

## Review

## Cleaner production for achieving the sustainable development goals

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## ABSTRACT

Cleaner production is a lively concept in which new procedures and technologies constantly emerge introducing methods and practices to prevent damages to the environment. A broad range of cleaner production initiatives contribute to sustainable development not only through the efficient management of resources and energy, but also through the development of new and smart technologies, new ways of assisting policies development, and organizing supply chains, sectors and individual companies. The authors of this Virtual Special Issue sought to introduce first-hand knowledge and discussions identifying and highlighting the ways cleaner production can contribute to reach the United Nations sustainable development targets. The intent of the Virtual Special Issue is to provide an overview of the recent trends that cleaner production practitioners/researchers are following in the chase of the sustainable development goals, and in this context, this editorial was designed to summarize and underscore the link between cleaner production concepts and practices and the sustainable development goals. An adequate response to this challenge required scientific knowledge and reassessment of the papers ensuring that the science is responsive to the evolving needs of sustainable development. This Virtual Special Issue of the Journal of Cleaner Production is mainly dedicated to the 7th International Workshop on Advances in Cleaner Production, held at Universidad de La Costa, Barranquilla, Colombia on 21–22 June 2018. Based upon the examination of the papers of this Virtual Special Issue, the authors were able to establish that there is an pressing need for research on the assessment on which/when cleaner production interventions are more effective; inter and multidisciplinary cooperation among social and technical scientists to distinguish and address the cleaner production/sustainable development goals interactions and connect cleaner production solutions and large-scale sustainability approaches.

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## 1. Introduction

In 2015, the 2030 Agenda declared 17 Sustainable Development Goals (SDGs) along with 169 related targets highlighting their cohesive and indissoluble nature (UN, 2015), and trying to overcome the deficiencies of integration among policies, strategies and applications that have been noticed as key drawbacks of the prior efforts towards sustainable development (SD), such as the preceding Millennium Development Goals (Liu et al., 2018; Obersteiner et al., 2016; Le Blanc, 2015). The SD targets are supposed to cover the scopes of sustainable development – economic, environmental and social – and their institutional and/or governance structures (Costanza et al., 2016). Therefore, integrated approaches are required to clarify and evidence the interdependencies among the SDGs and to expedite their effective implementation through Cleaner Production (CP) practices and concepts.

The understanding of the SDGs embodies a foremost accomplishment for evaluating environmental, social and economic improvements (UN, 2015a) and directing forthcoming developments (Ripple et al., 2017 - with 15,364 scientist signatories from 184 countries). Worldwide, authorities have committed to safeguard the environment, foster equity, and encourage SD, while concurrently acknowledging the connections among these objectives for achieving social wellbeing. In this regard, several authors provided models to understand the SDGs to help policy makers and society to identify the SDGs connections and priorities. The wedding cake model (Fig. 1A) was developed by the Stockholm Resilience Centre (Stockholm Resilience Centre, 2016) and set the priority on the biosphere - which holds economy and society - and biosphere health as a precondition to economic development and human wellbeing. However, there the goals were also organized in a way in which people, environment and spiritual issues are linked to determine the pathway to sustainability (SDG pyramid, 2019) prioritizing human welfare and human actions. Whatever the mental model considered, the role of the scientific community in understanding and reaching the SDGs is vital. Encouragement to research on sustainability – and on the tools to achieve it - allows the protection of the environment, the economy and equity, and act for a first step of the coalition between SD and current policies - which still do not prevent society from surpassing the limits of natural resources exploitation - to succeed in reaching the SDGs (Leal Filho et al., 2018).

The relationships among the 17 SDGs have also been explored in recent publications, since prioritizing one or other SDG may trigger conflicting results (Weitz et al., 2017). Pradhan et al. (2017) analyzed the SDG interactions identifying synergies and trade-offs using data from 227 countries. Taking SDGs couples, synergies and trade-offs were ranked on national and global scales, and among them SDG 1 was found synergic with most goals, while SDG 12 was mostly connected to trade-offs. For these authors, the

accomplishment of the SDGs will deeply depend on leveraging the identified negotiating trade-offs. van Soest et al. (2019) proposed the use of integrated assessment models to analyze the interactions/connections among the SDGs showing how modelling can contribute to policies logic and coherence.

There are several studies trying to establish indicators to measure how far are the SDGs and introducing quantification to proposed procedures (Alleyn et al., 2015), how to discern progress (Bebbington and Unerman, 2018), and how to evaluate accomplishments in different countries and regions (BCCIC, 2016; European Union, 2016, 2017). At global level, two reports (Report on the Forty-eighth Session, and the United Nations The Sustainable Development Goals Report, 2017b) were published underscoring both benefits and threats to sustainability as the societies move towards the 2030 Agenda for Sustainable Development Goals (UN, 2017a, b), but there are also reports that are dedicated to the performance of countries (Sachs et al., 2017), continents and regions (OECD, 2017; World Bank, 2017). Europe, for example, has been advancing in enhancing energy efficiency and the portion of renewable sources used. There was also progress in resource use, sustainable and responsible consumption, decrease in waste generation and CO<sub>2</sub> emissions, but indicators still showed that the conditions of ecosystems have not satisfactorily improved (European Union, 2017). In Latin America and the Caribbean the major challenges were identified as required improvements in the health and education systems (Sachs et al., 2017; World Bank, 2017). Progresses related to environmental aspects were related to industrial innovation and increasing energy access, while inequality and employment were still critical issues to be resolved (Nicolai et al., 2016).

In the pursuit of the SDGs, society should use a multidisciplinary and transformative approach bringing together different disciplines that would allow policy development built upon a consistent scientific approach (Schmalzbauer and Visbeck, 2016). In this context, scientific guidance was pointed out as the required basis to obtain effective solutions to complex problems, projecting and modelling future scenarios and offering a bottom line for policy making establishing priorities for action (ICSU, 2017).

One of the responsibilities of the scientific community is to help in the interpretation of the large-scale goals into the real-world local level agenda. Another of the responsibilities of the scientific community is to help to reaffirm the required support of education (Annan-Diab and Molinari, 2017; Dlouhá et al., 2017; Storey et al., 2017) and research (Bebbington and Unerman, 2018; Leal Filho et al., 2018). Research is a constructive route to foster sustainability, and a sustainable future can be only achieved by relying on scientific guidance (Schmalzbauer and Visbeck, 2016). Therefore, the academia is striving to fill out a number of knowledge gaps on how to achieve the SDGs and, consequently, contribute to sustainability (Soini et al., 2018; ICSU, 2017; Décamps et al., 2017).

There are still few publications explicitly directed to the degree to which the SDGs are being pursuit/reached through the numerous CP actions and practices, although CP is considered worldwide as a tool to reach SD. CP combines the use of preventative environmental methods to processes, products and services targeting to increase efficiency and to diminish the threats to society and environment. These preventive practices contribute to achieve economic savings as well as a better-quality environment for society, which are fundamentally emphasized in the SDGs description. The advances in CP are accounted for processes (saving energy and raw materials, reducing the use of toxic substances, diminishing the quantity of waste and emissions) and products (decreasing impacts along the whole life cycle), as well as for services (Shereni, 2019). CP can be particularly advantageous to developing countries and those experiencing economic transition

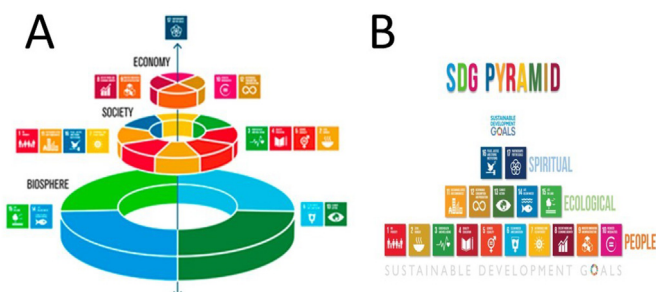


Fig. 1. Proposed models for the Sustainable Development Goals. A: the wedding cake model and B: the pyramid model.

by facilitating innovative advances in the reuse, remanufacturing and recycling. Among the studies that relate CP practices with the SDGs, research was focus on resource use (Mugagga and Nabaasa, 2016; Fader et al., 2018), energy efficiency (Chirambo, 2018), and the role of environmental assessment methods to meet the goals (Laurent et al., 2019; Sala and Castellani, 2019; Hoekstra et al., 2017). The SDGs guidance for the operation of supply chains (Russell et al., 2018), industrial sectors (Oliveira-Neto et al., 2018), individual companies (Fonseca and Carvalho, 2019), and services (Di Vaio and Varriale, 2019; Avrampou et al., 2019) were also explored.

This introductory paper acts as an overview to the Virtual Special Issue (VSI) of the Journal of Cleaner Production dedicated to the 7th International Workshop on Advances in Cleaner Production (IWACP) held in Barranquilla, Colombia on 21–22 June 2018. From a total of 138 papers that have been submitted for this VSI, 40 highly qualified submissions were accepted for publication. We hope that the contribution from this VSI papers can support insights upon the contribution of CP to the SDGs.

## 2. Overview of the papers integrating this VSI

The contributions of the authors in proposing/adopting CP practices presented in this VSI made it possible to highlight the CP practical and/or conceptual contributions to most of the SDGs, with exception of SDGs 5 and 16, Table 1. The contributions were


















organized following the authors choices in regard to their contribution to a particular goal.

### 2.1. Contributions to SDGs 1, 2, 4 and 10

A contribution to reach SDG 1/SDG 8 was shaped by Husted and Salazar (2020), who suggested a market-based instrument for companies to scale down income inequality. Reviewing the concepts of companies diverseness and externalities associated with income imbalance, the authors proposed a model by determining targets for a sample of fifteen firms, building a marginal income inequality reduction cost curve, and coordinating supply and demand to obtain the fair price. Carvalho et al. (2019) stated that since thousands of families are economically reliant on the tobacco production, efforts to direct to produce biodiesel in tobacco farms and promote agricultural diversification are praiseworthy. A LCA of Solaris seed tobacco was performed considering seed production, oil extraction and biodiesel yield. The results showed that the Solaris tobacco biodiesel generates similar impacts to those accounted for other crops. The LCA results can be also used to upgrade biodiesel production and avoid potential environmental damages. The connections between mining activity and the SDGs were also examined by Monteiro et al. (2019), who provided suggestions for attaining the SDGs in the mining sector in three mining industries, in Brazil, such as the provision of decent jobs (SDG 8) aiming the reduction of poverty (SDG 1) and hunger (SDG 2)

**Table 1**

Summary of the articles in this VSI and their contributions to the SDGs.

SDG	Article	SDG	Article
	Husted and Salazar (2020); Carvalho et al. (2019); Monteiro et al. (2019); Eustachio et al. (2019)		Husted and Salazar (2020)
	Monteiro et al. (2019); Eustachio et al. (2019); Giannetti et al. (2020)		Guimarães et al. (2019); Deus et al. (2020); Ike et al. (2019); Márquez et al. (2019); Giannetti et al. (2020), Xydis et al. (2020).
	Eustachio et al. (2019); Giannetti et al. (2020)		Teixeira and Cancigliieri Junior (2019); Qin et al. (2019); Naciti (2019); Oliveira-Neto et al., 2019; Preziosi et al. (2019); Silva and Figueiredo (2020); Pohlmann et al. (2020); Reche et al., 2019; Ribeiro and Kruglianskas, 2010; Pereira et al. (2019); Hammes et al. (2019); Merli et al. (2019); Wang et al., 2019; Ike et al. (2019); Eustachio et al. (2019); Gunarathne and Lee (2019); Giannetti et al. (2020)
	Rampasso et al. (2019); Ike et al. (2019); Eustachio et al. (2019); Gunarathne and Lee (2019); Giannetti et al. (2020)		Eustachio et al. (2019); Giannetti et al. (2020)
			Yang et al. (2019); Ike et al. (2019); Eustachio et al. (2019)
	García-Caceres et al. (2019); Gastaldi et al. (2019); Leong and Lebel (2020); Eustachio et al. (2019); Giannetti et al. (2020)		Lombardi et al. (2019); Shah et al. (2019); Eustachio et al. (2019)
	Cucchiella et al. (2020); Viteri et al. (2019); Méndez et al. (2019); Eustachio et al. (2019); Xydis et al. (2020).		
	Husted and Salazar (2020); Carvalho et al. (2019); Monteiro et al. (2019); Ike et al. (2019); Eustachio et al. (2019); Gunarathne and Lee (2019); Giannetti et al. (2020)		Ike et al. (2019); Eustachio et al. (2019); Gunarathne and Lee (2019); Márquez et al. (2019); Giannetti et al. (2020)
	Santos et al. (2019); Shih et al., 2019; Tajbakhsh and Shamsi (2019); Ribeiro and Kruglianskas, 2010; Pereira et al. (2019); Hammes et al. (2019); Merli et al. (2019); Ike et al. (2019); Eustachio et al. (2019); Gunarathne and Lee (2019); Giannetti et al. (2020)		

through the increase of income in isolated and deprived areas. However, a lack of investment in education for employees was consistently noticed, as well as the lack of concern to waste disposal and emission control compromising the realization of SDG 13. Deficiencies in the education system were already mentioned in the Latin America and the Caribbean reports (Sachs et al., 2017; World Bank, 2017). In this regard, Rampasso et al. (2019) evaluated the engineering students' perception regarding sustainability. The data were examined through the technique of structural equation modeling. 162 answers validated the model and showed that the students do not cogitate support for local communities and concern with employees when considering sustainability. Their findings may expand the discussion about incorporation of sustainability issues in engineering schools, facilitating didactic activities.

## 2.2. Contributions to SDG 6

Three articles addressed the SDG 6. Garcia-Caceres et al. (2019) introduced a decision making system envisioned to evaluate the productivity of the drinking water treatment chain sustainability. The support system uses a mathematical programming model and a solution method to maximize profit and minimize the emission of pollutants. Describing the Italian services for water treatment as deficient in regard to the collection and treatment of wastewater, Gastaldi et al. (2019) assessed the efficiency of selected Italian water companies. Their results, obtained from mathematical/linear programming of Data Envelopment Analysis (DEA), showed that the control water losses is essential to the environmental performance of these companies and that keeping a low loss level is vital to safeguard a very important natural resource. To complement the analysis from the production side, Leong and Lebel (2020) called the attention to an gradually significant policy option of using recycled drinking water in regard to the consumer perspective. According to these authors, the use of recycled drinking water struggles with what they call the "yuck" factor. Successful examples of recycled drinking water use showed that confidence, communication and social standards are important, but there are no studies comparing the virtual meaning of information to the dominance of social standards. The authors examined conformity, as a social model, in encouraging public tolerance of recycled water for drinking. They found that conformity by itself provided satisfactory motivation for behavioral change, rather than communication or economic incentives. The study presented empirical verification with concrete consequences on the use of conformity as incentive to take problematic decisions.

## 2.3. Contributions to SDG 7

Energy efficiency and renewable energy options were also evaluated. Cucchiella et al. (2020) explored the interesting topic on how to convert historical buildings on energy efficient ones. In Italy, historical buildings are a noteworthy share of the construction patrimony, and improving energy efficiency is difficult since interventions must consider historical materials and cultural context. The authors proposed a method to identify the valuable elements, the selection of insulating materials, and cost analyses organized in a multi-criteria matrix to distinguish the most effective alternative to improve energy efficiency. The method was applied in Aquila, and a multicriteria framework helped draw attention to the requirements of heating and/or cooling and costs. The results indicated that it is possible to adopt strategies for the purpose of improve the energy efficiency of historical buildings, thus contributing to the SDG7. To encourage the usage of renewable energy in the off-grid regions, Viteri et al. (2019) presented a model for designing electricity systems for off-grid communities, in Colombia, based on renewable

energy sources. The system assists evaluating dissimilar technological combinations of fossil fuels, batteries and renewables, including demand and climatic variables. The model was verified at an isolated community and the best solution at affordable prices was a combination of solar power and battery storage. Their results pointed at the potential for using renewable energy know-how to supply energy to off-grid areas replacing fossil-based fuels. Méndez et al. (2019) underscored the importance of designing efficient agricultural production systems regarding energy efficiency. Using six assessment methods – emergy, exergy, ecological footprint, network analysis, material flow analysis, and life cycle assessment - a multi-criteria evaluation was performed revealing the relationship between efficiency and utility. Xydis et al. (2020) proposed investigated if small scale wind turbines support small-scale hydroponic systems could provide additional income for the wind energy producers and increasing vegetables production in urban centers. The production of lettuce, tomato and basil were examined and lettuce was found as the most profitable.

## 2.4. Contributions to SDG 9

SDG 9 was the second goal preferred by the authors. Santos et al. (2019) examined 231 countries (58 developing countries and 173 from developed ones) sustainability reports indorsed by the Global Reporting Initiative with the purpose to assess, at the companies level, the configuration of eco-innovations of companies in developing and developed countries. They also examined the impact of eco-innovation on the companies', and their results indicated that only return on sales were significant for the environmental and social variables. This result diverged between companies from developing and developed countries. Shih et al. (2019) investigated the administration of a recycling fund via separated subsidy rates to support initiatives for the implementation of CP practices. The authors introduced the management of the recycling fund and trade-off models analyzing the fund management of waste printers in Taiwan. Their results showed that a differentiated rate could be difficult to accomplish and that some subsidies could bring a negative impact on the return rate. The authors recommended to raise fees to balance the goals of fund management in lon-term. For integrating sustainability proposals into managerial decision-making Tajbakhsh and Shamsi (2019) focused on the macro-level measurement of countries' performance through a nationwide sustainability composite index. Aa super-efficiency formulation was explored enabling discriminate between equally efficient countries. The model was applied in 133 countries and used to measure the countries' sustainable productivity. Their results showed that conservative metrics may misinform decision makers. Ribeiro and Kruglianskas (2010) examined the challenges that governmental agencies find when seeking for new ways to subjugate the restrictions of traditional regulatory models. The authors addressed the extended-producer responsibility innovations promoted in São Paulo state, Brazil. Changing the approach from customary regulation to discussed agreements, the authors established a "three steps change" model, targeting to grasp how change occurs and which were the critical elements. Catalysts for change included cultural changes in companies and the government perception. Among the barriers, the most decisive was the little retailers adherence, low involvement of municipalities, the lack of tax incentives, and higher operating costs. Ultimately, among the prospects for progress, results showed the increase of partakers, and the inclusion of environmental training programs, and incentives for recycling. The authors concluded that extended-producer responsibility innovations must be integrated to policy design with potential to overcome the application gridlocks in complex environmental protocols.



Pereira et al. (2019) identified ecodesign as one of the instruments that can effectively contribute to industry innovation, and do it require a strong attention from management. They examined the role of middle managers by analyzing effective projects coordinated by them. Their findings indicated that middle managers are responsible for many actions in different projects phases such as informing top managers, encouraging engagement, networking with ecodesign professionals, and gathering new information to improve ecodesign knowledge within the organization. Hammes et al. (2019) included reverse logistics as a tool to achieve sustainable production since it helps managers to identify efficiency and effectiveness of the materials return in civil construction. Twelve indicators were used to assess internal and supply logistics operations, and the waste management. The indicators were ordered using the analytic hierarchy process method, and priorities were established for Colombian Brazilian companies. As a result, both companies have improved their performances in green purchasing. The identification of strategies aimed at reducing its environmental impact of the construction industry was also explored by Merli et al. (2019) as a way to reinforce the circular economy principles. Through a literature review, the authors provided an in-depth analysis of the proposals for using recycled fibers in reinforced concrete focusing both on engineering aspects and environmental sustainability concerns. Their analysis revealed that there is a gap in advancing the potential of recycled fibers usage in regard to their classification and optimization for using/recycling, and that there is potential in investigating how recycled fibers can effectively be part of a construction industry oriented by circular economy principles.

### 2.5. Contributions to SDG 11

In regard to SDG 11, Guimarães et al. (2019) came up with smart cities as a feasible solution to combine public resources, human and social capitals, and information/communication technologies to foster SD. The authors analyzed the guidance of smart governance on the life-quality in the perspective of smart cities. A survey was applied to 829 inhabitants of a Brazilian city, and data were interpreted using multivariate data techniques and structural equation modeling method. Transparency, collaboration, participation and partnership, communication and accountability relationships with Quality of Life were measured, and the results indicated the drivers that can assist the smart city managers to develop public policies to achieve the SDGs. An assessment of best management practices was provided by Deus et al. (2020). These authors developed a combined indicator to evaluate the environmental management of municipal solid waste in small municipalities categorizing them according to their management practices. The results showed that the annual average waste generation in São Paulo state was 223kg/person, the annual average emissions of carbon dioxide equivalent was 0.1t tons/person, the annual average amount of energy savings was about 50 kWh/person, and that almost all the municipalities had appropriate solid waste destinations. The aggregated indicator allowed to rank the municipalities, and among the 10 best-ranked, there were 6 municipal and 4 four private landfills. The aggregate indicator proposed was considered applicable to measure the environmental performance of municipalities waste management and to identify the best management models.

### 2.6. Contributions to SDG 12

As expected, research to achieve SDG 12 was the most popular among authors of this VSI. Authors went through individual companies, supply chains and circular economy. Teixeira and Cancigliieri Junior (2019) argued that despite the multiplicity of instruments for

sustainable production, the incorporation of the idea in companies is still deficient due to the difficulty to distinguish the starting point to implement changes and to design the advancements in the ongoing process. These authors presented a strategic planning method aiming to guide, simplify the sustainability introduction into the product development weighing the companies' weakness and strengths to encourage a common vision among the companies sectors. Claiming that corporate environmental responsibility practices should contribute to the execution of national environmental plans, Qin et al. (2019) provided a general framework applicable to mixed economies and free-market, and providing an comprehensive framework for the country context. The framework was designed to detach the influence of the SDGs on firms' environmental responsible operations and to provide a model for policy makers to motivate the SDGs pursuit at a micro level through stakeholder pressure. Still concerning corporate environmental responsibility, Naciti (2019) reported that the structure of the board of directors influences the company's sustainability achievements. Since corporations are expected pioneer on sustainable actions, one of the tactics to encourage sustainable practices is the structure the board composition. Conversely, the relationships concerning the structure of boards and corporate's sustainability practices were not analytically studied. The authors targeted key corporate governance features – such as diversity, independence and CEOs duality – and assessed their effect on social and environmental sustainability. Using data from Sustanalytics and Compustat databases in 46 different countries for 362 firms, Naciti (2019) found that boards with high diversity show better sustainability performance, while higher numbers of autonomous directors lead to worse sustainability performance.

Reaffirming that CP practices produce economic and environmental benefits, Oliveira-Neto et al. (2019) reported that there are still limited research linking those benefits to the SDGs and used as example the CP practices of the textile industry to evaluate their contribution them. A broad literature review resulted in the proposition of a theoretical framework corroborated by case studies. As a consequence, it was established that CP practices in textile industries managed to show the economic and environmental improvements relative to the SDGs 9, 12 and 15. Under the consumer-side perspective, Preziosi et al. (2019) stated that consumers' awareness through certified ecolabel toward are tools to reduce the environmental load of hotel services. The authors conducted a survey in two hotels granted with the EU-Ecolabel in Portugal. Results show that the guest's own environmental conduct and guest's discernment of hotel CP practices influences their fidelity toward these hotels. The outcomes are useful for hotel managers, highlighting the importance of environmental communication.

Silva and Figueiredo (2020) petitioned for a change in the studies of supply chains sustainability, from an approach focusing on performance to approach focusing on practice, assuring sustainable processes within the notion of sustainability as routine. The practical-approach suggests a move from the triple bottom line to the SDGs standpoint. Using a medium organization and its supply chain practices towards the SDG 12, the authors identified five different practices to contribute to the SDGs: cooperating, understanding, deeming, improving, and changing the logic. Pohlmann et al. (2020) discussed the responsibility of the focal company for achieving the SDGs using a food poultry supply chain as example. Their results indicated that Brazilian focal companies are strategic for the vertical set-up of the poultry supply chain, especially on the integration of feed mill suppliers, poultry transport and processor, and distributors. The vertical integration has as advantage the production integration through the technical support in many chicken business activities. However, a lack of action with regard to environmental and social issues was noted.

Challenges to be overcome include changes in business models, environmental assessments, implementation of corporate social responsibility and the nonexistence of frameworks to implement SDGs specific for food supply chains. [Reche et al. \(2019\)](#) analyzed 33 selected papers on Integrated Product Development Process and Green Supply Chain Management, and identified the outstanding limitations and the practical applications of these concepts. The authors found a lack of integration between product development processed and the (green)management of the supply chain, particularly linked to the operations concerning procurement, distribution and manufacturing green aspects.

Finally, [Wang et al. \(2019\)](#) explored the lack of research on the effects of circular economy on direct and indirect carbon emissions. These authors used a carbon-based life cycle model to build a matrix for the carbon footprint of China's coal-fueled power circular economy parks. Results showed the impacts (positive and negative) of circular economy from 2000 to 2016, and suggested resource-recycling procedures to diminish the total carbon emissions of the Chinese industrial parks through the replacement of carbon-intensive energy sources. The correspondence of circular economy and carbon emissions reduction was determined and policy suggestions to reduce carbon emissions.

### 2.7. Contributions to SDG 14 and 15

Although SDGs 14 and 15 may seem far from CP practices and concepts, environmental assessment techniques widely used by CP practitioners can be very useful in assessing the conditions and the production of aquatic systems ([Yang et al., 2019](#)) and land use ([Lombardi et al., 2019](#); [Shah et al., 2019](#)). The importance of aquatic ecosystem services has explored by [Yang et al. \(2019\)](#). The authors discuss the complexities of some aquatic ecosystems and the ambiguities hovering over the delivery mechanism. Calling the attention to the absence of an accounting method the authors addressed an aquatic categorization system (source, process and sink type); their formation mechanisms; and a meticulous ecosystem services valuation accounting techniques. Aquatic ecosystem services were divided into direct, indirect and existing services, and the results allowed to integrate specific aquatic ecosystems when measuring their services, to assess supply side, and to provide unified metric. The developed accounting method was applied to aquatic ecosystems in China, and the results showed that Sichuan has the largest total value, Tibet has the largest value per unit area and that microclimate regulation was the most valuable service for most Chinese aquatic ecosystems. The study provided scientific basis for policy making on management and to individual aquatic ecosystems. [Lombardi et al. \(2019\)](#) examined the modifications that disturb rural systems through different means related to changes in land use, damage in biodiversity, and destruction of habitats. Using the Land Food Footprint for evaluating the growth of food systems and land shift, and the Shannon, Dominance and Sharpe landscape indexes allowed to evaluate landscape alteration and its influence on agricultural resources. The growth of land food footprint and changes in landscape were monitored from 1970 to 2010 to assess the regional ability to fulfil the food requirements of Sardinia's population. The reduced diversity of regional food was attributed to the change of systems of food production and consumption. The agriculture ecosystem was evaluated in regard to the services and dis-services it can provide according to their management and agriculture practices ([Shah et al., 2019](#)). The authors established a non-monetary valuation for ecosystem services based on an energy theory. Ecosystem services were organized as direct, indirect and existing services. Using as example a case in Pakistan, five agriculture systems were examined - wheat, rice, maize, cotton and sugarcane. 11 ecosystem services were examined, and the

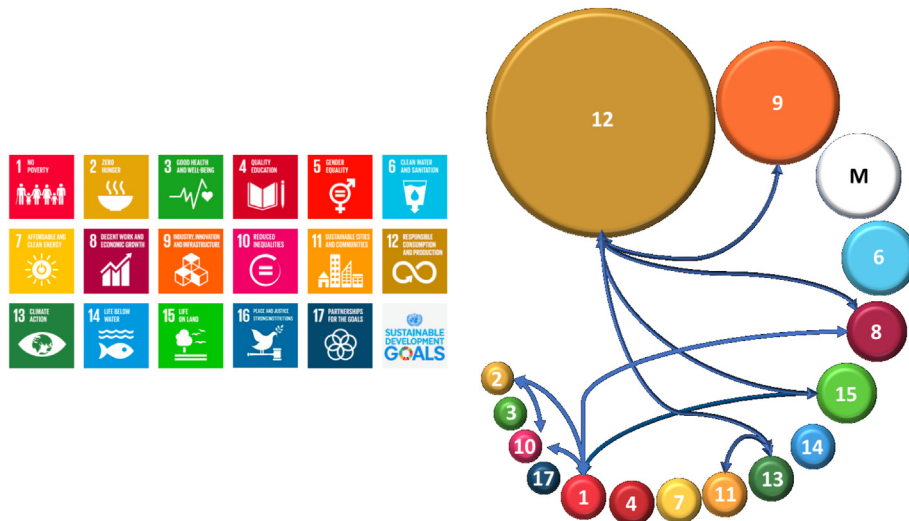
results showed that agriculture systems highly depend on human feedbacks (fertilizers, pesticides, energy) which leads to dis-services for both anthropogenic and natural ecosystems. The method introduced allowed to discern policy insights to the valuation of ecosystem services provided (or not) by the agriculture ecosystems.

### 2.8. Contributions to multiple SDGs

Some authors explored the ways to achieve multiple SDGs or to monitor actions toward multiple targets. The selection of adequate indicators was explored by [Ike et al. \(2019\)](#), who noted a lack of research regarding the SDGs application at the firm level, emphasizing that the operationalization through corporate sustainability remains vague. The question of how SDGs can be prioritized and what internal and external variables may affect their adoption is explored in Japanese multinational enterprises and their corporate sustainability activities in overseas subsidiaries. Using a case-study approach, the authors categorized the goals considered by Japanese companies using retrospective analysis of corporate sustainability data from companies operating in the Vietnam Philippines, Thailand and Indonesia. The results showed show policy makers in the Japan considered the several SDGs in their decision making process: SDG4, SDG 8, SDG 9, SDG11, SDG 12, SDG 14 and SDG 17. A framework for a systemic indicator of sustainable development using systems theory was proposed by [Eustachio et al. \(2019\)](#). The framework was built upon 47 variables of 219 countries and the correlation among the UN's SDGs is examined and connected with the decision-making process. The systemic perspective of the proposed indicator evidences the food-water-energy nexus putting together decision-makers and political sectors using a multi-stakeholder approach to deal with sustainability concerns. The proposed framework may improve appraising the sustainable development process of countries and regions attenuating the complexity for decision and policy makers.

[Márquez et al. \(2019\)](#) acknowledged that decreasing the waste generated through prevention, reduction, recycling, and reuse has turn out to be essential. Landfill mining was introduced as a tactical tool that can contribute to SD. This article examined more than a hundred projects all over the world, and the economic, social and environmental benefits were classified according to their compliance to the SDGs. Landfill mining fulfills at least 11 of the 17 SDGs and must be encouraged by public policies. [Gunarathne and Lee \(2019\)](#) reviewed the significance of information (managerial and environmental) in promoting CP strategies and practices and corporate sustainability. Their study exposed that due to the disconnected and not planned usage of information by the companies in the operative stage, CP is only related to efficiency schemes and that the companies in this stage make only a narrow CP contribution to the fulfilment of SDGs. By analyzing the information usages in promoting CP strategies, their research reinforces CP inclusion to achieve the SDGs along with internal and external communication mechanisms.

Finally, the results of the in-depth discussions that occurred during the thematic sections of the 7th IWACP provided unique perspective on the distribution of UN-SDGs as significant for managing environmental, economic and social capital under two theoretical models for sustainability ([Giannetti et al., 2020](#)). The five sectors sustainability model (5SenSu) and the traditional one that considers a trade-off among the three capitals. Results showed the social capital was identified as the most significant by the SDGs, and for both sustainability models an unequal allocation of the SDGs among the capitals. The authors pointed out that the sector relative to the environment, as a resources/energy provider to support collective development is only pertinent for SDG 6. These



**Fig. 2.** Distribution of the authors inputs to the Sustainable Development Goals in this VSI. The size of the circles is proportional to the number of papers and the arrows indicate the relationships suggested by the authors. The M (miscellaneous) circle represents the eight papers that deal with several SDGs.

authors recommended additional efforts towards an unbiased interpretation of the SDGs, the use of scientific models to succeed a more well-adjusted definition of SDGs through the different aspects of sustainability.

### 3. Final remarks

This introductory paper presented advances of CP on the basis of its contributions to the SDGs. The JCLEPRO VSI was dedicated to the 7th International Workshop on Advances in Cleaner Production, but also received contributions from JCLP authors. After presenting recent advances the SDGs literature, some CP practices and were identified as not taking sufficient research consideration.

The overview of the selected papers emphasized the authors' contributions and their relationship with the SDGs. The articles outline approaches and actions to alleviate challenges and boost knowledge to reach the targets and contribute to the path to SD. In this VSI, papers were grouped to a correspondent target, and it was clear that most of the authors intended to contribute to SDG 12 and 9 (Fig. 2), but most of the articles showed connections to more than one SDG. However, there were contributions to the majority of the SDGs, except for SDGs 5 and 16.

The selected papers in this VSI brought contributions to both theory and practice. Knowing that the SDGs offer a detailed and reasonably realistic view of the complex challenges in the path to SD, it was clear that they need attention in both practical and theoretical fields. It is not enough to only define the SDGs, there is a need to distinguish the ways to implement them. This understanding will certainly be useful in developing new theories and practices.

The authors uncovered a pressing need for research on:

- the evaluation on which CP practices should be applied for each case
- when CP interventions are more applicable
- inter-multidisciplinary partnerships among technical and social researchers to distinguish and address the pertinent CP/SDGs interactions;
- and integration of CP solutions with large-scale sustainability research.

The authors this introductory article expect that the papers and main ideas provided in this VSI will add to the awareness about the SDGs understanding and shall be a sound foundation for scientists and students concerned with the theme of CP concepts and practices targeting the success of the sustainable development goals.

### Declaration of competing interest

The authors declare that this work has not been published previously, and it is not under consideration for publication elsewhere.

We also declare that we have no conflicts of interest.

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