

# SUSTAINABLE DEVELOPMENT GOALS AND CIRCULAR ECONOMY RELATIONSHIP ROLES IN EDUCATION AND INDUSTRY FOR WASTE COLLECTION IMPLEMENTATION

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## ABSTRACT

Interest on circular economy (CE) is growing from many points of view. After discussing its relationship with the Sustainable Development Goals (SDGs), this article focuses on the role played in this frame by waste collection and specifically by education and industry. The importance of source separation emerged from the analysis. This is not limited to municipal solid waste only as special waste management can contribute to the circularity of the products.

*Keywords: circular economy, education, industry, municipal solid waste, sustainable development goals.*

## 1 INTRODUCTION

In the last decade the knowledge regarding the earth pollution (air, water, soil) and the possibility in the future to remain without many materials that are needed for future human development brought attention to the necessity to inform the citizen since the early years. In 2000 the Millenium Development Goals (MDGs) were issued by the United Nation (UN) Agency to support a restart after the financial crisis, to decrease the level of poverty in the World, to increase the population health and the possibility to make education affordable for all, under a sustainable environment before 2015. In 2014 after a check of the level of achievements regarding the eight goals from the MDGs, the UN General Assembly Open Working Group proposed to implement a new Agenda for 2030: Sustainable Development Goals (SDGs) with 17 goals at international level suitable for all the countries to sustain a better human life on the planet at all levels [1]–[3]. In 2021, to be in agreement with the EU Climate Law that asks to reach carbon neutrality by 2050, a new package was issued, named FIT for 55. The aim is to help the implementation and achievements of the targets from the European Green Deal (EGD) launched in 2019, under an economic growth and assuring the principle of *No One Left Behind* [4]–[6]. The EU is preparing a second EGD (II EGD) for an equitable sustainability transition for the benefit of all [7].

All these laws and packages are useful and important to be implemented and their target to be achieved but for that it is very important that all the citizens of all ages are prepared and understand them and the need to comply with them for reaching a sustainable future for all. To achieve this, an environmental knowledge is necessary from the early stages and not only at university level [8]–[15]. Generally, the scientific research gave more attention to the Circular Economy (CE) at university level [16]–[26]. However, in the last decade CE and citizens knowledge at different ages has been developed because of its connection to day-to-day activities and products: clothes, municipal solid waste, energy, etc. [27]–[34].

At industrial level, the introduction of the concepts from EGD, CE, SDGs change from a country to another because of different legislations and limits. Generally, their introduction is more related with the economic part and less with the environmental one.



The present article focusses on an issue that deals with both education and industry as well as waste collection, in the framework of CE and SDGs. Indeed, waste collection is a key aspect for organising the streams of materials that is at the base of their circular valorisation with visible effects on the environment.

## 2 MATERIALS AND METHODS

The Scopus® database is a useful tool to analyse the relevance of a topic in the international scientific literature. For that reason, an analysis of its contents towards specific subjects was made as a first step of the present article. The used keywords were CE, SDGs, education, industry, waste collection.

The second step concerned a conceptual analysis of the relationship between CE and SDGs.

The third step was an analysis of the role of waste collection as a linking aspect in two strategic sectors (education and industry), in the frame of CE and the related SDGs.

## 3 RESULTS AND DISCUSSION

### 3.1 Scopus analysis

The analysis started from the papers published in the Scopus® database using the keywords reported in Table 1.

Table 1: Scopus analysis results (August 2024).

<b>Keywords</b>	<b>Number of documents</b>
SDGs	5445
Circular economy	21647
SDGs and Circular economy	121
SDGs and Education	626
Circular economy and Education	306
SDGs and Circular economy and Education	2
SDGs and Circular economy and Industry	15
Waste collection	6128
Waste collection and SDGs	6
Waste collection and Circular economy	68
Waste collection and Education	43
Waste collection and Industry	77
Waste collection and Municipal waste	623
Waste collection and Waste	2166

The data in Table 1 opens a few comments:

- Despite being clearly visible in Scopus® database, SDGs and CE are not often presented together in the scientific articles;
- The links between SDGs and education and CE and education are visible in Scopus but the cross references are very limited;
- Despite being at the base of (waste) material flows valorisation, waste collection is not often presented as keyword together either with SDGs or with CE;



- The fact that the articles dealing with ‘waste collection’ and ‘waste’ have a significant presence could depend on the prevalence of a technical vision of the problem that ‘forgets’ the role of the overall strategies in waste management (specifically, the case of lack of an explicit CE vision in the articles on waste collection is an anomaly depending on a mostly vertical approach on the topic).

### 3.2 CE and SDGs

The 17 SDGs and the relationships with CE are presented in Table 1, where the vision emerged in Rodriguez-Anton et al. [35] is reported in the third column whilst the results of the revised/integrated vision emerged from the analysis of the present article is available in the last column. Rodriguez-Anton et al. [35] was chosen because of its scientific approach in the cross analysis. As can be seen, the links between CE and SDGs are multiple, but the vision in the sector is not homogeneous.

From Table 2, a few differences emerged from the two points of view, e.g., quality education must be considered a key aspect in CE implementation; sanitation can have some technical options open to material recovery from waste; some forms of energy generation can have a link to ash recovery.

### 3.3 Waste collection in CE and SDGs

In this section some considerations on waste collection towards SDGs firstly and CE secondly are presented in Tables 3 and 4. Some key aspects are reported in italics.

What is clear from Table 3 is the significant role of waste collection in supporting the SDGs. Indeed, waste collection, e.g.,

- Prevents problem of health (water, soil, air) avoiding waste dispersion (also referred to sanitation issues) – SDGs 2, 3 and 6
- Waste selective collection is a direct experience of environmental management based also on educational concepts – SDG 4
- Needs an adequate organisation to protect the workers involved – SDG 8
- Can be enhanced thanks to innovative solutions – SDG 9
- Is an opportunity to offer to all the citizen the same environmental protection – SDG 10
- Can be organised smartly in smart and sustainable cities – SDG 11
- Supports circularity in case of SC (responsible consumption) – SDG 12
- Allows implementing low CO<sub>2</sub> options and environmental footprints decrease in case of food waste collection and biological treatment (diverting waste from landfill) – SDG 13
- Waste selective collection is a direct connected with the decrease of marine and land pollution – SDGs 14 and 15.

Table 4 is dedicated to waste collection and CE, underlying the crucial role of selective collection (SC).

Table 4 refers to municipal solid waste as special waste which opens to a huge variety of cases. Plastic packaging is presently the object of international attention because of the dispersion of plastic into the oceans. Some international projects are oriented to a better sensibilisation to the criticalities, e.g., the project EDU4Plastic – Education for Plastic in a Circular and Climate Neutral Economy – Preventing Waste Ending Up into the Environment and Pro-Pla – Protein from Plastic [35], [36]. More in general plastic is a tricky issue that must be faced with also in term of microplastic management [37], [38].



Table 2: Relationships between SDGs and CE.

SDG number and name	CE relationship [35]	SDGs and CE
1. No poverty	–	<b>Partially related thanks to</b>
		Job creation
		Economic stability
		Resource efficiency
		Environmental benefits thanks to pollution reduction
		Innovation and inclusivity
2. Zero hunger	Related	<b>Related thanks to</b>
		Food waste reduction
		Sustainable agriculture
		Local food system
		Nutrient recycling
		Resource efficiency.
3. Good health and well-being	Related	<b>Related thanks to</b>
		Pollution reduction: waste, water, soil, air
		Sustainable resource use: maintain natural ecosystems
		Healthier products: no toxic and safe
		Economic stability: stress reduction
		Community resilience: local products
4. Quality education	–	<b>Related thanks to</b>
		CE principles in the education curricula at different levels
		Practical projects: waste recycling, sustainable products design, etc.
		Partnership projects with local businesses
5. Gender equality	Related	<b>Related thanks to</b>
		Job opportunities for all
		Inclusive policy
		Health and safety for all thanks to a healthier environment
		Education and training for all
6. Clean water and sanitation	No relationship	<b>Partially related thanks to</b>
		Wastewater treatment and reuse under CE view
		Resource recovery: energy, nutrients, clean water
		Sustainable water management
		Resilient water systems
7. Affordable and clean energy	–	<b>Partially related thanks to</b>
		Sustainable energy systems: renewable energy and longer life cycles
		Innovation and technologies
		Recycling and reuse of some materials need for energy plants developments
8. Decent work and economic growth	Related	<b>Related thanks to</b>
		Job creation and skills developments
		Sustainable economic growth avoiding compromising the future
		Inclusive policies
		Resilient economies: minimise waste production and resources use

Table 2: Continued.

SDG number and name	CE relationship [35]	SDGs and CE
9. Industry, innovation and infrastructure	Related	<b>Related thanks to</b>
		Sustainable industrial practices
		Innovative business models
		Efficient infrastructure: longer life
		Technological advancements
10. Reduced inequalities	–	<b>Partially related thanks to</b>
		Job creation and economic opportunities for marginal communities
		Environmental justice (mainly connected with low-income communities)
		Inclusive policies and global impact
11. Sustainable cities and communities	Related	<b>Related thanks to</b>
		Urban resources management
		Smart city initiatives
		Policy and planning
12. Responsible consumption and production	Related	<b>Related thanks to</b>
		Resource efficiency and waste reduction
		Sustainable business models
		Consumer awareness
13. Climate action	Partially related	<b>Related thanks to</b>
		Material efficiency: lower emissions
		Waste reduction: emission reduction
		Sustainable products: carbon footprint reduction
		Adaptation and resilience: local and not global resources use
14. Life below water	Partially related	<b>Related thanks to</b>
		Marine pollution reduction
		Sustainable fishing
		Resource efficiency: less footprint
15. Life on land	No relationship	<b>Related thanks to</b>
		Sustainable agriculture
		Forest conservation
		Soil health: compost
		Biodiversity protection
16. Peace, justice, and strong institutions	Related	<b>Related thanks to</b>
		Conflicts over resources decrease
		Better institutions: transparency, accountability and sustainability
		Access to Justice: law and regulation
17. Partnerships for the goals	–	<b>Related thanks to</b>
		Collaborative innovation
		Resource sharing
		Economic and social benefits



Table 3: Relationships between waste collection and SDGs.

SDG number and name	Waste collection relationship
1. No poverty	Health problems
	Economic burden
	<i>Environmental</i> impact
2. Zero hunger	Food waste reduction
	<i>Environmental</i> impact
3. Good health and well-being	Diseases prevention
	<i>Environmental</i> health
	Economic benefits: health care cost decrease
4. Quality education	Raising awareness
	Bahaviour change
5. Gender equality	–
6. Clean water and sanitation	Less water pollution:
	Health impact
	<i>Environmental</i> pollution
7. Affordable and clean energy	Energy recovery from waste: cost effective solution and <i>environmental</i> advantages
8. Decent work and economic growth	Job creation
	Improving working conditions
	Skills developments
9. Industry, innovation and infrastructure	Smart waste management
	Waste to energy systems
	Sustainable infrastructure: urban planning
	Economic growth and job creation
10. Reduced inequalities	Access to services
	Health and safety improvements
	Economic opportunities
11. Sustainable cities and communities	Efficient waste management
	Innovative and smart technologies
	Policy and regulations
	<i>Environmental</i> and economic benefits
12. Responsible consumption and production	Waste reduction
	Recycling and reuse
	Consumer awareness
13. Climate action	<i>Emission</i> reduction
	Carbon footprint reduction
14. Life below water	<i>Pollution</i> prevention
	Biodiversity protection
15. Life on land	<i>Pollution</i> prevention
	Habit protection
	Soil health
16. Peace, justice, and strong institutions	Rule of law and enforcement
	Inclusive decision-making
	Transparency and accountability
17. Partnerships for the goals	Collaborative efforts
	Resource mobilisation
	Knowledge sharing
	Policy and regulation



Table 4: Common relationships between (municipal) waste collection and CE.

<b>Waste collection aspects</b>	<b>CE relationship</b>
SC of food waste and green waste	Direct/indirect compost production
SC of paper and cardboard	Production of cellulosic products
SC of plastic packaging	Production of plastic products
SC of glass packaging	Production of glass packaging
SC of metals	Production of metal packaging and other
SC of residual waste	Energy production

Summing up, waste collection has many links with SDGs and CE. The next step will zoom on the links among waste collection and education/industry.

### 3.3.1 Waste collection and education

Universities are living laboratories where learning reaches today's students and tomorrow's decision makers, but also (sometime indirectly) parents and other people. In this frame, SC of waste in university is an opportunity to directly understand the criteria of organising a separation of material flows aimed to CE strategies [39], [40]. Moreover, a university can propose teaching modules involving waste collection from the technical, economic and social points of view. However, education is not only at university level. High schools can take advantage on the topic of waste collection to use it as subject of discussion with contents depending on the orientation of the school (technical, humanistic, etc.). In reality waste collection must be a topic of learning also at lower levels of education. Future citizens used to interact with that in their childhood can guarantee significant results in term of CE and SDGs implementation. Examples of collaboration between classrooms at primary school level can be found also at international level.

### 3.3.2 Waste collection and industry

An optimised waste collection in companies is at the base of waste valorisation as material to be recycled. It must be pointed out that the streams potentially valorisable are often larger than the ones of municipal solid waste. When waste collection in companies is out of control (i.e., far to be optimised), often the destination of waste is a landfill even if that means loss of resources. In some countries the tariff for landfilling has grown so much that waste recycling can be economically sustainable. The reason of this increase in costs depends also on the need to comply with an EU target of maximum landfilling rate set at 10% of the waste generated within 2035.

Waste collection and industry are strongly connected and related to SDGs and CE through:

- Economic impact – waste collection costs
- Resource recovery – selected waste as input material
- Environmental benefits – industries must comply also with the waste regulation
- Achieving sustainability and circularity thanks to the waste integration.

## 4 CONCLUSION

Starting from cross considerations on SDGs and CE, the present article pointed out the need of a clearer valorisation of the cross connections between them. The literature on the topic is not yet fully developed and different visions can be easily found. Zooming in on the topic, what emerged are the multiple roles of waste collection in supporting a sustainable vision.



Moreover, waste collection emerged as key factor also in two sectors: education and industry. In the first case, waste collection can be the subject of activities of environmental education growth at many levels, where universities play a role that cannot be unique: all the education levels should be involved. Companies and waste collection are expected to be more connected also because some decisions at EU level concerning the role of landfill in the waste management sector: restrictions on landfilling of waste are forcing the companies to reorganise their strategies towards recycling.

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