



Editorial

Widening Cleaner Production scope and targets: From local to global initiatives



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ABSTRACT

Cleaner Production concepts and practices have matured with outstanding success since their introduction in the 1980s, currently being a central part of the agenda of companies, sectors, and governments by integrating theory, applied science, and policies. This VSI of the Journal of Cleaner Production reunites contributions from the 8th and the 9th International Workshop on Advances in Cleaner Production and aims at underscoring the role of Cleaner Production in contributing to sustainable development from the application of local actions to global interventions. The 62 articles that compose this VSI provide an overview of how Cleaner Production has evolved in scope, content, the range of sectors covered, and the targets to be achieved: from less pollution/waste generation to the food-energy-water nexus to the green/blue and the circular economy. The selected articles clearly show that the integration of multiple viewpoints has created a novel field of scientific collaboration.

1. Introduction

It is undeniable that the term Cleaner Production (CP) is currently used in different ways. However, researchers seem to prefer “a preventive, company-specific environmental protection initiative” or “the continuous application of an integrated preventive environmental strategy to processes, products, and services to increase overall efficiency, and reduce risks to humans and the environment” (Balkau, 2005). The most visible programs to date are the initiatives favoring cleaner technologies and the widespread use of environmental management systems in the industry or corporations. Still CP evolved over the past years, and the vision on CP changed considerably in scope, content, and the range of sectors applying the approach. This wide CP imposed new methods to address the range of sustainable development (SD) aspects that emerged. The targets moved: from less pollution and waste generation mainly during the production, over the design of products with less environmental impact, to the food-energy-water nexus, to green/blue and circular economy, environmentally sound services sectors, and quality of life in green/smart cities, regions and countries.

The widening area of CP applications is not limited to the increasing number of sectors, which might benefit from applying the concept. Larger structures and organizations can also benefit. The idea of green cities bounds to several environmental problems, such as increasing urbanization, cleaning up the past and present industrial wastes/emissions, and declining quality of life. Blue/green cities may reply to these problems by establishing policies and initiatives that are intrinsically CP when concerning water use, waste emissions, and carbon control (Lucarelli and Roe, 2012). Cities bordering the sea and rivers pay special attention to the blue economy, and for both blue and green, policies should include CP in several ways. Smart cities also depend on the

advancement of the green economy based on energy efficiency and renewable energy resources (Ferrara, 2015). While in some developing countries, smart cities follow the Rio+20 Conference recommendations (UN, 1992), combining green/blue aspects with the notion of cities as knowledge centers (De Jong et al., 2013) for producing CP initiatives.

Although progress was recently realized in integrating CP in the widening landscape of areas where the concept is applied, intellectual investments in fundamental, applied, and practical tools remain required. The broader application field generates new needs, such as baseline/monitoring indicators (Bell and Morse, 1999), specific measures to assess the effectiveness and efficiency of CP (Henriques and Catarino, 2015; Cabello-Eras et al., 2014), assessment methods to help preventing, avoiding and mitigating adverse effects on the environment (Devuyst, 1995) improving decision making and policies towards sustainable development. Therefore, collecting data, including the monitoring of foreseen/overlooked impacts, is essential and scientific models are an indispensable instrument to enhance the predictive capacity of the assessment approaches (Giannetti et al., 2009, 2019).

The broader scope covered by CP also results in broadening the aims to be accomplished by involving the service and administrative sectors, next to the decision-makers, and requires a broader societal understanding of sustainable development; by including quality and responsible use of energy and resources; by including CP at a strategy level; and by including sustainable and responsible consumption as a vital element of the whole process.

An overview of evolving ideas on CP can illustrate the logical steps taken during the widening of the concept and show the challenges that cannot be solved by technology alone (Gonella et al., 2019). A broader and more integrated approach, combining technological advances with human networks, policies, and ethical aspects is needed to ensure further steps towards SD (Giannetti et al., 2019).

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Table 1

Titles and scope of coverage of this VSI related to Trend 1 - CP integrating visions, strategies, policies increasing the attention for the environmental performance of companies, supply chains, and regions.

	Title	Scope
(1)	Implications for Sustainable Development Goals: A Framework to Assess Companies' Disclosure in Sustainability Reporting	Companies
(2)	The role of the environmental dimension in the Performance Management System: A systematic review and conceptual framework	Companies
(3)	Sustainable industries: Production Planning and Control as an ally to implement strategy	Companies
(4)	Evaluation of Economic, Environmental and Operational Performance of the adoption of Cleaner Production: Survey in Large Textile Industries	Companies
(5)	The Impact of Environmental Management on Firm Economic Performance: The Mediating Effect of Green Innovation and The Moderating Effect of Environmental Leadership	Companies
(6)	Factors influencing the perception of exposure to climate risks: evidence from the world's largest carbon-intensive industries	Companies
(7)	An integrative conceptual framework for supply chain sustainability learning: A process-based approach	Supply Chain
(8)	A clean global production network model considering hybrid facilities	Supply Chain
(9)	Managing micro and small enterprise supply chains: A multi-level approach to sustainability, resilience and regional development	Supply chain/ Regional
(10)	Enhance environmental policy coherence to meet the Sustainable Development Goals	Regional
(11)	Promoting circular economy transition: A study about perceptions and awareness by different stakeholders' groups	Regional
(12)	Closed-loop supply chain design for the transition towards a circular economy: A systematic literature review of methods, applications and current gaps	Supply chain/ Regional
(13)	The adoption of circular economy practices in supply chains – An assessment of European Multi-National Enterprises	Supply chain/ Regional
(14)	The impact of country of origin and operation on sustainability practices and performance	Global
(15)	Research on the Status and Priority Needs of Developing Countries to Address Climate Change	Regional

Since 2007, during the seven previous IWACPs, academics have presented, debated, explored, and assessed ways to improve the environmental performance of human-made systems. As one of the main results of those conferences, seven special issues were published in the JCLP. The 8th and the 9th International Workshop on Advances in Cleaner Production (IWACP) were co-organized by the Paulista University and the Advances in Cleaner Production Network, which was founded to exchange information to assist the desired transitions to Sustainable Societies. The 8th IWACP counted with the active participation of faculty from the Beijing Normal University (China), and the 9th in Melbourne, Australia, was co-organized by the faculty of Deakin University. Both events aimed at emphasizing and highlighting the role of CP in contributing broadly to SD, from the application of local actions to global interventions.

The guest editors of the VSI of the JCLP, “Widening Cleaner Production scope and targets: from local to global initiatives” reunited articles dealing with the widening of CP concept allowing to identify major trends for the future-focused upon the following themes:

- **Trend 1.** CP integrating visions, strategies, policies and increasing the attention for the environmental performance of companies, supply chains, and regions (Table 1).

The vision provided by the Sustainable Development Goals was explored under the perspective of companies in “Implications for Sustainable Development Goals: A Framework to Assess Companies’

Disclosure in Sustainability Reporting” by investigating how companies adjust their sustainability strategies to the prerequisites of the SDGs through an assessment framework (1). Still, at the company level, authors discussed the character and the integration between environmental dimensions and performance management systems, providing an understanding of the drivers, the missing concepts, and research challenges and opportunities (2). A similar idea was proposed in the article “Sustainable industries: Production Planning and Control as an ally to implement a strategy,” in which production planning and control concepts were extended to include strategies for industrial sustainability (3). For large textile industries, it was found that the adoption of CP practices improved the operational, environmental, and economic performance and provided a way to capture customers and obtain government subsidies (4).

The effects of the environmental management on the companies’ economic vigor were also analyzed in the face of green innovations and the efficacy of the moderating leadership (5), providing an in-depth analysis of how and why cleaner production, as a managerial technology, is diffused in developing countries. The evidence from the world’s largest carbon-intensive industries regarding the factors influencing the perception of exposure to climate risks helps to understand the responsibility of the public and industrial sectors and the challenges with relevant economic implications for companies (6).

The dimensions of the supply chain sustainability “learning concept” were explained along with how these dimensions are interrelated, amplifying the scale of research. Considering a distribution model for a global facility network, new reverse logistics facilities were proposed to reduce carbon emissions for product manufacturing and return activities. The carbon cap and trade policy was considered for regulating emissions (8). The driving factors that may lead micro and small enterprises supply chains to sustainability were explored using institutional and complexity theories to understand the dynamics behind neglected supply chain structures. Results show that micro and small enterprises supply chains contribute to regional development and enhance resilience to crises (9). Quantitatively analyzing the SDGs’ implementation in the European Union showed that some environmental goals are complex and sometimes incoherent. The need to improve data availability and monitoring and prioritize the coherence within the SDGs was highlighted to provide solutions for designing post-2030 Agendas with improved potential for achieving policy coherence (10). A similar conclusion was drawn when the experts’ perception from distinct groups on the transition to a circular economy was examined. All groups had a similar interpretation of the concepts, barriers, and drivers of the transition. Still, no consensus was found on the proper approach, which may result in unanticipated setbacks for the transition to a circular economy (11). Applications and gaps of the circular economy were also investigated at the supply chain and regional levels, and methodological contributions were considered proper to non-deterministic design problems, although a lack of empirical research was noticed (12,13). The investigation of the combined influence of country of origin and operation in the relationship between stakeholder pressures and the adoption of internal and external sustainability practices showed that country of origin and operation does not moderate these relationships. At the same time, they have a moderating effect on the relationship between sustainability practices and performance (14).

Regarding climate change priorities, the current situation of developing countries in terms of policies and actions, technology, financing, capacity building, and international cooperation for addressing climate change were systematically analyzed (15). The authors claim that these countries need to improve information exchange channels and strengthen South-South climate cooperation while optimizing the allocation of climate change resources according to their own needs.

- **Trend 2.** Proper monitoring and identification of the current issues, including assessment methods to establish more accurate and

Table 2

Titles and scope of coverage of this VSI related to Trend 2 - Proper monitoring and identification of the current environmental issues, including suitable environmental accountability, establishing more accurate and more targeted sustainability tools.

	Title	Scope
(16)	Corporate cleaner production strategy development and environmental management accounting: A contingency theory perspective	Companies
(17)	Diffusion of cleaner production in a developing country: The case of Sri Lanka	Companies
(18)	Productivity Modeling of Apparel Industry Using Hierarchical Evidential Reasoning	Companies
(19)	Green Marketing in Supermarkets: Conventional and digitized marketing alternatives to reduce waste	Companies/ consumers
(20)	A framework for sustainable and integrated municipal solid waste management: Barriers and critical factors to developing countries	Companies
(21)	LCA of an industrial luminaire using product environmental footprint method	Companies/ suppliers
(22)	Carbon emissions of coal supply chain: an innovative perspective from physical to economic	Companies/ suppliers
(23)	Machine Learning for cleaner production in Casablanca port	Companies
(24)	Life cycle analysis of electronic products for a product-service system	Companies/ consumers
(25)	A decision-making tool for transition towards efficient lighting in a context of safeguarding of cultural heritage in support of the 2030 Agenda	Regional
(26)	The impacts of multi-dimension urbanization on energy-environmental efficiency: Empirical evidence from Guangdong Province, China	Regional
(27)	Environmental Performance of Waste Management: Impacts of Corruption and Public Maladministration in Italy	Regional
(28)	One Planet Living and the Legitimacy of Sustainability Tools: From Standardized Information to Regenerative Systems	Sustainability tools

targeted (environmental, social, economic, combined) footprints (Table 2).

Regardless of the recognition of environmental management accounting as an approach to encourage corporate cleaner production measures, there are still differences in implementation efficacy depending on the strategic development stage within companies. Based on the contingency theory view of environmental management accounting system, cleaner production strategy development stages, and environmental management accounting uses, a framework was developed upon eighteen case studies of business in Sri Lanka (16). The findings showed that the use of environmental management accounting was higher in organizations with more developed cleaner production strategies (17). The apparel productivity performance attributes were evaluated using the Hierarchical Evidential Reasoning procedure to manage quantitative and qualitative measurements, considering uncertainties. A multi-criteria decision-making structure was developed to assess the productivity of twelve garments industries in Bangladesh and help decision-makers enhance overall productivity (18).

Broader accountability methods, including suppliers and consumers, are more and more popular. Green marketing actions towards reducing food waste were examined to propose mitigation alternatives in selected supermarkets (19). A background for integrated municipal solid waste management is provided, along with a description of barriers and critical factors (20). The LED luminaire environmental performance was evaluated using the product ecological footprint method, highlighting the trade-offs between using renewable/non-renewable resources for electricity generation (21). A carbon dioxide accounting model of China's coal supply chain was provided for electricity generation, revealing that the processing and conversion of coal are the major sources of carbon emissions in the coal life cycle (22). Machine learning

Table 3

Titles and scope of coverage of the articles of this VSI related to Trend 3 - CP targeting resource efficiency and environmental integrity and the use of ecosystem services by predicting, reusing, and conserving toward sustainable resource and energy use.

	Title	Scope
(29)	Briquettes of citrus peel and rice husk	Industrial
(30)	Reuse of Water and Materials as a Cleaner Production practice in the Textile Industry Contributing to Blue Economy	Industrial
(31)	Moving towards resource efficiency and circular economy in the brick manufacturing sector in Zimbabwe	Industrial
(32)	Synergistic dynamics of critical cofactors effectuates fuel relevant metabolic profile of <i>Scenedesmus</i> sp.: Targeting cleaner energy production	Industrial
(33)	The case study of a photovoltaic plant located at the University of L'Aquila: An economic analysis	Industrial
(34)	An Integrated Approach for Modelling and Quantifying Housing Infrastructure Resilience against Flood Hazard	Regional
(35)	Progress in urban metabolism research and hotspot analysis based on CiteSpace analysis	Regional
(36)	A Comprehensive Evaluation of the Eco-carrying Capacity and Green Economy in the Guangdong-Hong Kong-Macao Greater Bay Area, China	Regional
(37)	Hazardous chemical accident prediction for drinking water sources in Three Gorges Reservoir	Regional
(38)	Integrating principal component analysis with statistically-based models for analysis of causal factors and landslide susceptibility mapping: A comparative study from the Loess Plateau area in Shanxi (China)	Regional
(39)	Dissolved organic nitrogen structural and component changes in overlying water along urban river at molecular and material levels — Beiyun River case study	Regional
(40)	Mapping the spatiotemporal heterogeneity of ecosystem service relationships and bundles in Ningxia, China	Regional
(41)	Characteristics and significance of dissolved organic matter in river sediments of extremely water-deficient basins: a Beiyun River case study	Regional
(42)	Multi-basin water use network model for evaluating evolution of water resources systems toward sustainable water use	Regional
(43)	Dynamic changes in water conservation in the Beijing-Tianjin Sandstorm Source Control Project Area: a case study of Xilin Gol League in China	Regional
(44)	Urban ecological risk transmission model based on Bayesian network	Regional
(45)	Prediction of Water Security Level for Achieving Sustainable Development Objectives in Saskatchewan, Canada: Implications for Resource Conservation in Developed Economies	Regional

tools were used to search for inexpensive strategies and practices to reduce CO2 emissions (23). Business alternatives, such as Product-Service Systems, were also evaluated, and a model that interrelates the Product-Service System and the Life Cycle Analysis was proposed (24).

Decision-making tools based on different indicators were also investigated involving technical, architectural, economic, and environmental aspects. A framework combining life-cycle cost analysis and CO2 emissions was provided for scenario redevelopment projects regarding energy savings in urban centers (25). The influence of urbanization on energy-environmental efficiency for achieving energy savings and emissions reduction indicated that decision-making must consider the negative effect of land use (26).

The influence of corruption and maladministration was also analyzed regarding the environmental performance of waste management. Sixty-six Italian provinces were studied, and propensity score matching under the potential outcomes framework of causality was applied. The results showed that regions with higher levels of corruption and maladministration had higher urban waste per capita production, requiring further management and treatment. Still, no relevant differences were found concerning separate-waste collection rates and landfill use (27).

The legitimacy of sustainability tools that rely on standardized public

Table 4

Titles and scope of coverage of this VSI related to Trend 4: CP targeting social wellbeing and cleaner environment through neutral carbon balance, zero waste, and accessible green and blue spaces.

Title	Scope
(46) An Integrated Approach for Modelling and Quantifying Housing Infrastructure Resilience against Flood Hazard	City
(47) Land development in an urban megalopolis: A holistic environmental assessment of housing on Chongming Eco-island, China	City
(48) Construction and demolition waste in the Metropolitan City of Naples, Italy: state of the art, circular design, and sustainable planning opportunities	City
(49) Analysis of subnational CO ₂ mitigation policy pressure in the residential sector in China	Region
(50) Ecological Network Analysis of Carbon Emissions from Four Chinese Metropolises in Multiscale Economies	City
(51) The application of spatially explicit networks to compare carbon flows: A case study in Beijing, China	City
(52) Greener economic development via carbon taxation scheme optimization	Region

information was examined and confronted with the need for sustainability tools based on a regenerative approach. The analysis of the tools showed limitations to combine project effectiveness with scalability, suggesting that there is still the need to develop more scalable regenerative tools (28).

- **Trend 3.** CP targeting resource efficiency and environmental integrity, and the use of ecosystem services by predicting, reusing, and conserving sustainable resource and energy use (Table 3).

The study of wastes as potential resources for internal or external use was explored to develop and replace traditional sources of the heat of solid biofuel for domestic use (29), to reduce water consumption and limiting the use of toxics (30), and to identify potential for resource efficiency and circular economy (31). In a parallel approach, proposals for replacing fossil fuels went from algal bio-refineries (32) to photovoltaic applications (33). However, a great effort was noticed regarding preserving the living environment in which urban metabolism was examined to quantify the movements and transformations of matter and energy in cities providing targeted policy guidance to diagnose urban problems (34).

The carrying capacity of regions was also a great concern, both in terms of predicting and mitigating accidents that threaten the environmental integrity (35,36), pollution control (37), and benchmarking and modeling the state of regional environments to allow proper management, adequate resource use (38–40) and security of key environmental resources (41,42). CP concepts were also extended to wider areas in mapping the dynamic changes in ecosystems to set a foundation for targeted ecosystem management in different areas (43) or simulating the ecological risk transmission to propose risk control measures and negotiate with stakeholders from different areas (44,45).

- **Trend 4.** CP targeting SD coinciding with the aims of social wellbeing and cleaner environment interpreted in a blue/green/smart context (Table 4).

In the cities and regions context, such as green, blue, or smart, policies and initiatives were intrinsically related to housing infrastructure (46,47) and construction and urban zero waste (48), to water use and neutral carbon balance (Lucarelli and Roe, 2012). Accessible smart, green and blue spaces direct to policies that include CP in several ways from proposals of policies for CO₂ mitigation in the residential sector (49) to decarbonization actions (50,51) and carbon taxation (52).

Table 5

Titles and scope of coverage of the articles of this VSI related to Trend 5: CP helping to balance the food-energy-water nexus through improving the efficiency of water use and treatment; environmentally sound food production; energy efficiency; and food security.

Title	Scope
(53) Organic vegetables from community-supported agriculture in Italy: energy assessment and potential for sustainable, just, and resilient urban-rural local food production	Region
(54) Unfolding hidden environmental impacts of food waste: An assessment for fifteen countries of the world	Region
(55) Quantifying carbon stocks and sequestration potential in agroforestry systems under divergent management scenarios relevant to India's Nationally Determined Contribution	Region
(56) Renewable energy in agriculture: farmers Willingness-to-Pay for a photovoltaic electric farm tractor	Region
(57) Water-energy-food nexus approach at the core of businesses – How businesses in the bioenergy sector in Brazil are responding to integrated challenges?	Region
(58) Seafood-Energy-Water Nexus: A Study on Resource Use Efficiency and the Environmental Impact of Seafood Consumption in China	Region
(59) Cooperative Game-based Anchor Process Allocation within Sustainable Palm Oil Based Complex for Environment-Food-Energy-Water Nexus Evaluation	Region
(60) The spatial effects of city-level water-energy nexus: A case study of Hebei Province, China	Region
(61) Virtual carbon and water flows embodied in global fashion trade - a case study of denim products	Global
(62) Simulated responses of global rice trade to variations in yield under climate change: Evidence from main rice-producing countries	Region

- **Trend 5.** CP helping to balance the food-energy-water nexus by improving water use and treatment efficiency, environmentally sound food production, energy efficiency, and food security (Table 5).

The ecological consequences from agriculture and the balance between food provision and the planet carrying capacity appeared as a challenge that inspired authors to explore several aspects of this complex problem. The topics cover community-supported agriculture (53) to the hidden environmental impacts of food waste (54). Agricultural practices were explored concerning their carbon sink potential in different climatic conditions to address land degradation and mitigate climate change (55). The use of renewable energy in production operations (56) and the water-energy-food nexus that may have unintended consequences on land use, food security, water scarcity, and working conditions were also examined (57–60). The environmental impacts of the agricultural-based industry for food and clothing (61) were also discussed in terms of virtual carbon and water flows and resource/energy consumption and emissions. In contrast, the effect of climate-induced changes for rice production predicted adjustments in future imports and exports structures (62).

2. Concluding remarks

Recognizing that the CP concept was deepened and linked with other ideas, which came on the forefront since the 1992 Conference on Environment and Development (UN, 1992), this VSI intends to highlight the contributions of CP with blue, green, circular economy and all the assistance that CP may offer to balance the Energy-Water-Food Nexus. A variety of aspects and facets were explored. The possibilities for research developments that each article provides may inspire other authors to contribute to the journey towards a healthier and more human-friendly environment.

Local and specific studies on companies and sectors are vital for the operationalization of new ideas. Still, it is also clear that researchers have expanded the scale or boundaries of the systems of interest, aware that each company and each system are directly related to the larger

environment. The application of CP practices has become more realistic as it considers the interactions of single systems with the rest of the world and the fact that all CP actions taken on individual systems have a direct or indirect effect on the larger system - the planet. This VSI showed how CP could contribute to sustainable development without forgetting that 'our system' is inserted into the planet. Complex systems (a company, a supply chain, a city, an ecosystem) require systemic analysis. Sometimes, a tiny shift in one thing can produce significant changes in everything – for the good or the bad. Small actions can turn in leverage points (or not). But recognizing complexity and expanding boundaries, CP takes a more modern and realistic way of dealing with environmental issues and increases its contribution to sustainability.

The articles reunited in this VSI confirm that CP concepts and practices have experienced extraordinary success since their introduction in the 1980s. CP is now an integral part of the plan of corporations and governments, and its targets have become essential to the goals of academics worldwide. The field has progressed as a scientific branch, especially given the current agenda of integrating theory, applied science, and policy, making relevant contributions to SD, and introducing an innovative multidisciplinary fusion across fields. This VSI of the Journal of Cleaner Production shows, clearly, that the integration of different perspectives has created a new field of scientific collaboration. The CP Widening findings confirm the existence of a growing scientific field based on inclusive and ubiquitous scientific practices, with good omen as to its longevity and impact.

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