



Research article

Introduction of the circular economy within developing regions: A comparative analysis of advantages and opportunities for waste valorization



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ABSTRACT

The introduction of effective solid waste management strategies in developing countries should be considered for improving sustainability at global level. Many barriers should be overcome, concerning the introduction of environmental policies, effective investments, social inclusion and public awareness, which are significant issues in low-middle income countries. The Circular Economy could represent the answer for improving current solid waste management activities worldwide, since denote the principle of waste valorization and recycling for boosting developing economies. This paper is focused on this theme, analyzing main opportunities for improving the current state of solid waste management in developing big cities. The solid waste management of two countries are reviewed: Romania is the emerging country where Circular Economy is becoming a future objective due to economic aids and strength regulations which the European Union (EU) established for the nations forming parts the alliance; as a comparison, Bolivia is reported for evaluating main differences founded for developing recycling systems in a no-EU country. These two case studies could be of interest for highlighting main pros and cons of the participation into a wide organization like the EU for introducing in short terms Circular Economy principles. Moreover, a theoretical Circular Economy model for developing big cities in low-middle income countries is described within the study for effectively comparing which chances can spread for these countries as regard municipal solid waste exploitation. Despite the economic level, Romania and Bolivia are both facing with many solid waste management issues although in different magnitude. For the Romanian case study, it is visible how it cannot achieve the European goals for 2020 due the need of change in public recycling behavior. Bolivia, instead, represents the case where international aids and new investments are required, considering the informal sector into the formal management system as a real opportunity for improving local recycling rate. In conclusion, the comparison suggests how external supports led to implement the principles of the Circular Economy within a developing region. The model of Circular Economy proposed is recommended for developing big cities in order to advance a new form of safe employment, encouraging the activities that are still in action (i.e. informal sector) and boosting the principles of sustainable development.

1. Introduction

Solid waste management (SWM) in developing countries represents a real environmental and social concern since the most applied “treatment” choice is the final disposal in open dump sites or in unsuitable sanitary landfills (Al-Khatib et al., 2010; Ravindra et al., 2015; Maheshi, 2015; Ferronato et al., 2017). Sustainable measures should be introduced, integrating low carbon emission solutions and appropriate

technologies (Papargyropoulou et al., 2015). For that purpose, the shift from a linear to a circular economy (CE) which will preserve the environment, generate new economic growth and spread the ecological awareness of the population, can be considered the most adapt way for improving current SWM worldwide (Diaz and Otoma, 2013).

The theoretical objective and the perfectly circular system will be introduced when longevity of goods equals limitlessness (Franklin-Johnson et al., 2016). For instance, biomass can be always considered

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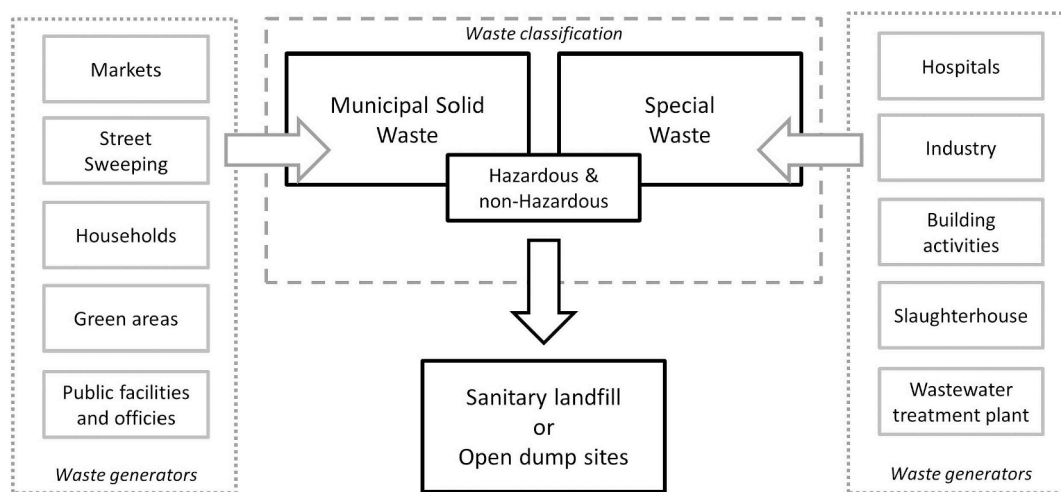


Fig. 1. Categories and sources of solid waste disposed to landfill or open dump sites in low-middle income countries.

in a cyclical flow because all biomass waste products can be re-entered the biosphere (Haas et al., 2015). As stated by Stahel (2016), “a CE system would turn goods that are at the end of their service life into resources for others”. However, every source of waste and every material fraction can be inserted in an autonomous CE scheme, while collection and treatment systems should be assessed differently in cities, towns or small communities, as well as in regions with particular geographical frameworks and touristic areas (Ciudin et al., 2014). For that purpose, municipal and “special” wastes should be evaluated in an integrated manner although, in low-middle income countries, these streams are not differentiated and the environmental impacts due to the solid waste inflow into the final disposal sites are worrisome, since the materials are mixed with hazardous fractions (i.e. hospital waste, oils, slaughterhouse rests) and all waste sources deliver the material at the same collection system (Fig. 1).

For introducing a sustainable CE all management aspects should be considered, such as technical, environmental, health, financial, social and organizational (Zurbrügg et al., 2014), parallel with the inclusion of the population, compulsory for achieving an effective user's acceptance of new SWM systems (Kirkman and Voulvoulis, 2016). For that purpose, the involvement of all the stakeholders and the enforcement of local policies is compulsory (Geissdoerfer et al., 2016). In addition, a successful implementation of CE policy requires efforts at three levels: micro-level (i.e. factories and agricultural products producers), meso-level (i.e. eco-industrial parks and eco-agricultural system) and macro-level (i.e. co-operative networks among industries), where the complexity of practices increase when the scale level rise (Su et al., 2013; Lewandowski, 2016).

The implementation of principles concerning material circularity is intensifying in developed countries (Singh and Ordoñez, 2016; Kirkman and Voulvoulis, 2016) while developing countries are still suffering inappropriate SWM due to the lack of economic funds, public awareness and political will, among others (Marshall and Farahbakhsh, 2013; Wilson et al., 2015). Developing countries like China, Serbia and India started to implement such principles (Geng et al., 2012; Ravindra et al., 2015; Ilić and Nikolić, 2016), although low-middle income countries are commonly introducing projects or management plans with no effective changes (Rada et al., 2010; Ionescu et al., 2015; Esbensen and Velis, 2016).

The aim of this study is to present the main opportunities for introducing the CE in low-middle and middle income developing regions, where recycling systems are not still developed. Two case studies are presented, comparing main difficulties and prospects for implementing the CE. The comparison between Romania, a European Country, and Bolivia, no-European, allows understanding which are the main issues

when policy makers must act in cooperation with a wider organization, by the aid of international funds, or alone. Considerations about this comparison provide an indication of which concerns are detectable in developing countries where regulations and laws are not still adopted and how future guidelines should be deal for the development in environmental, social and economic subjects. Improvements, according to the principles of the CE, are finally suggested as opportunity of economic development.

The paper is divided in three main parts: First, the general background of the two developing countries and of the European Union (EU) are presented, as well as the CE model, highlighting the main actors involved and the topics which are going to be deepened within the results. Secondly, in section 3, the main SWM activities and issues are reviewed both for the two case studies proposed. In this section, the main differences and similarities of these contexts are highlighted, discussing the application of the CE model suggested. Finally, conclusions are presented in the last section, along with some remarks and recommendations.

Nomenclature

CE	Circular economy
EC	European commission
EEA	Environmental European agency
EU	European union
GNI	Gross national income
MBT	Mechanical biological treatment
MSW	Municipal solid waste
NGO	Non-governmental organizations
PPE	Personal protective equipment
PPP	Public-private-partnership
RDF	Refuse derived fuel
RP	Recycling policies
SC	Selective collection
SDGs	Sustainable development goals
SWM	Solid waste management
WEEE	Waste electrical and electronic equipment

2. Methodology and analysis of the contexts

This study investigates the differences between two contexts where recycling policies (RP) are not still implemented, discussing the application of a theoretical CE model. The international collaboration among the universities involved in this article and a literature survey allow

implementing the review of the SWM issues within the study area. The main literature data obtained, useful for introducing Bolivia current state, are only provided by the study made by the Catalan international cooperation agency, which, in 2010, wrote a manual about SWM systems in Bolivia (MMAY, 2011), while Romanian studies, thanks to the reports provided by the EU, are more in numbers and allowed an integrated research. The realities suggested are presented like SWM example of developing region where further improvements are required. Therefore, this paper can be useful for decision-makers of developing countries, which are facing similar SWM issues for addressing new plans in a CE perspective. A brief overview of the study areas is reported, while the CE model is introduced.

2.1. Study areas

2.1.1. Romania, the EU developing region

Romania has a population of 21,584,365 inhabitants, with about 44.8% who live in rural areas, with a population density of 90.5 inhabitants per km² and a gross national income (GNI) of 9500 US\$ per inhabitants (World Bank, 2017). Romania is located in the southeastern part of Europe in the crossing point of its main axes: west-south east and north-south east. From the administration point of view Romania is divided in 41 counties, including 266 cities and towns and 2689 villages, contained in eight regions. Romania's entire development in the last decade is influenced by the process of transition from the old economic and social system to a new one that started after 1989, from a mostly self-centered economy to an economy integrated in the EU and world structures. In 2007, Romania entered to EU, and now it follows the regulations and laws of the EU.

2.1.2. Bolivia, the example of low-middle income developing country

Bolivia is classified by the World Bank (2017) as a low-middle income country (GNI of 3070 US\$ per inhabitants) with a population of about 10,500,000 inhabitants. Bolivia is located in the center of the South America continent, with no access to the sea. With a land extension of 1,098,581 km² and a population density of about 9.5 inhabitants per km², Bolivia is divided in nine department with 112 provinces and 327 municipalities. The capital city is Sucre, while the center of the Government is La Paz. At national level, Bolivia presented three levels of government: The central government, the autonomous departmental government and the autonomous municipal government, which are all active in regulation and management controls.

2.2. European framework in SWM

The EU is among the regions that introduced policies of sustainable development and resource use, but it is also a major consumer of resources and producer of emissions. In 2005, the EU accounted for 7.5% of the global population, and used 12.4% of the globally extracted materials (Haas et al., 2015). However, the aggregate recycling rate was only at 12.6%, roughly twice as high as the global average (Haas et al., 2015).

In a sustainable SWM perspective, The European Commission (EC) adopted an ambitious CE Package, which stimulates Europe's transition towards a CE for boosting a sustainable economic growth. The legislative proposal on waste sets clear targets for the reduction of waste and establishes a long-term path for waste management and recycling (EC, 2017). Moreover, EU developed a new process of environmental improvement that includes the principle of sustainable innovation: Horizon 2020. Horizon 2020 is the biggest EU research program ever with nearly €80 billion of funding available over 7 years (2014–2020). Main targets are reported in Table 1.

EU introduced many directives for improving waste management activities in compliance with Horizon 2020 and the improvement of such CE policies. The most important are the Directive 2008/98/EC on waste, which forces the improvement of waste management activities,

with a view to protecting human health and promoting a more CE; and the Directive 1999/31/EC on the landfill of waste, which makes progress in the implementation of the raw materials recovery by reducing landfilling of waste. According to the Environmental European Agency (EEA), latest available trends show that recycling rates for both municipal solid waste (MSW) and packaging waste have increased substantially: recycling rates for MSW increased by 13% between 2004 and 2014, and recycling rates for packaging waste by 10% between 2005 and 2013. In 2014, 43% of the MSW generated in the EU-27 and Norway was recycled, while in 2013, 65% of packaging waste generated was recovered (EEA, 2017).

Nevertheless, large differences in recycling rates among European countries prevail. In 2014, the rates ranged from 64% in Germany to 1% in Serbia. In six countries, recycling rates were equal or higher than 50%, while five countries recycled less than 20%. In 2014, 24 countries recycled 55% or more packaging waste and overall recycling rates ranged from 81% in Belgium to 41% in Malta (EEA, 2017). These differences indicate a large potential for improvement. The policies implemented by EU are in accordance also with the Sustainable Development Goals (SDGs) which have many relations with SWM. Most notably in Goal 12 and Goal 3 (UNDP, 2015), which aim to achieve, by 2020, the environmentally sound management of wastes and significantly reduce their release to air, water and soil; moreover, by 2030, the objective is to reduce the number of deaths and illnesses from hazardous chemicals and environmental pollution, in a CE perspective.

2.3. CE model

Many barriers still exist for developing the CE in developing countries, particularly due to low financial sustainability, presence of informal activities and the lack of technological facilities (Alam et al., 2008; Ragazzi et al., 2014). For these reasons, rise the need to develop a theoretical model that could be affordable for these specific areas of the world.

Any CE model cannot be equivalent for every context due to social, environmental, financial and political differences. Moreover, there are many discrepancies among SWM in big cities and small communities, since financial power, waste production, social habits and urban areas are extremely different and require specific insights, case by case. Opportunities and barriers, function of towns' dimension, are schemed in Table 2.

A general description of a reliable CE model for big developing cities, for the management of MSW (hazardous and non-hazardous), is introduced within this section. Such model is simply depicted in Fig. 2 and it intends to highlight recirculation and treatment solutions of waste materials through technical facilities and improved social behaviors. However, other considerations should be introduced as regard small-scale communities or the recovery and treatment of the special waste. Considerations about these topics are avoided within this study. Attention is provided to recyclables, fractions with high organic content, and other urban waste such as used tires, sanitary waste, used batteries and waste electrical and electronic equipment (WEEE) (oils fractions are not assessed).

Selective collection (SC) by municipal collection trucks is not considered, as too expensive to be applied in region with low GNI (< 10,000 USD). For that purpose, informal sector inclusion is suggested as main solution for improving the SC system. Moreover, other precautions, appropriate in a low-income region, are recommended. All such considerations are divided in three groups, each supported by three different actors: informal sector, public management and public-private partnership (PPP). Moreover, the CE is divided in two phases, in function of the times required for the application and for the urgency of its implementation.

2.3.1. Formalization of the waste pickers

The first issue is the formalization of the waste pickers. The informal

Table 1
EU and Horizon 2020 targets (EC, 2017).

Common EU targets in SWM for 2030	Horizon 2020
<ol style="list-style-type: none"> 1. A ban on landfilling the separately collected waste. 2. Simplified and improved definitions methods for recycling rates throughout the EU. 3. Actual measures to promote re-use and stimulate industrial symbiosis – turning one industry’s by-product into another industry’s raw material. 4. Economic incentives for producers to put greener products on the market and support recovery and recycling schemes (for packaging, batteries, WEEE, vehicles). 5. Promotion of economic instruments to discourage landfilling. 6. Recycling 75% of packaging waste. 7. Reduce landfill to maximum of 10% of MSW. 8. Recycling 65% of MSW. 	<ol style="list-style-type: none"> 1. 75% of the 20-64 years-old to be employed. 2. 3% of the EU’s GDP to be invested in Research and Development. 3. Greenhouse gas emissions 20% (or even 30%, if the conditions are right) lower than 1990, 20% of energy from renewables, 20% increase in energy efficiency. 4. Reducing the rates of early school leaving below 10%, at least 40% of 30–34 years-old completing third level education. 5. At least 20 million fewer people in or at risk of poverty.

trade implemented at municipal level is commonly an issue since the municipal perception of those who work in the informal waste sector is often negative and in some instances, the relationship is hostile (Wilson et al., 2009). However, the informal sector provides the major source of recycling and save municipal money through reducing the quantities of waste collected for MSW treatment and disposal (Wilson et al., 2009; Sembiring and Nitivattananon, 2010; Silva de Souza Lima and Mancini, 2017). So, the introduction of a CE, which comprehend the presence of informal waste pickers, become of utmost importance. Taking into account global examples, scavengers usually work commonly into final disposal sites or picking waste from road bins, street containers, and riverbanks (Vaccari et al., 2012). However, they are responsible of a large part of recycling activities, starting RP without the contribution of public financing. Therefore, efforts should be focused on supporting those countries in developing the strategies that incorporate waste pickers into the formal waste management process.

Therefore, the first step suggested in the model is the formalization of these workers, giving duties and rights, which can support the work. Public awareness should be improved by the introduction of advertisements and sensitivity campaigns in order to introduce the ‘ecological operators’ (name that should be given to the waste pickers) into the collection system. The municipality could guarantee sanitary assistance free and retirement at the end of their job career. Such aid should be assured by the introduction of the ‘zero tax’ principle within the recycling chain, as the demand of charges represent a real barrier for the operators that are not encouraged to enter into the formal system. This device introduces also a reliable information system about the amounts of recyclable materials that commonly face with miscalculations since the waste picker is not encouraged to provide the real amounts.

At the same time, the ecological operator should accept to be formalized within a waste recovery shop and to work within a limited district area, recollecting the waste, user by user. In this manner, the

citizens of each county will know every picker. For that purpose, municipal control and monitoring system are essential while the Government, to guarantee the same business for each shop and operator, should ensure market costs for waste recyclable materials. Finally, every worker should wear personal protective equipment (PPE), which could be provided by the municipality after the sign in into the recycling shops, in order to encourage the start of the process. This decision depends by local budget and willingness to participate of the pickers, main problem and challenge which should be addressed and considered case by case.

2.3.2. Formal MSW collection and pre-treatment before landfilling

The formalization of the informal sector should be supported by a pre-treatment system before landfill, since the organic matter grow in percentage as well as the inorganic exploitable matter decrease. Commonly, MSW is sent to open dumpsites that are dangerous for the environment. Moreover, environmental reclamation is too expensive, and it is not affordable for a low-income country, worsening contamination extent.

For that purpose, a mechanical biological treatment (MBT) can be implemented before the final disposal site. It can guarantee putrescible waste stabilization and refuse derived fuel (RDF) production, converting waste-to-energy as fuel, addressing the issue of energy demand and SWM in a CE perspective (Münnich et al., 2006). Such highly energetic material is exploitable in industrial factories (i.e. cement kilns), as used in other developing areas (Ravindra et al., 2015). In this manner, other economic revenues are guaranteed, and the final disposal site can be managed in a more sustainable framework since landfill gas production, leachate releases and unpleasant odours are reduced (Scaglia et al., 2010; Torretta et al., 2016). Moreover, disposal site useful life is improved, enhancing environmental protection.

MBT can be adopted in developing countries since it is a cost-

Table 2
Differences among big cities and small communities in low-middle income countries for introducing a sustainable SWM system.

Big cities	Small communities
<p>Opportunities</p> <ul style="list-style-type: none"> • High amount of waste available. • Relevant investment introduced by the Government. • Possible inclusion of big industries and private companies. • Optimization of the collection. <p>Main barriers</p> <ul style="list-style-type: none"> • High investments are required for including the population with sensitivity campaigns. • Difficulties in the application of selective collection systems into the community. • Difficulties in control and monitoring. • Lack of space for introducing new waste management plants and facilities. • Data available are mostly incomplete. • High investment risk. <p>General solution for a sustainable MSW management</p> <ul style="list-style-type: none"> • Introduction of big scale plants for treating mixed waste. 	<ul style="list-style-type: none"> • Easier involvement of the population. • Abundance of space. • Small scale plants, so lower risk. • Lower expense for the investments on new collection means and the construction of new final disposal sites. <p>• Small amount of waste available, most of which is putrescible.</p> <ul style="list-style-type: none"> • Unfeasible collection of the waste in the rural areas of the city, with scarce participation by the citizens. • Lack of public investment and funds. • Limited capacities for introducing new technological facilities and for its maintenance. • Lack of data. <p>• Introduction of small scale appropriate technologies in order to treat selected waste.</p>

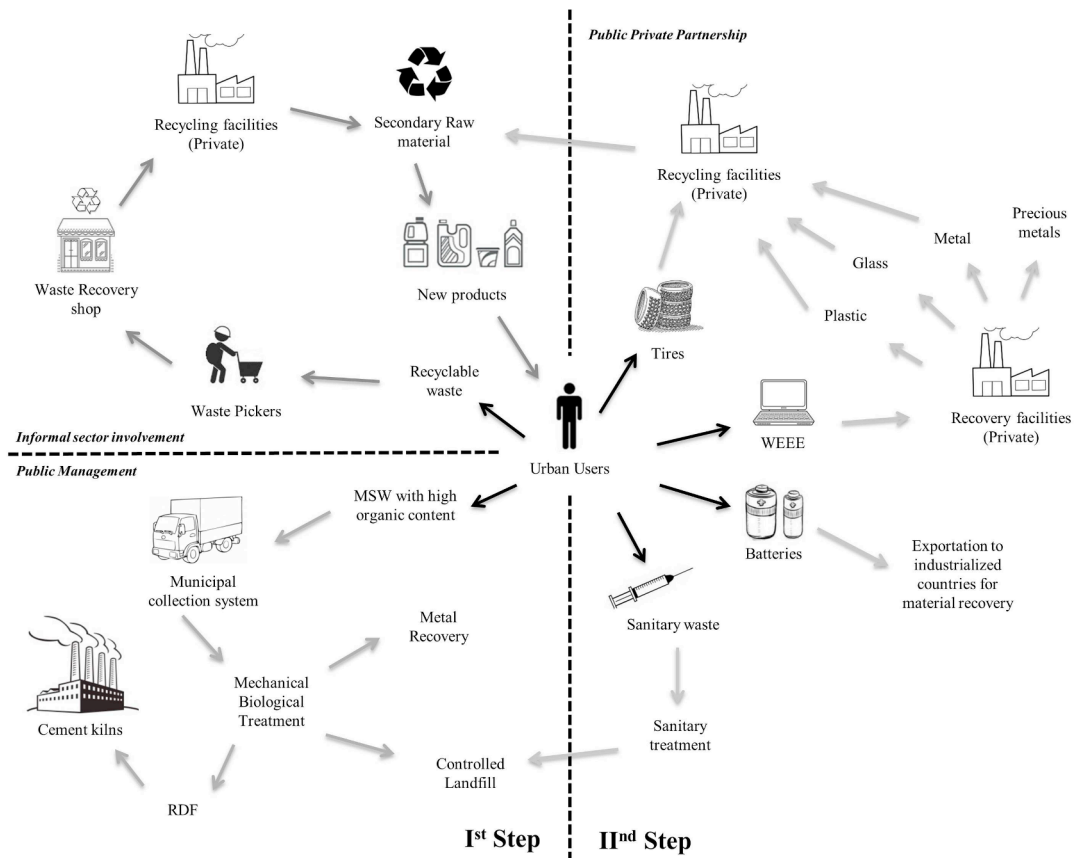


Fig. 2. Theoretical CE model applicable for developing countries.

effective treatment and it improves the environmental condition in emergency circumstances (Trulli et al., 2018). Moreover, the mechanical treatment applied could be introduced for the selection of recyclable materials, or could be applied manually, in order to boost the creation of new jobs.

Nevertheless, the model here suggested foreseeing the implementation of a controlled landfill, monitored and gated, so that no illegal activities can be introduced in the area and a control flux system can be adopted. The application of this step should be provided by the public management system and the main barrier consist in the lack of financial sustainability.

2.3.3. Second phase: SC and treatment of other solid waste typologies

The second phase of the CE model included the implementation of a more efficient SC applied by the citizens. In this case, SC cannot consider the inclusion of the informal sector since materials as tires, sanitary waste and batteries are generally not exploitable directly since economic revenues are not available, the treatment is unsafe, the transportation is uncomfortable, and the exploitation is not always introduced at local level. WEEE could be also recollected by the informal sector (Gu et al., 2016), however, this practice is dangerous for the environment and the population, since the WEEE contains hazardous materials and the informal selection is made with any precaution (Chi et al., 2011; Egeonu and Herat, 2016; Cesaro et al., 2017).

No specifications are provided in the model as regard the treatment methodology since many technologies are available for treating these waste fractions. However, WEEE and tires recovery is suggested, sanitary waste need to be treated for healthy precautions while batteries could be exported to developed countries that just adopted the recovery of these materials. Therefore, public economic efforts should be introduced in this step, which could be apply after the improvement and implementation of the objectives of the first phase, since public

behavior started to accept a CE system with consciousness and perseverance in material selection.

Theoretically, these two phases should be introduced in parallel in order to introduce an effective CE; however, two steps were introduced since, typically, in developing countries a formal recovery and recycling system is not still in action, so the primary practice to take into account is the improvement of the landfill and the inclusion of the local activities. In this framework, a PPP can be applied since collection, treatment and exploitation strategies require an important effort that can be overcome only by the cooperation between public organization and private financing and know how.

2.3.4. Stakeholders involved in the CE system

The system can be sustainable for households, private sector and municipality: main advantages and disadvantages are reported in Table 3. Households can access to a curbside collection system without economic efforts and such SC guarantees clean neighborhoods. To boost the population to apply such methods, a municipal competition system can be introduced. For instance, the most “green district”, that is the one which recycle the most per inhabitant, receive an economic discount in the sanitary charges or can be rewarded by public acknowledgments.

The private sector is also involved since more recyclable materials entered in the system without any financial improvement. The public sector reduces the costs of transports and final disposal since the expenses are commonly applied per ton of waste collected: so, the effort adopted to improve the informal sector is paid by the economic save enhancing environmental sustainability and public consensus. In addition, the inclusion of the national Government and the non-governmental organizations (NGO) is assumed, although they are not considered as main actors involved but as stakeholders which are included into the system for achieving a sustainable management, as suggested

Table 3
Advantages and disadvantages for each stakeholder involved within the first step of the CE model.

Waste Pickers	Municipality	Private sector	Households
Advantages			
<ul style="list-style-type: none"> Sanitary insurance for free and covering of the scholar expenses for the children. Organization with other operators, public acceptance and inclusion with the society. Work recognized by the municipality with retirement guaranteed. 	<ul style="list-style-type: none"> Improvement of public sensitivity in SWM practices and inclusion of the citizens on the recycling practices. Reliable information about recycling activities with reliable data for planning future improvements. Sustainable management of landfills, economic save and reduction of environmental impacts. Improvement of the recycling rate. 	<ul style="list-style-type: none"> Recycling activities enhanced by the collection of more recycling materials. New markets introduced within the area, with the collaboration of the municipality for spreading the public awareness 	<ul style="list-style-type: none"> Curbside collection for free and organized, with no request of charges. Upgrading of street cleanness with the improvement of the sanitary state of the area surrounding the district.
Disadvantages			
<ul style="list-style-type: none"> Introduction of a regulation in the daily collection activity. Change in habits. Collection areas limited and designated by the municipality. 	<ul style="list-style-type: none"> Preliminary investments are required, while a new management system should be introduced. New policies should be introduced, also at national level. Long time is necessary in order to introduce a visible change. 	<ul style="list-style-type: none"> Competition with new recycling companies that could be introduced thank to the high availability of recycling material. 	<ul style="list-style-type: none"> Efforts required changing the usual MSW delivering. Accepting the activities provided by the 'informal sector'. Provision of the material in a selected manner.

by other authors (Storey et al., 2015).

The same collection model can be adopted also for private companies and offices that produce high amounts of waste that can be collected by the informal sector. However, public facilities like schools, nurseries and universities could sell or deliver the recyclable waste directly to the recycling shops or to the municipality like parallel public campaign in order to involve students and higher educational institute to develop a CE plan. Furthermore, the income derived or saved thanks to the activity can be used for improving the public structure, for introducing other sensitivity activities or for buying new bins and objects useful for improving the recycling rate, even made by recyclable materials. Moreover, organic waste from agriculture, markets and green areas can be deviated to a SC system, which is implemented periodically for introducing composting facilities. These applications should be introduced in pilot scale and could be considered as the third step that could be applied for improving the CE and reducing environmental impacts.

3. Results and discussion

The findings of the literature review are reported in the sections below, as well as the comparison between the two different realities. Moreover, the discussion related to the opportunities for introducing the reference CE model suggested in Section 2.3 are reported.

3.1. Romania: current and future perspective in SWM

3.1.1. Legal framework

The first National waste management strategy in Romania was developed in 2003, and published in early 2004, following the transposition of EU legislation in the field of SWM and according with the provision of the governmental ordinance, approved in 2001. In Romania, regulation for managing MSW is in its early stages and the accession to the EU in 2007 has put the Romanian SWM under the regulative influence of the European Directives presented in Section 2.2. (Almasi, 2013).

The Ministry of the Environment introduced a new regulation system after 2008 that took into consideration thematic about waste prevention and recycling, among others (Atudorei, 2006). Future projects were connected with the construction of new landfills with the obligation to close-up the existing landfill with sorting and recycling stations for MSW and WEEE.

3.1.2. Waste generation, informal collection and final disposal

In Romania, the organization of MSW collection and treatment is under the responsibility of the local public administration (Atudorei, 2006; Almasi, 2013; Ciuta et al., 2015). In 2002 was estimated that the waste production overcome 8,800,000 tons per year and 251 landfills for MSW were functioning, out of which 15 complying landfills, and 236 non-complying landfills. Apart from landfills in urban area, in Romania there were 2686 dump sites in rural areas, equal to the number of villages, the most having the surface of 1 ha (Şchiopu et al., 2007). In 2012, 238 existing MSW landfills still were not in compliance with EU regulation and should be closed by 2013. At the same time 65 compliant landfills/transfer stations should be constructed, 50 of which with an average capacity of up to 100,000 tons year⁻¹ and another 15 landfills with an average capacity of up to 50,000 tons year⁻¹ (Almasi, 2013).

In some regions, uncontrolled waste disposal take place in the form of illegal dumping, which means risk to human health and the environment (Mihai et al., 2011). Indeed, not all the rural areas have organized services for waste management and in some places the transportation of waste to dumping sites is made individually by each generator (Şchiopu et al., 2007). In 2008, the vulnerability of urban areas to uncontrolled waste disposal was high, as an average of 30% of Romanian urban population lacks sanitation services (Apostol and Mihai, 2012). However, visible progresses were registered over the last years at country level: while in urban areas the situation has clearly improved (90% of the population have access to sanitary services), the same indicator does not achieve 60% for rural settlements. In other Romanian contexts, the application of vacuum collection was implemented in order to reduce traffic congestion, improve the city cleanness and improve the collection system (Ciudin et al., 2014). However, neither this method was introduced successfully, so more efforts should be applied in order to solve issues such as seasonal variation, tourists' flows and collection in external areas.

In 2011, Romanian MSW generation indicators were between 0.78 and 1.03 kg inh⁻¹ d⁻¹ in urban areas, although the estimation of waste quantities generated or disposed still suffered a high percentage of miscalculation (Mihai et al., 2011). A recent study confirms the generation rate of urban areas (0.9 kg inh⁻¹ d⁻¹), providing also the quantities per inhabitants in rural areas, which are 0.4 kg inh⁻¹ d⁻¹ (Ciuta et al., 2015).

Generally, poor data are available and the involvement of the informal sector within the collection of recyclable material is not monitored. The participation of the informal sector is still very significant (~40,000 people), caused mainly by low level of living. Direct trade of

recyclables is the main source of income for the significant portion of poor citizens, who pick recyclable materials from bins and open dumps. In addition, second hand market is prominent in the field of furniture and building materials. Environmental awareness and public willingness to participate in SC is still at low level, although it is increasing through general environmental campaigns and educational activities (EC, 2011).

3.1.3. Recycling rate, waste treatment and new policies

According with the European 2020 strategy and CE Package, Romania should recycle 50% of its waste for 2020. However, in 2004 Romania recycled only 3% of MSW (Fischer et al., 2013) while, in 2017, the recycling rate grew up to 13% (EEA, 2017). Therefore, recycling in Romania is not a well-developed practice. Moreover, the waste collected and treated achieved only 80% of the total amount estimated to be produced. No landfill taxes are required, and current typical landfill gate fee do not surpass €10 per ton (Fischer et al., 2013).

Same consideration can be made for waste-to-energy facilities, which are not declared in 2015 as regard MSW. Incineration is too expensive for the Romanian waste management market except for medical, industrial and hazardous waste (Căilean and Teodosiu, 2016). Even so, the plans for the integrated SWM system in the *Bucuresti-Ilfov* region includes the construction, in the coming years, of the first MSW incinerator in Romania (Almasi, 2013).

The waste-to-energy more applied is co-incineration, which is well established since all cement kilns have invested in specific technologies and have been authorized for the co-incineration of a wide range of waste fractions. It has been estimated that the co-incineration capacity in Romania and the potential demand for RDF at the cement kilns is ten times higher than the currently available quantities (Rada et al., 2008; Almasi, 2013; Stan et al., 2014).

As indicated by EU legislation, landfill targets for the diversion of biodegradable waste going to landfills, reported in Table 4, should be 50% of the total quantity of biodegradable waste generated in 1995, by 2013, whereas 65% of the total quantity of biodegradable waste generated in 1995, by 2016. In this topic, Romania did not decide to use the derogation option for the 2016 target and new information about current situation are still expected (EC, 2011). Nevertheless, the most widely used alternative option in Romania is still landfill while in terms of material valorizations, like compost facilities and digestion installations, some initiatives have been observed since 2011, for approximately a total of 20,000 tons of waste per year treated (Căilean and Teodosiu, 2016).

In 2011, there were no landfill ban for MSW disposal as only landfill disposal of packaging waste materials were prohibited in accordance with EU regulation. In 2017, good improvements were made for the recycling of plastic packaging waste, since the European goal has been surpassed, with 56.8% of recycling (EEA, 2017). It should be pointed out that data on packaging recycling were not available until the end of 2016 (Eurostat, 2014). Such improvement can be thanks to the EU and Government funds that developed the waste management

infrastructures in some rural areas by introducing SC points and building transfer stations equipped with waste sorting and composting facilities, in line with EU directives (Apostol and Mihai, 2012).

Furthermore, according to EU regulations, Romania implements the principle of the Extended Producer Responsibility (EPR) in solid waste, concerning tires disposal (Torretta et al., 2015) and packaging waste (EC, 2011). However, limited producer responsibility (applied for few waste streams) or equivalent systems in place are not able to cover the full costs of SC and recycling of main waste streams, while no incentive systems to favor prevention and participation to separate collection (pay as you throw schemes) are in place (EC, 2011). The required budget that can be co-funded by the EU for the period 2014–2020 has been estimated in a recent study to €1.3 billion (EC, 2011). Approximately €300 million from EU funding were assigned in 2012 to improve MSW management in Romania, covering ten projects across ten counties. Applications for funding the remaining counties were in the preparation phase, with a total planned investment of €730 million (Almasi, 2013).

3.1.4. Future developments

Waste recycling is one of Romania's key priorities, striving to reach the average level of EU's countries regarding the value of this indicator of sustainable development (Lakatos et al., 2016). High educational institutes are including policies of SC, although only a few have functional one and the majority have no waste quantity monitoring system (Iojă et al., 2012). In Europe, six countries (Bulgaria, Croatia, Latvia, Lithuania, Slovakia and Romania) require an annual increase rate of between four and five percentage points. Such an increase rate has not been achieved by any of these European countries in the periods 2001–2010 or 2006–2010 (Lakatos et al., 2016).

Romania is one of the countries that received a derogation period for the fulfilment of the 2020 target of 50% MSW recycling. However, Romania will not accomplish this target if progress continues at the current rate, therefore an exceptional yearly increase in the recycling rate is needed (Almasi, 2013). Including some of the recycled packaging waste from MSW sources will also increase the recycling rate: An exceptional effort from the regional and national Romanian authorities will be needed to increase the recycling level to 50% by 2020 but a similar effort will be required even with a five-year derogation period to 2025.

An important aspect, which could lead to improved results, is raising the level of awareness among citizens, who are not used to selectively collecting their waste, even though the infrastructure is already in place in some Romanian cities (Almasi, 2013). In addition, Romania is a European country where SWM system analysis were not applied at national level because communication channels among stakeholders were not developed, as well as sustainable development concepts (Pires et al., 2011). Hence, some more efforts should be introduced at political and technical level.

Table 4

Targets set up for the Romanian SWM provided by EU (Atudorei, 2006).

Target year	Landfills	Reduction of biodegradable MSW to landfills ^a	Packaging waste	MSW recycling rate
2011		25%		
2013	Closure of 238 existing municipal landfills which are not in compliance with EU. Construction of 65 municipal landfills in compliance with EU regulations (min. capacity of 100,000 t year ⁻¹ at regional level).		Recycling target level - 55%	
2015		50%		
2016	Reduction of the quantity of MSW disposed in 101 municipal landfill which are not in compliance with EU regulations.	65%		
2020				50%

^a Compared with the quantities generated in 1995.

3.2. SWM barriers in Bolivia

At national level, the SWM is in charge of the Deputy Minister of Potable water and Sanitation, by means of SWM direction agency, responsible of the introduction of new polices and development plans. It has been estimated that in 2010 the generation of solid waste achieved 1,677,650 tons per year, among which 85% were produced within urban areas, while 15% in rural towns. The national (Bolivian) production of MSW in urban areas was about $0.5 \text{ kg inh}^{-1} \text{ d}^{-1}$ while in rural areas was about $0.2 \text{ kg inh}^{-1} \text{ d}^{-1}$.

Generally, within the cities, municipal companies in four different forms provide sanitation services: (1) direct management from the municipalities, (2) from an indirect office of the municipality, (3) from decentralized companies that can be autonomous or (4) engaged by the municipality. In 2010, 51% of the municipalities, which are mostly of little dimensions (2000 inhabitants), were not provided by sanitation services. Within the cities where SWM is applied, only 17% obtained urban charges, which allow covering 40–60% of the total costs. As a result, this practice influences the financial sustainability of a municipality, which must use an important part of economic resources for the collection of MSW (MMaYA, 2011).

The service covered 86% of the areas in capital cities, 78% of bigger municipalities, 63% of the minor municipalities and 42% of the rural areas. It has been estimated that, at national level, only 4.6% of MSW is recovered by the informal and formal sector and introduced within the recycling chain. The informal sector is widespread within the country, since it is a common practice for poor people or households, which can achieve a financial sustainability by sending recyclable materials to an informal sector that is growing in dimension. It has been estimated that around 10,000 people work like informal pickers (MMaYA, 2011). Considering that each picker can collect more than 100 kg of exploitable waste per week, about 50,000 tons per year of recyclable materials are recovered by the informal sector.

An important role is made by the NGO that work in the country at direct contact with the population, both in rural and urbanized areas, and collaborate with different national and international stakeholders (Ferronato et al., 2016). The efforts applied by these groups led to implementing new programs that aid the public governments to improve the informal sector and the recycling systems. For instance, *Swisscontact*, with the program “*Ecovecindarios*” allows the implementation of 378 new jobs and the collection of 15,900 tons of recyclable waste in three years (Swisscontact Projects, 2017; Wilson et al., 2015).

The worst environmental issue come from final disposal sites, which receive only 45% of solid waste from formal collection systems in the whole country, since only 8% of final disposal sites in Bolivia are sanitary landfills. It means that final disposal is mostly uncontrolled, without environmental monitoring, growing the threat of disease and pollution (Ferronato et al., 2017). Low financial sustainability, technical facilities and management plans do not encourage Bolivian policymakers to introduce new solutions in order to improve sanitation systems (MMaYA, 2011). However, in 2015 the first national law was introduced by the National Government, while in 2016 was introduced the first regulation about solid waste management. In these documents, some new concepts were introduced, such as the EPR, which has been introduced although it has not been applied yet due to the lack of monitoring and a management system. Finally, some technological improvements are going to be introduced, mostly by the international cooperation and by South American economic aids.

In 2011, the national program for SWM was introduced, where future strategies, projects and goals were announced. For the end of 2015 the objectives were the reduction of the MSW generation index of about 1% in comparison of 2010, improve the operation activity of 15% of the final disposal sites, improve the service covering of 5% at national level, involve the citizens in 15% of the Bolivian municipalities and at the same time improve the technical management within 15% of the cities.

This program is carried out by the national policy; however, international economic funds were introduced for an amount of about 62 million US\$ (MMaYA, 2012). To date, there are not public information about the evolution of such indicators, and it is difficult to estimate the current improvement applied within the country. SWM is still a difficult issue and in continue development while only a few and scattered studies about SWM are available into the scientific literature as well as reliable data (Alvarez and Liden, 2008; Perreault, 2013; Storesund and Vigerust, 2016; Bautista and Calvimontes, 2017; Mancilla García, 2017; Ferronato et al., 2018). However, the recycling activities applied by the private sector could be a viable way for public MSW management service, since the recyclable materials could be sold to these recycling facilities. Differently by the occidental approach, currently the public management could gain form the sold of recyclable materials. So, municipalities should not pay for its exploitation, and it means that circular economy could be more attractive.

3.3. Bolivia and Romania: the comparison

Romania is an emerging region that takes positive support by EU for SWM improvements. European social funds and regulation limits enable the upgrading of sanitary conditions although without high efficiency. The answer gave to the European efforts is slow because, since 2007, the recycling rate improved only by 10% while 30% of national area is still not covered by sanitation systems. At the same time, good response is given by packaging waste recycling which overcome European goals.

Bolivia is a developing country with a low economic growth, where regulation systems are not still in action and the introduction of new technologies is under development. Lack of national recycling goals controlled by other international organization do not stimulate the improvement of sanitation, which is developed only by the support of international NGO. The Environmental Ministry and all departmental and municipal Governments are working for improving the current SWM situation, but with pilot projects and without the involvement of the population at big scale; the main practice that improves the recycling rate is the informal sector. However, the market of recyclable materials could be exploited also at public level, since the private sector is just applying a circular economy approach, although in small amounts.

Many differences are detectable between Bolivia and Romania as expected. First, the economic progress, as reported in Fig. 3, which implies the introduction of new facilities and the improvement of population wellness. Romanian economic development is based on the entrance in EU and on financial aids came from European private sectors that invested in the country since the lower outgoings in the production chain represent an opportunity for all big and small firms. As a result, also the recycling rate improved at the same time. In 2004, the recycling rate was about 3% while in 2014 achieved 13%. Nevertheless, Romania is one of the EU countries, which received many financial aids by the European bank, and when the economic support will end, the local industry could suffer a crisis due to the lack of continuous investments.

This consideration underlined the importance and the correlation between economic growth and recycling rates improvement within the EU, theory not valid worldwide. Many developing countries improved its financial sustainability, while the waste generation raise, without significant technological development (Wilson et al., 2015). This might be the example gave by Bolivia, where the economic improvement is not followed by an increased awareness on environmental behavior. As a result, CE and recycling chain in Bolivia are not well developed yet and economic aids are still required. Other differences are evident concerning MSW average generation and waste collected sent to landfill, as described in Table 5.

Waste production in rural and urban areas range between 0.2 and $0.6 \text{ kg inh}^{-1} \text{ d}^{-1}$ in Bolivia whereas $0.78 \text{ kg inh}^{-1} \text{ d}^{-1}$ in Romania.

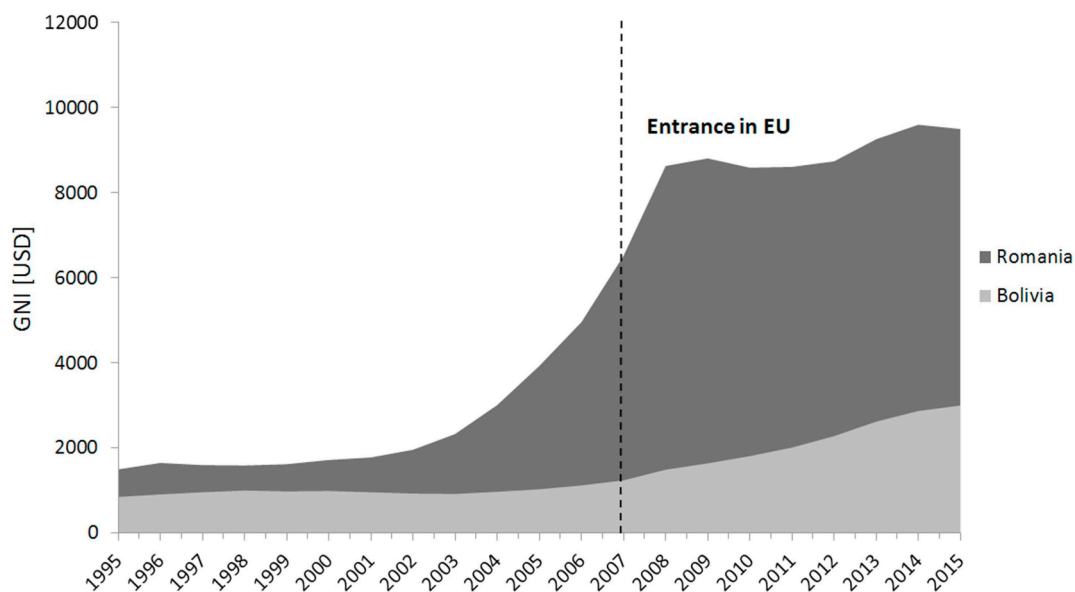


Fig. 3. Bolivia's and Romania's GNI trend (World Bank, 2017).

These generation rates are respectively comparable with the values typical of low-middle income countries and upper-middle income countries. On the other hand, waste composition is mostly similar (Fig. 4) and comparable with ones of low-middle income countries (Wilson et al., 2015), although more monitoring studies are required, since data could not be always true.

Worrying is the level of the sanitation system provided for both countries. In Bolivia has been estimated that only 51% of the municipalities is provided by a sanitation system, which recollect and send to landfill only 45% of the MSW generated. The percentage remain is not collected, or is sent to open dumpsites, buried, burned or threw in water bodies. This data is date on 2010, however, the survey conducted in 2016 confirm this habit also in towns situated within the countryside (Ferronato et al., 2017).

Improved is the situation within the metropolis, which received a better sanitation service, although without covering the urban area. This situation is better quality in Romania. However, many efforts should be applied as in 2012 still more than 2000 open dump sites were introduced near urban areas while the collection system was not provided for all the municipalities. Hence, in both cases, 8% (in number) of the final disposal sites are open dumpsites. The 20% of the Romanian waste is final dumped with this methodology, while in Bolivia the situation is worrisome, since 55% of the total amount is dumped without precaution.

In this framework, the informal sector has an important role for

both countries as regard the recycling chain and the CE. Romania, despite the GNI achieved in the last years, is constantly supported by the work of the waste pickers, and the European Commission in 2011 estimated that about 40,000 pickers worked into the recycling chain, about one every 500 inhabitants. Similarly, the informal sector operates into the Bolivian framework, with about one waste picker every 1000 inhabitants. Therefore, the CE is mainly introduced by waste pickers, which operate constantly in both countries, and is introduced equally in Romania and Bolivia like opportunity of employment, although it is not recognized.

The considerations that were introduced in this section lack of recent and reliable information, especially for the case of Bolivia. However, global reflections could be made concerning the introduction of the CE within the case studies presented, highlighting pros and cons for a developing region inserts in the EU framework. Table 6 sums up such advantages for an upper-middle income like Romania.

The main tool, which commonly miss in a developing country, is the introduction of reliable regulations that can support the development of recycling activities. Bolivia main issue is the introduction of suitable rules for the application of RP including the informal sector and all the stakeholders involved. As a result, international hints, the implementation of sustainable goals and the support of experts can provide an effective aid for introducing the CE in developing regions. The Romanian case study is an example, which, on one hand, has been attended during the process of developing by financial aids, technical

Table 5
Comparison between Romania and Bolivia national SWM.

	Inhabitants	GNI ^e (USD)	Waste production (kg inh ⁻¹ d ⁻¹)	(t year ⁻¹)	Recycling rate (%)	Waste collected and treated (%)	Lack of sanitation service (%)	Informal sector activities (people)
Bolivia ^h	~10,000,000	3000	0.2–0.6	1,677,650	4.5	45	51	~10,000
Romania	~21,000,000	9500	0.78–1 ^a	8,800,000 ^f	13 ^b	80 ^c	30 ^d	~40,000 ^e

Note.
^a (EC, 2011).
^b (EEA, 2017).
^c (Fischer et al., 2013).
^d (Apostol and Mihai, 2012).
^e (EC, 2017).
^f (Șchiopu et al., 2007).
^g (World Bank, 2017).
^h (MMAY, 2011).

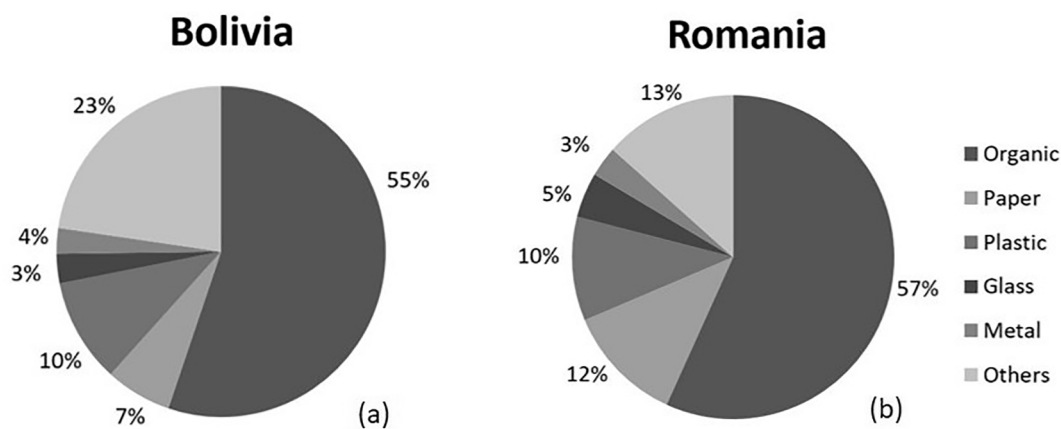


Fig. 4. Average solid waste fraction in (a) Bolivia (MMaY, 2011) and (b) Romania (Ciuta et al., 2015).

Table 6
Pros and cons for the entrance of a developing country into the EU in a SWM perspective.

Pros	Cons
<ul style="list-style-type: none"> ✓ Regulation systems ready to be introduced. ✓ Economic aids and European fund available. ✓ Reliable information sets required by EU. ✓ Obligatory introduction of CE principles. ✓ Technical support and open markets among the EU countries 	<ul style="list-style-type: none"> × Goals quite strengths for a developing region. × Scarce indications for achieving the recycling rate required. × Expensive penalties which should be paid in case of failure. × Poor consideration of current SWM practices (i.e. informal sector).

knowledge, private investments and CE principles, unknown before the entrance in the union. On the other hand, EU waste directives are challenging in developing and transition countries, as stated also by other authors (Mihajlović et al., 2016), since the lack of expertise and improved systems do not allow the implementation at short terms of such principles. Citizens, municipal governments and the private sector should implement EU regulations that are new for the area, hence not easy to implement and to introduce.

3.4. The implementation of the CE model

The model suggested in section 2.3 is a simplification of the application of a CE system valid in a developing big city for managing MSW, considering specific issues that are not improved. It could be used as reference example for explaining the current situation of the both countries reviewed and for underling main opportunities for waste valorization in its big cities.

The main opportunity of a general circular system does not mean direct economic benefits for a single urban user. The system is free of charges only in the case that the informal sector is involved, while other expensive management options should be introduced by financial and policy supports. It means that the application of a reliable and effective user charges collection system is required for improving financial sustainability.

The main opportunities, requirements and general outputs of a small-scale CE is schematically represented in Fig. 5. CE is a good occasion for spreading the SWM quality for the whole community, even though explanation should be provided to the population for avoiding miss understanding. Typical wrong assumption is that waste materials have a value, so people should receive an economic amount for selecting it. While the first assumption is right, the second could not be considered true without the introduction of financial incentives, which could be private or public. As a result, informative campaigns are compulsory for introducing new management plans. Opportunities and challenges for the development of the circular economy model suggested in this paper are briefly reported in Table 7.

The main activity suggested for introducing the CE in developing

big cities is the involvement of the informal sector into the sanitation system. It is particularly relevant for the Bolivian case study: the recycling rate is mostly improved by waste pickers, which have introduced a shape of recycling activities within the country. The presence of recovery shops is common, and they are widely scattered in the main big cities.

This practice can be introduced without many difficulties, except as regard public inclusion and waste pickers involvement, topic that should not be neglected. However, the secondary raw material produced by the informal recycling chain is currently sent mostly in other neighbor's nations and are exploited locally by big companies only in low rates. Similar consideration could be introduced for the Romanian case, although EU regulations do not involve the informal sector into the formal recycling chain. On balance, the informal activity is just applied in both countries, while the process of formalization is not well developed.

The difference between Romania and Bolivia in the CE model suggested is the possibility for implementing a MBT plant before land-filling. The exploitation of the organic fraction, in Romania, as indicated by the EU, should be implemented by the introduction of anaerobic digestion plants. However, such technology could not be effectively applied in Romanian big cities, due to the lack of know-how and the contribution of the population in the SC of organic fractions. The method introduced in this model is suggested like short-term solution for the municipalities that are not able to introduce expensive facilities, and, at the same time, because RDF can be immediately introduced within the cement kilns widespread in the area. Bolivian big cities, instead, can be the reference example for introducing MBT plants, since it is a quite low-cost methodology that can solve environmental issues typical of a region with no controlled landfills and with the lack of monitoring. Of course, such method should be evaluated for each study area in order to be a cost-effective method. In addition, in Bolivia, the exploitation of metals recovered by the system can be an appropriate option while a mechanical or manual selection could be introduced, instead of producing RDF, which could be difficult to be introduced due to the lack of specific regulations. Anyhow, the manual selection of recyclable materials before landfilling could be

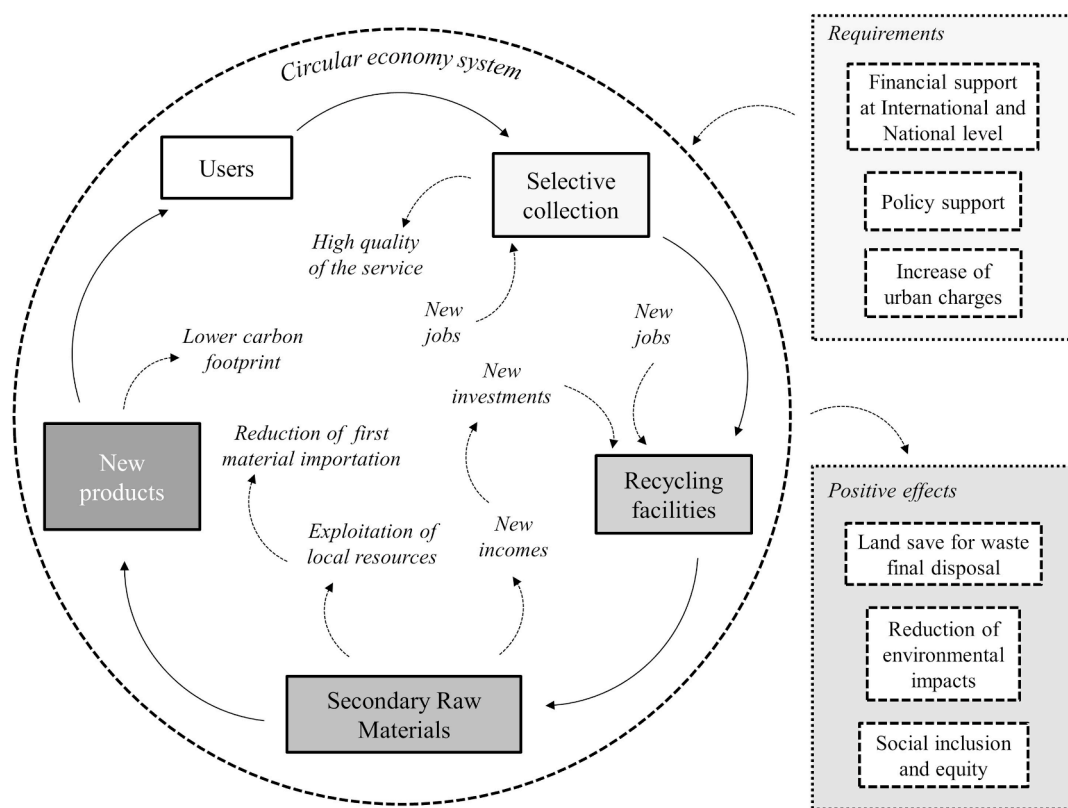


Fig. 5. Main requirements and positive effects of a CE system.

Table 7
Opportunities and challenges for developing the CE in Bolivia and Romania.

	First step	Second Step
Bolivia	<p>Opportunities: Inclusion of the informal sector could be a real advantage since it is the first form of autonomous recycling applied within the country. In this manner, the waste to final disposal could be reduced. At the same time, the implementation of pretreatment before landfills could be an important activity for reducing environmental impact and exploit the recyclable material.</p> <p>Challenges: The lack of technical support does not allow the application of new landfills and technological facilities, while new regulation are required at national level. The miss of national regulation about the use of RDF and the inclusion of the informal sector do not allow the introduction in short terms of these solutions.</p>	<p>Opportunities: WEEE could be managed by the private sector, while a few pilot projects were introduced for its valorization. New plans were introduced for the treatment of waste tires, while neighborhood countries could accept the materials for valorization. Hence, national policies could apply these principles, involving the private sector for building new plants, taking advantage of international grants.</p> <p>Challenges: This step is difficult to be applied in rural areas, where collection systems and treatment are still lacking. Moreover, regulations are not still in action. Healthcare waste and batteries, among other waste, are disposed into open dump sites or landfills with scarce or absent precautions.</p>
Romania	<p>Opportunities: RDF is just request by cement kilns while many controlled landfills were just applied. The EU could encourage the application of MBT for reducing environmental impacts. The inclusion of the waste pickers could spread within rural areas, reducing the waste inflow into open dump sites.</p> <p>Challenges: No regulation is still in action for the inclusion of the informal sector which is introduced mainly within rural areas. To date, the main technology suggested by the EU is the anaerobic digestion for the exploitation of the putrescible material, which cannot be applied due to the lack of public compliance in the SC.</p>	<p>Opportunities: Some pilot projects were introduced at national level in order to respect the European regulation. European neighbors' countries could accept the material selected or financial supports could be optioned for building new plants by EU. New investments could be introduced thanks to the involvement of the private sector.</p> <p>Challenges: The lack of collaboration by the citizens is common and the management practices are not uniform within the country. Form of corruption could be a barrier which should be overcome, as well as the willingness of the policy makers to introduce new technologies and form of collection.</p>

applied with appropriate precautions.

Despite which model, methodology or application will be introduced, the common issue in both countries is the presence of open dumpsites; hence, the construction of controlled landfills is imperative and international supports are required in both study areas.

Concerning the second step, the most important consideration, valid both for the Romanian and Bolivian case study, is that the progress of the CE can be introduced only by the recovery of all the material discarded by households. However, there are materials more difficult to recover and many investments, most of all private, are required. PPP is essential for implementing suitable recovery plants that can treat

sanitary and hazardous materials, end of life batteries, tires and WEEE.

Romania introduced a few pilot plans in order to develop the second step of the model, as suggested by the European regulation and by the CE principles. Instead, Bolivia still lack such practices. The second step is commonly the most difficult practice that should be applied in these developing regions, although pros for its application are many and could represent an opportunity of sustainability: reduction of material inflow into the landfill, decrease of environmental contamination, introducing new secondary raw materials into local economies and spread the involvement of new investors for waste valorization.

4. Conclusions and remarks

The case study presented in this paper provides indication about main opportunities and difficulties for a developing region for applying the CE as a model for waste valorization and management. Findings suggest how many advantages are detectable if a developing country is included into a wider organization as the EU, while the CE model introduced could be considered as a baseline practice for improving solid waste management in developing big cities of low-middle income countries.

Despite the economic level, Romania and Bolivia are both facing with many management issues although in different amounts: Romania is an emerging region that takes positive aids by EU for improving the SWM while Bolivia is a developing country with a low economic growth, where regulation systems and the introduction of new technologies is still poor.

The development of a CE model in Romania requires national strategies, which includes means to sustain the adoption of new consumption behaviors. Recycling options in Romania have started to emerge, but the financial crisis of 2008 has slowed down the trend. Positive changes could be seen since 2010, although 2–3% of recycling rate, which today raised to 13%, is still very far from the desired scenario: the European Commission set a target for recycling 50% of MSW by 2030. So, the situation in Romania cannot be described as encouraging, since it is one of the countries with the lowest level of waste recycling in the EU-28. European social funds and regulation limits led to improving sanitary conditions although with low efficiency. Nevertheless, good responses are given by packaging waste recycling which overcome the European goal of 55% recycling rate although there is the tendency to adopt laws and regulations resulting from an acceptance of standards from high income countries that may not be financial sustainable. On one hand, it is visible how Romania cannot achieve EU goals for 2020 for poor improvement and behavior changes, on the other, EU recommendations are of utmost importance for starting a CE approach, which is more difficult for developing countries where financing sustainability and regulations systems are still lacking.

One of the main problems in Bolivia is the lack of reliable data sets and the miss of monitoring on sanitary burden and natural resources contamination. Moreover, literature about SWM is scarce, making more difficult to obtain an historical approximation of the experiences on environmental science and engineering. The informal sector is the main actor that improves the recycling rate while the lack of monitoring and data collection do not encourage the development of a CE. As a result, Bolivia needs international aids, cooperation and assistance in order to improve in short terms its SWM since future economic improvements could be of interest for international markets.

The CE model suggested in this paper can be a reliable and applicable theoretical framework for big cities of developing countries. However, financial sustainability, stakeholder inclusion and regulation development are required. Some considerations could be introduced for developing the principles of the CE in developing countries, earning incomes by its introduction, such as:

- Including the informal sector into the solid waste management practices.
- Introducing pretreatment systems before landfilling or open dumpsites, since the putrescible fraction is a real issue in disposal sites, while the recovery of material or energy from waste could be a real missed opportunity.
- Evaluating the possibility to apply new form of SC for municipal hazardous waste or 'special' waste for reducing the waste inflow into the landfill and valorizing the materials.

These suggestions could be of interest for countries that are facing the main SWM issues reported by the Romanian and Bolivian big cities, and where policy-makers are interested in the introduction of effective

improvement for waste valorization in short terms. Construction of suited sanitary landfill, improving charges collection and promoting private sector involvements are always suggested, however such considerations are too obvious and too difficult to be applied in a developing region where the most applied 'treatment' is the open dump.

The implementation of a CE system should consider the specific needs of a country, city, town or community, applying specific plans, case by case. This paper provided a general indication for starting the implementation of the principle of the CE for a sustainable development in big cities, providing the comparison with two case studies inserted in two different frameworks. This comparison would introduce a direction for RP improvements in developing countries, since the sustainable development pass through the international implementation of the CE principle, guarantying the preservation of natural resources and environmental conditions.

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