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THE SEA URCHIN VALUE CHAIN

FROM WASTE TO PRODUCT

AN EXAMPLE OF CIRCULAR ECONOMY ON APPLICATIONS DERIVING FROM MARINE COLLAGEN

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LIST OF ACRONYMS

AAFC Agriculture and Agri–Food Canada

BMC Business Model Canvas

CAD Canadian dollar

CalCOFI California Cooperative Oceanic Fisheries Investigations

CCNL Contratto Collettivo Nazionale di Lavoro

CE Circular Economy

COP21 21st Conference of Parties

DMR Department of Marine Resources

EC European Commission

EDCMs Echinoderm–derived collagen membranes

EMF Ellen MacArthur Foundation

ESA Environmental Services Association

FAO Food and Agriculture Organization

FSC Food Supply Chain

GHG Greenhouse gas

GTR Guided tissue regeneration

LCA Life Cycle Assessment

HORECA Hotellerie–Restaurant–Café

MLS Minimum landing size

PUHA Pacific Urchin Harvesters Association

RoHS Restriction of Hazardous Substances Directives

TLBMC Triple–Layered Business Model Canvas

UN United Nations

WCGUA West Coast Green Urchin Association

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INTRODUCTION

In the last decade, circular economy (CE) has become one of the most discussed issues in the European and non–European political debate (Monier, V. et al., 2014), as a result of continuous and increasingly evident phenomena related to climate change and the growing emissions of greenhouse gas (GHG) (Zafeiriou et al., 2018).

The traditional linear economy model based on extraction, processing, production and waste no longer seems to be functional in a world where natural resources are starting to run out (European Commission, 2014).

According to the United Nations, the world population will reach 9 billion by 2050, causing several problems in terms of food security and in the increasing consumption of raw materials (Hamam et al., 2021). Therefore, rulers are called upon to pay attention to alternative forms to reduce pollution and waste of these resources, thus inserting the topic of circular economy in the political agenda (European Commission, 2015, 2014; Monier, V. et al., 2014). Sustainable economic growth has several purposes: mitigate price volatility, improve food security in the poorest regions of the planet, limit waste of resources, reduce environmental impact and create new jobs (Kalmykova, Y. et al., 2018). Indeed, precisely with regard to the last point, according to the Environmental Services Association (ESA), the circular economy in the United Kingdom has encouraged the hiring of about 50,000 new jobs and USD 12 billion in investments (ESA, 2013). In this context, in 2015 the European Commission (EC) introduced the First Action Plan in its agenda with the aim of helping Europe in a process of transition from the linear to the circular economy (Smol et al., 2020). The Action Plan provides for 54 measures that seek to close the life cycle of products: from production to consumption and waste management (European Commission, 2019). A further step forward was taken by the EC last March 2020, with the adoption of the European Green Deal (European Commission, 2020). This aims to achieve climate neutrality in Europe by 2050, restore biodiversity and incentivize a society that is balanced with a clean and cost–efficient circular economy (European Commission, 2020; Smol et al., 2020). In addition, the Green Deal is committed to supporting the supply, the use of renewable energy sources, by–products and the reuse of waste and residues (Raimondo et al., 2021).

In many countries, without contribute from the legislator (e.g., subsidy, frameworks, taxes, etc.), an autonomous and convinced awareness on the part of citizens in adopting initiatives to contrast climate change is still missing. It is therefore necessary to rethink the world economic system in a new perspective, which makes eco–innovation and better food waste management its strengths.

Regarding to this latter aspect, FAO estimates that about 1.3 billion tonnes of food are lost or discarded every year, equal to one third of total edible food (FAO, 2019). Nowadays, with the increase in fish consumption, most wild fish stocks are classified as fully exploited, with several species facing extinction (Delgado, C. L. et al., 2003). Moreover, a remarkable share of waste is represented by the discarded fish, which includes many species and by–catches (Caruso, G., 2015). Fishing waste is estimated to exceed 20 million tonnes each year, about 25% of the annual world harvest (Caruso, G., 2015; Kim, S. K. and Mendis, E., 2006). Therefore, this is an increasingly emerging problem, even because fish industries are suspected of being responsible for significant risk to the environment (Arvanitoyannis, I. S. and Tserkezou, P., 2014). The fish waste occurs for several reasons: products that are caught but not sold because they have a low commercial value (Caruso, G., 2015), damaged goods, inadequate management of the supply chain, improper storage of the product and finally waste deriving from domestic consumption (Zilia et al., 2021). There are also species such as sea urchins, where waste is abundant due to the high content of inedible parts, such as shells, spines and viscera (Raman, M. and Gopakumar, K., 2018). Lacking management of fish waste and overfishing have several negative implications on ecosystems and the protection of marine species (e.g., damage to habitats, illegal fishing, endangered fish species). Therefore, from food waste, the reuse of discarded fish represents a valid tool to reduce the environmental impact of fishing (Caruso, G., 2015) and to promote new forms of sustainable business through more virtuous economy. In addition to better waste management and the reuse of waste to obtain biomaterials or energy sources, by implementing a circular economy approach it is also possible to maximize the value of food production and to reduce waste (Borrello et al., 2020a).

Therefore, this study aims to provide concrete examples of circular economy such as the creation of new products deriving from sea urchin waste and the sustainable transition in the sea urchin industry.

The monograph is organized as follows: Chapter 1 provides a literature review of the key topics of the work such as the concept of circular economy and waste management, through an integrated model. Chapter 2 provides a brief description of the sea urchins biology and habitats. Chapter 3 analyses the global sea urchin trade and the supply chain. reuse of waste in several sectors such as biomedicine, cosmetics, and pharmaceuticals. It will be analysed also the potentials deriving from marine collagen extracted from sea urchin waste. Chapter 4 provides an accurate description of the transition from food waste, specifically fish products and sea urchins, to reuse in various sectors such as biomedicine, cosmetics, and pharmaceuticals. It will be analysed also the potentials deriving from marine collagen extracted from sea urchin waste. In Chapter 5, it is explained the market survey, carried out with a questionnaire administered via web, about the use and opinions of participating consumers of future eco–sustainable products made with sea urchin scraps. Chapter 6 broadly analyses the concept of business models in the literature, focusing on the Business Model Canvas methodology applied to companies that process sea urchins. In addition, this chapter focuses on a Triple–Layered analysis for the sea urchins industry's transition, focusing on the main items that make up the environmental and social layers.

CHAPTER I

CIRCULAR ECONOMY AND WASTE MANAGEMENT

LITERATURE REVIEW

1.1. Circular Economy Concept Overview

Today, the consequences caused by human activities exceed the resilience of ecosystems around the world (Borrello et al., 2020b). Therefore, in recent years, a greater awareness is emerging in making efforts to implement a transition into a circular economy system (Borrello et al., 2020b). Consequently, the discussion on the circular economy is attracting wide interest not only at the political and public debates, but also in the academic literature (Hamam et al., 2021). Indeed, there are many articles in the literature that try to define and explain the concept of circular economy. The origin of the term "Circular Economy" dates back to the late 1970s when Stahel and Reday (Stahel, W.R. and Reday, G., 1982) conceptualized a cyclical economy that could be able to limit waste, increase jobs and ensure the efficiency of natural resources.

Other scholars, like Ghisellini et al. (2016) (Ghisellini, P. et al., 2016) attributed the concept of circular to Pearce and Turner (1989). For these two economists, natural resources are able to influence the economy in providing inputs for production and consumption and outputs in the form of waste (Pearce, D.W. and Turner, K., 1989). To explain the circular model, they started by analysing the characteristics of contemporary linear and open–closed economic systems in which production, supported by capital goods, is aimed at the production of goods of consumption, whose ultimate goal is to create utility (Andersen, M.S., 2007).

To explain the transition from an open–closed to a circular system, it's important to understand the link that exists between used resources and residual waste (Andersen, M.S., 2007).

As the first law of thermodynamics states, that is, the energy and matter considered, remain constant in a closed system, it is also true in a circular economic system, in which the amount of waste generated in a given period must correspond to the quantity of depleted resources, so as to avoid failing (Andersen, M.S., 2007). In contrast to the linear open–ended system, capital goods in the circular model play a temporary role as resources for the production processes (Andersen, M.S., 2007), but after being consumed they turn into waste. Consequently, if it is considered the recycling factor, a part of the waste can be transformed into resources, thus starting a new production cycle.

However, according to Georgescu–Roegen (Georgescu–Roegen, N., 1971) not all waste can be recycled because of the second law of thermodynamics–entropy. Indeed, the process of recycling and recovering waste materials requires additional energy (Georgescu–Roegen, N., 1971). This recovery will never be total, but will produce other waste or collateral products (Korhonen, J. et al., 2018). For this reason, even the circular economy shows limits, specifically that of dissipating materials that are lost in the ecosystem and which are then impossible to recover (Korhonen, J. et al., 2018). A solution to this problem, at least in theoretical part, could be to always use renewable energy from the sun, for the entire recycling process. This solution, however, would require large investments and a lot more work to complete the whole cycle.

To better understand the concept of circular economy and its operating principles, it has been possible to find in the literature several reports and articles concerning the CE, published over the years by the Ellen MacArthur Foundation.

The most recent and recurrent definitions are the following: «an industrial economy in which material flows keep circulating at a high rate without entering the biosphere unless they are biological nutrients» (Ellen Macarthur Foundation, 2012); «an industrial economy that is restorative by intentions; aims to rely on renewable energy; minimizes, tracks and eliminates the use of toxic chemicals; and eradicates waste through careful design» (Ellen Macarthur Foundation, 2013); «an economy that provides multiple value–creation mechanism which are decoupled from the consumption of finite resources; in a circular economy, growth comes from "within", by increasing the value derived from existing economic structures, products and materials» (Ellen Macarthur Foundation, 2015a, 2015b).

Since the circular economy is not yet a common economic model because of application limits, already mentioned, it therefore remains a widely debated topic by economists and academics. However, among the most optimis-