Improving efficacy of MSW separate collection with a communicative approach based on easily understandable indicators

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Abstract

The main aim of the study was to propose a methodological approach useful to define easily understandable indicators to use in communication campaigns organized to improve the efficacy of MSW separate collection. For this purpose, six economic-environmental indicators were defined combining life cycle thinking and environmental communication. The indicators allow obtaining 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 they refer to the whole community although 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 they refer to the individual citizen, but they can be used also for global messages. As an example case, the methodology was applied to the collection of paper and cardboard in twelve Southern Italy cities. The maximum quantity of paper and cardboard recoverable from unsorted waste would allow Naples and Palermo to recover more than 15 million of Euro. The maximum potential economic saving for each citizen was 25 €/capita (corresponding to around 60 Euro/family). The

economic saving obtained for Naples and Palermo could be translated in more than one thousand position as young environmental communicators. Catania was the city with both the highest per capita potential saving of carbon dioxide equivalent (more than 60 kg CO_2 eq./capita) and maximum hypothetical per capita 'life-time recovery' (almost an hour).

Keywords: Environmental communication; Greenopoli; Life cycle thinking; Paper and cardboard; Separate collection; Southern Italy

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 limited availability of virgin raw materials (De Feo and Polito, 2015). If citizens do not collect separately these materials, they produce both economic and environmental damages (Desa et al., 2011), but people (in their role of waste producers) are often unaware of the consequences of their actions (or inactions). Therefore, it is of fundamental importance the key role of waste management policies (WMPs).

WMPs include a range of complementary measures such as economic instruments (Van Beukering et al., 2009; Morlok et al., 2017). Usually, 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, nowadays 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).

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

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. In particular, as an example case, 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 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 environmental impacts of activities through the life cycle assessment (LCA), but also a way to comprehend and visualize a broader set of upstream and

80 downstream consequences of decisions, because it gives stakeholders a holistic view that they
81 otherwise may not have (Thabrew et al., 2009).
82 Kikuchi-Uehara et al. (2016a) showed that products with an ecolabel presenting a reduction rate
83 of carbon dioxide emissions were the most preferred option by the respondents to a web-based
84 survey conducted with Japanese adults. LCT-based information can be useful in improving
85 environmental awareness also in citizens with relatively low LCT skills (Kikuchi-Uehara et al.,
86 2016b). Even streamlined approaches can facilitate the introduction of LCT in the day-to-day
87 practice based on scientifically sound and robust results (Bala et al., 2010) as long as they are
88 easily understandable.
89 However, LCT approaches should be broadened from comparing alternatives and avoiding
90 negative impacts, to also proactively enhancing positive impacts, and towards the achievement
91 of sustainability goals (Sala et al., 2013). In fact, this is one of the aim of this study, which try to
92 combine LCT and EC in order to obtain practical results by defining indicators to use citizens'
93 levers in the sense described by Heiskanen (2002).
94
95 **1.2 Background information on environmental communication (EC)**
96
97 The contemporary world is characterised by an abundance of information. However, the
98 overload of information has not been able to solve all the environmental issues. In fact,
99 information by itself does not solve problems. Only information converted into meaningful
100 knowledge can be a resource useful to improve sustainability and environmental quality (EEA,
101 1999).
102 EC can be seen as a link process between sources and the recipients of understandable and
103 effective environmental information between various audiences using different communication
104 media, approaches, principles, strategies and techniques (Pillmann, 2002; Flor, 2004). EC is
105 usually connected with environmental education, public participation and environmental politics

106 (Pillmann, 2002).

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

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

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

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

2. METHODOLOGY

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. Six are the indicators defined and 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 Figure 1, a maximum number of forty-two

158 parameters could be calculated.

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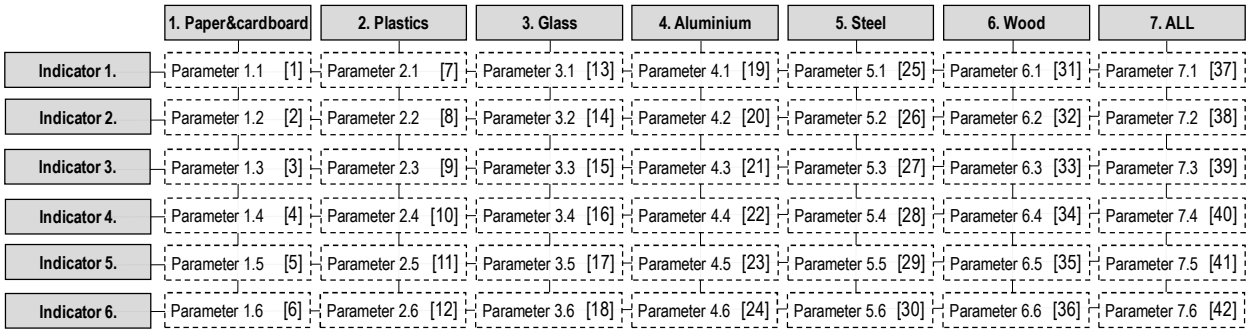

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162 **Figure 1.** All the possible parameters that can be calculated with the proposed procedure.

163

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

167

168 *2.1.1. Indicator 1: Quantity of recyclable materials*

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

172 Usually, the following information are known: 1) total quantity of MSW produced in a year in
173 the city under study; 2) quantities of recyclable materials separately collected from MSW in a
174 year; 3) total quantity of unsorted residual waste produced in a year.

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

179 If a composition analysis of the unsorted residual waste is not available, it will be necessary to

180 have a composition analysis, or an estimation of it, of the whole MSW. In fact, in this case,
181 Indicator 1 for a specific material can be calculated as a difference. First, it has to be calculated
182 the total quantity of each single material multiplying the related percentage for the total
183 production of MSW. Indicator 1 will be obtained subtracting the quantity of that material
184 separately collected from the total quantity of the same material. Obviously, also in this case,
185 Indicator 1 for all recyclable materials (Parameter 7.1) will be obtained simply summing the
186 values of Indicator 1 obtained for each single material (Parameters 1.1; 2.1; 3.1; 4.1; 5.1; 6.1 in
187 Figure 1).
188
189 *2.1.2. Indicator 2: Total potential economic saving*
190 Indicator 2 refers to the total potential economic saving for a specific recyclable material or all
191 recyclable materials recoverable from unsorted residual waste. Its unit of measure is Euro/year.
192 For each single material, Indicator 2 is obtained multiplying Indicator 1 (ton/year) for the sum of
193 the specific average EPR contribution and the saving for avoided disposal in landfill (Euro/ton).
194 Usually, the EPR contribution given to the municipality depends on the specific typology of
195 material as well as the level of impurity in the sense that the less discards are, the more the
196 recognized economic contribution is.
197 The purpose of this indicator is to communicate to all the citizens of the city under study the
198 economic value of the 'urban mining' presents in the unsorted residual waste and that they waste
199 into a landfill with a wrong or absent source separation of MSW. In fact, it is commonly
200 accepted that money is able to change people's motivation (mainly for the better) and their
201 behaviour (Vohs et al., 2006).
202 Indicator 2 for all recyclable materials (Parameter 7.2) will be obtained simply summing the
203 values of Indicator 2 obtained for each single material (Parameters 1.2; 2.2; 3.2; 4.2; 5.2; 6.2 in
204 Figure 1).
205

206

207 *2.1.3. Indicator 3: Number of jobs for young people as communicators*

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

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

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

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

219

220

221 *2.1.4. Indicator 4: Potential economic saving for each citizen*

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

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

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

231 Indicator 4 for all recyclable materials (Parameter 7.4) will be obtained 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 Figure 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). Indeed, Cifrian et al. (2013) suggested the use of the carbon footprint indicator because it complements individual waste management indicators and would be useful to support decision making and policy analysis.

Indeed, Indicator 5 refers to the per capita saving of carbon dioxide equivalent (in a global warming perspective) for a specific recyclable material or all recyclable materials recoverable from 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. In fact, LCA permits 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 et al., 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 MBT 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 unsorted residual waste, i.e. Indicator 1, sent to recycling and not disposed.

Treatment and disposal stages have to be considered, while 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 impacts but 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 recyclable materials (Parameter 7.5) will be obtained 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 Figure 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 recyclable materials recoverable from 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 about time frame and other issues. ReCiPe includes both midpoint (problem oriented) and endpoint (damage oriented) impact categories. In particular, 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. In particular, Indicator 6 is related to the endpoint damage category Human Health, expressed as the number of year 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 recyclable material (Parameter 7.6) will be obtained 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 Figure 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). For instance, in terms of paper and cardboard, which are the materials considered in the case study developed, it is strategic the role of Comieco, 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 prevention and development of separate collection. Upon agreement with Conai, Comieco operates the collection, recycling, and recovery of paper and cardboard packaging and of the

paper and cardboard collected separately at municipal level.

In 2015, each Italian collected 51.5 kg of paper and cardboard. The performance of citizens in Centre and Northern Italy were quite similar with a per capita collection of around 62 kg per year. People in Southern Italy collected lesser quantity of 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.

Twelve were the Southern Italy cities 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 with regarding to the year 2014, when the percentage incidence of paper and cardboard on the total source separation in Italy was 10.6%.

Table 1.

Demographic characteristics of the twelve Southern Italy cities considered in the study as an example case (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	2,788.67	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	8,309.49	41.70	26.50	78.50	83.30
Caserta		76,887	1,442.00	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	4,224.93	42.00	19.10	79.50	83.80
Catania		315,601	1,725.54	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	1,890.72	42.98	19.49	79.53	84.09
Italy		60,665,551	200.80	43.90	12.40	80.30	85.00
Difference		-	+842%	-2.1%	+57.2%	-1.0%	-1.1%

Comparison with the national average shows above all the gap with the rest of the country with 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 unique (in 2014) with a house-to-house kerbside collection system. In fact, the other 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 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 unique city with a performance even better of Northern Italy cities, namely around 63 kg/capita/year. Naples was

perfectly in line with the data of Southern Italy. Finally, it is worth to mention the good performance of Sassari with a performance better of the average national data (around 52 kg/capita/year).

Paper and cardboard can be collected with regarding 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).

Table 2.

Absolute data about the collection of MSW and paper and cardboard in the twelve Southern Italy cities considered in the study as an example case – 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	1,079	1,698	2,777	61
Naples	500,086	511.1	22.02	14,665	14,310	28,975	49
Caserta	41,23	536.2	48.53	2,181	720	2,901	25
Catanzaro	42,433	467.1	6.8	622	942	1,564	60
Messina	111,278	462.9	7.59	1,042	2,166	3,208	68
Palermo	345,468	509.2	8.29	3,861	2,049	5,910	35
Catania	205,791	652.1	9.29	3,837	4,349	8,186	53
Syracuse	62,922	513.6	4.71	636	197	833	24
Ragusa	33,631	460.5	17.19	619	863	1,482	58

Sciacca	22,713	552.9	17.35	-	-	664	-
Sassari	61,262	480.0	42.92	4,874	2,441	7,288	33
Average	140,086	513.7	18.2	4,033.0	3,757.6	7,194.5	47.1

[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 an example case – 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

[a] JC = paper and cardboard collected from households ('joint collection')

[b] SC = cardboard packaging waste collected from commercial (and similar) activities ('selective collection)

On the average, during 2014, in Italy, the total quantity of paper and cardboard collected separately weighted on the total MSW for 10.6%. As shown in Table 3, only Bari and Sassari had a percentage incidence greater of 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 base 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/t and a saving for avoided disposal in landfill of 175 Euro/t, for a total economic saving of 250 Euro/t 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

394 collection services and disposal.
395 In order to calculate the hypothetical number of young environmental communicator positions a
396 remuneration of 15,000 Euro/capita/year was assumed.
397 The LCA was performed using the SimaPro 8 software tool (PRé Consultants, Amersfoort, The
398 Netherlands), using the Ecoinvent v.3.3 database. The developed case study has to be considered
399 as a simple example of application of the methodological procedure proposed. Therefore, only
400 treatment and disposal stages were considered. Landfilling was be the disposal process
401 considered for the fraction of paper and cardboard in unsorted waste. Regarding the modelling of
402 the waste treatment processes, all inventory data used for the modelling of landfilling and
403 recycling process of paper and carboard are available in De Feo at al. (2016). The datasets of
404 Ecoinvent database are not perfectly representative for the situation under analysis, but, as
405 already written, this was not the aim of the developed case study.
406
407
408 **2.3 The communicative approach adopted**
409
410 The communicative approach adopted is named 'Greenopoli'.
411 Greenopoli is a website (www.greenopoli.it), a Facebook page, and, mainly, a teaching method
412 as well as an environmental educational program, which from December 2014 up to December
413 2017 has involved more than 200 schools and around 30,000 students in Southern Italy. An
414 image search on any Internet search engine by typing the word 'Greenopoli' can give an idea of
415 the communicative impact of the method. Two are its main key words: sharing and
416 sustainability. Sustainability ('*Sostenibilità'* in Italian), Environment ('*Ambiente'* in Italian),
417 Waste ('*Rifiuti'* in Italian) and Water ('*Acqua'* in Italian) are some of the main topics of the
418 environmental educational program 'Greenopoli'. 'Sara', one of the protagonists of Greenopoli,
419 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 necessarily have to take care of it if we want to survive on the planet Earth. We have to change the way that we usually use to look at those that we continue to call 'waste': they are materials at one end of their life cycle and that 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's 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 (Figure 2).

(a) (b) (c) (d)

Figure 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) Giovanni De

436 Feo with primary school students; (b) Giovanni De Feo with the Councillor of the Environment
437 of Bari, Pietro Petruzzelli; (c) Pasquale Parente and Valentina Iannone with primary school
438 students; (d) Valentina Iannone in the role of the character 'Comieco Vale' while sings the rap
439 songs of Greenopoli.
440
441
442 In terms of waste, Greenopoli proposes a new classification of waste, taking into account the life
443 cycle thinking approach and the concept of usefulness as previously described in De Feo and
444 Napoli (2005). The basic idea is that those we call 'waste' are mainly materials that have
445 momentarily 'exhausted' their function becoming a sort of 'exhausted materials'. In the light of
446 this consideration, on the base of their origin, we could have Normal Exhausted Materials
447 (NEM), corresponding to the Municipal Solid Waste (MSW), and Special Exhausted Materials
448 (SEM), mainly corresponding to the industrial, agricultural, demolition and construction waste,
449 etc. Definitively, taking into account the concept of hazard, there will be four kind of exhausted
450 materials: Non Hazardous NEM, Hazardous NEM, Non Hazardous SEM, Hazardous SEM (De
451 Feo, 2008).
452
453
454 **3. RESULTS AND DISCUSSION**
455
456 Table 4 shows the maximum theoretically amounts of paper and cardboard that can be further
457 intercepted from the unsorted residual municipal waste of the twelve Southern Italy cities taken
458 into consideration, for each of the three scenarios considered. The values contained in Table 4
459 are the basis for the further calculations reported and discussed in the following sections.
460
461 **Table 4.**

462 Maximum theoretically amounts of paper and cardboard that can be further intercepted from the
463 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	5,188	14,433
Foggia	69,326	2,777	4.0	4,572	7,622	11,088
Naples	500,086	28,975	5.8	24,034	46,038	71,042
Caserta	41,230	2,901	7.0	1,469	3,284	5,345
Catanzaro	42,433	1,564	3.7	2,934	4,801	6,923
Palermo	345,468	5,910	1.7	30,710	45,910	63,184
Messina	111,278	3,208	2.9	8,587	13,484	19,048
Syracuse	62,922	833	1.3	5,837	8,605	11,751
Ragusa	33,631	1,482	4.4	2,083	3,563	5,244
Catania	205,791	8,186	4.0	13,628	22,683	32,972
Sciacca	22,713	664	2.9	1,744	2,743	3,879
Sassari	61,262	7,288	11.9	0.00	1,901	4,964

464 [a] JC = paper and cardboard collected from households ('joint collection')
465 [b] SC = cardboard packaging waste collected from commercial (and similar) activities ('selective
466 collection)
467
468
469 As it can be noted, in Scenario 1, there are not further possible recoveries for Bari and Sassari,
470 because this scenario considers a total recovery equal to the national average value (10.6%),
471 while these cities recovered an amount of paper and cardboard around 12% of MSW.
472

3.1 Socio-economic results

Table 5 shows the economic recovery obtainable for the cities under study with paper and cardboard theoretically present in the unsorted residual waste.

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/t and a saving for avoided disposal in landfill of 175 Euro/t).

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)

The maximum hypothetical economic recovery for Naples and Palermo breaks the threshold of 15 million of Euro, 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.

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.

Particularly significant are the values related to Scenario 3, which involves 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 less than 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.

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.

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)

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. Following is Catania with 550. Bari and Messina are in the 200-400 range. All 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.

The citizens' participation 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 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).

3.2 Environmental results

Particularly significant are the per capita equivalent carbon dioxide equivalent data shown in Table 7. Catania is the city with the highest per capita potential saving of carbon dioxide equivalent, with more than 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 from the economic and environmental benefits of a more virtuous and correct approach to separate collection of paper and cardboard.

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	2,819	4,700	6,837	18	31	45
Naples	14,820	28,388	43,806	15	29	45
Caserta	906	2,025	3,296	12	26	43
Catanzaro	1,809	2,960	4,269	20	33	47
Palermo	18,936	28,309	38,961	28	42	57
Messina	5,295	8,315	11,745	22	35	49
Syracuse	3,599	5,306	7,246	29	43	59
Ragusa	1,284	2,197	3,234	18	30	44
Catania	8,403	13,987	20,331	27	44	64
Sciacca	1,075	1,691	2,392	26	41	58
Sassari	0	1,172	3,061	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)

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

562 compared to average life expectancy, calculated through the LCA procedure for the three
563 different scenarios considered.
564
565 **Table 8.**
566 DALY (Disability Adjusted Life Years), in years and minutes per inhabitant, that is the time lost
567 (and, therefore, theoretically gained) in conditions of disability, morbidity or deficit compared to
568 average life expectancy, obtainable with recycling and avoided landfilling of paper and
569 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

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

For Catania there is a per capita 'life-time recovery' (with reference to 2014) of 58 minutes, 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 as a prize for his/her virtuous behaviour. The same, as previously discussed, also applies to the economic counterpart. Definitely, 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 well the separate collection should make people feel better.

3.3 Economic-environmental indicators useful for communication purposes

Table 9 shows the values of the six economic-environmental indicators that can be used in communications directed to the city (the whole community) and/or individual citizen, obtained with reference to the most optimistic scenario (Scenario 3).

The first three indicators are expressed in absolute value, and therefore they refer to the whole community (although they are also good for single-targeted messages); while, the second three indicators, however, are normalized with respect to the number of inhabitants, and therefore they refer to the individual citizen (but they are also good for messages addressed to the community).

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	5,345	1,336,251	89	17	43	39
Catanzaro	6,923	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	5,244	1,311,064	87	18	44	40
Catania	32,972	8,243,046	550	26	64	58
Sciacca	3,879	969,647	65	24	58	53
Sassari	4,964	1,241,108	83	10	24	22

The six 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 events organized by Comieco and other subjects;
- In TV spots;
- In radio messages;

- Social network (Facebook and Twitter) with the use of hashtag (thematic aggregator) containing: the name of the cities (#Bari, #Foggia, #Napoli, #Caserta, #Catanzaro, #Palermo, #Messina, #Syracuse, #Ragusa, #Catania, #Sciacca, #Sassari), #Comieco, #paper and #cardboard, #saving, #health, #carbondioxide, #greeneconomy, #greenjobs, etc.

Economic and health aspects (very popular in Southern Italy) allow increasing the communication efficacy as in the following message example developed for the city of Naples: '*Dear citizen of Naples, if you collected all paper and paperboard which today is thrown, 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*!

Considering the social structure of the cities studied, 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.

There are approximately 450,000 school age students (6-19 years) in the twelve cities considered in the study, 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, it comes out a number close to four. It is worth nothing that, a student is part of a family, with parents, grandparents, and uncles, a number of people not 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: 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 goes into the collection container for organic. Another important aspect is to invite people not to deposit paper inside plastic bags.

Therefore, doing 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 more than 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.

By dividing 100 proportionally to 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 with a gaze on their smartphone. At school, on the other hand, people are there and usually they listen. Until now, it was thought that environmental communication at school was only educational. Instead, we need to go to school to ‘ask for a hand’ for students to communicate with ‘the world out of school’. Children, boys and young people are ‘naturally’ willing to change. Adults are too overlaid on their own, 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. For this reason, it is necessary to start from school and university: in the twelve cities considered in the study there are 800,000 potential communicators.

4. CONCLUSIONS

663 The main aim of the study was to propose a methodological approach useful to define easily
664 understandable indicators to use in communication campaigns organized to improve the efficacy
665 of MSW separate collection. For this purpose, six economic-environmental indicators were
666 defined combining life cycle thinking and environmental communication. The indicators allow
667 obtaining several combinations within communications that can follow a variety of channels.
668 Three indicators are expressed in absolute value and therefore they refer to the whole community
669 although they are also good for single-targeted messages. The other three indicators are
670 normalized with respect to the number of inhabitants and therefore they refer to the individual
671 citizen, but they can be used also for global messages.
672 With regarding the case study developed as an example application of the defined methodology,
673 the following are the main numerical outcomes with regarding the six economic-environmental
674 indicators developed combining life cycle thinking and environmental communication:
675 • The maximum quantity of paper and cardboard recoverable from unsorted waste were around
676 71,000 tons and 63,200 tons for Naples and Palermo, respectively: these values would allow
677 Naples and Palermo to recover more than 15 million of Euro.
678 • The maximum potential economic saving for each citizen was 25 €/capita and it was obtained
679 for Catania (it corresponds to around 58 Euro/family).
680 • The economic saving obtained for Naples and Palermo could be translated in more than one
681 thousand position as young environmental communicators.
682 • Catania was the city with the highest per capita potential saving of carbon dioxide equivalent,
683 with more than 60 kg CO_2 eq./capita (around).
684 • For Catania there was a maximum hypothetical per capita 'life-time recovery' of almost an
685 hour.
686 Considering the social structure of the cities studied, the environmental communication
687 campaign should follow a pyramid approach with schools at the base. In the cities studied, the
688 new communication approach Greenopoli is beginning to be very promising.

AKNOWLEDGEMENTS

The authors wish to thank Comieco (Italian Consortium for the Recovery and Recycling of Paper and Board Packaging) for having supported this study.

REFERENCES

Bala, A., Raugei, M., Benveniste, G., Gazulla, C., Fullana-i-Palmer, P., 2008. Simplified tools for global warming potential evaluation: when 'good enough' is best. Int. J. Life Cycle Assess. 15(5), 489-498.

Bucholtz, I., 2017. Environmental Communication in Latvian Municipal Newsletters, Environment. Technology. Resources, Rezekne, Latvia. Proceedings of the 11th International Scientific and Practical Conference. June 15-17, 2017, Rezekne Academy of Technologies, Rezekne, Latvia, Volume I, 46-50.

Carvalho, A. 2009. Communication for sustainable policy: connecting science, society and government. Science for Environment Policy 17, 1-8.

Cifrian, E., Andres, A., Viguri, J.R., 2013. Estimating Monitoring Indicators and the Carbon Footprint of Municipal Solid Waste Management in the Region of Cantabria, Northern Spain. Waste Biomass Valori. 4(2), 271-285.

Comieco, 2015. Raccolta, Riciclo e Recupero di carta e cartone 2014 - 20° Rapporto (Collection, Recycling and Recovery of paper and cardboard 2014 – 20th Report), <http://comieco.media.mweb.pro/allegati/2015/7/xx-rapporto-comieco_147608.pdf>, (Retrieved 16/08/ 2017) (In Italian).

715 Cooper, T. 2005. Slower Consumption Reflections on Product Life Spans and the "Throwaway
716 Society", J. Ind. Ecol. 9(1-2), 51-67.
717 Cote, S., Wolfe, S.E., 2017. Evidence of mortality salience and psychological defenses in bottled
718 water campaigns, Applied Environmental Education and Communication, 1-18,
719 <https://doi.org/10.1080/1533015X.2017.1399836> (Retrieved 05/01/2018).
720 Cozen, B., Endres, D., Peterson, T.R., Horton, C., Barnett, J.T., 2017. Energy Communication:
721 Theory and Praxis Towards a Sustainable Energy Future. Environmental Communication, 1-
722 6, <https://doi.org/10.1080/17524032.2017.1398176> (Retrieved 05/01/2018).
723 Curran, M.A., 2008. Life cycle assessment, Encyclopaedia Ecology 3, 2168-2174.
724 De Feo, G., 2008. Fenomeni di Inquinamento e Controllo della Qualità Ambientale (Pollution
725 phenomena and control of the environmental quality), Editor Aracne, Rome, Italy, ISBN
726 9788854817128 (In Italian).
727 De Feo, G., 2014. Il Metodo Greenopoli (The method Greenopoli), Editor Il Papavero,
728 Manocalzati (Av), Italy, ISBN 9788898987139 (In Italian).
729 De Feo, G., Ferrara, C., Iuliano, C., Grosso, A., 2016. LCA of the Collection, Transportation,
730 Treatment and Disposal of Source Separated Municipal Waste: A Southern Italy Case
731 Study. Sustainability 8, 1084.
732 De Feo, G., Napoli, R.M.A., 2005. New and old paradigms on the production and management
733 of municipal solid waste, Proceedings of the Tenth International Waste Management and
734 Landfill Symposium, S. Margherita di Pula, CISA publisher, Cagliari, Sardinia, Italy, 3-7
735 October 2005.
736 De Feo, G., Polito, A., 2015. Using economic benefits for recycling in a separate collection
737 centre managed as a 'reverse supermarket': A sociological survey, Waste Manage. 38: 12-
738 21.
739 Desa, A., Kadir, N.B.A., Yusooff, F., 2011. A study on the Knowledge, Attitudes, Awareness
740 Status and Behaviour Concerning Solid Waste Management. Procedia – Social and

741 Behavioral Sciences 18, 643-648.
742 Dubois, M., Eyckmans, J., 2015. Efficient Waste Management Policies and Strategic Behavior
743 with Open Borders. Environ. Resour. Econ. 62(4), 907-923.
744 EEA, 1999. A new model of environmental communication for Europe from consumption to use
745 of information, European Environment Agency Environmental issue report No 13,
746 <https://www.eea.europa.eu/publications/92-9167-125-8/at_download/file> (Retrieved
747 05/01/2018).
748 Ferreira da Cruz, N., Ferreira, S., Cabral, M., Simões, P., Cunha Marques, R., 2014. Packaging
749 waste recycling in Europe: Is the industry paying for it? Waste Manage. 34, 298-308.
750 Ferreira, S., Cabral, M., da Cruz, N.F., Simões, P., Marques, R.C., 2017. The costs and benefits
751 of packaging waste management systems in Europe: the perspective of local authorities. J.
752 Environ. Plann. Man. 60(5), 773-791.
753 Flor, A.G., 2004. Environmental Communication: Principles, Approaches and Strategies of
754 Communication Applied to Environmental Management, UP Open University, Quezon City,
755 Philippines.
756 Fricke, K., Bahr, T., Bidlingmaier, W., Springer, C., 2011. Energy efficiency of substance and
757 energy recovery of selected waste fractions, Waste Manage. 31, 644-648.
758 Harris, U.S., 2017. Engaging communities in environmental communication. Pacific Journalism
759 Review 23(1), 65-79.
760 Haupt, M., Vadenbo, C., Hellweg, S. 2017. Do We Have the Right Performance Indicators for
761 the Circular Economy? Insight into the Swiss Waste Management System. J. Ind. Ecol.
762 21(3), 615-627.
763 Heiskanen, E., 2002. The institutional logic of life cycle thinking. J. Clean. Prod. 10, 427-437.
764 Hoewe, J., Ahern, L., 2017. First-Person Effects of Emotional and Informational Messages in
765 Strategic Environmental Communications Campaigns. Environ. Commun. 11(6), 810-820.
766 Huijbregts, M.A.J., Steinmann, Z.J.N., Elshout, P.M.F., Stam, G., Verones, F., Vieira, M.D.M.,

767 Hollander, A., Zijp, M., van Zelm, R., 2016. ReCiPe 2016. A harmonized life cycle impact
768 assessment method at midpoint and endpoint level. Report I: Characterization.
769 <http://www.rivm.nl/dsresource?objectid=b0c868fc-15af-4700-94cf-
770 e0fd4c19860e&type=pdf&disposition=inline> (Retrieved 14/08/2018).
771 Intergovernmental Panel on Climate Change. 2013. IPCC Fifth Assessment Report. The Physical
772 Science Basis. <http://www.ipcc.ch/report/ar5/wg1/> (Retrieved 14/08/2018).
773 Ispra, 2015. Rapporto Rifiuti Urbani – Edizione 2015 (Municipal Solid Waste Report – Edition
774 2015), <http://www.isprambiente.gov.it/files/pubblicazioni/rapporti/rifiuti-urbani-
775 2015/RapportoRifiutiUrbani_Ed.2015n.230_Vers.Integrale_agg22_12_2015.pdf>
776 (Retrieved 16/08/2017) (In Italian).
777 ISWA, 2016. Environmental communication strategy for municipal solid waste management in
778 Sao Paulo, Brazil,
779 <http://www.waste.ccacoalition.org/file/2443/download?token=wnnrr1Om> (Retrieved
780 05/01/2018).
781 Jiang, H., Kim, J.-N., Liu, B., Luo, Y., 2017. The Impact of Perceptual and Situational Factors
782 on Environmental Communication: A Study of Citizen Engagement in China, Environ.
783 Commun., 1-21, <https://doi.org/10.1080/17524032.2017.1346517> (Retrieved
784 05/01/2018).
785 Kikuchi-Uehara, E., Nakatani, J., Hirao, M., 2016a. Analysis of factors influencing consumers'
786 proenvironmental behavior based on life cycle thinking. Part I: effect of environmental
787 awareness and trust in environmental information on product choice. J. Clean. Prod. 117,
788 10-18.
789 Kikuchi-Uehara, E., Nakatani, J., Hirao, M., 2016b. Analysis of factors influencing consumers'
790 proenvironmental behavior based on life cycle thinking. Part II: trust model of
791 environmental information. J. Cleaner Prod. 125, 216-226.
792 Massarutto, A., 2014. The long and winding road to resource efficiency – An interdisciplinary

perspective on extended producer responsibility. Resour. Conserv. and Recy. 85, 11-21.

Morlok, J., Schoenberger, H., Styles, D., Galvez-Martos, J.L., Zeschmar-Lahl, B., 2017. The Impact of Pay-As-You-Throw Schemes on Municipal Solid Waste Management: The Exemplar Case of the County of Aschaffenburg, Germany. Resources 6, 8, doi:10.3390/resources6010008.

Pillmann, W., 2002. Environmental communication: Systems analysis of environmentally related information flows as a basis for the popularization of the framework for sustainable development, <http://enviroinfo.isep.at/UI%20200/PillmannW270700.el.ath.pdf> (Retrieved 05/01/2018).

Publicover, J.L., Wright, T.S., Baur, S., Duinker, P.N., 2017. Music as a tool for environmental education and advocacy: artistic perspectives from musicians of the Playlist for the Planet. Environ. Educ. Res. 1-12, <https://doi.org/10.1080/13504622.2017.1365356> (Retrieved 05/01/2018).

Rigamonti, L., Ferreira, S., Grosso, M., Cunha Marques, R., 2015. Economic-financial analysis of the Italian packaging waste, Management system from a local authority's perspective, J. Clean. Prod. 87, 533-541.

Sala, S., Farioli, F., Zamagni, A., 2013. Progress in sustainability science: lessons learnt from current methodologies for sustainability assessment: Part 1. Int. J. Life. Cycle Assess. 18(9), 1653-1672.

Scheinberg, A., Nesic, J., Savain, R., Luppi, P., Sinnott, P., Petean, F., Pop, F., 2016. From collision to collaboration - Integrating informal recyclers and re-use operators in Europe: A review(Review). Waste Manage. Res. 34(9), 820-839.

Thabrew, L., Wiek, A., Ries, R., 2009. Environmental decision making in multi-stakeholder contexts: applicability of life cycle thinking in development planning and implementation. J. Clean. Prod. 17, 67-76.

UNEP-SETAC Life Cycle Initiative, 2017. What Is Life Cycle Thinking?

819 <http://www.lifecycleinitiative.org/starting-life-cycle-thinking/what-is-life-cycle-thinking/>
820 (Retrieved 05/01/2018).
821 Van Beukering, P.J.H., Bartelings, H., Linderhof, V.G.M., Oosterhuis, F.H. 2009. Effectiveness
822 of unit-based pricing of waste in the Netherlands: Applying a general equilibrium model.
823 Waste Manage. 29, 2892-2901.
824 Vohs, K.D., Mead, N.L., Goode, M.R. (2006). The psychological consequences of money.
825 Science, 314, 1154-1156.
826 Wagner, T.P., 2013. Examining the concept of convenient collection: An application to extended
827 producer responsibility and product stewardship frameworks, Waste Manage. 33, 499-507.