Non-conventional applications of circular economy

Anastasia Thoma

SCHOOL OF ECONOMICS, BUSINESS ADMINISTRATION & LEGAL STUDIES

A thesis submitted for the degree of

Master of Science (MSc) in Bioeconomy

December 2019
Thessaloniki – Greece

Student Name: Anastasia Thoma

SID: 4402180011

Supervisor: Dr. Savvas Genitsaris

I hereby declare that the work submitted is mine and that where I have made use of another's work, I have attributed the source(s) according to the Regulations set in the Student's Handbook.

December 2019

Thessaloniki - Greece

Abstract

This dissertation was written as part of the MSc in Bioeconomy at the International Hellenic University. Circular economy is a concept with increasing interest for the academia, policy makers and the business sector and is presented as viable economic model providing for cheap raw material sourcing, energy, water and input savings and solutions for product disposal. While it has only recently become popular, circular economy practices have been active for a quite a long time. These can be characterized as “conventional”. This study focuses on non-conventional circular economy applications which derive their raw materials from waste streams mainly of the agricultural, textile and plastic sectors. The circular angles examined are the production processes, the ways of product and company promotion, the social engagement of the companies and the reporting and certification possibilities and practices.

Keywords: circular economy, innovative, waste stream valorization

Acknowledgements

My warmest thanks to my supervisor, Dr. Savvas Genitsaris, for his scientific insight and suggestions and also for his constant support and encouragement.

Anastasia Thoma

31.12.2019

1. Introduction

1.1 Definitions of the Circular Economy

Circular economy can be identified as a multi-level, socio-constructed concept that can either be considered a paradigm shift, a new toolbox, a conceptual umbrella or a portmanteau discipline. In the 20th century it began being discussed in the 1960's and continues to develop until today (1, 2). It has roots in schools of thought such as ecological transition, green economy, functional economy, life cycle thinking, cradle-to-cradle, shared value, industrial ecology, extended producer responsibility, ecodesign, loop economy, lake and loop economy and material efficiency (1, 3).

Circular economy is a hot topic in academic circles. It has begun to be referred to as a defined field of research, distinguished from the schools of thought that constitute its basis, since 2006. Scientific publications are increasing by the year and appear mostly in journals with a focus on environmental sustainability (4). At policy level, circular economy or similar practices appear in European countries both at national and at EU level, while some of the United Nations Sustainable Goals could be achieved with circular economy applications. All this activity has resulted in the production of several reports and policy papers by consulting firms, foundations, institutes etc. At practical level, there are many businesses claiming to apply circularity in the line of production.

As to what circular economy actually is, academic study has produced more than 100 definitions (5), some of which are mentioned below. Considering the multitude of stakeholders it was deemed necessary to include some definitions from each stakeholder category, that is academia, state organs, consultancy firms/thinking tanks and actual enterprises.

Among peer-reviewed journals, the ones that have published the most definitions are the Journal of Industrial Ecology and the Journal of Cleaner Production (5). In a paper by Blomsmba and Brennan (2017) published in the Journal of Industrial Ecology, circular economy is defined as a framework for cyclic waste and resource management as opposed to current take-make-dispose practices (2). Saachi Homrich et al. (2018), in a paper published in the Journal of Cleaner Production, define circular economy as an emerging strategy different than the traditional open-ended system, that targets scarcity of resources and waste disposal in an approach with economic and value perspective (6).

The Ellen McArthur Foundation is a charity aiming to promote circular economy. With several publications, case studies, toolkits, collaboration with business partners such as Renault and Philips and educational institutions such as the International Baccalaureate, participation in the European Circular Economy Stakeholders' Platform (ECESP) Coordination Group and present in the World Circular Economy Forum, the Foundation is one of the most important champions of the circular economy. Circular economy is defined by this Foundation as "an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models" (3).

The Waste and Resources Action Programme (WRAP) was set up in 2000 and is a charity based in the United Kingdom. WRAP performs research in resource management, initiates and manages voluntary agreements between governments, organizations, companies and community groups and conducts consumer awareness campaigns, with the aim to accelerate the transition to a sustainable and resource-efficient economy. WRAP views circular economy as an alternative to a traditional

linear economy (make, use, dispose) where resources are kept in use for as long as possible with the maximum value while products and materials are recovered and regenerated the end of each service life" (7).

The European Union launched a Circular Economy Action Plan in 2015, a Strategy for Plastics in a Circular Economy in 2018 and revised its legislative framework on waste in 2018. As a recognition for the work accomplished in the sector it was awarded by the World Economic Forum the Circular Economy Prize in 2019 (8). The action plan states that "The transition to a more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised, is an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource efficient and competitive economy" (9). According to the Greek National Strategy circular economy makes rational use of resources while it is based on the concept of recycling-reuse and the industrial symbiosis model. Its aim is the use of secondary materials and waste as productive resources and useful materials (10).

From the business perspective, furniture producer and retailer IKEA views transformation in a circular business as using resources in order to prolong the life of products and materials; turning waste, reused and recycled materials into resources; sending zero waste to landfill; having positive environmental impact; applying systems and services to enable a circular economy (11). The European Investment Bank in its guidelines for the eligibility of circular economy projects suggests considering projects that fall under any of the following categories: circular design and production, circular use and life extension, circular value recovery and circular support (12).

Having taken into consideration the above the circular economy applications presented in this study fulfill at least one of the following: their production process implements the principles of using recycled materials and waste; they use less material; they design products that can be easily repaired or taken apart; they generate less waste during the production process, and; they reuse the products after their customers do not want them or they produce items that are biodegradable or compostable.

1.2. Conventional applications of circular economy

Definitions of the word "conventional" include lacking originality or individuality; of traditional design (13). A conventional method or product is one that is usually used or that has been in use for a long time (14). While circular economy has been theorized rather recently, actual circular economy practices have been implemented for quite a long time in multiple sectors of human activity.

Clothes, necessary in everyday life, were and continue to be passed down from one person to another as the initial owner ceases to have need of it. This is a common practice between friends and family members with growing children. Beyond household level it has been associated, often negatively, with charity as several charity and religious organizations collected such items and donated them to families in need. Goodwill was founded in 1902 in Boston by Reverend Helms, a Methodist minister who collected used clothes and household goods and then hired poor people who would repair them in order to resell them or keep them. Today Goodwill is a non-profit, international organization worth more than 5 billion dollars providing training and job opportunity for the underpriviledged, accepting donated items and selling through local stores and online (15). Second-hand markets exist for many other commodities, such as furniture, tools, automobiles etc.

Another example of everyday practice is transportation. Car sharing attempts were organized for the first time in 1947 but the first professional systems took off in the

1980s beginning in Switzerland and then spreading on to Germany and other European countries followed by Canada and the USA. The service started to develop in Asia in the late 1990s, in Australia in 2003 and in South America in 2009. Today there are international companies in the market while 1,8 million car sharing members were recorded in 2012 worldwide (16).

Food banking, the procurement of surplus food that would otherwise end up in landfills and its redistribution to people in need, is a historically more recent activity than the ones described in this section. Examples of food procuring are farms with edible produce that does not meet the market standards for appearance or surplus of fresh markets at the end of the day. The first food bank was founded in 1967 in Arizona by John van Hengel. The Global Food Banking Network, established in 2006, counted in 2018 811 member Food Banks in 31 countries that distributed 472 tonnes of food for 7,78 million people (17).

In the sector of agriculture and food and feed production, such examples are numerous. Manure in pits mixed with straw or spread in the fields is mentioned in the Old Testament. Composting is also a long-standing practice, followed at household level until the 20th century, when research on the field began to be published and also companies making and trading in compost products emerged (18). Feeding animals with food waste, both at household and at farm/business level is standard practice around the world. Hydroponics offers a way to avoid soil contamination with fertilizers and pesticides and also to re-use the culture medium, although recycling of the growing media can prove problematic. Closed hydroponics systems where water and nutrients are reused can save irrigation water and fertilizer while protecting the soil and groundwater from irrigation runoff. These systems can be combined with rainwater collection (19).

In the industrial sector, a characteristic example is that of biofuels, fuels produced from biomass that have been suggested as an alternative to fossil fuels. Since 2006 several countries have legislation establishing blending mandates for fossil fuels and biofuels and sustainability criteria for biofuel production. First generation biofuels are produced from crops that are cultivated specifically for this purpose. Although these dominate the global biofuel market, they have raised concerns because part of the land used for their production is made available through deforestation or use of wetlands and peatlands either directly (Direct Land Use Change) or indirectly, claiming land formerly used for food crops and leading to land change for the cultivation of the displaced food crops (Indirect Land Use Change). Solutions for this problem are changes in legislation and advances in technology. The technological approaches explored include production of biofuels from agricultural waste, from algae or from synthetic cells (20). While all these approaches are certainly innovative, in-depth covering would require a separate paper, therefore it must be stressed that the application presented here is not at all representative of the wealth and volume of research and development of the sector.

All these approaches, either having been established for a long time or even if more recent, having very wide acknowledged applications, can therefore be characterized “conventional”. The applications described in this paper do not fall in any of the above categories, or if they do, they introduce an innovative twist, such as organization of previously household or off-the-grid activities in an enterprise; online marketing; certified resources and end products, introduction of new business models etc.

2. Selection of innovative applications and relative information

Of the numerous innovative applications of circular economy, the companies selected for this study use as raw materials either waste streams or materials generated

without deliberate human intervention. Each application has a unique characteristic, even if the raw materials or end products are similar. However there could be other companies with similar characteristics that are not presented here, for economy reasons. Although geographical representation was not a selection criterion the companies finally included in this study have headquarters, production sites or sourcing sites on all five continents.

The information presented is drawn from the companies' websites or from their sustainability reports, where available. Many companies also disclose information on the production methods but without comprehensive details, which is why their description here is much shorter. For companies producing more than one products it was not always clear whether the circular economy production methods applied only to the products featured in this study or for all their products. Also some companies apply circular production methods only to some of their facilities, which is mentioned when the information was available. Some companies produce more circular products than the ones mentioned here.

The 71 applications presented belong to the sectors of personal care, furniture, textiles and clothing, shoes and apparel, food and beverages, packaging, homeware, paper and ink and fuel and energy, while 3 enterprises not belonging to any of the above have been classified as "other". A graphic presentation is shown in Chart 2.1. The raw materials used are sourced from agricultural and food waste, textile waste, plastic waste and used tires. Other waste streams are also used, such as mining waste and paper waste. Materials other than waste include seaweeds and energy produced by trains slowing down. A graphic presentation is shown in Chart 2.2.

Chart 2.1. Circular economy applications by end product

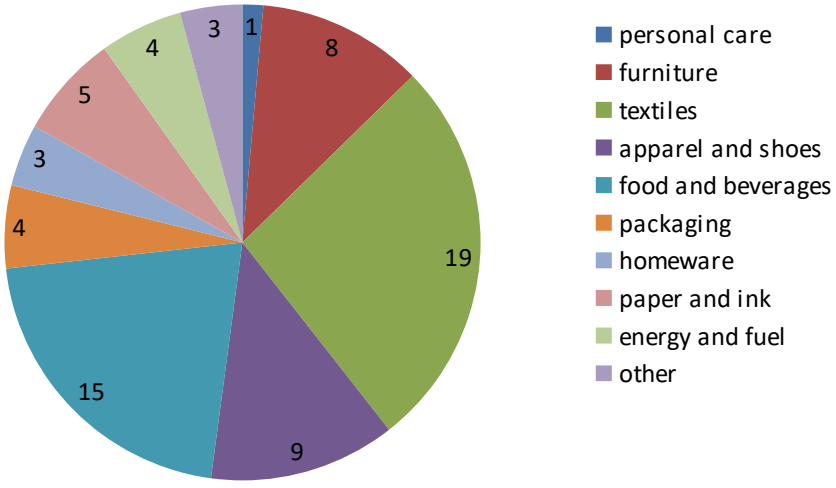
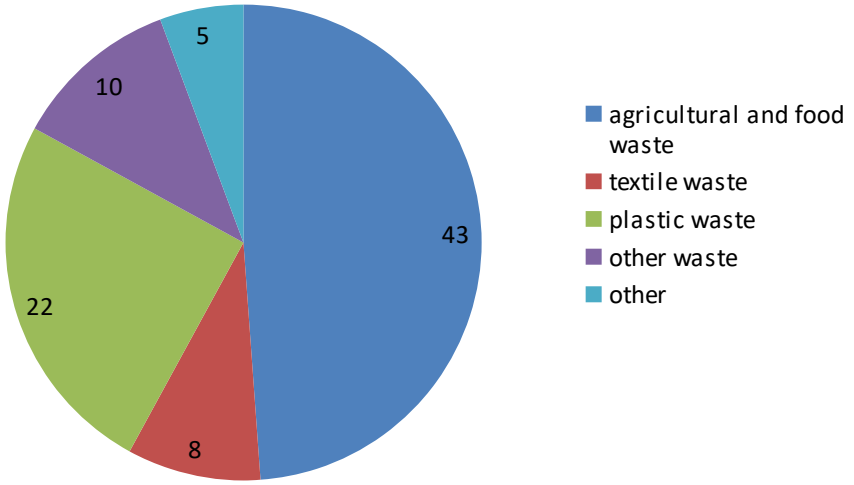


Chart 2.2 Circular economy applications by raw material



3. Non-conventional applications of circular economy

3.1 Agricultural waste

Agricultural waste is a collective term for food loss and food waste including non-edible parts of fruit and vegetables and production originally intended for human consumption but finally used as animal feed or diverted to other destinations. Disposing such waste to the environment causes serious pollution (21, 22). When burnt, especially in inadequate burning systems, such as systems used for domestic fuel, agricultural waste generates emissions with an adverse health impact (23, 24).

Food loss is the food produced but not used, from post-harvest up to, but not including, retail level. It occurs due to harvesting time decisions and weather conditions, harvest and handling practices, market changes, inadequate storage, inadequate facilities and technical problems during processing and packaging. Food not used for human consumption but as animal feed or the inedible parts of food products may be (25) or not be considered food loss (26). Food waste is the food discarded at retail and consumer levels due to aesthetic criteria, variability in demand, poor meal planning, excess buying, inadequate storage Food loss and waste was estimated around 30% of the global food production in 2011, including food originally meant for human consumption but directed to other uses (25).

In 2019 initial estimates of food loss amounted to 14% of the global food production in 2019, not including food originally meant for human consumption but directed to other uses. Food loss consisted mainly of roots, tubers and oil bearing crops, followed by fruit and vegetables, meat and animal products and cereals and pulses. Food is mostly lost in Central and South Asia followed by North America and Europe, Sub-Saharan Africa, Latin America and the Caribbean, West Asia and North Africa, Oceania, East and South East Asia and Australia and New Zealand (26).

a. Banana waste

Banana culture and processing generate a huge amount of waste (27, 28) comprising of rotten fruit, peel, branches, stem, pseudo-stem, leaves and rhizome (29). Banana plants bear fruit once a year and after harvest the aerial parts of the plant die out, leaving the bottom part of the stem and the rhizome out of which the new plants grow the next year. One tone of banana picked results in rejection of 100 kg non-marketable fruit and 4 tonnes of waste (27). While it is difficult to have an accurate picture of global banana production, since it is mostly cultivated by smallholders and consumed locally, it is estimated that in 2017 global production reached 114 million

tonnes (30). Of the global banana production, about 30-40% is rejected as non-marketable (22). Rotten fruit and peels can be used as animal feed, leaves for wrapping fruit, pseudo-stem for rope, paper, textile and boards while all banana parts can be composted and used as fertilizer (29). However often this waste is simply dumped (28, 29).

Innovative circular economy applications use this waste to create valuable products. Fibres extracted from the trunks of the banana tree are used to make biodegradable sanitary pads by an Indian company and veneer by a company in Martinique. Fresh banana fruits that are overripe, have scuffs or do not have a specific size, cannot be exported and are often left to rot. A USA-based company buys such bananas from Latin American countries and uses them to make snacks.

b. Tropical fruit waste

Tropical fruits have lately been gaining importance in the international food market. Pineapples, mango, avocado and papaya exports are showing the fastest growth rates among internationally traded food commodities. Production takes place in developing countries mainly in Asia, followed by Latin America and Africa. The farmers are mostly smallholders, possessing less than 5 ha of land and most of the production is consumed locally while only about 5% is exported. However such exports can provide for a significant percentage of the exporting country's earnings (31).

Pineapple production was estimated at 25,7 million tonnes in 2017 (31). Pineapples are either consumed fresh, canned or juiced. On-farm waste consists of leaves, stems and root remnants and is estimated at 6-8 kg per tree after harvest. The processing of the harvest of one acre of pineapples generates 9 tonnes of waste consisting of rejected fruit, and the fruit crowns, peel and core (32). Pomace of the fruit pulp that is separated from the juice must also be added to this waste (22).

One of the companies studied, uses waste leaves from pineapple production to develop a leather type fabric based on the cradle to cradle philosophy. The fibres of the pineapple leaves are extracted by on-site by the farmers and then undergo a process that generates a leatherlike textile that can be used for clothing, shoes, interior furniture and automobile upholstery. The waste produced during this process can be used as fertilizer or biofuel.

c. Coffee waste

Coffee is produced in more than 26 countries in Africa, Asia, Mexico, Central America and South America. Annual global production amounts to more than 9 million tonnes for the years 2015-2018 (33). Coffee is produced from the beans of the coffee cherry (the fruit of the coffee tree), while the rest is discarded. This is translated as about 1 kg of waste for every kg of coffee. Waste handling is difficult as the pulp is acidic, corrosive to equipment and a serious environmental threat to soils and water bodies as it is usually dumped without any processing. Environmental problems are also caused by the disposal of the water used for the coffee beans separation. Coffee pulp composting is difficult due to its high biological and chemical demand of oxygen and the high concentration of polyphenols result in poor quality fertilizers. Use of the pulp as animal feed is also problematic because of the toxic compounds contained (34). Also, in order to help the flowers develop into ripe and tasty coffee berries, farmers cut the coffee leaves which are usually burned or left to rot on the ground (35). Post-consumer waste, namely coffee grounds, often also end in landfills, where they emit harmful greenhouse gasses including methane. Around 500 thousand tonnes of coffee grounds are annually generated in the United Kingdom. Anaerobic digestion in special plants is not working very well either because coffee grounds tend to inhibit the rate of biomethane production (36).

Innovative circular economy applications show that the whole of the coffee tree and coffee production and consumption waste, instead of being a difficult to solve problem, can be creatively used. The coffee cherry pulp is used by two companies to make flour with high nutritional value, as it contains fibres, anti-oxidants, iron, potassium and calcium. The flour can be added to baked goods or beverages. Another company extracts soluble dietary fibres from the coffee cherry pulp which are used by the food and pharmaceutical industries as thickeners, emulsifiers, drug barriers and as base for biopolymers and prebiotics. Coffee husks are used for the production of (coffee) mugs while coffee leaves are brewed to make alcoholic beverages. Used coffee grounds are also a valuable raw material. They are used as substrate for mushroom farming, as well as for the creation of (coffee) mugs; for the extraction of pigments to be used for printing ink; for the creation of textiles; for the creation of high-end sneakers, and; for the production of fire logs and pellets.

d. Other fruit waste

Global production of citrus fruit (oranges, tangerines, lemons, limes and grapefruit) amounted to 131 million tonnes in 2015 (37). Citrus juice by-products consist of peel, pulp, membranes and seeds and their disposal is a problem for factories, while their use for pectin extraction, oil extraction or as animal feed is limited and not profitable (38, 39). An Italian company uses citrus juice by-products to create a cellulose-based, silky fabric.

Wine making generates marc, a mixture of grape skin, seeds and stalks that is traditionally used to make grappa. An Italian company offers an alternative, generating fabric from grape marc. In the case of table grapes, waste is produced when trimming the fruits for packing in the punnets. A British food importer together with a distiller have used these grapes, that are otherwise unflawed, to create the first premium gin made from table grapes. Global production of table grapes in 2018 reached 22,1 million tonnes (40).

Global apple production in 2018 amounted to 69 million tonnes (40). Of the global production, 30–40% of apples rejected as non-marketable, and 20–40% are processed for juice extraction, leaving a non-used residue (22). The estimated global production of waste generated by the apple processing industry in 2008 amounted to 17-21 million tonnes of solid waste and to 3-7 million tonnes of liquid sludge, the direct disposal of which is a serious environmental problem (41). A German company has developed a leatherlike textile by mixing dried leftovers from the apple industry with polyurethane, applying the mixture to a cotton fabric base and then heating it. This textile is used to make handbags. The lining for these bags is made from recycled ocean plastic.

e. Flower waste

Millions of pilgrims daily offer flowers to temples in India. Flowers are gathered at large quantities at temples and are subsequently dumped at roadsides, in water bodies or at landfills, creating health hazards and serious environmental pollution (42, 43). The flowers are gathered and used for the production of incense sticks and cones by one Indian company, while the stems and leaves are used for the production of vermicompost. Another company uses the waste flowers in order to extract dyes which are used for khadi, a traditional hand-crafted fabric.

f. Rice waste

Rice husks are a by-product of rice processing and they are rich in cellulose and silica (44, 45). They are not suitable for composting as they contain a small amount of nitrogen, while the current practice of open burning poses serious environmental concerns (46, 47). Innovative valorization of rice husks has resulted in the creation of a wood-like material with many applications, such as wall-covering, decking, UP boards and also in the use of rice husk ash as a substitute for silica in tires. Rice husks are also used to make briquettes.

g. Milk and whey
Global milk production reached 843 million tonnes in 2018 (86). In some cases, e.g. disruptions in the transport system, milk cannot be marketed and has to be disposed of on-farm unless it can be tranferred to an acceptable disposal site. Milk has a very high BOD therefore constituting a serious pollution risk and should not enter watercourses or groundwater. In most cases, excess milk is sprayed over farm land (48, 49). One German company uses non-marketable milk for polymers that can be spun into fibres to produce clothes and toilet paper. Whey is a by-product of cheese and yoghurt production. While in some cultures it is drunk as-is, it is mostly dumped. A USA-based company uses whey from its yoghurt production to make beverages, flavored in order to suit developed world taste.

h. Agricultural waste combinations
Edible vegetables and fruit that are rejected by retailers due to cosmetic blemishes, unusual shapes and sizes or for being overripe are being available both to consumers and to businesses through online shops and platforms. In addition to selling them as-is, one food distributor uses them for soups and juices. Surplus fruit is also used to make snacks and beverages. Waste from fibrous crop production, such as banana, sugarcane, tobacco, oil-seed and palm leaves is used by companies to make fibres, food packaging, disposable tableware and paper. Okara, a by-product of soymilk production, is used for flour and cookies.

i. Other food waste
Of the other numerous waste streams generated by production of food for human consumption, innovative circular economy applications presented in this study include use of used cooking oil for the production of aviation fuel, of eggshells for the production of food supplements and cosmetics and use of shells from the marine industry for the production of swimwear. While chopsticks are not a food or agricultural waste stream, they are products directly connected to food and therefore the company producing furniture out of used chopsticks is included in this section.

3.2. Textile waste

Clothing production has approximately doubled since 2000, mainly because of a phenomenon termed “fast fashion” involving several new styles circulated each year at frequently low prices. This leads to clothes being used less and discarded more often, at least in several countries. After use clothing is usually discarded into landfills, incinerated or passed on to less developed populations and at the end of its life discarded into landfills or incinerated. Recycling amounts to 13% of the total material input and produces materials for other uses, such as insulation, wiping, and mattress stuffing which when no longer usable is landfilled or burnt. Only 1% finds its way into new clothing (50, 51).

The production process uses fossil fuels for energy, oil for production of synthetic fibres, pesticides and fertilizers for production of natural fibres. Dyeing and treatment of fabrics requires more water and several chemicals, 165 of which are classified as hazardous by the EU, generating 20% of the global industrial water pollution. Synthetic fabrics, when washed, release plastic microfibers that end up in the ocean and are a major source of pollution of the ocean life (50, 51).

Eight companies included in this study use textile waste as raw material. Textile waste is sourced from recycled clothing, waste generated through cutting fabrics in factories and through cutting fabrics for customers. The products include fibres, textiles, mats, clothing and shoes.

3.3. Plastic Waste

Global production of plastics reached 322 million tonnes in 2015. In the European Union 25,8 million tonnes of plastic waste are generated each year, less than 30% of which is collected for recycling, while disposal to landfills and incineration rates are high. Globally 5-13 million tonnes of plastics end up in the oceans, 150.000-500.000 tonnes of which come from Europe. The ocean plastic debris may end up on land or remain in the water, either as litter or degraded into microplastic. Among the key points of the EU strategy for plastics are the easier recyclability in terms of design, collection, capacity and creation of markets; the reduction of plastic waste and littering, with emphasis both on producers and consumers; the establishment of a regulatory framework for biodegradable plastics; the banning of intentional use of microplastics, and; the encouragement of research and innovation towards circular economy solutions (53).

Plastic waste is widely used in circular economy applications, on its own or in combination with other materials. Of the companies included in this study, 22 use plastic as raw material. Recycled PET bottles are used for a variety of products such as carpets, yarn for the seats of strollers, finishing for kitchen cabinet doors, bottles and shoes. PET bottles in combination with other plastic such as yoghurt pots and plastic packaging are used to create surfaces that can be used for furniture, cubicles, countertops etc; in combination with textile waste they are used to make household textiles, and; in combination with shell waste they are used for the creation of swimwear. Nylon from several sources is recycled into yarn that is used by more than 100 companies for apparel, clothing, household and industrial textiles. Plastic fished out of the oceans or collected before becoming ocean litter is used for furniture, lining for handbags, eyeglass frames. Soft plastic from the agricultural, food and industrial sector is used for the production of cable covers, adhesive tapes and garden equipment. Plastic is also used for stroller frames, wristwatches and printers. Except for defined products, some companies also produce plastic resin, to be then manufactured in various products by their customers.

3.4. Other waste

Other waste used as raw material are end-of-life tires, which are used in soles for shoes; waste from mines and the construction industry, used for paper and for surfaces that can be turned into furniture and similar products; cardboard and paper waste, used for paper and packaging.

3.5 Other

Other sources used in the applications presented here are not waste, but are naturally generated, without conscious human intervention. These include seaweeds, washed on beaches and becoming an environmental problem (54, 55) which are used for insulation mats, wall coverings and shoes. Seaweeds are also used for production of food packaging, which is edible in itself. Another interesting application is the valorization of the power generated from trains slowing down, which is kinetic energy produced when the train motor begins working in reverse. This energy can be turned into electric energy and be used either by other trains or in the stations buildings.

4. Production

The principles of “reduce-reuse-recycle” are also applied in the production process. Reduction strategies are used in order to minimize the energy and the materials necessary for production. Reuse involves design approaches, aimed to facilitate dismantling and reusing product components, refurbishing, offering of second-hand goods and take-back services, facilitating collection. Recycling is an alternative optimally for end-of-life products whose components cannot be used anymore and

for non-usable by-products, but also for products in general, providing a solution for their disposal and also generating energy.

Reduction of the energy used for manufacturing is reported by 20 companies. This is achieved by several ways. Reduction of the fuels demanded for transportation is implemented through local sourcing of raw materials. One company advocates the operation of microfactories, which are manufacturing facilities located in the same city where the raw materials are collected, while target customers are also local. So far there are four and new microfactories shall be established in cities that combine raw materials, an existing demand of the company's products and communities that have shown interest in green lifestyle. The same company uses a specifically designed software to calculate the best route for its trucks when collecting raw materials, in order to consume as little fuel as possible. Another company, that uses banana fibre as raw material, has built its factory near the fields. Two companies collect raw materials, in their case coffee grounds, through bike based couriers. However for some companies only the first processing takes place near the raw material source, while the final production and finishing are carried out elsewhere. Another way used to reduce transportation fuels is the use of alternative fuels and electric vehicles.

While ocean plastic collection is not a local sourcing process, one company has developed a technology that uses the energy of the ocean and waves and therefore requires no fossil fuel consumption. Handcrafting is also a technique resulting in energy reduction, although this might not be the primary reason for applying it. Another approach, applied to sectors as different as textiles and aviation, is the development of technologies that make use of existing infrastructure therefore eliminating the need for production and acquirement of new machinery. Customized products, offered by 10 companies, ensure that there is no overproduction or overstocking. Additionally there are 5 companies that use production waste for the generation of energy.

Reduction of the water used for production has been achieved by 6 companies, through developing processing and dyeing techniques that require no water, but also through forgoing washing or dyeing altogether. Reduction of chemicals is practiced by 16 companies which have stopped the use of glue and bleach or have developed natural dyes or dyes that require no solvents. Substrate sterilization is not required when using an already safe substratum for mushroom growing, such as coffee grounds.

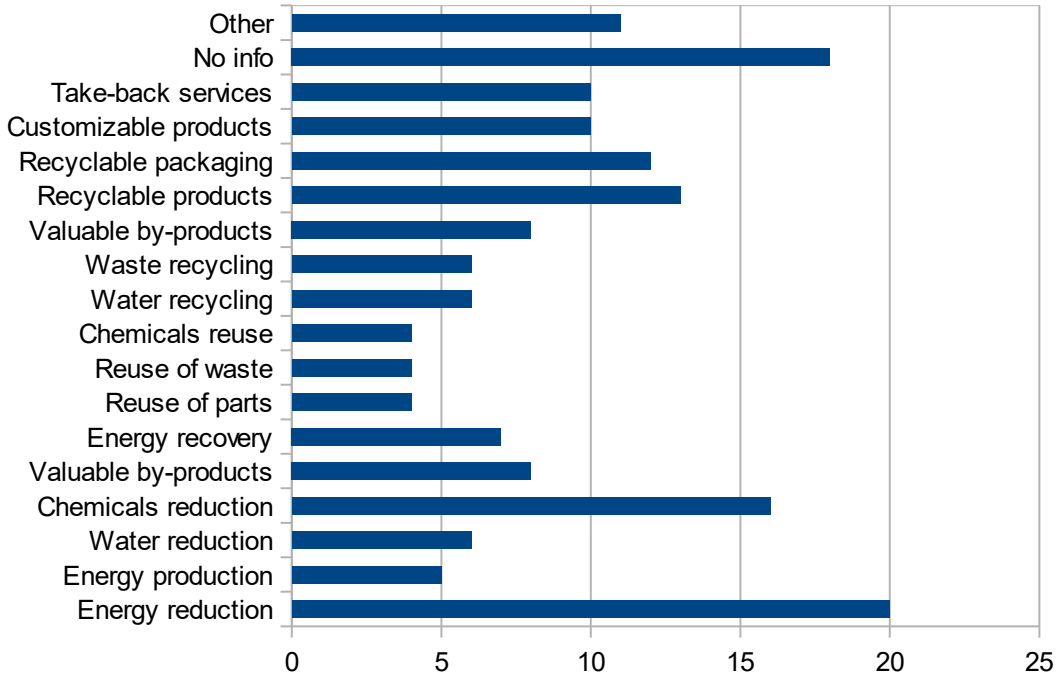
Reuse of salvaged components is practiced by 4 companies in the manufacturing of furniture, apparel, computer hardware and homeware. The same companies offer take-back services, offering a way to the consumer for safe disposal while enabling the producers to collect material for refurbishing or recycling. In total 10 companies offer take-back services, including take-back for packaging, sometimes with financial incentives for the returning customers. One company operates on the basis of this service, having partnered with several companies and developed reusable packaging for their products. Groceries and homeware in this packaging are delivered to the customers' home, while empty packaging is cleaned, refilled, and reused for new deliveries.

Waste generated through production, such as cuts and trimmings of fruit and vegetables in the case of a large food distributor, or sawdust in the cased of a furniture producer, is incorporated into new products by 4 companies. Another 4 companies reuse materials necessary for production, such as glue and solvents. Use of the waste generated through production is also achieved with the production of valuable by-products, such as fertilizers, compost and polymers, is implemented by 8 companies. Energy generated through production, such as heat and steam, is recovered and reused by 5 companies, while one diverts it to a nearby water park. One company has developed a regenerative braking system, that recovers the kinetic

energy produced when trains are slowing down and transforms it to electricity that can be used by other trains or by station buildings.

Water recycling is practiced by 6 companies and waste recycling also by 6. End products that are recyclable, biodegradable or compostable are produced by 13 companies. While recycling of the end product poses no concern for companies producing food, food ingredients and beverages, 3 companies use recyclable packaging while reused, recyclable or compostable packaging is used by 12 companies in total. Other circular economy production processes include leasing or subscription services, swapping between customers, production in small batches so as to avoid overstocking and slow fashion and are practiced by 10 companies. A graphic presentation is shown in Chart 4.

Chart 4. Circular production processes



5. Promotion

Sustainability is a concept promoted both in policy agendas and in company strategies. Its frequent use has lent it different nuances so that in 2007 it was estimated that there were about 300 definitions of the term (56). The concept's roots are quite deep but for the first time it was widely communicated through the Brundtland Report of the World Commission on Environment and Development as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (57). The World Summit in 2002 reaffirmed the "need to ensure a balance between economic development, social development and environmental protection as interdependent and mutually reinforcing pillars of sustainable development" (58). These three pillars are else known as "people-planet-profit".

Circular economy has been viewed as an important component or even as a necessary condition to achieve sustainability. Other opinions present circular economy as one approach to sustainability that must be combined with other routes, such as lifestyle changes. Other authors yet support the view that circular economy could have negative long-term consequences on sustainability, by generating long-term social

insecurity or by creating closed loop production systems that could actually hurt the environment. Generally the relationship between the circular economy and sustainability has not been clearly defined but in many cases the former is viewed as an economic model with implicit social and environmental benefits while the latter as a holistic three-pillar concept (59).

The ways that the companies present their circularity efforts in their websites are comprehensively presented in the annex. In the analysis of the results, companies that also produce other, non-circular products are not included, with the view that in a website, whatever actions one company takes in benefit of the environment or society are presented as a whole and not on account of one product. Of the 55 remaining companies, 25 companies used “sustainable” or “sustainability” in order to describe their products and 6 used the terms “circular” and “circular economy”. A combination of “sustainability” or “sustainable” with “circular economy” or “circular” was used by 5 companies. Phrases without the use of either were preferred by 19 companies.

6. Social Engagement

Circular economy has been criticized for placing emphasis on the economic results while neglecting the social angle. The absence of the social dimension is mentioned as one of the concept’s limitations (60). However an economic and development model cannot be implemented without social consequences. In their definition of the circular economy Korhonen et al. describe the social objectives as the sharing economy, increased employment, democratic decision-making and the use of the existing physical material capacity through the culture of user groups as opposed to individuals (61). The creation of jobs is also emphasized by the Ellen MacArthur Foundation and the European Union (3, 9).

Of the 71 enterprises included in this study, 39 show some form of social engagement. This can be narrowed down to generation of additional income, creation of jobs, the way of operation of the enterprise itself and general social activities. Generation of additional income is considered here as a social criterion because in the developing countries where it is applied it can make a difference in living conditions and access to healthcare and education. Assuming that social engagement depends on the company and not on the type of the product, companies producing non-circular products also should not be included in this discussion, leaving 28 out of 55 companies displaying some form of social engagement.

Additional income is generated by 9 enterprises through buying from their suppliers waste to be used as raw material. New jobs are created by 6 companies, one of which outsources to sheltered employment companies and another has a close collaboration with a social workshop. Two companies lay particular emphasis on the improvement of the working and living conditions of their workers, compared to their former jobs.
A mixed approach is followed by 7 companies that have B-Corporation certification, which is a measure of their social and environmental performance, evaluating the impact of the company on its workers, the community, the environment and its customers. There are 2 social enterprises, one Social Purpose Corporation and one RSB and one Fair Trade certified company, all of which show a motivation toward the good of society. Additionally there are 6 companies with active social engagement, donating to charities and organizing social and educational activities for the community.

Other forms of social engagement do not fall in any of the above categories. One company is a member of the Business Social Compliance Initiative, a management system that implements the principal international standards protecting workers. The employees of one enterprise own 10% while another has adopted B-Holacracy, an

organizational structure allowing workers freedom and autonomy. One enterprise establishes local networks between suppliers of the principal raw materials, workers and suppliers of tools and machinery. One food producer has helped its suppliers, who are indigenous families of the Amazon area, to obtain organic certification while a clothing producer has in its factory in India a water pump and well that is used by the community.

7. Circularity measurement, disclosure, certifications and labels

In order to plan their strategy and to promote their activity, companies that aim to enter the circular economy need to measure the circularity of their products and business (62) and to publish their environmental and social benefits through credible and standardized methods. Therefore it is necessary to develop impact assessment methods taking into consideration lifecycle assessment, environmental management systems, corporate social responsibility schemes, product labeling schemes and cost-benefit analysis. At the same time, development of a definition and taxonomy of circular economy would enable measuring the economic, social and environmental impact of projects and compare its possible benefits in comparison to relative linear economy projects (63). Currently none of this is crystallized in a standardized and widely recognized methodology but there is a significant research activity (62, 64, 65).

The Sustainability Reporting Standards have been developed by the Global Reporting Initiative, an international non-profit organization based in the Netherlands. The Standards are broadly classified as economic, environmental and social can be used by any entity that wishes to report about its impacts and sustainability. The Environmental Standards contain, among others, disclosures on the materials used for production and packaging and the percentage of recycled and reclaimed materials (66); the energy consumption, energy consumption reduction and energy requirements reduction of products and services (67); withdrawal, consumption and disposal of water (68), and; discharge, treatment, reuse, recycling, landfill disposal of waste water and effluents (69). Therefore the sustainability reports compiled according to the Global Sustainability Reporting Standards can be used as an information point for the consumer for some circular economy aspects although not for all.

Of the companies presented in this study, 9 have published reports on sustainability and circular economy practices. The reports are titled “Sustainability Reports”, except for 3 cases, the one featuring an “Urban Impact Report”, the other a “Circular Economy Report” and the third an “Environmental Report”. Only one company used the Global Reporting Initiative Standard for its report. Of the reporting companies, 7 are public, although the Global Reporting Initiative encourages smaller companies, such as SMEs, to report.

Independent, third party assessment, is another way to attest to business circularity. Auditing companies provide certifications in compliance with several standards. Ecolabelling provides information to consumers about the relative environmental quality of a product. The certification includes multiple criteria and takes into account life cycle considerations which may include raw material extraction, manufacture, distribution, use and disposal. Ecolabelling objectives are protection of the environment, encouragement of environmental innovation and leadership and consumer awareness of environmental issues (70). The standards are developed by country and environmental criteria tend to focus on limited key attributes such as reduction of toxicity and pollution, energy efficiency and recyclability and not on comprehensive full life cycle assessments. Problems such as establishing the environmental preferability of a product that has improved scores on one attribute

but reduced on another still remain to be solved (70). The EU Ecolabel does not include medicinal products and devices or food products (71).

Other certification standards include, but are not limited to, the Eco-Management and Audit Scheme, which helps businesses improve their environmental performance and make their transition towards circular economy (72); the Environmental Product Declaration, a document containing transparent and comparable information on the life-cycle environmental impact of products, which however does not confirm environmental superiority compared to alternatives (73), and; cradle to cradle certification. The last one has been developed by the Cradle to Cradle Products Innovation Institute and awarded to products that achieve requirements in material health, material reutilization, renewable energy and carbon management, water stewardship and social fairness. However cradle to cradle certification is not available for food, beverages, pharmaceuticals or fuels and does not include the product's packaging unless required by the client (74).

Certification might be available for one but not for all products. Forest Stewardship Council (FSC) certification, which asserts environmentally appropriate, socially beneficial and economically viable forest management, has been awarded to 3 products. There are 5 products that have Cradle to Cradle certificates while one company uses one cradle to cradle certified material in the production process. One product has an Environmental Product Declaration. Oeko-Tex certification, asserting safety of the product for humans, is used by 6 companies. Another certification for human safety is the CRI Green Label, used by one company. One company has DQS-Ecostep Certification, which is an integrated quality and environmental management certification tailored for SMEs. Product Environmental Footprint Certification is held by 2 companies and EU Ecolabel by one. Five companies have their facilities ISO 14001 certified. One company has US ASTM, 2 use DIN certification on the compostability of their products and one EN-13432 on home compostability. Three companies have LCA third party certifications and 3 have REACH certification. B-corporation certification is held by 7 companies.

It should be noted that certification is not always available for all products. For example EU Ecolabel for textiles defines fibres made from recycled content as "fibres originating from pre-consumer waste (including polymer and fibre production waste, cuttings from textile and clothing manufacturers) and post-consumer waste (textile and all kind of fibre and textile products, as well as non-textile waste including PET drinking bottles and fishing nets)" (75) which does not apply to the textiles generated from agricultural waste that are presented here. One company clearly states in its website that using agricultural waste as a raw material for paper is "so innovative that renowned (environmental) organisations such as FSC, EU Eco label, and the WWF, do not yet acknowledge this agri-waste raw material for paper and paperboard as a possibility in their policy" (76).

Of the 15 companies producing food ingredients, food and beverages, 5 companies offer certain products with organic certification. One company has FSSC 22000 certification meaning that it follows a Food Safety Management System. There are 2 certified B-corporations, 3 companies whose products are non-gmo certified and 2 with kosher certification. Kosher and halal certifications are also held by a non-food company and regenerative organic certification by a fibre-producing company.

A pilot certification programme is the EU-ETV (Environmental Technology Verification), mostly intended to dynamic and innovative Small and Medium Enterprises using technologies that are not covered by existing standards or certifications. The statement of verification confirms that the verified technology has the described function and results under the described conditions. The programme is financed by the EU with the aim to fix the procedure cost to around 20.000, while at EU level there are programmes for which the ETV related costs may be eligible.

Participation is voluntary. Since 2013 263 applications have been submitted, 114 verifications have been awarded and 34 technologies have been verified in the areas of water, energy and materials, waste and resources (77). The EU has developed other tools that are still in transition phase such as the Product Environmental Footprint and the Organization Environmental Footprint, with the goal to unify measurement of environmental performance (78).

8. Conclusions

The purpose of this study is to highlight innovation in circular economy and more particularly the use of material that for conventional businesses is considered waste. It is evident that on the basis of the circular economy principles, several technological solutions have been developed for the valorization of waste streams of agricultural and industrial origin, the disposal of which with conventional methods such as landfilling and incineration poses serious environmental problems. The end products are often hard to connect to the source, with indicative examples veneer made of banana trunks and carpets created from used PET bottles. Except for the sourcing of the raw materials, the circular approach often involves production practices that include reduction of inputs such as energy, water and chemicals, reuse of production-generated waste and product parts and recycling or composting of the products at the end of their life. The examples included in this study are not exhaustive. Innovation is also in progress in exciting fields such as construction of bioplastic packaging from shell waste, extraction of water from the air and human body composting.

Of the applications presented there are several examples of companies active in the sector for more than 10 years, showing that they are valuable and well established in their field. However there are also several startups whose viability remains to be seen and who could be helped by favorable policies and financing. It is therefore necessary to decide upon uniform methodologies and tools that would identify businesses as following the circular economy model. The existing tools cover circularity in a fragmentary way, especially in the food sector, but several companies show willingness to use them.

Considering that the starting point is the valorization of waste, particular attention should be paid to the way of the products' disposal. End-of-life treatment should be well defined for each product. Specifically for products deemed recyclable, further clarifications should be provided. In many cases recycling means passing on to another country where their fate is unknown. The amount of energy necessary, the emissions generated during recycling and the cost should also be taken into account. An unfavourable combination of these factors means that even if recycling is technologically possible, recycling benefits neither the economy, nor the environment. In such cases alternative treatments, such as energy generation, should be considered and weighed against recycling.

Annex

Table 1. Companies by product, year of introduction into the market, country and circular economy applications (raw materials, production process and product characteristics)

Company	Year	Country	Product	Circularity
			Personal care	
Saathi (79)	2015	Headquarters and production	Sanitary pads	Raw material
		India		Banana fibre from the stems of the banana plants
				Production process
				no bleach residues can be used as fertilizer
				Product characteristics
				biodegradable and compostable
			Furniture	
FIBandCO (80)		Headquarters and production	Veneer, Acoustic panels	Raw material
		Martinique		Banana stems
				Production process
				No use of water or glue production facilities close to raw material source major power source: solar power
Gercona (81)		Headquarters	Material that can be shaped into boards or into veneer	Raw material
		Germany		60% rice husks
		Raw material sourcing		Production process
		France, Spain and Italy		No phenol and formaldehyde resins
				Product characteristics
				100% recyclable can be tailored to the customer's need
Icestone (82)	2003	Headquarters and production		Raw material

Company	Year	Country	Product	Circularity
		USA	Surfaces that can be used for furniture, kitchen countertops, tubs, sinks	recycled glass, post-consumer recycled paper, crushed waste stone left over in quarries, recycled post industrial plastics
				Production process
				Energy reduction in the factories by using light from the skylights water recycling waste recycling no resin or petrochemicals for some products
				Product characteristics
				Some products recyclable can be tailored to the customer's need
Plastic Whale-Vepa (83, 84)	2014	Headquarters and production	Furniture and boats for plastic fishing	Raw material
		The Netherlands		plastic fished out of Amsterdam canals
				Production process
				98% of production waste flow is recycled or used for green energy heat recovery systems solar panels
				Product characteristics
				Furniture renting/leasing Take back service product parts reused for new furniture
Metis (85)		Headquarters	Surfaces that can be used for wall covering and veneers	Raw material
		Greece, United Kingdom		seagrass
				Production process
				bound with natural raw materials and biological binders
				Product characteristics
				surfaces could be customised

Company	Year	Country	Product	Circularity
Chopvalue (86)	2016	Headquarters and production	Furniture, décor, accessories	Raw material
		Canada		used chopsticks
				Production process
				Special app used for planning pickups with the min energy consumption setting up of local microfactories close to the collection areas reuse of production waste recycling/reuse of adhesive resin adhesive resin free from phenol and formaldehyde vegetable-based oils for finishing
				Product characteristics
				packaging with biodegradable starch-based peanuts wrapping and labels on recycled paper
Smile Plastics (87)		Headquarters and production	Panels to be used for furniture, cubicles, countertops, homeware etc.	Raw material
		United Kingdom		waste (used PET bottles, yoghurt pots, plastic packaging etc.)
				Product characteristics
				100% recyclable Can be tailored to the customer's need
IKEA (88)		Headquarters	Kitchen doors	Raw material
		Sweden		particle board made from recycled wood, finishing from recycled PET bottles
				Production process (depending on the product)

Company	Year	Country	Product	Circularity
		production of the specific product		Part of the polyester used in production was recycled PET Use of dyes from agricultural waste Use of duck feathers from the duck industry use of biodegradable fire-retardant Use of low-grade recycled plastic in the core of some products Collecting data on kitchen waste in order to plan food waste reduction Use of wood waste generated during manufacturing for other products or as fuel Use of renewable energy Use of electric trucks and alternative fuels for product transport
		Italy		Product characteristics (depending on the product) 75% of packaging from recycled materials Buy-back service and second-hand products offered in some stores Product design adjusted to using less space during transport
Textiles				
Ananas Anam Ltd (89)		Headquarters United Kingdom Production Philipinnes Finishing	Textile	Raw material pineapple leaf fibre (waste from pineapple production) Production process

Company	Year	Country	Product	Circularity
		Spain		First processing near the farms providing the raw material residual biomass from production is used as fertilizer
Orange Fiber (90)	2014	Headquarters and production	Textile	Raw material
		Italy		citrus juice by-products
Vegea (91)	2016	Headquarters and production	Textile	Raw material
		Italy		grape marc
Singtex (92)	2008	Headquarters and production	Textile	Raw material
		Taiwan		recycled polyester and waste coffee grounds
				Production process
				oil extracted through manufacturing can be used in textiles and cosmetics solvent free dyeing and finishing no water dyeing heat recycling system less water and energy than traditional systems sewage recycling and reuse
				Product characteristics
				Product 100% reusable
Qmilk (93)	2011	Headquarters and production	Biopolymers	Raw material
		Germany		non-food milk and other renewable raw materials
				Product characteristics
				compostable
Convert (94)	2018	Headquarters and production	Mats that can be used for insulation, paper, textile, growth media etc.	Raw materials
		Denmark		eelgrass, paper waste, textile waste
				Product characteristics
				Customizable products

Company	Year	Country	Product	Circularity
Circular Systems (95)		Headquarters and production	Fibres, packaging	Raw materials
		No info		waste from banana, oil-seed hemp, oil-seed flax, pineapple, bagasse, rice crops, banana trunks, sugar cane bark, cotton waste (pre- and post-consumer, post-industrial), recycled fibres
				Production process
				by-products used for soil amendments and bio-energy
Lenzing (96)		Headquarters	Tencel Textiles	Raw material
		Austria		Pre-consumer cotton waste
				Production process (depending on the product)
				Water recycling solvent recycling longer lasting dyes with less water consumption Wood pulp produced in biorefineries also producing bioenergy and biobased materials Energy production by incineration of municipal solid waste
				Product characteristics
				Compostable and biodegradable
		Production		
		Austria, Czech Republic, UK, USA, China		
Pure Waste (97)		Headquarters	Clothing	Raw material
		Finland		post-industrial textile waste and post-consumer clothing
		production		Production porcess

Company	Year	Country	Product	Circularity
		India		No use of dye 95% of the energy used for production comes from wind power Waste from bio-toilets is turned to fertilizer and bio energy Fence made from used plastic bottles
				Product characteristics
				Shipping in reusable package and customers rewards for its return
Mohawk (98)		Headquarters and product assembly	Carpets	Raw material
		USA		used PET bottles
				Production process
				48 zero waste to landfill sites
Finlayson (99)		Headquarters	Household textiles	Raw material
		Finland		recycled PET bottles, pre- and post-consumer textile waste
		Production		Production process
		Finland, Portugal, Turkey, Belgium, Latvia		Use of wind power some products handwoven
				Product characteristics
				Packaging: non plastic reusable bags and paper bags (for a charge) in-store and online, recyclable corrugated board packaging for some products
Nofir (100)		Headquarters	Recycled material, used for the production of ECONYL yarn	Raw material
		Norway		
		Production		discarded fishing equipment
		Lithuania, Turkey		
Aquafil (101)	2011	Headquarters	Econyl, recycled nylon yarn	Raw material
		Italy		nylon waste

Company	Year	Country	Product	Circularity
		production of ECONYL yarn		Production process
		Slovenia		100% electricity from renewable sources excess thermal energy transferred to a water park water recycling waste recycling with production of technopolymers
				Product characteristics
				Recyclable
Sunbrella (102)		Headquarters	Textiles	Raw material
		USA		up to 50% leftover fibres, yarn and fabric from the production facilities and after cutting for customers
		Production		Production process
		USA, France, China		Zero waste facilities solar power generation
				Product characteristics
				Accepts end-of-life company products from customers
Waste Free Oceans (103)		Headquarters	Material tailored to the customer's needs	Raw material
		Belgium		ocean plastic collected by trawls that are leased or sold
		Plastic collection		Production process
		Mediterranean Sea, Baltic Sea, North Atlantic, North Sea, Turkey, Carribean, Central America, South America, Hong Kong		Can produce customized products
Infinited Fiber (104)		Headquarters	Technology licensing	Raw material
		Finland		pre- and post-consumer textile, cardboard and agricultural waste

Company	Year	Country	Product	Circularity
				Production process
				Technology compatible with existing infrastructure of pulp and viscose factories No need for carbon disulphide for viscose production Technology leasing
MUD jeans (105)	2013	Headquarters	Clothing	Raw material
		The Netherlands		23% recycled cotton. Cutting waste from production is also used
		Production outsourcing		Production process
		Tunisia		Water recycling at production facilities No washing jeans No water for dyeing Cradle to cradle certified dye electricity generated through steam from the boilers
				Product characteristics
				Slow fashion Clothing leasing and free repairs during the leasing period carton boxes and reusable bags for packaging take back service Sale of second-hand MUD clothing
The Ocean Cleanup (106)	2013	Headquarters	Recycled plastic material. Products that have been already created	Raw material
		The Netherlands		ocean plastic
		Plastic collection		Production process

Company	Year	Country	Product	Circularity
		Great Pacific Garbage Patch Rivers in Jakarta, Indonesia and Malaysia	include water bottles, T-shirts, sweaters, hats and jackets	Passive system for catching the ocean debris (powered by the wind, waves and ocean currents, all electronics employed use solar power) energy neutral device that prevents debris from the rivers to enter the sea The technology is still under development
Because of Nature-MATR (107)		Headquarters and production Australia Production India	Natural dyes for own fabrics	Raw material flower waste from temples
Apparel and shoes				
Circular Clockworks (108)	2017	Headquarters and production The Netherlands	Wristwatches	Raw material post-consumer plastic and post-industrial leather Production process No glue Designed for easy disassembly with limited parts and materials Product characteristics Products can be customized Purchase back service Re-use of parts
Nuuwaï (109)		Headquarters Germany	Luxury bags	Raw material 50% apple industry waste, ocean plastic
nat-2™ (110)	2007	Headquarters Germany	Shoes	Raw material recycled corn, coffee waste, recycled milk, blood, PET bottles, cotton, glass, wine corks, leather Product characteristics

Company	Year	Country	Product	Circularity
				Slow fashion Some products compostable Some parts can be replaced Shoeboxes from recycled paper, reusable packaging
Renovare (111)		Headquarters and production	Shoes	Raw material
		Mexico		used PET bottles and sargazo seagrass
Sole Rebels (112)		Headquarters and production	Shoes	Raw material
		Ethiopia		end-of-life tires
				Production process
				Materials locally sourced Handcrafted product
ELVIS&CRESSE (113)	2005	Headquarters	Bags, wallets, homeware etc.	Raw material
		United Kingdom		used fire hoses, used military parachutes, post-industrial leather waste
		production		Production process
		United Kingdom, Turkey		Handcrafted Production in small batches
				Product characteristics
				Reclaimed packaging Products can be customized
Freitag (114)	2011	Headquarters and production	Bags, wallets, phone cases etc.	Raw material
		Switzerland		used truck tarpaulins, compostable fabric created from linen, hemp and modal
				Product characteristics
				Initiation of swapping between product owners
Sea2See (115)		Production	Eyeglass frames and sunglasses	Raw material
		Italy		
		Raw material sourcing		ocean plastic, collected by company's trucks from Spanish ports

Company	Year	Country	Product	Circularity
				Production process
		Spain and Ghana		Chemical recycling
Londre Bodywear (116)	2017	Headquarters	Swimwear	Raw material
		Canada		recycled PET bottles and shell waste
		Production		Product characteristics
		Taiwan		Take back service with discount for next purchase
Food and Beverages				
Foxhole Spirits (117)	2019	Headquarters and production	Premium Gin	Raw material
		United Kingdom		table grapes waste, surplus to supermarket requirements
Snact (118)	2016	Headquarters and production	Fruit Snacks	Raw material
		United Kingdom		Surplus fruit (apples, blueberries, raspberries, bananas, mangos)
				Product characteristics
				Home compostable packaging
The Coffee Cherry Co. (119)			Coffee Cherry Flour	Raw material
				coffee cherry pulp
Petcof (34)		Headquarters and production	Soluble Dietary Fibre (Dutch Gum)	Raw material
		The Netherlands		coffee cherry pulp
Grocycle (120)		Headquarters and production	Mushrooms, mushroom growing kits and online courses	Raw material
		United Kingdom		waste coffee grounds, used as substrate for mushrooms
				Production process
				Urban farming No need for substrate sterilization
AM Breweries (35)	2017	Headquarters	Beverages	Raw material
		Denmark		waste coffee leaves
Innain (121)		Headquarters	Ingredients for food, food supplements and cosmetics	Raw material
		Spain		eggshells (industrial by-product)
Sanam (122)		Headquarters and production		Raw material

Company	Year	Country	Product	Circularity
		Colombia	Coffee concentrate, Flour and Beverages	coffee cherry pulp, coffee husks
Wtrmln Wtr (123)	2013	Headquarters	Beverages	Raw material
		United Kingdom		Non-marketable melons
				Product characteristics
				recyclable packaging
Renewal Mill (124)			Flour and cookies	Raw material
				okara (by-product of soymilk production)
Barnana (125)	2012	Headquarters	Snacks	Raw material
		USA		non-marketable organic bananas from small farms in Latin America
Baldor (126)		Headquarters	Food products	Raw material
		USA		own company's fruit and vegetable parts generated from processing, imperfect fruit and vegetables
White Moustache (127)		Headquarters	Beverages and frozen pops	Raw material
		USA		whey from the company's yoghurt production
				Production process
				handmade
Imperfect Foods (128)	2015	Headquarters	Food	Raw material
		USA		Food rejected from grocery stores due to cosmetic blemishes, size, excess inventory, packaging change, lack of demand, close expiration date. Suppliers are informed of the company's policy not to buy food that could be donated to food banks
		suppliers		Product characteristics

Company	Year	Country	Product	Circularity
		USA and other countries		Home delivery Packaging partly made of recycled material and recyclable Take back service for used company boxes
Full Harvest (129)		Headquarters and distribution	Food (web platform connecting farmers with buyers)	Raw material
		USA		oddly-shaped and surplus produce
Packaging				
Loop (130)		Headquarters and distribution	Food and groceries	Production process
		USA		Home delivery of food and groceries of partner brands in specifically designed reusable packaging.
				Product characteristics
				Used packaging is picked up by the company, cleaned and refilled
BIO-LUTIONS (131)	2018	Headquarters	Packaging and disposable tableware	Raw material
		Germany		agricultural waste collected from small farmers through the NGO VIKASANA
		production		Production process
		Germany, India, Thailand		Waste is turned to self- binding fibers that are hot pressed into the products Local sourcing No chemical treatment
				Product characteristics
				biodegradable, compostable, biodegradable foil products can be customized
Bionatic Gmbh-Greenbox Online Shop (132)		Headquarters	Disposable tableware and packaging	Raw material
		Germany		agricultural waste (sugarcane, palm leaves, wood powder), recycled PET bottles, biobased plastic, recycled paper
		Palm sourcing		Product characteristics

Company	Year	Country	Product	Circularity
		India		Depending on the product: biodegradable, compostable, reusable
Notpla (133)	2019	Headquarters and production	Food packaging	Raw material
		United Kingdom		brown seaweed
				Product characteristics
				Edible and biodegradable
Homeware				
Kaffeeform (134)		Headquarters and production	Cups	Raw material
				coffee grounds combined with plant-based materials and hardened with biopolymers
				Production process
		Germany		Coffee grounds are collected by a bike courier, dried in a social workshop, processed in small plants and gathered back to the social workshop for polishing and packaging
				Product characteristics
				Take back service, cups are broken down and used as raw material Products can be customized
Huskee (135)		Headquarters and production	Cups	Raw material
				up to 50% coffee husks (coffee industry by-product)
		Australia		Product characteristics
				Recyclable Huskee swap: involves cafes and clients who bring back their Huskee cup and take away another one
Phool (136)	2017	Headquarters and production		Raw material

Company	Year	Country	Product	Circularity
			Incense sticks and cones, vermicompost	Indian temples flower waste
		India		Production process
				handcrafted Water used for washing the flowers is later on used to make the vermicompost
Paper and Ink				
Caffe Ink (137)		Headquarters and production	Pigment to be used in printing ink	Raw material
		The Netherlands		used coffee grounds
				Production process
				Raw material collected through a bike based system
Hewlett Packard (138)	2000	Headquarters	Ink and toner cartridges, printers	Raw material
		USA		recycled ink and toner cartridges (for ink and toner cartridges) post-consumer recycled plastic, using ocean recycled plastic (100% for some printers)
				Production process
				recycling and refurbishing IT products materials recovery and reuse Collection and reusing of imaging oil reduction of potable water consumption
				Product characteristics
				3-D laser printer enabling clients to print their own spare parts 65% Paper based packaging take-back service, subscription services less packaging material
Ecopaper (139)		Headquarters and production	Paper and Stationery	Raw material
				banana, coffee, mango and tobacco waste, pre- and post-consumer paper waste

Company	Year	Country	Product	Circularity
				Production characteristics
		Costa Rica		no acid or chemicals for bleaching use of less energy comparing to virgin pulp paper
				Product characteristics
				Product can be customized
Paperwise (140)		Headquarters	Paper and board	Raw material
				agricultural waste
		The Netherlands		Production process
				Production sites are near the fields Energy: biofuel produced by anaerobic digestion of the biomass that cannot be used for paper
		Production		Product characteristics
		Asia and South America		Packing recyclable and continually made thinner
Karst Stone Paper (141)		Headquarters and production	Paper and stationery	Raw material
				waste from the mining and construction industry
				Production process
		Australia		No water or bleach in the production process Production partly solar powered waste from production incorporated in new products
				Product characteristics
				Take back service, recycling into new products products can be customized
Fuel-Energy				

Company	Year	Country	Product	Circularity
Biohusk energy (142)		Headquarters and production	Briquettes	Raw material
		Malaysia		rice husks
Bio-bean (36)	2016	Headquarters and production	Fire logs and pellets	Raw material
				coffee grounds
		United Kingdom		Product characteristics
				Recycled paper packaging
Mitsubishi Electric (143)		Headquarters and production	Regenerative braking system	Raw material
		Japan		Kinetic energy generated when trains are slowing down
				Production process
				A traction inverter turns kinetic into electric energy
SkyNRG (144)		Headquarters	Sustainable Aviation Fuel	Raw material
				used cooking oil
		The Netherlands		Production process
		production		locally sourced
		USA		Product characteristics
				Compatible with existing engines
Other				
Greentom (145)	2014	Headquarters and production	Strollers	Raw material
		The Netherlands		for frame: post-consumer plastic for seat yarn: recycled PET bottles
Goodyear (146)		Headquarters	Tires	Raw material
		USA		silica produced from rice husks
				Production process (generally)
				Virginia plant: lighting update Brazil plant: waste heat recovery all plants: zero waste to landfill water recycling
		Headquarters and production		Raw material

Company	Year	Country	Product	Circularity
Plastic Forests (147)			Resin, underground cable cover, root barrier, dunnage, garden edging	soft plastics from agriculture, industry, consumers
				Production process
		Australia		Cleaning technology for removal of food residues, ink, liquids etc. without water
				Product characteristics
				Charges apply for recycling and materials are accepted only if the client buys back an equivalent volume of the resins produced. Recycling for agricultural soft plastic waste is free

Table 2. Promotion, Social Engagement, Reporting and Certification data of companies with non-conventional circular economy applications

Company	Product	Social engagement	Certification	Promotion	Reporting	Other products	Public
Personal care							
Saathi (79)	Sanitary pads	pads sold at discount or donated to women in slums or rural areas, workshops for awareness on menstrual hygiene	No info	Eco-friendly products, good for the body, the environment and the community	No	Yes	No
Furniture							
FIBandCO (80)	Veneer	Benefits to farmers by creating extra income and providing them with long term skills	Forest Stewardship Council, LCA analysis	Corporate Social Responsibility	No	No	No
Gercona (81)	Material that can be shaped into boards or into veneer	No info	REACH certification	Sustainability, Upcycling, Recycling	No	No	No

Company	Product	Social engagement	Certification	Promotion	Reporting	Other products	Public
Icestone (82)	Surfaces that can be used for furniture, kitchen countertops, tubs, sinks	Employees own 10% of the company, Certified B-Corporation	(depending on the product) Cradle to Cradle, NSF51 for splash zones in food related establishments, FSC, Greenguard, Certified B Corporation	People, Planet, Profit	No	No	No
Plastic Whale-Vepa (83, 84)	Furniture and boats for plastic fishing	Certified B-corporation donating furniture to social organizations (Vepa), outsourcing to sheltered employment companies, (Vepa)	PEFC certified oak (raw material)	Circular Economy (under sustainability)	No	No (Plastic Whales) Yes (Vepa)	No
Metis (85)	Surfaces that can be used for wall covering and veneers	No info	No info	Sustainable Architecture, Naturally Unique, Eco-Friendly	No	No	No
Chopvalue (86)	Furniture, décor, accessories	Building networks within local communities	No info	Sustainability/Circular economy	Urban economy report	No	No

Company	Product	Social engagement	Certification	Promotion	Reporting	Other products	Public
Smile Plastics (87)	Panels to be used for furniture, cubicles, countertops, homeware etc.	No info	No info	Sustainable	No	No	No
IKEA (88)	Kitchen doors	Mentoring for start-ups, Participation in Sustainable Lifestyles and Education Programme, Encouraging smallholders to gain FSC certification, Partnerships with social enterprises, Social activities with local communities	Depending on the product	Circular and climate positive	Sustainability report	Yes	Yes
Textiles							
Ananas Anam Ltd (89)	Textile	Generates additional farmer income by buying stems which would otherwise be wasted	No info	Circular Economy	No	No	No
Orange Fiber (90)	Textile	No info	No info	Sustainability-Environment	No	No	No
Vegea (91)	Textile	No info	No info	Sustainability	No	No	No

Company	Product	Social engagement	Certification	Promotion	Reporting	Other products	Public
Singtex (92)	Textile	seminars on blue economy, internships and scholarships, charity, bluesign certification	depending on the product: Bluesign, Cradle to Cradle, USDA biobased product, OEKO-Tex, Global Recycle Standard, Product Carbon Footprint, Recycled Material	Ethical and sustainable	No	Yes	Yes
Qmilk (93)	Fibre	No info	No info	No info	No	No	No
Convert (94)	Mats that can be used for insulation, paper, textile, growth media etc.	No info	Not for all products: cradle to cradle certification	Sustainability, Corporate Social Responsibility, Close the circular production loop	No	Yes	No
Circular Systems (95)	Fibres, packaging	Social purpose corporation	Regenerative Organic certification	Circular Tech + regenerative impact	No	No	No

Company	Product	Social engagement	Certification	Promotion	Reporting	Other products	Public
Lenzing (96)	Textiles	Support of social projects	Depending on the product: EU Ecolabel, USDA Certified Biobased Product, Biodegradability, OEKO-Tex, FSC, PEFC, Responsible Care, Fair Trade, ISO 14001, FKT Medically Tested-Tested for Toxins, ISEGA, Recycled Claim Standards	Circular Economy and Sustainability	Sustainability report according to the Global Reporting Initiative Standard	Yes	Yes
Pure Waste (97)	Clothing	Water pump and well in the factory property are used by the community	No info	Pure Waste philosophy	No	No	No
Mohawk (98)	Carpets	Financial and volunteer help to communities, contribution to philanthropic Foundation and to non-profit organizations where the manufacturing facilities are etc.	CRI Green Label Plus on Indoor Air Quality	Sustainable, Corporate Sustainability	Sustainability Report	Yes	Yes

Company	Product	Social engagement	Certification	Promotion	Reporting	Other products	Public
Finlayson (99)	Household textiles	Member of the amfori BSCI social responsibility system	Depending on the product: OEKO-Tex, BSCI certified manufacture partners	Recycled materials, This is how we reduce our environmental impact	No	Yes	No
Nofir (100)	Recycled material, used for the production of ECONYL yarn	Generation of income for some suppliers	Life Cycle Assessment, 3rd party ISO 14040 verification of the LCA activities	Recycling discarded material	No	No	No
Aquafil (101)	Econyl, recycled nylon yarn	support of local communities with education and sports activities	Environmental Product Declaration, third party certification on recycled content, REACH compliant, ISO 14001 for some facilities	Sustainability	Sustainability Report	Yes	Yes
Sunbrella (102)	Textiles	No info	ISO 14001 certification, Greenguard, Facts	Committed to the environment	No	Yes	No
Waste Free Oceans (103)	Material tailored to the customer's needs	No info	No info	Sustainability	No	No	No
Infinited Fiber (104)	Technology licensing	No info	Not applicable	Together we sustain, Closed loop solution to the textile problem	No	No	No

Company	Product	Social engagement	Certification	Promotion	Reporting	Other products	Public
MUD jeans (105)	Clothing	Member of the Social & Labor Convergence Program, Certified B-Corporation	Certified B-Corporation, Member of the Circle Economy, Member of MVO Nederland, Cradle to Cradle Certified dye	Circular, Sustainability	Sustainability Report	No	No
The Ocean Cleanup (106)	Recycled plastic material. Products that have been already created include water bottles, T-shirts, sweaters, hats and jackets	No info	No info	Cleanup	No	No	No
Because of Nature-MATR (107)	Fabric dyes	Creation of jobs Social enterprise	No info	Ethical, sustainable, slow colour label	No	Yes	No
Apparel and shoes							
Circular Clockworks (108)	Wristwatches	No info	No info	Circular	No	No	No
Nuuwaï (109)	Luxury bags	No info	PETA approved, OEKO Tex	Vegan and sustainable	No	No	No
nat-2™ (110)	Shoes	No info	No info	Eco	No	No	No

Company	Product	Social engagement	Certification	Promotion	Reporting	Other products	Public
Renovare (111)	Shoes	Philanthropic activities	No info	Healthy planet	No	No	No
Sole Rebels (112)	Shoes	Creation of well paid jobs, Step from exporting low-value commodities to high-value products, Providing funding for the education of workers' children, Fair trade certification	Fair Trade certified	Historically eco-sensible, green by heritage	No	No	No
ELVIS&CRESSE (113)	Bags, wallets, homeware etc.	50% of the profits is donated to charity, Certified B-Corporation, Certified Social Enterprise Business for Good	Certified B-Corporation, Certified Social Enterprise Business for Good	Sustainable and Ethical, Three Pillars: Rescue, Transform, Donate	No	No	No
Freitag (114)	Bags, wallets, phone cases etc.	Factory: self-governing organization (B-Holacracy)	No info	Circular, closed loop	No	No	No
Sea2See (115)	Eyeglass frames and sunglasses	No info	Cradle to Cradle certified material	Circular Economy	No	No	No
Londre Bodywear (116)	Swimwear	No info	OEKO Tex	Passion for the environment	No	No	No
Food and Beverages							

Company	Product	Social engagement	Certification	Promotion	Reporting	Other products	Public
Foxhole Spirits (117)	Hyke Premium Gin	No info	No info	A step in the right direction	No	yes	No
Snact (118)	Fruit Snacks	No info	No info	Sustainability	No	No	No
The Coffee Cherry Co. (119)	Coffee Cherry Flour	Generation of income for supplying farmers, Creation of jobs, especially for women, Certified B-Corporation	Certified B-Corporation, KVH kosher certification, non-gmo verification	Sustainability	No	No	No
Petcof (34)	Soluble Dietary Fibre (Dutch Gum)	No info	No info	The pulp potential	No	No	No
Grocycle (120)	Mushrooms	Social enterprise	No info	Low tech mushroom farming	No	No	No
AM Breweries (35)	Beverages	Generation of income for supplying farmers, Work with organizations to improve the livelihood of the farmers and communities	No info	Sustainability	No	No	No
Innain (121)	Ingredients for food, food supplements and cosmetics	No info	FSSC 22000 Certificate (food safety)	Eco-Sustainability	No	No	No
Sanam (122)	Coffee concentrate, Flour and Beverages	Generation of income for supplying farmers	No info	Environmental impact	No	No	No

Company	Product	Social engagement	Certification	Promotion	Reporting	Other products	Public
Wtrmln Wtr (123)	Beverages	Generation of income for supplying farmers	Certified non-GMO, gluten-free, kosher and vegan	Drink clean promise	No	No	No
Renewal Mill (124)	Flour and cookies	No info	No info	Sustainable, circular economy	No	No	No
Barnana (125)	Snacks	Helping collaborating farmers acquire organic certification, Certified B-Corporation	Certified B-Corporation, USDA certified organic, non-GMO	Sustainability	No	No	No
Baldor (126)	Food products	Food donation, support of a soup kitchen, Support to a scientific research centre, Organization and material support of school activities	Depending on the product	Sustainable, Responsible production and consumption, Sustainability	No	Yes	No
White Moustache (127)	Beverages and frozen pops	No info	No info	Magic elixir	No	Yes	No
Imperfect Foods (128)	Food	Generation of income for suppliers Reduce cost boxes delivered to low income families	Depending on the product	Eliminate food waste	No	No	No
Full Harvest (129)	Food	No info	Depending on the product	Environment, sustainability	No	No	No
Packaging							

Company	Product	Social engagement	Certification	Promotion	Reporting	Other products	Public
Loop (130)	Food and groceries	No info	Depending on the product	Sustainability, Reduce, Reuse, Recycle	No	No	No
BIO-LUTIONS (131)	Packaging , disposable tableware and medical equipment	Generation of income for suppliers Creation of jobs and economic value	No info	Sustainable, circular economy	No	No	No
Bionatic Gmbh-Greenbox Online Shop (132)	Disposable tableware and packaging	Job creation for suppliers BSCI certified	Depending on the product: BSCI certified, US ASTM certified compostable, DIN 13432 certified compostable DQS-EcoStep certified	Sustainability	No	No	No
Notpla (133)	Food packaging	No info	No info	An alternative to plastic	No	No	No
Homeware							
Kaffeeform (134)	Cups	close collaboration with a social workshop	No info	Sustainability	No	No	No
Huskee (135)	Cups	No info	No info	Sustainable	No	No	No
Phool (136)	Incense sticks and cones, vermicompost	Job creation	No info	Sacred, ethical, humane	No	No	No
Paper and Ink							

Company	Product	Social engagement	Certification	Promotion	Reporting	Other products	Public
Caffe Ink (137)	Pigment to be used as printing ink	No info	No info	Sustainable	No	No	No
Hewlett Packard (138)	Ink and toner cartridges	Environmental and philanthropic activities	Depending on the product	Corporate responsibility/Driving the circular economy/Sustainable technology innovation	Circular economy report	Yes	Yes
Ecopaper (139)	Paper and Stationery	role of the business in society by improving the quality of life locally, nationally, and globally. Support of nonviolent ways to achieve peace and justice.	No info	Environmental	No	No	No

Company	Product	Social engagement	Certification	Promotion	Reporting	Other products	Public
Paperwise (140)	Paper and board	For the communities where the factories are: Investments in education, infrastructure, and healthcare	LCA by the IVAM University of Amsterdam, ISO 9001, ISO 14001, Elemental Chlorine Free certified, EN-13432 certified (industrial composting), DIN Home Compostable certified, Production with Green Energy Not recognized as raw material for EU Ecolabel	Wise with waste, Environmental benefits	No	No	No
Karst Stone Paper (141)	Paper and stationery	Certified B-Corporation	Certified B-Corporation, ISO 9001, ISO 14001, REACH Compliant, ROHS Compliant, Cradle to Cradle certified	Sustainable	No	No	No
Fuel-Energy							
Biohusk energy (142)	Briquettes	No info	No info	Sustainability	No	No	No
Bio-bean (36)	Fire logs and pellets	No info	No info	Sustainability-Recycling	No	No	No

Company	Product	Social engagement	Certification	Promotion	Reporting	Other products	Public
Mitsubishi Electric (143)	Advanced Power Technology for Trains	Philanthropic activities	No info	Our stories/Support of the global environment	Environmental Report	Yes	Yes
SkyNRG (144)	Sustainable Aviation Fuel	No info	RSB certification	Sustainable/Sustainability	No	No	No
Other							
Greentom (145)	Strollers	No info	OEKO Tex and Organic certified	Reduce, reuse, recycle, circular	No	No	No
Goodyear (146)	Tires	Campaigns for safety on the road, Collaborative programmes for communities regarding safe mobility and education	ISO 14001, Kosher certification, Halal certification	Corporate Responsibility, Sustainable sources	Sustainability report	Yes	Yes
Plastic Forests (147)	Resin, underground cable cover, root barrier, dunnage, garden edging	No info	No info	Rescuing, Recycling, Reprocessing	No	No	No

References

1. CIRAIG (International Reference Center for the Life Cycle of Products Processes and Services).2015. Circular economy: A critical literature review of concepts. Montréal, Québec, Canada: Bibliothèque et Archives nationales du Québec (BAnQ), http://www.ciraig.org/pdf/CIRAIG_Circular_Economy_Literature_Review_Oct2015.pdf

2. Blomsma, F. and Brennan, G., 2017. The emergence of circular economy: A new framing around prolonging resource productivity. *Journal of Industrial Ecology*21(3), pp. 603–614, https://doi.org/10.1111/jiec.12603

3. Ellen MacArthur Foundation, 2013. Towards the circular economy, 1. Economic and business rationale for an accelerated transition, https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf

4. Merli, R., Preziosi, M. and Acampora, A., 2018. How do scholars approach the circular economy? A systematic literature review. *Journal of Cleaner Production*, vol 178, pp. 703-722, https://doi.org/10.1016/j.jclepro.2017.12.112

5. Kirchherr, J., Reike, D. and Hekkert, M., 2017. Conceptualizing the circular economy: An analysis of 114 definitions, *Resources, Conservation and Recycling*, vol 127, pp. 221-232, https://doi.org/10.1016/j.resconrec.2017.09.005

6. Saachi Homrich, A., Galvao, G., Gamboa Abadia, L. and Carvalho, M., 2018. The circular economy umbrella: Trends and gaps on integrating pathways. *Journal of Cleaner Production*, vol. 175, pp. 525-543, https://doi.org/10.1016/j.jclepro.2017.11.064

7. Waste and Resources Action Programme (WRAP), http://www.wrap.org.uk/

8. European Commission, 2019. Press release- World Economic Forum recognises European Commission as champion in the circular economy https://ec.europa.eu/info/news/world-economic-forum-recognises-european-commission-champion-circular-economy-2019-jan-22-0_en

9. European Commission, 2015. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Closing the loop – An EU action plan for the circular economy, COM(2015) 614 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614

10. Hellenic Republic, Ministry of Environment and Energy, 2018. National Circular Economy Strategy. http://www.ypeka.gr/LinkClick.aspx?fileticket=pYSLQXgjjOU%3D&tabid=37&language=en-US

11. Inter IKEA Systems, 2018. IKEA Sustainability Strategy-People and Planet Positive, p. 15, https://preview.thenewsmarket.com/Previews/IKEA/DocumentAssets/511938.pdf

12. European Investment Bank, 2019. The EIB Circular Economy Guide. Supporting the circular transition, https://www.eib.org/attachments/thematic/circular_economy_guide_en.pdf

13. Merriam-Webster dictionary, , https://www.merriam-webster.com/dictionary/conventional

14.Collins dictionary, https://www.collinsdictionary.com/dictionary/english/conventional

15. Goodwill, https://www.goodwill.org/about-us/

16. Jung, A., 2014. Car-sharing in China. A contribution to Sustainable Urban Transport? *Sino-Germanic Cooperation Project on Electro-Mobility and Climate Protection*, http://www.sustainabletransport.org/wp-content/uploads/2017/08/Carsharing_China_Final_EN.pdf

17. The Global Food Banking Network, 2018. The State of Global Food Banking 2018. Nourishing the World, http://www.foodbanking.org/wp-content/uploads/2018/10/GFN-The-State-of-Global-Food-Banking-2018.pdf

18. Fitzpatrick, G., Worden, E. and Vendrame, W., 2015. Historical Development of Composting Technology during the 20th century. *HortTechnology*, vol. 15(1), pp. 48-51, https://doi.org/10.21273/HORTTECH.15.1.0048

19. EIP-Agri Focus Group, 2019. Circular Horticulture final report, https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_fg_circular_horticulture_final_report_2019_en.pdf

20. United Nations Conference on Trade and Development, 2016. Second-generation biofuel markets: State of play, trade and developing country perspectives, https://unctad.org/en/PublicationsLibrary/ditcted2015d8_en.pdf

21. Kholif, A., Elghandour, M., Rodriguez, G., Olafadehan, O. and Salem, A., 2017. Anaerobic ensiling of raw agricultural waste with a fibrolytic enzyme cocktail as a cleaner and sustainable biological product. *Journal of Cleaner Production*, vol 142(4), pp. 2649-2655, https://doi.org/10.1016/j.jclepro.2016.11.012

22. Wadhwa, M. and Bakshi, M., 2013. Utilization of fruit and vegetable wastes as livestock feed and as substrates for generation of other value-added products, RAP publication, http://www.fao.org/3/i3273e/i3273e.pdf

23. Cardoen, D., Joshi, P., Diels, L., Sarma, P. and Pant, D., 2015. Agriculture biomass in India: Part 1. Estimation and characterization. *Resources, Conservation and Recycling*, vol102, pp.39-48, https://doi.org/10.1016/j.resconrec.2015.06.003

24. Fiksel, J. and Lal, R., 2018. Transforming waste into resources for the Indian economy. *Environmental Development*, vol 26,pp. 123-128, https://doi.org/10.1016/j.envdev.2018.02.002

25. FAO, 2011. Global food losses and food waste. Extent, causes and prevention, http://www.fao.org/3/a-i2697e.pdf

26. FAO, 2019. The State of Food and Agriculture. Moving forward on food loss and waste production, http://www.fao.org/3/ca6030en/ca6030en.pdf

27. Nurhayati, A., Sulaiman, F. and Rahmad, |M., 2013. Characterization of Banana (Musa spp.) Plantation Wastes as a Potential Renewable Energy Source. *AIP Conference Proceedings*, 1528.325, https://doi.org/10.1063/1.4803618

28. Gumisiriza, R., Hawumba, J., Okure,M. and Hensel, O., 2017. Biomass waste-to-energy valorisation technologies: a review case for banana processing in Uganda. *Biotechnology for Biofuels*, vol 10, https://doi.org/10.1186/s13068-016-0689-5

29. Rahmad, M., Nurhayati, A., Fauziah, S. and Muhamad, A., 2014. Characterization of Banana (Musa spp.) Pseudo-Stem and Fruit-Bunch-Stem as a Potential Renewable Energy Resource . *International Journal of Energy and Power Engineering,* vol 8 (8), pp. 712-716

30.FAO, Banana facts and figures, http://www.fao.org/economic/est/est-commodities/bananas/bananafacts/en/#.XatADVQzbIU

31.Altendorf, Sabine, 2018. Global prospects for major tropical fruits. Food outlook, vol. 70, pp. 69-81, http://www.fao.org/fileadmin/templates/est/COMM_MARKETS_MONITORING/Tropical_Fruits/Documents/Tropical_Fruits_Special_Feature.pdf

32. Banerjee, S., Ranganathan, V., Patti, A. and Arora, A., 2018. Valorisation of pineapple wastes for food and therapeutic applications. *Trends in Food Science and Technology*, vol. 82, pp. 70-80, https://doi.org/10.1016/j.tifs.2018.09.024

33. International Coffee Organization, 2019. http://www.ico.org/prices/po-production.pdf

34.Petcof, https://pectcof.com/the-pulp-potential/

35. AM Breweries, https://www.ambreweries.dk

36. Bio-bean, https://www.bio-bean.com/

37. FAO, 2016. Citrus fruit fresh and processed: Statistical bulletin. http://www.fao.org/3/a-i8092e.pdf

38. Mamma, D., Christakopoulos, P., 2014. Biotransformation of Citrus By-Products into Value Added Products. *Waste and Biomass Valorization*, vol 5(4), pp. 529-549, https://doi.org/10.1007/s12649-013-9250-y

39. Torres-León, C., Ramírez-Guzman, N., Londoño-Hernandez, L., Martinez-Medina, G.A, Díaz-Herrera, R., Navarro-Macias, V., Alvarez-Pérez, O. A., Picazo, B., Villarreal-Vázquez, M., Ascacio-Valdes, J. and Aguilar, C., N. 2018. Food Waste and Byproducts: An Opportunity to Minimize Malnutrition and Hunger in Developing Countries. *Frontiers in Sustainable Food Systems*, vol 2, article 52, https://doi.org/10.3389/fsufs.2018.00052

40.United States Department of Agriculture and Foreign Agricultural Service, 2019. Fresh Apples, Grapes and Pears: World Markets and Trade, https://apps.fas.usda.gov/psdonline/circulars/fruit.pdf

41. Gurpreet, S., Surinder, K. and Satinder, K., 2013. Perspective of apple processing wastes as low-cost substrates for bioproduction of high value products: A review. *Renewable and Sustainable Energy Reviews*, vol. 27, pp. 789-805, https://doi.org/10.1016/j.rser.2013.06.046

42. Singh, P., Borthakur, A., Singh, R., Awasthi, S., Pal, D.B., Srivastava, P., Tiwary, D. and Mishra, P. K. 2017. Utilization of temple floral waste for extraction of valuable products: A close loop approach towards environmental sustainability and waste management. *Pollution*, vol 3(1), pp. 39-45, https://doi.org/10.7508/pj.2017.01.005

43. Tiwari, P. and Juneja, S., 2016. Management of floral waste generated from temples of Jaipur city through vermicomposting. *International Journal of Environment*, vol 5(1), pp. 1-13, https://doi.org/10.3126/ije.v5i1.14561

44. Mansaray, K. andGhaly, A., 1998. Thermal degradation of rice husks in nitrogen atmosphere. *Bioresource Technology*, vol 65(1-2), pp. 13-20, https://doi.org/10.1016/S0960-8524(98)00031-5

45. Mansaray, K. and Ghaly, A., 1997. Physical and Thermochemical Properties of Rice Husk. *Energy Sources*, vol 19(9), pp. 989-1004, https://doi.org/10.1080/00908319708908904

46.Joharab, N., Ahmadab, I. and Dufresnec, A., 2012. Extraction, preparation and characterization of cellulose fibres and nanocrystals from rice husk. *Industrial crops and products*, vol 37(1), pp. 93-99, https://doi.org/10.1016/j.indcrop.2011.12.016

47. Zheng, J., 2007. Bio-oil from fast pyrolysis of rice husk: Yields and related properties and improvement of the pyrolysis system. *Journal of Analytical and Applied Pyrolysis*, vol 80(1), pp. 30-35, https://doi.org/10.1016/j.jaap.2006.12.030

48. Government of Western Australia, Department of Primary Industries and Regional Development. Disposing of milk, https://www.agric.wa.gov.au/dairy-cattle/disposing-milk

49. United Kingdom Government. How to dispose of milk from your farm or dairy, https://www.gov.uk/guidance/how-to-dispose-of-milk-from-your-farm-or-dairy

50. Ellen MacArthur Foundation, 2017. A new textiles economy. Redesigning the fashion's future, https://www.ellenmacarthurfoundation.org/assets/downloads/publications/A-New-Textiles-Economy_Full-Report_Updated_1-12-17.pdf

51. EU Parliament Briefing. Environmental impact of the clothing and textile industry. What consumers need to know, http://www.europarl.europa.eu/RegData/etudes/BRIE/2019/633143/EPRS_BRI(2019)633143_EN.pdf

53. European Commission, 2018. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A European Strategy for Plastics in a Circular Economy, COM 28 final, https://eur-lex.europa.eu/resource.html?uri=cellar:2df5d1d2-fac7-11e7-b8f5-01aa75ed71a1.0001.02/DOC_1&format=PDF

54. Convert, https://convert.as/eelgrass-for-insulation-and-rooftops/

55. Seaweed invasion threatens tourism in Mexico's beaches as problem worsens, 28.06.2019, The Guardian,

https://www.theguardian.com/world/2019/jun/28/mexico-seaweed-invasion-tourism-caribbean-beaches

56. Johnston, P., Everard, M., Santill, D. and Robert, K., 2007. Reclaiming the Definition of Sustainability. *Environmental Science and Pollution Research*, vol. 14 (1), pp. 60-66, http://dx.doi.org/10.1065/espr2007.01.375

57. World Commission on Environment and Development, 1987. Our common future, https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

58. United Nations General Assembly, 2002. World Summit on Sustainable Development, https://www.un.org/ga/search/view_doc.asp?symbol=A/C.2/57/L.83&Lang=E

59. Geissdoerfer, M., Savaget, P., Bocken, N. and Hultink, E., 2017. The Circular Economy – A new sustainability paradigm? *Journal of Clean Production*, vol. 143, pp. 757-768, https://doi.org/10.1016/j.jclepro.2016.12.048

60. Murray, A., Skene, K. and Haynes, K. 2017. The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context. *Journal of Business Ethics,* vol 140(3), pp. 369-380, https://doi.org/10.1007/s10551-015-2693-2

61. Korhonen, J., Honkasalo, A. and Seppälä, J. 2018. Circular Economy: The Concept and its Limitations. *Ecological Economics,* vol 143, pp. 37-46, https://doi.org/10.1016/j.ecolecon.2017.06.041

62. Ellen MacArthur Foundation, 2015. Circularity Indicators. An approach to measuring circularity. Project Overview, https://www.ellenmacarthurfoundation.org/assets/downloads/insight/Circularity-Indicators_Project-Overview_May2015.pdf

63. European Commission, 2019. Accelerating the transition to the circular economy-Improving access to finance for circular economy projects, https://ec.europa.eu/info/sites/info/files/research_and_innovation/knowledge_publications_tools_and_data/documents/accelerating_circular_economy_032019.pdf

64. Sassanelli, C., Rosa, P., Rocca, R. and Terzi, Z., 2019. Circular economy performance assessment methods: A systematic literature review. *Journal of Cleaner Production*, vol 229 (20), pp. 440-453, https://doi.org/10.1016/j.jclepro.2019.05.019

65. Kristensen, H. and Mosgaart, M., 2020. A review of micro level indicators for a circular economy-Moving away from the three dimensions of sustainability?*Journal of Cleaner Production*, vol. 243,p. 118531 https://doi.org/10.1016/j.jclepro.2019.118531

66. Global Reporting Initiative, 2016. GRI Standard 301: Materials, https://www.globalreporting.org/standards/gri-standards-download-center/?g=55ef170e-c270-4e1a-8aa6-69de3f0d6cf8

67. Global Reporting Initiative, 2016. GRI Standard 302: Energy, https://www.globalreporting.org/standards/gri-standards-download-center/?g=55ef170e-c270-4e1a-8aa6-69de3f0d6cf8

68. Global Reporting Initiative, 2016. GRI Standard 303: Water and Effluents, https://www.globalreporting.org/standards/gri-standards-download-center/?g=55ef170e-c270-4e1a-8aa6-69de3f0d6cf8

69. Global Reporting Initiative, 2016. GRI Standard 303: Effluents and Was, https://www.globalreporting.org/standards/gri-standards-download-center/?g=55ef170e-c270-4e1a-8aa6-69de3f0d6cf8

70. Global Ecolabelling Network, 2004. Introduction to Ecolabelling, https://globalecolabelling.net/assets/Uploads/intro-to-ecolabelling.pdf

71. EU Ecolabel, www.ecolabel.eu

72. European Communities, 2011. The Eco-Management and Audit Scheme, https://ec.europa.eu/environment/emas/pdf/leaflets/emasleaflet_en.pdf

73. The International EPD System, https://www.environdec.com/

74. Cradle to Cradle Products Innovation Institute, 2014. Cradle to Cradle Certified Product Standard Version 3.1, https://s3.amazonaws.com/c2c-website/resources/certification/standard/STD_C2CCertified_ProductStandard_V3.1_082318.pdf

75. European Commission, 2014. Commission Decision establishing the ecological criteria for the award of the EU Ecolabel for textile products (notified under document C(2014) 3677), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014D0350

76. PaperWise, https://paperwise.eu/en/labels/

77. European Verification Technology, https://ec.europa.eu/environment/ecoap/etv

78. EU, Single Market for Green Products Initiative, https://ec.europa.eu/environment/eussd/smgp/index.htm

79. Saathi, https://saathipads.com/

80. FIBandCO, https://fibandco.com/

81. Gercona, https://www.gercona.com/en/

82. Icestone, https://icestoneusa.com/

83.Plastic Whale, https://plasticwhale.com/

84. Vepa, https://vepa.nl/?lang=en

85. Metis, https://metis-seagrass.com/

86. Chopvalue, https://chopvalue.com/

87. Smile Plastics, https://smile-plastics.com/

88. IKEA, https://www.ikea.com/

89. Ananas Anam, LTD, https://www.ananas-anam.com/

90. Orange Fiber, http://orangefiber.it/en/

91. Vegea, https://www.vegeacompany.com/

92. Singtex, http://www.singtex.com/en-global/home

93. Qmilk, https://www.qmilkfiber.eu/?lang=en

94. Convert, https://convert.as/

95. Circular Systems, https://www.circular-systems.com/

96. Lenzing, https://www.lenzing.com/

97. Pure Waste, https://www.purewaste.org/

98. Mohawk, https://www.mohawkflooring.com/carpet

99.Finlayson, https://finlaysonshop.com/

100. Nofir, https://nofir.no/#section-about

101. Aquafil, https://www.aquafil.com/

102. Sunbrella, https://www.sunbrella.com/

103. Waste Free Oceans, https://www.wastefreeoceans.org/

104. Infinited Fiber, https://infinitedfiber.com/our-tech/

105. MUD Jeans, https://mudjeans.eu/

106. The Ocean Cleanup, https://theoceancleanup.com/

107. Because of Nature, https://www.becauseofnature.com.au/

108. Circular Clockworks, https://circularclockworks.com/

109. Nuuwaï, https://www.nuuwai.com/

110. nat-2™, https://nat-2.eu/
111. Renovare, https://www.renovareco.com/quienes-somos/?lang=en
112. Sole Rebels, https://www.solerebels.com/
113. Elvis & Kresse, https://www.elvisandkresse.com/
114. Freitag, https://www.freitag.ch/en
116. Londre Bodywear, https://londrebodywear.com/
117. Foxhole Spirits, https://www.foxholespirits.com/
118. Snact, https://snact.co.uk/
119. The Coffee Cherry Co., https://coffeecherryco.com/
120. Grocycle, https://grocycle.com/
121. Innain, https://innain.com/
122. Sanam, https://sanam.company/en/
123. Wtrmln Wtr, https://wtrmlnwtr.com/
124. Renewal Mill, http://www.renewalmill.com/
125. Barnana, https://barnana.com/
126. Baldor, https://www.baldorfood.com/
127. White Moustache, https://whitemoustache.com/
128. Imperfect Foods, https://www.imperfectfoods.com/
129. Full Harvest, https://www.fullharvest.com/
130. Loop, https://loopstore.com/
131. Bio-lutions, https://www.bio-lutions.com/
132. Greenbox, https://www.biologischverpacken.de/
133. Notpla, https://www.notpla.com/
134. KaffeeForm, https://www.kaffeeform.com/en/
135. Huskee, https://huskee.co/
136. Phool, https://phool.co/
137. CaffeInk, https://caffeink.net/
138. Hewlett Packard, https://www.hpe.com/
139. Ecopaper, https://www.ecopaper.com/about-ecopaper
140. Paperwise, https://paperwise.eu/en/
141. Karst Stone Paper, https://karststonepaper.com/
142. Biohusk Energy, https://www.biohusk.com/
143. Mitsubishi Electric, https://www.mitsubishielectric.com/en/index.html
144. SkyNRG, https://skynrg.com/
145. Greentom, https://greentom.com/
146. Goodyear, https://www.goodyear.com/en-US/international
147. Plastic Forests, https://plasticforests.com.au/