

# Chapter 20

## A Circular Economy Perspective for Dairy Supply Chains

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### ABSTRACT

*The environmental issues and the projected world population increase have brought into light many different terms and concepts. For over 20 years, sustainability attracts the main focus of most researchers; however, recently the concept of circular economy (CE) is considered to be its successor. CE is based on a closed loop supply chain, where waste is minimized and reintroduced into the supply chain, thus requiring a systemic change. In the agri-food sector, the CE principles have many possible applications. This chapter provides a CE perspective for the dairy supply chain by identifying and analyzing the associated technologies and strategies through a literature review taxonomy based on the related stage of the supply chain.*

### INTRODUCTION

Over the past few years, the emerging environmental issues have been in the center of attention of people, cities, countries and organisms all around the world. In 1992, when the United Nations Framework convention on Climate Change was adopted, the problems of climate change came to light, leading to the Kyoto Protocol in 1997 and the Paris Agreement in 2015 (United Nations, 2017a). Thus, the idea of sustainability was born. It is based on three pillars: the environmental, the social and the economical. In order to be sustainable, a product, company or country needs to balance these three aspects.

At the same time, Circular Economy (CE) has recently gained in importance, with the academic world, policymakers and companies realizing its worth (Geissdoerfer, Savaget, Bocken, & Hultink, 2017) and the EU promoting it (Korhonen, Honkasalo, & Seppälä, 2018). This concept gives life back

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to the product after its use, aiming to reduce, reuse, recycle and recover materials, as the 4R Framework suggests (Kirchherr, Reike, & Hekkert, 2017). It is an alternative model to the traditional Linear Economy following the 'take-make-dispose' pattern resulting to environmental and economic impacts (Ellen MacArthur Foundation, 2012).

CE is considered to be a means to achieve sustainability (Ellen MacArthur Foundation & McKinsey Center for Business and Environment, 2015), but there are major differences as well, e.g. their purpose, priorities and beneficiaries (Geissdoerfer et al., 2017). Their main connection is their way of thinking; CE combines sustainability and closed-loop supply chains into the business model of the industry (Preston, 2012), with sustainable development being its main goal (Kirchherr et al., 2017). Thus, while the two have common ground, CE focuses more on the environmental and economic aspects.

Along with the environmental issues, by 2050 the World's population will have reached 9.5 billion people according to UN's projections of 2017 (United Nations, 2017b). This will result in an increase of agricultural production, which is affected by the existing climate change but can also have a negative impact on the environment. The sector is developing globally, with 28.06% production growth in 2016 compared to the 2004-2006 period (FAO, 2018), while it employs 30.7% of the total workforce (World Bank, 2019). Agri-food supply chains, technological solutions for energy production and waste management are only some of the main challenges today. As a result, the term Circular Agriculture, i.e. Circular Economy in Agriculture, has been introduced.

One of the basic types of agriculture is livestock farming. Animal products, by-products and co-products are important for human nutrition and the economy, with the annual consumption achieving an annual growth of 1.2, 0.4 and 1.5% for meat, milk and eggs respectively (FAO, 2013). Dairy products in particular have a critical role, as they are important for human nutrition and development throughout life and represent around 14% of total calorie consumption (FAO, 2013). However, they have an undeniable impact to the environment. According to FAO, more than 10% of Dairy products are lost or wasted in Europe, a lower percentage than most regions but significant nonetheless (FAO, 2011). Most of that percentage is during the consumption period (40-60% of the total), however the percentage during agriculture is also high. Other than waste, there are other important issues; the animals themselves and their feed, the production and distribution of products, but most importantly what happens with leftover products and wastewaters. Considering the above-mentioned population increase, all these challenges present an opportunity for the development of CE.

However, despite the importance of the dairy industry and the considerable amounts of produced waste, there is a lack in the research literature of a holistic framework that analyses the CE perspective of the dairy supply chain, while identifying state-of-the-art technologies that can contribute to this objective. This has been the key motivation for this chapter. To that end, in this chapter, the circular dairy processing system is presented as well as its additional components with respect to the conventional system. Different technologies and solutions are analyzed and discussed along with the resulting classification of relevant literature. This allows for the identification of existing gaps, overlaps and future research areas of CE in dairy supply chain.

The objectives of this chapter are to determine:

- Which are the state-of-the-art technologies aligning with the CE principles?
- How can CE be applied in Dairy Supply Chains?
- What is the future of the CE in Dairy Supply Chains?

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