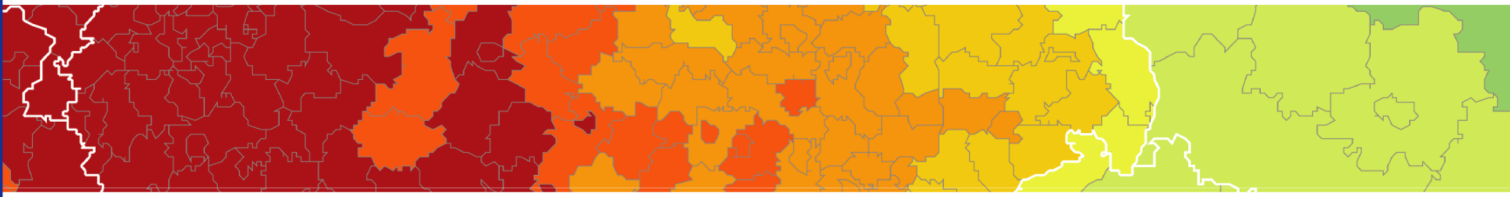
Co-financed by the European Regional Development Fund

Inspire policy making by territorial evidence



CIRCTER – Circular Economy and Territorial Consequences

Applied Research

Final Report

Annex 1

A territorial definition of the circular economy

Version 09/05/2019

Final Report

This applied research activity is conducted within the framework of the ESPON 2020 Cooperation Programme, partly financed by the European Regional Development Fund.

The ESPON EGTC is the Single Beneficiary of the ESPON 2020 Cooperation Programme. The Single Operation within the programme is implemented by the ESPON EGTC and co-financed by the European Regional Development Fund, the EU Member States and the Partner States, Iceland, Liechtenstein, Norway and Switzerland.

This delivery does not necessarily reflect the opinion of the members of the ESPON 2020 Monitoring Committee.

Authors
Carlos Tapia, Marco Bianchi, Tecnalia Research and Innovation (Spain)

Advisory Group
Project Support Team: Paolo Angelini, Ministry of Environment (Italy), Sophie De Mulder, RWO Flemish government (Belgium), Maarten Piek, Ministry of Environment (Netherlands).

ESPON EGTC: Marjan van Herwijnen (Project Expert), Akos Szabo (Financial Expert)

Information on ESPON and its projects can be found on www.espon.eu.

The web site provides the possibility to download and examine the most recent documents produced by finalised and ongoing ESPON projects.

This delivery exists only in an electronic version.

Contact: info@espon.eu

ISBN: 978-99959-55-70-0

Table of contents

List of Figures

List of Tables

List of Maps

Abbreviations

B2B	business-to-business
B2C	Business to Consumer
C2C	Consumer to Consumer
CBM	Circular Business Model
CDC	Caisse des dépôts et consignations
CE	Circular Economy
CEAP	Circular Economy Action Plan
CER	European Remanufacturing Council
CLD	Causal Loop Diagram
DE	Domestic Extraction
DMC	Domestic Material Consumption
DMI	Direct Material Input
EC	European Commission
EEA	European Environmental Agency
EMAS	European Monitoring and Audit Scheme
EMF	Ellen MacArthur Foundation
EPR	Extended Producer Responsibility
ERDF	European Regional Development Fund
ESPON	European Territorial Observatory Network
EU	European Union
GDP	Gross Domestic Product
GPP	Green Public Procurement
GWR	Geographically Weighted Regression
JRC	Joint Research Centre
IS	Industrial Symbiosis
LMM	Last Minute Market
MBT	Mechanical-Biological Treatment
MFA	Material Flow Analysis
MS	Member States
MSW	Municipal Solid Waste
NACE	Nomenclature of Economic Activities
NUTS	Nomenclature of Territorial Units for Statistics
OLS	Ordinary Least Squares/Linear Regression
OVAM	Public Waste Agency of Flanders
P2B	Peer-to-business
P2P	Peer-to-peer
PPP	Purchasing Power Parity
RMC	Raw Material Consumption
RMI	Raw Material Input
ResCoM	Resource Conservative Manufacturing
SME	Small and Medium Enterprises
RIS3	Regional Innovation Strategies for Smart Specialisation
ToR	Terms of Reference
WEEE	Waste from Electrical and Electronic Equipment

"While territories, with their social, environmental and institutional realm, are crucial for a successful transition to a circular economy, the circular economy in turn represents a key source of competitive advantages for territories and regions"

adapted from (Crescenzi and Rodríguez-Pose, 2011)

1 Introduction

The circular economy is an integrated development strategy that aims at developing restorative or regenerative industrial systems in which the energy and material flows are reduced to their technical limits. In doing so, the circular economy promotes high value material cycles. The circular economy principles are being embraced by governments and business alike as an effective strategy towards resource efficiency, profit maximization and job creation in the face of growing resource scarcity and environmental degradation. For once, the agendas of economic, social and political actors seem to be aligned over such a persuasive win-win narrative like the circular economy.

The growing academic literature in this field is led by a community of researchers that are mostly interested on the innovations adopted on the production-side of the economy, including traditional green business strategies (e.g. cleaner production, corporate responsibility, eco-design, etc.), as well as on the new business models linked to the circular economy (e.g. sharing and collaborative economies, service-based business models, waste-as-a-resource business models, etc.), with a fraction of those studies developing practical approaches to underpin decision-making at company level (Merli et al., 2018).

Still, despite the attempts made by some scholars to set the theoretical foundations for a shared ground of knowledge (see e.g. Kalmykova et al., 2018; Prendeville et al., 2018), this area of research is still in a consolidation phase in terms of definition, boundaries, principles and associated practices (Merli et al., 2018). This lack of theoretical and conceptual development is also perceivable when it comes to the interpretation on how complex socio-economic systems and sub-systems may affect and be affected by the so-called 'circular-economy transitions' (Korhonen, Nuur, et al., 2018).

The territorial aspects and new spatial logics are no exception. The regulation of circuits by new actors and the relational logic of geographical norms and scales as factors for an adequate management of resources and their local development (Barles, 2009) remain very little discussed for the moment, even if a number of contributions have recently addressed some of these aspects under a circular economy logic (Bahers et al. 2017, Chen et al. 2012). The key analytical challenges related to the elaboration of a territorial definition of a circular economy relate to the characterization of: (1) the scales of operation of circular economic systems; (2) the territorial factors that may affect the development of closed material loops, and; (3) the territorial outcomes that might derive from the penetration of circular business models at various levels.

In this document we mostly contribute to the second challenge, with side contributions to the remaining two. We focus on the analysis of relevant territorial factors for a circular economy, i.e. the set of spatially-bound assets and features that may condition the way a circular economy is operationalised locally. The factors analysed include nature-based aspects, agglomeration economies, accessibility conditions, knowledge- and technology-based enablers, governance and institutional drivers, as well as territorial milieus.

To a limited extent we also dig into the likely impact of those factors on a set of circular economy strategic areas at firm, cluster and regional level, thereby addressing the scale challenge. The strategic areas considered include material sourcing and circular input, production patterns (including design, manufacturing and distribution), consumption and use models, waste management (collection, disposal, recycling, recovery, remanufacturing), as well as a selection of key supportive policies.

2 Methodology

This work has been completed by means of a comprehensive literature review, including mostly academic literature but also a set of grey literature reports. The references have been identified by searching for the expressions “circular economy” and “territory”, as well as equivalent terms[1]. The search was performed in April 2018 on the Scopus abstract and citation database of peer-reviewed literature. A total of 148 papers were identified. These were analysed by first checking the abstracts and subsequently by acquiring and reading the most relevant papers.

Additionally, a number of cross-citing searches were conducted as well. These searches allowed to identify a smaller subset of potentially relevant papers, as well as a reduced group of seminal works that led to other pertinent documents. Even if not addressing specifically the circular economy, such seminal works contributed to the identification and characterization of a set of territorially-relevant factors for economic development that were subsequently assessed under a circular economy prism.

1 The exact search was as follows: KEY ("circ* econ*" OR "clos* loop*" OR "Product*service*system*") AND TITLE-ABS (("city" OR "cities" OR "urba*" OR "regiona*" OR "territor*" OR "spat*" OR "space*" OR "geogr*")) AND ("europ*" OR "EU") AND (LIMIT-TO (DOCTYPE , "ar ") OR LIMIT-TO (DOCTYPE , "cp ") OR LIMIT-TO (DOCTYPE , "ch ") OR LIMIT-TO (DOCTYPE , "ip ")) AND (EXCLUDE (SUBJAREA , "COMP ") OR EXCLUDE (SUBJAREA , "MATH ") OR EXCLUDE (SUBJAREA , "PHYS ") OR EXCLUDE (SUBJAREA , "BIOC ") OR EXCLUDE (SUBJAREA , "MEDI ") OR EXCLUDE (SUBJAREA , "NEUR ") OR EXCLUDE (SUBJAREA , "PHAR ") OR EXCLUDE (SUBJAREA , "HEAL ") OR EXCLUDE (SUBJAREA , "IMMU ") OR EXCLUDE (SUBJAREA , "ENGI "))

3 The circular economy: definition and scope

3.1 Theoretical basis

The circular economy is not a new concept. The idea is rooted in old industrial ecology concepts and approaches (Socolow et al). Some of these concepts are industrial metabolism (Ayres,), industrial symbiosis (Frosch &), Design for Environment (Graedel &), etc.

Presently, there is no single and universally accepted definition of a circular economy. A multiplicity of denotations have been advocated according to the diversity of views by the stakeholders involved. A recent academic review has collected 114 different definitions of circular economy (Kirchherr et al). The most wide-spread definition is the one proposed by the Ellen MacArthur Foundation (EMF). This think-tank defines the circular economy as an *industrial system that is restorative and regenerative by intention and design* (Ellen MacArthur).

The Circular Economy Package of the European Commission (EC) provides a two-folded definition of the circular economy: in the EC Communication Towards a circular economy: A zero waste programme for Europe that put the circular economy on the EU Agenda (COM(2014) 398 final/2), the circular economy is described as an *economic system* that keeps the added value in products for as long as possible by looking beyond the current take-make-dispose model (EC,); in the Annex to this same Communication, the circular economy is characterised as a *development strategy* that "entails economic growth without increasing consumption of resources, deeply transform production chains and consumption habits and redesign industrial systems at the system level" (EC, 2014, Annex I). In the main Communication 'Closing the loop', that introduces the EU Action Plan for a Circular Economy (COM(2015) 614), the concept is simply defined as an *economy* "where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised" (EC,).

While keeping a tight alignment to the above policy definitions, in this report we will base on the more explicit characterisation proposed by Korhonen et al. (2018b). These researchers describe the circular economy as "a sustainable development initiative with the objective of reducing the societal production-consumption systems' linear material and energy throughput flows by applying materials cycles, renewable and cascade-type energy flows to the linear system. The circular economy promotes high value material cycles alongside more traditional recycling and develops systems' approaches to the cooperation of producers, consumers and other societal actors in sustainable development work". This definition build on four key elements:

1. The circular economy is presented as a **policy strategy geared at sustainability**, like also the EC's definition does. Under this principle, the circular economy is to be understood as an aspirational economic model that can be facilitated by direct and indirect policy intervention.

2. It identifies one **key strategic goal**, namely reducing throughput flows generated by economic action, alongside three enabling features: (1) high value material cycles – mostly – for the technical materials; (2) cascade use of biotic resources, and; (3) renewable energy provision. This goal is also explicitly recognised in EMF's and EC's definitions.

3. It emphasises the relevance of **cooperation mechanisms** between societal actors. The definition implicitly acknowledges the governance and management implications stemming from the implementation of such mechanisms, and implicitly acknowledges the importance of inter-sectoral and inter-organizational management and governance models. Cooperation within and between value chains is also mentioned in the Circular Economy Communication as a requisite to support design and innovation for a more circular economy (EC,).

4. It adopts a **system's perspective**. This aspect is evinced by the emphasis that the definition puts on the interactions between production and consumption systems and on their mutual flows and cooperation mechanisms that are established between the different economic actors. This aspect is explicitly taken up in EC's definition and is also mentioned in some EMF's documents.

Building on the previous definition and drawing on the work by Kalmykova et al. (2018), we propose a classification of circular economy strategic areas based on two different organizational widths or approaches: (1) a small organizational width, which refers to practices implemented by single firms i.e. cleaner production, energy efficiency or eco-design, and; (2) a large organizational width which refers to a systemic economy-wider implementation e.g. industrial cluster, regions, city. The classification is shown in Table 3-1, which summarizes the circular economy strategic areas along with a non-exhaustive list of circular *implementation practices*.

Table 3-1: Circular Economy strategic areas

Circular economy strategic areas	Organizational width	
	Small (single firm, consumer)	**Large (Cluster, Industry, region)**
Material sourcing and circular input	Material substitution Energy autonomy	Diversity and cross-sector linkages Bio-based materials Urban mining Cascading and by-product use
Production (design, manufacturing, distribution)	Cleaner Production Eco-Design, including de-materialization, design for disassembly, design for modularity, design for reparability, etc. Energy efficiency Material productivity Reproducible and adaptable manufacturing (e.g. re-manufacturing) Optimized packaging Redistribute and resell	Urban symbiosis Industrial symbiosis Eco-industrial park/networks Eco-agricultural system

Consumption and use	Green Purchase and consumption Renting service Product re-use Virtualization	Community involvement Sharing economy Socially responsible consumption Eco-labelling schemes Stewardship Product-Service-Systems
Waste management (collection, disposal, recycling, recovery, remanufacturing)	Product recycle system Element/substance recovery Energy recovery Upgrading, Maintenance and Repair Restoration	Waste trade market Logistic/infrastructure building Separation Take-back and trade-in systems Upcycling/Downcycling High quality recycling Extraction of bio-chemical Refurbishment/remanufacture
Policy		Green procurement Taxation Tax credits and subsidies Extended Producer Responsibility Incentivized recycling Awareness campaign

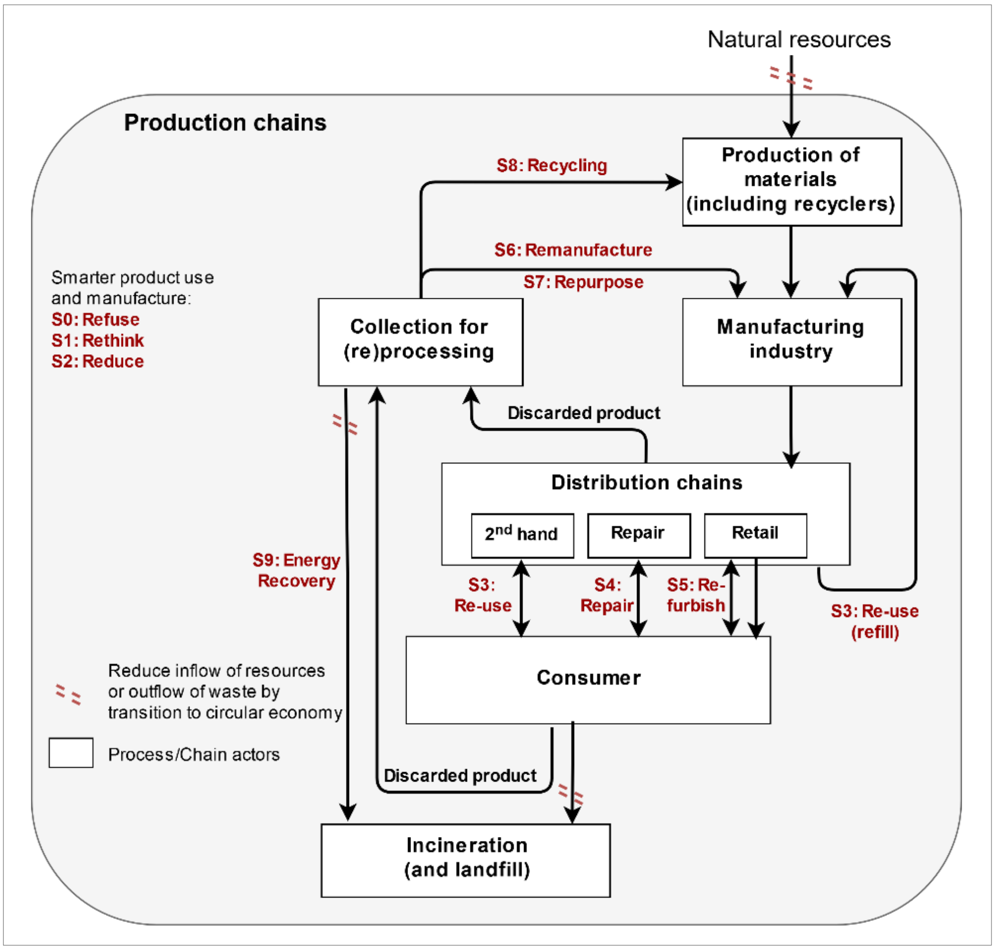
Source: own elaboration *based on Su et al. (2013) and Kalmykova et al. (2018)*

As shown in Table 3-1:, and also in line with Merli et al. (2018) findings, most of the strategic areas focus on economy-wide implementations, as this is the only way to really address the circularity of material flows, emphasising the systemic dimension of the circular economy concept. The broad organizational widths are in fact those better placed to accommodate all the inter-sectoral, intra-community, inter-organizational activities required to materialize progress towards circular economy transitions at systemic level. On the other hand, the practical implementations tied to small organizational widths are those that seem more effective for the introduction of innovations, not only technological (e.g. eco-design), but also those related to new business models e.g. product-service-system, waste-as-a-resource, etc.

3.2 Practical application

The aspects described on the previous section have been largely discussed in the circular economy literature from a practice-oriented perspective. One of those is the conceptual model proposed by the Netherlands Environmental Agency – PBL (Potting et al), shown in Figure 3-1. In this framework, the circular economy is structured around a number of strategies (labelled as S0 to S9 in Figure 3-1) to achieve less resource and material consumption in production-consumption chains and make the economy more circular. These, usually known as R-strategies, build on the traditional waste hierarchy (EC,) to represent a range of approaches to achieve less resource and material consumption throughout the value chain, rather than relying solely on solutions at the end of life of a product. R-strategies are ordered from high circularity (low S-number) to low circularity (high S-number). In this study we have based on these strategies to illustrate how the circular economy operates at systemic and territorial levels.

Figure 3-1: Circularity strategies and value chain actors in a circular economy



Source: based on Potting et al. (2017)

Albeit all these practical and implementation aspects have been described long ago, the basic assumptions concerning the economic and social structures, cultures, etc. conditioning territorial potentials for a circular economy still remain largely unexplored (Korhonen, Nuur, et al., 2018). Therefore, in the next sections we will attempt to fill this research gap by documenting circular economy potential through a territorial perspective.

3.3 Conceptualizing territorial factors: proximity, territory space and region

Despite the alleged homogenizing effects of globalization, individual territories (nations, regions or cities) continue to exhibit dramatic differences in terms of specialization, competitiveness, and industrial dynamism (Dicken et al., 2008). Successful industries in territory often retain their leading edge over extended periods of time, despite attempts by others to imitate their success.

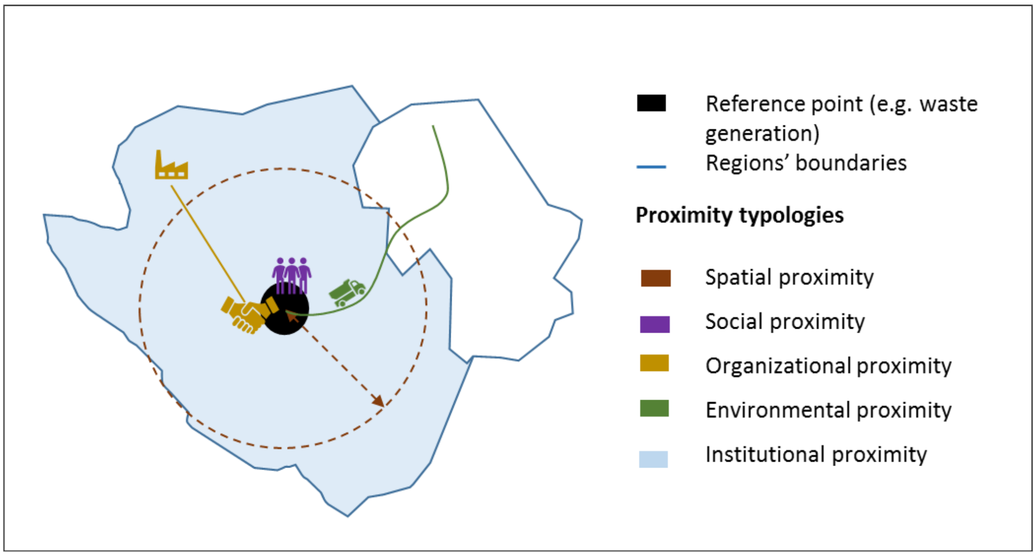
> *Certain territorial circumstances determine the innovative and thus the competitive strength of a given industry. Specialised factors of production are being formed historically in interactions between firms and institutions. Localized capabilities stand for those infrastructures, resources, institutions and competencies that make certain territories especially apt when it comes to promoting the development of certain type of economic activity* (Porter, 1998)*.*

To properly analyse the territorial dimension of the circular economy, we first need to define what is meant by "territory" in this context. Despite the general consensus on the importance of the territorial dimension of policies designed and applied at various scales (e.g. EU, MS, regions, cities communities and businesses are regularly cited (EC, 2015: 2,3)), the European Commission rarely refers to the concept of "territory". Among other things, this reflects a lack of differentiation between the concepts of "space", "territory" and "region", which is a fundamental distinction when it comes to analysing the processes by which territorial aspects can unleash circular economy potentials.

Space refers to the distribution of people, material objects (resources) and activities (processes) in an area in which the spatial scale only relates to physical distances; this is also referred to as spatial (or geographical) proximity (Bahers et al., 2017; Bahers and Durand, 2017). ***Proximity*** can be defined in different ways according to contexts, actors, and typology of material flows; this finally means that different proximities exists depending on the context. Bahers et al. (2017a) identify up to nine different forms or manifestations of proximity (see Figure 3-2), distinguishing between those characterized by a functional perspective (e.g. accessibility, efficiency) and those characterized from socio-politic perspectives (e.g. socio-economic or politic-administrative proximity).

Territories still reflect the distribution of people, objects and activities in space, but they are structured through a pattern of boundaries imposed by individuals or groups. This mainly relates to the political sphere in terms of institutional or administrative boundaries that are agreed upon to manage people, objects (resources) and activities in space. The territorial basis is therefore dependent on the clear recognition of the role that human constructs, including political and administrative jurisdictions, cultural values, etc., have in shaping the understanding of place-based potentials. In this sense, the combination of different proximities constitutes a major element of the territorialisation process; an industrial proximity for instance could manifest in an industry cluster whereas boundaries reflect the territorial influence of such proximity.

Figure 3-2: Proximity typologies



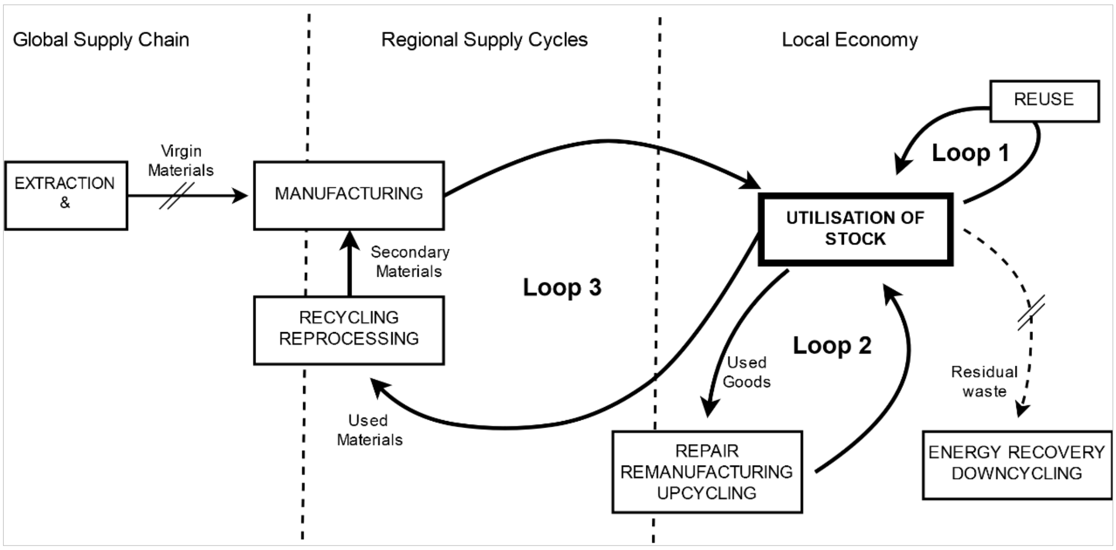
Source: own elaboration based on Bahers and Durand (2017)

In this context, it is also important to acknowledge what is meant by **region**. This is certainly different from space or territory and reflects a specific territorial structure. In the European context, it generally corresponds with a NUTS 2 or 3 delineation of territorial units. In some countries it can also refer to city-regions or city-states. In fact, the inconsistency in the physical size of the official (NUTS 2 and NUTS 3) regional units in Europe reflects its purely political (rather than spatial) origin. It furthermore reflects inherited political, administrative, and socio-economic rationales that may not necessarily comply with territorial needs related to a circular economy strategy.

3.4 Scales of operation

Based on previous definitions and according to Stahel and Clift (2016, the circular economy can be structured in a series of Loops that are operated ad different scales (Figure 3-3).

Figure 3-3: The basic loops of a circular economy



Source: modified from on Stahel and Clift (2016)

Loop 1 focuses on product *reuse*, through second-hand markets (e.g. flea markets) as well as commercial and private reuse of goods (e.g. refilling of beverage containers). These activities are usually carried out locally, but not always (e.g. platforms such as Ebay allow to trade used products on a global scale). Indeed, some discarded products and materials may go to other uses,or be exported for re-use in other locations. **Loop 2**, includes product *repair*, *remanufacturing* to meet new technical requirements and *upgrading* to meet new uses and markets. These may be local activities (e.g. *refurbishing* of domestic appliances) or may be carried out via regional service centres (e.g. *remanufacturing* of industrial equipment). **Loop 3** represents recycling in which residual products and materials are reprocessed to recover secondary materials for return to the production system for same use (*recycling*). Reprocessing may be a regional activity or may be part of a global supply system. Reprocessing includes operations such as *recycling* of paper and plastics, *re-refining* of fluids, or other sophisticated chemical transformations. Finally, residual materials may “cascade” into lower specification applications (*downcycling*) including energy *recovery*, or may leak from the economic system as waste.

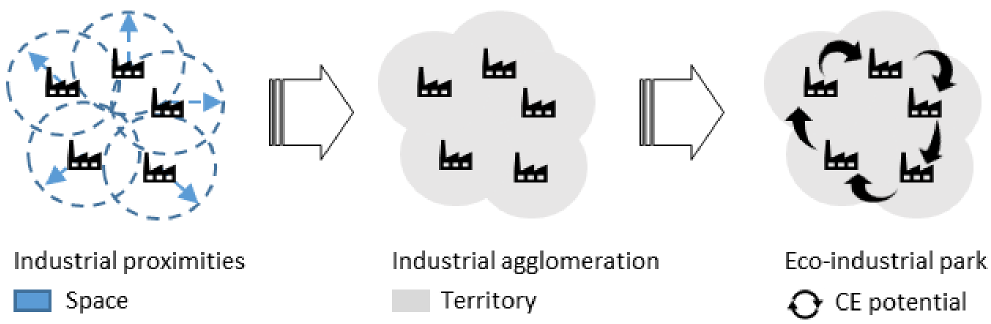
4 The territorial dimension of circular economy: territorial factors vs territorial outcomes

If the above discussions have emphasized the rationale behind the notion of territory and have identified a number of linkages between various related concepts, in this section we will provide an overview of a number of well-known territorial factors. These will be re-assessed under a circular economy perspective.

As previously described, a territory delimits an area underpinning specific assets, both tangible and intangible, of private, public or mixed nature (e.g. infrastructures, innovativeness capacity, cooperation, natural resources etc.). These territorial assets, which are also at the base of general regional economic performance, may hold various degrees of capacity and attractiveness to host circular economy initiatives. For instance, let's consider one of the most cited circular economy's principles, the achievement of an "*industrial system that is restorative by intention and design*" (Hobson, 2016; Kalmykova et al., 2018). In this case a territory with a diversified and spatially concentrated industrial tissue might show a greater potential for implementing a fully circular eco-industrial park than a territory having poor cooperation and scarce innovation capacity. Similarly, a territory with a very large urban agglomeration could generate enough organic waste so to make economically viable its circular management (e.g. collection, composting and by-product recovery).

Therefore, by overlapping the notion of territory to the logics of a circular economy shown in Table 3-1 , it follows that whereas territorial factors may contribute to circular economy transitions, the diffusion of circular practices, including technological innovations and new business models, will have territorial impacts themselves. In other words, circular economy transitions will be simultaneously conditioned by territorial factors and will also have an impact on the spatial distribution of people, material objects (resources) and activities (economic processes). In turn, the territorial factors conditioning circular economy development are themselves shaped by the often-interrelated spatial proximities (see Figure 4-1).

Figure 4-1: The overlap of territorial proximities in a circular economy



Source: own elaboration

To summarize, territorial factors may drive, enable or hinder the transition toward the circular economy. Being territorial, these factors are place-based (i.e. non-uniformly distributed in space) and they depend on the local, societal, cultural and political contexts, as well as how these contexts interact with environmental changes. This also means that they account for the "pre-conditions" for circular economy innovations at a regional level. On the other hand, circular economy outcomes operationalise the concept of territorial factors by providing real examples of how these factors influence the circular economy.

Against this conceptual background, what follows is a brief, non-comprehensive but systematic, overview of the territorial factors identified in the CIRCTER project.

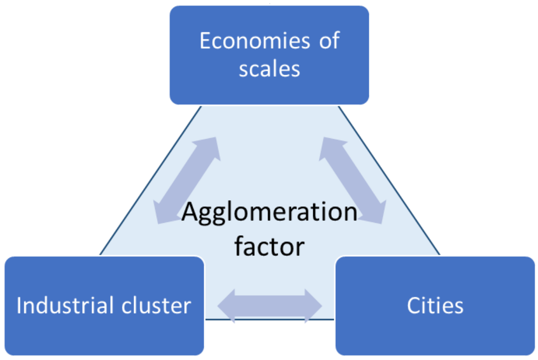
4.1 Agglomeration factors

Agglomeration can be defined as the spatial concentration of a range of territorial features (e.g. inhabitants giving rise to cities, or firms creating industry clusters) and it depends on the distance between agents rather than on political boundaries. Depending on the different forces driving agglomerations (e.g. resources-sharing, natural advantages, labour market pooling, etc.), these can affect circular economy transition in different ways, e.g. favouring eco-industrial parks, enabling economies of scale or encouraging community-led initiatives.

To describe how agglomerations can benefit or hinder circular economy transition, we distinguish between industrial agglomerations and urban agglomerations. We refer to industrial agglomerations to stress the *market-supply* component (e.g. industrial districts), and to urban agglomerations to stress the *market-demand* component (e.g. cities). Both typologies have been largely described in regional development literature (Camagni, 2004), and scholars do not always make a clear distinction between them; in fact, to great extent both types of agglomerations are stimulated by the same driving forces, and often they are bounded in a unique agglomeration.

Furthermore, we can differentiate a third factor influencing both industrial and urban agglomerations, namely economies of scale. Industrial clusters, cities and economies of scale represent the three interrelated *materializations* of the agglomeration factor (i.e. outcomes delivered by agglomeration factor) (Figure 4-2).

Figure 4-2: Agglomeration factor and its materializations



Source: own elaboration

4.1.1 Industrial agglomerations and industrial clusters

The clustering of companies results in synergies and economic benefits due to shared access to information, networks, suppliers, distributors, markets, resources and support systems (Marshall, 1890; Porter, 1998). In a localised economy, characterised by a concentration of a particular industry, the input of a firm uses to be the product from a nearby firm which in turn buy input from a neighbouring firm; this dense network of input suppliers facilitates innovation by making it less costly to bring new ideas to fruition (Helsley and Strange, 2002). **Input sharing** is not the only advantage resulting from industry cluster; **labour market pooling** and **knowledge spillover** are also among the most cited factors leading to industrial agglomeration. While the first imply a "*constant market for skill"* (Marshall, 1890: 271) which results in increased productivity, the latter refers to the informal interactions between firms that boost innovative capacities.

4.1.2 Urban agglomerations and cities

Urban agglomeration can be defined as the spatial concentration of population and economic activities that are closely connected through an adequate transportation network and other infrastructures. If industrial parks are the outcome of industrial agglomeration, cities represent the product of urban agglomeration. Unlikely industrial agglomerations, where driving forces are mostly production-oriented, here the driving forces refer mainly to the consumption-side; cities grow because of the advantages they offer to the people that live in, proximity to jobs, availability of housing and increased earnings are just some examples of why cities tend to grow over time. Urban agglomeration constitutes a perfect environment for social interactions, higher cohesion and sense of belonging which, in turn, enhance organized social networks and community-led initiatives.

4.1.3 Economies of scale

Agglomeration concept relates strictly with economies of scales. Economies of scale refer to the cost advantage experienced by a firm when it increases its level of output. The advantage arises due to the inverse relationship between per-unit fixed cost and the quantity produced. The greater the quantity of output produced, the lower the per-unit fixed cost. A major league sports franchise, for instance, requires a significant fan base to be economical. Similarly, recycling waste practices may be profitable only beyond a certain threshold of collected waste. On the other hand, agglomeration economies can also deter specific activities, as firms and workers may incur in substantial costs if willing to change their locations.

All forms of agglomeration are eventually enabled by the different forms of proximity described on section 3.3 above. While proximity and agglomeration factors have been historically recognized as key enabling factors for economies of scale and industrial agglomerations, they have recently started to be considered as fundamental element for closing material loops and creating effective circular business models (Bahers et al. 2017b). For instance, whereas recycling facilities tend to operate on a relatively large scale to keep stable operations, different types of facilities should have different recycling boundaries.

Chen et al. (2012) through the analysis of 23 eco-town in Japan showed as recycling boundaries vary according to the type of waste and recycled products. These boundaries depend on the marginal costs of transportation (driven by distance) and on the availability of established markets (i.e. potential users) for the recycled products (driven by agglomeration economies). The waste collection distance changes according to these variables. Waste with high market values, relatively low cost of transportation such as metal, plastic, paper and WEEE can be circulated in larger regions. Wastes with low market value and high costs for long-distance transportation, such as organic wastes and demolition waste, are only suitable for local recycling and recovery.

4.2 Land-based resources (physical endowment, nature and nature-based resources)

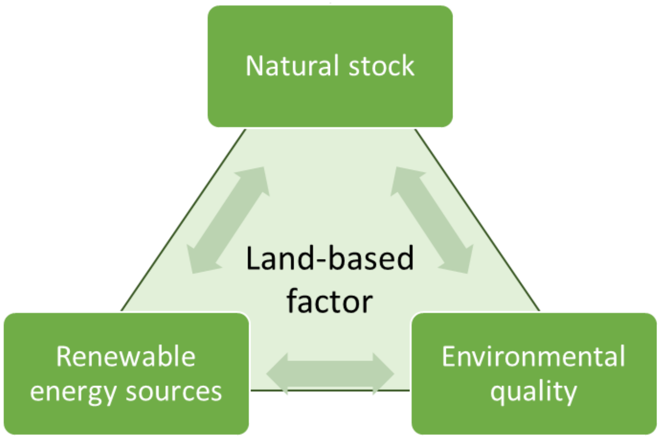
Firms are responsive to geographic distance and to spatial variation in the availability of necessary resources to run their activities, also, or especially, when it comes to gaining access to raw materials. For instance, heavy manufacturing has historically developed close to mineral deposits and water courses. The competitive edge of a firm or industry is driven, among other factors, by the natural assets and environmental conditions existing in the location where the firm operates (especially for firms with a nature-based business). As a result, a sort of matching between land-based resources and typology of local economies exists. The more natural resources a territory holds, the more likely that its economy relies on such assets. This said, the capacity to capitalise on the natural assets is also strongly linked to other factors such as governance and/or strategic framework in a specific region.

One good example of these logics are renewable energy transitions. Here, a huge gap still exists between the theoretical potentials for renewable energy and the actual and realist penetration rates of different renewable energy sources (see e.g. Deng et al. 2015). Whereas the choice of the most appropriate renewable energy mix is constrained by the availability of local resources (e.g. wind, sun, biomass), the existence of such resources is not in itself enough to boost energy transitions. Other aspects, in particular regulations and governance aspects, including spatial planning, as well as existing vested interests (leading to path dependencies and lock-ins) are also fundamental factors conditioning economic transitions (Atkeson and Kehoe, 2001, Kalkuhl et al. 2012, Wilts and von Gries, 2015).

Also, it is important to emphasise that by natural resources we do not only refer to the stock of physical assets provided by the environment (water, timber, minerals, etc.), but also to the *ecosystem flows* that provide *supporting, regulating and cultural services*, like soil formation, water purification, recreational services etc. (Jones et al., 2016). These services are particularly important if analysed under a circular economy prism, as one of the key manifestations of this strategy is to decouple economic and social progress from resource extraction/depletion. This implies that from a circular economy perspective the provision of environmental services becomes strategically more important than the provision of natural resources per se. Some authors claim that a “sustainable intensification” process (Garnet, 2012), which to some extent calls for a new conceptualization of urban-rural relations (Marsden and Farioli, 2015; Sonnino et al., 2016), will be necessary to keep the biosphere within the operating space in a context of growing global population (Firbank et al. 2018).

Consequently, a territorial perspective built under a circular economy paradigm should not only refer to the minimization of material and energy flows, but also stress the importance that ecosystem services have to prevent the negative consequences of environmental change. We can broadly distinguish three different *materializations* of natural based factor, namely natural stocks, renewable energy sources and environmental quality (Figure 4-3:).

Figure 4-3: Land-based factor and its materialization



Source: own elaboration

4.3 Accessibility factors

Accessibility in general refers to the “the degree to which a product, device, service, or environment is accessible by as many people as possible” (Reggiani et al., 2015), and a lack of adequate infrastructure (i.e. presence or absence of terminals for ships, trains, and trucks) could hinder access to markets or even impede the existence of it.

Territorial infrastructures and the integration of multiple transport modalities play a key role in reducing travel distance and time (Accorsi et al., 2015), thus lowering transport costs, improving access to input materials and fostering markets development. The circular economy is no exception to this logic. For instance, port cities are facilitated in large-scale collaborations within waste management (see Rotterdam case focussing in bio-based economy activities (Gemeente Rotterdam, 2015), or internationals airport hubs can figure as powerful local actors boosting cooperation and innovative circular economy practices (see Schiphol airport of Haarlemmermeer) (Prendeville et al. 2018).

4.4 Knowledge-based factors

Territories which benefit a high knowledge-based factor are those undertaking more often activities of basic and applied R&D; these are in general characterized by the presence of universities or, more in general, by research centers and by public/private or private/private cooperation network. Strategic partnerships for R&D supported by public agencies, which facilitate the dissemination and transfer of knowledge, are the key tools for a fair and fast implementation of a knowledge society (Capello et al., 2007).

The advantages of a public/private partnership strategy do not reside only in stimulating radical innovations, but also in preventing occupational mismatch, where the skills and employment experience of people looking for work don't match the jobs on offer. The close interaction between businesses and universities favours a prompter re-adjustment of educational system so to provide qualified skills required by the market. Such adaptation is particularly crucial for a circular economy, where "new sets of capabilities ranging from deeper knowledge of material composition to rich understanding of social behaviour will be needed" (De los Rios and Charneley, 2017).

4.5 Technology-based factors

Several innovations promising productivity improvements, better health, or environmental sustainability come with disruptive business models and/or economic structures; consequently, many of these require costly but beneficial revolution in technologies. High research costs, regulatory barriers, and high up-front financial investment can prevent technology innovation, especially for small market applications. On the other hand, for those territories that already benefit a well-established technology-base is easier to specialise further and upgrade the technology.

Besides, it is also true that the high entrance cost characterising specialised technologies come with severe and long term financial investments, which requires many years to be fully repaid; a mining company for example requires nearly a decade of time, money and infrastructure to develop a "greenfield" site for mining activity (Knapp, 2016). This in turn create a sort of path-dependency, i.e. territories that engage in specific technologies tend to stick-up to such technologies despite the potential availability of better alternatives (e.g. e-waste mining technologies). Therefore, technology choices may also create path dependence and locks-in in specific territories, which cannot switch easily to another type of technology without incurring in substantial financial losses. In circular economy terms this also means that the new innovations, such as reuse, refurbishment and remanufacturing technologies will have to compete on the market with traditional, often cheaper, alternatives (Korhonen et al. 2018c).

4.6 Governance and institutional factors

Quality government is historically acknowledged as a key enabler favouring socio-economic development and, more recently, also as significant factor contributing to environmental sustainability. Local policies help to create favourable framework conditions, reduce the cost of investments and increase knowledge development, while national legislation and regulations are highly important, in turn, in steering the development of domestic sectors.

Despite European Union moved forward in creating a cohesion policy supporting regional realities (European Commission, 2017a), it still suffers from fragmented and highly bureaucratic government policies which are the results of the historical heritage of each country and/or region (Crescenzi et al., 2007). This fragmentation reflects a multi-scalar space of governance, encompassing the “local state” through the national, as well as supranational jurisdictions as the European Union.

Such governed spaces act as significant “containers” of distinctive sociocultural practices, regulatory institutions and processes (Dicken and Malmberg, 2001, Boschma, 2005), which in turn not only stimulates firms to seek out the most favourable *package* of resource (thus triggering regions to attract and retain as much productive investment as possible within their boundaries), but also *operationalise* EU visions into local realities through national legislation and regulations.

The circular economy creates opportunities for local and regional actors to actually push for more transformative policies. As urbanization processes continues worldwide, cities in particular are becoming key players in sustainability transitions. Cities are hotspots of the globalized economies, with great economic power and a large share of responsibility for the massive consumption of resources that is driving global environmental change. But, at the same time, cities provide economies of scale where circularity can be enabled by various forms of proximity, as described in Section 4.1 above. Moreover, cities have become lighthouses for innovative and sustainable solutions, and are increasingly concentrating political power, to a large extent as a result of citizen activism pushing for radical change (de Oliverira et al. 2013).

4.7 Territorial milieus

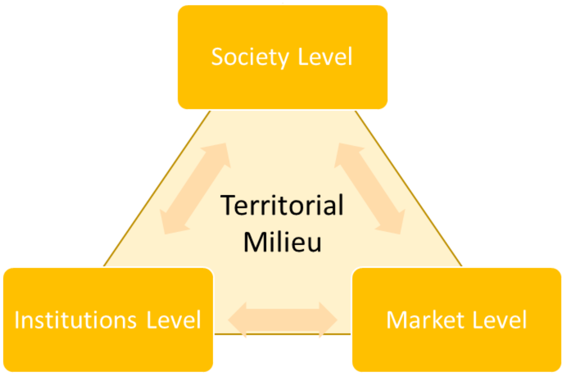
Territories are also characterized by the interactions happening over time between companies and residents living in the immediacies (see e.g. relational proximities (Bahers et al., 2017) or relational capital (Capello et al., 2007)). The competencies of a corporate unit for instance are created over extended periods as a firm interacts with its surrounding environment (Dicken and Malmberg, 2001). On the other side, some companies do not hesitate to jointly create activities with residents by subsidizing local environmental associations to monitor industrial impacts (Bahers et al., 2017); this contiguity between individuals and firms in social and professional networks are crucial when it comes to exchanging good practices, pool resources, and creating trustful relationships.

These territories wherein the human link still represents an important factor of collaboration (and thus performance) are defined by Camagni (1991) as territorial *milieu*:

"the set, or the complex network of mainly informal social relationships on a limited geographical area, often determining a specific external 'image' and a specific internal 'representation' and sense of belonging, which enhance the local innovative capability through synergetic and collective learning processes".

The main feature of the milieu is the capability to relate physical resources with local actors facilitating the normal mechanism of information circulation and coordination of agents within a market; It connects and integrates three dimensional levels: the society (value attitude, life-style, actions, perceptions); the institutional (regional policy context) and the market level (networks, cooperation, etc). In doing so, "*it reduces uncertainties in decisional and innovative processes through socialised processes of information transcoding and imitation/control among potential competitors; ex-ante coordination among economic actors facilitating collective action; and collective learning, a process occurring within the local labour market and which enhances competencies, knowledge and skills*" (Capello et al., 2007).

Figure 4-4: Dimensional aspects of Territorial milieus



Source: own elaboration

Several authors have shown how territorial milieus have an impact on sustainability governance, in particular at the local level (see e.g. Bevilacqua et al. 2014). The diffusion of circular business models and the implementation of circular economies will surely be conditioned by established milieus in a context of deep economic transformations involving both the production and consumption sides, as well as the governance of such components.

5 Mapping the territorial factors in EU

In this section we discuss the likely implication of each territorial factor for circular economy transitions. We also provide practice-based examples, and propose some proxy indicators that can be used to monitor these factors at the EU level.

5.1 Agglomeration factors

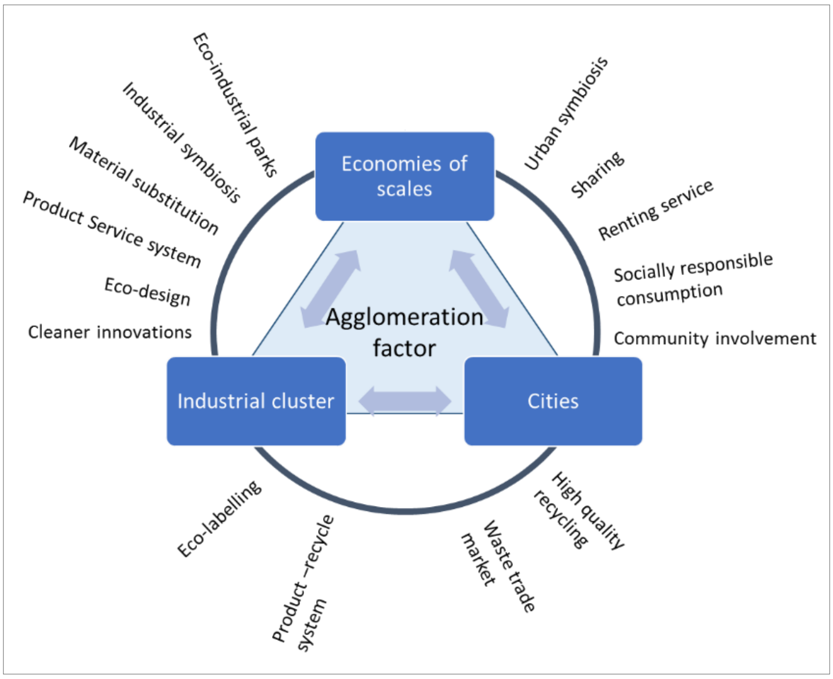
As described previously, agglomerations are regional concentrations of activities in groups of related industries which benefit different advantages (i.e. knowledge spill-overs, labour pooling, input sharing etc). Industrial agglomeration, or industrial cluster, represent a fertile ground for the development of a circular economy due to its intrinsic innovative capacity and its potential substitution synergies that can be implemented among firms. **Eco-design, cleaner production, design for modularity**, etc. are all circular economy practices that require strong innovation capacities. Dynamic innovative actions are only possible if an intensive personal networking is in place. Direct contacts between a variety of actors based on face-to-face communication facilitate technology spill-over effects and promote the technical developing and sharing of most circular economy practices with a strong innovative component. Within a given territory, people speak the same language, and tend to trust each other. Even the most modern form of communication technology is inferior to face-to-face contacts between people when it comes to building trustful relations and to communicating noncodified types of information (Crescenzi et al 2011). As a result, network relations between all economic actors are stronger when such contacts are local rather than international.

Additionally, social networks can encourage **community involvement** which might have an indirect but relevant impact on sustainable transformations. For example, grassroots communities and citizens can engage in co-creating futures visions toward circular cities. These may deliver innovative solutions for sustainable development that respond to local scenarios, such as community driven **energy programs**, creative maker-networks like Fab Labs, **repair and reuse networks** (Prendeville et al., 2018), or **sharing and circulating network** like Coffee

Clubs (Holmes, 2018). All these community-driven initiatives can increase the uptake of circular innovations and have a multiplying effect on sustainable urban transitions (Geels, 2002).

However, increased competitiveness and innovative capacity are not the only advantages that territorial agglomeration can bring to a circular economy. Proximity and economies of scale also favour the development of synergies for **materials substitution**, which has its maximum manifestation in **industrial symbiosis** or **eco-industrial parks**. These are the concrete physical expressions of the implementation of circular economy principles. In eco-industrial parks or industrial symbiosis initiatives, residual materials or forms or energy are reused in production process usually beyond the boundaries of individual firms (through increased synergies), while the grouping of means contribute to reduce the cost of incoming resources, management services and residual waste management (through mutualisation). In this respect, the effect of agglomeration factors should not only be judged in terms of volumes, but also in terms of diversification and complementariness (Jensen, 2016).

Figure 5-1: The possible expression of agglomeration factors in a circular economy



Source: own elaboration

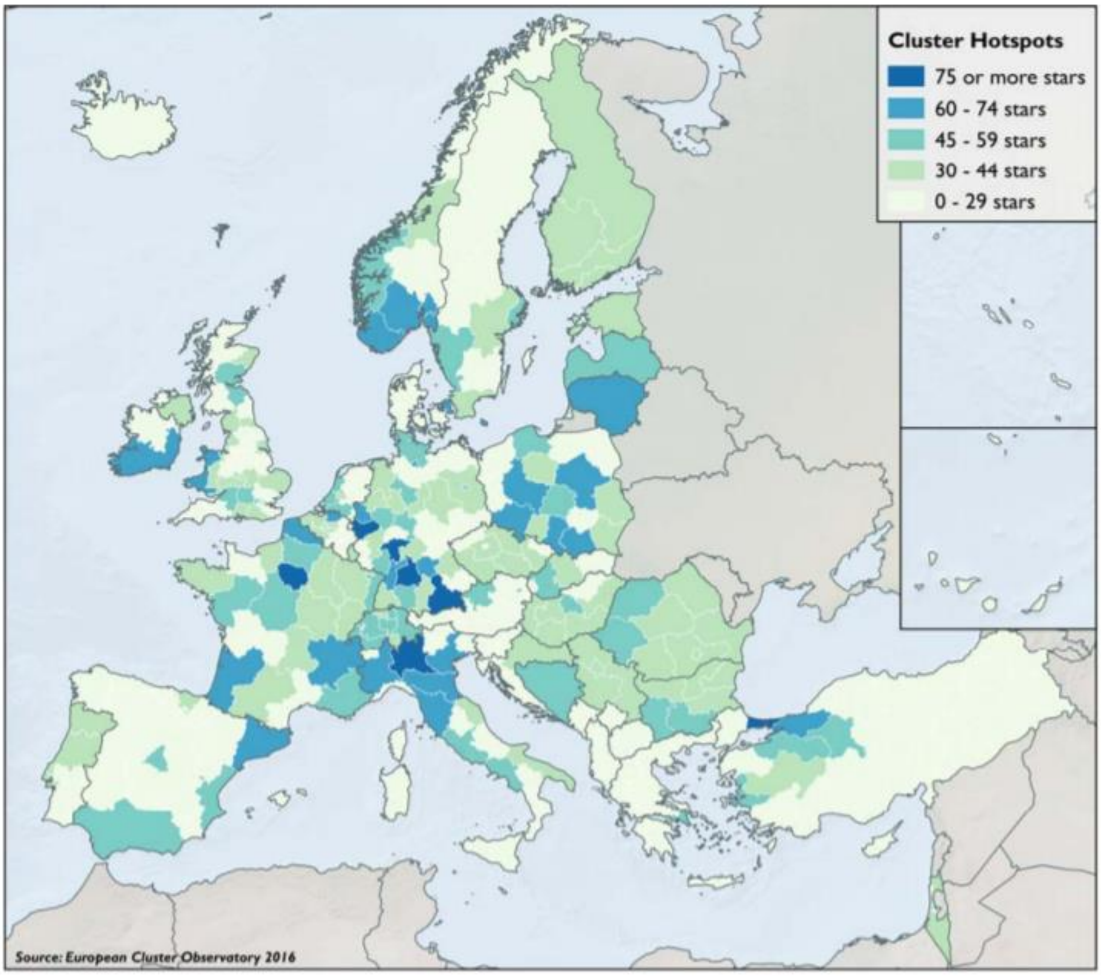
The development of eco-industrial parks may be hindered by non-technical barriers which, to some extent, reflect territorial factors. For instance, Lombardi (2017) cites the lack of information and poor understanding of each other's processes' as clear barriers – among others –

for industrial exchanges, while Beaurain et al. (2017) refer to the importance of building trustful and long-term inter-firms relationships.

Cities themselves may also be integrated in industrial ecology frameworks. Low-value materials (e.g. organic or demolition waste) can only be used as by-product when available in large amounts, offsetting transport and operational costs. For instance, food waste represents a potential feedstock for **biorefineries** that replaces the use of virgin ones; however, its profitability is strictly dependent on waste available on the market and its price (Cristóbal et al., 2018). The same logic applies to **waste recycling** practices. As an example, Ghisellini et al. (2016) cite the lack of economies of scale as one of the most important hindrances preventing recycling of high rare earth metals. In sum, large urban agglomerations could decrease prize volatility of specific resources by providing a constant supply of secondary materials. But, given the low prize of many of those materials, these advantages can only be achieved if big markets for secondary materials are established.

Mapping Agglomeration/Cluster – Several indicators are used in empirical analyses to map agglomeration factors. The indicators vary depending on the specific focus area. When the focus is on the innovation capacity linked to urban and industrial agglomerations, territories may be classified in terms of the critical mass of specific industrial clusters. For example, the European Cluster Observatory computes regional cluster performance drawing on a composed star-scale rating; it assigns a star for each cluster dimensions, being these: specialisation, absolute size, productivity and dynamism. The sum of star reflects the regional cluster performance (Map 5-1).

Map 5-1: European regional hotspots for sectoral clusters by number of stars

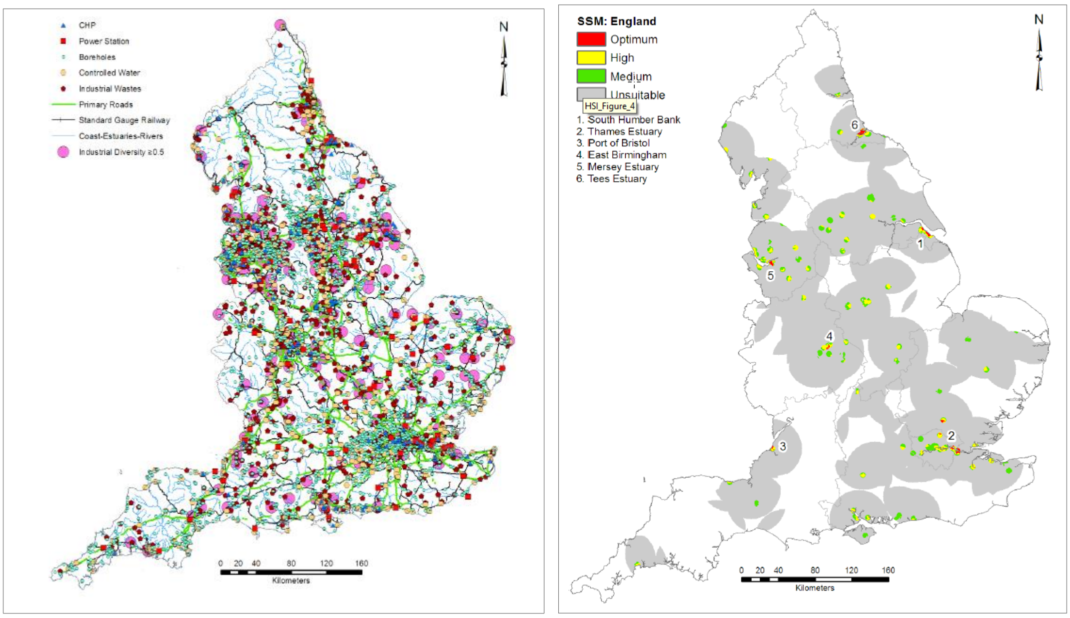


Source European Cluster Observatory 2016 (Ketels and Protsiv, 2016)

Other, more straightforward, approaches could consist in using specialisation indexes to measure local aggregated economies (e.g. Krugman index (Crescenzi et al., 2007) and/or location quotients; see (Palan, 2010) for a specialization index review).

On the other hand, when the focus is on industrial ecology potentials, specific territories may for example be assessed in terms of the degree of diversity, complementarity and concentration of their industrial sectors. Jensen et al. (2012) provide a spatially-explicit suitability index for industrial symbiosis planning based on a combination of nine key 'site variables', including industrial waste generation (volumes) and potential complementarities between industries (diversity).

Map 5-2: Map of England showing an industrial symbiosis suitability index



Source: Jensen et al. (2012)

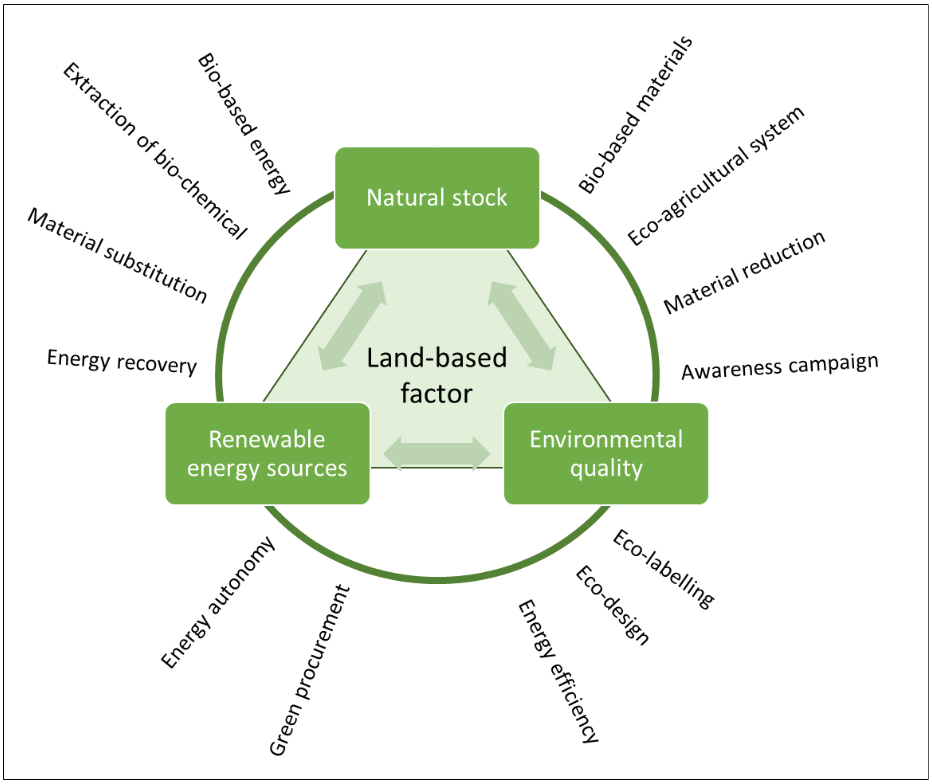
5.2 Land-based resources

As it has been claimed before, the circular economy focuses on the efficient use of natural resources derived from our natural capital and is highly dependent on the functioning of biological cycles to produce e.g. food, other biomass and the provision of fresh mineral resources (Breure et al., 2018). Consequently, the natural factor of territories may essentially concern: (1) the regional biomass stock available as enabler for the adoption of **bio-based materials**; (2) the type of renewable energy that regions can benefit toward a decarbonized economy; (3) the availability of **secondary mineral resources**, and; (4) the overall **environmental quality** which will ultimately enable healthy ecosystems and sustainable provision of ecosystem services.

Environmental quality is crucial to promote a more efficient use of natural resource, not only from the production point of view (e.g. energy or material efficiency) but also from the land management perspective. The so called "**circular land use**" look at the regeneration of brownfields as a key part of reducing greenfield use – (see for instance Eu research projects HOMBRE www.zerobrownfields.eu). **Land recycling** is thus an important part of any land use management strategy and is beneficial not only from an environmental viewpoint, but also because it satisfies economic requirements (e.g. by avoiding investment in new infrastructure and optimising exploitation of existing infrastructure) and social needs, for example by contributing to a functional and social inclusion (Preuß and Ferber, 2005).

Biomass on the other hand is at the core of the biotic circular flows. **Bio-based material** demand is increasing worldwide and there is a growing need to assess and better understand how much biomass is available and can be mobilized sustainably, how much is being used and for which purposes, what are the biomass flows in the economy and how the increased pressure on natural resources can be reconciled with environmental, economic and social sustainability (Camia et al., 2018). Main biomass sources are usually classified in three categories: agriculture, forestry and waste; while the latter has mainly a territorial component related to agglomeration, agriculture and forestry are clearly influenced by natural-based factor. Indeed, the prevalence of biorefineries differs considerably between countries. The type of **biorefinery** is clearly dependent on the locally available biomass. Wood-based biorefineries can be found mainly in Northern Europe while sugar-/starch based biorefineries mainly in France, Belgium, Germany and Hungary, where higher yields in sugar and starch are available.

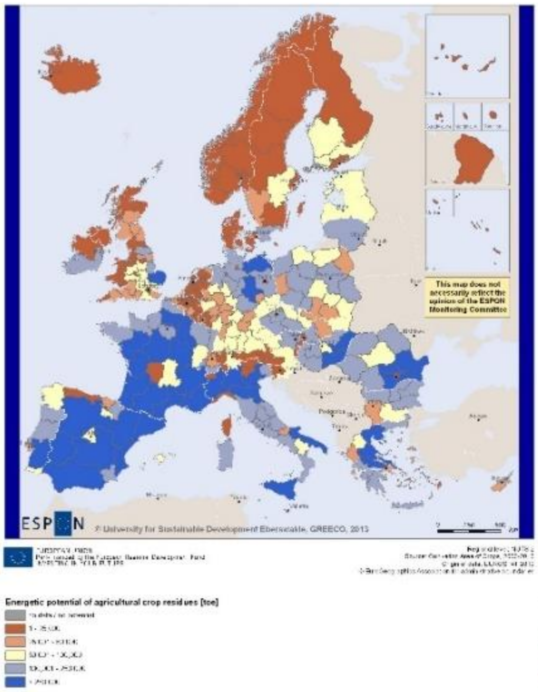
Figure 5-2: The possible expression of nature-based factors in a circular economy

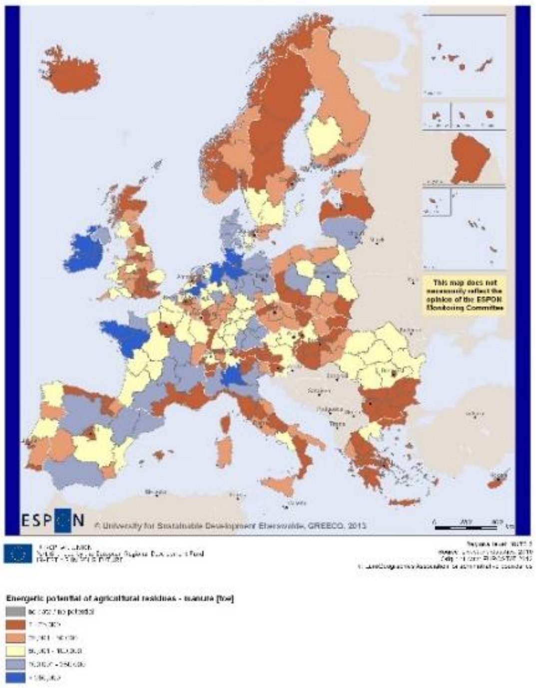


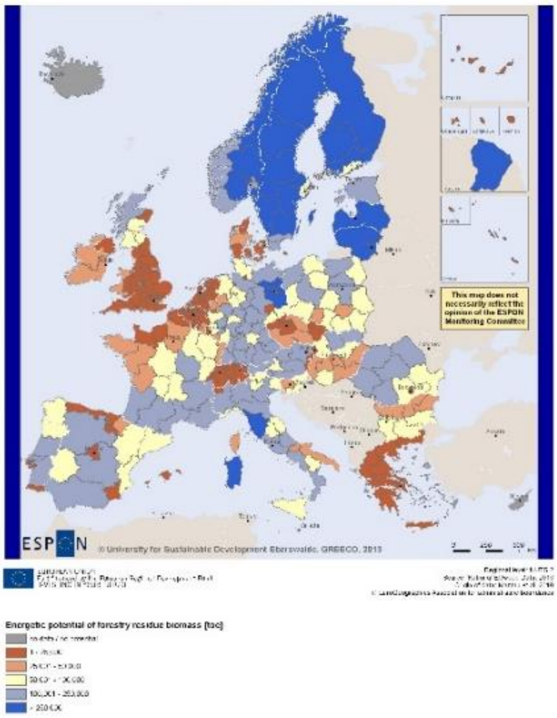
Source: own elaboration

Mapping land-based resources – The available land-account datasets, such as CORINE land cover and Eurostat surveys, combined with socio-economic indicators, also available from Eurostat, and technical information on the qualities of selected farming practices and processing technologies, can provide a good basis for the analyses of the potentials and impacts of bio-based products across Europe. This may be illustrated by energy production from residual biomass, which has a very relevant, obvious and direct link to land-based territorial assets. The following maps show an example of a proxy indicator informing on the energy potentials of European regions from three alternative sources of biomass residues.

Map 5-3: Technical biomass energy potentials of agricultural crop residues (left); Map 5-4: manure (right), and Map 5-5: forest residues (bottom), expressed in Tonnes of Oil Equivalent





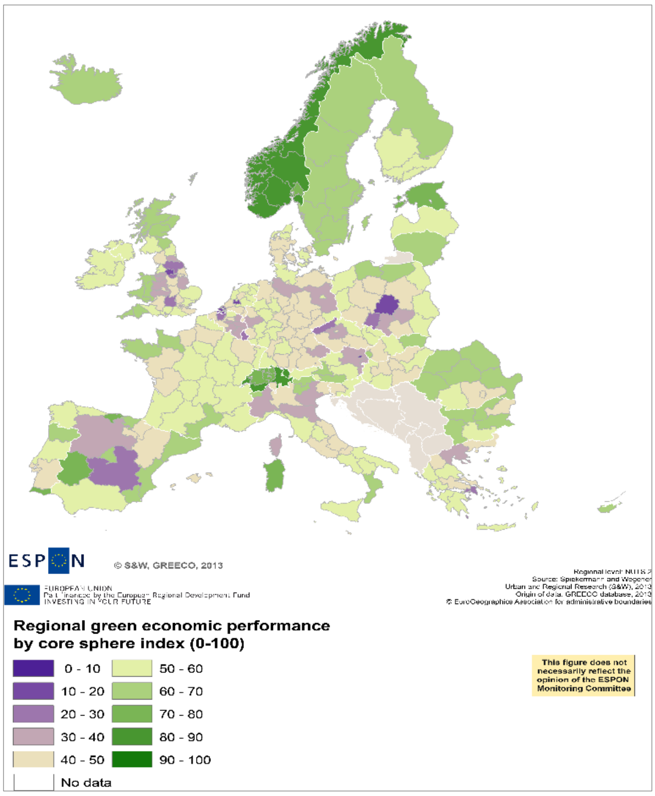


Source: ESPON GREECO project

On a different level, the availability of **secondary resources** for mining and quarrying has also attracted much attention in the last few years (Jones, 2013). There are many reasons for this. To begin with, the concentrations of specific materials in landfills, particularly metals, frequently exceed the concentration of excavated ores (Ratcliffe et al. 2012). Additionally, the exploitation of secondary mining resources significantly reduces energy consumption and the overall environmental impact of material extraction (Krook et al. 2012). However, in Europe the promotion of secondary mining has been also motivated by the recognition of an intrinsic vulnerability of the industrial sector to imported materials, and particularly to minerals with high cost volatilities and supply risks. Many of these materials are officially considered *critical* for the European economy (Blengini et al. 2017).

Two key strategies are available to tackle this challenge, namely landfill mining, including both urban (Krook et al. 2012) and mineral waste mining, as well as recovery of bottom ashes from incineration facilities (Allegrini et al. 2014). None of these two alternatives seem ideal under a circular economy paradigm, which should aim at waste prevention and value conservation rather than at the recovering of residual materials from waste streams. Still, in Europe there are between 150,000 and 500,000 landfill sites and 500 waste-to-energy incineration facilities2, offering an enormous potential for waste mining in the years to come.

Map 5-6: Green Economy performance index, 2010: Environmental Sphere



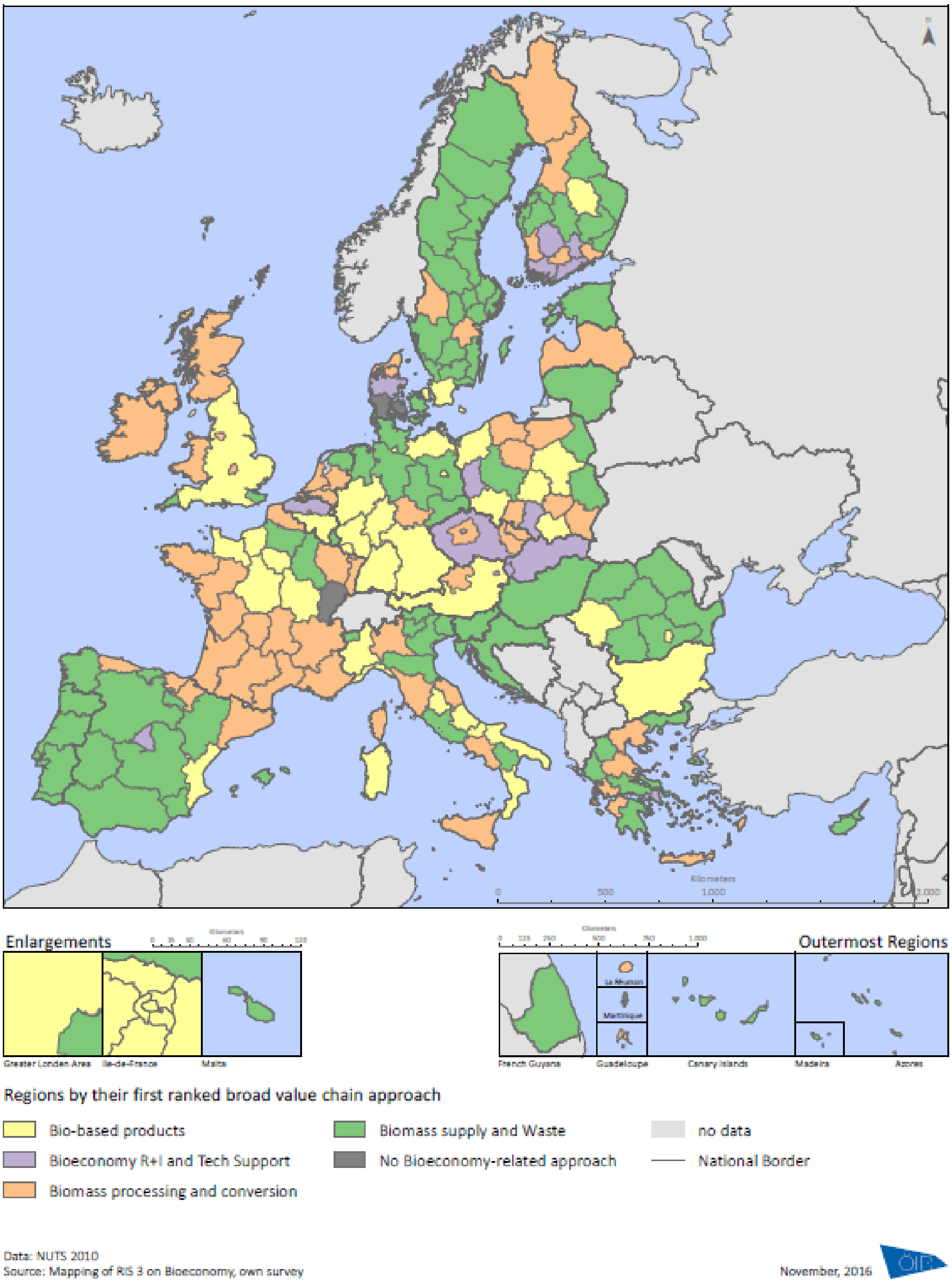
Source: ESPON GREECO project

Ultimately, fully functioning biotic systems, with unaltered capacity to provide ecosystem services should also be considered an enabler for circular economy transitions (Jones et al., 2016). At a territorial level,

2 http://www.cewep.eu/2018/03/27/interactive-map-of-waste-to-energy-plants/

this capacity to provide ecosystem services may be characterized in many different ways. Map 5-6 shows the territorial distribution of a synthetic index that combines information on the availability of environmental and natural assets with the emission levels in NUTS-2 regions, hence exemplifying the source and sink functions of the environment. Map 5-7 shows a classification of regions according to their predominant role in the bioeconomy value chains.

Map 5-7: Regions by their first ranked broad value chain approach



Source: Spatial Foresight et al. (2017)

5.3 Accessibility factors

A closed-loop network comprises many different links and nodes, including suppliers' facilities, manufacturing plants, distribution centres, retailers, collection centres, recycling plants, disposal centres and so on (van Buren et al., 2016). The actual existence and intensity of material flows occurring in closed loop networks will depend, among other factors, on the *accessibility* of individual economic actors, which in turn is conditioned by overall territorial accessibility (Accorsi et al., 2015).

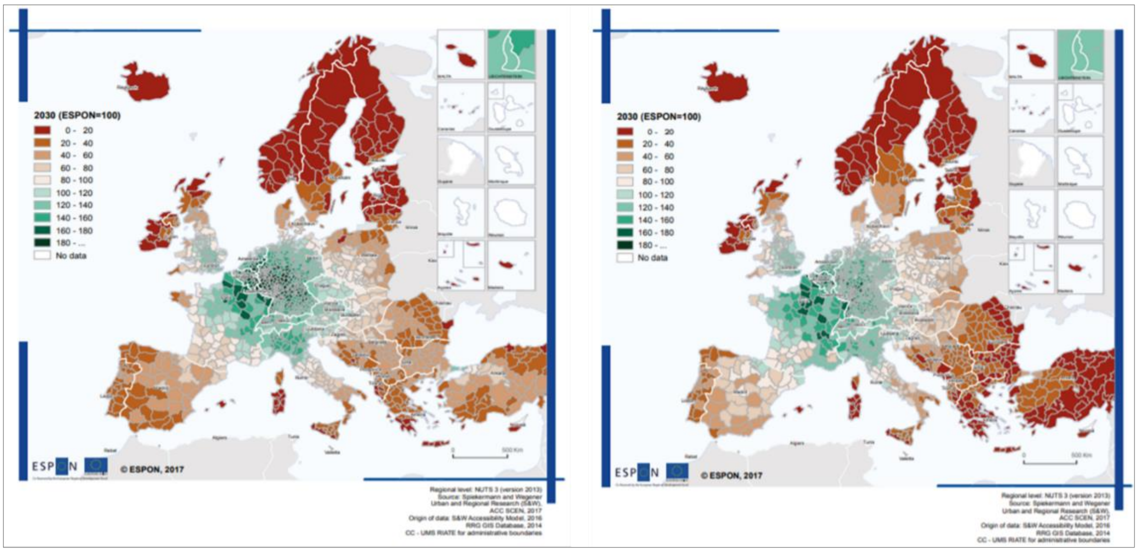
Hence, adequate infrastructures represent a determinant enabling factor for the transition to a circular economy, particularly considering the financial resources required to build them. And those areas beneficiating a proximity to transportation hubs (airports, ports, railway stations), and/or having in place effective intermodal transportation systems and logistic hubs are clearly advantaged when it comes to triggering the economies of scale related to secondary raw materials (e.g. low-value waste collection-recycling), and in developing disruptive business models based, e.g. on reverse logistics and take-back programmes.

These new business models do not depend solely on the presence or not of adequate infrastructures but also call for a disruptive change in the logistic industry wherein the *linear economy thinking* has always been the status quo (van Buren et al. 2016). In fact, many circular economy initiatives are not economically viable because they still rely on existing logistics capabilities and structures. For instance, in reverse logistic the cost of get back the goods is comparably higher than the residual value of the goods. Collection of goods is often expensive due to geographic dispersion and consequently the transport cannot be fully efficient due to a lack of scale. Also, the lack of local infrastructure makes often expensive sorting processes. Therefore, to reach sufficient scale and build effective and efficient reverse logistics companies should be able to access and consolidate their return flows collaborating along the incumbent value chain, as well as next to adjacent or cascaded activities; on the other hand, final users need to be included in the reverse logistics (for instance through incentives) so that companies can get more easily their products back.

On top of that, the legacy infrastructure and forms of communication that are typical of linear economies are not suitable for the new forms of relation and value creation, which rely on increased communication and reinforced cooperation over the entire value chain. For this reason, even when the infrastructure exists, if there is not a good relational network in place that ensures information exchange for an optimal resource management, it is likely that the potentials for circular business models will remain unfulfilled, and the existing 'hard' infrastructures will remain under-utilised.

Mapping accessibility factor – Internal and external accessibility of the European Union is recognized as a key factor of growth, employment and competitiveness. "Connecting" Europe, through improved transport networks is one of the major goals set under the Lisbon strategy (3rd and 4th report on economic and social cohesion, European Commission, 2004). Hence, metrics and indicators are abundant in empirical analyses.

Maps 5-8 and 5-9: Accessibility potentials by road (left) and by rail (right), 2030.

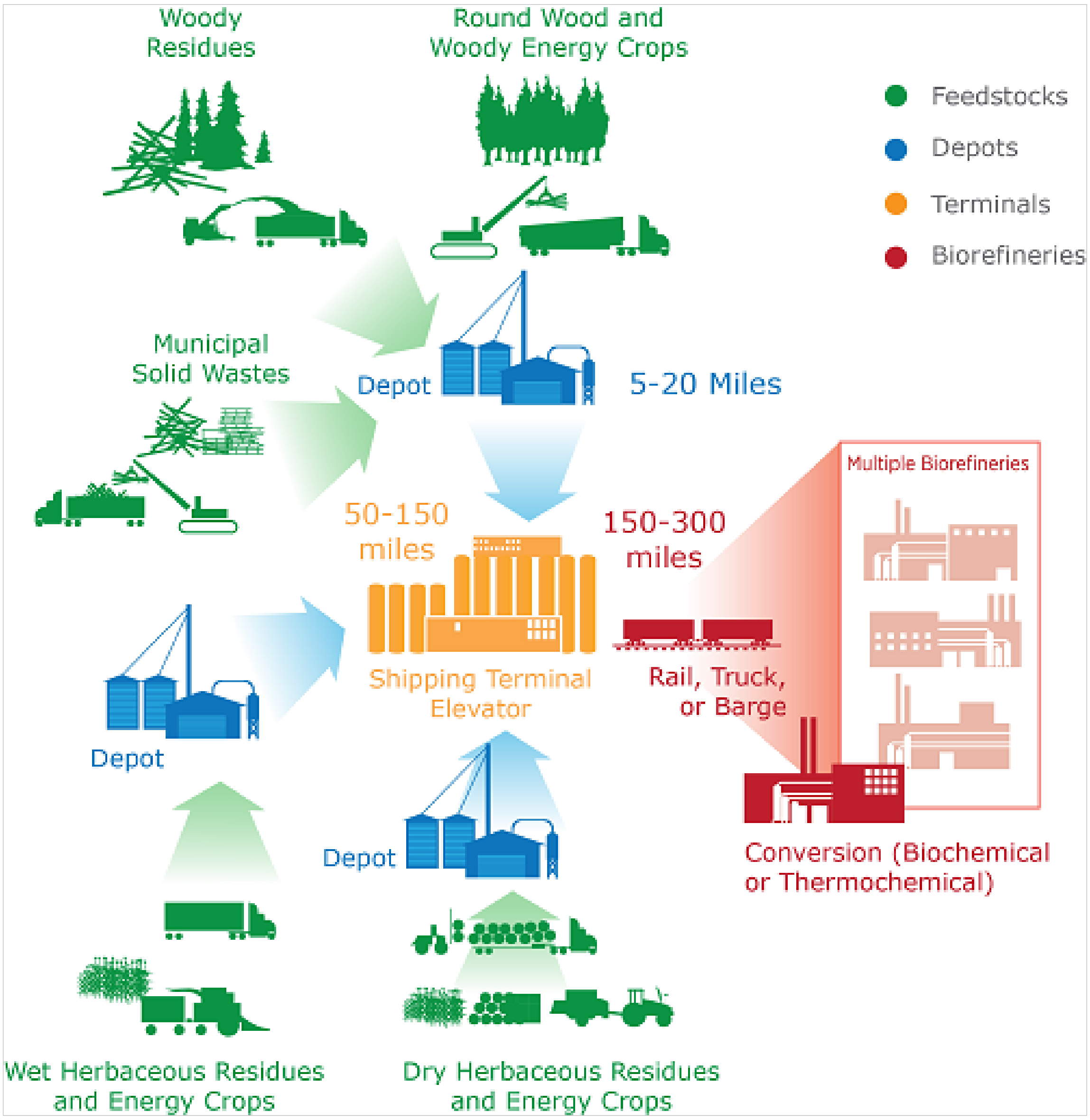


Source (ESPON, 2017)

Within the ESPON framework, for instance, potential accessibility has been analysed for different transport modes (Maps 5-8 and 5-9) as an indicator for the size of market areas for suppliers of good and services (ESPON, 2017). Potential accessibility assumes that the attraction of a destination increases with size, and declines with distance, travel time or cost. Hence, destination size can be represented by regional population. Other straightforward metrics use in general traffic volumes (e.g. passenger, or freight tonnes) as a proxies of accessibility level.

As evinced from the maps shown in Maps 5-8 and 5-9, there is a great disparity between the central European regions (Pentagon) and peripheral regions. The territories coloured in green are characterized by an accessibility higher than the average of the European Union (EU27 = 100). The regions represented in orange / red are below the EU average and can be considered as peripheral in term of accessibility. In other words, accessibility, in part due to a lack of efficient and readily available infrastructure, still remains a big challenge for many peripheral and remote regions in Europe.

Figure 5-3: Optimal location of the different activities related to the storage and processing of biological feedstocks according to transport costs



Source: US Department of Energy, 2018

5.4 Knowledge-based factors

Given the relative novelty of the circular economy concept the installed knowledge-base at territorial levels becomes a fundamental ingredient of successful transitions. *Territorial intelligence* in relation to the circular economy in not only crucial for the development of disruptive products and more sustainable process through practices such as eco-design, life-cycle-thinking and the adoption of new business models by the private sector, but it is also a fundamental ingredient for policy design and implementation by the public sector. For instance, it is well known that effective regulations are strongly influenced by the specialised knowledge owned by the actors within territories, and by the intensity of the cooperation they can put in place (Marra et al., 2018).

Furthermore, a circular economy calls for technical skills which are currently not present in the workforce (EC, 2014). Skills would for instance enable businesses to design products with circularity in mind, and to engage in reuse, refurbishment and recycling. Missing technical skills could be particularly problematic for SMEs (Bourguignon, 2016). Consequently, the involvement of the university system through doctoral programs on circular economy as well as a specialised professional formation (e.g. Master's degree) could be a determinant key toward circular economy transition.

At a more strategic level, the assessment of the progress towards a circular economy is still far from being operationalised, in particular at lower territorial levels (Prendeville et al., 2018). Only earlier this year the European Commission issued a monitoring framework composed by a set of indicators that capture the essential elements of the circular economy (EC, 2018) and this was not done without much debate and important limitations (EPA Network, 2017). Consequently, the collection of resource-flow data, the development of indicators that track material and waste flows, and the elaboration of studies on how these should be managed still represent a greenfield for scientific community.

Mapping knowledge factors – the relationship between basic-research and territorial innovation has been examined in scientific literature using different proxies. For example, the geographical proximity of companies to universities is a common indicator to measure firms' accessibility to primary research and thus cooperation (see for instance Abramovsky and Simpson, 2011; Liu, 2013). Other indicators focus on R&D expenditure, green patents granted to universities and/or firms (see e.g. Kim & Kim, 2015 for a very sophisticated utilization of these indices in a policy design context), or even support their statements on educational attainment indicators (like in Crescenzi et al., 2007). All of them are proxies that have been broadly used to characterise the knowledge-potential at various territorial levels, generally as a way of capturing the innovation potential within a given policy area.

5.5 Technology-based factors

Circular economy innovations, designed for product reuse, remanufacture and refurbishment, have to compete in the market with more conventional recycling technologies and waste management systems, mostly structured around low-quality recycling and rudimentary energy-recovery solutions. Even if the new technologies are economically, ecologically and socially superior than the established ones, a set of vested interests and path dependencies around existing technologies may hinder the uptake of superior circular models.

One sector where path dependency clearly operates is the bio-based economy. Here traditional carbon-based agri-food systems are increasingly challenged by the use of biological resources to food and feed for industrial and energy production, and delivers a broader range of environmental goods and services in a more sustainable way (Marsden and Farioli, 2015).

Resistance to the new solutions operates through established clusters, networks, stakeholder discourses and financial investments directed to, e.g. slowing-down the depreciation time of traditional technologies (Korhonen, Honkasalo, et al., 2018). Hence, the economics and business logic of path dependency may thus result in a sort of **technological lock-in**, limiting the introduction of substantially improved, disruptive technologies and decreasing the competitive market forces that drive their development (CIWM, 2014).

A good and pertinent example of technological lock-in are the waste-to-energy facilities. Many European countries, like Sweden, Denmark and Finland, to name a few for which this trend is very well documented, have over-invested in waste-to-energy facilities, and hence underinvested in high-quality recycling facilities. This has not only led to the stagnation of waste prevention and recycling rates, but also to high greenhouse emissions compared to more ambitious waste management systems.

The case of **waste incineration** in the Göteborg Metropolitan Area is a very good example of how a technology with a sustainability record may evolve overtime into a lock-in that slows the emergence of more sustainable circular economy-technologies (Corvellec et al., 2013). The incineration facility resulted in a lock-in that wedged the waste management in Göteborg to the next lowest step of the European Waste Hierarchy (i.e. recycling) and slows the transition of Göteborg and its region toward a circular economy. Unfortunately, similar examples can be found in other geographical areas and economic sectors.

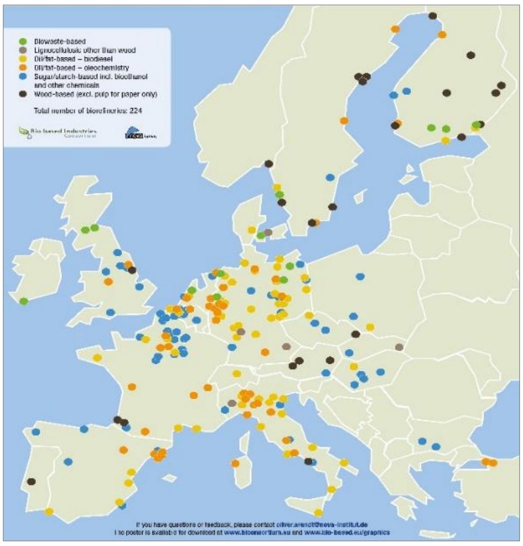
The bottom-line is that the strategic investment decisions taken at any point in time may have an impact well beyond the expected pay-back and amortization periods of those investments. Any decision regarding technologies, when scaled and replicated, creates an inertia that is very difficult to stop or even deviate. The constellation of solutions, approaches and models that fit into the circular economy and bio-economy frameworks are no exception to this logic. Hence, much attention should be paid by current decision makers to avoid creating future path dependencies around those solutions.

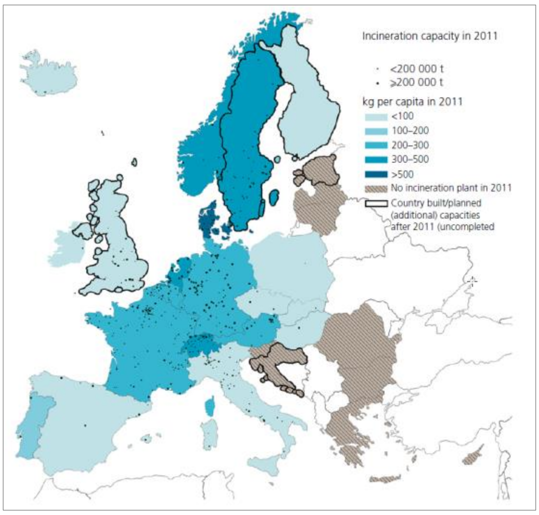
Mapping technology factor – Depending on the economic sector and type of technology considered, the number of infrastructure utilities and/or the installed capacity can be good indicators of technology choices at territorial levels, also informing on the likelihood that a given area might experience technological lock-ins.

As shown in Maps 5-10 and 5-11: (right), some member states have incineration over-capacity. Several countries such as Germany, Denmark, Sweden, Holland and the UK have the capacity to incinerate more non-recyclable waste than what is actually generated locally. This situation is actually increasing waste shipments towards and within the EU, and at the same time preventing recycling, even low-quality recycling (Jofra and Ventosa, 2013).

One of the most important bottlenecks for the bio-economy deployment is the challenging implementation of new and modified value chains and of the **technological conversion** that influences many downstream and upstream business and production processes (EC, 2017b). Therefore, technological specialization may not result only in lock-ins, but also in up-front barriers that prevent entire deployment of the biomass potential of territories. In this respect, the overlay of the map in Maps 5-10 and 5-11: (left) showing the currently operating bio-refineries in Europe, with the three maps showing regional biomass stocks presented in Map 5-3: , offer interesting insights into the maturity of the different bio-refining technologies, as well as on the potential lock-ins that could be created in certain regions as a consequence of a massive investment on specific technologies.

Maps 5-10 and 5-11: Biorefineries in Europe in 2017 (left) and Incineration capacity in the EU in 2011 (right)





Source: nova-Institut GmbH and Bio-based Industries Consortium

Source: Wilts and von Gries (2015)

5.6 Governance and institutional factors

Governance and institutional systems are key enablers for the transition to a circular economy. While EU and national policies and targets create the overall framework of operation, regions and municipalities play a key-role in translating this vision into regional and local realities.

This said, circular economy transitions advocates for policies and regulations that go well beyond recycling targets and/or green taxes; institutional reforms encouraging radical changes to production and consumption system are needed (Hobson, 2016). For example, just to cite some, **taxation reforms** lowering VAT for **repair activities**, second hand goods, remanufactured products etc., the extension of **extended producer responsibility schemes**, or the mandatory provision of **consumer information** on expected lifetimes, repair and upgrade options (Lazarevic and Valve, 2017).

From the territorial perspective, the presence of different institutional environments leads to different outcomes when it is about circular economy transition (Ranta et al., 2017). Regions favouring regulatory measures may experiment an increase in end-life waste management efforts (e.g. recycling). For example, in the UK the translation of the WEEED3 into national law has meant that producers are responsible for financing e-waste collection and treatment based on their market share. As a result, while helping to decrease the proportion of e-waste going to landfill, the mode of waste governance remained the same, with nothing to little improvement in bringing eco-design principles front and centre of production- consumption- systems (Hobson, 2016).

Mapping Governance-Institutional factor – Albeit it is possible to build ad-hoc policy inventories and indices focusing on sets of policies and institutions with direct links with the circular economy, there is growing evidence that 'good governance' and well-functioning and participatory institutions, may have a more positive impact on sustainability-driven transformations than sophisticated policy mixes focusing on specific policy areas. A feasible indicator of good governance in this broad sense available in Europe at NUTS-2 level is the European Quality of Government Index produced by the University of Gothenburg (Charron et al., 2014), which is based on the World Bank Government Indicator (Kaufmann et al., 2008).

3 European Waste Electronic and Electrical Equipment Directive (WEEED)

5.7 Territorial milieus

In close connection to governance and institutional factors, it has been claimed that a strategic and shared vision of a region is a major driver for achieving ambitious techno-economic transitions, such as the circular economy (Preston 2012). A strong sense of belonging and territorial loyalty coupled with a far-sighted business perspective, are prerequisites to such a vision. The milieu itself favours the **participation of a wide group of regional stakeholders** - public, private, non-governmental sector and academia - resulting in favourable collective action, easier people-to-people agreements and simpler identification of local synergies.

Mapping territorial milieu –The definitory features of territorial milieus are easily found in urban areas, which have always been the foremost hubs of systemic innovations, acting as 'incubators' of new knowledge (Capello et al., 2007). Yet, it is indisputably that certain non-metropolitan areas of smaller size sometimes show an innovative capacity which persistently outperforms that of other geographical areas presenting similar assets. Sometimes, these areas may achieve levels of innovation capacity that are several orders of magnitude greater to their economic and demographic weight, at least in their initial stages of development. These 'gifted' regions benefit from a combination of institutions, rules, practices, producers, research institutions and policy makers that, together, make certain innovations possible. Regions that have been historically characterised by such an 'atypical' innovation capacity include Baden-Württenberg in Southern Germany, Jutland in Denmark, Småland in Sweden, Sophia-Antipolis close to Nice, in the EU, as well as the paradigmatic American examples of Silicon Valley, in California, and 'Route 128', in the Boston area (Capello et al., 2007).

Along these lines, when it comes to circular economy, we can recognize a *milieu effect* in those regions that are driving circular economy transitions (through e.g. broad, depth, consistent, stable and participated interventions). Some of the front-running areas in the EU, such as Scotland, the Brussels region and the city of Maribor, are included in our list of case studies. But there are many other EU regions showing particular push when it comes to circular economy initiatives. Perhaps the main commonality of those areas is the existence of strong territorial milieus, showing greater capacity to relate physical resources with local actors, by connecting society (value attitudes, life-style, actions, awareness), by enabling local economies through close cooperation between firms and industries (Ruggeri et al., 2016), and by aligning institutions around shared goals. This links-back the idea that the soft and intangible features often constitute the key-aspect characterizing the circular front-runner regions.

6 Conclusions

It is widely accepted that a materialization of a circular economy requires an integrated and long-term system change (van Buren, Geissdoerfer et al). Given its breadth and scope, this transformation can be compared to the Second Industrial Revolution (1860-1900): entire production systems are to be transformed from linear to circular models, all actors in the economic circuits are expected to re-organise around new ways of value creation, all forms of consumption are expected to adopt new modalities based on the satisfaction of functional needs without generalised ownership of the consumed goods and services; etc.

Still, as it has been emphasised in this report, a lack of theoretical and conceptual development still persists when it comes to the interpretation on how complex socio-economic systems and sub-systems may affect and be affected by circular economy transitions (Korhonen et al). Uncertainties on particularly definition, boundaries, principles and associated practices still persist (Korhonen et al, Merli et al). This also holds for the relational logic of geographical norms and scales as factors for an adequate management of resources (Barles,). All these uncertainties make difficult to streamline and operationalise the concept under a territorial perspective.

This work has aimed to advance in the clarification of three key analytical challenges related to the characterisation of a circular economy under a territorial perspective, namely: (1) the scales of operation of circular economic systems; (2) the territorial factors that may affect the development of closed material loops, and; (3) the territorial outcomes that might derive from the penetration of circular business models at various levels.

Regarding the first challenge, we have shown that the circular economy can be characterised and studied at different **scales** depending on the specific sub-systems that are considered. The circular economy clearly has a global expression that should be analysed beyond the borders of city, regions, or countries. This can be done by e.g. focusing on the geographies of international supply chains and globalised waste management flows (Clapp, , Velis,). Some scholars actually suggest that larger regional areas may be the most suitable level for closing material loops and creating sustainable industrial ecosystems (Sterr &). But the circular economy also has a lower scale, including the local one. At this level, which is materialised e.g. in local food systems (Jurgilevich et al) or closed circuits of low-value secondary materials (e.g. demolition materials or organic wastes).

In any case, the debate on the territorial definition of a circular economy goes well beyond the delimitation of scales of operation based on administrative-unit boundaries. This definition should also base on the characterisation of the influence of **territorial factors**, i.e. the set of spatially-bound assets and features that may condition the way a circular economy is operationalised locally. The territorial factors include land-based aspects, agglomeration economies, accessibility conditions, knowledge- and technology-based enablers, governance and institutional drivers, as well as territorial milieus

Table 6-1 represents an attempt to visualise the complex inter-linked relationships occurring between territorial factors and a subset of CE strategic areas or materialisations. The strategic areas linked to the circular economy that have been considered include material sourcing and circular input, production patterns (including design, manufacturing and distribution), consumption and use models, and waste management components (collection, disposal, recycling, recovery, remanufacturing). The table is by no means comprehensive, nor totally objective. In fact, to some extent it could be claimed that at some point each CE activity might – and most probably will – be affected by any of the territorial factors considered. Nevertheless, by highlighting the most important linkages pin-pointed by the literature, we can better capture the actual relevance of each territorial factor in relation to the strategies and to other factors.

According to our review, agglomeration factors, both urban and industrial, seem to be an important territorial determinant for the CE. There are no doubts that urban and industrial agglomerations are growing and still will grow for many decades to go (Fang et al), nor that they represent potentially the most important carriers for an integrated and organized circular economy. Industrial clusters play a key role in unloading innovative potential, urban agglomerations ensure the necessary critical mass to e.g. adopt low-value end-of-pipe waste management approaches, as well as to endorse a range of community-based circular initiatives. Additionally, cities also represent the natural environment to develop community awareness and to promote consumption and/or behavioural change.

However, whether agglomerations will support a circular economy will ultimately depend on soft and intangible factors. In fact, the governance and institutional factors, together with the territorial milieus, act as rather transversal forces that may facilitate and create the necessary conditions for CE transitions to materialise. Political vision and leadership are essential requirements to e.g. put in place the right tax and regulation systems that not only promote CE principles, but also favour the establishment of other territorial factors, such as better accessibility, increased knowledge and new technologies (for instance through green procurement, incentives, etc…).

In sum, the success or failure of circular economy innovations does not only depend on the territorial endowment, including physical assets, capacities and installed technologies. Soft and intangible features embedded in governance, cultural and social aspects are even more important. These are intrinsically localized, embodied in human capital and relational networks, in labour market, and in the local context that have a clear territorial expression. Such intangible elements, which are accumulated through slow process of individual and collective learning, are essential factors shaping the innovation capacity of territories. And, if anything, transitions towards a CE will require a great deal of innovation capacity and a prone-to-change attitude by all parties (see e.g. Edbring et al., 2016, Heshmati, 2015 and Planing, 2015).

Perhaps the main take-away from this analysis is that understanding the territorial specificities, with their socio-economic, environmental and institutional realms, is crucial to envisage a successful transition to a circular economy, as similar features may act as enablers or barriers depending on the specific territorial context. Once more, this calls for place-based policy approaches that take account of the installed capacities within each territory and promote inclusive and participatory policy design and implementation processes as the best way to unlock the territorial potentials.

Table 6-1: Overview of territorial factors on a subset of circular economy strategic areas

Main circular economy strategies	Illustrative examples of circular economy enablers and innovations	Main scales of operation*	Key territorial factors							Relevance
			Agglomeration	Land- based resources	Accessibility	Knowledge	Technology	Governance	Milieus	
S0 (Refuse)	Non-transactional forms of consumption (e.g. freecycling movement, repair-cafes, allotments, maker collectives, etc.)	Micro, Meso	x		x	x		x	x	Holmes (2018), Charter, (2018), Prendeville et al. (2018)
S0 (Refuse), S1 (Rethink), S2(Reduce)	Socially responsible consumption, collaborative consumption (e.g. sharing platforms)	Micro, Meso, Macro	x			x	x	x	x	Jurgilevich et al. (2016), Edbring et al. (2016), Ghisellini et al. (2016), Marra et al. (2018)
S1 (Rethink), S3 (Reuse), S4(Repair)	Second-hand markets, access-based consumption (e.g. renting and leasing), product-service-systems	Micro, Meso	x		x	x		x	x	Hobson (2016), Prendeville et al. (2018), Edbring et al. (2016)
S1 (Rethink), S2 (Reduce)	Cleaner Production & eco-design (including material substitution and energy efficiency/reduction)	Micro, Meso, Macro	x	x		x	x	x	x	Stewart et al. (2016), Breure et al. (2018), Braun et al. (2018), Stahel (2013), Henning et al. (2015)
S4 (Repair), S5 (Refurbish)	Upgrading maintenance, repairing and restoration	Micro	x		x		x	x	x	Franklin-Johnson et al. (2016), van Rhijn (2017)
S6 (Remanufacture), S7 (Repurpose)	Design for modularity, circular design	Micro	x		x	x	x	x		Den Hollander et al. (2017), Lieder et al. (2015)
S3 (Re-use), S4 (Repair), S5 (Refurbish), S6 (Remanufacture), S7 (Repurpose)	Remanufacture, refurbishing, take-back systems, reverse logistics	Micro, Meso	x	x	x		x	x		Singh and Ordoñez (2016), Accorsi et al. (2015), Chen et al. (2012), van Buren et al. (2016), Gregson (2015)
S1 (Rethink), S7 (Repurpose), S8 (Recycle), S9 (Recover)	Urban/(eco)industrial symbiosis (cross-sector linkages)	Meso	x		x	x	x	x	x	Lombardi (2017), Chen et al. (2012), Accorsi (2015), Breure et al. (2018)
S8 (Recycle)	Upcycling, recycling, composting	Micro, Meso, Macro	x	x	x		x	x	x	Bahers et al. (2017), Corvellec et al. (2013), Chen et al. (2012), Preuß & Ferber (2005), Borrello et al. (2017)
S9 (Recover)	Energy recovery systems	Micro, Meso, Macro	x	x	x		x	x		Malinauskaite et al (2017), Corvellec et al. (2013), Ingrao et al. (2018)

Source: Own elaboration based on Kalmykova et al. (2018), Su et al. (2013), Potting et al. (2017) and Vis et al. (2016)

***** Most relevant scales of operation:***

- Micro - *single firms, communities, small cities*
- Meso - *industrial clusters, intermediate and large big cities, regions*
- Macro - *national, international, global*

7 References

Abramovsky, L. & Simpson, H. (2011). Geographic proximity and firm-university innovation linkages: Evidence from Great Britain. *Journal of Economic Geography*, *11(6)*, 949–977.

Accorsi, R., Manzini, R., Pini, C. & Penazzi, S. (2015). On the design of closed-loop networks for product life cycle management: Economic, environmental and geography considerations. *Journal of Transport Geography*, *48*, 121–134.

Allegrini, E., Maresca, A., Olsson, M. E., Holtze, M. S., Boldrin, A. & Astrup, T. F. (2014). Quantification of the resource recovery potential of municipal solid waste incineration bottom ashes. *Waste Management*, *34(9)*, 1627–1636.

Ayres (1989). Industrial metabolism. In J. H. Ausubel & H. E. Sladovich (Eds.), *Technology and environment* (pp. 23–49). National Academy Press.

Bahers, J.-B. & Durand, M. (2017). Le retour de la proximité ! Quelles implications pour les services urbains en réseau ? *Flux*, *109-110(3)*, 1.

Bahers, J.-B., Durand, M. & Beraud, H. (2017). Quelle territorialité pour l'économie circulaire? Interprétation des typologies de proximité dans la gestion des déchets. *Flux*, *109-110(3)*, 129.

Barles, S. (2009). Urban metabolism of Paris and its region. *Journal of Industrial Ecology*, *13(6)*, 898–913.

Beaurain, C., Maillefert, M. & Lenoir Varlet, D. (2017). La proximité au cœur des synergies éco-industrielles dunkerquoises. *Flux*, *109-110(3)*, 23.

Bevilacqua, C., Maione, C., Pizzimenti, P., Calabrò, J. & Zingali, L. (2014). Territorial milieu as driver for sustainability through urban regeneration initiatives: The case of san diego, CA. *Advanced Engineering Forum*, *11*, 364–375.

Blengini, G. A., Blagoeva, D., Dewulf, J., Others, & Others (2017). Assessment of the Methodology for Establishing the EU List of Critical Raw Materials.

Borrello, M., Caracciolo, F., Lombardi, A., Pascucci, S. & Cembalo, L. (2017). Consumers' perspective on circular economy strategy for reducing food waste. *Sustainability*, *9(1)*, 141.

Bourguignon, D. (2016). Closing the loop New circular economy package. *European Parliamentary Research Service*, *(January)*, 9.

Braun, A. T., Kleine-Moellhoff, P., Reichenberger, V. & Seiter, S. (2018). Case study analysing potentials to improve material efficiency in manufacturing supply chains, considering circular economy aspects. *Sustainability (Switzerland)*, *10(3)*.

Breure, A., Lijzen, J. & Maring, L. (2018). Soil and land management in a circular economy. *Science of The Total Environment*, *624*, 1125–1130.

van Buren, N., Demmers, M., van der Heijden, R. & Witlox, F. (2016). Towards a circular economy: The role of dutch logistics industries and governments. *Sustainability*, *8(7)*, 647.

Camagni, R. (1991). Local "milieu", uncertainty and innovation networks: towards a new dynamic theory of economic space. In *Innovation Networks: Spatial Perspectives* (pp. 121–142).

Camagni, R. (2004). Uncertainty, Social Capital and Community Governance: The City as a Milieu. In *Contributions to Economic Analysis*, Volume Volume 266 (pp. 121–149).

Camia, A., Robert, N., Jonsson, R., Pilli, R., GarcÃ-a-Condado, S., LÃ³pez-Lozano, R., van der Velde, M., Ronzon, T., GurrÃ-a, P., Mâ€™Barek, R., Tamosiunas, S., Fiore, G., Araujo, R., Hoepffner, N., Marelli, L. & Giuntoli, J. (2018). Biomass production, supply, uses and flows in the european union. first results from an integrated assessment. Technical report, JRC. EUR 28993 EN, Publications Office of the European Union, Luxembourg.

Capello, R., Camagni, R., Chizzolini, B. & Fratesi, U. (2007). *Modelling Regional Scenarios for the Enlarged Europe: European Competiveness and Global Strategies*. Springer Science & Business Media.

Charron, N., Dijkstra, L. & Lapuente, V. (2014). Regional Governance Matters: Quality of Government within European Union Member States. *Regional Studies*, *48(1)*, 68–90.

Charter, M. (2018). Repair Cafes. *The Journal of Peer Production*, *3(12)*, 37–45.

Chen, X., Fujita, T., Ohnishi, S., Fujii, M. & Geng, Y. (2012). The Impact of Scale, Recycling Boundary, and Type of Waste on Symbiosis and Recycling: An Empirical Study of Japanese Eco-Towns. *Journal of Industrial Ecology*, *16(1)*, 129–141.

CIWM (2014). The Circular Economy : what does it mean for the waste and resource management sector? *The Chartered Institution of Wastes Management* (pp. 1–32).

Clapp, J. (2001). *Toxic exports: The transfer of hazardous wastes from rich to poor countries*. Cornell University Press.

Corvellec, H., Campos, M. J. Z. & Zapata, P. (2013). Infrastructures, lock-in, and sustainable urban development: The case of waste incineration in the Göteborg Metropolitan Area. *Journal of Cleaner Production*, *50*, 32–39.

Crescenzi, R. & Rodríguez-Pose, A. (2011). Innovation and Regional Growth in the European Union. *(Lundvall 1992)*, 9–30.

Crescenzi, R., Rodríguez-Pose, A. & Storper, M. (2007). The territorial dynamics of innovation: A Europe-United States comparative analysis. *Journal of Economic Geography*, *7(6)*, 673–709.

Cristóbal, J., Caldeira, C., Corrado, S. & Sala, S. (2018). Techno-economic and profitability analysis of food waste biorefineries at European level. *Bioresource Technology*, *259*, 244–252.

Deng, Y. Y., Haigh, M., Pouwels, W., Ramaekers, L., Brandsma, R., Schimschar, S., GrÃ¶zinger, J. & de Jager, D. (2015). Quantifying a realistic, worldwide wind and solar electricity supply. *Global Environmental Change*, *31*, 239–252.

Dicken, P., Malmberg, A., Geography, E. & Oct, N. (2001). Firms in Territories: A Relational Perspective. *Economic Geography*, *77(4)*, 345–363.

EC (2010). *Being wise with waste. the EUâ€™s approach to waste management*. European Commission (EC).

EC (2014a). COM(2014) 398 final/2 - Towards a circular economy: a zero waste programme for Europe.

EC (2014b). *Scoping study to identify potential circular economy actions , priority sectors, material flows and value chains*. Number August. European Commission.

EC (2015). COM(2015) 614 - Closing the loop: An EU action plan for the Circular Economy. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions*.

EC (2017). *7Th Report on Economic, Social and Territorial Cohesion*.

EC (2018). COM(2018) 29 final - A Monitoring Framework for the Circular Economy. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions* (pp. 1–11).

Edbring, E. G., Lehner, M. & Mont, O. (2016). Exploring consumer attitudes to alternative models of consumption: motivations and barriers. *Journal of Cleaner Production*, *123*, 5–15.

Elbersen, B., Startisky, I., Hengeveld, G., Schelhaas, M.-J., Naeff, H. & Bottcher, H. (2012). Atlas of EU biomass potentials. *Biomass Futures de*.

Ellen MacArthur Foundation (2015). Growth Within: A Circular Economy Vision for a Competitive Europe. Technical report, Isle of Man, UK.

EPA Network (2017). Input to the European Commission from European EPAs about monitoring progress of the transition towards a circular economy in the European Union . European Network of the Heads of Environment Protection Agencies (EPA Network) - Interest group on Green and Circular Economy.

ESPON (2007). Revealing territorial potentials and shaping new policies in specific types of territories in eu-rope: Islands, mountains, sparsely populated and coastal regions. Espon working paper, ESPON.

Fang, K., Dong, L., Ren, J., Zhang, Q., Han, L. & Fu, H. (2017). Carbon footprints of urban transition: Tracking circular economy promotions in Guiyang, China. *Ecological Modelling*, *365*, 30–44.

Firbank, L. G., Attwood, S., Eory, V., Gadanakis, Y., Lynch, J. M., Sonnino, R. & Takahashi, T. (2018). Grand challenges in sustainable intensification and ecosystem services. *Frontiers in Sustainable Food Systems*, *2*.

Franklin-Johnson, E., Figge, F. & Canning, L. (2016). Resource duration as a managerial indicator for circular economy performance. *Journal of Cleaner Production*, *133*, 589–598.

Frosch, R. A. & Gallopoulos, N. E. (1989). Strategies for manufacturing. *Scientifi c American*, *3(261)*, 144–152.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy*, *31*, 1257–1274.

Geissdoerfer, M., Savaget, P., Bocken, N. M. & Hultink, E. J. (2017). The Circular Economy: A new sustainability paradigm? *Journal of Cleaner Production*, *143*, 757–768.

Ghisellini, P., Cialani, C. & Ulgiati, S. (2014). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, *114*, 11–32.

Graedel, T. E. & Allenby, B. R. (1996). *Design for environment*. Prentice Hall.

Helsley, R. W. & Strange, W. C. (2002). Innovation and input sharing. *Journal of Urban Economics*, *51(1)*, 25–45.

Heshmati, A. (2015). A Review of the Circular Economy and its Implementation. Discussion Paper IZA Discussion Paper No. 9611.

Hobson, K. (2016). Closing the loop or squaring the circle? Locating generative spaces for the circular economy. *Progress in Human Geography*, *40(1)*, 88–104.

den Hollander, M. C., Bakker, C. A. & Hultink, E. J. (2017). Product design in a circular economy: Development of a typology of key concepts and terms. *Journal of Industrial Ecology*, *21(3)*, 517–525.

Holmes, H. (2018). New spaces, ordinary practices: Circulating and sharing within diverse economies of provisioning. *Geoforum*, *88(November 2017)*, 138–147.

Ingrao, C., Faccilongo, N., Gioia, L. D. & Messineo, A. (2018). Food waste recovery into energy in a circular economy perspective: A comprehensive review of aspects related to plant operation and environmental assessment. *Journal of Cleaner Production*, *184*, 869–892.

Jensen, P. D. (2016). The role of geospatial industrial diversity in the facilitation of regional industrial symbiosis. *Resources, Conservation and Recycling*, *107*, 92–103.

Jensen, P. D., Basson, L., Hellawell, E. E. & Leach, M. (2012). â€˜Habitat’ Suitability Index Mapping for Industrial Symbiosis Planning. *Journal of Industrial Ecology*, *16(1)*, 38–50.

Jofra, M. & Ventosa, I. (2013). Incineration overcapacity and waste shipping in Europe: the end of the proximity principle? (p.23).

Jones, L., Norton, L., Austin, Z., Browne, A. L., Donovan, D., Emmett, B. A., Grabowski, Z. J., Howard, D. C., Jones, J. P., Kenter, J. O., Manley, W., Morris, C., Robinson, D. A., Short, C., Siriwardena, G. M., Stevens, C. J., Storkey, J., Waters, R. D. & Willis, G. F. (2016). Stocks and flows of natural and human-derived capital in ecosystem services. *Land Use Policy*, *52*, 151–162.

Jones, P. T., Geysen, D., Tielemans, Y., Passel, S. V., Pontikes, Y., Blanpain, B., Quaghebeur, M. & Hoekstra, N. (2013). Enhanced landfill mining in view of multiple resource recovery: a critical review. *Journal of Cleaner Production*, *55*, 45–55.

Jurgilevich, A., Birge, T., Kentala-Lehtonen, J., Korhonen-Kurki, K., PietikÃ¤inen, J., Saikku, L. & SchÃ¶sler, H. (2016). Transition towards circular economy in the food system. *Sustainability*, *8(1)*, 69.

Kalkuhl, M., Edenhofer, O. & Lessmann, K. (2012). Learning or lock-in: Optimal technology policies to support mitigation. *Resource and Energy Economics*, *34(1)*, 1–23.

Kalmykova, Y., Sadagopan, M. & Rosado, L. (2018). Circular economy: From review of theories and practices to development of implementation tools. *Resources, Conservation and Recycling*, *135(February 2017)*, 190–201.

Kaufmann, D., Kraay, A. & Mastruzzi, M. (2008). Governance Matters VII: Aggregate and Individual Governance Indicators, 1996-2007. *SSRN Electronic Journal*.

Ketels, C. & Protsiv, S. (2016). European Cluster Observatory in Brief: European Cluster Panorama 2016. Technical report.

Kim, C. & Kim, M.-S. (2015). Identifying core environmental technologies through patent analysis. *Innovation: Management, Policy & Practice*, *17(1)*, 139–158.

Kirchherr, J., Reike, D. & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, *127(September)*, 221–232.

Knapp, F. L. (2016). The birth of the flexible mine: Changing geographies of mining and the e-waste commodity frontier. *Environment and Planning A*, *48(10)*, 1889–1909.

Korhonen, J., Honkasalo, A. & SeppÃ¤lÃ¤, J. (2018a). Circular Economy: The Concept and its Limitations. *Ecological Economics*, *143(January)*, 37–46.

Korhonen, J., Nuur, C., Feldmann, A. & Birkie, S. E. (2018b). Circular economy as an essentially contested concept. *Journal of Cleaner Production*, *175*, 544–552.

Krook, J., Svensson, N. & Eklund, M. (2012). Landfill mining: A critical review of two decades of research. *Waste Management*, *32(3)*, 513–520.

Lazarevic, D. & Valve, H. (2017). Narrating expectations for the circular economy: Towards a common and contested European transition. *Energy Research and Social Science*, *31(October 2016)*, 60–69.

Lieder, M. & Rashid, A. (2015). Towards circular economy implementation: A comprehensive review in context of manufacturing industry. *Journal of Cleaner Production*, *115*, 36–51.

Liu, W. H. (2013). The role of proximity to universities for corporate patenting: Provincial evidence from China. *Annals of Regional Science*, *51(1)*, 273–308.

Lombardi, R. (2017). Non-technical barriers to (And drivers for) the circular economy through industrial symbiosis: A practical input. *Economics and Policy of Energy and the Environment*, *2017(1)*, 171–189.

Malinauskaite, J., Jouhara, H., Czajczynska, D., Stanchev, P., Katsou, E., Rostkowski, P., Thorne, R., Colón, J., Ponsá, S., Al-Mansour, F., Anguilano, L., Krzyzynska, R., López, I., A.Vlasopoulos & Spencer, N. (2017). Municipal solid waste management and waste-to-energy in the context of a circular economy and energy recycling in europe. *Energy*, *141*, 2013–2044.

Marra, A., Mazzocchitti, M. & Sarra, A. (2018). Knowledge sharing and scientific cooperation in the design of research-based policies: The case of the circular economy. *Journal of Cleaner Production*, *194*, 800–812.

Marsden, T. & Farioli, F. (2015). Natural powers: from the bio-economy to the eco-economy and sustainable place-making. *Sustainability Science*, *10(2)*, 331–344.

Marshall, A. (1890). *Principles of Economics*.

Merli, R., Preziosi, M. & Acampora, A. (2018). How do scholars approach the circular economy? A systematic literature review. *Journal of Cleaner Production*, *178*, 703–722.

Palan, N. (2010). Measurement of Specialization - The Choice of Indices. *FIW Working Papers*, *(62)*.

Planing, P. (2015). Business model innovation in a circular economy reasons for non-acceptance of circular business models. *Open journal of business model innovation*, *1(11)*.

Porter, M. E. (1998). Clusters and the New Economics of Competition. *Harvard Business Review*, *(November-December)*, 77–90.

Potting, J., Hekkert, M., Worrell, E. & Hanemaaijer, A. (2017). Circular Economy: Measuring innovation in the product chain - Policy report. *PBL Netherlands Environmental Assessment Agency*, *(2544)*, 42.

Prendeville, S., Cherim, E. & Bocken, N. (2018). Circular Cities: Mapping Six Cities in Transition. *Environmental Innovation and Societal Transitions*, *26*, 171–194.

Preston, F. (2012). A Global Redesign? Shaping the Circular Economy. *Energy, Environment and Resource Governance*, *(March)*, 1–20.

Preuß, T. & Ferber, U. (2005). Circular Flow Land Use Management : New Strategic , Planning and Instrumental Approaches for Mobili- sation of Brownfields. *2005*.

Ranta, V., Aarikka-Stenroos, L., Ritala, P. & Mäkinen, S. J. (2017). Exploring institutional drivers and barriers of the circular economy: A cross-regional comparison of China, the US, and Europe. *Resources, Conservation and Recycling*.

Ratcliffe, A., Prent, O. & van Vossen, W. (2012). Feasibility of material recovery from landfills (MFL) in the European Union. In *The ISWA World Waste Congress*.

Reggiani, A., Nijkamp, P. & Lanzi, D. (2015). Transport resilience and vulnerability: The role of connectivity. *Transportation Research Part A: Policy and Practice*, *81*, 4–15.

van Rhijn, G. & Bosch, T. (2017). Operator-oriented product and production process design for manufacturing, maintenance and upgrading. In *Dynamics of Long-Life Assets* (pp. 133–149). Springer International Publishing.

los Rios, I. C. D. & Charnley, F. J. (2017). Skills and capabilities for a sustainable and circular economy: The changing role of design. *Journal of Cleaner Production*, *160*, 109–122.

Schut, M., van Asten, P., Okafor, C., Hicintuka, C., Mapatano, S., Nabahungu, N. L. L., Kagabo, D., Muchunguzi, P., Njukwe, E., Dontsop-Nguezet, P. M., Sartas, M. & Vanlauwe, B. (2016). Sustainable intensification of agricultural systems in the Central African Highlands: The need for institutional innovation. *AGRICULTURAL SYSTEMS*, *145*, 165–176.

Singh, J. & OrdoÃ±ez, I. (2016). Resource recovery from post-consumer waste: important lessons for the upcoming circular economy. *Journal of Cleaner Production*, *134*, 342–353.

Socolow, R., Andrews, C., Berkhout, F. & Thomas, V. (Eds.). (1994). *Industrial ecology and global change*. Cambridge University Press.

Sonnino, R., Marsden, T. & Moragues-Faus, A. (2016). Relationalities and convergences in food security narratives: towards a place-based approach. *Transactions of the Institute of British Geographers*, *41(4)*, 477–489.

Spatial Foresight, SWECO, ÖIR, t33, Nordregio, Berman Group, Infyde (2017). *Bioeconomy development in EU regions. Mapping of EU Member States/regions Research and Innovation plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy for 2014-2020*. Study commissioned by DG Research & Innovation, European Commission. Brussels.

Stahel, W. R. (2013). Policy for material efficiency–sustainable taxation as a departure from the throwaway society. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *371(1986)*, 20110567–20110567.

Stahel, W. R. & Clift, R. (2016). Stocks and flows in the performance economy. In *Taking Stock of Industrial Ecology* (pp. 137–158). Springer International Publishing.

Sterr, T. & Ott, T. (2004). The industrial region as a promising unit for eco-industrial development - Reflections, practical experience and establishment of innovative instruments to support industrial ecology. *Journal of Cleaner Production*, *12(8-10)*, 947–965.

Stewart, R., Bey, N. & Boks, C. (2016). Exploration of the barriers to implementing different types of sustainability approaches. *Procedia CIRP*, *48*, 22–27.

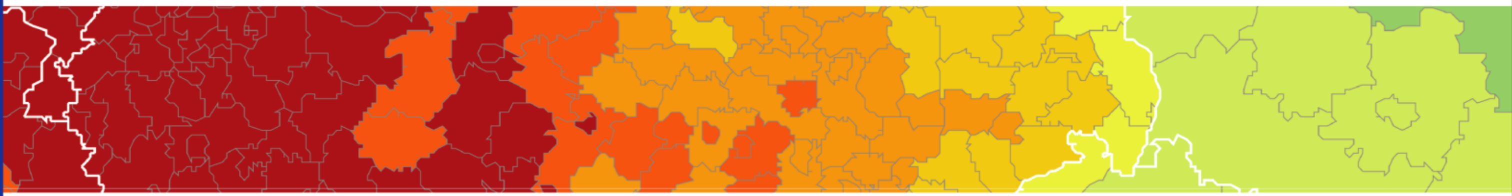
Su, B., Heshmati, A., Geng, Y. & Yu, X. (2013). A review of the circular economy in China: Moving from rhetoric to implementation. *42*, 215–227.

US Department of Energy (2018). Biomass feedstocks. https://www.energy.gov/eere/bioenergy/biomass-feedstocks (accessed 21/09/2018).

Velis, C. A. (2015). Circular economy and global secondary material supply chains. *Waste Management and Research*, *33(5)*, 389–391.

Vis M., U. Mantau, B. Allen (Eds.) (2016). Study on the optimised cascading use of wood. no 394/pp/ent/rch/14/7689. final report. Technical report, European Commission. DG GROW. Brussels.

Wilts, H. & von Gries, N. (2015). Europe’s waste incineration capacities in a circular economy. *Proceedings of the Institution of Civil Engineers - Waste and Resource Management*, *168(4)*, 166–176.



ESPON 2020 – More information

ESPON EGTC
4 rue Erasme, L-1468 Luxembourg - Grand Duchy of Luxembourg
Phone: +352 20 600 280
Email: **info@espon.eu**
www.espon.eu, **Twitter**, **LinkedIn**, **YouTube**

The ESPON EGTC is the Single Beneficiary of the ESPON 2020 Cooperation Programme. The Single Operation within the programme is implemented by the ESPON EGTC and co-financed by the European Regional Development Fund, the EU Member States and the Partner States, Iceland, Liechtenstein, Norway and Switzerland.