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Improving the efficacy of municipal solid waste collection with a communicative approach based on easily understandable indicators

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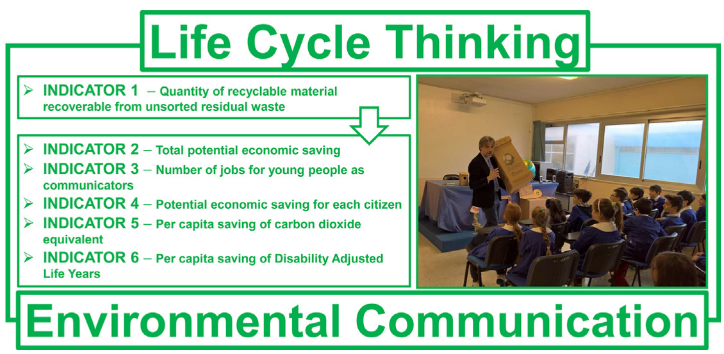
HIGHLIGHTS

- The study proposes a methodological approach with an example case.
- Life cycle thinking and environmental communication have been combined.
- The communicative approach is based on six easily understandable indicators.
- Indicators allow obtaining many combinations to use in communication campaigns.
- Communication campaigns should follow a pyramid approach with schools at the base.

GRAPHICAL ABSTRACT



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ABSTRACT

The main aim of the study was to propose a useful methodological approach to define easily understandable indicators to use in communication campaigns organized to improve the efficacy of municipal solid waste collection. For this purpose, six economic-environmental indicators were defined, combining life cycle thinking and environmental communication. The indicators make it possible to obtain several combinations that can follow a variety of communication channels. Three indicators (quantity of recyclable materials recoverable from unsorted residual waste; total potential economic saving; number of jobs for young people as communicators) are expressed in absolute value and therefore refer to the whole community even if they are also good for single-targeted messages. The other three indicators (potential economic saving for each citizen; per capita saving of carbon dioxide equivalent; per capita saving of Disability Adjusted Life Years) are normalized with respect to the number of inhabitants and therefore refer to the individual citizen, but can also be used for global messages. As a case example, the methodology was applied to the collection of paper and cardboard in twelve Southern Italy cities obtaining very promising results. For example, the maximum quantity of paper and cardboard recoverable from unsorted waste would allow Naples and Palermo to recover more than €15 million. The maximum potential economic saving for each citizen was 25 €/capita. The economic saving obtained for Naples and Palermo could be translated in more than one thousand positions as young environmental communicators. Catania was the city with both the highest per capita potential saving of carbon dioxide (>60 kg CO_2eq./capita) and maximum hypothetical per capita 'life-time recovery' (almost an hour). The innovative communication method used ('Greenopoli') assumed that school is the starting point to obtain a change of mindset because speaking with students (all potential communicators) means indirectly communicating with all other targets.

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1. Introduction

Separately collected recyclable materials from municipal packaging waste as well as from municipal solid waste (MSW) are precious materials to be recovered, especially in Italy and other European countries with a limited availability of virgin raw materials (De Feo and Polito, 2015). If citizens do not collect these materials separately, they produce both economic and environmental damage (Desa et al., 2011), but people (in their role of waste producers) are often unaware of the consequences of their actions (or inactions). The key role of waste management policies (WMPs) is, therefore, of fundamental importance.

WMPs include a range of complementary measures such as economic instruments (Van Beukering et al., 2009; Morlok et al., 2017), for instance the 'pay-as-you-throw' (PAYT) scheme. The main aim of an economic instrument is to persuade waste producers to divert waste from landfilling or incineration towards material recovery, in order to optimise the use of resources while contributing to the costs of the waste management service (Scheinberg et al., 2016; Morlok et al., 2017). By increasing convenience, there is the potential to increase user participation (Wagner, 2013). Moreover, making resource efficiency a priority will be the final step of the paradigm shift: 'more resource management, less waste disposal' (Fricke et al., 2011).

Inside the economic instruments, the extended producer responsibility (EPR) is a cornerstone of MSW management policies throughout the world (Massarutto, 2014; Dubois and Eyckmans, 2015). It is based on a system of financial transfers between industries and local authorities, which are ultimately responsible for the separated collection of packaging waste and its recovery (Rigamonti et al., 2015; Ferreira et al., 2017). On the other side, the separated collection of putrescibles and unsorted residual waste is usually a responsibility of municipalities.

Recyclable materials that go into the unsorted residual waste represent an economic damage (loss of EPR contribution and payment of disposal fees) as well as an environmental burden (loss of environmental benefits of recycling and impacts of disposal). Therefore, it is very important to convince citizens to separate correctly MSW fractions, avoiding that they go into the unsorted residual municipal waste by mistake.

This study aims to define easily understandable indicators with a procedure that combines life cycle thinking (LCT) and environmental communication (EC) in order to improve the efficacy of MSW separate collection. This approach falls within the scope of the theory of environmental performance indicators (Perotto et al., 2008) with several recent applications in current literature (De Gisi et al., 2014a, 2014b; Sabia et al., 2016). In particular, as a case example, the procedure is applied to the collection of paper and cardboard in twelve Southern Italy cities. Background information on LCT and EC are given in the next two subsections.

1.1. Background information on life cycle thinking (LCT)

LCT considers the sequence of raw materials extraction, manufacturing, distribution, use, and disposal, which is the life cycle, from an environmental perspective (Cooper, 2005). It is a sort of 'lever' (Heiskanen, 2002), which can be used to go beyond traditional point of views by including the environmental, social and economic impacts of a product, process or service over its entire life cycle (UNEP SETAC, 2017).

LCT is not just a method to examine the environmental impacts of activities through the life cycle assessment (LCA), but also a way to comprehend and visualize a broader set of upstream and downstream consequences of decisions, because it gives stakeholders a holistic view that they otherwise may not have (Thabrew et al., 2009).

Kikuchi-Uehara et al. (2016a) showed that products with an ecolabel presenting a reduction rate of carbon dioxide emissions were the most preferred option by the respondents to a web-based survey conducted with Japanese adults. LCT-based information can be useful in improving environmental awareness also in citizens with relatively low LCT skills (Kikuchi-Uehara et al., 2016b). Even streamlined approaches can facilitate the introduction of LCT in the day-to-day practice based on scientifically sound and robust results (Bala et al., 2010) as long as they are easily understandable.

However, LCT approaches should be broadened by comparing alternatives and avoiding negative impacts, to also proactively enhancing positive impacts, and towards the achievement of sustainability goals (Sala et al., 2013). In fact, this is one of the aims of the study, which tries to combine LCT and EC in order to obtain practical results by defining indicators to use citizens' levers in the sense described by Heiskanen (2002).

1.2. Background information on environmental communication (EC)

The contemporary world is characterised by an abundance of information. However, the overload of information has not been able to solve all the environmental issues. In fact, information by itself does not solve problems. Only information converted into meaningful knowledge can be a resource useful to improving sustainability and environmental quality (EEA, 1999).

EC can be seen as a link process between sources and the recipients of understandable and effective environmental information between various audiences using different communication media, approaches, principles, strategies and techniques (Pillmann, 2002; Flor, 2004). EC is usually connected with environmental education, public participation and environmental politics (Pillmann, 2002).

EC plays a fundamental role in the social process of environmental education, which facilitates an aware access to information (ISWA, 2016). EC is a potentially transformative practice, because environmental campaigns provide information to encourage people to alter their behaviours, with it also being a strategic endeavour to catalyse change (Cote and Wolfe, 2017; Cozen et al., 2017). The possibilities for addressing environmental problems depend on human perceptions, attitudes and behaviour, which are linked to values, preferences and beliefs about the world. EC is crucial to analysing the relation between all of these aspects (Carvalho, 2009).

Hoewe and Ahern (2017), as the results of an experiment, showed how informational messages about the environment produced third-person effects, while environmental advertisements meant evoking emotion caused first-person effects. Jiang et al. (2017), based on a national sample of citizens living in China, tested a situational model of problem solving and extended it by adding citizens' environmental engagement behaviour as an immediate consequence of their communicative action. Harris (2017) developed a case for alternative communication models as a means of strengthening networks for both dialogue and social actions in EC. In addition, the arts can help provide some of the affective components of EC such as emotions, values, and motivations driving pro-environmental behaviour. For instance, Publicover et al. (2017) suggested that as one of the arts, music could captivate, entertain, and create a sense of community.

One of the tasks of a municipal governance is to keep the stakeholders informed about the topicalities and policies under its supervision. The population is a key stakeholder, and its awareness about their environment and activities of the municipality is crucial to the accountable and effective implementation of these policies (Bucholtz, 2017).

This study aroused from the above conjectures in an attempt to merge LCT and EC into a new and effective way, using the levers of money, health and the environment to create indicators easily understandable by the citizens in order to improve the efficacy of MSW source separation.

2. Methods

2.1. Framework of the proposed methodology

The proposed methodology can be applied to all the main MSW recyclable materials, such as paper and cardboard, plastics, glass, aluminium, steel, and wood, considered singularly or globally, depending on the aim of the subsequent environmental campaign and/or available data.

There are six indicators defined, that can be used for communication purposes for the citizens of the city/cities under study:

- Indicator 1: Quantity of a specific recyclable material or all recyclable materials recoverable from unsorted residual waste;
- Indicator 2: Total potential economic saving for a specific recyclable material or all recyclable materials recoverable from unsorted residual waste;
- Indicator 3: Number of jobs for young people as communicators for a specific recyclable material or all recyclable materials recoverable from unsorted residual waste;
- Indicator 4: Potential economic saving for each citizen for a specific recyclable material or all recyclable materials recoverable from unsorted residual waste;
- Indicator 5: Per capita saving of carbon dioxide equivalent for a specific recyclable material or all recyclable materials recoverable from unsorted residual waste;
- Indicator 6: Per capita saving of Disability Adjusted Life Years for a specific recyclable material or all recyclable materials recoverable from unsorted residual waste.

Therefore, combining the six single materials plus the possibility to consider together all the materials, joined with the six indicators, as shown in Fig. 1, a maximum number of forty-two parameters can be calculated.

How to calculate the six indicators is explained in the next sections. The first three indicators are referred to the whole city, while the second three indicators are per capita values. Each single indicator refers to the year under study.

2.1.1. Indicator 1: Quantity of recyclable materials

Indicator 1 refers to the total quantity of a specific recyclable material (M_i) or all recyclable materials (ΣM_i) recoverable from unsorted residual waste. Indicator 1 is the basis from which the other five indicators are calculated. Its unit of measure is ton/year.

The following information is known: 1) total quantity of MSW produced in a year in the city under study; 2) quantities of recyclable materials separately collected from MSW in a year; 3) total quantity of unsorted residual waste produced in a year.

If a composition analysis of the unsorted residual waste is available, Indicator 1 for a specific material can be easily calculated multiplying the total quantity of unsorted residual waste for the corresponding percentage of that material. Indicator 1 for all recyclable materials will be obtained simply summing the values of Indicator 1 obtained for each single material.

If a composition analysis of the unsorted residual waste is not available, it will be necessary to have a composition analysis, or an estimation of it, of the whole MSW. In this case, Indicator 1 for a specific material can be calculated as a difference. First, the total quantity of each single material multiplying the related percentage for the total production of MSW has to be calculated. Indicator 1 will be obtained by subtracting the quantity of that material separately collected from the total quantity of the same material. Also in this case, Indicator 1 for all the recyclable materials (Parameter 7.1) will be obtained by simply summing the values of Indicator 1 obtained for each single material (Parameters 1.1; 2.1; 3.1; 4.1; 5.1; 6.1 in Fig. 1).

2.1.2. Indicator 2: Total potential economic saving

Indicator 2 refers to the total potential economic saving for a specific recyclable material or all the recyclable materials recoverable from the unsorted residual waste. Its unit of measure is Euro/year.

For each single material, Indicator 2 is obtained by multiplying Indicator 1 (ton/year) for the sum of the specific average EPR contribution and the saving for avoided disposal in landfill (Euro/ton). The EPR contribution given to the municipality depends on the specific typology of material as well as the level of impurity in the sense that the less the discards are, the more the recognized economic contribution is.

The purpose of this indicator is to communicate to all the citizens of the city under study the economic value of the 'urban mining' present in the unsorted residual waste and that they waste into a landfill with a wrong or absent source separation of MSW. In fact, it is commonly accepted that money is able to change people's motivation (mainly for the better) and their behaviour (Vohs et al., 2006).

Indicator 2 for all the recyclable materials (Parameter 7.2) will be obtained by simply summing the values of Indicator 2 obtained for each single material (Parameters 1.2; 2.2; 3.2; 4.2; 5.2; 6.2 in Fig. 1).

2.1.3. Indicator 3: Number of jobs for young people as communicators

Indicator 3 refers to the number of potential jobs for young people as communicators for a specific recyclable material or all the recyclable materials recoverable from the unsorted residual waste. Its unit of measure is number of communicators.

For each single material, Indicator 3 is obtained by dividing Indicator 2 (Euro/year) for a fixed per capita earning as a communicator (Euro/capita/year).

Expressing economic saving in terms of potential job positions for young professionals working in the field of environmental communication could be particularly sensitive in those areas with a high level of youth unemployment.

Indicator 3 for all the recyclable materials (Parameter 7.3) will be obtained by simply summing the values of Indicator 3 obtained for each single material (Parameters 1.3; 2.3; 3.3; 4.3; 5.3; 6.3 in Fig. 1).

2.1.4. Indicator 4: Potential economic saving for each citizen

Indicator 4 refers to the potential economic saving for each citizen for a specific recyclable material or all the recyclable materials recoverable from the unsorted residual waste. Its unit of measure is Euro/capita/year.

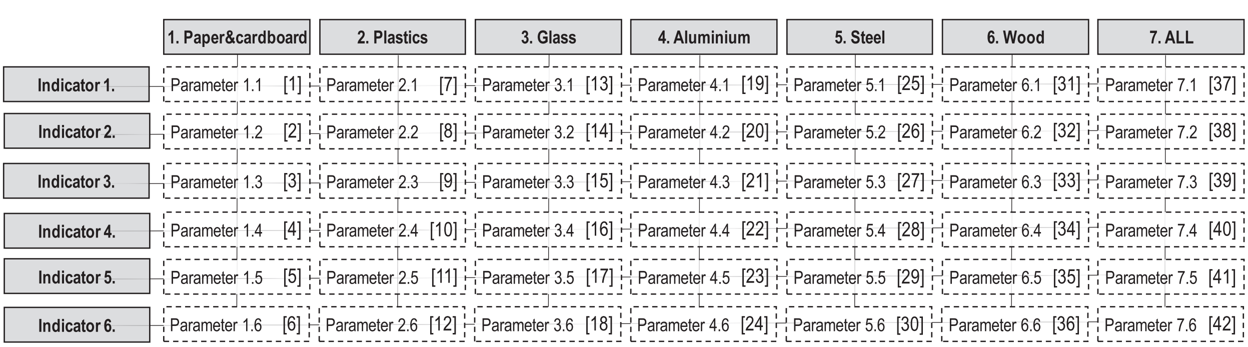

Fig. 1. All the possible parameters that can be calculated with the proposed procedure.

For each single material, Indicator 4 is obtained by dividing Indicator 2 (Euro/year) for the population size of the city under study (number of inhabitants).

The purpose of this indicator is to communicate to each single citizen the money passing through his or her hands and that will be disposed of with an incorrect or absent MSW source separation. Even for this indicator, as the previous one, the basic assumption is that money is able to change people's motivation and behaviour for the better.

Indicator 4 for all the recyclable materials (Parameter 7.4) will be obtained by simply summing the values of Indicator 4 obtained for each single material (Parameters 1.4; 2.4; 3.4; 4.4; 5.4; 6.4 in Fig. 1).

2.1.5. Indicator 5: Per capita saving of carbon dioxide equivalent

MSW generation and management have environmental impacts and generate emissions of greenhouse gases (GHG). Cifrian et al. (2013) suggested the use of the carbon footprint indicator since it complements individual waste management indicators and would be useful in supporting decision making and policy analysis.

Indicator 5 refers to the per capita saving of carbon dioxide equivalent (in a global warming perspective) for a specific recyclable material or all the recyclable materials recoverable from the unsorted residual waste. Its unit of measure is kg CO_2 eq./capita/year.

For each single material, this indicator has to be calculated by means of a life cycle thinking approach using the life cycle assessment. LCA allows to evaluate the environmental performance of alternative systems considering both the whole life cycle (i.e. from cradle-to-grave) and only some parts (e.g. from cradle to gate or from gate to grave, as in the case of MSW management) (Curran, 2008).

LCA has to be used for the calculation of environmental benefits (in term of avoided impacts, CO_2 equivalent in this case) that could be obtained if the recyclable material present in the unsorted residual waste was collected separately. The environmental benefits are the algebraic sum of three contributions: avoided impacts due to lack of disposal (e.g. landfilling and/or incineration with or without previous mechanical and biological treatment and/or selection processes), impacts produced by recycling process, and avoided impacts associated with the secondary raw material produced with such recycling process (due to the avoided production of the same material from raw virgin resources).

The LCA can be performed using software tools such as SimaPro (PRé Consultants, Amersfoort, The Netherlands), using primary data and/or secondary data from available databases such as Ecoinvent depending on the specific goal of the study as well as the availability of data.

The functional unit (i.e., unit of output for which results will be presented) can be defined as the total quantity of the specific recyclable material (under study) recoverable from the unsorted residual waste, i.e. Indicator 1, sent to recycling and not disposed.

The treatment and disposal stages have to be considered, while the collection and transportation steps can be excluded from the analysis if this assumption is reasonable (e.g. in the case that transportation for recycling and disposal are quite similar) or discussing the implications of this exclusion. It is worth noting that the main aim of this procedure is not to make a ‘perfect’ calculation of the impacts but rather to define powerful indicators, easy to communicate in a communicative campaign aimed at modifying people's behaviour for the better.

The recommended Life Cycle Impact Assessment (LCIA) method is the baseline model developed by the International Panel on Climate Change (IPCC) with a timeframe of 100 years (IPCC, 2013).

Indicator 5 for all the recyclable materials (Parameter 7.5) will be obtained by simply summing the values of Indicator 5 obtained for each single material (Parameters 1.5; 2.5; 3.5; 4.5; 5.5; 6.5 in Fig. 1).

2.1.6. Indicator 6: Per capita saving of disability adjusted life years

Indicator 6 refers to the per capita saving of Disability Adjusted Life Years (DALYs) for a specific recyclable material or all the recyclable materials recoverable from the unsorted residual waste. Its unit of measure is min/capita/year.

For each single material, analogously to the previous one, this indicator has to be calculated by means of a life cycle thinking approach using the life cycle assessment adopting the LCIA method ReCiPe 2016 at the endpoint level using the hierarchist (H) perspective (Huijbregts et al., 2016). H perspective is based on the most common policy principles relating to time frame and other issues. ReCiPe includes both the midpoint (problem oriented) and endpoint (damage oriented) impact categories. At the midpoint level, 18 impact categories are addressed, while, at the endpoint level, most of these midpoint impact categories are multiplied by damage factors and aggregated into three endpoint categories: Human health, Ecosystems, Resource scarcity. Indicator 6 is related to the endpoint damage category Human Health, expressed as the number of years of life lost and the number of years lived disabled (DALYs), as proposed by the World Bank and WHO (Huijbregts et al., 2016).

Indicator 6 for all the recyclable material (Parameter 7.6) will be obtained by simply summing the values of Indicator 6 obtained for each single material (Parameters 1.6; 2.6; 3.6; 4.6; 5.6; 6.6 in Fig. 1).

2.2. Background information for the Italian case study developed

In Italy (and similarly in many other countries), based on a covenant, a municipality receives from the National Packaging Consortium (Conai) an economic amount proportional to the quantity and quality of packaging waste separately collected. For the recovery operations of individual materials (steel, aluminium, paper and cardboard, wood, plastic, and glass), Conai co-ordinates the activities of the six Material Consortia (Rigamonti et al., 2015). In terms of paper and cardboard, which are the materials considered in the case study developed, the role of Comieco is strategic, which is the Italian Consortium for the Recovery and Recycling of Paper and Cardboard Packaging. The main aim of Comieco is to achieve the paper and cardboard packaging recycling target set by the European rules through a policy aimed at the prevention and development of separate collection. Upon agreement with Conai, Comieco operates the collection, recycling, and recovery of paper and cardboard packaging as well as of the paper and cardboard collected separately at municipal level.

In 2015, every Italian collected 51.5 kg of paper and cardboard. The performance of the citizens in Centre and Northern Italy were relatively similar with a per capita collection of around 62 kg per year. People in Southern Italy collected less paper and cardboard, with an average value of 31.5 kg/capita/year. In order to increase the quantity of paper and cardboard collected, in 2015, Comieco launched the ‘Plan for South’ with special investments in targeted areas in order to recovery part of the over 700,000 tons of paper and cardboard that still (likely) goes into the unsorted residual waste.

12 Southern Italy cities were taken into consideration (Table 1): Naples and Caserta in the Campania region; Bari and Foggia in the Apulia region; Catanzaro in the Calabria region; Messina, Palermo, Catania, Syracuse, Ragusa and Sciacca in the Sicily region; Sassari in the Sardinia region. The total population of the twelve cities considered was 3,225,004 inhabitants. The study was developed regarding the year 2014, when the percentage incidence of paper and cardboard on the total source separation in Italy was 10.6%.

A comparison with the national average shows above all the gap with the rest of the country regarding the unemployment rate and life expectancy, which can be used as levers of the communication campaign.

Population density is one of the main parameters used to evaluate (roughly) the intrinsic difficulties of a territory in terms of separate collection. Naples is the most populous city among those studied as well as the most densely populated.

It is worth nothing that the city that had the highest level of source separation (Table 2), namely Caserta with 48.53%, was the only one (in 2014) with a house-to-house kerbside collection system. The other

Table 1
Demographic characteristics of the twelve Southern Italy cities considered in the study as a case example (Istat, Italian National Institute of Statistics).

Cities	Region	Population	Population density	Average age	Unemployment rate	Male life expectancy	Female life expectancy
		Inhabitants	Inhabit./km^2	Years	%	Years	Years
Bari	Apulia	327,361	2788.67	41.70	19.30	80.50	84.90
Foggia		152,770	299.98	42.80	19.40	80.50	84.90
Naples	Campania	978,399	8309.49	41.70	26.50	78.50	83.30
Caserta		76,887	1442.00	43.30	11.60	78.50	83.30
Catanzaro	Calabria	90,840	805.86	43.30	21.50	79.60	84.60
Messina	Sicily	240,414	1.124.72	43.80	24.90	79.50	83.80
Palermo		678,492	4224.93	42.00	19.10	79.50	83.80
Catania		315,601	1725.54	42.60	20.50	79.50	83.80
Syracuse		122,503	589.58	43.00	21.60	79.50	83.80
Ragusa		73,030	164.24	43.80	16.70	79.50	83.80
Sciacca		41,082	214.34	43.10	17.20	79.50	83.80
Sassari	Sardinia	127,625	233.30	44.60	15.60	79.70	85.30
Average		257,293	1890.72	42.98	19.49	79.53	84.09
St. Dev.		292,404	2482.39	0.88	4.03	0.61	0.66
Italy		60,665,551	200.80	43.90	12.40	80.30	85.00
Difference		–	+842%	−2.1%	+57.2%	−1.0%	−1.1%

cities had a bring collection system (Foggia, Syracuse and Sciacca) or a mixed collection system. Thus, it is not surprising that the worst source separation performance was registered for two cities with a bring system, i.e. Syracuse with 4.71% and Foggia with 6.25%.

As shown in Table 3, Syracuse, Palermo, Messina, Sciacca, Catanzaro, Foggia, Ragusa and Catania, had a performance in terms of total per capita collection of paper and cardboard under the average performance of Southern Italy (for 2014) that was around 30 kg/capita/year (considering all the municipalities in Southern Italy). Bari was the only city with a performance that was even better than the Northern Italy cities, namely around 63 kg/capita/year. Naples was perfectly in line with the data of Southern Italy. Finally, it is worth mentioning the good performance of Sassari with a performance better than the average national data (around 52 kg/capita/year).

Paper and cardboard can be collected according to two different codes from the European Waste Catalogue (EWC):

- 15.01.01 - Separately collected paper and cardboard packaging waste ('selective collection', SC);
- 20.01.01 - Separately collected paper and cardboard ('joint collection', JC).

On average, during 2014, in Italy, the total quantity of paper and cardboard collected separately weighted on the total MSW was 10.6%. As shown in Table 3, only Bari and Sassari had a percentage incidence higher than the average national performance. While, all the other cities had a negative collection performance in terms of paper and cardboard.

2.2.1. Assumptions made for the case study developed

The maximum supposed total quantity of paper and cardboard in the MSW was 20% for all the twelve cities. This assumption was made on the basis of the average compositions of the MSW in the studied cities. This percentage was used for the calculation of the six economic-environmental indicators defined in the previous sections. Moreover, in order to take into consideration the fact that between '0' and '100', there are intermediate possibilities, two additional intermediate scenarios were considered. Therefore, three scenarios of paper and cardboard recovery were considered: 1) 10.6% of MSW (corresponding to the national average); 2) 15% of MSW (corresponding to a partial recovery of paper and cardboard from unsorted residual waste); 3) 20% of MSW (corresponding to a total recovery, it was used for the calculation of the six indicators).

An average EPR contribution for paper and cardboard of 75 Euro/ton and a saving for avoided disposal in landfill of 175 Euro/ton, for a total economic saving of 250 Euro/ton of paper and cardboard potentially present in the unsorted residual waste, were assumed on the basis of the average values in the cities under study. The total value is perfectly the same of that estimated by Rigamonti et al. (2015) in terms of the cost savings that local authority benefits per tonne of packaging waste separately collected by diverting packaging waste from the residual waste collection services and disposal.

Table 2
Absolute data about the collection of MSW and paper and cardboard in the twelve Southern Italy cities considered in the study as a case example– first part (Comieco, 2015; Ispra, 2015).

Cities	MSW tot	MSW per capita	Separate collection	Joint collection (JC[a])	Selective collection (SC[b])	JC + SC	[SC / (JC + SC)]
	ton	kg/capita/year	%	ton	ton	ton	%
Bari	184,896	564.8	27.02	10,947	11,599	22,546	51
Foggia	69,326	453.8	6.25	1079	1698	2777	61
Naples	500,086	511.1	22.02	14,665	14,310	28,975	49
Caserta	41,23	536.2	48.53	2181	720	2901	25
Catanzaro	42,433	467.1	6.8	622	942	1564	60
Messina	111,278	462.9	7.59	1042	2166	3208	68
Palermo	345,468	509.2	8.29	3861	2049	5910	35
Catania	205,791	652.1	9.29	3837	4349	8186	53
Syracuse	62,922	513.6	4.71	636	197	833	24
Ragusa	33,631	460.5	17.19	619	863	1482	58
Sciacca	22,713	552.9	17.35	–	–	664	–
Sassari	61,262	480.0	42.92	4874	2441	7288	33
Average	149,073	513.7	18.2	4033.0	3757.6	7194.5	47.1
St. Dev.	151,614	57.3	14.7	4664.2	4720.5	9115.4	15.3

[a] JC = paper and cardboard collected from households ('joint collection').
[b] SC = cardboard packaging waste collected from commercial (and similar) activities ('selective collection').

Table 3
Per capita data about the collection of MSW and paper and cardboard in the twelve Southern Italy cities considered in the study as a case example – second part (Comieco, 2015; Ispra, 2015).

Cities	Joint collection (JC[a])	Selective collection (SC[b])	JC + SC	(JC + SC) / MSW	(JC + SC) / MSW Italy	Collection deficit
	(kg/capita/year)	(kg/capita/year)	(kg/capita/year)	(%)	(%)	(%)
Bari	34.1	36.2	70.3	12.2	10.6	1.6
Foggia	7.0	11.1	18.1	4.0	10.6	−6.6
Naples	15.2	14.8	30.1	5.8	10.6	−4.8
Caserta	27.6	9.1	36.7	7.0	10.6	−3.6
Catanzaro	6.7	10.1	16.7	3.7	10.6	−6.9
Messina	4.3	8.9	13.2	2.9	10.6	−7.7
Palermo	5.9	3.1	9.0	1.7	10.6	−8.9
Catania	12.9	14.7	27.6	4	10.6	−6.6
Syracuse	5.1	1.6	6.7	1.3	10.6	−9.3
Ragusa	8.5	11.9	20.4	4.4	10.6	−6.2
Sciacca	–	–	16.2	2.9	10.6	−7.7
Sassari	38.0	19.1	57.1	11.9	10.6	1.3
Average	15.0	12.8	26.8	5.2	10.6	−5.5
St. Dev.	11.8	8.8	18.6	3.4	0.0	3.4

[a] JC = paper and cardboard collected from households ('joint collection').
[b] SC = cardboard packaging waste collected from commercial (and similar) activities ('selective collection').

In order to calculate the hypothetical number of young environmental communicator positions a remuneration of 15,000 Euro/capita/year was assumed.

The LCA was performed using the SimaPro 8 software tool (PRé Consultants, Amersfoort, The Netherlands), using the Ecoinvent v.3.3 database. The developed case study has to be considered as a simple example of the application of the methodological procedure proposed. Therefore, only the treatment and disposal stages were considered. Landfilling was the disposal process considered for the fraction of paper and cardboard in the unsorted waste. Regarding the modelling of the waste treatment processes, all the inventory data used for the modelling of landfilling and recycling process of paper and cardboard are available in De Feo et al. (2016). The datasets of Ecoinvent database are not perfectly representative for the situation under analysis, but, as already written, this was not the aim of the developed case study.

2.3. The communicative approach adopted

The communicative approach adopted is named 'Greenopoli'.

Greenopoli is a website (www.greenopoli.it), a Facebook page, and, mainly, a teaching method as well as an environmental educational program, which from December 2014 up to December 2017 has involved >200 schools and around 30,000 students in Southern Italy. An image search on any Internet search engine by typing the word 'Greenopoli' can give an idea of the communicative impact of the method. There are two main key words: sharing and sustainability. Sustainability ('*Sostenibilità*' in Italian), Environment ('*Ambiente*' in Italian), Waste ('*Rifiuti*' in Italian) and Water ('*Acqua*' in Italian) are some of the main topics of the environmental educational program 'Greenopoli'. 'Sara', one of the protagonists of Greenopoli, is the Italian acronym made with the initials of the four main topics (De Feo, 2014).

Sustainability is linked to the future and, thus, with children, who love games, ideas, asking questions endlessly, learning, laughing, joking, etc. The environment is everything around us: we have to take care of it if we want to survive on the planet Earth. We have to change the way that we usually look at what we continue to call 'waste': they are materials at one end of their life cycle and can assume a new shape in a life cycle thinking perspective. Water is the blue gold of the third millennium. It is a limited resource, similarly to all the other Earth's resources. Therefore, water has to be preserved in order to be saved for our children and for the children of our children, and so on. In the Greenopoli world, together with Sara, there are other funny characters such as Mr. Error, inspector Garbage and Mr. Rubbish, etc. All these characters, together with new green fairy tales, rap songs ('green raps') and games are the main tools used during the environmental education meetings managed by Greenopoli for adults and children (Fig. 2).

In terms of waste, Greenopoli proposes a new classification of waste, taking into account the life cycle thinking approach and the concept of usefulness as previously described in De Feo and Napoli (2005). The basic idea is that what we call 'waste' is mainly materials that have momentarily 'exhausted' their function becoming a sort of 'exhausted materials'. In the light of this consideration, on the basis of their origin, we could have Normal Exhausted Materials (NEM), corresponding to the Municipal Solid Waste (MSW), and Special Exhausted Materials (SEM), mainly corresponding to the industrial, agricultural, demolition and construction waste, etc. Definitively, taking into account the concept of hazard, there will be four kind of exhausted materials: Non-Hazardous NEM, Hazardous NEM, Non-Hazardous SEM, Hazardous SEM (De Feo, 2008).

3. Results and discussion

The results obtained for the developed case example are presented and discussed in the next paragraphs. Starting from the values obtained for the collection of paper and cardboard in the twelve Southern Italy cities taken into consideration, the results will be commented emphasizing the general validity of the methodology developed.

The starting point is Table 4, which shows the maximum theoretically amounts of paper and cardboard that can be further intercepted from the unsorted residual municipal waste of the twelve cities, for each of the three scenarios considered. Similar tables can be constructed for all the other recyclables materials (such as plastics, glass, aluminium, steel, and wood). They are resources passing through the hands of citizens, but that are not properly separated and collected. Through an effective communication action, capable of producing positive behavioural changes (Timlett and Williams, 2008), it must be avoided that precious recyclable materials end up in the unsorted residual waste.

The values contained in Table 4 are the basis for the further calculations reported and discussed in the following sections. It is worth remembering that the values of Scenario 3 (those in the rightmost column), corresponding to the maximum theoretical collection, are those used for the calculation of the indicators.

Regarding the case example, in Scenario 1 there are no further possible recoveries for Bari and Sassari, because this scenario considers a total recovery equal to the national average value (10.6%), while these cities recovered an amount of paper and cardboard around 12% of MSW. From this result, it can be argued that the methodological approach defined is particularly useful in those situations with poor

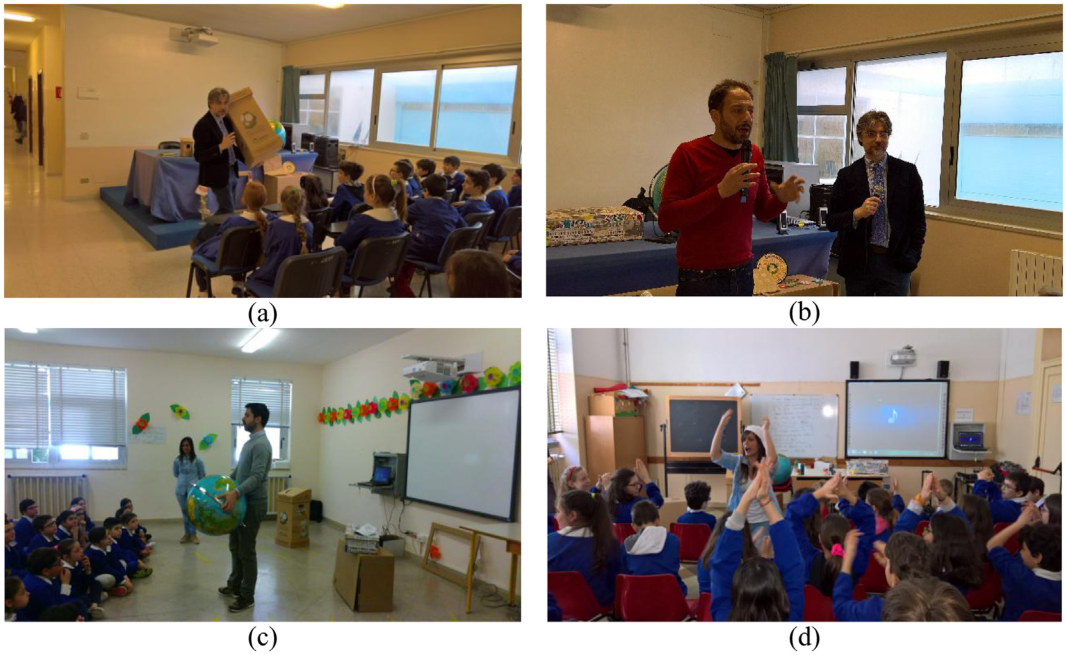

Fig. 2. Some moments of the environmental communication program performed by the authors in the city of Bari in the Apulia region of Southern Italy in March 2017: (a) the Greenopoli method with primary school students; (b) the Councillor of the Environment of Bari; (c) two young communicators with primary school students; (d) the character 'Comieco Vale' while she sings the rap songs of Greenopoli.

results in terms of separate collection and where there are likely high quantities of materials in the residual waste.

In the next three sections, the results are presented and discussed separately regarding the socio-economic, environmental and communication perspectives.

3.1. Socio-economic results

The quantities of recyclables theoretically present in the unsorted residual waste can be conveniently translated into socio-economic results. This translation has to be intended in the perspective to give easily and powerful indications to the citizens involved in the separate collection programs. Regarding the case example, Table 5 shows the economic recovery obtainable for the cities under study with paper and cardboard theoretically present in the unsorted residual waste.

The maximum hypothetical economic recovery for Naples and Palermo breaks the threshold of €15 million, because Naples is the biggest cities, while Palermo is the second biggest city as well as because it is in the group of cities with the lowest values of separate collection and paper and cardboard recovery. This huge amount of money could be further incremented considering all the other materials. This approach fills with meaning the concept of 'urban mining' (De Feo and Polito, 2015).

The values calculated in Table 5 can be expressed in terms of potential economic saving for each citizen and hypothetical number of young environmental communicator positions. The obtained values are reported in Table 6. These are elements of a certain interest to the population of the cities under study, given the high rate of unemployment and per capita income compared to other cities in Central-Northern Italy. This approach is particularly suggested for countries where there are

Table 4
Maximum theoretically amounts of paper and cardboard that can be further intercepted from the unsorted residual municipal waste of the twelve Southern Italy cities taken into consideration.

City	Real data (2014)			JC + SC that can be further intercepted (ton)		
	MSW	JC[a] + SC[b]		Scenario 1	Scenario 2	Scenario 3
	ton	ton	%	JC + SC = 10,6%	JC + SC = 15%	JC + SC = 20%
Bari	184,896	22,546	12.2	0.00	5188	14,433
Foggia	69,326	2777	4.0	4572	7622	11,088
Naples	500,086	28,975	5.8	24,034	46,038	71,042
Caserta	41,230	2901	7.0	1469	3284	5345
Catanzaro	42,433	1564	3.7	2934	4801	6923
Palermo	345,468	5910	1.7	30,710	45,910	63,184
Messina	111,278	3208	2.9	8587	13,484	19,048
Syracuse	62,922	833	1.3	5837	8605	11,751
Ragusa	33,631	1482	4.4	2083	3563	5244
Catania	205,791	8186	4.0	13,628	22,683	32,972
Sciacca	22,713	664	2.9	1744	2743	3879
Sassari	61,262	7288	11.9	0.00	1901	4964

[a] JC = paper and cardboard collected from households ('joint collection').
[b] SC = cardboard packaging waste collected from commercial (and similar) activities ('selective collection').

Table 5
Economic recovery (€) obtainable for the cities under study with paper and cardboard theoretically present in the unsorted residual waste (assuming an average EPR contribution for paper and cardboard of 75 Euro/ton and a saving for avoided disposal in landfill of 175 Euro/ton).

Cities	Scenario 1 (JC[a] + SC[b] = 10.6%)	Scenario 2 (JC[a] + SC[b] = 15%)	Scenario 3 (JC[a] + SC[b] = 20%)
Bari	0	1,297,116	3,608,321
Foggia	1,142,877	1,905,459	2,772,028
Naples	6,008,528	11,509,473	17,760,548
Caserta	367,346	820,876	1,336,251
Catanzaro	733,473	1,200,235	1,730,647
Palermo	7,677,395	11,477,540	15,795,886
Messina	2,146,867	3,370,925	4,761,900
Syracuse	1,459,183	2,151,324	2,937,849
Ragusa	520,729	890,673	1,311,064
Catania	3,406,959	5,670,659	8,243,046
Sciacca	435,893	685,735	969,647
Sassari	0	475,330	1,241,108

[a] JC = paper and cardboard collected from households ('joint collection').
[b] SC = cardboard packaging waste collected from commercial (and similar) activities ('selective collection').

situations of great economic disparities as well as a high rate of unemployment.

The values related to Scenario 3 are particularly significant, with it including the total hypothetical source separation of paper and cardboard from MSW (i.e. 0% of paper and cardboard in the unsorted residual waste).

As shown in Table 6, only Catania crosses the threshold of 25 €/capita; Palermo, Sciacca and Syracuse are between 20 and 25 €/capita; Caserta, Ragusa, Foggia, Naples, Catanzaro and Messina are in the range 15–20 €/capita; Bari is the only city in the range 10–15 €/capita; Sassari is in the last position with slightly <10 €/capita. Sassari and Bari are in the last positions, in terms of potential economic recovery, because they have the highest level of paper and cardboard source separation. Even in this case, it is worth remembering that the values calculated are only those corresponding to paper and cardboard and can significantly increase when considering all the other recyclable materials.

An equally interesting opportunity can be considered in terms of potential jobs as a communicator to be offered to young people in the place, both to enhance the *genius loci* as well as to answer - albeit very partial - to the social plight of youth unemployment.

As shown in the table, with reference to the most optimistic scenario (Scenario 3), the highest numbers are (obviously) obtained for Naples and Palermo (for the reasons already mentioned) with 1.184 and 1.053 potential job positions, respectively. This is followed by Catania with 550. Bari and Messina are in the 200–400 range. All the other cities are among the 65 of Sciacca and 196 in Syracuse.

These numbers can be translated into effective slogans for citizens, such as:

- ‘*On paper, in the rubbish of* (*name of the city*) *there are more than* (*number*) *jobs for young people*!’
- ‘*Waste paper and cardboard can be the gold of* (*city name*)!’
- etc.

Similar slogans and messages could be developed for all the other recyclable materials and packaging wastes potentially present in the unsorted residual waste with different approaches and features taking into account the peculiarities of the cities under study. The participation of the citizens in the life-cycle of packaging waste is essential for the efficiency and effectiveness of recycling (Ferreira da Cruz et al., 2014). However, often, only the collection rates are communicated to the citizens, giving neither an adequate picture of the available quantity of secondary resources produced nor information about the final destination of these materials (Haupt et al., 2017). On the contrary, with the proposed approach, there is a significant involvement of the citizens, who are strongly motivated to actively and effectively participate in the separate collection program.

3.2. Environmental results

The quantities of recyclables theoretically present in the unsorted residual waste can be converted into environmental results in order to give effective indications to the citizens involved in the separate collection programs. Regarding the case example, the per capita equivalent carbon dioxide equivalent data shown in Table 7 are particularly significant. Catania is the city with the highest per capita potential saving of carbon dioxide equivalent, with >60 kg CO_2 eq./capita. Three other Sicilian cities, Palermo, Sciacca and Syracuse, have a potential saving between 57 and 50 kg CO_2 eq. In the range 40–50 kg CO_2 eq./capita, there are six cities (Caserta, Ragusa, Foggia, Naples, Catanzaro and Messina). Sassari and Bari are the cities with the lowest potential saving, because they are the cities with the highest per-capita values of paper and cardboard collected: they are already partially taking advantage of the economic and environmental benefits of a more virtuous and correct approach to the separate collection of paper and cardboard.

Citizens do not frequently identify their own actions as causes of global warming and other environmental impacts (Whitmarsh, 2009). Truelove and Parks (2012) pointed out correlations between the belief in the mitigating potential of a behaviour and intention to perform each behaviour. Therefore, the same authors confirmed the potential for practical application in mass communication campaigns and behaviour change strategies. The proposed methodology has to be considered in the light of the perspective traced by Truelove and Parks (2012).

In order to reinforce the effectiveness of the communicative campaigns as well as behaviour change strategies, social messages concerning people's health can be very useful. Regarding the case example, Table 8 shows the results in terms of DALYs, in years and minutes per inhabitant, that is the time lost (and, therefore, theoretically gained) in conditions of disability, morbidity or deficit compared to the average life expectancy, calculated through the LCA procedure for the three different scenarios considered.

For Catania, there is a per capita ‘life-time recovery’ (with reference to 2014) of 58 min, and therefore almost an hour. It is clear that, the more paper and cardboard is source-separated from MSW (and then, the less paper and cardboard remains into the unsorted residual waste), the less the annual maximum recovery is. In practice, the citizen who collects more paper and cardboard is as if he/she began to gradually cash out the lifetime recovery, just like a prize for his/her virtuous behaviour. The same, as previously discussed, also applies to the economic counterpart.

Table 6
Potential economic saving for each citizen and hypothetical number of young environmental communicator positions at 15,000 Euro/capita/year for three different scenarios.

Cities	Per capita recovery (€/capita)			Number of young environmental communicator positions (Pos.)					
	Scen. 1	Scen. 2	Scen. 3	Scenario 1 (JC[a] + SC[b] = 10.6%)		Scenario 2 (JC[a] + SC[b] = 15%)		Scenario 3 (JC[a] + SC[b] = 20%)	
				Pos.	Inhab./Pos.	Pos.	Inhab./Pos.	Pos.	Inhab./Pos.
Bari	0	4	11	0	–	86	3807	241	1358
Foggia	7.5	12.5	18.1	76	2010	127	1203	185	826
Naples	6.1	11.8	18.2	401	2440	767	1276	1184	826
Caserta	4.8	10.7	17.4	24	3204	55	1398	89	864
Catanzaro	8.1	13.2	19.1	49	1854	80	1136	115	790
Palermo	11.3	16.9	23.3	512	1325	765	887	1053	644
Messina	8.9	14	19.8	143	1681	225	1069	317	758
Syracuse	11.9	17.6	24	97	1263	143	857	196	625
Ragusa	7.1	12.2	18	35	2087	59	1238	87	839
Catania	10.8	18	26.1	227	1390	378	835	550	574
Sciacca	10.6	16.7	23.6	29	1417	46	893	65	632
Sassari	0	3.7	9.7	0	–	32	3988	83	1538

[a] JC = paper and cardboard collected from households (‘joint collection’).
[b] SC = cardboard packaging waste collected from commercial (and similar) activities (‘selective collection’).

Table 7
Potential theoretical savings of carbon dioxide equivalent (in terms of Global Warming) obtainable with recycling and avoided landfilling of paper and cardboard present in the unsorted residual waste for three different scenarios.

Cities	ton CO_2 eq.			kg CO_2 eq./capita		
	Scenario 1[a]	Scenario 2[b]	Scenario 3[c]	Scenario 1[a]	Scenario 2[b]	Scenario 3[c]
Bari	0	3199	8900	0	10	27
Foggia	2819	4700	6837	18	31	45
Naples	14,820	28,388	43,806	15	29	45
Caserta	906	2025	3296	12	26	43
Catanzaro	1809	2960	4269	20	33	47
Palermo	18,936	28,309	38,961	28	42	57
Messina	5295	8315	11,745	22	35	49
Syracuse	3599	5306	7246	29	43	59
Ragusa	1284	2197	3234	18	30	44
Catania	8403	13,987	20,331	27	44	64
Sciacca	1075	1691	2392	26	41	58
Sassari	0	1172	3061	0	9	24

[a] Scenario 1: JC[d] + SC[e] = 10.6%
[b] Scenario 2: JC + SC = 15%.
[c] Scenario 3: JC + SC = 20%.
[d] JC = paper and cardboard collected from households (‘joint collection’).
[e] SC = cardboard packaging waste collected from commercial (and similar) activities (‘selective collection’).

This is a singular and innovative point of view, which could open a gap in the hearts and minds of citizens. Being rewarded with a few more minutes of life is not a common thing. Going beyond a punitive approach to those who do not respect the rules of separate collection, which is however important, has to be accompanied by a new and even morally approach: doing the separate collection well, should make people feel better. This perspective could overcome the classic economic reward approach (De Feo et al., 2017).

3.3. Economic-environmental indicators useful for communication purposes

The main aim of the methodological approach was to define easily understandable indicators that can be used in communications directed to the city (the whole community) and/or individual citizens to improve the efficacy of the MSW separate collection.

Table 8
DALY (Disability Adjusted Life Years), in years and minutes per inhabitant, that is the time lost (and, therefore, theoretically gained) in conditions of disability, morbidity or deficit compared to the average life expectancy, obtainable with recycling and avoided landfilling of paper and cardboard present in the unsorted residual waste for three different scenarios.

Cities	DALY (years)			min/capita		
	Scenario 1[a]	Scenario 2[b]	Scenario 3[c]	Scenario 1[a]	Scenario 2[b]	Scenario 3[c]
Bari	0.0	5.5	15.3	0	9	25
Foggia	4.8	8.1	11.8	17	28	40
Naples	25.5	48.8	75.4	14	26	41
Caserta	1.6	3.5	5.7	11	24	39
Catanzaro	3.1	5.1	7.3	18	29	43
Palermo	32.6	48.7	67.0	25	38	52
Messina	9.1	14.3	20.2	20	31	44
Syracuse	6.2	9.1	12.5	27	39	54
Ragusa	2.2	3.8	5.6	16	27	40
Catania	14.5	24.1	35.0	24	40	58
Sciacca	1.8	2.9	4.1	24	37	53
Sassari	0.0	2.0	5.3	0	8	22

[a] Scenario 1: JC[d] + SC[e] = 10.6%.
[b] Scenario 2: JC + SC = 15%.
[c] Scenario 3: JC + SC = 20%.
[d] JC = paper and cardboard collected from households (‘joint collection’).
[e] SC = cardboard packaging waste collected from commercial (and similar) activities (‘selective collection’).

Regarding the case example, Table 9 shows the values of the six economic-environmental indicators obtained with reference to the most optimistic scenario (Scenario 3) and considering only paper and cardboard. However, as explained in the methodological section, the indicators could be calculated for all the other MSW recyclable materials depending on the aim of the subsequent environmental campaign and/or available data.

The first three indicators are expressed in absolute values, and therefore refer to the whole community (they are also good for single-targeted messages); while, the second three indicators are normalized with respect to the number of inhabitants, and therefore refer to the individual citizen (but they are also good for messages addressed to the community). In order to increase the probability of success, it is important to speak to citizens considering them both as individuals and as social members.

In general, the economic-environmental indicators allow obtaining several combinations within communications that can follow a variety of channels:

- Road signs with posters;
- Within brochures to be distributed at training and awareness events organized by the recycling consortia (‘Comieco’ in the case example) and other subjects;
- In TV spots;
- In radio messages;
- Social network (Facebook, Twitter and Instagram) with the use of hashtag (thematic aggregator) containing: the name of the cities, the name of the recycling consortium (‘#Comieco’ in the case example), the name of the recyclable materials (‘#paper and #cardboard’ in the case example), #saving, #health, #carbondioxide, #greeneconomy, #greenjobs, etc.

Economic and health aspects allow to increase the communication efficacy as in the following message example developed for the city of Naples: ‘*Dear citizen of Naples*, *if you collected all your paper and paperboard which today is thrown away*, *you may save for your beautiful city something like 17,760,548 Euro*, *i.e. 18 Euro of saving for you*! *With your act*, *you would also avoid producing 45 kilograms of carbon dioxide and you might give yourself 41 minutes of good health*: *think about it*!’. Similar messages can be developed for any recyclable material and for any city.

In general, the main recipients of the communication actions must be schools, families, parishes, public offices, and business activities. The order is not random, since it is a ‘pyramid’ communication model with the schools at the basis of the communication building.

In particular, in the twelve cities considered as a case example, there are approximately 450,000 school age students (6–19 years), while 360,000 are college students. Summing up these two numbers, a potential student population of 810,000 people is obtained. The total population of the twelve cities is about 3,200,000. By making the ratio between the total population and the number of students, results a number close to four. Similar considerations can be developed in any other city or group of cities.

It is worth nothing that a student is part of a family, with parents, grandparents, and uncles, a number of people no less than four can be intercepted within each single family. This means that when we talk to a student, we are indirectly speaking to the whole population, if the communication is effective and invites students to communicate with their family members. For this purpose, a rap song has been written following the approach suggested by the Greenopoli method: it is the ‘*Unwrap unwrap rap*’ (‘*Scarta scarta rap*’ in Italian). The rap teaches students (and their family members) how to properly separate paper and cardboard by avoiding the mistakes commonly committed by putting objects in the paper collection that go elsewhere, such as cashouts, greaseproof paper, carbon paper, plasticized paper, which goes in undifferentiated garbage; while paper handkerchiefs and pizza cardboard

Table 9
Economic-environmental indicators that can be used in communications directed to the whole community and/or individual citizen.

Cities	Indicators for the whole community			Indicators for each single citizen		
	Indicator 1	Indicator 2	Indicator 3	Indicator 4	Indicator 5	Indicator 6
	ton/year	Euro/year	Green jobs	€/cap./year	$kgCO_2$/cap./year	min/cap./year
Bari	14,433	3,608,321	241	11	27	25
Foggia	11,088	2,772,028	185	18	45	40
Naples	71,042	17,760,548	1184	18	45	41
Caserta	5345	1,336,251	89	17	43	39
Catanzaro	6923	1,730,647	115	19	47	43
Palermo	63,184	15,795,886	1053	23	57	52
Messina	19,048	4,761,900	317	20	49	44
Syracuse	11,751	2,937,849	196	24	59	54
Ragusa	5244	1,311,064	87	18	44	40
Catania	32,972	8,243,046	550	26	64	58
Sciacca	3879	969,647	65	24	58	53
Sassari	4964	1,241,108	83	10	24	22

goes into the collection container for organic. Another important aspect is to invite people not to deposit paper inside plastic bags. Similar rap songs are available (and many others can be developed) for all the other recyclable materials.

Communication at school is indirectly communicating with all other targets. School is the starting point if we want to get a change of mindset. This assumption was conceived by the Greenopoli method that in three years of activity has allowed a single part-time volunteer to meet >30,000 students, with about 10,000 students per year. If a part-time communicator has been able to meet 10,000 students per year, what can 100 full-time communicators do? They would easily be able to meet 1,000,000 people.

Regarding the case example, by dividing 100 proportionally into the population of the cities considered, the number of communicators per city can be calculated: Naples, 30; Palermo, 21; Bari, 10; Catania, 10; Messina, 7; Foggia, 5; Sassari, 4; Siracusa, 4; Catanzaro, 3; Caserta, 2; Ragusa, 2; Sciacca, 1.

It is a daily experience to attend conferences and meetings with little public participation, often distracted and inattentive, with many people gazing at their smartphones. At school, on the other hand, people are there and usually listen. Until now, it was thought that environmental communication at school was only educational. We need to go to school to 'ask for a hand' for students to communicate with 'the world outside of school'. Children, boys and young people are 'naturally' willing to change. Adults are too overburdened on their own lives, their habits (which often become real prisons) to be open to change. Communicating with adults must be able to arouse emotions, turn on appeals, smile and reflect at the same time.

4. Conclusions

The study, through a methodological approach combining life cycle thinking and environmental communication, defined easily understandable indicators to use in communication campaigns organized to improve the efficacy of MSW separate collection. The indicators allow obtaining several combinations within communications that can follow a variety of channels. Three indicators are expressed in absolute values and therefore refer to the whole community. The other three indicators are normalized with respect to the number of inhabitants and therefore refer to the individual citizen.

Regarding the case study developed as an example application of the defined methodology, the following are the main numerical outcomes in relation to the six economic-environmental indicators:

- The maximum quantity of paper and cardboard recoverable from unsorted waste were around 71,000 tons and 63,200 tons for Naples and Palermo, respectively: these values would allow Naples and Palermo to recover more than €15 million.
- The maximum potential economic saving for each citizen was 25 €/capita and was obtained for Catania (it corresponds to around 58 Euro/family).
- The economic saving obtained for Naples and Palermo could be translated in more than one thousand positions as young environmental communicators.
- Catania was the city with the highest per capita potential saving of carbon dioxide equivalent, with >60 kg CO_2 eq./capita (around).
- For Catania, there was a maximum hypothetical per capita 'life-time recovery' of almost an hour.

In general, environmental communication campaigns should follow a pyramid approach with schools at the base. It is necessary to organize every communication campaign starting from schools where there are plenty of potential powerful communicators (i.e. the students) able to speak with all the other targets.

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