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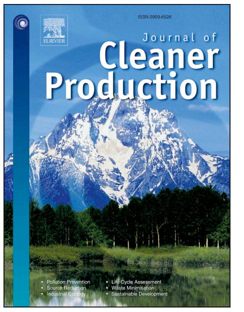

Sustainable consumption and production – Research, experience, and development – The Europe we want

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Sustainable consumption and production – research, experience, and development – the Europe we want

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Abstract

Since the publication of the Brundtland Report, production processes and consumption patterns towards sustainability have improved. This Special Volume Section of the Journal of Cleaner Production focuses on sustainable consumption and production (SCP), and identifies further challenges and provides solutions related to resource efficiency (ReE), sustainable water systems, sustainable management, cleaner production (CP), and sustainable urban development. In order to better understand the state of the SCP issues globally, existing policy directions have been explored within this paper, as well as six newly emerged sustainability terms, which have been integrated into the existing terminology classification to better describe and understand sustainable development concepts. In this Special Volume Section, the authors have demonstrated many valuable theoretical and practical contributions to the aspects of SCP, including a number of practical examples of achieving sustainability in companies, such as using bottom-up and a top-down approaches or by implementing theoretical models. There are also examples of achieving eco-efficiency in water systems (including urban), further requiring economic incentives and governmental support, and practical experiences, providing in-situ data and evidence of impacts of measures on processes and systems regarding resource efficiency, cleaner production, and also considering life cycle assessment (LCA). A model on how to achieve a sustainable urban development, based on small communities and neighbourhoods is also provided. The examples of SCP research and development in the fields of ReE presented in this section of the SV indicate that existing production and service processes in companies and social (urban) environment could be more sustainable, using a holistic approach to the SCP and achieving global policy recommendations.

Keywords: sustainable consumption and production; resource efficiency; sustainable development sustainability pyramid; sustainable management

Acronyms:

ASN – autonomous sustainable neighbourhoods
BAT – Best Available Technology
CE – Circular Economy
COP 21 – 21st Conference of Parties
CP – Cleaner Production
EPA – Environmental Protection Agency
ERSCP – European Roundtable on Sustainable Consumption and Production
ESD – Education for Sustainable Development
EU – European Union
EVAT – Economic Value-chain Analysis Tool

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GHG – Greenhouse gas
ICT – Information and Communication Technology
IPCC – Intergovernmental Panel on Climate Change
IPPC – Integrated Pollution Prevention and Control
ISO – International Organization for Standardization
LCA – Life Cycle Assessment
LCI – Life Cycle Inventory
LCIA – Life Cycle Impact Assessment
RECP – Resource Efficient and Cleaner Production
ReE – Resource Efficiency
OECD – Organization for Economic Co-operation and Development
OLED – Organic Light Emitting Diode
SC – Sustainable Consumption
SCP – Sustainable Consumption and Production
SD – Sustainable Development
SDG – Sustainable Development Goals
SEAT – Systemic Environmental Analysis Tool
SmC – Smart City
SP – Sustainable Production
SmS – Smart Specialization
SURESCOM – SUstainable and RESponsible COMpany
SUSG – Strategic Urban Sustainability Goals
SV – Special Volume
UN – United Nations
UNCED – United Nations Conference on Environment and Development
UNDP – United Nations Development Programme
UNEP – United Nations Environment Programme
UNESCO – United Nations Educational, Scientific and Cultural Organization
UNFCCC – United Nations Framework Convention on Climate Change

1. Introduction

Sustainable development (SD) has been on the global agenda for almost three decades: it was first identified in the Brundtland Report (Brundtland Commission, 1987) and further highlighted by Agenda 21 (UN, 1992). Since then, global society has achieved some significant successes, such as the reduction in ozone-depleting chemicals and the increased use of renewable energy sources, as well as in decoupling emissions and economic development (UNEP, 2011), becoming more efficient in terms of production, consumption and re-use of resources and materials. As resources and material consumption grows, there is a decline in emissions, energy and material use per output (Krausmann et al, 2009). Technological improvements and development have reduced the energy and material intensity while increasing per capita wealth (Sorrell, 2015). Further positive steps have been taken in the area of access to fresh water, where nearly 90 % of the world's population in developing countries now has access to improved sources of drinking water (UNEP, 2011). However, sustainability-related challenges still exist and have been identified by Hutt (2016) at the World Economic Forum, emphasizing also resource security, a topic on which this Special Volume (SV) section provides information on current research of both a theoretical and practical nature.

This SV section on sustainable consumption and production (SCP) identifies challenges and provides solutions related to resource efficiency (ReE), sustainable water systems, sustainable management, cleaner production (CP), and sustainable urban development. Sustainable solutions are seen as key for changing production and consumption patterns, where experts in the areas of business development, design for sustainability, consumer behavior and system innovation come together to play a role in shaping such solutions, since many sustainability problems seem to be unsolvable by actors in the production-consumption value chain (Tukker et al, 2008). Lorek and Fuchs (2013) distinguished between “strong” and “weak” SC, where the “weak” approach assumes that SC can be achieved by improvements in RE, as a consequence of technological solutions and innovations. SC is based on the assumption that changes in consumption patterns are necessary to achieve SC, where the need for reduction of overall resource consumption rather than of the product based individual consumption is emphasized (Lorek and Fuchs, 2013).

Achieving “strong” SC, which provides a framework for exploration of linkages between consumption, SD and de-growth, and emphasizes social innovations and technological pessimism (Lorek and Fuchs, 2013), could lead to solutions to the above mentioned challenges, and a transformation of global society towards SD (Waas et al, 2012).

Such a transformation requires political, economic, institutional, behavioural and technological shifts, which are realized not only through SC, but also through Sustainable Production (SP) principles, approaches and strategies that will require increased efforts towards their implementation in future decades. Therefore, radical changes are needed regarding CP, zero waste approaches, increased ReE, and the circular economy (CE) paradigm.

Global policy recommendations and international agreements regarding sustainable development, such as Sustainable Development Goals (SDGs) led by United Nations (UN) and its organizations (e.g. UN Environment Programme (UNEP) or UN Development Programme (UNDP)) are shaping our common future (Unteregger, 2015); however, the inability to accept a common “sustainable policy” shows individualism of people, corporations, nations and countries, and not a collectivism towards our common responsibility for the future generations. Individualistic behaviours with their search for profit maximization and wealth accumulation (see OXFAM International, 2015) are identified as having created economic, environmental and social imbalances. Calls and efforts towards SD seek to establish a dynamic equilibrium among these elements, where collaboration represents one of the key factors in the transition towards more sustainable societies (Lozano, 2007). Global action and international laws can diminish the negative effects of climate change, resource depletion, and biodiversity reduction. Control of population, use of renewable energy sources, and SCP can slow down the pollution and resource depletion, reduce the increasing non-equilibrium, and a possible uncontrolled, stochastic development (Glavič, 2010).

This SV section was developed mainly from papers presented at the 17th European Roundtable on Sustainable Consumption and Production (ERSCP), held in Portorož, Slovenia, 14–16 October 2014, which had as its title "The Europe We Want" and at which SCP was the over-reaching theme. The SV section brings to the forefront SCP solutions to the global challenge related to resource security. It presents new knowledge and contributes to the SCP discussion through articles covering both the theoretical and practical perspectives, across a range of topics, also emphasized at the conference. These topics include: solutions of SCP, and ReE in companies through environmental management, resources efficiency related to water systems, ReE and CP in textile industry and a brewery, and sustainable urban development cases.

2. Sustainable Consumption and Production update

Two achievements from Autumn 2015 have to be mentioned – the Paris Agreement and the adoption of the United Nations (UN) Sustainable Development Goals (SDGs). They are connected to UN Development Programme's (UNDP) Strategic Plan focus areas: SD, democratic governance and peace building, and climate disaster resilience.

The Agreement dealing with GHG emissions mitigation, adaptation and finance, starting in the year 2020, has been accepted within the United Nations Framework Convention on Climate Change (UNFCCC) at its 21st Conference of the Parties (COP 21). It sets out a global action plan for the world to avoid dangerous climate change by limiting global warming to below 2 °C. At the Paris climate conference in December 2015, 195 countries adopted the first-ever universal, legally binding global climate deal (European Commission, 2015).

SDGs contain 17 goals with 169 targets covering a broad range of SD issues. SD Goal No. 12 aims to ensure SCP patterns – it is about promoting resource and energy efficiency, sustainable infrastructure, and providing access to basic services, green and decent jobs, and a better quality of life for all. SCP aims at "doing more and better with less", increasing net welfare gains from economic activities by reducing resource use, degradation and pollution along the whole lifecycle, while increasing quality of life by involving various stakeholders (e.g. businesses, consumers, policy makers, researchers, scientists) (UN, 2015). SD Goal 12 places the most emphasis on water and energy (UN, 2015), topics covered directly or indirectly by this SV section. Only 0.5 % of World's *water* is fresh (drinking water); more than 780 million people still do not have access to it. Humans are polluting water faster than nature can recycle and purify it in rivers and lakes. Excessive water use contributes to the global water stress. Despite the *energy* efficiency gains, energy use in OECD (Organization for Economic Co-operation and Development) countries will continue to grow another 35 % in 2015–2020. Commercial and residential energy use is the second most rapidly growing area of global energy use after transport. Households consume 29 % of global energy and consequently contribute to 21 % of resultant CO_2 emissions.

Out of the UN's 17 SDGs, four are specifically considered in the articles appearing in this SV section: (6) Water – ensuring availability and sustainable management of water and sanitation for all; (7) Energy – ensuring access to affordable, reliable, sustainable and clean energy for all; (12) Consumption – ensuring SCP patterns; and (17) Sustainability – strengthening the means of implementation, and revitalizing the global partnership for SD.

The United Nations Environment Programme (UNEP, 2012) strives to promote SCP and ReE in both developed and developing countries. The focus is on achieving increased understanding and implementation by public and private decision makers of policies and actions for SCP and ReE. This includes the promotion of sustainable resource management in a life cycle perspective for goods and services. International scientific assessments such as the Millennium Ecosystem Assessment, the Global Environmental Outlook, and the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), make it increasingly evident that the world cannot achieve sustainable economic growth without significant innovation in both the supply (production) and demand (consumption) sides of the market. UNEP's ReE Programme focuses on four central themes: 1) strengthening and communicating the knowledge base for SCP and ReE; 2) building governmental capacity; 3) consolidating and extending partnerships with business and industry; and 4) influencing consumer choice. UNEP is working with a range of partners to ensure that: a) ReE is increased and pollution is reduced over product life cycles and along supply chains; b) Investment in efficient, clean and safe industrial production methods is increased through public policies and private sector action; and c) Consumer choice favours resource efficient and environmentally friendly products.

The European Union (EU) recognized the great challenge faced by economies to integrate environmental sustainability with economic growth and welfare by decoupling environmental degradation from economic growth, and doing more with less (EU, 2008). This is one of the key objectives of the EU, but the consequences of climate change and the growing demand for energy and other resources are challenging this objective. An Action Plan on SCP and Sustainable Industrial Policy was adopted by EU to maximise business potential by transforming environmental challenges into economic opportunities and providing a better deal for consumers. In addition, the European Commission adopted an ambitious CE Package, which included revised legislative proposals on waste to stimulate Europe's transition towards a CE boosting global competitiveness, fostering sustainable economic growth and generating new jobs.

3. Terminology and European perspectives of Smart Specialization integration

This section briefly reviews the development of terminology in the field of SCP and ReE, and how the terminology can be used to foster better communication by integrating a European perspective on Smart Specialization (SmS), including a theoretical framework for achieving SCP. It is aimed at supporting an easier understanding of sustainability knowledge within the SCP community. The classification has been used, together with a brief review of the literature, to provide an in-depth picture of the topics as well as to define the trends within the SCP that can contribute towards SD at a global level (Glavič and Lukman, 2007).

As sustainability research continues to develop, new definitions of existing terms were also emerging. New terms such as SCP, ReE, smart cities (SmC), education for SD (ESD), SmS, and CE were identified. These terms are now also in common use in scientific publications, policy recommendation and directives as well as other field oriented expert papers, e.g. publications from the Ellen MacArthur Foundation about the CE (Ellen MacArthur Foundation, 2016). The terms have been integrated into the hierarchical classification of sustainability-oriented terms (see ellipses in Fig.1), which identifies relationships between those terms, using a system's approach, based on several elements: principles, approaches (tactics), sub-systems (strategies) and sustainable system. These six terms and their definitions are clarified and explained, and Fig.1 shows their hierarchical position.

Insert Fig. 1

The lowest position in a hierarchy are principles, which are semantically narrow and refer to one activity. Two terms have been identified at that level – ReE and ESD.

"Resource efficiency", based on its definition, has been positioned along a side of the triangle, between the economic and environmental dimensions. It has a number of definitions including those of the European Commission (2015), UNEP (2016), and EPA Tasmania (2016). All the definitions, albeit with different words, highlight the need for efficiency and effectiveness, to create more value with less impact, and to limit the total environmental impact of the production and consumption of goods. The UNEP definition includes life cycle and value chain perspectives, from raw materials extraction to final use of disposal. The EPA Tasmania definition argues the need for process optimization in order to limit consumption of energy, water and materials. From the sustainability terms perspective, ReE potentially replaces the term "eco-efficiency" which had a similar definition.

"Education for sustainable development" (ESD) was defined by UNESCO (2016) as "*a learning process (or approach to teaching) based on the ideals and principles that underlie sustainability, and is concerned with all levels and types of learning to provide quality education and foster sustainable human development.*" Agenda 21 (UNCED, 1992) recognized ESD as an essential tool towards sustainability. Furthermore, the Agenda 21 described the four components of the ESD: 1) improve basic education, 2) reorient existing education, 3) develop public understanding and awareness, and 4) provide training. These components actually present tools, and ESD could represent a principle to achieve sustainability. Despite that, ESD is placed at the Principles level as it is holistically oriented, covering all the three dimensions of sustainability: environmental, economic and societal ones. Therefore, it is positioned at the centre of the Principles layer.

Two terms have been identified at the sub-system level – CE and "smart specialization" (SmS). The sub-system level introduces strategies and represents a part of a more complex system, consisting of approaches which are made of principles.

"Circular economy" has been defined by the Ellen MacArthur Foundation (2016) as "*a generic term for an industrial economy that is, by design or intention, restorative, and in which materials flows are of two types – biological nutrients, designed to re-enter the biosphere safely, and technical nutrients, which are designed to circulate at high quality without entering the biosphere*". CE is based on three principles that: a) preserve and enhance natural capital; b) optimize components and materials in use and c) foster system's effectiveness. The term comprises economic and environmental dimensions, including several principles like maintenance, reuse, recycling, renewables, regeneration, and eco-design; thus it is positioned at the sub-system level. On the other hand, from the content perspective of its definition, CE is closely linked to 'industrial ecology' with which it shares many commonalities.

"Smart Specialization" was defined as a strategy to reach economic development through targeted support for research and innovation (Midtkandal and Sörvik, 2012). It is a strategy, implementing the EU innovation policy (Foray and Goenaga, 2013). Furthermore, EU Regulation 1301/2013 defined SmS as national or regional innovation strategies with priorities to build competitive advantage by developing and matching research and innovation strengths to business needs in order to address emerging opportunities and market developments in a coherent manner, while avoiding duplication and fragmentation of efforts. Although SmS covers several priorities (topics), depending on the region, such as: agri-food, biotechnology, ICT, technologies for SD, nanotechnologies, advanced materials, etc., it can be concluded that "smart specialization" interested is in the economic dimension focusing on the future growth. In relation to the sustainability and innovation, as in a case of SmS, Hargadon (2015) argues that not all the aspects of sustainability require innovation, e.g. reducing institutional footprint through improved lighting is not an innovation; not all the aspects of innovation are sustainable, such as the latest pizza delivery application on smart phones.

The papers in this SV section build on the SmS idea in terms of natural and traditional resources for the future: transition to the CE, smart cities and communities, Industry 4.0 – factories of the future, that contribute to the Europe 2020 Growth Strategy together with innovation policies at a European level (COM, 2015). At the system level, two terms have been identified – SCP and "smart city" (SmC). A system level consists of interdependent and related sub-systems, and according to the hierarchy represents the highest level of activities to achieve sustainable development.

"Sustainable consumption and production (SCP)" is about *"the use of services and related products which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of further generations"* (Oslo Symposium, 1994). The concept of SCP was later recognized in the Johannesburg Plan of Implementation, adopted at the World Summit on SD (2002). SCP aims at "doing more and better with less", increasing net welfare gains from economic activities by reducing resource use, degradation and pollution along the whole lifecycle, while increasing quality of life. It involves different stakeholders, including businesses, consumers, policy makers, researchers, scientists, retailers, media, and development agencies, etc. It also requires a systemic approach and cooperation among actors operating in the supply chain, from producer to final consumer. It involves engaging consumers through awareness-raising and education on SC and lifestyles, providing them with adequate information through standards and labels, and engaging in sustainable public procurement, among others (UN, 2015).

"Smart city" is a more 'fuzzy' concept, where many definitions exists and the term is mostly used in a non-consistent ways (Albino et al., 2015). All the definitions have in common that the SmC is a developed urban area, creating sustainable economic development and high quality of life through investing in human and social capital, including a modern Information and Communications Technology (ICT) infrastructure, wise management of natural resources and participatory government (Caragliu et al., 2009; Business Dictionary, 2016). Schaffers et al. (2011) argue that the SmC definition balances economic and social demands, and emphasizes the process of economic recovery for well-being purposes. Although "the smart city" comprises environmental management, its prevailing dimensions are of economic and societal orientation. Based on the definition and key components (living, economy, people, governance, mobility, and environment), the term can be positioned at the sustainable system level, located at the edge between the economic and social dimension nodes.

4. Summary of the Papers in this Special Volume Section

This section briefly presents a summary of the articles in this SV section. As Figure 1 demonstrates, sustainability terminology is a complex relationship between social, economic and environmental principles, and a range of policies, systems, sub-systems and approaches. These relationships become ever more complex as new terms are added and definitions of existing terms change as a result of new thinking, academic research, global policy development, and the application of theoretical models in real-life situations.

The papers in this SV section start with a number of theoretical papers around the broad theme of SCP & ReE (papers 1 to 3). These are followed by a series of papers related to ReE and water use systems (papers 4 to 9). Paper 9 relates to ReE in the textile industry and it is within that same industry that paper 10 examines a CP assessment for a textile mill. That paper also examines ReE and energy efficiency, which are discussed in papers 11–13. The final paper in the SV section considers the development of a holistic model for sustainable urban development (paper 14).

Paper 1 (Siva et al., 2016): The authors carried out a review of literature into how Quality Management (QM) methods, tools and practices have been used in conjunction with SD initiatives. Articles were identified by searching multiple research databases followed by review of articles in two rounds, while a snowballing review identified further articles, with 67 articles reviewed in total. Those articles were then coded for basic quantitative analysis with articles being classified under four themes: (i) supporting sustainability through integration of management systems; (ii) QM as support to environmental management system implementation and to managing sustainability; (iii) supporting integration of sustainability considerations in daily work; and (iv) supporting stakeholder management and customer focus. Following analysis of the literature reviewed, based on the coding criteria, a thematic analysis was undertaken to identify correlations between themes and criteria. The authors identified that the majority of research has been conducted under themes (i) and (ii) above, relating to management systems. They identified the need for further research on how to link integrated management systems (IMS) to critical business processes, for example, and the need for QM practices and tools to be developed and adapted to support SD.

Paper 2 (Maletic et al., 2016): The authors examined corporate sustainability practices of manufacturing and service industry organizations in five countries: Germany, Poland, Serbia, Slovenia and Spain. Using a web-based survey for primary data collection, the authors questioned whether sustainability exploitation (SEI) and sustainability exploration (SER) practices were characterized by the country of origin of an organization. Multiple regression with categorical predictors (dummy variables) was used to examine whether country of origin had any statistically significant effect on five organizational performance measures; financial and market, quality, innovation, environmental and social performance. The authors identified that there is evidence of differences in both SEI and SER implementation based on country of origin, with legal and institutional factors in those countries influencing the way organizations approach corporate sustainability challenges and gain performance benefits from sustainability practices.

Paper 3 (Jonkute et al., 2016): The authors reviewed the literature on models, frameworks, roadmaps and approaches related to corporate sustainability and SCP for the period 1993–2015. Arising from their analysis of the literature, they presented a detailed theoretical model for the implementation of SCP in companies. The SURESCOM (SUstainable and RESponsible COMpany) model is based on a classical closed loop cycle scheme for management systems. That model integrates a number of widely-accepted SD measures and tools including RE and CP, industrial ecology, life cycle assessment, eco-labelling, and corporate social responsibility, for example. It integrates environmental, social and economic aspects of sustainability, offers practical solutions, incorporates a range of engineering, management and communication tools and measures, and engages with a range of stakeholders. An algorithm for integrated sustainability assessment of the overall company state was developed as the basis for application of the SURESCOM model. That algorithm, comprising of 10 stages, was applied in two Lithuanian enterprises, a telecommunications company and a construction and real estate company. Sustainability indicators were identified from existing sustainability reporting by those companies. These indicators were then analysed to produce an integrated index for the overall sustainability state of the companies. The SURESCOM model, together with the algorithm for its application, can be adapted for companies in various sectors and can help companies select and introduce appropriate tools to achieve environmental and social performance goals.

Paper 4 (Arampatzis et al., 2016): The authors considered the eco-efficiency assessment of a water use system at the meso-scale and the estimation of eco-efficiency improvements, based on the findings of the EcoWater Toolbox, developed from the Eco-Water project (2014) and which has been adopted as an online platform from that project. The Toolbox, which combines a "Systemic Environmental Analysis Tool (SEAT)" for environmental assessment and an "Economic Value-chain Analysis Tool (EVAT)" for economic assessment, supports a four-step process to assess a water use system through system framing, baseline eco-efficiency assessment, identification of technologies and technology scenario assessment. Detailed information on the structure and functionalities of the EcoWater Toolbox were presented, including discussion of the system architecture and its accessibility and functionality for different user groups; six system wide user groups and three case study-specific user groups. The scope, objectives, operational aspects and methodology of both SEAT and EVAT modelling tools were outlined, together with a demonstration of the Toolbox looking at environmental impacts and eco-efficiency performance of the water value chain in a milk production unit. The various stages of the process, from baseline eco-efficiency assessment (environmental and economic), through to identification of technologies and technology scenario assessment, were presented, including a graphical presentation of eco-efficiency indicators in three different scenarios. The authors identified that the Toolbox had been successfully tested in eight case studies, in three different sectors of water use. They identified that the strength of the Toolbox is to support decision making through comparison of two or more alternative configurations within a given system, identifying that while it cannot dictate the most eco-efficient option, it can assess trade-offs between environmental and economic performance and assist in prioritizing future actions).

Paper 5 (Angelis-Dimakis et al., 2016a): The authors undertook a systematic assessment of eight alternative water use systems of which two were agricultural ones (see Mehmeti et al, 2016 and Maia et al, 2016, in this SV section), two water supply systems in cities (one of which, Stanchev et al., 2016, is discussed in this SV section), and four industrial water use systems in the textile, dairy and automotive industries and relating to cogeneration of thermal energy and electricity. The textile industry case study is also presented in this SV section (see Angelis-Dimakis et al., 2016(b)). The authors used the meso-level methodological framework for the eco-efficiency assessment of such systems developed by the EcoWater Project. They used a four stage process to: (i) map each system and its respective value chain, (ii) assess each system's eco-efficiency using a life-cycle oriented approach, (iii) select innovative technologies, and (iv) to determine feasibility of implementing those technologies for each system. The SEAT and EVAT modelling tools were used to conduct economic and environmental assessments for three scenarios for each case study. The scenarios considered the potential for improvements in environmental performance of water systems for each of the eight case studies through implementation of innovative technologies in terms of ReE, pollution prevention and CE. `The authors identified that the systemic approach of the EcoWater methodological framework provides concrete, comprehensive economic and environmental performance assessment of a water use system. A number of weaknesses were, however, also identified, as was the need for further case studies to help validate the method and develop a system for cross-sectoral technology benchmarking.

Paper 6 (Mehmeti et al., 2016): The authors investigated options for improved eco-efficiency in irrigation in the Apulia Region of South-East Italy. Using a multi-criteria meso-scale approach and modelling tools developed through the Eco-Water project the authors have set out a new methodological approach to better understand the interactions between different processes taking place in an agricultural water-use system. Those processes include: hydrological patterns (rainfall), fertilizer inputs, energy consumptions (including gas emissions), market price of agricultural products, and adoption of new technologies. A system-based approach was used to assess eco-efficiency improvements from adoption of various innovative technologies in order to identify environmental impacts, relevant costs, and added value of implementation of those technologies across three irrigation zones and 14 operational districts in the Apulia region. The EVAT assessment tool from the Eco-Water project was used to develop a baseline eco-efficiency assessment for the region, based on historical rainfall data, for example, and from this a graphical representation comparing the baseline for a normal year with that of a dry year was presented. Four technological scenarios were then selected, following consultations with local stakeholders, and the economic impacts of those scenarios were considered using life-cycle assessment tools conforming to ISO 14040–14044 requirements. The scenarios were compared with the baseline year and considered their impact on a range of factors such as climate change, fossil fuel depletion, human toxicity and mineral depletion, for example. This approach enabled the authors to assess alternative technological solutions across the entire life cycle, and identified the potential impact of the different scenarios on both the environment and economic productivity in the region.

Paper 7 (Maia et al., 2016): The authors examined the eco-efficiency assessment, at meso-scale, of water efficiency in the agricultural irrigation perimeter of Monte Novo in southern Portugal. They considered the potential benefits of the transition from rain-fed agriculture to irrigation based on new economic activities and new standards in innovation and technology. An eco-efficiency assessment in five phases was undertaken: (i) goal and scope definition; (ii) environmental assessment, using LCA; (iii) value assessment, considering the full life cycle of the system calculated in monetary terms; (iv) quantification of eco-efficiency, estimated as the ratio between the value of the product/service and the environmental impacts identified; and (v) interpretation. Factors considered in the assessment included resource usage (chemicals, energy) and raw materials (fertilizers, electricity), and a baseline scenario was developed against which an economic assessment of the different eco-efficiency agricultural improvements was made. Five scenarios were developed to consider the application of different eco-efficiency improvements against the baseline scenario, with economic costs (investment, management and operation costs) also considered in the assessment. Graphical representation of eleven eco-efficiency indicators were developed for each scenario and comparison between the baseline scenario and the eco-efficiency improvement scenarios enabled the authors to identify the best scenarios for maximizing economic productivity and reducing environmental impacts. General recommendations to increase eco-efficiency in the Monto Novo irrigation perimeter were proposed including changes in crop type and in agricultural practices in the region, for example.

Paper 8 (Stanchev et al., 2016): The authors examined the application of the recently published (2012) ISO 14045 international standard on eco-efficiency assessment for urban water systems. Their study expands on earlier work on assessing environmental performance using the life-cycle analysis (LCA) approach, and noted that environmental assessment has generally been applied to single elements of the urban water system such as water supply system, wastewater treatment, sludge treatment, for example, and do not address the entire urban water system or the new ISO 14045 standard. The authors presented the general framework of that standard and examined the complex nature of urban water systems from water abstraction to waste water treatment, and which includes the provision of drinking water, the domestic water supply system and the sewerage system. They discussed the possible adoption of ISO 14045 for urban water systems, including defining those systems, environmental assessment, determination of economic value, and undertook a test exercise using the urban water system of Sofia, Bulgaria. They concluded that the general framework of ISO 14045 can be applied across complex water systems in order to make assessments against a range of baseline eco-efficiency indicators.

Paper 9 (Angelis-Dimakis et al., 2016b): The authors assessed the eco-efficiency of a water use system for the textile industry in the Biella region of Northern Italy using the methodological framework developed by the Eco-Water project as it applies to an industrial water use system. Using that framework the authors examined two representative units of the textile industry, a unit with an in-house wastewater treatment plant where the dyeing process uses standard chemical methods, and a unit which uses both standard chemical and also natural herbal dyes in separate production lines and which is connected to the municipal wastewater network. These were selected as being representative of the more than 500 small and medium industrial units in the region. Environmental performance of the selected units was assessed through eight environmental midpoint indicators representative of the specific system and relevant to the textile industry. A value assessment of the financial costs of each unit was undertaken, together with an eco-efficiency assessment. Six innovative technologies were selected for implementation within the current system and were examined against two alternative technology scenarios; increased ReE, focusing on freshwater, pollution prevention and control, and on the treatment of water effluents. Those scenarios targeted the main regional issues of fresh-water resource depletion and toxicity of effluents discharges into the river. The authors identified that all technologies had the potential to improve the environmental performance of the system under both scenarios. Despite this, the pollution prevention and control scenario was considered not economically viable due to high investment while the RE scenario required additional economic incentives and governmental support to be considered as feasible by industrial stakeholders.

Paper 10 (Ozturk et al., 2016): The authors undertook a CP assessment study of a cotton/polyester-dyeing textile mill in Denizli, Turkey. All processes within the mill were defined in terms of input-output, specific consumption and waste generation/emissions calculations. Consumption of resources included water, energy and chemicals, while waste generation included wastewater, waste flue gas, waste heat and solid wastes, and these were identified through on-site inspections. Company-wide mass-energy balance analyses were performed and evaluated in terms of CP assessments, with specific mill performance criteria compared to similar mills and integrated pollution prevention and control (IPPC) measures. A CP suggestion list was prepared, initially with 92 Best Available Technology (BAT) options, from which feasibility analyses were subsequently performed for 22 BAT suggestions, selected using a range of different statistical methods. Onsite CP evaluation studies were conducted for water consumption and wastewater generation; for chemical consumption and chemical industry, for energy consumption and flue gas emissions, and for solid waste generation. Evaluation of existing resource consumption and environmental performance was benchmarked against other mills and international industry standards in the literature for the 22 BAT options. The study identified potential benefits and savings to the mill through reductions in water, energy and chemical consumption, and a decrease in wastewater generation, chemical oxygen depletion load, flue gas emissions, and in solid waste generation, should the BAT be implemented in the future. The study also identified the payback period for the various BAT options.

Paper 11 (Vukadinovic et al., 2016): The authors considered the connection between implementation of resource efficient and cleaner production (RECP) in coal thermal power plants in Serbia and the potential to reduce carbon intensity of power generation in those plants. They studied the largest electricity generating company in Southeast Europe which produced more than 50 % of electricity annually for Serbia, from 14 power generation units across 5 sites. They identified solutions to modernize existing units by increasing capacity and reducing specific energy consumption, together with reductions in emissions to air and water and waste generation. Analysis of collected data against specific performance indicators produced a number of RECP options across the company. More detailed analysis of a single thermal power plant with 6 power generation units was conducted and mathematical modelling was used to analyse possibilities for process optimization, new technological solutions and improvements of parts of the units to increase performance of the various units. The potential for resource and energy efficiency in areas such as water balancing and savings and energy savings, and the need for monitoring systems for emissions and pollution control measures were also considered. Many of the identified RECP measures (around 60 %) were implemented between 2011 and 2013, allowing for the collection of real data on benefits of such measures. This resulted in the development of a new approach using eco-efficiency indicators for the power plants in the areas of energy consumption, climate change, acidification and waste generation which should be applicable to similar companies.

Paper 12 (Kubule et al., 2016): The authors investigated the potential impact of energy efficiency improvements at different levels in a small brewery in Latvia, one of 21 active breweries in that country. Historical data on both thermal and electrical energy consumption and also production data for the case study brewery was analysed for a three year period (2011–2013) and was evaluated against available benchmarks for small, medium and large breweries. Specific data was also collected on the energy consumption of different types of packaging equipment at various times between October 2013 and July 2014. The authors identified monthly variations in thermal and electrical energy consumption related to outside air temperature, and in specific energy consumption related to the volume (and type) of beer produced. Specific issues associated with heat loss at the brewing stage, significantly exceeding recommended benchmarks, and to the need for improved monitoring of electricity consumption in the bottling department were identified. While some technological solutions for energy efficiency improvement had been put in place over a five year period to 2015, a number of energy efficiency barriers continued to exist, despite those changes. Those barriers included: management attitude towards energy efficiency; lack of financial capacity; and low status to energy efficiency compared to other priorities (resource and raw material efficiency), for example.

Paper 13 (Carter et al., 2016).: The authors investigated Organic Light Emitting Diodes (OLEDs) as alternative display and lighting options that have the potential for lower fabrication costs, greater versatility, and lower power consumption costs when compared to more traditional options, such as blue inorganic LEDs. LCA was used to analyse the economic, energy and environmental impacts of four different polymer-based OLEDs (P-OLEDs) architectures, with the assessment based on five metrics: device cost, including materials and manufacturing costs; yearly operating cost; cost to power the device; device CO_2 greenhouse gas (GHG) emissions; and yearly operating CO_2 emissions. Life cycle inventory (LCI) analysis was used to quantify the inputs and outputs for emissions and resources followed by a life cycle impact assessment (LCIA) to evaluate the potential environmental impacts based on the LCIA values. A number of improvements were identified to make P-OLEDs competitive in terms of operating cost, and energy and environmental impacts relative to traditional inorganic LEDs. Those improvements relate to electrical-to-optical power conversion efficiency and to extending the operational lifetime of the P-OLED (Carter et al., 2016). Comparison of various polymer-based OLEDs device architectures showed that the top-emitting inverted P-OLED is likely to be the most promising device architecture to pursue in terms of achieving operational lifetimes, device costs and efficiencies that are competitive with the blue inorganic LEDs and to achieving fully-solution processed large-scale manufacturing.

Paper 14 (Medvedev, 2016): The author identified the need for an interdisciplinary model for sustainable urban development that takes into account a range of inter-connected factors necessary to create long-term and successful autonomous sustainable neighbourhoods (ASNs). Examples of successful sustainable neighbourhoods were identified in the literature in both Northern and Southern European countries and some of those locations in Sweden and Germany were visited by the author for more in-depth study. A range of sustainable urban design (assessment) tools were examined which allowed the author to identify a network of interconnected strategic urban sustainability goals (SUSGs) and from this a "Structural model of ASNs" was proposed, based on four pillars of urban sustainability. Those pillars were: energy (and natural resources), sustainable transport, socio-economic balance, and sustainable urban design. A comparative analysis of those four pillars was conducted against SUSGs such as "Renewable Energy Cooperative" for the Energy pillar, "Efficient Public Transport" for the Sustainable Transport pillar, and "local (organic) food cooperative" for the Socio-Economic Balance pillar, for example. Through development of a holistic model of ASNs, the author has set out a framework of SUSGs based on best examples of sustainable neighbourhoods in Europe, highlighting the growing awareness and importance of socio-economic balance in urban planning in the 21st century.

6. Conclusions

The papers in this SV section present research, experiences and future developments regarding SCP. They examine recent theoretical developments in the field of SCP – theory which is then tested in real life situations through the development of standards, and of practical models and methods. These models and methods, applied in real-life situations and set out in this SV section, have the potential to be tested in other situations or contexts, and to be adapted to meet the needs of different industries, sectors, or scales, for example. They offer possible solutions, at least in part, to many of the problems and challenges identified by Hutt (2016).

The contributing authors investigated several aspects of SCP at different levels that, when considering Figure 1, relate to quality management and SD initiatives, corporate sustainability practices, and to a theoretical model of corporate sustainability. In practical areas, the papers present possible solutions to issues surrounding ReE with examples relating to: water efficiency in agriculture, urban areas, textile industry, and a brewery, CP practices in textile industry and thermal power plants, production processes, and sustainable neighbourhoods.

This SV section highlights that:

- Sustainability in companies can be supported through the integration of the management systems, and less supported through stakeholders and consumer focus – a combined bottom-up and top-down approaches are needed;
- Various European countries are already developing and using several measures and approaches that can influence sustainability evolution in companies – such measures and approaches require in-depth studies, identifying best practices and defining common recommendations, based on real-world experiences;
- The development of theoretical models, supporting the integration of sustainability at the company's level is necessary in order to test the suitability of such theoretical models; practical implementations are required to provide an evidence base to drive forward future developments in both theory and practice;
- The Eco-Water project has provided numerous valuable outputs regarding water use systems, such as eco-efficiency assessment, highlighting the requirement that increased ReE requires additional economic incentives and governmental support;
- Practical experiences, providing in-situ data and evidence of impacts on processes and systems have been studied regarding ReE, CP, and also considering LCA; and
- The development of a holistic model for sustainable communities highlighted the importance of using a socio-economic balance.

In many papers the production side of SCP was examined rather than a focus on SC. When considering Fig. 1, the papers are mostly aligned with the levels of principles and approaches, and are technology oriented, focusing also on material flows and environmental impacts. Based on this SV section and the papers contained within it, the sustainability terminology system has been extended, including six new terms and their definitions, which directly or indirectly emerged from the papers, and these new terms have been placed within the "terminology pyramid" (see Fig. 1). These terms are: resource efficiency, education for sustainable development, circular economy, smart specialization, smart city, and sustainable consumption and production.

Current global challenges, including social, economic, environmental and political questions are complex, holistic and must be considered as such. The papers in this SV section have shown that ReE, CP, and environmental management are important topics to approach sustainability in companies and industries, however technology and engineering will not be able to solve all the challenges. In order to achieve the 'Europe we want', emphasis should be given to changing lifestyles and improving collaboration on several political levels from international to local, especially considering a bottom-up and stakeholders' approach.

Another important issue of covering a systemic approach when considering SCP is that this kind of research shall not be de-coupled, but interlinked, making results more holistic and broadening the view of stakeholders. Also, a re-consideration should be given to existing financial supports for implementing sustainability measures as well – a robust and focused SCP policy is needed as it was proposed for the climate change within the Paris Agreement. Measuring a transformation towards sustainability and determining a status of a process or system from a sustainability perspective requires a concept that goes beyond GDP, developing indicators that are as clear and appealing as GDP, but more inclusive of environmental, social and political aspects of global progress.

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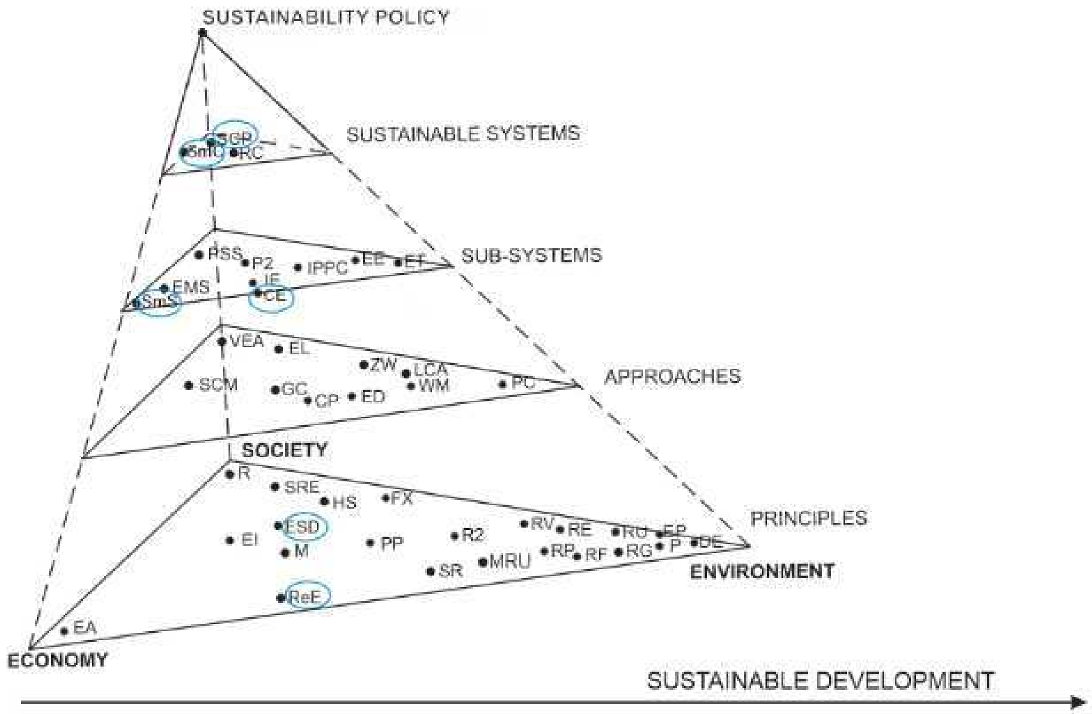
FIGURE

Fig. 1: Classification of sustainability oriented terms (updated from Glavič and Lukman, 2007)



Legend: **CE**, circular economy; CP, cleaner production; DE, degradation; EA, environmental accounting; ED, eco-design; EE, environmental engineering; EI, ethical investment; EL, environmental legalisation; EMS, environmental management strategy; **ESD**, education for SD; ET, environmental technology; F*X*, factor *X*; GC, green chemistry; HS, health and safety; IE, industrial ecology; IPPC, integrated pollution prevention and control; LCA, life cycle assessment; M, mutualism; MRU, minimization of resource usage; P, purification; PC, pollution control; PO, policy; PP, "polluter pays" principle; PSS, product service system; P2, pollution prevention; RC, responsible care; R, reporting to the stakeholders; RE, recycling; **ReE**, resource efficiency; RF, remanufacturing; RG, regeneration; RP, repair; RU, reuse; RV, recovery; R2, renewable resources; **SCP**, sustainable consumption and production; SCM, supply chain management; SD, sustainable development; **SmC**, smart city; SP, sustainable production; SR, source reduction; SRE, social responsibility; **SmS**, smart specialization; VEA, voluntary environmental agreement; WM, waste minimization; and ZW, zero waste.

Highlights

- A Special Volume section of the Journal of Cleaner Production
- Policy directions and sustainability terminology are explored.
- Authors demonstrated theoretical and practical contributions to SCP.