

Editorial

The Circular Economy Challenge: Towards a Sustainable Development

Alessia Amato 

Department of Life and Environmental Sciences-DiSVA, Università Politecnica of Marche, Via Brecce Bianche, 60131 Ancona, Italy; a.amato@staff.univpm.it

As it is now known, we have only one earth available for our life and it is our duty to preserve it.

The more recent manifestations in the squares worldwide confirm the increase of people's awareness of this subject. Nevertheless, the forecast is not promising to describe a resource consumption equal to three planets by 2050 [1] and the effects are in front of our eyes, just think of the biodiversity loss, the water stress and the climate change. Furthermore, the effect on the environment is often translated into economic impacts, the increase of the social gap and the poverty growth [2,3].

In this context the conversion of our economic system, from linear to circular, represents a challenge to overcome, no longer postpone.

Although the circular economy term is often reduced to the simple recycling concept, it represents a complex strategy which aims at the achievement of many ambitious targets. Among these: the increase of product life cycles, the implementation of the industrial symbiosis, the conversion of products into services, the reduction of waste production, the creation of secondary raw materials market [4]. The four main actors of the circular change are the institutions, the industry, the consumers, and the scientific research. Their actions must be closely linked to push the global markets toward the sustainability. Policies can dynamizing the low impact production and drive the consumers towards sustainable choice. On the other hand, the research could supply innovative solutions to the industries, increasingly interested in low impact technological innovation.

In this regard, the COVID-19 pandemic has given us an important lesson proving the resilience of our global market and its conversion rate to respond to the sudden change of consumer demand. The pandemic has proved the capability of consumers, companies and researchers to act on the product design for example for the production of disinfectants from residual products and face masks from textile leftovers for hospitals [5]. COVID-19 has tested the ability of countries to provide solutions (in a very short time) able to combine all the circular characteristics: repairability, reusability, and potential for remanufacturing, proving the relevance of secondary raw materials stocks and the competitiveness of countries [5].

Considering the results achieved in the most critical period of COVID-19 crisis, we should be able to transform the crisis into a chance. The current step of world recovery from pandemic must be the opportunity for the removal of barriers (bureaucratic, technical and economical) that often slow down the conversion to an effective circular economy [6].

The possibilities offered by the post-pandemic period to match the targets of circular economy and the Green Deal are discussed by Bucea-Manea-Toniş et al., in the first contribution of Special Issue. They have carried out an analysis of competitiveness and innovation focusing on Romania and Serbia, an emerging country from the EU and EU accession country, respectively. They have proved a correlation between the eco-innovation index and the research and development sector, using a dual comparative analysis. The authors have demonstrated the essential role of research and human resources that, stimulated through innovative teaching in the circular economy field, produce positive effects for both society and market levels. In this transition towards a sustainable system, policies



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can make the difference by economic support and the monitoring of the best available technique use (Contribution 1).

Zhang et al. have analyzed another geographical area, considering the manufacturing sector of Pakistan. They have deepened the concept of circular economy implemented in a developing country. They have studied the connection between the constructs of total quality management and organizational sustainability with the mediating effect of knowledge management by the implementation of a structural equation modeling. The authors have proved that the transition towards the circular economy is not a very quick process and that it does not include only an industrial restructuring. There is the necessity of a structural shift and a change in the mindset, behavior, and priorities stakeholders involved in the market. They have concluded the paper discussing the necessity of the transition from a linear to a circular economy as opportunity to increase the competitiveness of companies in Pakistan (Contribution 2).

The implementation of an effective circular economy could have positive effects on several goals identified by The United Nation within the 2030 Agenda for Sustainable Development. In addition to the most obvious Target 12, related to the responsible consumption and production. In this regard, Buch et al. have proposed the circular economy as solution to address the issue of waste pickers in developing countries. They have described a cooperative system able to maximize the collection and the waste sorting (mainly plastic fraction), with an environmental gain in emission terms and an increase of landfilling site lifespans. Furthermore, the designed solution could alleviate several issues including in the 2030 Agenda, such as poverty, hunger, gender equality, and social inequality (Contribution 3).

It is evident that circular economy means new opportunities and Ilić et al. have chosen to analyze the European indicator of competitiveness and innovation considering both investments and patents related to the circularity field. The regression model performed by authors has identified the investment as the most crucial factor that stimulates the new patents. However, they have concluded that other elements should be added to the model for a sustainable economy, such as creating new jobs in the green field, the policy support, green public procurement, education for understanding, and the implementation of digital and transferable knowledge and competencies. The paper represents the starting point for the development of successful strategies for the overcoming of the old linear model in Romania (Contribution 4).

The availability of sustainable processes which respect the principles of circular economy represents an urgent need. In this regard, Almeida et al. have compared different strategies for the exploitation of tailings from Panasqueira mine, located in Portugal and classified as the largest Sn-W deposit in Western Europe. As reported by authors, the extractive industry needs technological innovations to increase its sustainability level and decrease the resulting environmental burdens and waste to manage. The implementation of a life cycle approach has allowed to estimate the benefit of an innovative approach able to combine the recovery of raw material, with the removal of hazardous As and the H₂ recovery which could drive the mine towards a clean energy transition (Contribution 5).

An interesting reflection is proposed in the Contribution 6, where authors have discussed about construction and building sector, one of the key value chains reported in the European circular economy action plan [4]. They have analyzed the vernacular architecture in Egypt, the oldest civilization in the world, identifying the compliance with the principles of circular economy (i) Refuse, Reduce, Reuse, Repurpose and Recycle, (ii) Reduce by design, (iii) Repair, Refurbish and Remanufacture. Starting from the case study analysis, Debaieh et al. have suggested to draw inspiration from vernacular architecture to considerably reduce the impact of modern buildings (Contribution 6).

A connection with key product value chains could be recognized also in Contributions 7 and 8 (in particular Batteries and vehicles and Electronics and ICT), which have addressed issues related to end-of-life batteries and printed circuit boards, respectively. As reported by Giosuè et al. the self-sufficiency in the battery sector is one of the most ambitious European

targets. Indeed, the demand of raw materials for battery manufacturing is expected to increase due to the growing diffusion of electric vehicle, in response to the Green Deal objective of reduction of the transport emissions [7]. The relevance of this topic has pushed the authors to undertake the study of regulations on end-of-life batteries in different European countries. The paper has allowed the identification of strength and weaknesses of policies, highlighting the necessity of a creation of a homogeneous reference schema for waste collection, able to improve the further recycling. The results have identified the need of specific regulations dedicated to Li-ion batteries to avoid loss of valuable materials to send to exploitation (Contribution 7).

The development of urban mining strategies, where the waste becomes a resource of secondary raw materials in agreement with the circular economy pillars has been discussed in the Contribution 8. The choice of printed circuit boards as waste to treat has been due to a double reason: the availability of high quantities of this kind of equipment (for its use in many applications) and its metal concentrations, higher than that the ores. Therefore, the identification of sustainable processes is essential to reduce the waste flows to manage and to create relevant stocks of valuable elements. In this regard, Becci et al. have developed a biotechnological approach able to extract copper from printed circuit board with high efficiency, using the fungal strain *Aspergillus niger*, avoiding the use of both high temperatures and high impact chemicals which characterize the most common hydrometallurgical treatments. In the perspective to maximize the eco-design of the process authors have suggested the use of milk whey as substrate for the fungal growth (Contribution 8).

The results described in Contribution 9 seem almost a provocation, encouraging the readers to a critical analysis of the solutions proposed in the circular economy field. The other authors, and me, have carried out a critical review of the scientific literature about the exploitation of agriculture by-products for the manufacturing of secondary products. The impact due to each process has been estimated by a life cycle assessment approach and compared to that of the corresponding traditional product (from virgin material). The results have proved that recycling is not always the most sustainable choice and that the development of innovative solutions should be always combined with a sustainability assessment, able to evaluate the real convenience of applications. These observations do not want to discourage the research of innovative recycling but want to sensitize the stakeholders to a more critical view of the available circular options (Contribution 9).

The development of the circular economy strategy has the great responsibility to face the current crisis of earth. As reported in the European action plan, the new strategy must contribute to the climate neutrality by 2050 and decoupling economic growth from resource use [4]. Innovation means opportunities so the environmental gain should be translated into the competitiveness of the EU and developing countries, as discussed in several contributions of the present special issue.

Although the topic of circular economy is a very popular topic in the current scientific literature, this special issue offers the possibility to broach the subject from different point of views. Authors belong to very different Department allowing a holistic overview that should be the foundation of an effective circular economy. The papers combine economical, scientific, engineering, mathematical approaches to face the challenge of circular economy in different corners of globe each one with specific criticalities.

List of Contributions

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