial statements, which may, in turn, be used to justify expenditures by public authorities on sustainable-use projects and as a basis for further investment in such incentives. We drew on the findings of existing research into sustainable use, undertaken by the Municipal Urban Cleaning Company in the city of Rio de Janeiro, Brazil, to establish a conceptual framework for setting out the economic results of the collection of household solid waste.

Keywords

Sustainability, solid waste, environmental and economic benefits, report recycling, waste prevention

Introduction

Population growth and the increasing consumption of non-recyclable materials aggravate the problem of the overflow of landfill sites and of pollution generated by inappropriate waste disposal. For this reason the management of solid residue has, in recent years, become a major issue for public administrators throughout the world. One of the core and increasing concerns is the urgent need to reduce the disposal of solid urban residue in landfill sites, diverting it instead to the recycling industry and minimizing energy costs, the extraction of raw materials and their use in manufacturing processes (The Economist, 2009).

This was one of the tenets of the European Union Environmental Directives of the 1990s which, based on concerns about climate change, prohibited the disposal of organic waste in landfill sites given that the decomposition of such waste emits greenhouse gases. Since the 1980s, the Unites States Environmental Protection Agency (EPA) prohibited the establishment of any new open dumps and issued guidelines for plans of management of solid waste where States should consider resource recovery (EPA, 2012).

In Brazil, the management of urban waste is a municipal duty in accordance with the 1988 Federal Constitution, but only Law 12.187 of December 2009, which set out the National Policy on Climate Change and established voluntary targets for the reduction of emissions in all sectors of human activity, including the disposal of residues.

Further, in 2010—following 19 years of debate—the National Congress (Brasil, 2010) finally passed Law 12.305, which established the National Policy on Solid Residues (NPSR). The policy included provisions establishing the joint responsibility of all those involved in the production chain for environmental damage arising from the disposal of the residues from this process. It also established that landfill site disposal of residue is permissible only when putting said residue to alternative use (re-utilization), and is not technically, economically or environmentally viable. Consequently, systems and methods for analyzing in economic and environmental terms the use to which solid urban residues are put are relatively recent in Brazil.

This article examines the selective collection of solid household waste from domestic dwellings in the city of Rio de Janeiro

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undertaken by the Municipal Urban Cleansing Company – Comlurb, a public–private joint stock corporation controlled by the Municipality. The key question guiding the work was the following:

> In accordance with sustainable development, is it possible to report the obtained economic and environmental benefits derived from putting solid domestic residues to sustainable use?

The aim of this study was, on the basis of the identification and classification of the composition of solid domestic residue, to propose that such residue be put to sustainable use, and to report the benefits generated by reducing to a minimum the use of landfill sites and making maximum use of the residue in the generation of energy, supply to industry and recycling so that these benefits can be visualized in economic terms or better perceived from the evidence provided as to the efficacy of public expenditure in the provision of this service (EPE, 2008; Morris, 1996).

Given that the re-utilization methods considered in this article are used widely in the northern hemisphere (OECD, 2012; SWANA, 2012)—and are, therefore, technically and environmentally viable in Brazil (Henriques, 2004; Vespa, 2005)—the only question that remains is whether they are economically viable for Brazilian municipalities. Nevertheless, boundaries of 'economic viability' need to be clearly determined in concrete terms when drawing up and granting public service concessions as it may be perceived in markedly different ways by social agents, or by the private and the public sectors.

Literature review

The overriding objective of public entities is to promote the welfare of citizens. In the specific case of Comlurb, the activities it performs are linked intrinsically to sustainability. Public services are generally performed by supervised agents of the administrative authority, with the agents under a duty to comply with the principles of equity (fairness), transparency and accountability (furnishing of accounts).

In the public sector the principle of equity governs the relationship between the direct and indirect agents of the public administration on the one hand and society on the other. It is the community (society) that provides the financial resources for the administration's budget and is, in turn, a creditor of public services and benefits.

Addressing the question of the environmental impacts of human activities, Ferreira (1998: 6) states that the means to resolve consequent problems may be summarized into the following phases: (i) awareness raising, (ii) the will to resolve the problems, (iii) understanding of the causes and the extent of the results/effects, (iv) the search for information on preservation technology and non-polluting production processes, and (v) sources of financing.

According to Serôa da Motta and Chermont (1996) cited in Oliveira (2000: 12),

> The uses to which solid urban residue may be put and then finally disposed of may be set out hierarchically. When said hierarchy is based on the criterion of minimum final residue it is known as an Integrated System for the Management of Solid Residues [...] and the means employed should be prioritized as follows: (1) reduction of the generation of garbage at source, (2) re-use of the material produced, (3) recycling, (4) recovery of energy and (5) disposal to landfill site.

The literature on solid urban residues contains several studies, some of which we refer to below, that are relevant to a socio-environmental approach. Pimenteira (2000) investigated the socio-economic aspects of the management of solid residues with the objective of 'drawing up a comparative profile of the recycling situation and further aspects of the management of solid residues, both from the perspective of economic viability and the social aspects involved'.

Thomas (2001) researched the public's level of awareness and understanding of recycling in the County of Hampshire and the city of Milton Keynes, both in England. Oliveira (2008) analyzed the sustainability of using residues in the energy industry in Brazil, after Oliveira et al. (2003: 19) stated, consistently with the above approach, that 'making use of garbage for energy is recognized [...] for bringing together the inhibition of two sources of pollution: methane and carbon dioxide'.

Williams and Kelly (2003) researched public perception of recycling in Wyre, England, reaching the conclusion that 'considerably more could still be done to improve the public's involvement and consequently, the Borough's recycling rate'. Mancini et al. (2007) studied the characterization (classification) of solid urban residue, focusing on the potential for recycling in the city of Indaiatuba in the State of São Paulo.

McDougall et al. (2001) presented a study on the integrated management of garbage with an analysis of its life cycle and practical use for sustainable development. Motta and Sayago (1998), in a very useful study, proposed certain economic and environmental instruments for the reduction of urban garbage and the re-use of scrap, and Emery et al. (2007) compared garbage collection costs in South Wales, demonstrating that an integrated garbage system led to cost reductions, as well as benefits for the environment.

The above studies are similar in approach to that described in this article, but none of them had the specific objective of exploring the sustainable use of solid domestic residue, and of demonstrating the efficacy of such use in terms of efficient and effective public expenditure. This present study aims to fill this lacuna and, for such purposes, defines the putting to use ('destination') of residue as an activity undertaken by a public-service company responsible for the collection and disposal of urban solid residue.

Methods

As to our methodology, the case study method was applied, as recommended by Yin (1994) for the examination of a contemporary phenomenon within its real context. Various internal Comlurb reports, as well as financial statements and documents, and legislation pertinent to the activity of the company, were analyzed for the purpose of the study. The findings of other relevant research projects were also examined.

The study was subject to the limitations generally applicable to the case study method, as described by Lee (1989), which are the inability to: (i) control the empirical observations, (ii) control technical validity, (iii) replicate the study, and (iv) make generalizations.

The outcome of calculations in this study should be handled with care. They are sensitive to the data used and estimations made, and, like others economization models, cost-benefit analyses are likely to truncate or underestimate costs and gains that are not easily quantified.

The order of the next sections of this article follows the same revenue–cost–investment logic of statement of economic result (SER) assembly and were: (i) describe strategy, financial goals, premises and the conceptual framework used; (ii) calculate the recycling (Table 1) and (iii) the energy productions revenues (Table 2); (iv) verify the actual costs for domestic residue collection door-to-door (Table 3) and the classification of cost types (Table 4); (v) project inception investment and administrative expenditures for energy production of the power plants; and(vi) the indirect economy from virgin raw materials (Table 5) and economic benefits in terms of its energy saving (Table 6). Putting these together, the SER is presented in Table 7.

The SER model

Model's objectives and premises

The Declaration of the Conference on the Environment and Development, held in Rio de Janeiro, Brazil (ECO92) states that the priority is '… to reduce and eliminate unsustainable standards of production and consumption with a view to achieving sustainable development' (UNCTAD, 1992). Nowadays, there is still little or no public perception that the gathering of recyclable solid residues by unofficial garbage pickers'/scavengers, commonly found in urban centers in Brazil, is a beneficial contribution to the environment and to sustainability (Gutberlet, 2008).

There is an urgent need to change society's perception of isolated actions and their positive environmental effects by adopting environmental policies (Ayalon et al., 1999), such as the PSAU (Ministry of the Environment, 2010) and the ECOAMPLA (2009), which could be translated into effective actions that

Table 1. Estimated economic revenue of Rio waste recycling (Source: CEMPRE, 2010).

Materials	Composition of waste (%)	Quantity (thousand tons/y)	Price (US$/ton)*	Revenue (million US$/y)
Paper	12	48	330	60.7
Cardboard	3	22	168	8.0
Long life (Tetrapak)	1	236	108	2.4
Plastic film	15	84	540	127.8
Plastic	5	26	720	60.7
Clear glass	2	19	120	3.1
Colored glass	1	27	120	2.3
Metal	2	85	216	5.9
Aluminum	–	–	1201	–
Others	5	–	–	–
Total revenue from recycling				270.9

*1US$=R$1,6658

Table 2. Estimated economic revenue from anaerobic digestion energy production.

Materials	Composition of waste (%)	Weight (thousands tons)	Energy generation (KWh/ton)	Production (thousands MWh/year)	Price (US$/MWh)	Revenue (millions US$)
Organic matter (T_m)	54	847	1.5	127	89	11.3
Total income from energy						11.3

Table 3. Cost of collection types of domestic solid residue.

Type of collection	Quantity (thousand tons/y)	Amount (US$/ton)	Total cost (million US$/y)
Regular	932	48	44.9
Selective	647	129	83.7
Total	1.579	–	128.6

enable society to reap the short- and long-term benefits of the effective management of solid residue by the companies responsible for its collection and disposal.

Table 4. Cost type of the collection of solid domestic residue.

Cost type	Percentage (%)	Total cost (million US$/y)
Direct cost	85	109.4
Indirect cost	15	19.3
Total	100	128.6

Following the same lines as Oliveira et al. (2003) we concluded that the effective re-direction of solid urban residues requires further, and more detailed, research into the economic viability of the two available groups of systems for the use of solid urban residues for energy purposes, namely recycling and transformation, and that both should be used in tandem.

ECO92 also stated that governments should encourage corporations '(a) to provide relevant environmental information through transparent reporting to shareholders, creditors, employees, governmental authorities, consumers and the public; (b). To develop and implement methods and rules for accounting for sustainable development'. More recently, at Rio +20 United Nations

Table 5. Estimate of the environmental benefits generated by recycling.

Materials	Energy generation (US$/t)	Greenhouse gas emissions (US$/t)	Water consumption (US$/t)	Biodiversity (US$/t)	Total (US$/t)
Steel	15	29	<1	<1	44
Aluminum	102	102	<1	–	204
Cellulose	6	5	<1	3	14
Plastic	3	31	<1	–	34
Glass	2	5	<1	–	7

Source: Adapted from IPEA (2010:20)

Table 6. Indirect earnings from the sustainable use of solid domestic residue. As before, all values were converted from 1US$=R$1,6658 on 31 December 2009.

Materials	Quantity (thousand tons)	Environmental benefits generated by recycling (US$/t)	Indirect earnings (thousand US$/y)
Paper	184	14	2651
Cardboard	48	14	687
Long life	22	14	321
Film	236	34	7947
Plastic	84	34	2835
Clear glass	26	7	169
Colored	19	7	127
Glass	27	44	1220
Metal			
Total			15,956

Table 7. Municipal Urban Sanitation Company – Comlurb. Statement of economic results (SER) financial year 2009 (values in US$).

Specification	2009
Economic revenue from the sustainable use of solid domestic residue	282,203,229
(-) Identified direct costs	(109,350,316)
(=) Gross margin	172,852,913
(-) Indirect costs	(19,266,852)
(-) Anaerobic digestion plant amortization	3,361,892
(-) Administrative plants expenditure	10,800,000
(+) Indirect earnings – environmental benefits of recycling	15,956,251
(=) Ascertained economic results	155,380,420

Note: There are further benefits, yet to be measured quantitatively, to the sustainable use of solid residues, such as: (i) increase in the lifespan of landfill sites, obtained from the use of 1,578,936 tons of solid domestic residues, with recycling and energy generation; (ii) benefits from the generation of employment resulting from the activity of recycling; and (iii) promotion of environmental education.

Conference on Sustainable Development (UNCSD, 2012: 77), many nations reaffirmed their commitment to 'promote an integrated and holistic approach to planning and building sustainable cities through …' reducing waste.

Therefore, a responsible administration should record in financial accounting statements (i) the potential environmental impact, (ii) the means to sustainably use solid residues, and (iii) the measurement and evaluation of the results. As indicated earlier, we propose in this article the use of the accounting system as a management tool in the sustainable use of urban solid residue.

The relevant guidelines and conceptual basis for this in Brazil were drawn in the 'Accounting Statements Applied to the Public Sector [...] and other measures' (Brazil, 2009) that proposes a SER [Demonstração do Resultado Econômico (DRE)] as an alternative means of demonstrating efficiency in the management of public service resources. The key concepts in the SER are (Brazil 2009: 49):

> Opportunity Cost (OC)—the cost related to the next best alternative available among several mutually exclusive possible choices for the execution of a public action.
> Economic Income (EI)—the value corresponding to the benefits generated to society by public action, the applicable figure being arrived at by means of the multiplication of the quantity of services provided or goods or products supplied (N), by the Opportunity Cost (OC), hence: EI = N × OC.
> Execution Cost (EC)—the economic value expended by the Entity on the action that is the object of the Assessment of Economic Income. Execution Costs are divided into direct and indirect expenditure.

The proposed aim in relation to the sustainable use of solid residue is to provide a means to express the putting into practice of economic, environmental and social policies. The proposed use of the SER in this context would enable the gathering of relevant information as to the sustainable use of solid domestic waste collected by sanitation authorities, thereby demonstrating the effectiveness of public expenditure on this service.

However, the extent of the resources involved and the practical difficulties faced by members of the Public Administration in effectively measuring the economic result of services provided to society means that it is virtually impossible for public managers to correctly evaluate the results of their actions (Drucker, 1994), even with the introduction in the public sector of methods drawn from the techniques and methods of the private sector with a view to increasing the efficiency and efficacy of public organizations.

The search for alternatives that enable cost management aimed at optimizing the effective provision of public services is a significant challenge to Brazilian researchers and public administrators. Until recently, their main concern was restricted largely to procedures directed towards satisfying applicable Brazilian legal prerogatives, with little attention paid to cost-management and financial results, unlike in the private sector, in which these aspects are prominent.

The basis for drawing up the SER in our study is the same as that adopted in existing research (Mancini et al., 2007; Motta and Sayago, 1998; Oliveira, 2000; Oliveira et al., 2003), namely the sustainable use of solid domestic residue by means of recycling and the generation of electric energy.

The key premises underlying our proposal for a SER of the sustainable use of solid domestic residue collected by Comlurb are the following: the gravimetric characterization of the solid urban waste, drawn up by Comlurb (Applied Research Management, 2009); selective collection of garbage in some regions, with recyclable matter being transferred to cooperatives that then sell it for industrial use; information as to the cost of collecting solid urban waste; and a partnership between Comlurb and educational institutions aimed at analyzing the viability of setting up electricity generation plants using garbage (Comlurb, 2010).

In drawing up the SER, the figures for Economic Income applied are drawn from recycling and energy-generating activities, with direct costs being the expenditure incurred in the collection of domestic residue (in other words, the operational costs of the activity of collection).

The SER also requires the identification of indirect costs, which are the costs inherent to support activities at the company. Part of the indirect Comlurb costs is then identified as the cost of the collection of domestic solid residue for the purposes of calculating the economic result.

Estimated economic revenue of recycling

To ascertain the economic revenue obtained from recycling it was necessary to draw up Table 1 with the price of recycled materials in the Rio de Janeiro market and to establish the composition of solid domestic residue in relation to the 2009 financial year (CEMPRE, 2010).

We notice the absence of aluminum in the composition of urban waste in Rio de Janeiro. This phenomenon is a result of its high commercial value and to the income problem within the country. In 2010, Brazil was the world champion of recycling, with about 97.6% of all aluminum cans discarded (ABAL, 2012). This rate was 80.6% in 2000 and 87% in 2003 (Medina, 2003).

The calculated revenue from all waste recycling, with the exception of organic matter, is US$270,917,723. Perhaps 100% of recycling might sound unrealistic, as the recycling rates in Brazil are 14% for plastic, 42% for paper and 47% for glass. Despite that, we believe that near 100% of waste recycling and energy production is not impossible in a mixed and joint solution in the near future and, depending on the subsidies, as is seen in the cases of aluminum (97.6%) and tetrapak (100%) (Carvalho, 2011). The idea was to (i) estimate the recycling potential and, consequently, (ii) the value lost at landfill, and to (iii) evaluate a minimum landfill solution.

Estimated economic revenue of energy production

Energy may be generated from these materials via many technological routes. Nowadays, there are 2000 working power plants in Brazil; almost half of them use landfill gas emissions, 700 use incineration and 120 use anaerobic digestion to produce energy. The remainder, approximately 100 plants, use other technologies or some variation of these main technologies (CEWEP, 2010;IVIG/COPPE, 2005; Juniper, 2005).

As stated earlier, Brazilian regulations (NPSR) only permit the use of landfills for rejected residue. Therefore, the internationally accepted technologies, also applied in Brazil for energy generation, are incineration and anaerobic digestion. The conversion efficiencies are 450kWh/ton and 150kWh/ton respectively (Oliveira et al., 2003: 17).

Accordingly, for each 500 tons per day of residue, it is possible to use these technologies to supply a plant producing 10 MW and 3 MW respectively. In combined cycle incineration plants, which feature thermal equipment burning other fuel (including biogas), this efficiency rises to 750kWh/t, so that 500 tons of residue is capable of providing the necessary fuel for 1 day in a 16MW power plant.

Note that there is a tradeoff between the technological choices given that the residue is finite. Incineration requires a minimum calorific level, which, in turn, depends on the presence of certain recyclable materials. When total recycling is possible, the organic matter is treated by anaerobic digestion, thereby restricting the use of incineration.

On the basis, therefore, that industry makes use of all the recyclable matter, the resulting organic portion—846,783 tons of residue—is capable of generating the equivalent of 127,018 MW.

Further, bearing in mind the ceiling price per MWh of generated energy in government-sponsored energy auctions of US$88.85 according to Costa (2009), the income from the generation of energy = 127,018 MWh × US$88.85, the result being US$11,285,506.

Table 2 was drawn up to facilitate comprehension of the calculation of the economic revenue from energy production. The Total Economic Revenue of the entire project would be US$282,203,229.

Solid domestic collection—identified direct cost

The amount of US$129.42 per ton will be used to identify the cost of residue destined for recycling. This amount refers to the cost of selective collection by means of the door-to-door service offered by Comlurb. In relation to residue used for the generation of energy, the reference amount used in relation to the 'regular' (as opposed to 'selective') collection is US$48.17 per ton. The 'regular' collection occurs weekly and there is no segregation of residues at source (IPEA, 2010: 21). Table 3 shows the cost of collection of solid domestic residue.

Table 3 sets out a total cost of US$128,617,168 relating to the collection of domestic solid residue. Once the total cost has been obtained it is necessary to identify how much of this total relates to direct and indirect cost. According to Horngren et al (2004), direct costs are those that are identifiable specifically and exclusively by means of a given cost object. Indirect costs are the opposite; in other words, they cannot be identified with a given cost object.

The information contained in the Comlurb management report was used as a reference for the calculation of direct and indirect costs. According to this management report, 14.98% of the total ascertained costs are indirect. Table 4 sets out the calculation of direct and indirect costs.

Project setup investment and administrative expenditures

It needs to be borne in mind that an anaerobic digestion plant with the capacity to process 600 tons per day and with a 25-year lifecycle requires investment of approximately US$27.5 million each. If so, we would need 4 power plants to process this study amount of organic matter that, with the scale gain with in common structures, would cost only US$84 million.

Further, these plants consume approximately US$2.7 million in administrative expenditure per year for proper maintenance. These values were considered in the SER statement as Anaerobic Digestion Plant Amortization (US$3,361,892) and Administrative Plant Expenditures (US$10.8 million).

Energy saving and opportunity cost—indirect earnings

The information set out in Tables 1–4 was used to draw up a SER for Comlurb, specifically for the activity of domestic residue collection. In accordance with the provisions of Ordinance n° 751 (Brazil, 2009), we included in the information provided the environmental benefits set out in Table 6, such as energy savings from economy of natural resources. These savings were calculated on the basis of Table 5, which was prepared by the Brazilian Institute of Applied Economic Research IPEA (2010).

Notwithstanding the limitations of the calculations presented in Table 6 (IPEA, 2010), it is important to estimate these savings because they enable comprehension of the damage caused to the environment. Table 5 shows the environmental benefits generated by recycling based on the view that the recycling of one ton of each of the materials listed in the table benefits the environment and society in that the use of 'virgin' raw materials for production is avoided. The conclusion is then reached that recycling generates wellbeing to which a value may be applied in accordance with Table 6, in line with the premises that recycling leads to reduced use of natural resources and avoids the emission of greenhouse gases. This economic benefit is then identified as indirect earnings arising out of the sustainable use of solid domestic residue.

Another important aspect is that the production of materials from raw materials is highly energy intensive. We therefore conclude that recycling, in reducing the need for these virgin raw materials, leads to substantial energy savings for society.

Table 6 shows indirect economic earnings of US$15,956,251 obtained from recycling. It can therefore be seen that the implementation of an information system regarding the cost of urban solid residues is an opportunity for transparency by any company responsible for the management of said residue. It is important to bear in mind the importance of awareness of the economic and (principally) environmental benefits derived from production based on recyclable materials as a substitute for virgin raw materials.

SER

Set out in Table 7 is the SER for the sustainable use of solid domestic residue, based on the data contained in Tables 1–6.

The SER presents a positive economic balance of US$160,906,799, which represents a net increase in benefits generated to society from the efficient and effective action of public sector management, thereby demonstrating the effective use of public funds.

The ascertained result demonstrates, from the point of view of management of natural resources, the reduction of negative environmental externalities. It should be stressed, however, that the values set out are estimates only.

Conclusion

We sought, in this study, to undertake an economic analysis of the sustainable use ('destination') of solid domestic residue in the city of Rio de Janeiro and how such use might generate benefits to justify the cost involved. The findings of the research indicate that sustainable use ('destination') could lead to benefits generating a positive economic result that can be estimated and reported.

It is important to note that the objective of sustainable use ('destination') is not merely to generate economic resources, but also to reduce the volume of residues sent to landfill sites, which therefore leads to gains in environmental terms. This benefit is not measured and disclosed in this work, and can be carried out by future researches. The same can be said about all gains and employment opportunities resulting from this sector of green economy.

An analysis based merely on financial equations of municipal spending on residue, without taking into consideration the future environmental, social and economic gains accruing to the community, is therefore inadequate. The use of mechanisms that enable a better evaluation of the results obtained by bodies that make up the public administration is primordial when world transformations are demanding a differentiated response from public administrators. This, in turn, calls for the adequate evaluation of results of the administration's principal or support activities so that their relevance and importance to society can be demonstrated clearly.

One solution for the problem of residues' disposal, which is currently subject to considerable discussion in Brazil and, indeed, throughout the world, is minimizing the use of landfill sites. However, there is a general lack of awareness among public administrators as to the costs of putting solid residues to sustainable use.

As shown in Table 6, putting solid urban residue to sustainable use generates economy in the use of resources, such as energy, raw materials and water. It also leads to a reduction in the emission of greenhouse gases. Tables 5 and 6 demonstrate, for example, energy savings of US$1,523,357 in relation to the recycling of cellulose (183,946.00 + 47,683.89 + 22,263.0 in Table 1 × 6.00 in Table 5).

Although the ascertained economic result demonstrates the potential benefits of putting solid urban residue to sustainable use, some caution and future research are desirable to clarify this study's limitations. As recycling represents the majority of project revenue and this study considered it in a rate of 100%, some sensibility studies are necessary. Maintaining the actual waste composition, a 57% rate of recycling will simply nullify the result.

This study obeyed the production arrangement of using anaerobic digestion after recycling, but next researches should consider a mix of technologies (as incineration) to optimize the use of residues that could not be recycled or biodigested.

An intense educational campaign is also necessary, as is widespread dissemination of the results of sustainable use so that the general public becomes aware of the benefits and is further encouraged to cooperate with, and participate in, the selective collection of residue.

The basis for the proposal of a SER is to highlight the transparency problem and meet the objectives of this research so as to set out information enabling awareness of and comparison between different selective collection projects. This, in turn, should stimulate fresh investment in the selective collection of urban residue and consequently a gradual reduction in the pollution of urban soil.

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