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E GESTÃO DE POLÍTICAS PÚBLICAS (FACE)
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TATIANA MARINS CAIADO

FROM GRAVE TO CRADLE: ECONOMICS AND CIRCULARITY TOWARDS SUSTAINABLE CONSUMPTION AND PRODUCTION

MESTRADO EM ECONOMIA
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ABSTRACT

The unbridled economic growth is a global concern. In this regard, the United Nations has established seventeen Sustainable Development Goals (SDGs) in order to reach the 2030 Agenda. Irresponsible consumption and production patterns (SDG 12) affect the climate change (SDG 13). Part of this issue is due to inefficient waste management systems. Environmental impacts at products' end-of-life, as a consequence of waste handling, generate negative externalities. Hence, governmental intervention is necessary to address market failures through public policies. Besides the public waste management service being costly, the implementation of polluters-pay principles is challenging. The question here is: what are the alternatives to ensure efficiency at grave that will reflect on a change at cradle, during product design? Moreover, this study seeks to answer how recycling and Economics interact towards sustainable consumption and production. This research presents a critical literature review with qualitative approach, including scientific papers, legislation and professional documents. We begin with a backwards analysis evaluating supply and demand systems, from grave to cradle, from urban solid waste management phases to the manufacturing stage. Our hypothesis suggests the power of economic and policy instruments for a circular economy transition so as to achieve the sustainable development. Potential solutions for waste management level such as Deposit Refund Systems (DRS) and preparation for reuse might express improvements in industry requirements, as well as technologies for cleaner production and resource efficiency. Consumers also can demand products with ecodesign, ecolabels and life-cycle assessment (LCA) information for a greener decision-making process. Sustainable lifestyle may promote circularity of materials, new business models and sharing economy. In the final discussion, the nexus from grave to cradle is applied in the contexts of Denmark, within European Union, and Brazil, which provides an inspiration to shift the current arrangements in a ten-year horizon.

Keywords: Sustainable consumption and production, circular economy, recycling, economic analysis, waste management

RESUMO

O crescimento econômico desenfreado é uma preocupação global. Nesse sentido, as Nações Unidas estabeleceram dezessete Objetivos de Desenvolvimento Sustentável (ODS) para alcançar a Agenda 2030. Os padrões de consumo e produção irresponsáveis (ODS 12) afetam as mudanças climáticas (ODS 13). Parte desse problema se deve a sistemas ineficientes de gerenciamento de resíduos. Os impactos ambientais no final da vida útil dos produtos, como consequência do manejo de resíduos, geram externalidades negativas. Portanto, a intervenção governamental é necessária para enfrentar as falhas do mercado por meio de políticas públicas. Além do serviço público de gestão de resíduos ser custoso, a implementação dos princípios do poluidor-pagador é um desafio. A questão aqui é: quais são as alternativas para garantir a eficiência no túmulo que se refletirão em uma mudança no berço, durante o design do produto? Além disso, este estudo busca responder como a reciclagem e a Economia interagem para o consumo e a produção sustentáveis. Esta pesquisa apresenta uma revisão crítica da literatura com abordagem qualitativa, incluindo artigos científicos, legislação e documentos profissionais. Começamos com uma análise retrospectiva avaliando os sistemas de oferta e demanda, do túmulo ao berço, desde as fases de gestão de resíduos sólidos urbanos até a fase de fabricação. A hipótese sugere o poder dos instrumentos econômicos e políticos para uma transição da economia circular de forma a alcançar o desenvolvimento sustentável. Soluções potenciais para o nível de gerenciamento de resíduos, como Sistemas de Depósito Reembolso (SDR) e preparação para reutilização podem expressar melhorias nos requisitos da indústria, bem como tecnologias para produção mais limpa e eficiência de recursos. Os consumidores também podem exigir produtos com ecodesign, rótulos ecológicos e informações de avaliação do ciclo de vida (ACV) para um processo de tomada de decisão mais verde. O estilo de vida sustentável pode promover a circularidade de materiais, novos modelos de negócios e economia compartilhada. Na discussão final, o nexo do túmulo ao berço é aplicado nos contextos da Dinamarca, dentro da União Europeia, e do Brasil, que fornece uma inspiração para mudar os arranjos atuais em um horizonte de dez anos.

Palavras-chave: Consumo e produção sustentáveis, economia circular, reciclagem, analise econômica, gestão de resíduos

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

ADF	Advance Disposal Fee
BAT	Best Available Technique
BCA	Benefit-Cost Analysis
CCS	Carbon Capture Storage
CEA	Cost-Effectiveness Analysis
CEBDS	Conselho Empresarial Brasileiro para o Desenvolvimento Sustentável (Brazilian Business Council for Sustainable Development)
CGPL	Comitê Gestor de Produção mais Limpa (Cleaner Production Steering Committee)
CNI	Confederação Nacional da Indústria (National Confederation of Industry)
DRS	Deposit Refund Systems
EC	European Commission
EIA	Environmental impact assessment
EIR	Environmental Implementation Review
EMAS	Eco-Management and Audit Scheme
EPR	Extended Producer Responsibility
EU	European Union
GDP	Gross domestic product
GHG	Greenhouse gas
GPP	Green public procurement
GWP	Global Warming Potential
INMETRO	Instituto Nacional de Metrologia, Qualidade e Tecnologia (National Institute of Metrology, Quality and Technology)
IPEA	Instituto de Pesquisa Aplicada (Institute of Applied Economic Research)
ISO	International Organization for Standardization
ISWA	International Solid Waste Association
IRR	Installation for Resources Recovery
LCA	Life-cycle assessment
LCC	Life-cycle Costing
LCI	Life-cycle inventory
LCIA	Life-cycle impact assessment
LFG	Landfill gas
MCA	Multi-criteria analysis
MMA	Ministério do Meio Ambiente (Ministry of the Environment)
MRF	Materials Recovery Facility
MSW	Municipal solid waste
NGO	Non-Governmental Organizations
PAYT	Pay-as-you-throw
PDCA	Plan-Do-Check-Act
PNRS	Política Nacional de Resíduos Sólidos (National Solid Waste Policy)
PNMC	Política Nacional de Mudança Climática (Climate Change National Policy)

PPCS	Plano de Ação para Produção e Consumo Sustentáveis (Action Plan for Sustainable Production and Consumption)
R&D	Research and Development
RS	Rio Grande do Sul
SCP	Sustainable consumption and production
SDGs	Sustainable Development Goals
SENAI	Serviço Nacional de Aprendizagem Industrial (National Industrial Training Service)
SINIR	Sistema Nacional de Informações sobre a Gestão dos Resíduos Sólidos (National Information System on Solid Waste Management)
SMEs	Small medium-sized enterprises
SPPEL	Sustainable Public Procurement and Environmental Labelling Project
TCO	Total cost of ownership
UN	United Nations
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
WBCSD	World Business Council for Sustainable Development
10YFP	10-year framework of programmes

TABLE OF CONTENTS

INTRODUCTION

The United Nations' Sustainable Development Goals (SDGs) are well known around the world. Responsible consumption and production (SDG 12) and climate action (SDG 13) are considered SDGs due to the impact on everyone's lives. They are either directly or indirectly related to solid waste generation. Consumption and production are, on one hand, basic source of solid waste. On the other hand, municipal waste management, incineration and landfill operation emit greenhouse gases and impact on climate change (UN CLIMATE SUMMIT, 2014). In this context, Porter (2002) suggests that recycling represents an alternative to decrease pollution, save energy and mitigate gases emissions.

From the economics of waste perspective, as proposed by Porter (2002), it is essential to submit recycling to evaluation through economic principles. This seems to be a prerequisite to an actual sustainable waste management as defended by Das *et al*. (2019). Waste management creates negative externalities and consequently external costs to society. Therefore, policies and instruments should be implemented to minimize these market failures (KIRAKOZIAN, 2016). How a mix of policy instruments could be more economically efficient to handle waste since products' conception until final destination? This question is discussed in the following sections.

Economic instruments are desired to promote household participation in recycling as well as new production patterns such as 'design for environment' to decrease extraction of virgin materials (CALCOTT; WALLS, 2005). Also, zero waste strategy seems to be a relevant target to communities in order to achieve a behaviour change (ZAMAN, 2015). However, Nogueira Junior (2006) argues in regard to policies that the aim to provoke a change in utility functions might be more difficult than in production functions in a given society.

In this context, circularity might be an alternative. The circular economy principle is highly discussed in Europe and is increasing in the rest of the world. Korhonen, Honkasalo and Seppälä (2018) argue that the concept has its origins in Ecological Economics. Similar ideas had been already debated previously as well as recycling. The difference is basically in terminology because all of them propose alternative solutions to reduce environmental impacts from linear approach. Narrowing, slowing and closing the resource loop represent a change in products' requirements and industry responsibility. Nevertheless, the concept of circular

economy still faces some limitations (GHISELLINI; CIALANI; ULGIATI, 2016; KORHONEN; HONKASALO; SEPPÄLÄ, 2018). Mcdonough and Braungart (2010) come up with cradle-to-cradle (C2C) alternative for producing circularly.

Circular economy is based on cradle-to-cradle principle, while life cycle assessment (LCA) focuses on cradle to grave (ELLEN MACARTHUR FOUNDATION, 2020). Even though LCA seems a shorter measurement than circular economy, LCA still has a huge potential to support decision-making process in regard to environmental impacts. LCA is widely recommended in relation to waste management, recycling, zero waste, sustainability and also circular economy (ARAFAT; JIJAKLI; AHSAN, 2015; DAS *et al.*, 2019; GHISELLINI; CIALANI; ULGIATI, 2016; KINNAMAN, 2016; KORHONEN; HONKASALO; SEPPÄLÄ, 2018; LIIKANEN *et al.*, 2018; ZAMAN, 2015). Some of those trends are being performed in Denmark, and still have opportunities to scale up in Brazil.

Denmark and Brazil have developed the waste sector differently, as well as its industrial production. As part of European Union, Denmark is under European legislation. The Danish historical context evidences the use of economic and policy instruments in order to allocate resource efficiently. There, exist a clear nexus between waste management and the industry's requirements. On the order hand, the Brazilian economy faces barriers for implementing long run programmes for waste handling. At the same time, resource efficiency and the industrial policy are still demanding more robust instruments to promote economic efficiency. The extreme opposite situation represents an opportunity for investigation. Hence, this both countries have been chosen for a discussion and comparison in terms of economic efficiency. The Danish lessons learnt can be an inspiration for Brazil.

As a matter of fact, the existence of economic inefficiency in household recyclable waste management might be a consequence of the unsustainable production-consumption system. Moreover, sustainable requirements such as recyclability should be defined since the product´s design. Economic analyses are relevant to identify benefits and costs, from the end of materials' lifecycle as trash (grave), to the beginning of products' lifecycle as resource (cradle), in the opposite direction. Also, contrasting Brazilian and Danish realities regarding urban solid waste management and industry requirements is appropriate to evaluate different strategies, instruments and technologies, in distinct continents.

This study aims to apply Economics for analysing efficiency in household recyclable waste management to reflect a change for sustainable production and consumption schemes. Furthermore, it investigates trends in recycling that might encourage more responsible behaviours and mixed policy alternatives. This enquiry includes the understanding of circular economy and lifecycle assessment. Finally, policy evaluation is applied in the Brazilian and Danish contexts in regard to recovery forms, manufacturing and spending habits.

This dissertation is an applied research in Economics regarding sustainability in supply-demand systems that impact upon recycling and waste management. It is structured into five chapters besides the introduction and conclusion. Therefore, we aim at answering two research subquestions (SQ1 and SQ2), and then an overall research question (RS) sums up the whole discussion in this study, as following:

SQ1: How the economics of solid waste can promote circularity in the industry (from grave to cradle)?

SQ2: What is the policy mix to promote sustainable consumption and production in European Union, Denmark, and Brazil?

RQ: How can circular economy move towards sustainable consumption and production?

First of all, in Chapter 1, a literature review shows the Economics of urban solid waste management. Waste management represents the grave of thrown-away products. There are many types of classification, treatment technologies and operational solutions to handle waste. Here, urban solid waste comprises waste generation at household, which is usually managed by the public sector. The phases of those managerial activities, from source until final destination, will be investigated in the lights of Economics. Moreover, recycling is seen as a more environmental-friendly alternative. Then, economic incentives and other instruments are discussed to deal with household waste. Finally, evaluations as Benefit-Cost Analysis (BCA) and Cost-Effectiveness Analysis (CEA) might bridge the theory and practice regarding waste.

Chapter 2 brings the paths towards responsible behaviour for producers and consumers according to trends on market and governmental intervention. Undoubtedly, supply and demand systems affect the environment. The global

movement to achieve sustainability concerns with production and consumption patterns. The interaction among society, planet and economic system aims at growing efficiently, but also depends on ways of consuming and living. Thus, circular economy comes up to narrow, close and slow the resources loop. Moreover, life-cycle assessment (LCA) brings an opportunity to recognize products' impact along the whole cycle. Ultimately, public policies have the potential to implement those solutions in a nexus perspective to ensure sustainable consumption and production, SDG12 according to the United Nations global strategy.

Then, the research and conceptualizations investigated on Chapters 1 and 2 are applied in the context of Denmark, Chapter 3. Denmark, as European country, aims at being sustainable. Here we evaluate first the waste sector development, at grave, then, the industrial production, at cradle. The strategy to solve problems at the products' end-of-life, as well as to green the Danish industry converge to a circular economy transition. Hence, not only the European Union legislation, but also Danish laws contain elements to achieve sustainable production and consumption. Those opportunities and challenges are discussed and we understand why Denmark is considered one of the front-runners in this topic.

The topic in the context of Brazil is discussed on Chapter 4. From impacts at grave to trends at cradle, there is a potential to change patterns towards sustainable development across instruments and resource allocations, let's investigate it. Brazil also faces challenges to deal with unsustainable patterns. As a developing country, poverty, managerial difficulties and unqualified workforce are some variables that disturb the implementation of certain policy instruments. Its enormous population and the large territory, different from Denmark, affect the solutions to handle waste and to develop the industrial sector. However, the Brazilian economy also poses opportunities to be more circular in order to achieve responsible consumption and production.

The Danish inspiration for Brazil is discussed on Chapter 5. The final discussion considers lessons learnt from Danish initiatives that might be implemented in Brazil. The economics of solid waste evidences opportunities to change the current linear approach. Moreover, we bring back our subquestions and search questions to make sure we have answered them. Finally, we conclude our study looking at the highlights regarding waste management, sustainable

consumption and lifestyle, sustainable production and circular economy. In order to sum up our findings, we propose a flow of resources based on circularity, from grave to cradle.

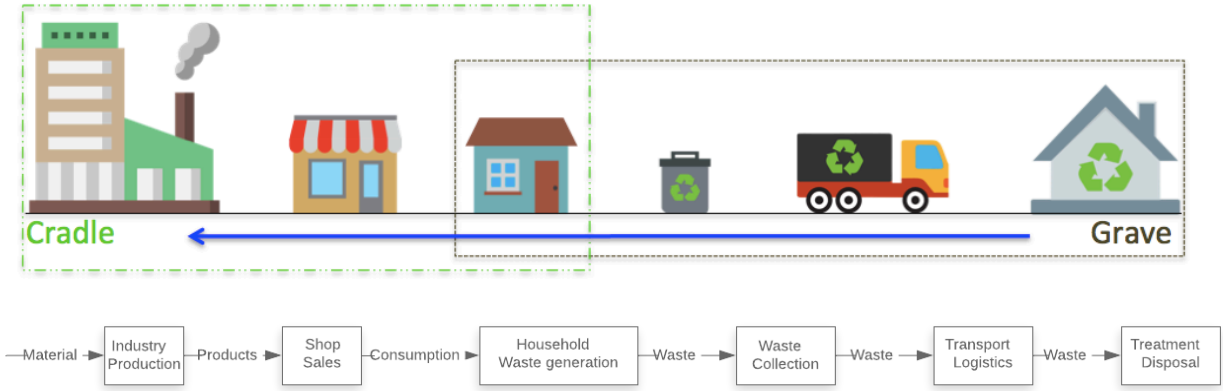
Methods and Procedures

Blaug (1999) mentions his concordance with Bruce Caldwell (1982) in regard to methodology of Economics as being the investigation between theories and conclusions applied in the real world. Methodology is both a descriptive and prescriptive subject. The authors defend that Economics theories should be tested empirically to evidence the truth. Indirect examinations as to specific principles could deduct actual phenomena in our lives. Genuine trials would be necessary to understand the causes that act in the economic system.

However, it is known that some experiments are difficult and ambiguous for refutation, thus not viable for all conceptual theories. Blaug (1999) supports science as based on abduction followed by deduction. Deductive logic brings demonstrative arguments, since true premises come up with true conclusions, from general to specific. In summary, this theoretical review is an applied research in Economics.

In the conceptual framework "from grave to cradle", as stated in Figure 1, the elements go through the process with different actors and will be investigated within the Economics theoretical framework. Figure 1 is a simplistic input-output model, and will be completed over our chapters, including economic, environmental and policy instruments, as well as alternative flows to make the system more efficient. The image is not finished yet. Environmental pollution, neither international trade (imports/exports), nor its economic system which are not embedded in this Figure 1 yet. As it is shown, there are evidences of the linear thinking and loss of circularity potential to reinsert resource in the production chain. In this regard, governmental intervention can avoid overconsumption and unsustainable options.

Figure 1 - From grave to cradle flowchart



Source: own elaboration, based upon Reike, Vermeulen and Witjes (2018)

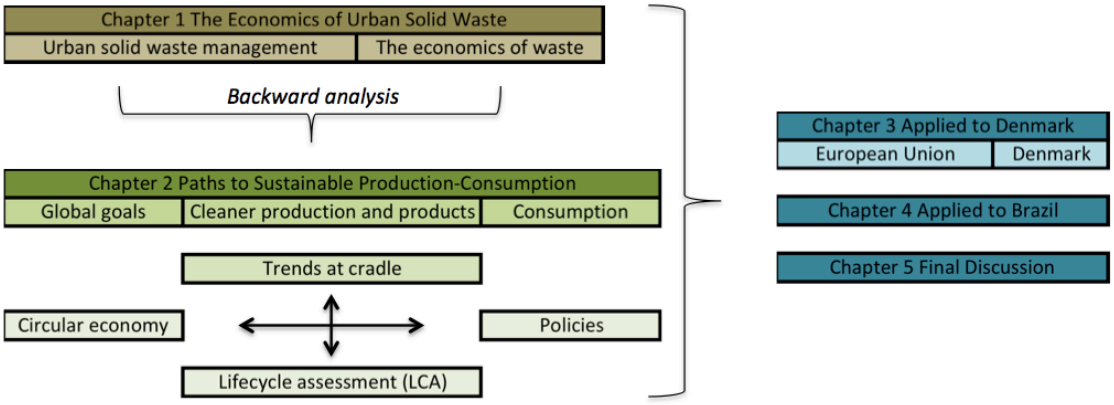
The method used in this research was a critical literature review and qualitative approach. The strategy includes gathering scientific articles regarding the topic in indexed journals, as well as professional documents, books, reports, frameworks, legislations and norms. The keywords applied in *Web of Science* database were: “Economics of waste”, “waste management”, “recycling”, “sustainable production”, “sustainable consumption”, “zero waste”, “circular economy”, “lifecycle”, “industry”, “policy”, “environment*”, “sustainabl*”, “LCA” and others.

These keywords were often presented in relevant papers within the *Economics* category in the last five years. Also, the main principles to achieve the global goals established by the UN were considered on searching. Some combinations among concepts were done to identify connections and trends in the topic. Geographic filters and focal research were applied to consider the contexts of Brazil and Denmark. Language differences were both an advantage, by finding articles in Portuguese, and a limitation, by avoiding papers in Danish. The author’s living experience in both countries was the reason for choosing Brazil and Denmark, by recognizing industrial and lifestyle differences. Also, her field of work in waste management and policy evaluation were an opportunity to research deeper, locally.

Procedures used in this study are presented in Figure 2. The understanding of the Economics of urban solid waste management starts at grave. The waste phases and recycling alternative are discussed in terms of economic and policy instruments for household waste. Then, at cradle, related externalities drive to global goals within the interaction between economic system and environment. Production and consumption bring opportunities for sustainable development by trends in the market.

This conceptual framework is applied in Danish reality, considering European Union policy, national efforts and challenges to reduce environmental, social and economic impacts. In contrast, legislation in Brazil has gaps for improvements as to waste management that affect industrial patterns and requirements for SCP.

Figure 2 - Thesis structure



Source: own elaboration

CHAPTER 1

THE ECONOMICS OF URBAN SOLID WASTE MANAGEMENT

1. 1. PHASES OF URBAN SOLID WASTE MANAGEMENT

Since the moment we are born, we generate waste. In order to handle this waste properly infrastructural and operational activities are necessary, as well as technologies and administrative tools. Several requirements should be attended to guarantee public service at kerbside. Different contexts and budgets may interfere in the way the waste management system operates. Das *et al.* (2019) divide waste management in four steps: (a) waste generation; (b) waste collection; (c) waste transport/logistics; (d) waste treatment and disposal. However, some authors may differ waste treatment and final disposal in separated phases. For instance, JUCÁ (*et al.*, 2013) mention recycling as waste valorisation, and landfilling as final disposal. Besides these phases, it is important to quantify and characterize solid waste for decision-making process and strategies, particularly urban solid waste.

1.1.1 Waste generation

This represents the beginning of waste cycle at residences or at production units, when a product turns waste because its holder recognizes no other value on it. Das *et al.* (2019) ponder that waste generation depends on the country's economic status. Waste composition varies among nations because finance influences consumption. Porter (2002) also includes the difference in terms of density, since developed countries have a less dense waste due to less food and more paper waste. Kolekar, Hazra and Chakrabarty (2017) investigate the effects on waste generation and waste generator profiles due to the number of people, per capita income per year, literacy rate, age clusters, and consumer expenditure per month.

The main challenge in this stage is waste generation increase (DAS *et al.*, 2019; LIIKANEN *et al.*, 2018). Differently, Degli Antoni and Vittucci Marzetti (2019) argue that waste generation might be reduced as a result of recycling kerbside collection service. This was demonstrated by an empirical study in Italy, showing a link between recycling and waste generation. It means that the following phases – (b) waste collection and (c) waste transport/logistics – may interfere on the previous – (a) waste generation. However, Kirakozian (2016) disagrees of that since household motivation to recycle is a greater problem than providing public kerbside collection.

1.1.2 Waste collection

Porter (2002) presents two kinds of trash collection: house-to-house kerbside collection and waste containers for the neighbourhood. For recycling there is another option called drop-off centres that works as a volunteer activity, and consequently has a lower engagement. This collection might be basically done in open trucks or compactor trucks. Regions with less job opportunities tend to be labour-intensive in collection. It represents inefficient productivity to solve unemployment issues by over allocating human resource for the collection phase.

In terms of costs, recyclables collection is two or three times more expensive than conventional waste mixed per ton (PORTER, 2002). One reason for that is waste compaction, since traditional waste can be compacted to reduce its volume by one fourth. Recyclables cannot be compacted due to sorting activities and loss of recyclability potential (PORTER, 2002). Actually, collection costs may vary among cities depending on truck model, amount collected per house, staff group size, public or private service, average distances between stops, materials specific collected, and so on (MILLER, 1993; STEVENS, 1994 *apud* PORTER, 2002). Also, multifamily houses as apartments, for example, provide less recyclables than single-family housing. Das *et al.* (2019) add the presence of waste pickers at this phase, also called scavengers or decomposers. They are on the streets mainly of developing countries collecting recyclables before public service transports them properly for treatment.

1.1.3 Waste transport/logistics

Transport costs usually are high. One alternative to drop costs is using transfer stations, from smaller trucks to larger equipment to reduce fuel-costs. In what regards frequency, there is no consensus about costs, neither as to recycling rates. Also, there is a fluctuation in the amount of waste collected in different weeks (PORTER, 2002). In regard to negative environmental impacts due to waste logistics, Global Warming Potential (GWP) is affected by direct emissions from transportation; distances and payload capacity (LIIKANEN *et al.*, 2018). Das *et al.* (2019) defend the need of efficiency in logistics operations and resource allocation to ensure flow. In parallel, clear accountability and communication should be created inside the waste system and outside for citizens. The authors suggest the use of devices such as waste logistic tracking systems to support it and increase efficiency in the system.

1.1.4 Waste treatment and disposal

According to Das *et al.* (2019) the main challenges at this phase are energy consumption, skilled labour, disposal and footprint. The authors present pros and cons about cost-effective waste solutions. First of all, he suggests the use of composting approaches for organic waste, then, energy recovery technologies (thermo-chemical conversion and bio-chemical conversion) and finally innovative ways. Waste burning aims to reduce volume where land is unavailable, however it is costly. Final disposal in landfills is also a cost-intensive process and is a source of greenhouse gases direct emission, although less than burning technologies (DAS *et al.*, 2019).

Instead, waste buried in landfills is a widespread practice as final disposal. There are many negative externalities such as methane emission, litter, noise and odour, though. Prevention of leaching is another concern as well as global warming due to greenhouse gases emanated at the landfill. Some alternatives are flaring methane to convert to carbon dioxide or, a better option, landfill gas (LFG) production to use as energy (PORTER, 2002).

1.2 RECYCLING: AN ALTERNATIVE OF SOLID WASTE MANAGEMENT

Besides these options for waste treatment and disposal, there is the recycling alternative. There are, however, different requirements and processes to recover materials at recycling industry. This kind of treatment is relevant for our analysis. The recycling technological route treats waste to become a resource by sorting material from kerbside collection (JUCÁ *et al.*, 2013). It is a physical process, which could depend on the source of materials, if they come from a selective or commingling collection. Recycling kerbside collection is recommended as long as households separate potential recyclable materials at home. Porter (2002) complements the lack of economic incentive for household to recycle. It represents a market failure in recycling since there is no price signal sent.

Materials are transported to facilities where recyclables are sorted. These sites have many different names as Materials Recovery Facility (MRF), Recycling Centre, or even Installation for Resources Recovery (IRR). All of them are basically the same, since they have the equivalent purpose to return materials to the production chain. Also, those facilities involve high costs due to labour-intensive

operations and expensive equipment such as conveyor belts, forklift and baler (PORTER, 2002; JUCÁ *et al.*, 2013). Caiado *et al.* (2018) distinguish the five main activities developed at an IRR: waste reception, recyclables sorting, refused removal, pressing and baling, storage and commercialization. They suggest the use of PDCA cycle (Plan-Do-Check-Act) to manage operation and production at IRRs.

Porter (2002) explains that recycling facilities are not profit-oriented, most are controlled or owned by the municipalities. Its revenues from the sale of recovered materials are lower than the operations costs at such facilities. Nowadays, those are shortfall entities unless government subsidizes them aiming at recycling as much as possible. In a similar movement, the state government contracted waste pickers cooperatives as service providers to sort materials at recycling centres in Brazil, in the context of closing the world's second largest dumpsite (CAIADO *et al.*, 2018). Refused waste also needs to be removed and sent to landfill, which is costly.

Recycling markets face challenges as secondary markets. Fluctuations in prices, supply and demand with sharp changes are usual, which disturbs efficient allocations. Moreover, recycling materials are not considered close substitutes to the raw material, because they do not have the same value as a virgin material. A second-best policy to compensate it would be subsidising recycling as a substitute action. This substitutability also depends on the type of material and its industry power. Another disadvantage is the lack of attention on virgin materials production and external costs generated by government (PORTER, 2002). Finally, Calcott and Walls (2005) argue that recycling markets encourage 'design for environment' and a greater participation in separating materials. Kerbside recycling collection also helps population engagement in recycling, even though transaction costs exist.

1.3 BASIC PRINCIPLES IN ECONOMICS

It is clear that solid waste management, as a whole, and recycling, in particular, are influenced not only by technical issues, but also by economic variables. During our whole life we need to deal with waste and seek efficient economic solutions. The economic model considers people's economic behaviour as rational because individuals choose economically to make themselves better. Pareto theorem or welfare Economics axiom state that a change that makes at least one person better off and leaves nobody else worse off expresses an increase of welfare; the inverse would represent loss of welfare. Therefore, how can we consider waste

management as economically efficient? In this section we analyse urban solid waste in terms of Economics.

Since we live in a real world, there are failures in managing waste systems. Pearce and Turner (1993) have categorized four basic waste management failures: information failure, lack of "systems thinking", lack of economic cost-benefit thinking and market failure. In the majority of economic studies, the most important is market failure, which justifies government intervention to address them through public policies (NOGUEIRA JUNIOR, 2006).

There is a failure whenever the market is not efficient according to Pareto's criterion, as happen to negative externalities[1]. In other words, if anyone does anything that makes someone else worse off directly, and leaves no compensation for it, an external cost arises (PORTER, 2002). Sterner and Coria (2013) point out six types of market failure: externalities, public goods and common property, property rights, non-competitive markets, asymmetric information, and non-convexity. Among them, externalities are highlighted in urban solid waste management and will take more attention from us.

When the waste management system generates pollution, which would not be internalized by their generators, these external costs to society are externalities. Kinnaman (2016) exemplifies this kind of market failure in terms of air pollutants emitted by incinerators or landfills once solid waste is disposed. As long as externalities related to urban solid waste exist, government regulation might be needed to correct them.

Negative externalities in waste management are associated to polluters. For Kirakozian (2016), handling externalities is an important aspect to identify responsible polluter. For her, there are two options: the waste generator or the last waste holder, since producers are pondered separately. Thus, the author defends consumers as strategic agents to achieve regulations goals. However, Das *et al.* (2019) argue the questionable success of the polluters-pay concept. Socio-economic layer is considered a system that imposes incentives or taxes by the Government, but it is still insufficient. In terms of measuring external costs to society, both Pigou

[1] "Negative externalities lead markets to produce a larger quantity than is socially desirable. Positive externalities lead markets to produce a smaller quantity than is socially desirable. To remedy the

(1932) and Coase (1960) proposed very important corrections regarding pollution and its effects to society (COSTA, 2005).

The difference between marginal private cost and marginal social cost denotes the costs to society that are not paid by producers (or consumers), the so-called marginal external cost. Pigouvian tax aims at “internalizing the externality” (PIGOU, 1932) which means a tax equal to the marginal external cost. Also, to get prices right, which is the first-best Pigouvian externality tax rate, the price should be the same as the marginal social cost, and both lower than the willingness to pay, or at least as much as the social cost of its production (PORTER, 2002). When prices fail to contemplate full social cost, the market fails to allocate resources efficiently (PEARCE; TURNER, 1993).

However, Coase (1960) criticized Pigou (1932) because he ignored transaction costs. Coase theorem says that in the absence of transaction costs, private and social costs are equal, since externalities have been already internalized (COASE, 1960). Property rights well defined and no transaction costs mean equilibrium by the Coasian negotiation. Therefore, there is no need for governmental intervention. Calcott and Walls (2005) corroborate the unnecessary regulation between consumers and recyclers unless there are transaction costs. On the other hand, Porter (2002) emphasizes the number of people negotiating. Usually, waste-related externalities involve a disorganized and massive population, consequently, transaction costs will appear and derail Cosian negotiation.

1.3.1 3E meets 3R Economics

Efficiency, efficacy and equity are the gold criteria in economic analysis and usually are presented in the context of solid waste management (NOGUEIRA JUNIOR, 2006). Moreover, the 3R principle (Reduce, Reuse and Recycle) is always part of waste policy discussions. There is a hierarchical order: first, waste minimization, then reusing/recycling, being the last option the final disposal in a landfill (CHAKRABARTI; STARKHEL, 2003). Nogueira Junior (2006) combines these three economic criteria and the 3R concept. His study aims at understanding human behaviour in terms of economic motivation considering the whole solid waste management cycle, Table 1. In his discussion, there are at least nine possibilities, where for each “R” for waste, different instruments focus on each economic criteria “E”. Thus, 3E meets 3R and might be conflicting depending on the political strategy.

Table 1 3E and 3R

Efficiency	Policy that achieves or tends to achieve the point where the marginal costs of reduction (degradation or pollution) are equal to the marginal damages caused by such degradation or pollution. The reduction of marginal damages represents the social benefits of the policy. Efficiency means the search for allocating resources at the best benefit-cost ratio, maximizing benefits and minimizing costs. (FIELD, 1997 in NOGUEIRA JUNIOR, 2006).
Efficacy	Considering efficacy in a policy refers to achieving established targets with precision (FIELD, 1997 *apud* NOGUEIRA JUNIOR, 2006).
Equity	This criterion indicates ethical and moral issues related to social justice. It represents equality and supporting the poor. Moreover, it is about who will receive the benefits and who will pay the costs associated to the policy (NOGUEIRA; MEDEIROS, 1999).
Reduce	Reduction suggests a change in production patterns, including use of fewer materials, 'design for environment', lower loss during production, as well as, zero waste strategies (NOGUEIRA JUNIOR, 2006).
Reuse	This action aims at delaying and minimizing the use of virgin raw materials. It is usually applied in returnable bottle systems, which need to be cleaned, sterilized and painted before reusing (NOGUEIRA JUNIOR, 2006).
Recycling	It requires some reprocessing of materials to supply the demand of virgin raw materials (PORTER, 2002).

Source: own elaboration

Efficiency is the first criterion used by environmental economist to choose environmental policies (JACOBS, 1991 *apud* NOGUEIRA JUNIOR, 2006). Pondering with efficacy, if a policy is efficient, it is also effective, although the inverse would not necessarily represent the same (FIELD, 1997 *apud* NOGUEIRA JUNIOR, 2006). Nogueira and Medeiros (1999) explain the second-best solution, by choosing an effective option with lower administrative costs of implementation and monitoring. Which means this is not the perfect solution, but the most feasible among all alternatives available. On the other hand, equitable decision distributes benefits as

well as costs among people. Maximization of the benefit-cost ratio might signify social injustice, contrary to equity (NOGUEIRA; MEDEIROS, 1999).

Reduction or waste prevention takes the main priority in the ‘waste management hierarchy’. Conservationists usually defend a change in consumption, in human behaviour, in lifestyle (NOGUEIRA JUNIOR, 2006). While reuse practices have the challenge of operation and cleanness, besides their costs. Furthermore, reusing is not feasible for all kinds of products such as those that present health risks and “one way” products (NOGUEIRA JUNIOR, 2006). On the other hand, shared ownership is a trend in Circular Economy based in collaborative consumption models (GHISELLINI; CIALANI; ULGIATI, 2016), which is debated later as well.

Recycling, for sure, is the widest explored proposal in waste management, especially within Economics. However, Porter (2002) defends that it is not an optimal solution to recycle everything, neither recycling nothing at all. Different types of materials and their degree of recyclability may influence recyclable markets and their potential, besides mitigating environmental impacts on landfills. Recycling is the main line of investigation in this review.

1.3.2.Instruments and incentives for household waste

Combination as a policy mix is strongly highlighted in waste Economics, Table 2. Here we analyse some of them, such as taxes and subsidies working together (KIRAKOZIAN, 2016; DUBOIS; EYCKMANS, 2015; PORTER, 2002; KINNAMAN, 2016; CALCOTT; WALLS, 2005). Moreover, a combination between deposit-refund system as economic incentive plus command and control to make product refund imperative seems to be an efficacy solution for certain products (ZAPATA, 2002). Alternatively, behavioural Economics and information-based instruments are also complementary to those economic incentives mentioned previously to encourage household recycling (KIRAKOZIAN, 2016).

Table 2 Incentives and instruments

Tax	A value to reflect full social cost for waste disposal (PORTER, 2002).
Advance Disposal Fee (ADF)	Producers pay for the further treatment and waste disposal of their products (PORTER, 2002).
Pay-as-you-throw (PAYT) or unit pricing	Trash collection charges (PORTER, 2002).
Subsidies	Illegal disposal is one of the reasons for subsidising waste. Its risk motivates municipalities to apply subsidies as the collection charge tends to zero or even zero (PORTER, 2002).
Deposit-Refund System (DRS)	Payment refund to consumers on returning products at drop-off centres (KIRAKOZIAN, 2016)
Command and control instrument	Command and control is an environmental regulation that establishes prohibitions and/or limits in terms of pollution allowed. The government defines the socially suitable level to be emitted and implements public policies to reach it (KIRAKOZIAN, 2016).
Extended Producer Responsibility (EPR)	Producer take-back responsibility or extended producer responsibility (EPR) is an application of the polluter-pays principle. This means that the polluters, specifically the producers, are responsible for all negative externalities they have generated to make their products during the whole lifecycle (NOGUEIRA JUNIOR, 2006).
Behavioural Economics and Information-based instruments	Behavioural tools and information-based instruments can influence recyclables sorting. Households' relation to waste management and motivation to recycle has both extrinsic and intrinsic values (KIRAKOZIAN, 2016).

Source: own elaboration

Tax is the simplest incentive for efficient recycling according to Calcott and Walls (2005). Kirakozian (2016) consider that environmental taxes for household waste are effective as an economic instrument to inspire changes in human behaviour via price signal. However, this price signal does not encourage individual waste reduction if this tax is uniformly distributed. The volume of waste decreases if taxes rise. On the other hand, with increasing in income, waste generation grows. Porter (2002) corroborates the positive income elasticity, as less than one.

Advance Disposal Fee (ADF) might be an incentive to reduce waste and generate revenue for the government, however, it does not interfere in recycling and reusing. Furthermore, in the ADF, it is not possible to identify where the product will end-up being transported to and finally disposed (PORTER, 2002).

If a uniform value is applied, an unit pricing might be too high for cheap disposal products and too low for disposal of expensive materials. Usually, PAYT demands operation for: waste generator identification, measurement of waste quantities produced and price definition based on individual effort (BILITEWSKI, 2008; REICHENBACH, 2008). Miranda *et al.* (1996 *apud* PORTER, 2002) present three options for implementing a system to charge waste collection: priced bags, priced tags and subscription can. All of them are volume-based systems, as the household does not pay per weight of waste. There is a risk of purchasing a waste compactor to reduce its disposal, and consequently, its costs. Porter (2002) concludes that marginal social waste cost depends on both weight and volume.

Subsidies might discourage waste prevention, sorting and recycling waste, if not combined with other instruments (DUBOIS; EYCKMANS, 2015). Calcott and Walls (2005) include the importance of customizing taxes and subsidies in terms of recyclability of different kinds of products, even if they are a combination between tax and subsidy. Kinnaman (2016) defends that recycling subsidies might be inefficient because it encourages consumption growth. Porter (2002) calls hidden subsidies the first type of failure endemic to waste issues. It is the same as selling something cheaper than its production cost, in this case, waste collection paid by the government. Moreover, another type of subsidy is an antilitter policy. It means a refund for legal disposal by choosing the socially more appropriate waste disposal system instead of litter.

In DRS, individuals will receive back an amount of money paid at the moment they have bought a product, once they return the product when there is no other use for it. Calcott and Walls (2005) get the idea that refund motivates buyers to bring products back for recycling. Nevertheless, the authors emphasize about unclaimed deposits, which should not be kept with producers. Manufacturers should put up with the social cost of landfilling products as trash, for example.

Kinnaman (2016) also supports deposit-refund programs as the best solution for internalizing waste disposal costs within downstream and upstream discussion. It is more efficient than recycling subsidies and waste collection charges, since it prevents from overconsumption (deposit) and illegal dumping (refund), respectively. He complements that the literature assumes that external costs related to final disposal are sizeable. Zapata (2002) defends the hypothesis of economic efficiency through DRS by recycling, reusing and changing consumers' behaviour. For him, this tool is both economically and environmentally feasible for policymaking. It means an economic incentive to return products at the end of its lifecycle to be reprocessed as a recovery strategy.

One way of doing command and control instrument is creating a law restricting or banning pollution-related issues. In this sense, the external costs recognized represent a major misallocation problem, which does not mean a non-efficient allocation. Usually, it is not cost-effective (PORTER, 2002).

Pearce and Turner (1993) argue that waste-recycling targets under command and control regulatory standards might not be achieved because of the lacking system perspective and information faults. Command and control may likewise be used as requirements in product design to force recycling by recyclable materials. Furthermore, in deposit-refund systems, consumers and firms would be encouraged to consume and to produce recyclable products, but this obligation would also be prejudicial to the process of creating new ventures (FULLERTON; WU, 1998 *apud* ZAPATA, 2002).

Despite the implementation of EPR in Europe having achieved notable recycling results, there is a criticism about lacking of waste reduction incentives. Dubois and Eyckmans (2015) point out that EPR interaction with other policy instruments is still unclear. In order to be efficient, EPR recycling targets need to be combined with waste collection charge to household. These authors also reveal the

challenges for implementing EPR among countries with different policy instruments and the growth of international trade of waste materials. EPR should be according to product-specific materials, since products are heterogeneous, especially hazardous components (AALBERS; VOLLEBERGH, 2008; ACUFF; KAFFINE, 2013; *apud* DUBOIS; EYCKMANS, 2015).

Kirakozian (2016) analyses behavioural Economics literature related to household waste management and motivations to recycle. This study discusses aspects that influence selective sorting action and ways to promote it through policies. Kirakozian (2016) suggests the use of nudges in order to influence individual choices conducted by group decision. Recycling participation might be a contribution to a public good. The author defends that behavioural tools and informational instruments should be used to complement economic incentives in multiple policies. It is the only way to achieve maximum welfare. Otherwise, household will under-recycle if they do not have information about reprocessing infrastructure – what, how, where etc. (AADLAND; CAPLAN; PHILLIPS, 2005 *apud* KIRAKOZIAN, 2016). On the other hand, Porter (2002) contrasts with rational Economics view, looking for market-oriented incentives to correct failures. He understands that it is not only about education and moral values, it is about price and tax power to enforce the environmentally correct thing to do.

1.4. FROM THEORY TO PRACTICE: BCA AND CEA

Roscoe (2011) states that the main objective of benefit-cost analyses (BCA) is to analyse an investment decision. It considers if benefits are greater than investment costs. Hanley and Spash (1993) defend benefit-cost analyses as the most reliable tool to choose democratically and objectively, since rules are explicit during the decision-making process. Moreover, they present other alternatives such as cost-effectiveness analysis (CEA), multi-criteria analysis (MCA), and environmental impact assessment (EIA). All of them are helpful to decision-makers to deal with uncertainties due to economic criteria.

BCA and cost-effectiveness analyses (CEA) are both used to reduce environmental risks. Pereira (1999) argues that these two techniques are the main practical skills to be applied on social welfare economic fundaments in terms of environmental issues. While BCA looks for the optimal social welfare through public policies based on Pareto's view, CEA needs to define targets to describe as

monetary evaluation, at a lower cost. Social costs are analysed in both tools to support decision-makers and policies development[2].

Although BCA and CEA are not enough for policymaking, both are an important step to achieve economic efficiency (PORTER, 2002). Pereira (1999) also implies that the potential of using CEA in solid waste management. It might be used to choose the most efficient action, especially by externalities created in the system that directly and indirectly affects human health. Both authors mention the challenges with measuring intangible benefits and cost, as well as estimating events distant in time.

Many studies related to solid waste management have been already done using BCA and CEA. Das *et al*. (2019) present the saving costs found through BCA at a flight solutions company by avoiding incinerators, landfill and disposal stations. Instead, this USA enterprise had sent those materials to recycling and got financial returns. Recycling rate in Japan has also been investigated via benefit-cost analyses (KINNAMAN; SHINKUMA; YAMAMOTO, 2014).

Aadland and Caplan (2006) analysed benefits and costs regarding kerbside recycling in a group of American cities. Alternatively, a cost-effectiveness analysis for reducing greenhouse gas (GHG) emission by recovering energy from municipal solid waste (MSW) was made in Croatia (SCHNEIDER; KIRAC; HUBLIN, 2012). Pereira (1999) uses CEA to consider solid waste management as policy for recycling, in the context of Brazil's capital, Brasília.

1.5 FINAL COMMENTS

The waste path is costly from generation at source to final disposal. Urban managers must deal with collection, logistics and ideally material treatment to avoid dumping resources. Recycling is an alternative for recovery, but does not solve the whole amount of related issues for all types of substances. Moreover, usually economic incentives to sort recyclables at household and to provide efficient public service at kerbside are still missing. Then, how urban solid waste management could be more efficient and cost-effective?

[2] However, many studies criticize this kind of technique as Stirling (1997) does. He believes that it is impossible to deal with consciousness, either mathematically or quantitatively, aggregating individual's preferences in a plural society. He also complements that any rational way solves contradictions and diverse interest conflicts or people's values. Therefore, there is not only one analytical procedure capable of substituting the political-democratic process.

In Economics it is said that there are negative externalities while handling waste. Dealing with this market failure is essential to consider external costs to society due to waste management practices. Often enough Economic analyses have efficiency, efficacy and equity as criteria, while, reducing, reusing and recycling are waste treatment priorities. Furthermore, there are instruments and economic incentives that can be combined as solutions for waste management and the related pollution. The issue is, how those principles could be used optimally to internalize social costs?

Economics theories help visualize variables and behaviours regarding urban solid waste management. However, empirical problems and situations demand tools to support the decision-making process. BCA and CEA, for instance, are analyses used to ponder benefits and costs regarding investment decisions and techniques. Both of them can be applied into waste management systems, unless there are no accurate data and procedures available. Our concern here is understanding waste issues and options to address its impacts, and how they are implemented in practice as a policy mix.

CHAPTER 2

PATHS TO SUSTAINABLE PRODUCTION AND CONSUMPTION

2.1 GLOBAL GOALS FOR SUSTAINABLE DEVELOPMENT

The United Nations (UN) published the 2030 Agenda in 2015. The Agenda intends to transform the world by means of 17 sustainable development goals (SDG) and 169 targets. Since then, SDGs became universal language for improving our current system in terms of people, planet, prosperity, peace and partnership. The expected change is being put into action by the countries and stakeholders. Nevertheless, it still faces challenges of implementation, monitoring, measurements and effective outcomes. Also, it is easy to observe different engagements among nations, as well as investments on research and technology. The desired "win-win" cooperation brings opportunities to have enhanced biosphere, society and economy.

Our focus is on Goal 12 and its aim to "*ensure sustainable consumption and production patterns*". Despite the fact that many other SDGs could be explored in this issue, SDG12 represents the most suitable one, since it includes the key concepts and targets regarding waste management and supply-demand systems. As a consequence, environmental degradation and pollution still are a current risk and need Member States to take action. Climate change and economic growth are part of the challenge of producing more efficiently and consuming more responsibly, for today and tomorrow. In this sense, according to UN webpage[3]:

> Sustainable consumption and production is about promoting resource and energy efficiency, sustainable infrastructure, and providing access to basic services, green and decent jobs and a better quality of life for all. Its implementation helps to achieve overall development plans, reduce future economic, environmental and social costs, strengthen economic competitiveness and reduce poverty.

Nonetheless, the issue of unsustainable patterns of production and consumption has already been discussed during Rio 92, as well as by the UN (1992) and, in a similar respect, Agenda 21 issued chapter 4 in regard to changing consumption patterns. As a consequence, national strategies and policies would

[3] The UN webpage is https://www.un.org/sustainabledevelopment/sustainable-consumption-production/

have been developed to encourage progress towards sustainability. Few years later, in 1994, the Oslo Symposium proposed a definition of sustainable consumption as:

> the use of goods and services that respond to basic needs and bring a better quality of life, while minimising the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardise the needs of future generations.

Every year, the UN provides a report to update the progress towards sustainable development goals. For 2019 in regard to SDG12, the main concern is on the increase of material consumption. It alerts to the degradation of environment and the over extraction of natural resources. Consequently, there is a need for public policy to guarantee efficient resource management as well as waste reduction. The Secretary-General states that “in 2018, 71 countries and the European Union reported on a total of 303 policy instruments” (UN Report on SDG Progress, 2019, p.18). However, it might have not reflected on a change yet in terms of material consumption in 2019. The data presented in the report is basically related to GDP and does not show other relevant indicators (e.g.: national recycling rate).

For instance, the targets related to SDG12 include among others: implementation of decade programs to ensure sustainable consumption and production into national policies; management of natural resource using indicators such as material footprint, domestic material consumption, also combined with per capita and per GDP; decrease of waste generation by preventing, reducing, reusing and recycling; sustainable public procurement policies; providing education and information about sustainability and lifestyle; restructuring taxation and phasing out harmful subsidies as fossil-fuel among others (UN, 2015). The indicators highlighted for this investigation and found on Annex 1 are:

> 12.1.1 Number of countries with sustainable consumption and production (SCP) national action plans or SCP mainstreamed as a priority or a target into national policies
>
> ...
>
> 12.5.1 National recycling rate, tons of material recycled

Both indicators will guide the following sections. In the mentioned Annex 1, all targets and indicators are presented, although the two ones listed above suit better the key concepts and investigations in this study. The first one regards understanding national policies potential to promote sustainable production and consumption (indicator 12.1.1). Then, possibilities for complementing Chapter 1 in terms of recycling and waste management is discussed based on the circularity approach as proposed by indicator 12.5.1. The UN has been monitoring the indicators for material consumption (target 12.2), using GDP references, and that is why they were not measured in this study. The other SDG12 indicators are not contemplated in this study scope, such as initiatives for environmental education, neither organic nor hazardous waste. Hence, we focus on national policies and recycling rates at SDG12.

2.2 SUSTAINABLE PRODUCTION AND CONSUMPTION

The economy seeks growth. The environment is the stage, which fulfils the economic system with natural resources in order to produce goods and services for consumption. All elements are connected from the manufacturing process up to the daily choices and living conditions. In this sense, how is it possible to achieve sustainable patterns for industry and consumers without damaging the nature surrounded?

2.2.1 Interaction among systems

Mueller (2004) generically defines pollution as a flow of waste and material discarded into the environment as a consequence of economic system production. These streams might be harmful for humanity health, ecological systems stability and welfare. Pollution is classified into two types and opposite effects: the flow pollution dissipates and the stock pollution accumulates. The author exemplifies the lack of waste collection, inappropriate waste treatment and hazardous waste disposal as negative impacts to the environment due to stock pollution in the earth, especially in the local level. In Chapter 1 we saw that urban solid waste creates negative externalities to be regulated by policy instruments.

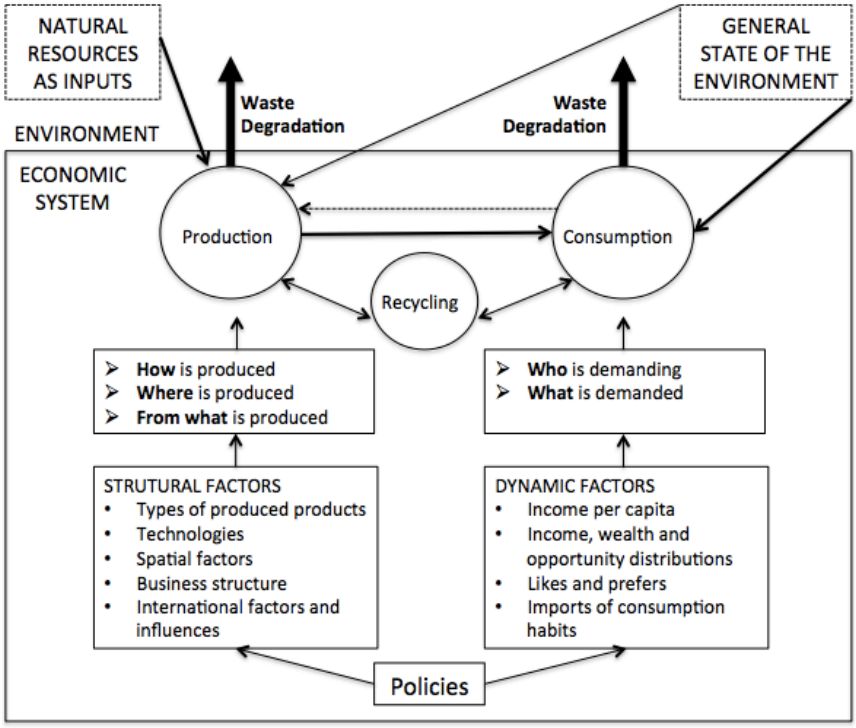
Industrial and consumption systems affect on the environment. Mueller (2004) argues that the scale of global economy has two main elements: population and income per capita, which reflects the level of material production per inhabitant. In general terms, both elements are related to environmental issues. Considering

population increase and gain in per capita income, both demand a larger production. Consequently, this larger production results in negative environmental impacts, unless the technology and production composition used in the system alter those impacts in scale. This cleaner production might be achieved through economic and environmental policies. Thrane and Remmen (2007) point out that cleaner production differs from cleaner products, since it represents manufacturing process and technologies, unlike life cycle thinking and product-oriented strategies.

Thrane and Remmen (2007) add that cleaner production is based on continuous improvements and pollution prevention principles. Considering economic growth, Mueller (2004) believes that demand has the potential to make requirements, such as use of less natural resource, lower pollution and emissions during production. At the same time, the technology applied should be in the same terms to keep expanding production with moderate increases in environmental degradation. However, there is still the risk of inverse direction, when there is an intense need of natural resources and lack of clean technology. It would be a chaotic situation (MUELLER, 2004). Human actions degrade natural resources to fulfil economy, which also needs ecosystem services for its existence. This risk of progress might encourage environmental preservation (FRASER, 2015; MILLER and SPOOLMAN, 2009 *apud* SANDBERG; KLOCKARS; WILÉN, 2019)

The scale of economy and environmental degradation is due to the style of its development. When a society is underdeveloped, its economy has the power to demand to different sectors the kind of technology applied, the intensity of using work force, capital, inputs and the consequent generation of waste and pollution. This interaction among systems is presented in Figure 3. As long as you know **who** is demanding **what**, the economy organizes those activities and resources allocation to provide demanded goods and services. Thus, it is defined **how** production is developing, **made from which** resources and **where** is its location. As to production, there are structural factors, while in the consumption side there are dynamic factors, considering societal groups. Public policies can affect both structural and dynamic factors, and also change the situation over time, more likely to be gradual and slow (MUELLER, 2004).

Figure 3 Inter-relation between economic system and the environment



Source: adapted from Mueller (2004)

Including Daly's analogies (1977) and in regard to Ecological Economics, the interaction among systems is assumed. The economic system is inside the society, which lives in environment surroundings. Mueller (2004) evidences in the diagram in Figure 3, that the economic system interacts with the environment, demanding natural resources and dumping waste into it. This means a local modification in the general state of the environment, based on the style of development. Fortunately, the environment is resilient, which means it is capable of regenerating from damage caused by the economic system. However, it has limitations. The edge of resilience is a discussion between neoclassic Environmental Economics and Ecological Economics.

2.2.2 Green growth X degrowth

There are, at least, two lines of studies in regard to economic growth, often considered as opposed to each other: green growth and degrowth. Sandberg, Klockars and Wilén (2019) contrast the two of them. Both aim at solutions to stop environmental loss, but in different ways of preservation. Green growth is based on decoupling. It means advances in technology to decrease the need of natural

resources and, consequently, keep the economic development. On the other hand, degrowth does not focus only on economic dimension, but on downscaling production and consumption to preserve the environment and increase society´s wellbeing and equity. According to Sandberg, Klockars and Wilén (2019), green growth is still preferable to solve environmental damages than degrowth. However, they defend degrowth, even though it is not featured the same way as green growth.

UN supports decoupling and green economy (UN, 2015). Conversely, Sandberg, Klockars and Wilén (2019) evidence that green growth has not succeeded in reducing environmental impacts (see FLETCHER; RAMMELT, 2017; JACKSON, 2016; KALLIS, 2017; WIEDMANN *et al.*, 2015). The authors consider researches to support their preference for degrowth through its feasibility and potentiality based on changing behaviour as lifestyle and consumption patterns (see LAAKSO; LETTENMEIER, 2016; LETTENMEIER; LIEDTKE; ROHN, 2014; WYNES; NICHOLAS, 2017). However, degrowth benefits and impacts have not been measured yet due to the lack of policy instruments, as those that are already available for green growth. The discussion regarding both strategies in terms of environmental sustainability is still going on, and needs a greater effort when the debate includes social dimension.

2.2.3 Sustainable Consumption

Changes in behaviour and in lifestyle are alternatives for sustainable consumption. Giulio *et at.* (2014) discuss the different concepts of sustainable consumption and implementation in practices across disciplines, and how they could be connected. First, the main argument is due to complexity of consumption. In this sense, the social context influences consumers' choices in their daily lives among which are: human interactions, group symbolism, institutions, culture, local area and technologies. The authors also observe that the freedom or enforcement to consume. In other words, if there is a clear incentive to consume more, or an encouragement to consume efficiently. For the second argument, the authors bring the idea of sustainability based on the meaning of need and reaching a good life.

This link with consumption references rights, responsibilities and sustainable criteria. The conceptual system defines: objective needs, subjective wishes, products and services to be consumed, level and amplitude of needs and wishes fulfilment, and natural resources. Combining the first and the second arguments, it is possible

to criticize both definitions of “sustainable consumption” (RIO 92 and OSLO 1994). Thus, Giulio *et at.* (2014, p.54) come up with a definition:

> the sustainability of consumption acts is defined by the degree to which individual acts of selecting, acquiring, using, and disposing of, or prosuming goods contribute to creating or sustaining external conditions that allow all human beings to meet their objective needs today and in the future. These external conditions comprise ecological, social, cultural, and economic resources and processes

For the following argument, those concepts might be assessed in terms of both ethnical approaches: intentions and impacts. Individuals’ consumption impacts on external conditions to achieve a good life. These impacts are evaluated as sustainable or unsustainable. In parallel, on the intention-oriented approach, there is a clear will to make a sustainable choice while consuming compared to the lack of concern regarding the issue. Intention and impact might be distinguished in situations when the individual buys a sustainable product (positive impact), for instance, without an intention to do so. Conversely, a person might have an intention to be sustainable, and decide for a product that presents an unsustainable impact. The most desirable case of sustainable consumption has both positive impact and positive intention to contribute to sustainability (GIULIO *et al.*, 2014).

The last argument evidences how effective a combination of strategies could be to intercede towards a more responsible consumption. Giulio *et al.* (2014) show that only economic incentives are not enough, neither access to information. Change in behaviour is a complex challenge and should be addressed through a mix of instruments, according to the context. The authors remind that technology alone does not solve issues such as natural resources scarcity, loss of biodiversity and climate change action. In the opposition direction, Solow (1974) defends that technical innovation and development are sufficient to face environmental shortages. Often this point of view is seen as technologically optimistic.

Kaufmann-Hayoz *et al.* (2012, *apud* GIULIO *et al*., 2014) present four instruments to guide consumers to sustainable behaviour. Regulation is the first alternative, which is driven by the government. Economic incentive is the next by applying price signal to change habits. Then, another instrument is based on communication to promote engagement, knowledge and community initiatives regarding sustainability. Finally, cooperation could be an alternative instrument to

regulation more likely to represent voluntary actions and hybrid strategies. Those instruments, as discussed previously, are more effective in combination to achievement of sustainable consumption patterns, in a complementary way. Many aspects, such as policies, culture and economy may influence the best selection of interventions in different contexts (GIULIO *et al*., 2014).

The contrast between 'consuming efficiently' against 'consuming less' has an argument to avoid a decrease in quality of life. However, less consumption of certain elements, such as carbon-intensive fuels due to their influence on climate change, also means efficiency in sustainable consumption (JACKSON; SMITH, 2018). As defended by Solow (1974), efficiency is reached with technological innovation. The solution infers cleaner production, less materials and resources, and consequently greener choices[4].

2.2.4 Lifestyle

Lifestyle differs from consumption because it incorporates habitual elements, not only those purchase-related. Moreover, it is important to reinforce the movement from 'green' towards 'sustainable' consumption and lifestyle (GILG; BARR; FORD, 2005). Jackson and Smith (2018) explain the challenges of acquiring a sustainable lifestyle. In the modern society, lifestyle is complex and paradoxically influenced by social and psychological circumstances. In this sense, both concepts of daily life and 'sustainable consumption' require policies. The authors defend governmental intervention to make a change and engage people in sustainability, as well as to influence industry and market conditions.

Jackson and Smith (2018) explain lifestyle in four different sections. First, 'lifestyles as livelihoods' is the basic need for living, for keeping alive. The second stage brings satisfaction as quality of life or wellbeing, an idea of improvements in basic living conditions. It is often measured by the Gross Domestic Product (GDP), considering per capita levels of national income. However, as presented by Monteiro (2017), the Economics of happiness takes into account environmental influences in wellbeing, not only GDP. This paradox in regard to life satisfaction and economic growth might suggest that income increase does not necessarily mean rise in

[4] As mentioned before, this is the principle of decoupling and green growth as pointed out by Jackson and Smith (2018), in opposition to Sandberg, Klockars and Wilén (2019) who defend degrowth. In regards to trends, Jackson and Smith (2018) alert that due to modern society complexity, some trends seem to be contradictory to each other.

happiness. This situation can also be explained by utility function and level of satisfaction: “the more of the good the consumer already has, the lower the marginal utility provided by an extra unit of that good” (MANKIW, 2014, p.443), which means diminishing marginal utility as wealth increases.

The third stage is about lifestyle and social interaction. Similar to the way Giulio (2014) mentions the influence of context and human practices, our choices are part of ‘social conversation’. Even the symbolism of goods and material possessions is a way to communicate our identity and our values. Jackson and Smith (2018) mention that it is a work in process, with continuous adjustment in a given society, which denotes an opportunity to change behaviour towards sustainable lifestyle. As to the last stage, Jackson and Smith (2018) agree with Giulio *et al.* (2014) in terms of consumers’ freedom or enforcement to choose, since institutional structures and cultural norms affect consumers’ choice and lifestyle. Misguided incentives, pure habits and technological trends may also explain unsustainable patterns. Hence, is it possible to live better by consuming less? (JACKSON, 2005).

In the lights of Economics, ‘the rational choice’ is a decision made based on maximizing the benefits/costs rate for a consumer among the options s/he has. In this case, if all alternatives bring the same benefits, the individual will be more willing to select the cheapest one. As discussed before, policy instruments might be used to correct market failures, such as internalizing external social costs as a consequence of private choices. Therefore, assuming that people make decisions depending on the cost, it is a legitimate avenue to adjust prices due to externalities and promote change in behaviour. Environmental and social sustainability dimensions should be emphasized as key elements for a policy that modifies lifestyles (JACKSON and SMITH, 2018).

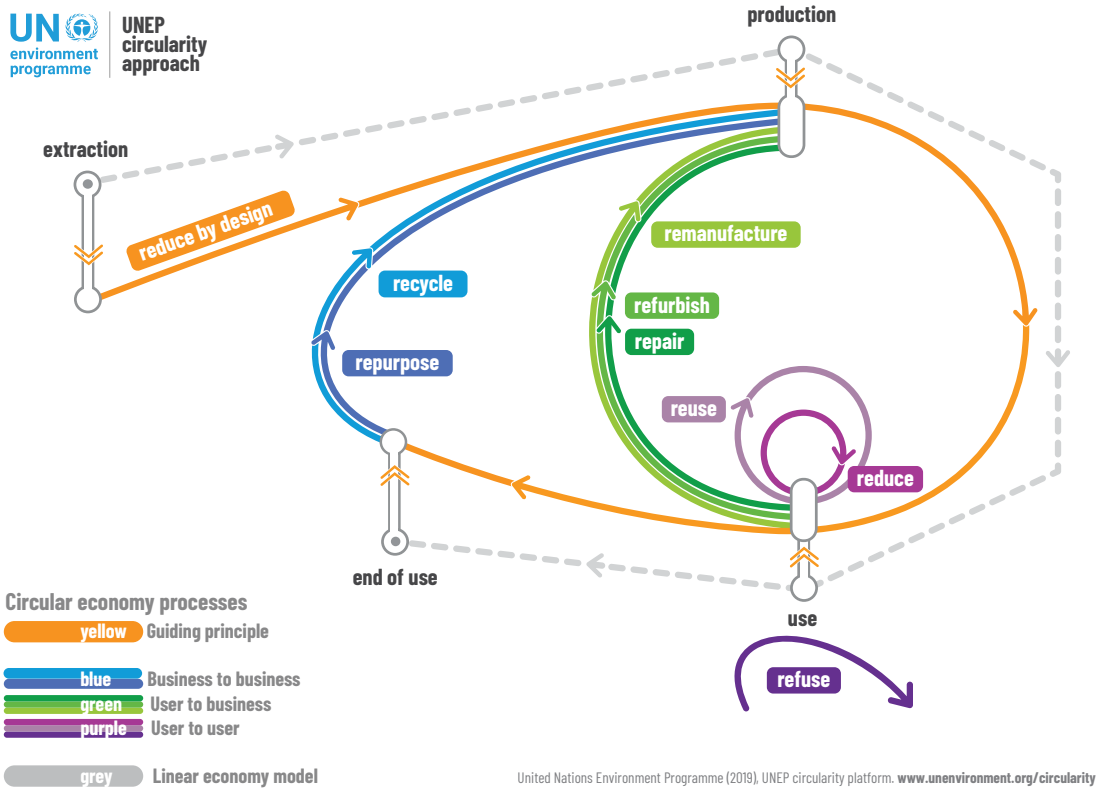
Institutions play an important role to change behaviour and lifestyle by adopting and driving environmental policies. In contrast, government is also seen “as a ‘co-creator’ of the culture of consumption” (JACKSON and SMITH, 2018, p.507). These authors suggest the identification of different lifestyle segments and sectors to outline their environment and resource impacts in all levels (nationally, regionally and locally). Moreover, the social and material patterns should also be mapped. According to the authors, the commercial sector was supposed to be in charge of this information. However, one of the challenges is the historical producers strategy to

recognize individuals desires and motivations based on lifestyle, and use it only in their own favour.

2.3 CIRCULAR ECONOMY

For United Nations Environment Programme (UNEP, 2019a), circularity is the answer to achieving sustainable consumption and production (Figure 4). The transition to green growth can be accelerated through economic, fiscal and trade policies, and also cost effective solutions to reach the 2030 Agenda. According to UNEP, there are multiple pathways such as: empowering policy change, promoting sustainability in business, encouraging sustainable consumption and lifestyles. However, there are still improvement opportunities to scale up circularity and its benefits, especially considering the implementation and resilience challenges in different industries. On the other hand, Daly (1977) claims that a 100% circularity in the economic system is impossible due to the entropy law, since there could be no endless loop of products and energy returning as raw materials.

Figure 4 - UNEP Circularity approach



Source: UNEP (2019a)

Circular Economy embeds models, implementation – micro, meso, macro levels – economy development patterns, challenges and limitations. At micro level, ecodesign and cleaner production are alternatives in the industrial sector. At the demand side, green public procurement and responsible consumption is getting scale. Waste management hierarchy (3R) and circularity are part of efficient resource allocation and environmental impact prevention. At meso level, the operation is in terms of eco-industrial parks and industrial symbiosis systems. Eco-cities, shared ownership models, zero waste initiatives and innovation in waste management are types of implementation at macro level. Indicators and decoupling economic growth worldwide converge all those elements to achieve sustainable development. It is clear to see that political conditions play a huge influence in the current patterns and needed changes (GHISELLINI; CIALANI; ULGIATI, 2016).

On the other hand, Korhonen *et al.* (2017) evidence limitations to circular economy considering the three dimensions of sustainability. The authors identify the six main challenges based on Planetary Boundaries concept: i. thermodynamic limits; ii. system boundary (spatial and temporal) edges; iii. rebound effects; iv. path-dependency and lock-in, v. governance and management; vi. social and cultural values. Despite the fact that circular economy deals with dare trade-offs, those practices are transversal and necessary to achieve sustainable production and consumption (SDG12), even though this terminology is not mentioned in 2030 Agenda (SCHROEDER; ANGGRAENI; WEBER, 2019).

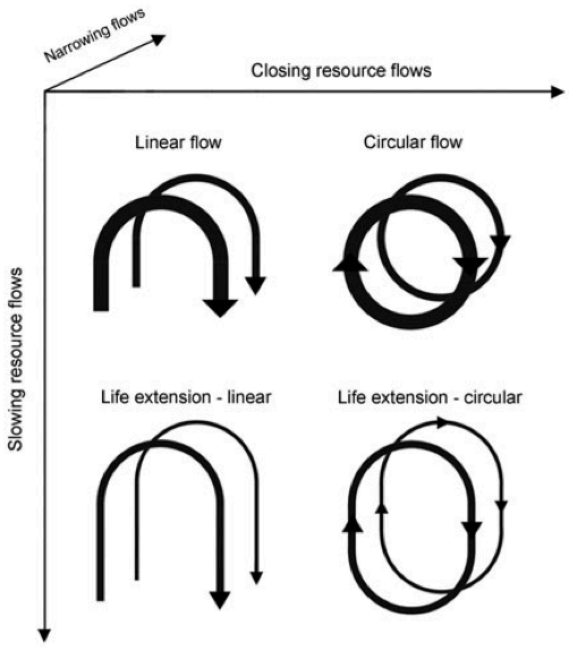
2.3.1 Narrow, slow and close the loop

Bocken *et al.* (2016) enlighten the transition from business-as-usual to a circular economy by narrowing, slowing and closing resource loops. This investigation includes business model strategy and product design to replace linear economy aspects by circularity. In the current days, the Ellen MacArthur Foundation (2020) works to accelerate this movement and bring popularity to the concept in private, public and academic sectors. The Foundation defends cradle-to-cradle (C2C) principle. However, circular economy principles have origins in industrial ecology, environmental and ecological Economics (BOULDING, 1966; GEORGESCU-ROEGEN, 1971; PEARCE; TURNER, 1990; AYRES, 1989).

Bocken *et al.* (2016) define those three types of flow (Figure 5). Narrowing flow is related to resource efficiency since it reduces inputs use per product unit

and/or a more efficient manufacturing process. Slowing the cycle is a slowdown action of resource flows to prolong products' lives, by designing for longer durability and extending product-life. Recycling is closing the loop by circulating materials after the post-use into the production phase again as a resource. Compare Figures 5 and 4: "narrowing" (Figure 5) relates to the yellow flow of Figure 4, "closing" in the Figure 5 below represents the blue loop above, "slowing" is compared to purple and green cycles. In both approaches, narrowing as reduction by design is different from the others because it does not include any service loop and interference in the speed of the stream.

Figure 5 - Types of flows in linear and circular approaches



Source: Bocken *et al.* (2016)

Bocken *et al.* (2016) also suggest some strategies to achieve resource circularity. For instance, the design for product-life extension should be easy to repair, maintain, disassemble and reassemble. Also, it should be adaptable, upgradable, standardized and compatible. For recycling, the design should consider technological and biological cycles, disassembling and reassembling too. Industrial Symbiosis is seen as a business model strategy to close the loop. It is a process-based solution that uses residual outputs from industrial activities to supply another process as

feedstock. Most of the alternatives for circular business model are in terms of value proposition and value-related approaches. These strategies are more likely to be implemented effectively in hydrib-forms.

Singh *et al.* (2007) exemplify one kind of hydrib-form by applying LCA to assess industrial symbiosis. According to the authors, it is important to evaluate benefits, costs and environmental impacts of those industrial ecosystems to avoid potential damage. Usually, LCA does not include financial parameters, but it can provide quantitative results about elements in the production system and information regarding environmental sustainability status. A comparative analysis was carried out to support decision-making among the proposed alternatives. The most eco-effective symbiosis for resource allocation and waste treatment included costs and profits along the process. Here, the economic dimension means the value added economic model per process by achieving maximum profit, at full production capacity (SINGH *et al.*, 2007). However, there are still trade-offs in distinct environmental impact categories to make a choice. Let's deepen our understanding of LCA.

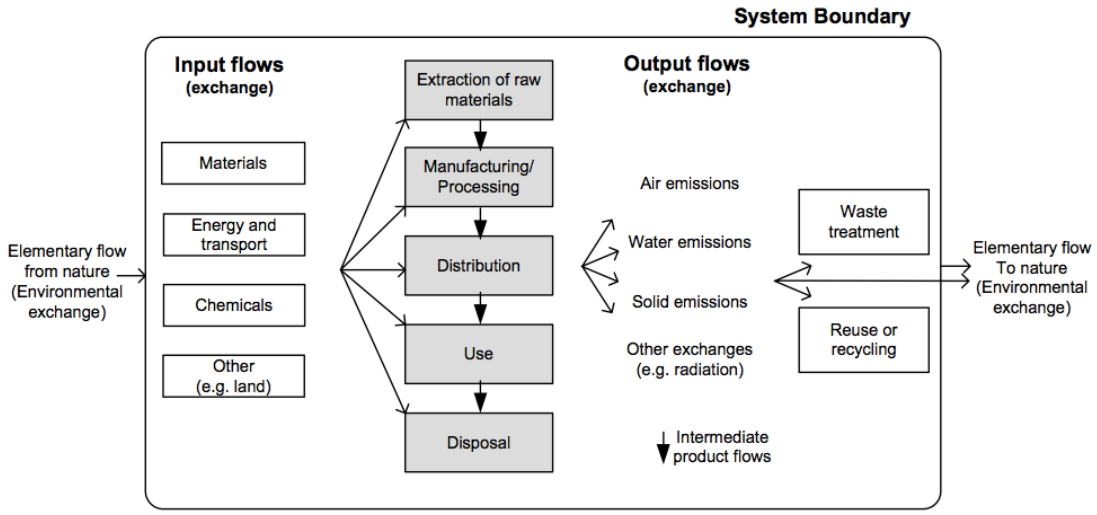
2.4 LIFE CYCLE ASSESSMENT (LCA)

Lifecycle thinking, in general terms, considers the whole loop from cradle to grave that might be assessed as a tool. Thrane and Schmidt (2007) outline life cycle assessment (LCA) in accordance to the International Organization for Standardization (ISO). Two of them should be highlighted: ISO 14040:2006, regarding environmental management and describing the principles and framework for LCA; and ISO14044:2006, which is about requirements and guidelines. Potential environmental impacts can be identified based on inputs and outputs into a life cycle perspective. They include the whole life cycle since raw material extraction, through the manufacturing process, logistic distribution, use stage up to the final disposal. Since late 1960s, LCA is a helpful tool in the decision-making process and in developing cleaner production and products. Some of the application areas are public policy-making, marketing, strategic planning, product improvement and development. However, LCA does not contain social and economic impacts, even though both are relevant and should be assessed.

Some of the potential environmental impacts are: ozone depletion, global warming, acidification and nutrient enrichment. The assessment of those impact categories enables comparison among products. Also, it is possible to identify where

the impacts happen considering the entire life cycle, their scale, the processes related and the substances. Figure 6 illustrates the main elements compiled from elementary flows in relation to inputs and output to provide a unit process (the smallest portion) as part of the product system in analysis. Each box is a composition of some unit processes that need data for input and outputs. Life cycle impact assessment (LCIA) is based on calculations through inventory exchanges and elementary flows in the end. LCIA is the result and presents an indicator number of impact category. Therefore it is a 'potential' impact instead of precise or absolute impact (THRANE; SCHMIDT, 2007).

Figure 6 - LCA elements conceptual overview



Source: Thrane and Schmidt (2007)

LCA may be applied in different levels of detail and sophistication. However, there are at least four desired tools to do so: methodological framework (ISO 14040:2006 and ISO 14044:2006), database for input and output information, LCIA method and a computer software tool. Basically, the study is carried out in four phases: goal and scope definition; inventory analysis (LCI); impact assessment (LCIA) and interpretation. It is an iterative and dynamic process to continuously change and adjust choices in the system. LCA studies may influence political decisions and industrial schemes depending on generic or specific purposes, as well as intention of documenting or strategic actions (THRANE; SCHMIDT, 2007). The choice between attributional (allocation) and consequential LCA modelling is a matter of social responsibility (WEIDEMA *et al.*, 2018)

Attributional approach includes value chain and supply chain system types, and a consequential approach is the product life cycle. A social responsibility among those three alternatives is different because allocation is based on average modelling, while the consequential approach refers to marginal and incremental modelling. In accordance to Weidema *et al.* (2018), marginal and incremental thinking for modelling LCA must always be the consequential approach of product life cycle to consider a change in demand and in future perspective. Besides, it may include supply chain and value chain responsibility for consequences as complementary issues.

By using LCA we are modelling the world, which means facing levels of uncertainty. The system is delimited and influenced by political conditions, which embeds 'hidden' assumptions. One of them is the absence of discount rate for future situations, which means the same level of importance between present and future. In contrast with economic analysis, such as BCA, the current status is not the same for upcoming generations. Also, societies from different countries, races and religions are considered equally important (THRANE; SCHMIDT, 2007). The policy level is interesting in our investigation, even though socio-economic aspects are lacking.

2.5 POLICIES

Roura *et al.* (2010) evidence the multiple facets around public policy development. The authors propose six stages for the public policy decision-making process: i. problem recognition; ii. problem analysis; iii. intervention planning and possible alternatives; iv. consultation and deliberation; v. parliamentary discussion; vi. execution. They imply that there are interconnections and delays among phases. Policies might be distinguished due to their characters as fundamental reform, either quantitative or qualitative, as well as according to the actuation level, as macroeconomic or microeconomic. Finally, the time horizon for policy might be short, mid or long run. Policy-makers can achieve goals in regard to general purpose, economic objective and social objective. Theoretically, among those objectives, it is likely to be conflicts of interest and interconnections such as fundamental nature, complementarity and interdependency among objectives.

Markandya (2005) investigates the relationship between environmental impacts and non-environmental policies. The complexity of the policy-making process is already known as well as its influence beyond the chosen objectives.

Policy fails when it lacks optimal result achievement under the given social and economic conditions where it is to be implemented. This understanding could be acceptable, although policy failure is not a well-defined term. Considering interactions, policy evaluations must assess environmental damage and alternatives for the particular policy including ‘do nothing’ and ‘best policy’. The context is dynamic and it is hard to get policy prescriptions unquestionable and clear. A combination of policy instruments to achieve specific targets and to compensate environmental impacts seems to be an effective option based on the theory of the second best. It should be balanced between benefits for the planet and society against costs for the economic system.

Klingberg (2016) discusses nexus thinking in the context of intersectoral policies and its effects along the whole chain. In political context, silo as functional structure is a barrier to recognize impacts and benefits beyond sector borders. Natural resource need is also a shared concern among industries and segments and has a common purpose in developing interconnected policies. Moreover, technology progress is part of the complex system of resource allocation and efficiency, which reinforces the power of nexus concepts and its interfaces with ecosystems, supply chain, consumption patterns and global interactions. The author analyses the transversal role of energy, water and sanitation. Also, spatial governance regards the topic in the national, state and municipal levels. The author illustrates the nexus approach of 2030 Agenda and the United Nations´ SDGs. Our research evidences nexus with production, consumption and waste.

Harrison, Martin and Nataraj (2017) bring some relevant lessons in regard to green industrial policy. The first lesson is the need for governmental intervention due to the clear existence of negative externalities. Emissions from burning fossil fuels are one of the main externalities in the spotlight. For this lesson, carbon tax would be the first-best policy along with subsidies for Research and Development to accelerate the progress of cleaner technology. Similar to carbon tax, cap-and-trade is a market-based mechanism where a permit and limit is established allowing to emit up to a certain level of pollutants. Firms are allowed to trade carbon permits between them. Another lesson suggests that environmental and industrial policies treated in the local level might have global, inter-related consequences. The authors also present

challenges and opportunities for implementing green industrial policy in emerging countries, a terminology that causes misunderstandings though.

Kemp and Never (2017) recommend a green transition approach on behalf of the industrial policy. According to the authors, six elements are helpful and have the potential to succeed in terms of innovation, management and political economy. As a starting point, a governmental planning initiative is essential to provide the direction for innovators and investors. It should include clearly defined long term view and guidelines, as well as objectives and targets to be reached. At the same time, it should communicate effectively and be attractive to prepare producers and consumers for the transition. Relevant stakeholders (e.g.: standardization institutions, business associations, manufactures, etc.) might be part of the discussion since the beginning by proposing for greening the industry.

Secondly, independent experts can offer supporting strategy such as auctions and rent management for old and new technology, since they are aware of the opposition side intention to delegitimize cleaner production (e.g.: fossil fuel supplier). Third and fourth elements are connected, considering the gradual improvement in requirements, standards and regulations to scale up those mechanisms. Then, based on the lessons learned, policies should be adjusted in accordance to the local context to be socio-economically accepted. Fifth, policy package contains push and pull elements, R&D, job creation measurements, identification of institution skills and capacities. Finally, the proper implementation control should take place for all aspects to ensure its execution in all stages (KEMP; NEVER, 2017).

2.6 FINAL COMENTS

The concern regarding unsustainable production and consumption is not new. The UN, and other stakeholders and nations are looking for “win-win-win” solutions to address challenges in the social, environmental and economic dimensions. National policy programs and recycling initiatives are some indicators to follow up the situation. However, does the current status evidence how SDG12 is being achieved? This question is answered in the following chapters, in the context of Denmark and Brazil. In fact, the form the political structure sees the interaction among systems implies environmental benefits or costs. Moreover, the need for a change in consumption and lifestyle patterns includes a way to conciliate with economic growth. So, we ask: how sustainable production and consumption is performed in practice.

Even though ‘Circular Economy’ seems to be “new labels for old bottles”, due to its origins decades ago in Industrial Ecology, Ecological and Environmental Economics, this new terminology represents a powerful trend. Circular economy is a keyword to promote sustainable production and consumption systems. UNEP reinforces circularity approach to achieve SDG12 and life cycle thinking as product-oriented strategies. Cleaner production and cleaner products mean a combination of manufacturing technologies and processes for resources efficiency, as well as holistic view of product impact during the whole value chain up to the final disposal. However, LCA misses monetary perspective, which is provided by the economic analysis. Our question is: how does the circular flow of resources influence environmental impacts, feasible technologies and financial measurements? European Union proposes tools to evaluate those parameters for public procurement.

Public policy making is a complex process. Very often there are conflicts among objectives and consequences to the environment. Thus, market failures around manufacture systems represent a clear demand for governmental intervention. Intersectoral decisions affect surrounding conditions when there is a lack of nexus perspective. Greener choices for factories through the implementation of policy instruments have the potential towards sustainability transition, in spite of the limitations of employing sophisticated policy mix mechanisms. Strategic to becoming reality, all elements mentioned previously in this work should be put into account to deal with trade-offs and decision-making issues. Our issue here is: how would be a nexus thinking applied into industrial policy, waste management and resource allocation? In our final discussion we combine them in this integrated approach.

CHAPTER 3

FROM GRAVE TO CRADLE IN DENMARK AS MEMBER STATE OF EUROPEAN UNION

3.1 GRAVE: WASTE SYSTEM

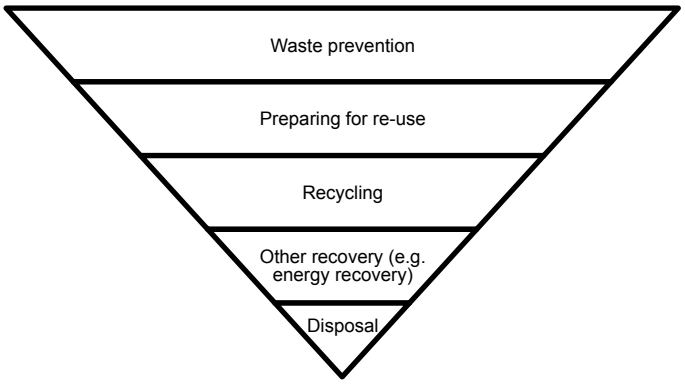
3.1.1 European Union Waste Framework Directive 2008/98/EC and 2018/851

The European Union establishes the general policy for the waste management system in its member states. Following that, each country has to develop its own strategy and operational conditions. The waste schemes in Denmark present bold improvements and investment in technologies, as well as the use of economic instruments. Since their creation, the European and Danish policies have been updated in order to incorporate circular economy principles and new targets.

The Waste Framework Directive represents the main references for waste related issues in the European Union (EU, 2008; 2018). The Directive establishes prevention and reduction of environmental and health impacts caused by waste generation and management. Denmark is one of the Member States and should implement those measures. Some definitions are presented and might disagree with specialists or even have an ambiguous meaning. For instance, re-use is a kind of prevention (user point of view), and at the same time, the preparation for re-use is defined in another lower layer in the waste hierarchy (waste authorities perspective) as seen in Figure 7. Circular economy terminology is not mentioned in 2008 Directive though.

In 2018, Directive (EU) 2018/851 amended Directive 2008/98/EC. The waste hierarchy remains the same, but the transition to a circular economy and European competiveness were included. The adjustments provide more details and additional definitions to clarify the accomplishment of those measures. Members States should prioritize actions in accordance with the waste hierarchy for developing the legislation and policy, including the engagement with stakeholders and citizens during the process. Thus, one of the amendments reinforces the use of economic instruments to motivate the implementation of the priorities mentioned in Figure 7, as exemplify those mechanisms in a new *Annex IVa* such as EPR, PAYT, DRS and others.

Figure 7 Waste Hierarchy according to Directive 2008/98/EC



Source: own elaboration according to Directive 2008/98/EC

The latest directive is still based on polluters-pay-principle. However, a full and robust new section for extended producer responsibility (EPR) is added. Producers should manage returnable and re-usable products, as well as assume financial responsibility and provide public information as to reusability, recyclability, targets, compliance and others. Design of products is another key element for reducing environmental impacts along the whole life cycle, pondering if it is economically viable and technically feasible. Requirements for circularity were included, such as preparation for reuse, durability and reparability, before considering recovery, and the final disposal.

Waste prevention section is replaced in the new Directive. One of the minimum measures to be taken is the support and promotion of sustainable production and consumption models. Much more details and ways to achieve reduction in waste generation are provided, based on the main principles and initiatives of circular economy. Resource efficiency through manufacturing processes, incentives to prepare for reuse and hazardous waste avoidance are some actions presented. Quantitative and qualitative targets and indicators should be used to assess and monitor waste prevention measures. Member States should report their progress and follow the deadlines adopted.

In the Directive, Article 11 is renamed as ‘preparing for re-use and recycling’, in previous documents the ‘preparation’ was not taken into account. Currently, Europe aims to be a ‘circular economy’ instead of being a ‘recycling society’ as before. The first measure is still reusability and preparation for re-use, thus the

necessary repair network for checking, cleaning and others. Economic instruments should be used to support the implementation of measures. For recycling, separate collections help meeting high quality standards for the industry. Since 2015, at least glass, plastic, metal and paper should already be collected separately, but the update includes textile to be separated until the end of 2024. By the current year (2020), preparing for re-use and recycling, without distinction, should represent 50% of the weight of household waste. New targets were included, such as 55% of the weight by 2025, 60% by 2030, and 65% in 2035. There is a complete section now that contains rules to calculate the targets defined to be reported yearly.

Waste management must not be dangerous for human health, neither harmful for the environment. It must ensure the absence of risk to animals, plants, soil, air or water, as well as avoid releasing odours and making noise. Moreover, places of special interest or the countryside must not be affected. Penalties might also be applied to uncontrolled waste handling and littering. Those obligations should also be covered by waste management plans, considering the entire geographical territory. The plans must incorporate the current status, measures for improvements, waste treatment alternatives, evaluations, types of collections, waste generation and composition, policies, economic instruments, awareness campaigns, historical contaminations, among others. The amended version includes quantitative and qualitative metrics too.

Article 29 of the Directive deals with waste prevention programmes. Since this kind of programme should also be included in waste management plans, waste prevention is to be considered again. Clear objectives, measures and evaluation are remained in Annex IV, adding other two new annexes IVa and IVb. Those programmes should contemplate generation of waste, eco-design, cleaner production and distribution stages, as well as consumption and use phases. Life cycle thinking, eco-labels, voluntary agreements, and public policy might encourage environmental performance, at both supply and demand sides (e.g. economic instruments). Economic growth should be linked to environmental impact avoidance. Guidelines, indicators, information shared and best practices should be spread among European countries.

3.1.2 Waste Management in Denmark

The waste sector in Denmark has changed considerably. The concern regarding the topic has more than half a century. The policy instruments have been adjusted and long-term targets have improved the infrastructure to handle waste more efficiently. Currently, the waste prevention strategy is the main focus to avoid overconsumption and to treat waste as a resource.

3.1.2.1 Development of the Danish waste sector

The waste management progress in Denmark occurred due to policy instruments. Over time, human health and environmental protection integrated resource recovery. Clear responsibilities for key actors became possible advances in waste treatment and new technologies. Danish lessons learnt from landfill to recovery plants demonstrate to be a considerable leap in efficient waste management. Increase in recycling rate and reduction in GHG emissions evidences how economic instruments and regulation can play a huge role to avoid environmental impacts due to waste generation.

The Danish Ministry of the Environment [n.d.] points out the main initiatives since the 1970s. In Denmark, from the 1970s to the 1980s dumping and landfilling of waste were still the usual disposal practices. In the 1980s, incineration was gradually being introduced. The first milestone was in 1985 with landfill exhaustion around Copenhagen, and the consequent need for mapping waste generation and disposal. At that time, 39% of Danish waste was discarded in landfills, 35% were aimed at recycling and 26% was waste-to-energy. In contrast, in 2008, 7% was landfilled, 69% recycled and 23% incinerated. This significant inversion ended up in reducing operation on landfills due to economic reasons. Another effect of this change was the direct emissions by burying waste as GHG avoided.

According to the Danish Ministry of the Environment [n.d.], there are two main aspects for this development on waste management. First, the approach of planning nationally and locally set understandable targets. Moreover, close communication with the key actors, mainly municipalities and industry, was essential to define solutions for over than 30 types of waste. Second, well-defined responsibilities among stakeholders, as well as implementation of producer responsibility, were essential for improving Danish waste sector. European Union also influenced

Denmark as a Member State. Since 1989, all Danish municipalities were required to publish a municipal waste management plan.

The municipal waste management plans were an overview of the waste situation in Denmark. Its first National Waste Plan covered the period from 1993 to 1997 focused on recycling targets. Those targets were achieved and the following plans were now handling quality of treatment, different types of waste streams and economic aspects. Moreover, since 1993, a data registration system was implemented to follow waste generation and destination. Another key element for waste management improvements was the cooperation with the energy sector by providing electricity and heat (DANISH MINISTRY OF THE ENVIRONMENT, n.d.).

Supporting legislation also played an important role for the Danish waste sector. Costly investment in incinerators, as well as full operation capacity reflected on disincentive to recycling. As a consequence, regulation was necessary to ensure the return of materials into the production chain. Taxes on burning and burying waste provided financial encouragement for the adoption of cleaner technology projects and recycling. Furthermore, deposit-refund system (DRS) was an obligation for beverages containers, either for returnable or recyclable packaging. “Both a carrot and stick was used to divert waste from disposal to recycling” (DANISH MINISTRY OF THE ENVIRONMENT, n.d., p.7). Since the 2000s, cleaner products are the priority for financial support through grant programmes.

Danish waste infrastructure enables efficiency in handling household waste. Municipalities collect different types of waste, including sorted recyclables and mixed waste at kerbside. There are also waste banks for recyclables in urban areas, and recycling centres to deliver all fractions of waste including bulky waste. Recyclables sorting is carried out at source, since significant safety and health problems were caused to employees due to manual sorting. Mechanical sorting sometimes is applied to mixed waste to remove valuable materials and to improve conditions for incineration and biogas-digestion. Denmark is still part of the international trade on recycling and was highly impacted when China quit receiving recyclable plastic. (DANISH MINISTRY OF THE ENVIRONMENT, n.d.). Waste prevention comes next.

3.1.2.2 Zero Waste Strategy

‘Denmark without Waste II’ is a waste prevention strategy released in 2015. Before that, in 2013, the same campaign had the goal to recycle more rather than incinerate, as a resource strategy (DANISH GOVERNMENT, 2013). Basically both have the objective to reduce environmental impacts due to waste management and at the same time promote resource-efficiency. While the first one goes deeper in recycling and alternatives for waste treatment considering different streams, the other one focus on initiatives to reduce waste generation. The Danish Government (2015) reinforces seven groups of initiatives for preventing waste: i. transition in Danish business; ii. green consumption; iii. less food waste; iv. the construction sector; v. clothing and textiles; vi. electrical and electronic equipment; and vii. packaging.

The Danish Government (2015) offers support to reduce waste generation and promote resource efficiency. Hence, it offers incentives for businesses to produce better with less resource, and for consumers to choose cleaner products and services. The Minister for the Environment states that “we must make it easy for businesses and individuals to make green choices” (Denmark without Waste II, 2015, p.7). Besides some examples of good ideas and potential initiatives to prevent waste, the strategy includes clear commitments by the government to ensure a green transition such as funding, monitoring indicators, legislation and others.

Initiatives for the green transition in Danish businesses represent the highest number of alternatives among action areas. Most of them are related to green consumption too. It includes circular economy principles, certification for environmental management systems, ecolabels, sharing economy and green accounts to ensure environmental performance. The government also promises funding for sustainable production, as well as research empowerment for new technologies based on innovation and partnerships. With a view to achieving a sustainable consumption, lifestyle and product design for disassembly and repair are also mentioned. EU environmental requirements are also linked to these initiatives (DANISH GOVERNMENT, 2015).

3.2 CRADLE: INDUSTRIAL PRODUCTION

The understanding of problems and solutions at product’s end-of-life provokes debates regarding the motivations to produce new products at the beginning. Not

only the waste generated during manufacturing processes are involved but also the strategy that connects supply and demand. It is important to investigate how the industry sector defines patterns and priorities while running businesses. The entire life cycle matters, from cradle to grave. Consequently, what are the costs and benefits to our society and impacts on the environment? The top schemes from the United Nations and Europe flow down to Member States and municipalities to put them into practice. Policy and economic instruments link waste issues (grave) to requirements (cradle), let's see.

3.2.1 European Industrial Strategy

Starting in 2020, Europe has a new industrial strategy (EC, 2020a). It has two main pillars to ensure global competitiveness: environment and technology. This twin transition considers industrial ecosystems and the European international leadership in innovation. For a green and digital transformation, Europe has seven fundamental factors to make it happen. One of them is *building a more circular economy*, which states "shift from a linear production to a circular economy" (EC, 2020a, p.1). The document mentions the new Circular Economy Action Plan (EC, 2020b). Besides consumers' empowerment for choosing greener, it brings opportunities for more jobs as part of social dimension. Moreover, the bold goal to be the first continent climate-neutral by 2050 depends on policy instruments for cleaner production.

3.2.2 History of greening the Danish Industry

Remmen (2001) brings the historical movement to green the industry in Denmark within the environmental policy. According to him, it started in the late 1980s based on pollution prevention and cleaner technology. The gradual process involved both private and public sectors, as well as consultants and associations. New forms of policy instruments and environmental regulation took place. Firms had to be responsible for the environmental impacts provoked by their production systems and products. The mechanisms applied reflected on changes in governmental regulations, production patterns, environmental strategies and goods to be consumed.

Before that, in the 1960s, the understanding of environmental problems was seen only in a local level. In the 1970s, end-of-pipe solutions were proposed to filter pollution, and environmental authorities asked for compliance regarding emission

limits. A new concern came up in relation to subproducts from this kind of solutions such as waste materials and sludge, as negative consequences to human health. Since the mid-1980s, cleaner production processes started being implemented in order to reduce resource consumption and emissions during the production stage, at source. Those solutions were spread due to the incentives of eco-efficiency and resource savings. However, lack of continuous improvements was still a weakness (REMMEN, 2001).

Since 1992, environmental management became the cornerstone. Certification for environmental management systems such as ISO 14001 and EU Eco-Management and Audit Scheme (EMAS), as well as simplistic models for continuous activities have changed the perspective between the enterprises and nature. It includes standards and manuals of procedures in a systematic view. It is important to highlight the Danish national programme 'Environmental Management in Small- and Medium-sized Companies' (SMEs) with economic incentives by the government. Also, Remmen (2001, p.57) points out that

> the increased green taxes in Denmark on emissions and resource consumption have caused economic benefits in continuing the preventive initiatives and provided more companies with an incentive to begin pollution prevention.

A product-oriented environmental policy was proposed by the Danish Environmental Protection Agency in 1996, and was initiated in 1999. The conditions to implement that policy are interconnect with market, products and actors. Requirements for cleaner products should ensure environmental and health patterns as energy consumption, resource use and reduction in emissions, as well as competitive functions, quality and prices for playing on market. Also, all stakeholders involved in the process should be engaged in avoiding causing product impacts in the environment. Life cycle assessment tools and eco-labelling instruments had been used before in cleaner technologies. However, product design and companies' strategy also were required to change in order to produce cleaner products for dynamic markets (REMMEN, 2001).

The innovation for achieving high environmental credibility was based on environmental management, cleaner production and cleaner products. It includes

improvements in companies' image, collaboration among stakeholders and greater competitive advantages in the market. Nevertheless, there is the appeal for inserting the social dimension towards sustainable development. In terms of environmental regulation, the polluter-pays-principle has been the root along four decades in Denmark environmental policy. On the other hand, front-runner companies are taking responsibility as self-regulation in regard to environmental issues, as the eco-labels market. The difference among companies, sectors and needs is a dare (REMMEN, 2001).

Authorities might reach the environmental performance by 'the stick' or 'the carrot' approach. Due to the different actors and environmental perceptions, regulations should be dynamic. For developing regulations, proactive against reactive environmental strategies should be taken into account, as well as innovation and the principle of 'best available technology'. Moreover, policy-making process and implementation in Denmark have a traditional feature of actively engaging stakeholders. In economic means, both taxes and subsides were used, such as 'sticks' for waste and 'carrots' for cleaner products. Information also plays a role for changes (REMMEN, 2001).

3.3 TOWARDS SUSTAINABLE PRODUCTION AND CONSUMPTION IN DENMARK

The connection from grave to cradle through circularity is noticeable. As a result, resource efficiency means action at waste source stage in order to change industrial patterns. The potential to mitigate environmental impacts takes place when upstream political instruments are applied. The strategy along the history and priority established in Denmark evidence the influence of the European Union. As a front-runner country, Denmark is currently engaged in Circular Economy to promote sustainability in supply and demand.

3.3.1 European Union towards Circular Economy

In 2020, the European Union released a new Circular Economy Action Plan (EC, 2020b). As a future-oriented agenda, it is based on sustainable development by means of policy frameworks. It is part of EU Green Deal strategy (EC, 2019b) to address environmental-related challenges and to implement 2030 Agenda. The commitment aims at modernity, resource-efficiency and competiveness in EU

economy, as well as at justice and inclusion during the transition. EU, as global leader in regard to Circular Economy, is taking action to mobilise the industry to implement a cleaner production and circular flow of resources. Its influence internationally and diplomatically plays a huge role.

The plan promotes circular design of products, due to the priority to reduce and reuse before recycling. Previously, there was a clear incentive for recycling, and now EU is required to improve its laws to promote waste prevention instead. Circular material use rate and consumption footprint are some indicators to follow the situation within Member States. Another concern is regarding waste exports from European countries to Asia and Africa, mainly. It has also an effect on third countries imports of environmental impacts and related issues. In this sense, it is necessary review regulatory rules for waste shipments and the promotion of waste solutions in Europe, so that climate neutrality can be achieved.

There is a focus on sectors that are intense in resource use. Some of the key product value chains can easily be characterized as recyclable household waste such as packaging, plastics, and textiles. For consumers, the perspective to create a 'right to repair' and standardized methodologies for informed decisions are essential requirements for ecological products. On the other hand, it is important to avoid the risk of 'green washing'[5], as well as premature obsolescence and unnecessary single-use products. The plan also considers circularity in production processes such as Best Available Technique (BAT) and industrial symbiosis. Key actions have a specific date to be accomplished.

3.3.2 Ecodesign in Europe

The European new Circular Economy Action Plan (2020) emphasizes a sustainable product policy framework. Product design phase plays an important role to avoid environmental impacts and to promote circularity. The Ecodesign Directive 2009/125/EC establishes requirements for energy-related products, while Regulation (EU) 2017/1369 deals with energy labelling (EU, 2009; 2017). Besides the requests for lower energy consumption in previous versions, the whole life cycle of products and their impacts were covered with potential improvements. The Ecodesign Directive defines (EU, 2009, p. 16):

[5] "Companies making 'green claims' should substantiate these against a standard methodology to assess their impact on the environment." EU Green Deal (EC, 2019b, p.8).

> ‘Ecodesign’ means the integration of environmental aspects into product design with the aim of improving the environmental performance of the product throughout its whole life cycle.

Bundgaard, Mosgaard and Remmen (2017) study the Directive, and display a transition in ecodesign from being efficient in energy towards resource efficiency. The authors agree that the Ecodesign Directive can play a relevant role. It is an instrument to allocate resources efficiently, as a demand from the EU political agenda. Other stakeholders’ requests also influence the implementation of those requirements in the industry sector, as well as voluntary agreements, ecolabel schemes and measurement standards. Even though some benefits for consumers are not as clear as they are in energy efficiency, the potential to extend products’ lives through durability and repairability are tangible. On the other hand, producers are expected to hesitate they will sell less and have a greater competition.

European Commission sets a process to define generic and specific requirements according to product category. Resource efficiency might mean criteria such as disassemblage, declaration of recycled content, waste from manufacturing, information requirements, packaging, mono-materials, efficiency during the use phase, level of recyclability, reusability and recoverability, among others. Basically, for product groups there are requirements and information related to target resource efficiency. For instance, relevant information should be provided on how to disassemble, recycle or dispose off at the end-of-life (BUNDGAARD; MOSGAARD; REMMEN, 2017).

Most of the requirements are generic information provided by producers. Bundgaard, Mosgaard and Remmen (2017) defend that consumers must have the information to decide which products they want to buy. For example, if the durability differs among products, the end-consumer might make a choice in accordance to the longest life cycle or even the possibility of upgrading a product. Hence, informed choice has the potential to push the market as to resource efficiency. Moreover, both generic and specific information requirements are essential to identify substances location such as hazardous components and raw materials.

According to Bundgaard, Mosgaard and Remmen (2017), there are still some impairments to the resource efficiency agenda. Even though the Directive is a consistent policy instrument to do so, and works as a driver, there are challenges in the industry and market surveillance to deal with. Also, proposed requirements should be verifiable, such as a common methodology to calculate reusability ratio or recycled content. Waste management system as an institutional condition might also impact on the agenda. For instance, waste generation and EPR connect consumption and production. That is why Waste Directive 2008/98/EC affects Ecodesign Directive and shall embrace nexus thinking.

Ecodesign Directive is an instrument different from Ecolabels. This distinction should be taken into account before transposing criteria. Both can serve as an inspiration though. Besides, voluntary agreements mean self-regulation measures defined by the industry, instead of implementing measures. Mandatory and voluntary measures shall be applied for the green transition. All of them are measures to achieve sustainable consumption and production defended by the European Commission (2011). Therefore, Ecodesign Directives and Ecolabels are complementary instruments to achieve SDG12.

3.3.3 Life Cycle Costing (LCC) – valuable information before consuming

Previously we analysed the life cycle perspective as a tool to assess environmental impact, LCA and LCIA. This holistic approach can be powerful for consuming responsibly. Even though change in lifestyle patterns and utility function is a hard task, there are some tools to reflect on cost-effective choices. Life cycle costing (LCC) can support decision-making process considering the whole life cycle, starting with production, and during the use phase until the final destination. At the same time, LCC adds monetary parameters. In Economics, cost analysis represent informed decision in practice, and can involve criteria such as efficiency, efficacy and equity. European Union has included LCC approach for public procurement since 2014.

Besides two EU Directives regarding the topic, in 2016 was released a handbook for “Buying green!” aimed at the European public sector (EC, 2016). Directives 2014/24/EU (Article 68, EUROPEAN UNION, 2014a) and 2014/25/EU (Article 83, EUROPEAN UNION, 2014b) are slightly different, only in what refers the buyer as being an authority or an entity, respectively. The handbook deals with both

and presents some successful acquisitions by using LCC, such as greener buses in Romania, and lifetime maintenance at a bus station in Germany. Fundamentally, procurement based on LCC may promote savings on water, energy and fuel consumption, on replacement and maintenance, and on final disposal. Those savings, by avoiding costs hidden for operation and end-of-life treatment, consider the whole life cycle and not only the purchase price (delivery, setup, warranty).

The costs of externalities may also be included. Environmental and social aspects should be covered in relation to the products, works and services. According to the Directives (2014, p.134) “their monetary value can be determined and verified”. For instance, costs of pollution, GHG emissions and actions for mitigating climate change may be considered, as well as the specific production process as an award criterion. Qualitative criteria may comprise design for all users, accessibility and innovation. The method for assessing externalities costs shall be accessible, non-discriminatory, and objectively verifiable. The procurement process should request data to be delivered with reasonable effort by proponents. A common method for calculating LCC is desired, and whenever it is set, it shall be applied as mandatory, as a law.

As a cost-effectiveness approach, LCC supports the decision for the most economically favourable proposal. Fair trade products, resource efficiency and waste prevention are relevant on LCC, and take into account different categories of suppliers and services. That is why common methodologies should be established pondering environmental and social issues. While applying LCC, some considerations are basic. First, lifespan affects life cycle costs, especially for long-term products; then, net present value (NPV) assumes a discount rate regarding costs in the future. Finally, data availability and reliability should consider uncertainties. The need for information and cost estimation may impact on future realities.

3.3.4 Sustainable Production and Consumption in Denmark

The Environmental Implementation Review (EIR) 2019 reports Denmark’s performance by the European Commission. Some of the thematic areas are circular economy, waste management and resource efficiency. The report contains implementation tools such as green public procurement, environmental taxation, investments, funding and environmental governance. The high standard of Danish

Environmental policy over time is recognized, as well as the additional effort needed to reach new recycling targets from now on. Eco-innovation is highlighted, in addition to the higher market of green products and services than the average offered by European countries. It is a result of a solid science base, since, in Denmark, around 3% of GDP is dedicated to R&D. In 2017, environmental taxes denoted 3.72% of GDP and total revenues of 7.98% (EC, 2019a).

As we have discussed along this work, waste management and circular economy are totally connected. Zacho, Mosgaard and Riisgard (2018) show in practice how value creation based on preparation for reuse and recycling can capture uncaptured values. At a Danish municipal waste management plant, the authors run an investigation to illustrate potentialities and challenges for circular economy transition. Material recovery is still the economically preferable by the majority of waste fractions, even though the law and taxes on incineration and landfill represent the environmental agenda. On the other hand, for sustainability performance, the direct reuse adds the highest value locally. Affordable second-hand products for low-income families, job creation and upcycling for extending product's life bring social and environmental benefits.

There are many initiatives to outline elements of sustainable production and consumption empirically in Denmark. Industrial symbiosis in Kalundborg is a traditional one, and it was assed through environmental and economic aspects (JACOBSEN, 2008). The Danish government promoted the development of LCC tools to calculate the total cost of ownership for green public procurement. Besides EU Ecolabel, Nordic countries[6] also have the official Nordic Swan Ecolabel to proof environmental efforts including life cycle perspective and circular economy (EUROPEAN COMMISSION, 2016). However, a decentralized platform persists to follow up targets and achievements for SDGs, EU, Nordic countries and Denmark.

3.3.5 SDG12 for Nordic Countries

Sustainable Consumption and Production (SDG12) is a concern for Nordic countries, which includes Denmark. In 2018, the Nordic Council of Ministers released an analysis on their progress towards SDG12 and future perspectives. The Generation 2030 programme was adopted to support SDGs accomplishment in the

[6] Nordic co-operation involves Denmark, Finland, Iceland, Norway, Sweden, the Faroe Islands, and Åland.

Nordic region. All targets and indicators are being monitored, using the same parameters established by UN (Annex 1). Indeed, SDG12 is one of the most challenging for them, even though Nordic countries are progressing well in the other 17 SDGs within global comparison.

We are using targets 12.1 and 12.5 as references and their respective indicators. For 12.1, in regard to national programmes on Sustainable Consumption and Production, Nordic status is ‘well on the way’, while for target 12.5 to reduce waste generation is ‘an uphill climb’, in worse situation. Both targets are related to circular economy strategy, but recycling-based indicator does not go up to waste prevention in the hierarchy as it should. According to the report, there is “ample room for improvement at both political and practical levels”, because SDG12 is interconnected with many other SDGs (NORDIC COUNCIL OF MINISTERS, 2018, p. 15). This logic brings the nexus approach to accelerate sustainability.

National circular economy strategies are the essence to achieve SDG12 for Nordics. As we have seen before, the circularity of elements ensures efficiency in resource allocation and in waste management. National policies embed these key aspects as well as recycling and reusing. However, Denmark presents the least progress with soft measures. The waste prevention strategy (2015), previously seen, mentions greener consumption, reduction in packaging waste, resource efficiency in business, among others. The report emphasizes that the political commitment has disappeared, and makes critics on the lack of quantitative targets for waste reduction on its plan.

Denmark faces challenges to put circular economy into action. Out of government, Danish Advisory Board on Circular Economy recommended 27 initiatives in regard to the topic to be included into a national policy in 2017. Those recommendations summed up with the Danish strategy (2018) are the path towards Circular Economy. European Union also promotes those principles by taking industry and stakeholders into account for a collaborative process. However, while there are no strong regulatory or economic instruments to implement circular economy, only soft measures represent the idea of circular economy such as target platforms, voluntary agreements and partnerships. Moreover, energy recovery in Danish context is still an obstacle for resource circularity due to the partial lock-in and

investments in incinerators (EEA, 2015 *apud* NORDIC COUNCIL OF MINISTERS, 2018).

Some other bolder indicators were added to reflect the actual progress in waste related issues. There are four of them: circular material use, recovery other than energy recovery, recycling rate of municipal waste, and generation of municipal solid waste per capita. Those additional indicators evidence that UN missed some relevant information to achieve 2030 Agenda. On the other hand, difficulties to gather data in other countries in a situation different from that of the Nordics are well known. In this sense, Denmark and its fellows bring the importance of monitoring waste generation and management over time.

Waste reduction is the main challenge for Nordic nations, even though recycling practices are doing well. Norway and Denmark face a challenge with their per capita municipal waste generation, since both countries have the highest levels in Europe. In terms of recycling, Danish rate is the best among them. It considers all kinds of waste, especially demolition and construction waste as part of a long-term strategy. Conversely, there is no ambitious goal for residential waste. According to the report, the Danish objective for recycling 50% of household waste has been the same already required in the EU Waste Framework Directive. Finally, the report recommends actions for Nordic countries based on targets for SDG12.

3.3.6 Circular Economy in Denmark

Circular Economy is being highly discussed in Denmark. Besides the 2018 national strategy, a recent update increases the topic emphasis even more. The circularity of resources and alternatives to reduce environmental impacts are also part of the climate plan. In this sense, the reduction of incineration and circular economy implementation are the main bets for the climate action in the country.

3.3.6.1 Danish Strategy for Circular Economy

The Danish Government launched in September 2018 the strategy for Circular Economy. A transition for making a sustainable growth is necessary to reach the 2030 Agenda. Six areas of effort contemplate fifteen initiatives, Appendix 2. Improvements in product design, and new business models for services instead of products and remanufacturing are some key elements, as well as rethinking consumption and new circular technologies. For waste management, recycling

facilities for sorting materials and take-back schemes are part of better use of waste. The expansion of DRS is also mentioned. Following the EU approach for circular thinking, Denmark' industry associations aims to increase resource productivity and recycling rates.

The government propose a value creation. Besides recirculation of resources and collaborative economy, there is an opportunity for product-service models where "they sell the access to using products, while the enterprises maintains ownership of them" (DANISH GOVERNMENT, 2018, p.15). This type of service increases the usage rate by sharing and leasing products. Circular Business models in SMEs are desired, therefore, financial incentives and knowledge development are offered by the national authorities. The topic is highly promoted in academic fields and gets investments for researches too. However, regulatory barriers may appear due to the innovation of those business models.

Responsible consumption is encouraged. Ecolabels are seen, as a supportive symbol for consumers to choose greener products, which are market-driven. In order to promote circular procurement, requirements for suppliers to ensure circularity and green public procurement (GPP) have already been incorporated into many purchasing protocols. Before governmental acquisition, the use of life cycle assessment and total cost of ownership (TCO) are considered essential tools in the decision-making process. Moreover, circular economy principles are being taught as part of the curricula. The transition goes over digitalisation and design, but also includes the promotion of new habits and markets to circulate resources along the entire value chain.

3.3.6.2 Climate plan for a green waste sector and circular economy

The most recently update is in regard to the political agreement for a green waste sector and circular economy (Klimaplan for en grøn affaldssektor og cirkulær økonomi, in Danish), on 16th June 2020 (DANISH GOVERNMENT, 2020). In order to achieve climate neutrality, incineration must be reduced since it has the major contribution on CO_2 emissions within waste treatments in Denmark. By 2030, this reduction should represent 30% compared to the current situation. The agreement emphasizes higher quality in recycling, plastic-related issues and separate collection for ten different waste fractions in all municipalities. Recycling plants are the priority instead of combustion capacity. Waste taxes analysis, requirements for recycled

plastic content, digital solutions and Carbon Capture Storage (CCS) actions are all part of the plan.

Before dealing with that, it is important to understand the historical demand for waste-to-energy technologies. Since the energy crisis in the 1970s, fossil fuel issues became a concern for energy supply. That is how incineration got the priority for the heating system instead of oil-based feedstock. Also, in 1997 combustible waste was completely banned for burying in order to fill incineration plants capacity. Waste import was another solution for the insufficient volume of waste and, as a consequence, Denmark has also imported CO_2 emissions. Hence, waste as a fuel in Denmark provides both electricity and heat, mostly in underground systems, for more than 100 years (DANISH MINISTRY OF THE ENVIRONMENT, n.d.). On the other hand, incineration emits GHG to the atmosphere. Thus, it is clear why the new Danish climate plan is connected to the waste sector, while circular economy promotes options to handle waste as resource instead of ashes.

3.4 FINAL COMMENTS

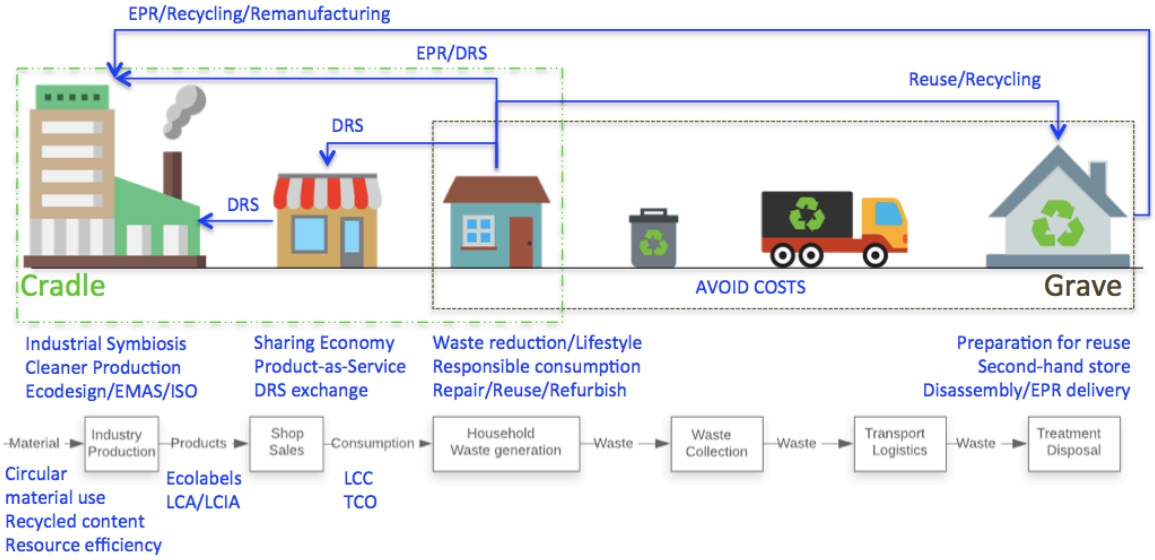
Under this strategy, directives, regulations, action plans and implementation reports represent the deployment of theories and studies in practice. From the macro level at the European Union to the micro level in Danish municipalities, we can easily observe drivers and barriers to achieve sustainable production and consumption. The principles and concepts are interconnected in opposition to a linear thinking and even less to a linear supply chain. Moreover, those improvements in a ten-year horizon within waste policy reveal necessary adjustments to implement circular economy. Since the use of instruments to promote recycling is different from waste prevention and preparation for reuse. Common methodologies are still a dare in EU though.

The historical development of both waste sector and industrial production evidences Denmark as one of the frontrunner countries in sustainability. The application of policy and economic instruments plays an important role aligned to EU. Long term and short term targets are part of robust planning and supportive legislation to achieve global goals. Due to the stronger ownership of commitments, relevant players are engaged to implement Danish strategy. Furthermore, close co-ordination with integrated sectors (e.g.: energy sector) represents an objective employment of nexus thinking. It is the same perspective connecting demand and

supply sides when we consider waste and ecodesign directives, thus from grave to cradle.

Circular economy is seen as the way to achieve sustainable production and consumption. Besides environmental and social aspects, cost-saving opportunities are meaningful to sustainability. The complex system needs actions in both sides of offering and buying in order to change the current patterns. The large number of different products, industries and services are part of the challenges on the market-basis and standardizations. Also, measures to monitor and update technologies are necessary, as well as stakeholders involvement. Figure 8 sums up alternatives for greener transition.

Figure 8 Opportunities to promote sustainable production and consumption



Source: own elaboration

CHAPTER 4

FROM GRAVE TO CRADLE IN BRAZIL

4.1 GRAVE: WASTE SYSTEM

4.1.1 Brazilian Solid Waste National Policy (PNRS) Law 12.305/2010

Waste management in Brazil is complex. Part of this complexity is due to the existence of waste pickers working informally on the streets or in dumpsite areas. The inappropriate final disposal in open dumps does not only portray direct pollution in the environment, but also poverty and social issues. In this context, the waste national policy aims at addressing waste-related problems, as well as defining obligations for manufactures such as reverse logistics.

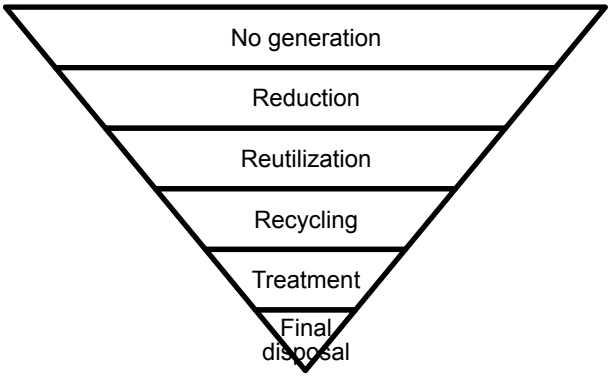
The main policy for managing waste in Brazil is *Política Nacional de Resíduos Sólidos* (National Solid Waste Policy - PNRS), Law 12.305 of August 8th, 2010 (BRASIL, 2010b). Federal Decree 7.404/2010 released its regulation in the same year, four months later in December 2010 (BRASIL, 2010a). The discussions to publish the final version of the PNRS text took twenty years in the Brazilian Congress. Until today, there is still room for improvements and in practice it faces barriers for implementation. Ten years have passed since PNRS was launched, and some sectorial agreements have not been signed yet. Currently, reverse logistics and its shared responsibility are the greatest elements for debates, as well as the existence of open dumps and waste pickers' organizations.

The Law emphasizes the integrated solid waste management. This integration means measures and responsibilities by the waste generators, public sector and the use of economic instruments to handle waste efficiently. It includes social, cultural, economical, political and environmental dimensions to achieve sustainable development. Environmentally appropriate final destination for waste comprises reutilization, recycling, composting and energy recovery, while final disposal must be done in landfills. Sustainable production and consumption patterns are also mentioned. Producers, importers, distributors and retailers share responsibility for the products' life-cycle defined in reverse logistic. It aims to protect human health and nature.

The PNRS is based on polluters-pay and protector-receiver principles. Besides its systemic view and eco-efficiency goal, the policy promotes collaboration

among stakeholders, waste as resource and respect for local and regional diversities. Among its objectives area clear incentive for cleaner production and recycling industry such as recycled content and recyclable materials. Moreover, it encourages waste pickers integration, life-cycle evaluations and ecolabels for sustainable consumption. Some instruments are solid waste management plan, separated kerbside collections, technical and financial cooperation, scientific research, monitoring systems, environmental licence, fiscal incentives and sector agreements. Waste is classified according to its source and its dangerousness. Figure 9 shows the priorities to handle waste:

Figure 9. Priorities to manage waste according to PNRS 12.305/2010



Source: own elaboration according to PNRS 12.305/2010

The policy requires a Solid Waste National Plan (Planares). The preliminary version was launched in 2011. Since then, many discussions and contributions have occurred, but the final version has not been officially published yet. In 2020, Planares is still opened for public consultation at MMA webpage. The plan has a 20-year horizon and is to be updated every four years. As requested at PNRS, the plan contemplates a diagnosis of the Brazilian solid waste situation, proposes scenarios and was built with social involvement by means of public consultations. Furthermore, it contains guidelines, strategies and targets deployed into programmes and actions, including waste pickers perspective. Environmental education is highlighted due to the importance to reach targets, and initiatives for different fractions of waste. National Information System on Solid Waste Management (Sistema Nacional de Informações sobre a Gestão dos Resíduos Sólidos, in Portuguese, SINIR) is part of the elements to follow the implementation on all level: national, states and municipalities.

All states and municipalities, or at least regional consortia, must develop their own waste management plan. It follows the same requirements for the national plan, but in a micro level. Environmental and social impacts caused as a consequence of waste streams should be described and diagnosed with sources, volume, composition and destination. The local waste manager plays the operational role in terms of public service, the costly part in other words. Besides the public sector, some enterprises also have to declare how they manage the waste they generate. If the government treats waste that is out of its responsibility, it should be refunded for that expense. However, that is not what usually happens.

4.1.2 Dumpsites and waste pickers in Brazil

Waste management in Brazil has its peculiarities due to the existence of open dumps and waste pickers. In PNRS (BRASIL, 2010b), the target to eliminate and recover dumpsites associates the economic emancipation and social inclusion of waste pickers. There is an incentive to create and develop waste pickers' cooperatives and associations composed by low-income people. It includes an uncomplicated process to contract them as public service providers for collecting materials and sorting recyclables. Some economic instruments might finance the infrastructure and equipment for implementing those organizations and projects related to reverse logistic cooperation

In order to illustrate it, only in January 2018 the largest Latin America's dumpsite in Brasília, the national capital of Brazil, was closed. The International Solid Waste Association (ISWA, 2019) published the work "Climate benefits due to dumpsite closure". One of the three case studies regard the Brazilian experience at '*lixão da Estrutural'* in Brasília. Here it is also easy to see the nexus with waste manage and climate action. Even though closing a dumpsite is a difficult task, the successful case in Brasília evidences that it is feasible. According to the case study, the main factors were "vigorous political will, significant subsidies, the involvement of multiple stakeholders and long-term planning" (ISWA, 2019, p.4).

Before closing the dumpsite at Estrutural neighbourhood, some structural conditions had to be implemented. First, a sanitary landfill was needed for appropriate final disposal. Moreover, waste pickers who were working in the area had to be replaced to recycling facilities, organized in cooperatives or associations. The transition demanded a huge engagement with many governmental bodies, informal

waste sector and Non-Governmental Organizations (NGOs). Besides the investments in infrastructure, the public sector made contracts with waste pickers' organizations for providing sorting materials service from the public selective waste collection. Some organizations were also able to collect their own recyclables around the Federal District, covered by public contracts too, according to the national law (ISWA, 2019).

One of the most recent programmes promoted in Brazil is called "Zero Dumpsites". As part of the National Agenda for Urban Environmental Quality, the programme includes establishing a diagnosis, depicting the desired situation, pointing indicators and axes of implementation, and finally making the action plan. In relation to waste pickers, the difficulty to get a precise number of people and their social and economic profiles due to the high level of informality in the sector is recognized. According to the Ministry of the Environment (MMA, 2020), the first year of implementation has delivered outcomes such as the governmental ordinance MMA/MME nr 274/19 and decree nr 10.117/2019 regarding energy recovery from urban solid waste (BRASIL, 2019a; 2019b), as well as investment to improve waste management in ten Brazilian states in the amount of R$ 64 millions. Incineration results in GHG emissions, besides being costly for Brazil compared to landfill.

4.1.3 Reverse Logistics and shared responsibility

Chapter III section II of PNRS (BRASIL, 2010b) brings details in regard to the shared responsibility. Since the policy was published, logistic reverse was supposed to be implemented gradually according to the chronogram established in the regulation. Sustainable strategies belong to economic agents that must reinsert materials back into the production chain. Post-use products should be delivered at drop-off stations for reusing and recycling, as a potential end-of-life solution. The main instrument is the sectorial agreements that must promote more efficient patterns and reduce negative impacts to the environment during the whole life of the product. The clear definition of responsibilities is still a challenge due to the many actors involved in the shared process such as manufactures, public sector, consumers and retailers. In contrast, the same companies have already operated in EU law conditions. Hence, they are supposed to pay for those negative externalities in Brazil too, not only in EU.

Guarnieri, Cerqueira-Streit and Batista (2019) point out the participation of waste pickers' organizations in the sectorial agreement. In the specific case of packaging materials, those organizations play an important role since informal waste recycling is still a source of income in developing countries, such as Brazil. Dourado (2020) corroborates this as to glass containers, and evidences the costs avoided by the government if the involved actors in fact comply with their responsibilities to pay what they must. Related costs might be the reason why reverse logistics faces barriers for its implementation. Guarnieri, Cerqueira-Streit and Batista (2019) illustrate some of them such as operation, technology and infrastructure. Also, waste pickers argue that they have to be refunded by their environmental work of sorting recyclables and reinserting materials into the production chain.

4.2 CRADLE: INDUSTRIAL PRODUCTION IN BRAZIL – PERSPECTIVES BY CNI

The National Confederation of Industry (Confederação Nacional da Indústria, in Portugese, CNI, 2018) has elaborated the strategic map for the 2018-2022 period, which basically means four years of the current government in power. The Brazilian industry aims at being competitive, innovative, global and sustainable. Compared to the previous map, the current one got a new theme focused on natural resources and the environment. Resource efficiency, new businesses models and circular economy are key factors demanded in the global economy for value creation. Thus, the agenda considers those trends in the world in terms of climate action and carbon neutrality, as well as the change in consumption patterns in order to avoid environmental impacts, while the national tendency is not concerned with any environment-related issue around the country.

The industry's strategy intends to achieve 'competiveness with sustainability'. Besides natural resources and the environment as production factors, the industrial policy has the goal to be aligned with international trades and innovation. Basically, Brazil desires to export more of its products. New digital technologies, private investments, legislation and research and development (R&D) are some initiatives promoted to reach foreign markets. The environmental agenda includes: waste as resource in circular economy terms, regulation for economic instruments from PNRS, reduction in emissions through energy efficiency, among others. Therefore, public

policies play an important role to empower the productive sector in Brazil, as well as global requirements for a greener and more efficient industry.

Besides the strategic map to guide the industrial production in Brazil, CNI also elaborates the Legislative Agenda (2020a). Different from the map, which contains eleven key factors, main objectives, macro target, priority themes and initiatives to turn into actions, the Legislative Agenda assesses the legislation proposals. Every year, all the laws that affect the industrial sector, convergent or divergent, are discussed in order to adjust the text or even to advocate the businesses competiveness. This kind of evaluation represents the nexus thinking, since it brings the sectorial policies and their interfaces with the industrial sector. As an institution to support the private sector, CNI debates public policies considering the systemic and complex context as it is.

4.3 TOWARDS SUSTAINABLE PRODUCTION AND CONSUMPTION IN BRAZIL

The supply and demand system in Brazil receives global influences to become more sustainable. International organizations such as the United Nations (UN) and the national policies can promote elements for achieving efficiency in the productive sector, as well as the recirculation of resources. Instruments at the products' end-of-life (grave) and green requirements for the industry (cradle) are connected to consuming and living more responsibly, as portrayed by SDG12.

4.3.1 The development of sustainable production and consumption in Brazil

The first milestone regarding sustainability in Brazil was the United Nations Conference on Environment and Development, short-called Rio 92 or ECO 92, in 1992. Besides the Agenda 21 that has already been mentioned here, an impressive speech by Severn Cullis-Suzuki, a Canadian girl, represented a call for a change. At this time, the world was already facing challenges to achieve sustainable development, including production and consumption patterns. In 2012, twenty years later, at Rio+20, the international community returned to Rio de Janeiro to discuss achievements and new targets. Thus, 'The future we want' was the event´s outcome, which includes the promotion of 10-year framework of programmes on sustainable consumption and production (10YFP) by UN (2012).

In 1995, the first National Cleaner Production Centre was opened in the south of Brazil (Rio Grande do Sul - RS). United Nations Environment Program (UNEP) and United Nations Industrial Development Organization (UNIDO) run a programme to implement those kinds of centre as a commitment set at Rio 92. The focus was on developing and transitioning countries where national experts have been trained to spread preventive environmental strategies among businesses, public sector, associations and society. In Brazil, the National Industrial Training Service (SENAI-RS, 2003) hosted the centre. According to SENAI, the industrial pollution into the environment started around 1950´s and 60's. Later, in the 1970's, end-of-pipe solutions for treatment were introduced in the industry, and since 1990's cleaner production and the use of economic instruments have raised.

In 2003, the Minister of the Environment published governmental ordinance nr. 454 to establish the Cleaner Production Steering Committee (Comitê Gestor de Produção mais Limpa, in Portuguese, CGPL). It aimed at promoting the Brazilian Network for Cleaner Production and Ecoefficiency as an instrument to manage the environment and to modernize the productive sector (BRASIL, 2003). Governmental bodies, financial institutions, NGOs, associations and other relevant stakeholders took part in the group. They had to define action plans, follow the initiatives, propose solutions and guide strategic activities. In 2008, the same minister revoked the previous ordinance implementing a new version, nr. 44 (BRASIL, 2008). The main update was the terminology for the national management committee, since sustainable production and consumption is wider than cleaner production. The change contemplates consumers' behaviour and responsibilities too. The Action Plan for Sustainable Production and Consumption (PPCS) was launched in 2011 and will be covered in the following section in more details.

Some other governmental decisions have been established to ensure sustainability in Brazil. Mainly in the PNRS (2010), which includes also economic instruments to promote sustainable production and consumption. It mentions funding and measures to prevent and reduce waste generation. Also, it promotes the development of products with less impact along its entire life-cycle. Cleaner production and technological innovation through research can improve manufacturing process and environmental management within businesses. In 2012, the National Institute of Metrology, Quality and Technology (Instituto Nacional de Metrologia,

Qualidade e Tecnologia in Portuguese, INMETRO) published ordinance Nr. 317/2012 which is a Normative Instruction for General Sustainability Requirements for Productive Processes. Decree 7.746/2012 was amended by Decree 9.178/2017 regarding Sustainable Public Procurement, for a better consumption too (BRASIL, 2012; 2017).

4.3.2 The Action Plan for Sustainable Production and Consumption (PPCS)

Followed by the PNRS 12.305/2010, in 2011 was released the Action Plan for Sustainable Production and Consumption (Plano de Ação para Produção e Consumo Sustentáveis in Portuguese, PPCS). The objective is fomenting policies, programmes and initiatives to address related social, environmental and economic challenges (MMA, 2011). The strategic action has six priorities: i. education for responsible consumption; ii. sustainable public procurement; iii. environmental agenda in the public administration (A3P); iv. increase recycling; v. sustainable retail; and, vi. sustainable construction. At this time, circular economy was not mentioned, but all elements were there. Other supportive legislations were in related to the plan, such as PNRS (2010) and the Climate Change National Policy (Política Nacional de Mudança Climática, in Portuguese – PNMC – BRASIL, 2009).

PPCS is structured in principles, instruments and strategies. The guiding principles are: sustainable development, shared responsibility, governmental leadership by the example, precaution, prevention, transparency and society participation, cooperation and environmental education. Some instruments are sectorial agreements, governmental actions, volunteer initiatives, campaigns and researches. The implementation starts with disseminating the concept regarding sustainable production and consumption in order to expand the range, including states and municipalities. Moreover, the engagement with relevant stakeholders is part of the strategy, as well as the monitoring and evaluation of measures. However, some targets have not been defined on the plan to be reported in sequence.

The four-year cycle was reported in 2014 for the 2011-2014 period (MMA, 2014). Due to the PNRS (2010), the federal government invested more than R$ 1.2 billions in waste management issues between 2010 and 2014 (PPCS Report, 2014). It includes infrastructure for handling waste, contracts for waste pickers, development of managing plans and expected increase in recycling rates. On the other hand,

some challenges recognized are the Brazilian diversity to implement the national policy and the shared responsibility, both of which are not yet widely spread among the productive sectors, government and citizens. Regarding cleaner production and sustainable consumption, only guidelines and consultancy programmes represented the actions in Brazil during the period. Considering some future trends, already observed in 2011, collaborative consumption/shared economy, fair trade and e-commerce are pointed out.

The second cycle for the PPCS was supposed to adjust gaps in the previous plan, 2016 to 2020. Public consultations were opened for the following cycle, including the references for SDG12. However the final version of the plan has never been officially published. Only preliminary versions are available in the project directory of the Ministry of the Environment as part UNEP partnership (MMA, n.d.). The products developed by expert consultants are not easily found, discording to the supposed right for public access to information and transparency by the government. Even less are the decisions regarding the absence of official final publication. It seems an investment that has been thrown away due to political reasons as shift in governmental power and changes in priorities.

4.3.3 Consumption and Lifestyle in Brazil

Law 13.186/2015 institutes the National Policy regarding education for sustainable consumption (BRASIL, 2015). In order to adopt responsible patterns for consumers and ecological techniques for industry, the public sector reinforces sustainable performance by the current generation. The policy's objectives are to promote encouragement for behaviour changes; reduction in water, energy and natural resource consumption; reusing and recycling products and packaging; lifecycle thinking; ecolabel promotion; and incentives for environmental certification. However, the legislation only mentions the use of mass communication campaigns and training for educational professionals to include in the curricula at schools. In fact, there is a lack of economic instruments to implement sustainable consumption in Brazil.

Ritter *et al.* (2014) have analysed what is the motivation for consuming green products in Brazil. The causal model tested five hypotheses, which could positively influence green consumption. The results suggest that 'social context', 'information and knowledge', 'environmental consciousness' and 'environmental attitude' strongly

influence the consumption of green products, while ‘quality and price’ does only moderately. The outcomes might be useful for policy-makers since the focus on environmental concern can promote sustainable consumption, besides new opportunities for products development through ecodesign, reverse logistics and ecolabels. However, it is important to apply the model in different regions of Brazil due to the diversity around the country and levels of education, which might interfere too.

The World Business Council for Sustainable Development (WBCSD) and the Brazilian Business Council for Sustainable Development (Conselho Empresarial Brasileiro para o Desenvolvimento Sustentável, in Portuguese, CEBDS) prepared a report regarding sustainable lifestyle in Brazil (WBCSD; CEBDS 2015). As both institutions represent the private sector, the report comes up with solutions about how enterprises can collaborate to shift the current lifestyle to sustainable ones. The analysis considers five main categories: ‘food and nutrition’, ‘home’, ‘mobility’ and ‘household goods’, as well as ‘leisure and other’. Those first four areas tend to have the highest impacts and represent the Brazilian consumption hotspots, excluding ‘leisure and other’. The sustainable lifestyle target for Brazil is based on lifestyle material footprint, considering possibilities for a future scenario.

According to the report (WBCSD and CEBDS, 2015), three ideas have the potential to transform and inspire sustainable lifestyle in Brazil. First of all, an interconnected multi-modal transport system for daily life, by using technology such as mobility dashboards and shared rides. Second, the future transformative home is where infrastructure and technology through design and sustainable solutions promote new habits for ‘the good life’. Finally, communities and media catalyse sustainable lifestyle in order to reach groups of new consumers through campaigns and online tools. However, all those solutions can be either encouraged or discouraged depending on policy instruments, which directly affects the achievements in scale or not.

As we have seen, the life-cycle perspective is a relevant criteria before consuming, as well as ecolabels. Those tools support the informed choice by consumers, and make easier the green acquisition. In 1993 INMETRO created the label for energy efficiency – PROCEL –, and in 2010 its National Council (CONMETRO) approved the Brazilian Life-cycle Assessment Program (Programa

Brasileiro de Avaliação do Ciclo de Vida, in Portuguese). In the Brazilian scenario, de Souza, Barbastefano and Teixeira (2017) recognize that the number of LCA research groups is growing recently, the most of them are in academic fields, specially engineering. Moreover, Carvalho (2020) links eco-innovation with ecolabels for products and services. The study considers the environmental impacts due to the iron industry in the Brazilian context, which can improve its manufacturing and organizational processes while promoting eco-innovating to acquire ecolabels. The topic has the potential to grow more.

4.3.4 Circular Economy in Brazil

The domestic scenario does not have a national strategy for circular economy. Basically, PNRS is the first law observed within circularity concepts, even though the terminology is not expressed in the text. Despite some other directives that may contemplate few elements, they are not centralized or have nexus perspectives. CNI (2020b) exemplifies the lack of incentives for recycling in the industry context, in 'circular' words, incentives for closing the loop. According to CNI, the transition from business-as-usual to recirculation of resources needs innovative businesses models, funding opportunities and public policies. Those three factors led the diagnosis about the current situation in the country regarding circular economy. Waste-related issues, lack of environmental education, R&D and incentive instruments are the main obstacles for changing the current patterns.

CNI (2020b) has published a strategic path for the industrial sector in Brazil regarding circular economy. Five lines of action to accelerate the transition are pointed out: education; public policies; financing; R&D and innovation; and markets. Future perspectives and actions to promote circular practices may include designing products for circularity, industrial symbiosis and energy recovery. Indeed, the productive sector represents a key element to achieve circularity in the Brazilian economy. However, most of the strategic path suggested by CNI depends on the government, instead of being an action proposition for the industrial production itself to be in charge of it.

Guarnieri, Cerqueira-Streit and Batista (2019) investigate the sectorial agreement as the instrument of reverse logistics for the transition towards circular economy. As part of the solid waste national policy (PNRS, 2010), the shared responsibility brings elements to close materials loop. Besides the environmental

gains by recycling, the authors defend that waste pickers get economic and social benefits if reverse logistics is implemented. Not only this category of workers, the whole society is supposed to pay less for public waste management if the responsible actors share their responsibility at products' end-of-life. In other words, those agreements represent "win-win-win" advantages as outlined in the policy. Even though the law does not reference circular economy terminology, the text contains goals and guiding principles in accordance with the concept. The authors explain the 'recent' conception as the reason for that, although we have already seen that circular economy origins is actually something remote, over than three decades ago.

Those sectorial agreements also have some limitations and barriers that need to be discussed and improved. For instance, consumers are not signatories in the packaging case, which only the Brazilian government, industries association and waste pickers representation have signed (GUARNIERI; CERQUEIRA-STREIT; BATISTA, 2020). At the same time, with so many actors involved in the signature, more complex and longer the debate might become. In the case of glass packaging, the industry association, which was supposed to sign the agreement, did not. Dourado (2020) shows how the State has been paying private costs to address the negative externalities due to glass container generation, while some industries neglect the shared responsibility, thus damaging the environment. It also explains why the product design has not improved enough yet.

4.3.5 SDG12

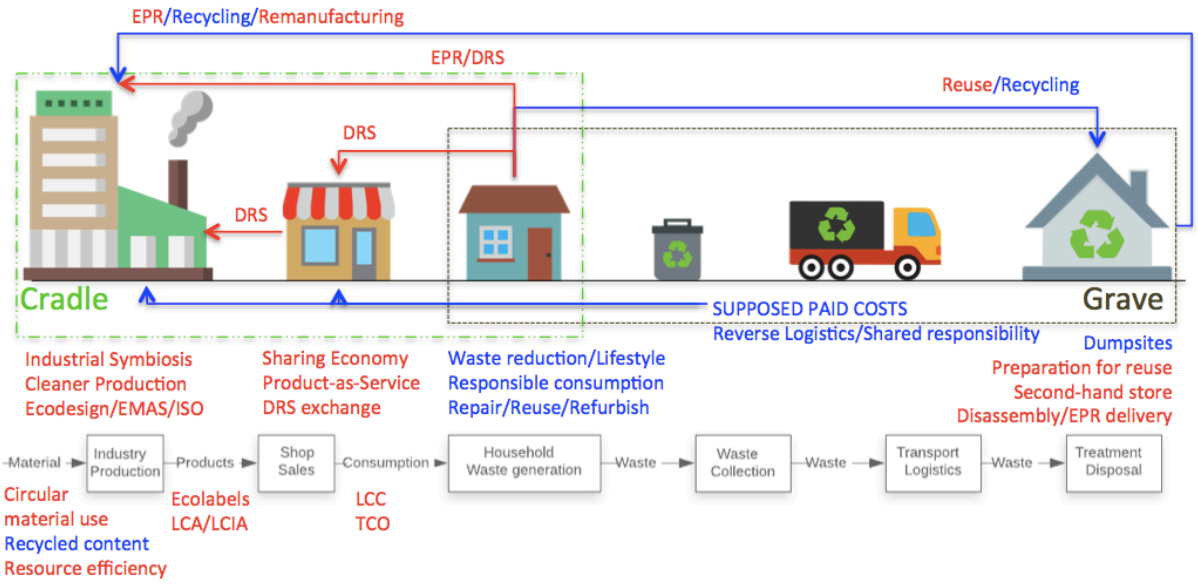
Goal 12 aimed at ensuring sustainable consumption and production is being monitored in Brazil. The UN Environment Brazil (UNEP, 2019b) disclosed a report about its initiatives around the country, which includes SDG12. UNEP and MMA cooperate to implement the action plan (PPCS) such as conscious consumption survey by Akatu; Sustainable Public Procurement and Environmental Labelling Project (SPPEL); eco-innovation for new business models and LCA booklet; and the 10YFP Trust Fund, which Brazil has contributed with one million dollars. Moreover, the Institute of Applied Economic Research (IPEA, n.d.) evaluates SDGs according to targets and indicators. Target 12.1 is considered achieved due to the PPCS, even though it is outdated. On the other hand, target 12.5 does not have a national recycling rate yet; therefore, it has not been measured.

4.4 FINAL COMMENTS

Indeed, Brazil differs from Denmark when we analyze from grave to cradle. First, the investments involved in the waste sector represent low cost compared to technologies applied in Europe, such as incineration. Moreover, the infrastructure and policies to handle waste properly still face challenges due to the presence of dumpsites. At the same time, economic instruments and incentives could change the situation, but have not been implemented yet. Figure 10 evidences the comparison between Danish and European Union opportunities to promote sustainable production ad consumption, versus Brazil. The initiatives in blue represent what have been doing in Brazil, while the red ones are gaps.

The economic analysis evidences inefficiency in the system. It is clear to observe the lack of economic and policy instruments in Brazil. Also, there are alternatives to promote circularity of resources and new business models that have not been implemented yet. It is important to ponder the nexus approach too, due to integration of action along the phases. Solutions at grave, for waste management, should meet solutions for industry, at cradle. Moreover, consumer are the bridge between new products and waste generated. Therefore, it is essential the policy mix for both sides, supply and demand, in order to promote economic efficiency.

Figure 10 Opportunities and gaps to promote sustainable production and consumption in Brazil



Source: own elaboration

CHAPTER 5

IS DENMARK BRAZIL TOMORROW?

LESSONS FROM THE ECONOMICS OF SOLID WASTE

5.1. LESSONS FROM THE ECONOMICS OF SOLID WASTE

The economics of solid waste was the first discussion we had in this study. We could understand the costly phases to manage urban solid waste, since generation until final disposal. Recycling, as an alternative of treatment, presents economic, social and environmental benefits. But the lack of economic incentive to sort recyclable materials portrays a market failure due to the absence of price signal. Also, the negative externalities, in regard to waste handling, request governmental intervention through public policies. Usually, polluters-pay principle is the main reference to deal with the marginal external costs. In this sense, Pigouvian tax suits better than Coasian negotiation in the topic. Moreover, we have seen that the waste hierarchy meets economic criterions. In other words, when we focus on reducing, reusing or recycling waste, we are also pondering efficiency, efficacy and equity.

It is clear to observe the different decisions to handle waste according to the national economy. The context and the budget influence the waste management efficiency. Moreover, the waste generation in developed countries is usually higher than underdeveloped nations. On the other hand, the overallocation of human resources in waste collection phase can represent the second-best alternative to solve unemployment problems, feature in poorer regions. Similar situation regards to waste pickers on streets and the existence of dumpsites and uncontrolled landfilling, which claims for equitable decision. The waste management system is costly, it does matter how rich the country is. Another difference is the efficiency to allocate resources and incentives to promote recycling. After recyclables sorting and separated collection at household, it is necessary recycling facilities to put back those materials into the production chain. The operation of those facilities usually depends on subsides by the government. We have analysed diverse instruments and incentives for household waste, and why the combination of them can increase efficiency.

Therefore, the economics of solid waste evidence instruments to lead change in behaviour. Thus, the efficiency within the waste management system represents the optimal resource allocation in order to maximize benefit-cost ratio. The experience in Denmark shows different strategies along decades, and how they have focused on incineration first, then recycling and now waste prevention. If Brazil follows a similar path, it might denote the same lock-in that happened in the Danish context. It is the perfect moment to evaluate Brazilian national policies and what are the goals and challenges to manage waste more efficiently. It is clear to observe the power of appropriate economic and policy instruments for the circular economy transition. Instead of produce-consume-throw away, Brazil has the potential to act according to the sustainable development goals, by lessons learned in Europe and other countries.

5.2. ANSWERING THE RESEARCH QUESTIONS

This study has discussed diverse elements of Economics upon production, consumption and waste management. Basically, we are investigating how we can allocate resources efficiently in order to consume and produce according to sustainable development patterns. Rather looking at demand and supply directly, we have proposed to first look at solid waste issues. In this sense, we become to consider waste as resource, when we recirculate materials back to the production chain again. This new condition for greener products also requests cleaner production and responsible consumption and lifestyle. For implementation, it is necessary governmental intervention through public policies. Then, the nexus approach comes to ensure circularity by integrating waste handling, industry and consumers. We have also illustrated how the system works in different contexts.

The first subquestion is: *how the economics of solid waste can promote circularity in the industry (from grave to cradle)?* First, we have discussed deeply the economics of urban solid waste and how it is connected with circular flow of resources. The waste hierarchy is the highlighted reference to minimize environmental impacts due to trash handling. However, different economic and policy instruments can focus on lower or upper levels in the hierarchy. The instruments chosen really make difference for circulating materials and changing industrial patterns. Therefore, the alternatives to manage waste do influence sustainable production, such as recyclability rate, recyclable content, reusable components and

returnable products. Consequently, if there is the offer of eco-products, consumers have the option to choose for products and services that impact less the environment. Hence, the backward analysis, from grave to cradle, evidences why the proper instruments applied for solid waste can promote a circular transition into the industry.

When we understand that circularity comes first from efficient waste management system, we can go to the second subquestion. If the goal is achieving sustainable consumption and production, so: *what is the policy mix to promote sustainable consumption and production in European Union, Denmark, and Brazil?* The different contexts and historical conditions influence the national policies and initiatives to implement or not sustainable patterns. The macro scheme from United Nations, then European Union and countries like Denmark and Brazil help us to understand why the paths might be distinct or similar. Technology, environmental management and resource efficiency along the whole life cycle are the key aspects for cleaner production. While material flow, ecolabels and ecodesign are relevant elements for greener products. In this sense, regulation and policies can drive the change for sustainable consumption and production. Circular economy is recognized as the main path to achieve it. Hence, policy mix is necessary to integrate all of them.

Finally, the overall research question is: *how can circular economy move towards sustainable consumption and production?* In order to answer this main issue, we have explored aspects that promote circularity through economic incentives and policies. The instruments applied to manage waste, at the end of product life cycle, can influence the product design at the beginning of industrial production. That is why economic incentives and public policies have the potential to promote circularity. United Nations, European Union and many developed countries, such as Denmark, have recognized the benefits for future generation if sustainable consumption and production is implemented. However, it is still challenging the best combination of economic and policy instruments to achieve eco-efficiency in supply and demand systems. We have investigated from grave, at waste system, to cradle, at industrial production, strategies, legislation and incentives to achieve sustainable consumption and production through circular economy and change in behaviour. The first chapter answered why the economics of solid waste is the first step to swift from a linear approach to a circular approach. Then, the second chapter showed policy mix to

ensure sustainable patterns for producers and consumers. Finally, the third and fourth chapters showed the cases in Europe, Denmark and Brazil.

5.3 FINAL DISCUSSION

Usually, the natural cycle of resources starts at cradle, flows along the chain and ends up at grave. Here we are investigating the opposite direction, which means the impacts that happen at the products' end-of-life in order to reflect on a change at the beginning, during the product design. A political frame around consumption and production can define requirements to ensure a sustainable stream of resources. The circular system requests simultaneous efficiency in three dimensions: social, economic and environmental. The network is tied with nexus lines since all nodes represent instruments to connect demand and supply fuelled with natural resources. The interaction of this economic system and the planet boundaries claims for balance.

Waste Management

The national waste system says a lot about a country. Not only about how much the nation consumes, but also how it defines responsibilities for polluters. The priorities established and the costs related to waste management represent the advances or setbacks that the industry must follow before creating thrown-away products. Due to the negative externalities caused and the many parties involved to negotiate solutions for waste generation, governmental intervention is necessary. However, public service to handle waste is costly and might be inefficient in its operation, technology use and communication with stakeholders. In this sense, the use of economic and policy instruments can support the implementation of the national strategy.

Different instruments encourage different behaviours. For instance, a strategy to reduce waste generation cannot be the same for promoting recycling. Unfortunately this phenomenon happens very often, as the case of climbing up the waste hierarchy, level by level, instead of straight applying the proper instruments for the highest priority. Those investments in the lower levels might create new lock-ins as a consequence of inefficient resources allocation. Denmark faces more challenges for waste prevention schemes than Brazil due to the different contexts and economy status. While Danishes present overconsumption, the Brazilian waste

policy tries to solve poverty issues through the promotion of recycling by waste pickers. The waste sector in Brazil has not been developed as in Denmark too.

Recycling is the well-known alternative to close the resources loop. A certain level of recycling, in fact, can bring economic benefits and develop the recyclables industry. Some specific production chains have established real markets in order to reinsert materials for reprocessing, and consequently demand fewer raw materials. It does not mean that all products must be recycled, which would be almost impossible, besides being inefficient. Instead, the valorisation of resources through the mapped value chain of waste streams could promote the optimum level of recycling. Hereupon, the waste composition and source of generation are essential to recognize respective producers and the geographical distribution. Thus, the municipal waste manager can arrange the most efficient solution at the lowest cost.

If recycling is the strategy chosen, economic incentives to sort recyclables at source are helpful. The costly operation to collect, transport and treat household waste, for recycling afterwards, can be even more expensive if the waste is mixed, not to mention the risk of contamination and loss of recyclability properties. In developing countries, the waste management is likely to be labour-intense and usually counts with formal or informal waste pickers participation,. On the other hand, the use of technology for mechanical sorting can represent high investments in rich countries. In this sense, both scenarios suggest subsidies for recycling. Alternatively, the use of economic instruments for sorting recyclables at source works to promote producers and consumers motivation to separate materials during waste generation.

Deposit-Refund System (DRS) has the potential to achieve economic efficiency. DRS encourages recyclables sorting such as packaging and beverage containers. Once you pay a deposit and wish to be refunded when the product is over, there is a clear incentive to separate the refundable part and exchange later on. Besides the environmental benefit by reducing overconsumption due to the deposit, DRS also avoids inappropriate littering thanks to the refund. In this system, the municipal waste manager does not interfere in the process, which depends on consumers, retailers and producers. Therefore, costs are avoided being an economic benefit for the public sector.

Extended Producer Responsibility (EPR) and the shared responsibility are two instruments highly discussed. In Europe, EPR is widely implemented, while in Brazil

reverse logistics and its shared responsibility still face barriers. Actually, in theory the distribution of costs among all producers, distributors, importers and retailers seems fair. However, in practice, the responsibilities are not well defined, and even less the costs that actors must pay. Based on the polluter-pays principle, there is not incentive for consuming less. On the other hand, if the actual polluters pay what they are supposed to, those instruments have the potential to encourage improvements in product design such as material reduction, reusability, durability and circularity of resources during the production phase.

Part of the challenge for reusing more is the difficulty to measure from the users perspective. The habit to repurpose items at home, or even provide for donations, reinforces the material valorisation. In other words, it represents alternatives to extend product's life before getting rid of it. However, in most of the cases, the number accounted, as weight of items reused for example, does not go to the public authority, as it can happen when recycling is the treatment. This means that the municipal waste manager cannot count the amount of resources that have been reused at household. In the opposite way from the users perspective, the municipality can measure reutilization once preparation for reuse is established as a public service, besides the second-hand stores with reusable and affordable articles. It incurs in costs for citizens through fees, though.

The waste policy does play a crucial role to regulate waste management systems. The European and the Brazilian legislations provide the direction for handling waste more efficiently, besides targets and requirements to ensure standard planning and operations. In Denmark, the tax increase to reduce landfill use and the cooperation with the energy sector are relevant factors for its efficiency. While in Brazil, illegal disposals and many open dumps with waste pickers working on still exist. The extreme opposite situations between the two countries evidence that a single solution does not fit everywhere. Even though the Danish lessons learnt can serve as an inspiration for Brazil, it is critical to adjust and get only the solutions that worked positively to improve the waste sector.

The waste management system represents the grave and influences the whole value chain backwards. When waste is generated, it means that someone has consumed products and services for its wellbeing. The industry or business had to produce those products or services, and generated waste and pollution to do so. The

process that ends up at grave has started at cradle, with raw material extraction. It is clear to see how the entire system is connected, and why it is fundamental to understand the impacts at the product's end-of-life to consider changes at the production stage. A shift from a linear thinking towards circularity can only be achieved if consumers understand the role they play when having sustainable lifestyles.

Sustainable Consumption and Lifestyle

People are looking for welfare and Pareto efficiency is part of the questionable motivation for consuming less. What does really mean more efficient consumption? If we consider the power to demand more intelligent solutions for the supply chain, pondering the use of natural resources and cleaner production, we are looking at the manufacturing processes. Also, consumers can request greener products, the ones that promote the circular flow of resources. However, which kind of instruments can inform consumers during the acquisition process? Ecolabels, sustainable requirements, LCA are really well spread in the market? Does this potential for informed-choices represent the consumers' willingness to pay and would change their utility function?

There are still many questions regarding responsible consumption. Indeed, the supply side aims at meeting demand requirements as part of the economic growth. However, different social contexts and economy status can influence consumers' restriction and awareness to choose environmental-related strategies. Especially if those decisions imply in costly products to incorporate green requirements, compromising the rational choice for the least cost. In order to overcome this situation, public policy can encourage sustainable behaviour and promote markets for products, services and productive process with a lower impact on the environment. For instance, sustainable public procurement and product-as-service are effective and innovative alternatives for spending more conscientiously.

New business models have the potential to promote more responsible ways of consuming and living. Shared ownerships and collaborative solutions bring the innovation for using products as a service. The objective is to increase the utilization rate by sharing and renting items and areas, such as bicycles, co-working offices and digital platforms. These new options are becoming more popular and getting scale around the world. For instance, EU and Denmark are leading alternatives to make

more informed-choices before buying. It is a great inspiration for Brazil. Hereupon, life-cycle costing (LCC) is a systemic and helpful tool to understand the total costs of ownership (TCO), since manufacturing, delivery and installation, operation prices along the use phase, up to the costs for final destination. However, some legislation barriers and lack of flexibility are still present in conservative governments.

Sustainable consumption and lifestyle does not look only at the moment the individual is buying a product or a service. In other words, the one who has an intention to contribute to sustainability, and in fact impacts positively on it, is the individual who understands externalities due to supply and demand systems. First of all, it is important to have a holistic view regarding daily choices, from acquisition desires, to operational features and waste generation. The consumer is supposed to ponder effects at products' end-of-life before making a decision, as well as to claim for information regarding the product impacts during its production. Information-based instruments are intended to complement economic instruments and support the decision-making process for consumers. Therefore, we should claim for the external costs that we are paying as society due to market failure on handling waste and producing industrially, even though our consumption may seem like an improvement in the quality of life.

Sustainable Production

Similarly to waste management systems that need governmental intervention due to market failures, the industrial sector also requires regulation. The intense use of natural resources, pollution and interfaces with other sectors make a complex negotiation to achieve sustainable patterns. Public policies should be based on nexus perspective in order to align targets in the short and long terms, among stakeholders. The conflict of interests is inherent of the process, which also makes more frequent trade-off decisions between progress and planet resilience. The mix of policy instruments seems an efficient alternative, since the combination of them should consider environmental impacts and its consequences in our economy.

This study focus on green growth and decoupling strategy rather than degrowth. This means the interaction among systems in a way that dynamic and structural factors to grow our economy should not represent the increase in environmental degradation. In other words, the technology and innovation for new business models may guarantee resource efficiency and pollution prevention. It is

important to highlight the advances in terms of innovation when R&D is encouraged in the national strategy. The increase in investments for greener solutions reflects on improvements not only in the productive sector, but also in consuming less harmful products. Therefore, manufacturing processes and cleaner technologies are as important as greener products and their life-cycle overview.

It is noticeable that command-and-control for mandatory end-of-pipe solutions progressed to investments in cleaner production, and then the consumer-point of view was included to ensure product-oriented strategies. Both a ‘carrot’ and a ‘stick’ have been used in the Danish industry, besides environmental management tools and eco-labels market-basis. However, it is important to point out that the historical phases that emerged in Denmark to green its industry, does not mean a necessary path to go through. If Danish industry can influence improvements in the Brazilian industry, a short way and more effective mix of policy and economic instruments should be adapted and applied.

There is a huge amount of product categories and distinct supply chains in the market that end up in the household. Ecodesign at the production stage and ecolabels at retailers might make easier for consumers to choose more responsibly. However, the process to define methods and parameters for different group of goods and services is long and complex. Depending on specific requirements, there are variables and conditions that interfere in other systems too. Moreover, objective methods are necessary to verify and test compliance, and also institutions to do so. Consumers may get confused due to too many options and available information before buying products. In this sense, it is important to define priorities, tools and managerial arrangements to ensure more sustainable products on the market. Life-cycle assessment (LCA) is also an alternative to know the products’ impact for informed-choices.

Even though circular economy claims for a closed cycle as cradle-to-cradle, the detailed overview from cradle to grave with LCA is also helpful. Especially in our study, we propose the opposite direction. The main reason for emphasizing LCA here is the systemic approach. It is important to understand all elements in the system boundaries, all exchanges and necessary adjustments to cause less impact to the environment. LCA also brings a deep comprehension regarding the impacts at the products’ end-of-life, which reflects on the local waste management system.

Within the economic perspective, life-cycle impact assessment (LCIA) merged with costs along the entire process would represent a more robust and complete tool for the decision-making process. The combination of both is an opportunity for future studies.

Circular Economy

The roots and origins of circular economy concept come from the schools of Economics. The new terminology suggests new principles, but in fact, the solutions to deal with the economic system based on the nature cycles are not that modern. The goals to optimize inputs and provide efficiency to production schemes are alternatives to keep the economic growth through innovative technology and waste as resource. At the same time, it aims at preventing pollution and environmental degradation. If the name ‘circular economy’ got an extra power to promote the theory in practice, let’s make the use of this tendency to build a real transition. The circularity approach faces barriers for implementation since its beginning, but the currently political will to scale up its benefits can represent an opportunity to overcome unsustainable patterns.

The top-down politics schemes stimulate circular economy strategies. It is clear to observe the huge influence the European Union plays, not only for its member states, but also globally. The political agenda is environmental-oriented and converses with the nexus perspective both on waste directive, industrial technology and ecodesign, all of which converge to circular economy principles. Besides the discussion to set polemic requirements as EPR, there is an encouragement to develop tools, guidelines and funding opportunities for implementing circularity patterns. Even though it is still difficult to measure indicators and establish a common basis for so many countries, the circular economy transition is progressing and increasing in popularity around the world.

Circular economy principles match the goal to ensure sustainable consumption and production patterns (SDG12). Indeed, the international drive for a circular transition promotes changes in the local patterns, especially to expand exports and deal with foreign markets. In this sense, the United Nations plays an important role due to the establishment of the global agenda for a green economy. SDG12 looks at all sections mentioned above, from waste management to sustainable production, consumption and lifestyle. However, it is still a challenge to

communicate achievements, barriers and potential improvements considering the huge diversity around the world. Hence, policy and economic instruments are the basis for promoting real changes locally.

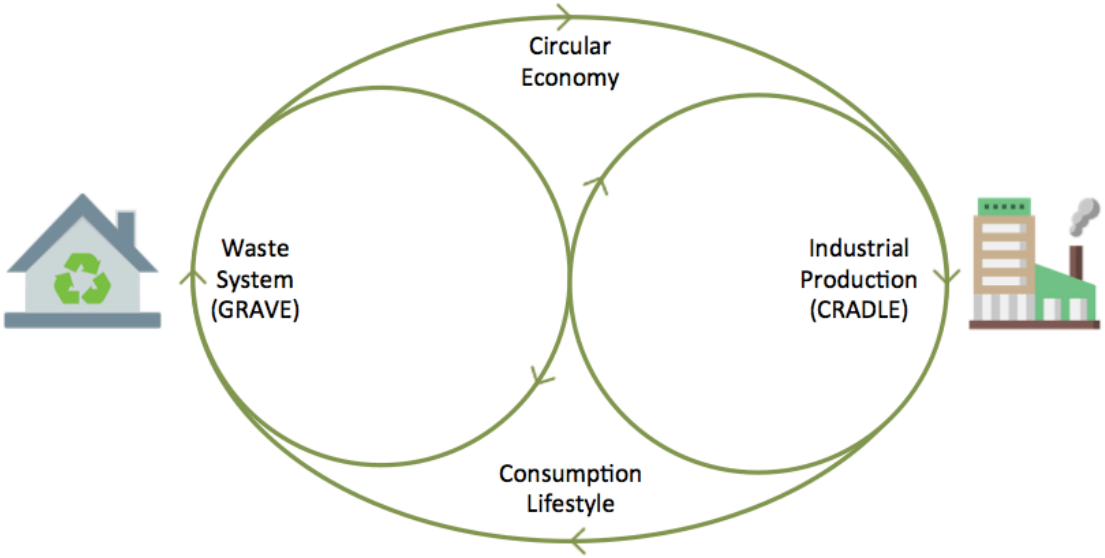
Those instruments can implement a national strategy for circular economy that will affect also the climate action. Here we suggest to national governments to start at the waste management system, understanding the waste generation, treatment solutions and alternatives for reduction of waste and GHG emissions. Landfill and incineration contribute for air pollution, unless alternatives are applied to recirculate resources. Once you recognize what is considered waste, instead of burning everything, it becomes easier to activate the responsible industry for specific raw materials, as it is happening with plastic. In Denmark, the last update regarding the climate plan aims at having circular economy and a green waste sector. It is additional evidence that climate action, waste management and circularity shall be seen in a nexus approach to reach 2030 goals. Brazil, on its side, still misses an action plan.

Circular economy is not only about closing the linear economy loop. It goes beyond, to the meaning of rethinking our economy as a whole. Circularity promotes value creation and many cycles along the production chain. The design of new business models is necessary, more efficient and with continuous improvements, in order to minimize negative externalities and increase benefits through value propositions. Public policies role aims at achieving long-term targets, by conducing the process in scale. Besides the concept alignment, it is fundamental to overcome fiscal barriers and promote change in consumer behaviours. Circular economy is an opportunity to address unsustainable supply and demand systems.

Recent publications evidence the most up-to-date strategies to become a circular economy. Currently, in year 2020, we are looking at the 2030 Agenda as a distance goal to be reached. However, we need to start now the implementation of the circularity approach to have some achievements for SDG12 in a ten-year horizon. Education has been on the action plan for a couple years, but by itself is not enough. The use of a robust combination of policy instruments, in cooperation with stakeholders´ engagement, holds the potential to meet not only political commitments, but also the planetary need of sustainable development. Those accomplishments will in fact represent the “win-win-win” desired solution to address our rampant growth.

Figure 11 sums up our final discussion.

Figure 11 Circularity from grave to cradle



Source: own elaboration

CONCLUSION

The problem investigated in this research is the unsustainable patterns for consuming and producing as a consequence of inefficient waste systems. Firstly, we understood how the waste is managed, which involves the costly phases of generation, logistics and final disposal. Recycling is an alternative to treat waste as a resource by reinserting materials back into the production chain again. The impacts that happen at grave represent negative externalities to our society. Therefore, governmental intervention may be necessary to deal with this market failure. The use of economic and policy instruments has the potential to ensure efficiency in waste management systems and reflect on a change in supply and demand structures, at cradle.

Unsustainable consumption and production is a global concern. Natural resources allocation, technological manufacturing process, goods and services, expenditures, habits and garbage are the main elements to overview the system and its interaction with the environment. The challenge is keeping the economic growth and preventing pollution and nature degradation. Therefore, the circular approach and life-cycle perspective suggest an opportunity to promote more efficient systems, where materials recirculate along the production chain and the impacts are recognized during the whole cycle. In this sense, public policies play an essential role to conduct the transition from business-as-usual towards circular economy.

This academic study was an applied research in Economics, with qualitative approach. The conceptual framework presented the literature review in the lights of Economics regarding waste management systems, industrial production and consumption patterns. Besides economic incentives, policy instruments have also been taken into account for seeking efficiency in demand and supply schemes. Since circular economy was born from environmental and ecological Economics, the conceptualization also matched the field of investigation. Moreover, the theory was analysed from the empirical experience in Denmark and Brazil. Thus, it was necessary to evaluate their legislations, strategies and local initiatives to promote changes from grave to cradle, pondering challenges at products' end-of-life back to design at production stage.

Sustainable consumption and production (SDG12) is one of the seventeen goals established by the United Nations. Therefore, the relevance of the topic

investigated here is clear, and the efforts are necessary to meet the 2030 Agenda globally. For instance, while Denmark has to deal with overconsumption and GHG emission due to high levels of incineration, in Brazil open dumps and low-income waste pickers still exist. Hence, both countries face barriers for circular economy implementation, despite being in different contexts and economy status. On the other hand, some advances in European and Danish regulations might serve as an inspiration to address the Brazilian difficulty to apply polluters-pay principles, especially as to reverse logistics and the DRS regarding to waste solutions, and ecolabels, life-cycle assessment (LCA) and costing (LCC) for green markets.

Circularity also brings opportunities to improve the national scenario. For the waste management phase, the implementation of EPR and DRS can avoid costs of waste collection and transport, besides affordable second-hand products if preparation for reuse is established. Responsible consumption and lifestyle represent a change in behaviour by reducing waste generation, repairing, reusing and refurbishing items at home. In the industry sector, inputs based on circular material use, recycled content and resource efficiency, as well as on transformative technology for cleaner production and industrial symbiosis, should be in combination with ecodesign and environmental management schemes. Ultimately, new circular business models encourage shared economy, product-as-service and digitalization.

Finally, it is essential to implement strong instruments for waste management in nexus with supply and demand systems in order to achieve sustainable production and consumption. Circular economy seems to be the most efficient alternative to narrow, slow and close the resources loop. However, future studies to evaluate its implementation and real changes in the industry and individual behaviour would be interesting. Despite LCA being a powerful tool to understand the systemic impact of products and services, it could incorporate cost analysis to be even more complete, as BCA and CEA. Another suggestion is the application of LCA with this economic perspective for specific materials such as plastic, or even assess logistic reverse implementation for those materials.

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APPENDIX A – Danish Strategy for Circular Economy

AREAS OF EFFORT	INITIATIVES
1. Strengthen enterprises as a driving force for circular transition	1.1 Promoting circular business development in SMEs
	1.2 Setting up a single point of entry to the authorities for enterprises with circular business models
	1.3 Expanding the access to financing of circular business models
2. Support circular economy through data and digitalisation	2.1 Supporting digital circular options by commercial use of data and challenges
3. Promote circular economy through design	3.1 Incorporating circular economy into product policy
	3.2 Boosting Danish participation in European work on circular standards
4. Change consumption patterns through circular economy	Promoting circular procurement
	Increasing focus on total cost of ownership in public procurement
5. Create a proper functioning market for waste and recycled raw materials	5.1 Promoting more harmonised collection of household waste
	5.2 Creating a level playing field on the market for waste and recycled raw materials
	5.3 Liberalising WEEE management
	5.4 Establishing a fund for the handling of regulatory barriers to circular economy
6. Get more value out of buildings and biomass	6.1 Developing a voluntary sustainability class
	6.2 Propagating selective demolition
	6.3 Getting more value out of biomass

ANNEX A – SDG 12 targets and indicators

TARGETS		INDICATORS	
12.1	Implement the 10-year framework of programmes on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries	12.1.1	Number of countries with sustainable consumption and production (SCP) national action plans or SCP mainstreamed as a priority or a target into national policies
12.2	By 2030, achieve the sustainable management and efficient use of natural resources	12.2.1	Material footprint, material footprint per capita, and material footprint per GDP
		12.2.2	Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
12.3	By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses	12.3.1	Global food loss index
12.4	By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	12.4.1	Number of parties to international multilateral environmental agreements on hazardous waste, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement
		12.4.2	Hazardous waste generated per capita and proportion of hazardous waste treated, by type of treatment
12.5	By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	12.5.1	National recycling rate, tons of material recycled
12.6	Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle	12.6.1	Number of companies publishing sustainability reports
12.7	Promote public procurement practices that are sustainable, in accordance with national policies and priorities	12.7.1	Number of countries implementing sustainable public procurement policies and action plans
12.8	By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	12.8.1	Extent to which (i) global citizenship education and (ii) education for sustainable development (including climate change education) are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment
12.A	Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production	12.A.1	Amount of support to developing countries on research and development for sustainable consumption and production and environmentally sound technologies
12.B	Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products	12.B.1	Number of sustainable tourism strategies or policies and implemented action plans with agreed monitoring and evaluation tools
12.C	Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities	12.C.1	Amount of fossil-fuel subsidies per unit of GDP (production and consumption) and as a proportion of total national expenditure on fossil fuels

Source: United Nations. Available: https://sustainabledevelopment.un.org/sdg12. Accessed 11/05/2020.