Co-financed by the European Regional Development Fund

Inspire Policy Making with Territorial Evidence

CIRCTER SPIN-OFF //

Cross-border Scandinavian area Case study

Final Report // May 2021

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Abbreviations

B2B	Business-to-business
B2C	Business-to-consumer
C2C	Consumer-to-consumer
CBM	Circular Business Model
CE	Circular Economy
CRV	Critical Raw Material
DE	Domestic Extraction
DMC	Domestic Material Consumption
DMI	Domestic Material Input
EC	European Commission
ESPON	European Territorial Observatory Network
ESPON EGTC	ESPON European Grouping of Territorial Cooperation
EU	European Union
GDP	Gross Domestic Product
GVA	Gross Value Added
MFA	Material Flow Analysis
NACE	Nomenclature of Economic Activities
NUTS	Nomenclature of Territorial Units for Statistics
PPS	Purchasing Power Standards
PU	Potential Users
RMC	Raw Material Consumption
SME	Small and Medium enterprises
ToR	Terms of Reference
WEEE	Waste from Electrical and Electronic Equipment

Foreword by Erik Hagen

“The ‘take-make-dispose’ model that characterizes the linear economy has driven the economic system well beyond the coping capacity of our planet. In order to reduce the impact of economic activities on global ecosystems, a circular economy needs to be adopted. A circular economy significantly reduces material throughputs and increases material efficiency over the long run. In doing so, a circular economy offers new possibilities for businesses and communities to create economic and social value.”

This message comes from the research team of the original ESPON CIRCTER Applied Research project in their synthesis report from 2019. Adding this message to the key role of circular economy in the EU Green deal, the opportunity given to Scandinavian partners by the ESPON EGTC on producing a Spin-off analysis from the CIRCTER project, was one that could not possibly be rejected.

In the spirit of the ESPON community and aiming at making the study relevant for a wider European audience, we decided to have the Spin-off analysis done for a cross border study area, defined by Eastern Norway and West Sweden regions. By this approach the results would cast light upon the potential for implementing a circular economy in European border regions, through cross border cooperation.

Given that the regions in question are also partners in an Interreg cooperation programme, the findings and policy recommendations from this project feed directly into the operational phase of the Interreg Sweden-Norway 2021-2027 programme.

For the Innlandet County Authority and its partners, cooperation with the authors at Technicalia Research and Innovation as well as the ESPON EGTC have been most rewarding. The research team processed volumes of local information and acquired a lot of data often hard to access, providing a report with a wealth of useful information and insights. Joint efforts across the Sweden-Norway border to promote the transition into a circular economy may therefore be intensified.

Erik Hagen
Head of Section, Policy Instruments
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1 Introduction

1.1 Spinoff background

The transition to a more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible and the generation of waste minimised, is an essential contribution to the European efforts to develop a sustainable, low carbon, resource efficiency and competitive economy. Such transition might represent a critical opportunity to transform European economy, create jobs and generate new and sustainable competitive advantages.

Monitoring and analysing material and waste flows is critical to establish whether existing actions and policy measures are beneficial to the objective of the circular economy, and to assess if Europe is on the right track towards a circular resource-efficient economy. In December 2015, the European Commission published an **EU Action Plan for the Circular Economy** followed by, two years later, a framework to monitor progress towards the circular economy. The **EC monitoring framework** consists of 10 indicators, some of them with sub-indicators, addressing a whole range of aspects related to the circular economy, including material consumption, waste management, secondary material uses and competitiveness and innovation around CE businesses. More recently, a new communication was released by the European Commission to set the basis for a strong and coherent product policy framework that will make sustainable products, services and business models the norm and transform consumption patterns so that no waste is produced in the first place (European Commission, 2020).

In parallel, the **CIRCTER project** (ESPON CIRCTER, 2019) made significant progresses in the identification of the potential territorial implications of a circular economy at subnational levels. The project took a special focus on a series of territorial factors that affect the distribution and manifestation of circular economies at subnational levels. These include land-based sources, agglomeration economies, accessibility conditions, knowledge and technology-based enablers, governance and institutional contexts. This territorial perspective was found to be critical not only to address the likely territorial consequences stemming from circular economy transitions, but also to identify the circular economy drivers and bottlenecks that characterise specific local contexts. Considering that the existing data on material consumption and waste generation is almost exclusively available at national level, the CIRCTER project produced regional estimates (at NUTS-2 level) for the main material consumption and waste generation and treatment indicators available from Eurostat. In addition, the CIRCTER project developed a sectoral perspective of circular economy. This differentiates between the demand-side and supply-side of circular product and/or services. The demand-side refers to the industries that adopt or rather demand new circular business processes, products and technologies that drive their uptake. Likewise, the supply-side is defined as the provision of materials, technologies and services for a circular economy. Thanks to this sectoral taxonomy of circular economy activities, the CIRCTER project produced regional estimates concerning the economic implications, in terms of employment and turnover, of the transition towards circular configurations.

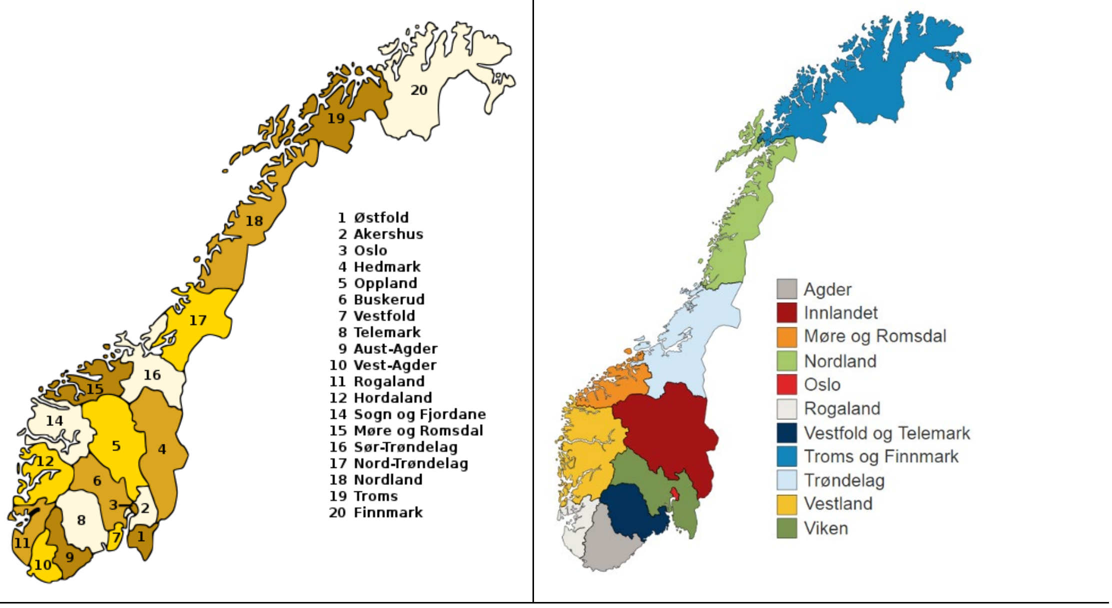
Following the impact generated by the CIRCTER project, the ESPON EGTC, together with the interested stakeholders, agreed to implement additional case studies for the countries Luxembourg, Norway, Switzerland and Liechtenstein with the aim of increasing the national, regional and local relevance and application of CIRCTER's evidence in policy processes and developments at different scales. This initiative is part of ESPON EGTC 's 2020 Annual Work Plan, which provides for the implementation of additional case studies as a spin-off of ongoing or closed research. This report will focus on the Norway case study, which, more specifically, considers the **central cross-border Scandinavian area** made up by the three Swedish border regions Västra Gotaland, Värmland and Dalarna, and the two Norwegian border regions Innlandet and Viken. In this regard, this SPINOFF aims to provide critical insights related to the transition to a circular economy that should be considered within the **Sweden-Norway cross border programme area during the 2021-2027 programme period**. In addition, the report also provides an in-depth analysis of current territorial patterns of material, waste and socioeconomic indicators that could fuel the design of regional strategies currently being developed in most of the interested areas.

1.2 Central cross-border Scandinavia

Traditionally, the Interreg Sweden-Norway programme area includes nine regional administrations – five Swedish *län* and four Norwegian *fylke* – which are arranged along the southern half of the long Sweden-Norway border that splits the Scandinavian Peninsula from north to south. The present study covers Värmland, Dalarna and Västra Götaland regions on the Swedish side, while Innlandet and Viken are the regions covered on the Norwegian side. It should be noted that recently Norway went through a regional reform which merged several counties. Regarding our study area, on 1 January 2020, Østfold and Akershus merged with Buskerud and formed the new region Viken. In addition, Hedmark has merged with Oppland and formed the new region Innlandet (Figure 1-1).

Figure 1-1: Counties of Norway before and after the regional reform

Counties of Norway between 1972 and 2018 | Counties of Norway from 1 January 2020



Source: https://commons.wikimedia.org/w/index.php?curid=86115547

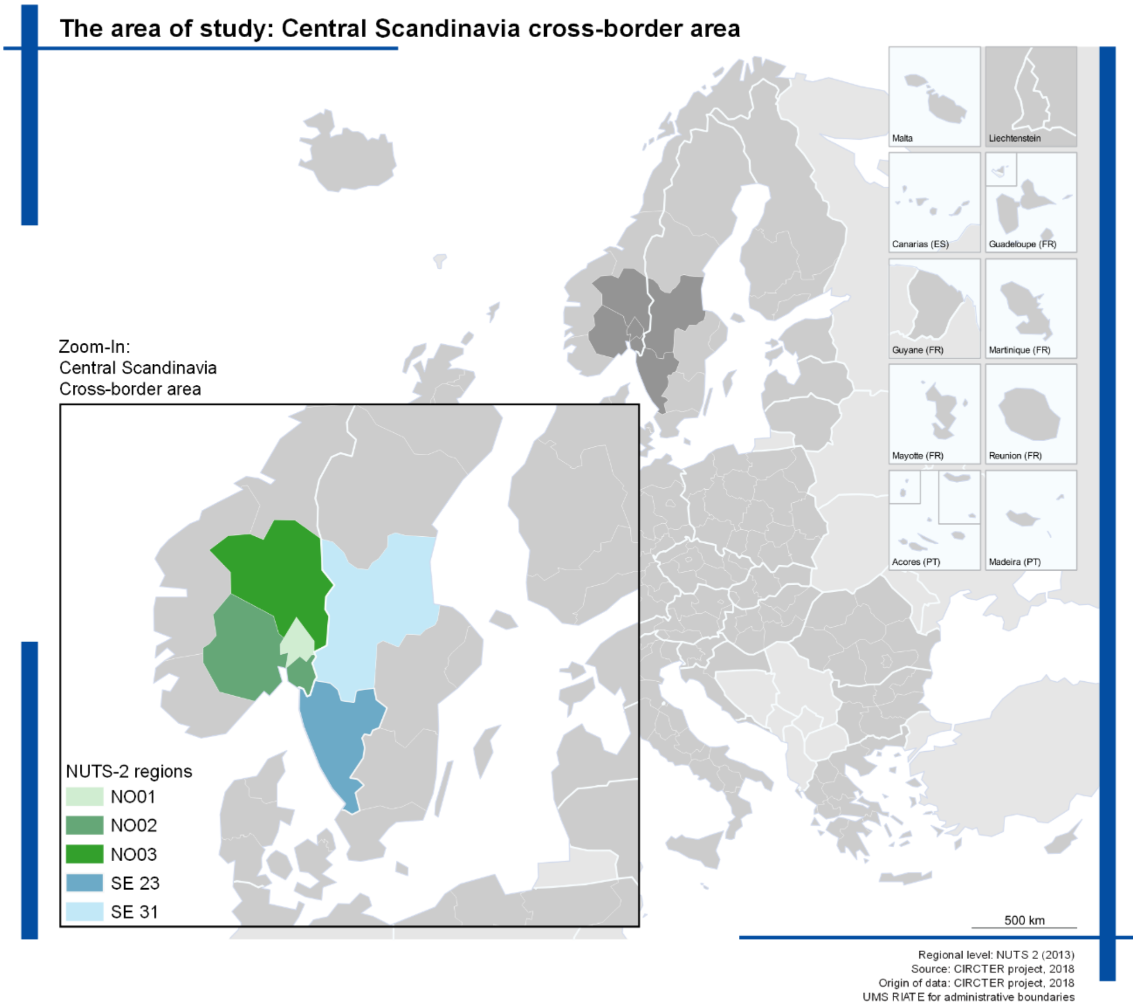
Source: https://commons.wikimedia.org/w/index.php?curid=85552553

While these changes in administrative boundaries have already been undertaken in the most recent regional strategies produced by local authorities and policymakers, this is not the case for the Norway statistics database, which still presents figures according to *old* administrative geography. Similarly, the analyses conducted in CIRCTER project have been carried out at NUTS 2 regional level. Such territorial subdivision is not perfectly aligned with the selected regions of the central cross-border Scandinavian area. Therefore, for practical reasons, depending on the data sources employed, the report will refer to the combination of regions that better reflect the area of study. This means that, according to CIRCTER statistics, this area will be the combination of the following NUTS-2 regions (Map 1-1):

- NO01 Oslo og Akershus
- NO02 Hedmark og Oppland
- NO03 Sør-Østlandet
- SE23 Västsverige (West Sweden)
- SE31 Norra Mellansverige (North Middle Sweden)

Likewise, when data are collected from national statistics databases, the most appropriate combination of regions and/or counties is selected in order to best represent the boundary of the central Scandinavian area.

Map 1-1: The area of study according to CIRCTER (NUTS-2) regional data nomenclature



1.3 Structure of the report

The report is organised as it follows. After this introduction, Chapter 2 presents the area of study, including its territorial characteristics and the regional policy frameworks. Chapter 3 provide an overview of CIRCTER estimates focusing on a selected set of indicators spanning from material consumption and waste generation to socio-economic indicators. The objective of this chapter is to position the situation in Norway and Sweden regions in the broader European context, identifying the key aspects that differentiate these territories from the rest of the European regions.

Once defined the broader picture, Chapter 4 provides a granular analysis of the cross-border Scandinavian area's metabolism, digging into specific material and waste streams and their evolution over time. This Chapter complements the data provided by CIRCTER project with complementary **primary** data retrieved predominantly by EUROSTAT and official statistical databases.

Basing on the evidence generated in previous chapters, Chapter 5 elaborates on the territorial implications for transitioning towards a circular economy configuration. To this aim, the taxonomy of territorial factors generated in CIRCTER is employed to discern specific lessons and/or input towards a comprehensive circular economy strategy.

Finally, Chapter 6 concludes the report by delivering CIRCTER key messages adapted to the cross-border Scandinavian context along with new lessons produced by the work done.

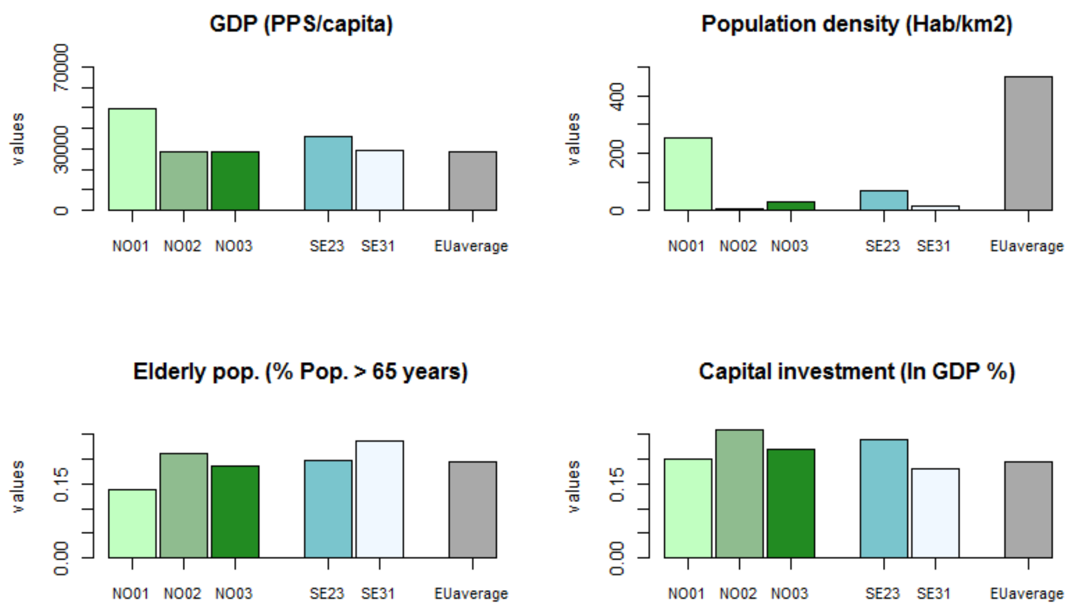
2 The central cross-border Scandinavia area

2.1 The territorial characteristics

One of the main messages of the CIRCTER project is that a transition to a circular economy does not happen suddenly through a one-fits-all strategy. Rather, the successful transitions to circular systems have generally been relied on place-based strategies that have first recognized, and then exploited, the territorial characteristics of the areas of interest. The cross-border area of central Scandinavia is made up of subnational territories which, although having similar characteristics compared to the rest of Europe, present specific differences when compared to each other. As these territorial differences could better help identify place-based mechanisms to support a circular transition, this section provides an overview of the socioeconomic data that characterize these areas.

Figure 2-1 compares the Scandinavian areas across a selection of socio-economic indicators available at NUTS-2 level, including GDP per capita (measured in purchasing power standard (PPS) per capita), population density, elderly population (measured as the percentage population older than 65 years) and fixed capital investment (measured as percentage of GDP). Oslo og Akershus (NO01) and West Sweden (SE 23) are the regions with the highest level of affluence, respectively PPS 50.000 and 36.000 per capita, well above the European average of PPS 28.000 per capita. In general, a higher GDP per capita is often associated with an economic structure mostly specialized in service activities. The latter have, on average, a greater added value than the primary and secondary sectors. A higher GDP per capita and a specialization in the tertiary sector generally occur in densely populated areas. Therefore, these two regions (NO01 and SE23) are not only the most populated within the regional sample, but also those most specialized in services activities (Figure 2-2)

Figure 2-1: Overview of socio-economic aspects of Scandinavian regions and comparison with European average



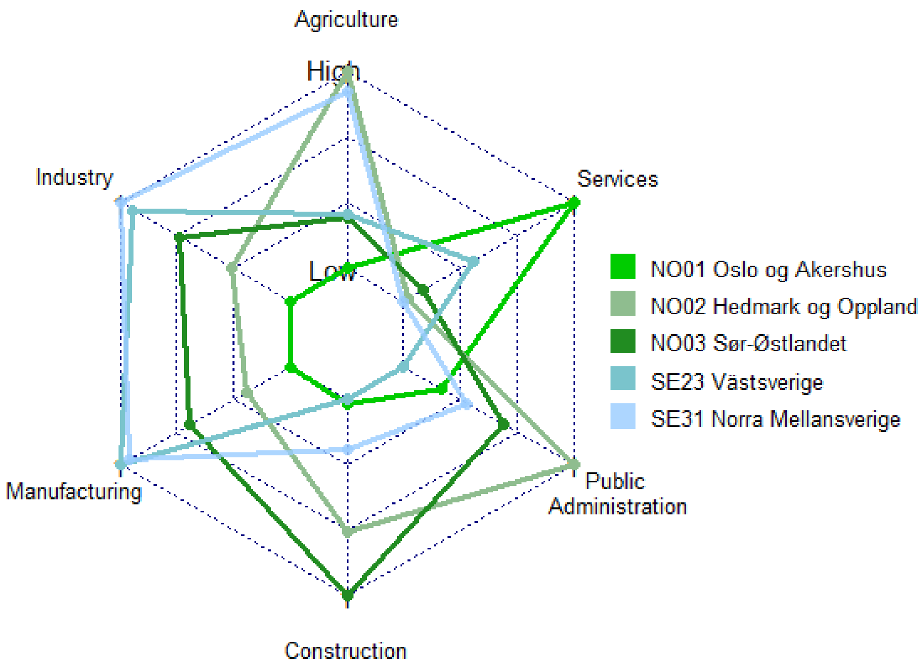
Source: own elaboration based on EUROSTAT data.

On the other hand, more rural areas such as Hedmark og Oppland (NO02), Sør-Østlandet (NO03) and North Middle Sweden (SE31), while having a GDP per capita in line with the European average, have the lowest numbers for the population density across Europe, i.e. less than 30 inhabitants per square kilometre. These regions are also characterised by higher shares of elderly population, in particular in the North Middle

Sweden region the elderly population represents a quarter of the total population. The consideration of the sociodemographic structure and its evolution is increasingly recognised as one of the key drivers for the circular economy transition for several reasons, including (1) the design of tailored campaigns supporting the implementation and acceptance of circular economy and (2) the correct forecasting of waste generation based on the evolution of consumer needs (OECD, 2020a; Rybová and Slavík, 2017). Similarly, population density is a key factor in areas such as waste management, energy consumption and material consumption, which are relevant for the circular economy. In this sense, the very low population densities of NO02, NO03 and SE31 might be a limiting factor, especially in waste sector, to achieve higher recycling rates, as the costs of waste collection and transportation might be higher in these areas.

Figure 2-2 compares the share of Gross Value Added (GVA) by NACE[1] economic activities over total GVA. In order to facilitate the comparison between the different magnitudes of economic activities, GVA shares have been normalised, i.e. translated on a scale from 0 to 1, where 0 equals the lowest GVA share and 1 equals the highest GVA share among regions for each economic activity. As anticipated above, Oslo og Akershus (NO01) is the region having the highest GVA share in services activities (i.e. 0.60%). This is largely explained by the presence of the capital Oslo, which is the largest city in Norway. West Sweden (SE 23) follows with a service share equals to 0.46%. West Sweden is also the region having among the highest GVA shares in industry and manufacturing, 0.23% and 0.21% respectively. Indeed, the presence of the Port of Gothenburg, the largest port in Scandinavia, represents the main gateway to the world for a large proportion of Swedish industry.

Figure 2-2: Comparison of economic activities shares between Scandinavian regions



Note: the figure is based on internally normalised values (from 0 to 1) of GVA by NACE economic activities over total GVA. NACE taxonomy[1]: A: Agriculture, forestry and fishing, B-E: Industry (except construction), C: Manufacturing, F: Construction, G-J + K-N: Services (wholesale and retail trade; transport; accommodation and food service activities; information and communication; financial and insurance activities; real estate activities; professional, scientific and technical activities etc.), O-U: Public Administration (public administration, defence, education, human health and social work activities etc.)

[1] Statistical Classification of Economic Activities in the European Community, Rev. 2 (2008): https://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=NACE_REV2&StrLanguageCode=EN

Concerning agricultural activities, Hedmark og Oppland (NO02) and North Middle Sweden (SE31) seems the most reliant in this sector, while Sør-Østlandet (NO03) has the largest economic share in construction activities (10%). Interestingly, it can be noted that the Norway regions NO02 and NO03 also have the highest GVA shares in public administration activities. Furthermore, although not apparent from Figure 2-2, the bio-economy sector is in general strong in all regions.

2.2 The policy framework

In the context of the European Cohesion policy, the cross-border Scandinavian regions present several regional policy priority areas aligned with the Greener Europe thematic objective. Many of these shared policy areas are already closely interlinked with the priorities of the EU, as outlined in overarching EU strategy documents like the Green New Deal, Urban Agenda, Digital Agenda and the Circular Economy and Bioeconomy Initiatives.

In relation to Greener Europe objectives, identified common policy areas are bioeconomy (including wood-based products, agriculture and food production), marine environment and blue growth, environmental protection, renewable energy production and circular economy, among others. On the other hand, several local priority policies are aligned with the Smart Europe thematic objective and may contribute greatly in providing the structural and economic basis for boosting circular transition at the local level from a more systemic approach. As an example, these priorities include: supporting entrepreneurship and innovation ecosystems (business, industry cluster development, industry-research institutes networks, testbeds, strengthening value chains), advanced process industries (advanced manufacturing, pulp and paper, chemicals) and digitalization (valorise the benefits of digitalization for citizens, companies and public administrations). All these interlinked policy priorities clearly present a strong potential for enabling synergies and achieve wins-wins outcome across the national (and regional) borders.

The circular economy is a key objective under Green Europe and all regions in the study area have initiatives that, directly or indirectly, support a shift towards circular systems across several contexts, e.g. industrial, built environment and/or consumer behaviour. Table 2-1 summarizes the main ongoing - or recently concluded - policy initiatives or commitments of the selected regions, together with the main priority areas of intervention that may be most relevant for a transition to a circular economy.

Table 2-1: Priority policy area in cross-border Scandinavian regions

County	Local strategies and commitments	Priority areas
Viken	Regional strategy «Veien til et bærekraftig Viken 2020-2024» (Draft 2020) Regional innovation strategies (former Oslo and Akershus 2025, Buskerud 2017-2020), Viken budget proposal 2020-2024	Circular business models & economy: production, new materials, recycling of materials and digitalization, sustainable consumption, green innovation, just green transition Sustainable land use, food production, nutrition and bioeconomy including sustainable blue and green industries with resources linked to agriculture, water, forest and soil, bio-based products New cross-sectoral industrial value chains Smart specialization: cluster and network development, entrepreneurship & SMEs, incubator initiatives Balanced regional development across urban and rural areas
Innlandet	Bioeconomy strategy for Inland (2017-2024) Inland Strategy: Regional planning strategy for the Inland (2020-2024) The Inland Strategy (Innlandsstrategien 2020-2024)	Balancing development and sustainable resource management, including climate and environmental targets Development of a sustainable and knowledge-based production and use of bioresources Clusters and industrial networks Smart societies for attractive rural areas

	Regional plan for competence and labour force in Hedmark 2019-2030 Regional plan for climate and energy in Oppland 2013-2024	Closer collaboration between businesses/business networks/clusters and education and research institutes Supporting the extraction of biomass and establishment of bioenergy plants (incl. small scale plants on farms and housing settlements). Reduce waste from landfills by 30% by 2024 in comparison to 2010 levels. Sustainable urban and rural development
Värmland	Värmland strategy 2014-2020 Värmland strategy towards 2040, draft Värmland's S3 strategy	High-tech orientation towards digitalization, servisitasion and advanced manufacturing. Forest-based bioeconomy (pulp and paper, packaging material) Creation of competitive clusters, incentives for entrepreneurship and business creation, private investments in R&D Resource efficient communities
Västra Götaland	Smart specialization strategy 2014-2020 Regional development strategy 2014-2020 Regional development Strategy (Consultation proposal) 2021-2030	Sustainable industry: including production and circular business models, as well as smart textiles and circular textiles within fashion and furnishing Bioeconomy including the blue and green industries with resources linked to water, forest and soil, food production/agriculture and green chemistry such as bio-based fuel, bio-based products and recycling of materials Sustainable urban and rural development
Dalarna	Regional development strategy 'Dalastrategin' 2014-2020 'Mobilize for growth' agenda for innovation and Smart specialization 'Societal challenges, potential and priorities for regional development' 2019 review document ahead of new strategy	Enhancing clusters and R&D capacities in domains of particular strength and finding new regional focus areas (advanced manufacturing, power transmission and steel production) Sustainable development, climate smartness and fossil freedom, renewable energy production, energy efficiency and renewable fuel uptake Bioeconomy: Sustainable forestry and agriculture

Source: own elaboration based on the Interreg Sweden-Norway mapping study

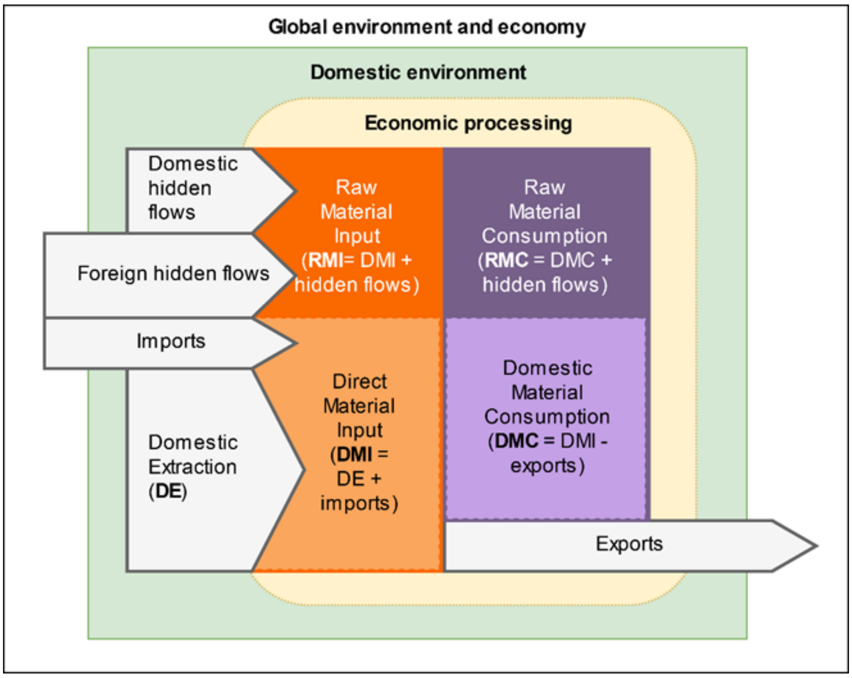
It should also be noted that the area covered by the present spin-off has a long tradition of cross border collaboration. Among others, this collaboration has been formalized through INTERREG Sweden-Norway programmes under which, in the recent past, cross border cooperation has pursued the goal to improve the development, innovation and competitiveness among the local economic actors. The INTERREG cross border programme 2014-2020 have had a great impact in relation to fostering cross-border innovation, particularly in forestry, bio-foods, manufacturing, and renewable energy solutions, and it made clear that this area has a great potential to embed the development of environmentally-driven businesses and green infrastructures to promote green and blue growth. Similar conclusions were drawn from the most recent INTERREG Sweden-Norway Mapping Study 2021-2027, which estimates that traditional resource-intensive industries across the Scandinavian regions should aim at the creation of a genuine circular bioeconomy system where resources, not only meant in terms of *physical* flows but also in term of knowledge, should be shared between different local actors, particularly in the areas of forestry, manufacturing, construction, life sciences and textiles.

3 An overview from CIRCTER statistics

3.1 Material consumption patterns

Progress towards a circular economy should ultimately lead to a significant reduction on the total amount of primary raw materials extracted from the environment, as well as on the total amount of waste sent to landfill. For the former objective, raw material consumption (RMC) would be the ideal indicator. RMC represents the world-wide amount of primary raw materials directly and indirectly used by an economy (Wiedmann et al., 2015). Unfortunately, estimates of RMC are only available at the aggregated EU economy and for few countries. Therefore, the headline indicator available from Eurostat, and also employed in CIRCTER, to track material consumption is Domestic Material Consumption (DMC). DMC is calculated by means of simplified mass balances. This implies that the indicator only accounts for the actual mass of imported and exported goods (either intermediate or end products) when crossing the international boundaries. Remarkably, the resources that were used upstream to produce imported goods are not considered in the calculation of the DMC. These neglected materials are commonly known as *hidden flows*. Nonetheless, considering that the development over time of DMC and RMC is very similar across European countries, the use of DMC is generally accepted as good proxy for RMC. Similarly, an alternative indicator for material consumption is Direct Material Input (DMI), which sums the domestic extractions plus imports. However, because it does not balance out the materials extracted in one country and then imported by another one, the use of DMI would lead to double counting in the European aggregates. For these reasons DMC remains the most popular indicators measuring material consumption for a domestic economy. Figure 3-1 provides a graphic overview of economic-wide material flow indicators and their relationships.

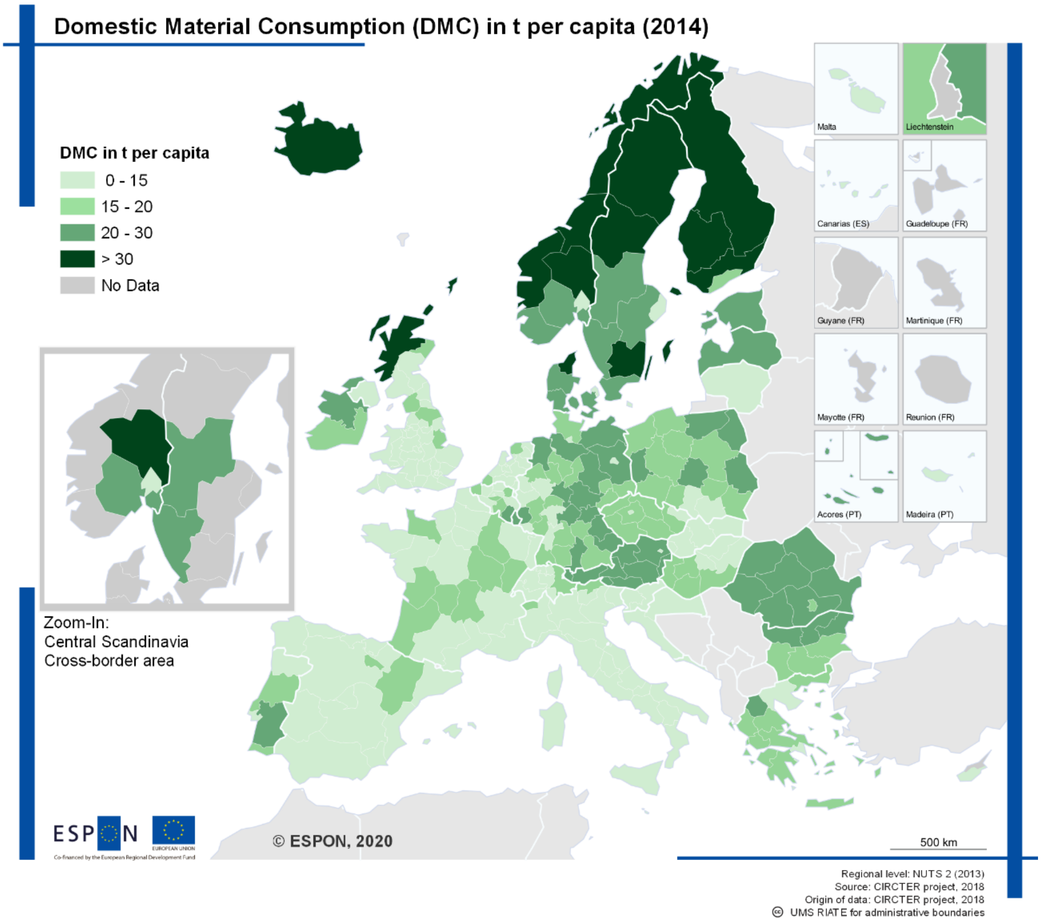
Figure 3-1: Simplified overview of material flow indicators



Source: CIRCTER project 2019.

Absolute values of DMC are generally very respondent to the size of a specific territory. Bigger economies and/or very populated regions will process and consume inevitably larger amounts of materials to meet respective human needs of domestic areas. Consequently, absolute values say relatively little about the qualitative prospect of a socioeconomic systems characterising a territory. Therefore, DMC is generally expressed in terms of DMC per capita and/or DMC intensity. The first measures the amount of material consumed per inhabitant, while the latter measures the amount of material consumed to produce a unit of economic output. Map 3-1 shows DMC per capita distribution in Europe in 2014.

Map 3-1 Domestic Material Consumption (DMC) per capita (2014)



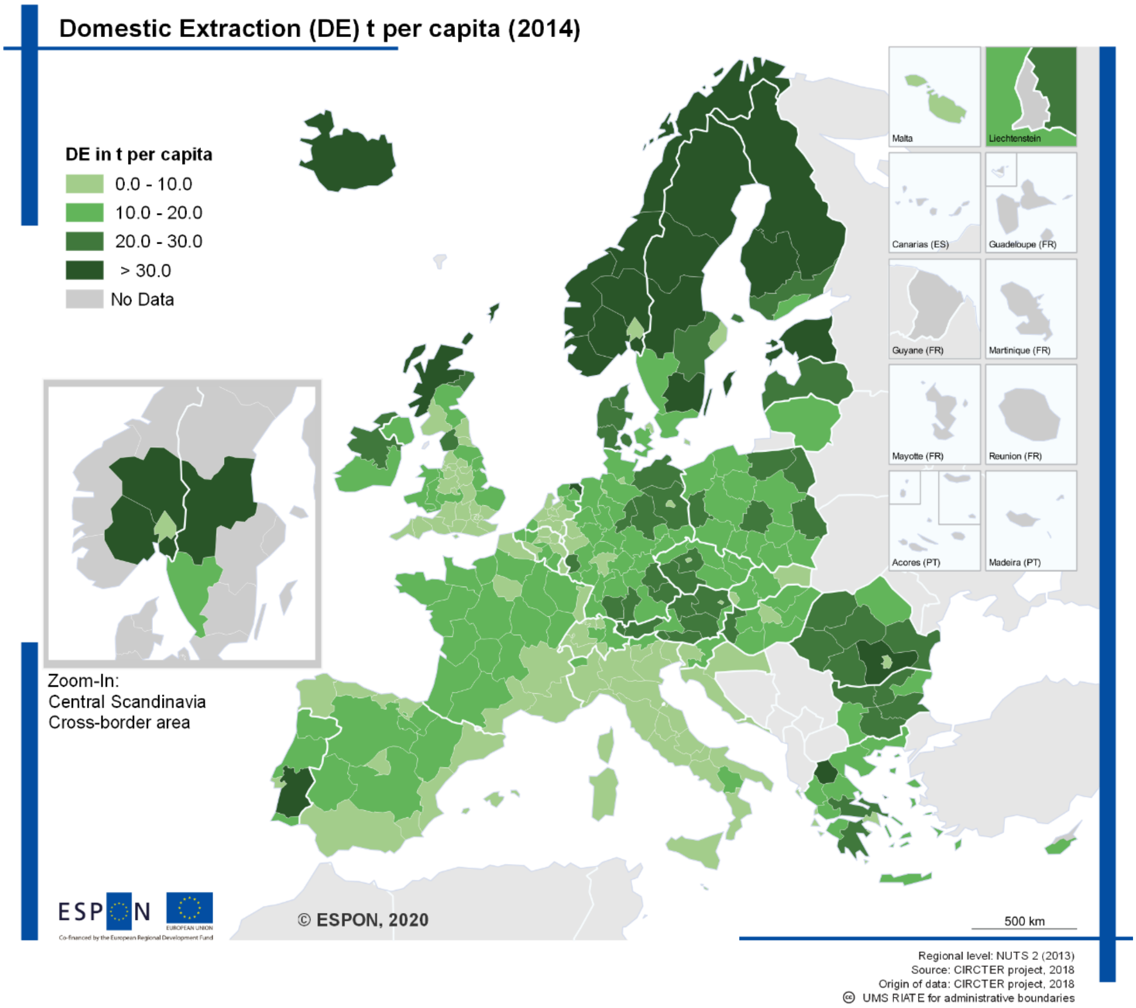
The Scandinavian area is constituted by regions having among the highest values of DMC per capita in Europe. This is mainly explained by two factors (with the exception of Oslo og Akershus region (NO01)): the very low population density characterising this area; and the prevailing economic structures of these regions, which are mostly oriented towards primary (agriculture) and secondary (industry & manufacturing) sectors (Figure 2-2).

Map 3-2 shows the amount of resource extraction (DE) per capita in European regions. Innlandet (NO02), Sør-Østlandet (NO03) and Norra Mellansverige (SE31) rank in the highest range, measuring 81, 47 and 39 t/cap respectively. These estimates well reflect the abundance of natural resources that characterize this area, and therefore the great potential in terms of job opportunity and environmental upgrade that a circular bioeconomy might deliver. As an example, Viken, the new county that largely overlaps with NO03, has approximately 20% of Norway's currently used agricultural land. According with the last statistical report of the county[2], over 60% of Norway's land used to grow wheat and oats is in Viken. Similar figures can also be observed for Innlandet, a county traditionally based on agriculture and forestry, with 20% of the total agricultural production and 40% of the forest felling nationally. On the Swedish side, Norra Mellansverige (SE31), which comprises the counties of Värmland and Dalarna, is also highly reliant on the primary sectors (agriculture and forestry), and it presents an agriculture specialisation level similar to the Innlandet region (i.e. 2.4)[3].

[2] https://viken.no/_f/p1/i4f0b8206-d207-4524-b400-9200b65ae0f9/kunnskapsgrunnlag-regional-planstrategi-viken-vi-i-viken.pdf

[3] Economic specialisation indexes refer to Location Quotients.

Map 3-2: Domestic Extraction in tonnes per capita (2014)



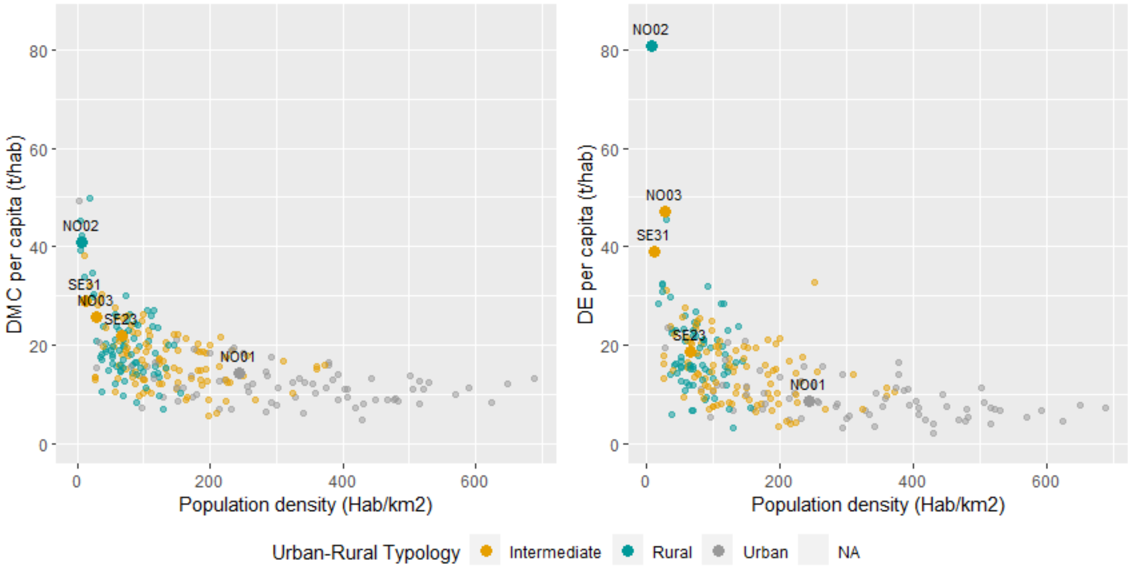
In general, it can be argued that there exists an inverse relationship between 1) population density, and 2) material consumption or domestic extraction per capita. This relationship is well reflected in Figure 3-2, where the Scandinavian regions show a high DMC per capita within their respective territorial categories (i.e. NO01 presents one of the highest DMC/cap value among urban regions, NO02 the highest DMC/cap among rural regions and so on). More concentrated populations not only favour agglomeration synergies and economies of scale, but also demand much lower input of energy and materials for the same level of supply of services per person compared to sparsely populated areas.

The type of territorial configuration (i.e. urban vs rural) also well reflects the underlying economic structure. As an example, the rural Innlandet region (NO02), which has one of the highest DMC per capita across European regions (40 t/cap), is strongly specialised in the agricultural sector. Indeed, Innlandet region exhibits an economy roughly 2.5 times more concentrated in agricultural activities than the European average (Bianchi et al., 2020) and it is the region having the highest concentration in agriculture among the Scandinavian regions considered. Contrarywise, the urban region of Oslo og Akershus region (NO01) is rather specialised in the service sector (see also Figure 2-2).

The direct comparison of DMC and DE levels in Figure 3-2 also permits to distinguish between export-oriented regions (i.e. DE>DMC) and import-oriented regions (i.e. DE<DMC). In this sense, the capital region of Oslo og Akershus region (NO01) is a clear example where most of domestic material consumption relies on imported goods. On the other hand, the much greater amount of resource extraction than domestic material consumption in the Innlandet region (NO02) seems to indicate that this region internalises most of raw-material refinement processes, exporting most of processed goods.

More granular details on the type of material consumption will be provided in section 4.

Figure 3-2: DMC and DE per capita Vs Population density

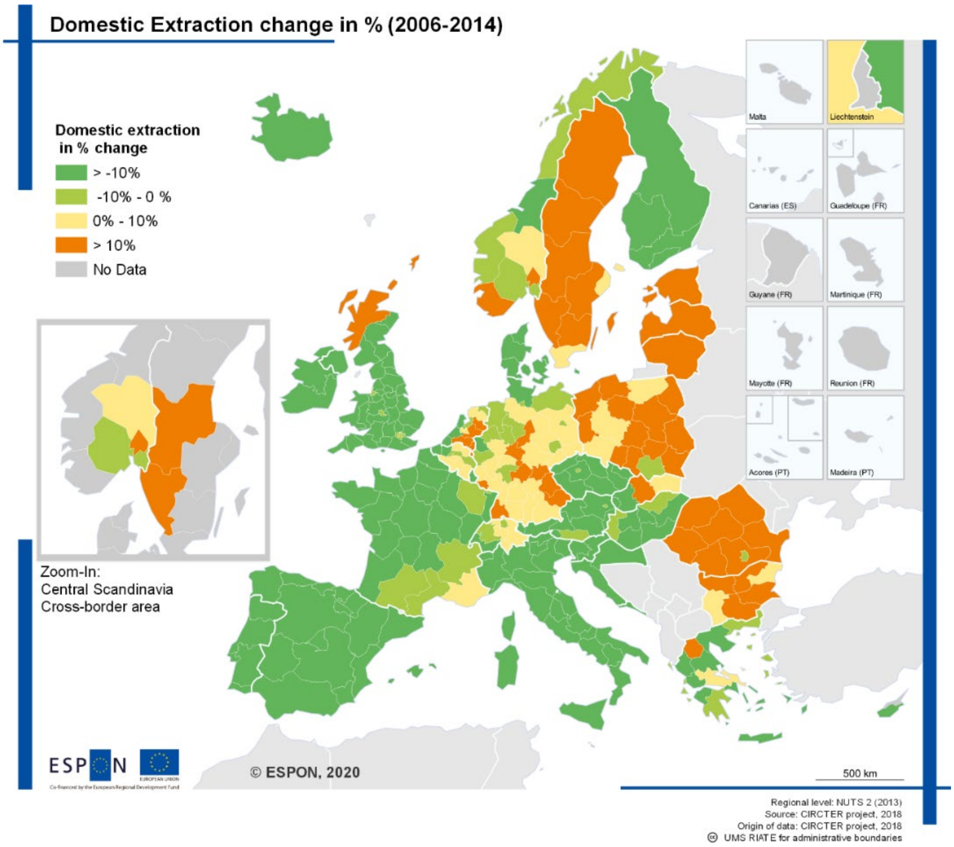


Source: own elaboration based on CIRCTER data

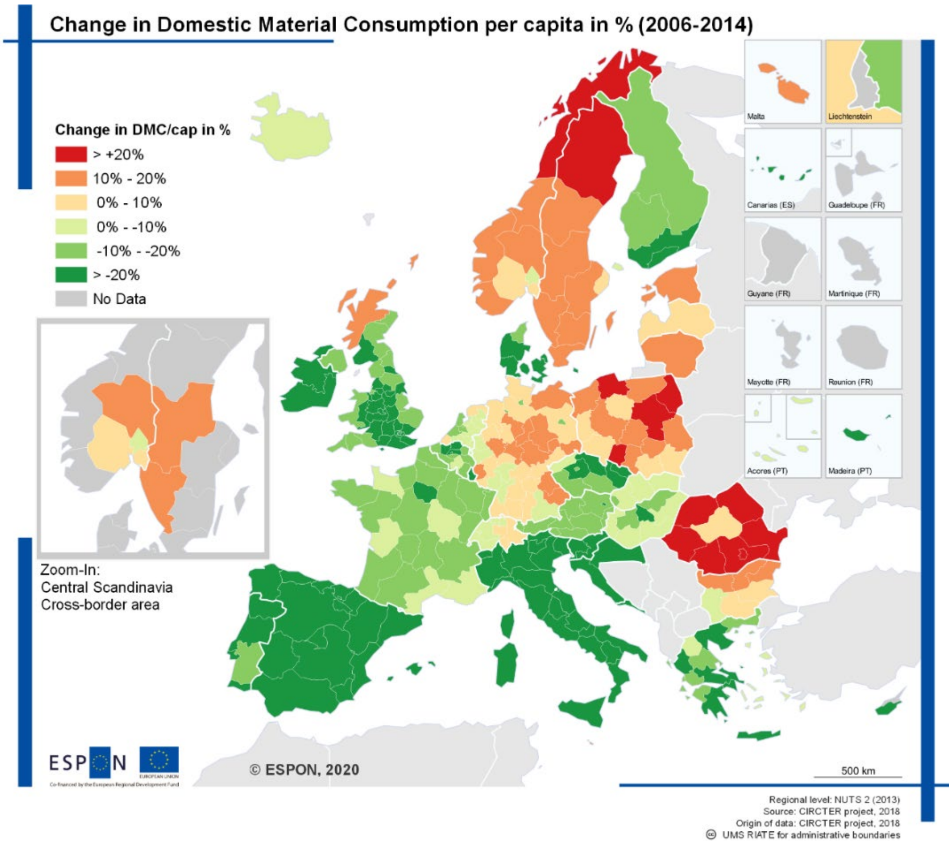
Domestic Material Consumption and Domestic Extraction per capita can be useful indicators to describe the type of an economy and understand whether a territory is rich in natural resources. However, they say little about the overall performance of a country towards more sustainable consumption patterns. From a rigorous environmental point of view, these figures should decrease in order to lighten the ecological burdens, as less consumption of resources would translate in fewer environmental impacts (e.g. emissions, biodiversity loss, soil degradation associated with their extraction). Map 3-3 and Map 3-4 show the percentage change in DE and DMC per capita observed between 2006 and 2014.

DE per capita increased by more than 10% in the Swedish regions and Oslo og Akershus region (NO01), and between 0-10% in the Innlandet region (NO02). Apparently, the only region showing decreasing patterns in DE per capita is Sør-Østlandet (NO03) (-1.91%). Similar increasing patterns were also recorded for DMC per capita. In particular, Innlandet region (NO02) led the rank (~ +18%), followed by North Middle Sweden (SE23) and West Sweden (SE31) with 15% and 13%, respectively. Interestingly, opposite patterns were found in Oslo og Akershus region (NO01) and Sør-Østlandet (NO03). In the first case, despite an increase in DE equal to 18%, Oslo og Akershus seems that succeeded in reducing domestic material consumption by 3.5%. In the second case, Sør-Østlandet (NO03) reduced domestic extraction (-1.91%) but increased domestic material consumption (7.42%). Theoretically, these figures could suggest, in the case of Oslo or Akershus region, an increase in commodity exports, i.e. most of extracted raw materials directed to foreign markets and not consumed domestically. However, it should be recalled that these are estimates based on most likely physical and socio-economic drivers of DE and DMC indexes. Therefore, more solid conclusions should be based on sectoral data taken on the ground.

Map 3-3: Change in Domestic Extraction per capita (2006-2014)



Map 3-4: Change in Domestic Material Consumption per capita (2006-2014)

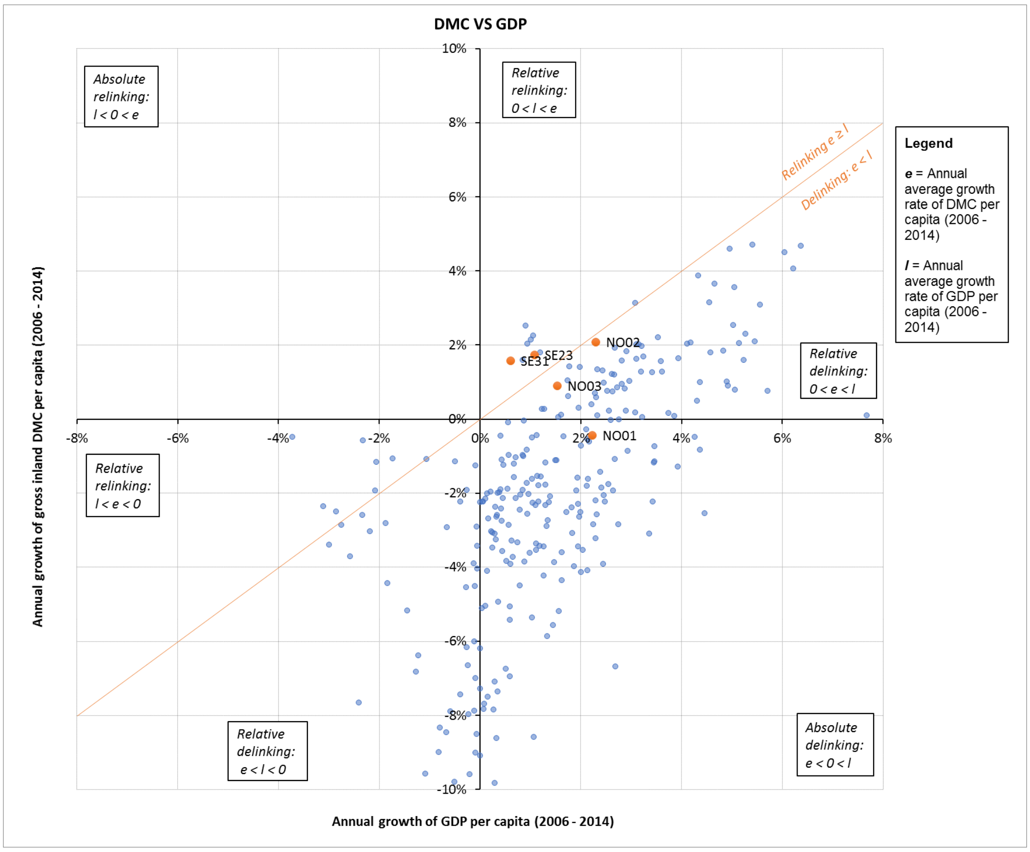


Focusing only on the resource consumption side and, neglecting the combination of socioeconomic forces driving material consumption patterns, might provide a biased picture of progress. As an example, one of the main catalysts of economy dematerialization is an economic recession (e.g. the case of Italian, Spain and Greece regions), which is not a socio-economically attractive strategy to curb environmental harms. For this reason, social indicators such as GDP and employment rates are also commonly included in monitoring frameworks to compare both, environmental and wealth progresses. Therefore, Figure 3-3 and Figure 3-4 show the annual growth of DMC along with the annual growth of GDP and employment, respectively.

These scatterplots are divided in six areas, which are defined by the different growth rates of GDP per capita and DMC per capita. All areas to the top-left of the diagnostic axis, coloured in orange, include regions that show a relinking pattern, i.e. the growth of the GDP was lower than the growth of the DMC. By contrary, all fields to the bottom-right of the orange diagonal, include delinking regions, i.e. regions where the GDP grown more than the DMC. Regions that achieved an absolute delinking, i.e. DMC per capita decrease and GDP increase, are shown in the bottom-right quadrant.

According to the estimates, Oslo og Akershus (NO01) is the only Scandinavian regions that achieved an absolute decoupling. Relative delinking patterns are instead observed for Innlandet (NO02) and Sør-Østlandet (NO03), while the Swedish regions of Västsverige (SE23) and Norra Mellansverige (SE31) are among the few European regions showing DMC growth rates higher than GDP.

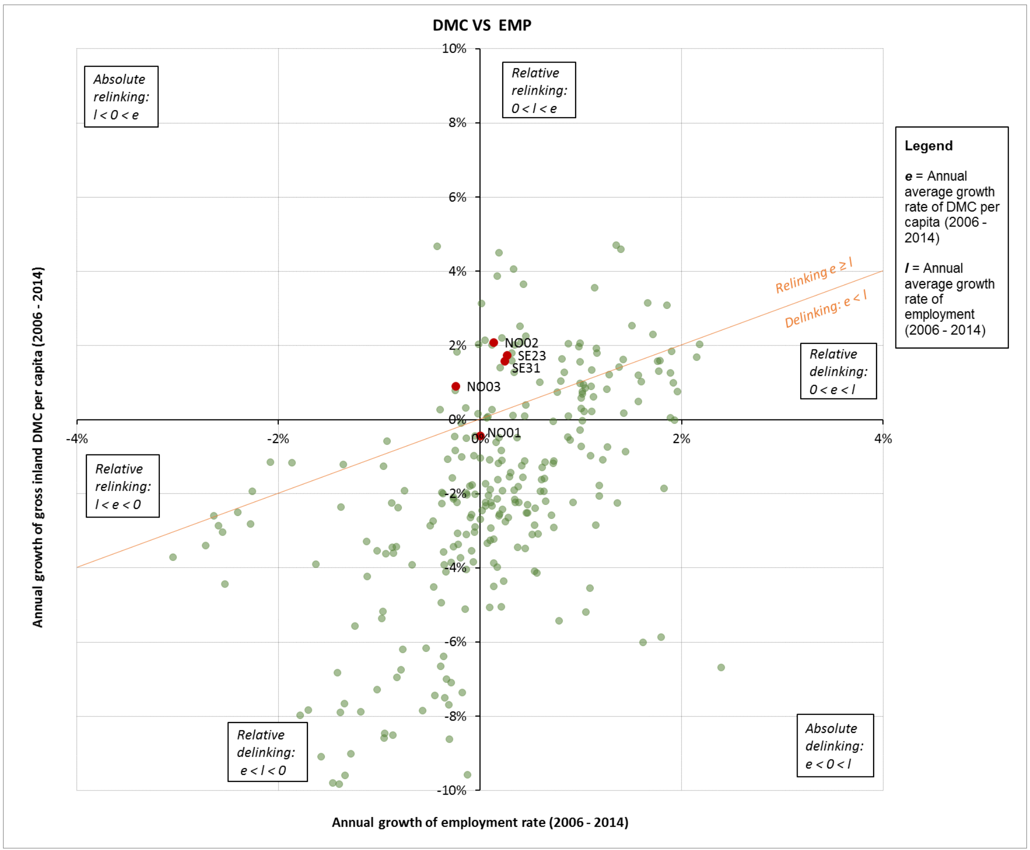
Figure 3-3: DMC Annual average growth Vs. GDP annual average growth



Source: own elaboration based on CIRCTER data

Figure 3-4 shows the same type of scatterplot, but with a different social indicator, i.e. employment growth. Employment might be considered a more inclusive social indicator than GDP, as this latter is often criticised for its weak link with sustainable growth[4]. Once again, Oslo og Akershus region (NO01) appears to be the only Scandinavian region that has managed to disconnect its economy (in terms of employment) from the direct and proportional consumption of resources. On the other hand, Innlandet (NO02), North Middle Sweden (SE23) and West Sweden (SE31) show employments that grow in line with material consumption levels. The most worrying situation is constituted by Sør-Østlandet (NO03), which seems to be struggling to maintain its workforce despite an increase in resources consumption. According to the European labour force survey and Eurostat data, Norway regions went from a clearly standing out position, with higher employment rates in the beginning of the analysed time-period (2006), to an under-rate performance, as employment levels have since then decreased. The lowest employment rate has been recorded in Østfold, which, indeed, make part of Sør-Østlandet region (NO03).

Figure 3-4: DMC Annual average growth Vs. Employment annual average growth



Source: own elaboration based on CIRCTER data

3.2 Waste generation patterns

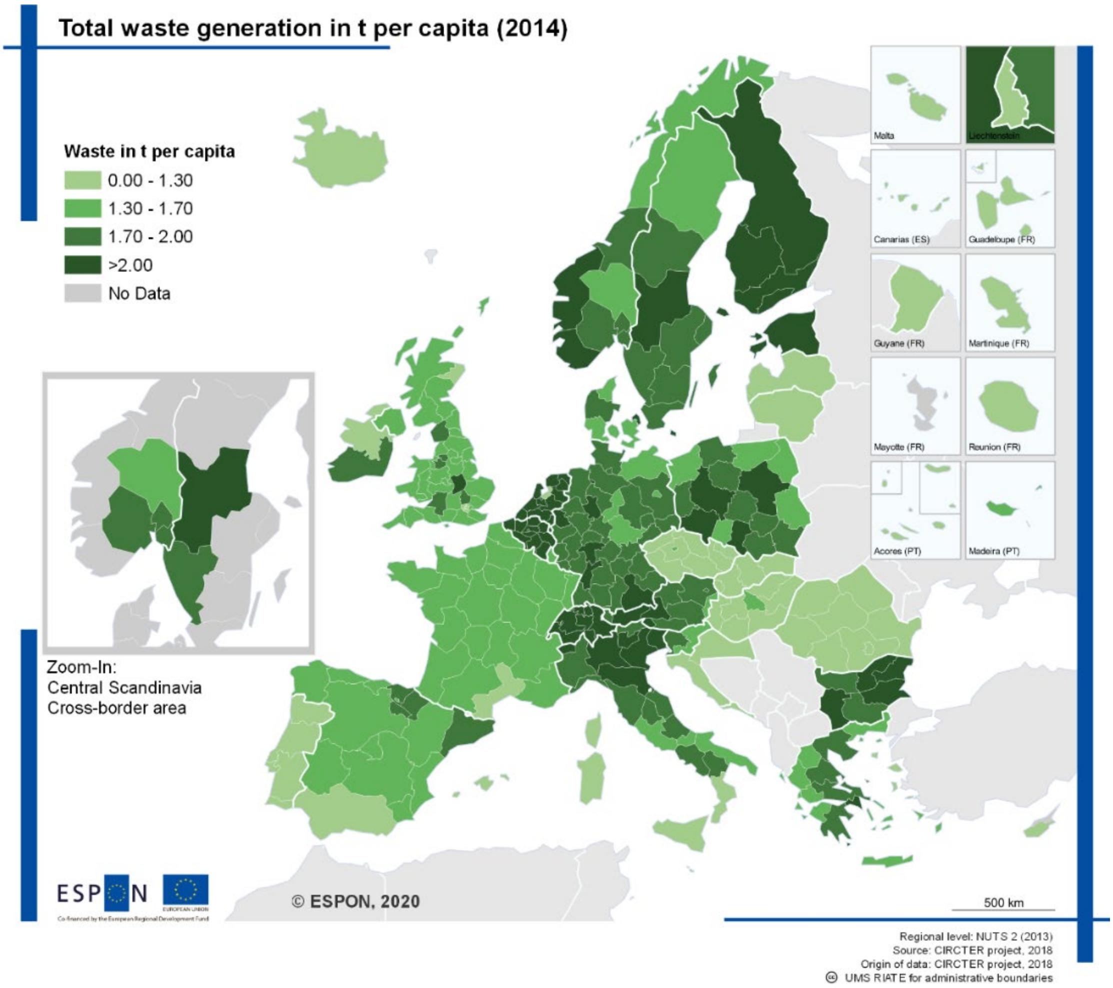
As highlighted in CIRCTER project, waste data comparability across countries and also within individual countries is somehow hampered by (1) the type of accounting methods employed by the countries, including surveys, administrative procedures and statistical estimations, and (2) the scope interpretation of, inter alia, municipal waste, secondary waste and recycling operations, which not always are the same between countries. As a result, it may be the case that the differences between countries in waste statistics respond to these outlined shortcomings, rather than to the actual quality of waste management infrastructure in place.

[4] GDP simply measures economic activity and not genuine improvements in the quality of our society. GDP lumps together costs with benefits, so that activities that enhance welfare (e.g., education expenditures) have equal weight as expenditures that represent the externalized costs of growth (e.g., oil spill remediation).

A higher level of mindfulness is therefore required when comparing waste indicators between regions belonging to different countries, as it is the case for Swedish and Norwegian regions.

Map 3-5 shows the total waste generated (excluding major mineral waste) in tonnes per capita in 2014. Most regions of the analysed Scandinavian area show, overall, waste per capita values above the European median (i.e. >1.7 t/cap). Innlandet region (NO02) is the only exception with 1.5 t/cap. Due to methodological limitations, the estimated change in waste generation between 2006-2014 is not sufficiently reliable and, therefore, omitted. On one hand, waste generation was one of the few CIRCTER indicators estimated with different parameters across the two years (2006 and 2014); on the other hand, waste generation parameters for Norway in 2006 were not available, so that elasticities where taken at European average. These technical limitations translated into unreliable waste change patterns for these regions, above all for comparison goals. We addressed the evolution of waste generation in section 4.2 relying on national statistics and, when available, primary regional data.

Map 3-5: Total Waste (excluding major mineral waste) in t per capita (2014)



Besides total waste generation, the CIRCTER project also produced a novel waste indicator related to food-waste, which is one of the priority areas identified by the EC (European Commision, 2015). Indeed, the European Union is committed to achieving the Sustainable Development Goal (SDG) 12.3. By 2030, SDG 12.3 aims to halve the volume of food waste per capita generated globally at the level of distribution and consumption, and to reduce the loss of food throughout production and supply chains, including post-harvest losses. Since the notion of food loss is not yet present in the EU regulatory framework and, hence, the respective monitoring cannot be effectively addressed through existing waste legislation, the CIRCTER project estimated food-waste indicator following the recommendation on food waste allocation by the Subgroup on food waste measurement of the Platform Food Losses and Food Waste[5]. According to these guidelines, food-waste includes the animal and vegetal waste generated by economic activities plus a 25% of total household waste.

Box 3-1: Difference between food loss and food waste

What is food loss and food waste?

Food loss and waste has become an issue of great public concern. The 2030 Agenda for Sustainable Development reflects the increased global awareness of the problem. Target 12.3 of the Sustainable Development Goals calls for halving per capita global food waste at retail and consumer levels by 2030, as well as reducing food losses along the production and supply chains.

To provide more clarity on the subject and to measure progress towards SDG Target 12.3, FAO is in the process of providing two separate indices: the Food Loss Index (FLI) and the Food Waste Index (FWI).

Food loss is the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retailers, food service providers and consumers. Empirically, it refers to any food that is discarded, incinerated or otherwise disposed of along the food supply chain from harvest/slaughter/catch up to, but excluding, the retail level, and does not re-enter in any other productive utilization, such as feed or seed.

Food waste refers to the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food service providers and consumers. Food is wasted in many ways:

- Fresh product that deviates from what is considered optimal, for example in terms of shape, size and colour, is often removed from the supply chain during sorting operations.
- Foods that are close to, at or beyond the “best-before” date are often discarded by retailers and consumers.
- Large quantities of wholesome edible food are often unused or left over and discarded from household kitchens and eating establishments.

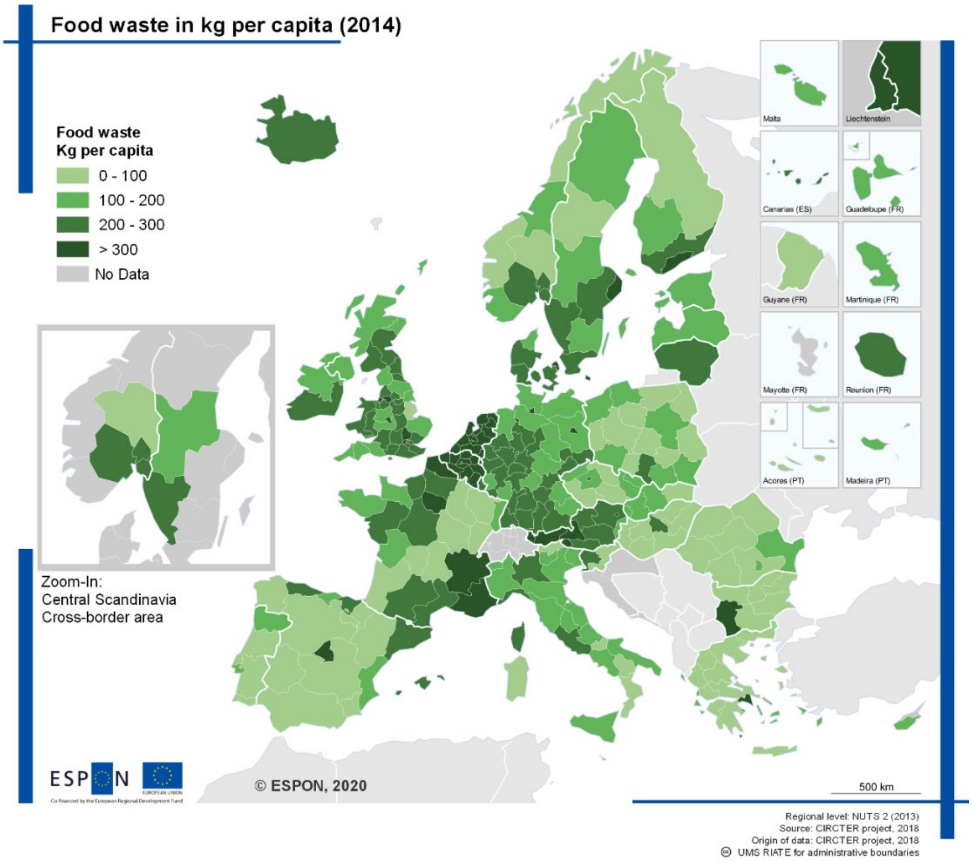
Less food loss and waste would lead to more efficient land use and better water resource management with positive impacts on climate change and livelihoods.

Source: http://www.fao.org

Map 3-6 and Map 3-7 show the food waste per capita and the change in food waste generation between 2006 and 2014, respectively. Oslo og Akershus region (NO01) and North Middle Sweden (SE23) are the only Scandinavian region having a food waste per capita (respectively 287 and 244 kg/cap) above European average (210 kg/cap). On the other hand, the rural and sparsely populated region of Hedmark og Oppland (NO02) recorded the lowest level (72 kg/cap). When considering food waste, and more in general all biotic flows related with primary consumption, an important consideration has to be kept in mind. Differently from the production and consumption of human-made materials, which benefit extremely from agglomerations and economies of scale, the consumption and waste generation of biomass is much more inelastic to agglomerations factors. In other words, the diet, understood in a functional sense, does not change substantially depending on population density or economic structure of a territory. If anything, rural and sparsely populated regions may do it better, as most biotic waste is directly composted or recycled on-site (i.e. food for animals) and thus less food waste per household will be collected compared to urban regions. On top of that, there is an increasing evidence that lifestyle and demographic structure are strongly related with food waste (Aschemann-Witzel et al., 2021; Savelli et al., 2019). In this sense, a positive correlation is generally observed between the richest and/or younger segments of the population and food waste. These factors might partly explain why the highest figures for food waste per capita are generally recorded in densely populated regions. The Scandinavian area is not an exception to this general rule and Figure 3-5 well exemplifies this relationship between food waste level and territorial configurations.

[5] https://ec.europa.eu/food/sites/food/files/safety/docs/fw_eu-platform_20170925_sub-fwm_pres-03.pdf

Map 3-6: Food waste in kg per capita (2014)



Map 3-7: Change in food waste per capita (2006-2014)

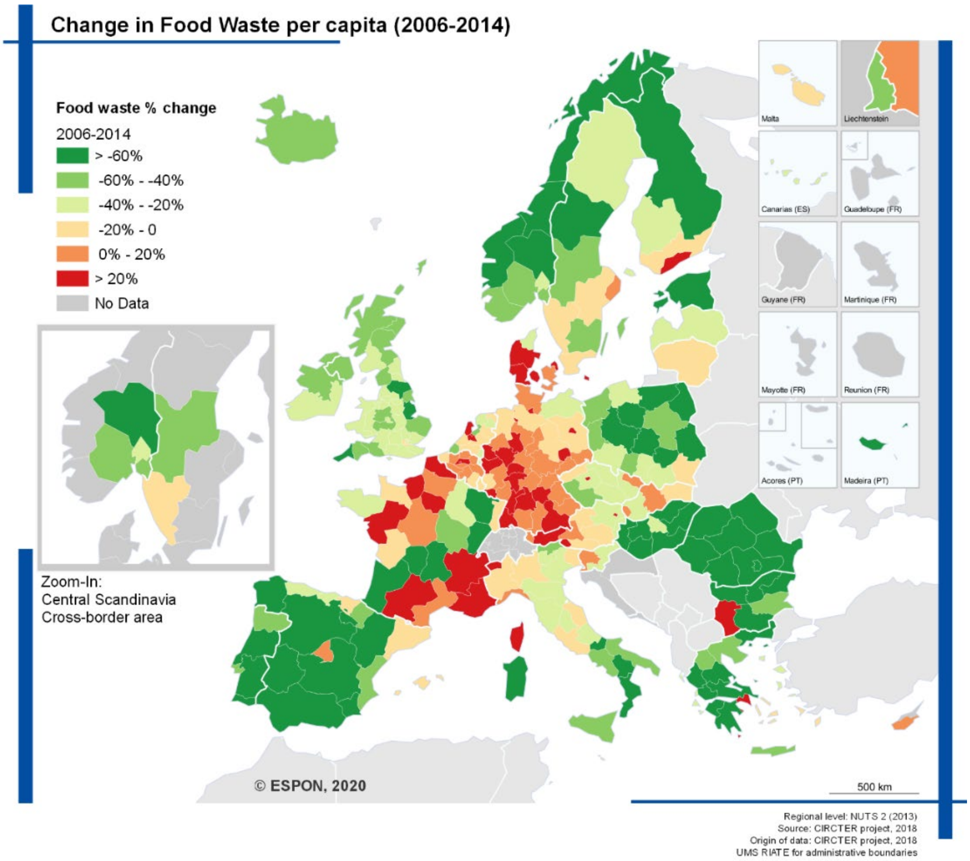


Figure 3-5: Food waste per capita and food waste change (%)

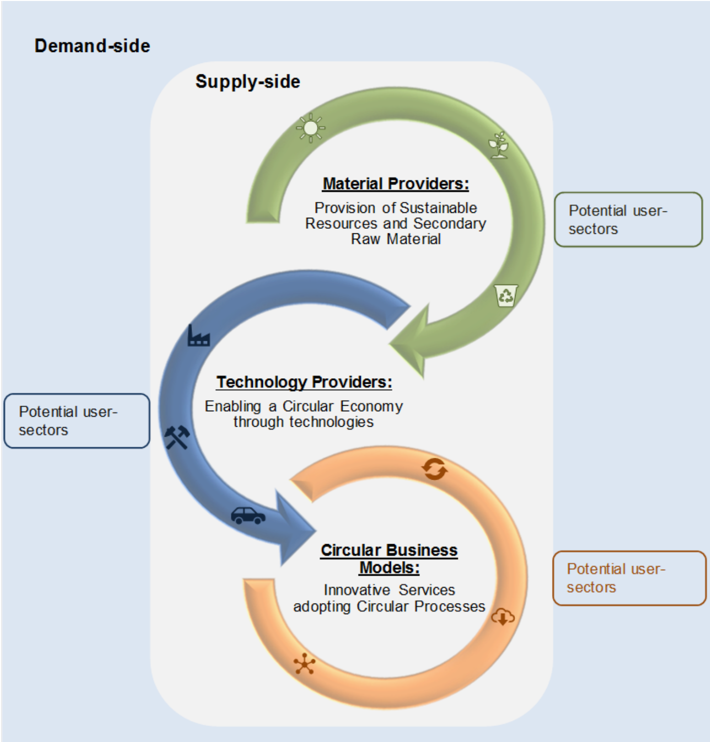
3.3 Sectoral perspective of Circular Economy: Material and Technology providers

Next to the indicators concerning material and waste patterns commonly used to measure the progress towards resource-efficient systems, CIRCTER project developed a new set of indicators related to the economic activities promoting circular businesses. The sectoral definition established in the CIRCTER project distinguishes between the supply-side and demand-side of the economy (Figure 3-6). The supply side is defined as the provision of materials, technologies and services for a Circular Economy and it is represented by the Material Providers, Technology Providers and Circular Business Models. On the other hand, the demand-side is defined as selected industries that adopt or rather demand new circular business processes, products and technologies that drive their uptake. These are referred to as Potential Users (ESPON CIRCTER, 2019). Since figures for Circular Business Models (CBM) and Potential Users (PU) are not available for the central cross-border Scandinavian regions, we will focus only on Material Providers and Technology Providers.

Circular Material Providers in a Circular Economy represent biological cycles, as well as those essential services that reintroduce wastes as a resource into existing value chains through technical cycles. In a nutshell, Circular Material Providers form the basic input-side by providing materials for a Circular Economy that are comprised of renewable and recycled materials. Illustrative examples are the market segments of forestry, sustainable agriculture and waste-to-energy value chains along with the production of high-quality secondary raw materials from wastes, i.e. the collection and recycling services.

On the other hand, Technology Providers provide technologies and key services that enable cyclical flows and more efficient use of resources. They also provide intermediate products and, in many ways, enable the implementation of Circular Economy processes through innovative technologies and resource-saving services throughout the value chain. Technology Providers' contribution to value generation is to recover and restore materials, components and products through the provision of technologies and services that aid the reuse, repair, recycling and remanufacture of durables and turn wastes into resources. Therefore, they provide the necessary technologies for the operating of Material Providers. Technology Providers also cover the production of consumables from renewable materials (e.g., natural fibres, bioplastics, composite materials), the generation of renewable energy, as well as installations and machinery for the treatment of material waste streams.

Figure 3-6: A conceptual visualisation of the pillars of a Circular Economy and their respective sectors

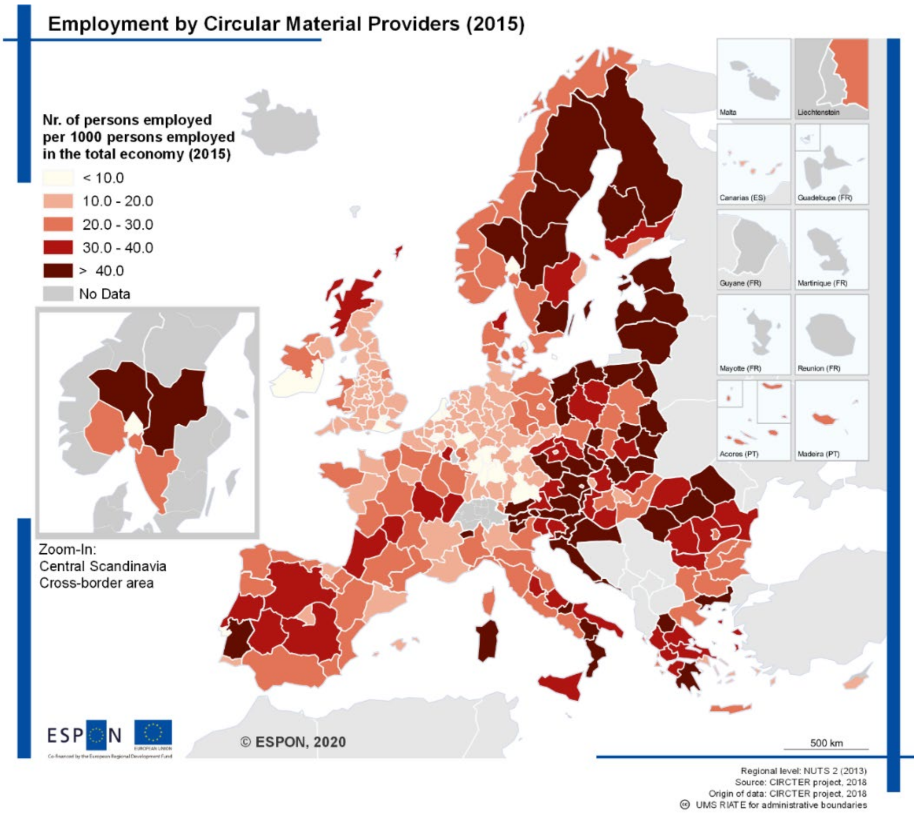


Source: CIRCTER project 2019.

Map 3-8 and Map 3-9 shows, respectively, the territorial distribution of the number of persons employed in Circular Material and Technology Providers sectors per 1000 persons employed in the total economy in 2015. Innlandet (NO02) and Norra Mellansverige (SE31) exhibit among the highest employment figures in Material Providers sectors across Europe, 48 and 74 respectively (European average is 26 employees for 1000 employees). In fact, as also depicted in Figure 2-2, these regions see an important role of primary sector, especially agriculture, in their economies. Furthermore, estimates are consistent with the natural endowments of these regions, which benefit above all from renewable forestry reserves. Not by chance, one of the main priorities of the Innlandet county (NO02) towards a sustainable development is to strengthen its bioeconomy sector.

Similar patterns can be observed for the employment generated by Technology Providers, even if, this time, Scandinavian regions present numbers rather close to the European average, i.e. 16 employees for 1000 employees). To mention Sør-Østlandet (NO03), which outperformed European average with 25 employees, and Hedmark og Oppland (NO02), which underperformed the European average with 14 employees. All in all, it can be said that the regions belonging to this cross-border Scandinavian area have among the largest shares of employment linked to the circular economy in all of Europe. Interestingly, except the region of Oslo og Akershus (NO01), the employment generated in Material Providers sectors is constantly higher than that generated in Technology Provider sectors. Indeed, all regions have significantly higher numbers of employment in Material Providers sectors, reflecting, once again, the close link with a resource-based economy.

Map 3-8: Employment generated by Material Providers (2015)



Map 3-9: Employment generated by Technology Providers (2015)

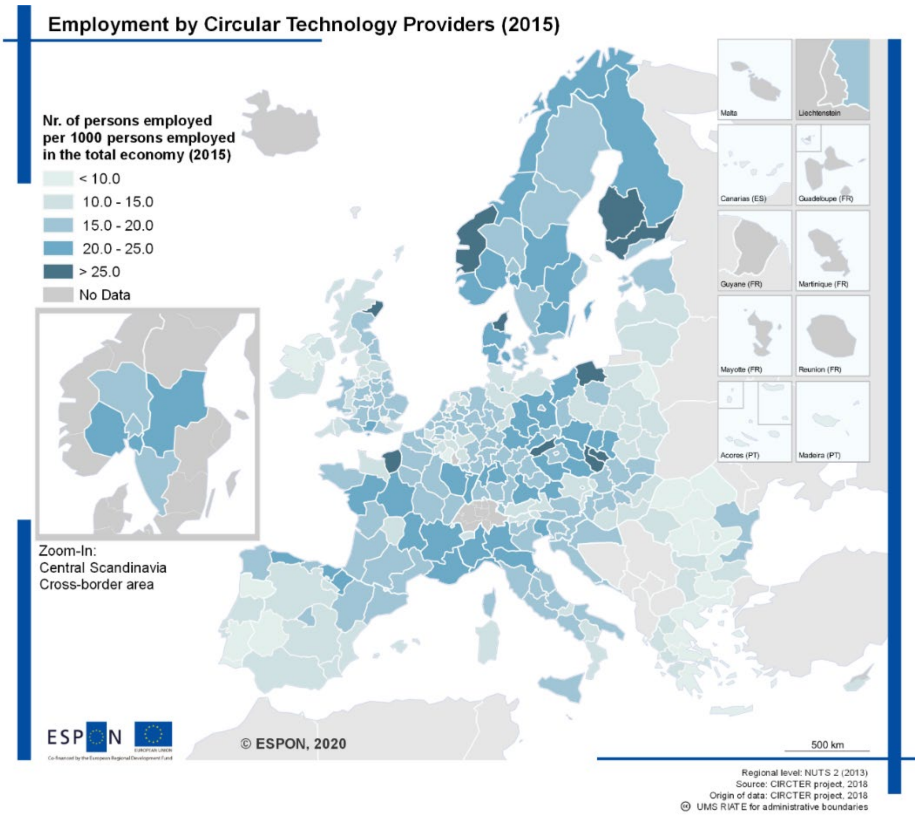
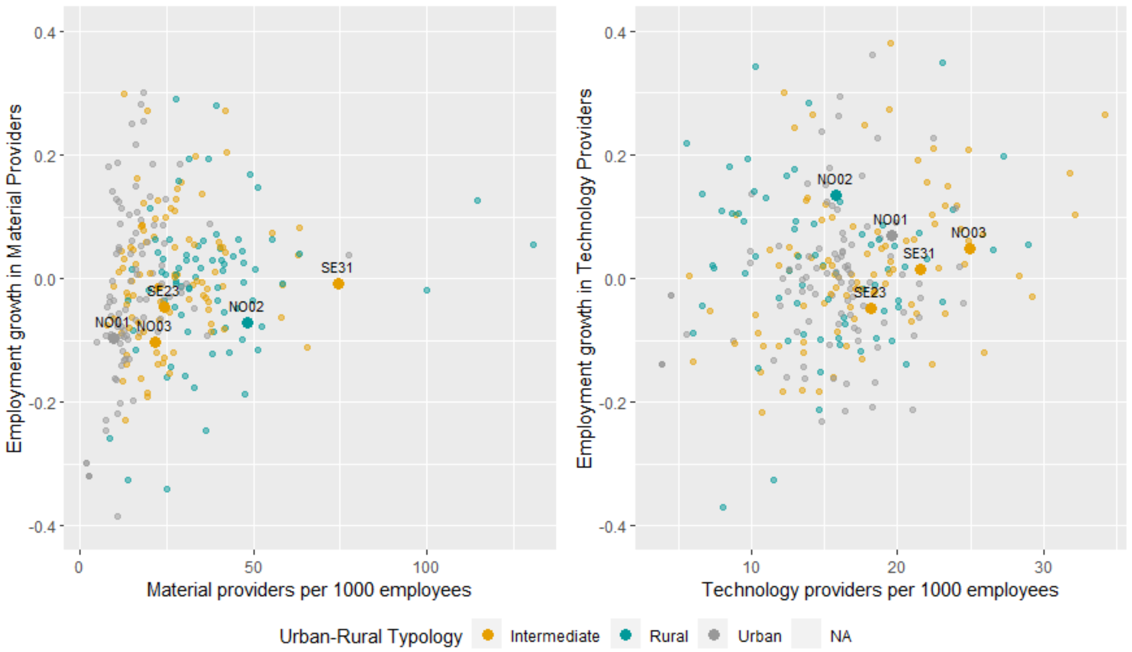


Figure 3-7 provides a complementary overview of Material and Technological Providers by comparing the levels recorded in 2015 and the change recorded between the 2010 and 2015. According to the results, it seems that the activities related to Technology Providers sectors are catching up with those of Material Providers. Indeed, all Scandinavian regions, except North Middle Sweden (SE23), recorded positive growth rates. In particular, Hedmark og Oppland (NO02), which has the lowest level in 2015, showed the highest growth rate. It is interesting to also note how, once again, the territorial configurations influence the specialisation of the regions. Whereas urban regions present very low employment in Material Productivity sectors, the rural regions present, on average, the highest (Figure 3-7, left scatterplot). On the other hand, urban or rural settlements do not seem to have a clear influence on Technology Provider, as the scatterplot is rather dispersed (Figure 3-7, right scatterplot).

Figure 3-7: Material and Technology providers in 2015 Vs. Material and Technology providers growth (2010-2015)



Source: own elaboration based on CIRCTER data

4 The cross-border Scandinavian area metabolism

This chapter provides a granular view on the material and waste flows previously described in order to provide additional insights on the metabolism of the cross-border Scandinavian area, and hence, a better understanding of the more incipient challenges towards closed-loop systems. It should be noted that given the level of the analysis (i.e. regional NUTS-2 level) the availability of material and waste data for these regions is very limited if not inexistent. In particular, material flows are generally assessed at the national level, while subnational figures are generally the result of some ad-hoc case-study. In this sense, the CIRCTER estimates for specific material consumption flows (i.e. biomass, construction and metal ores) are the only available indicators of this type[6]. On the other hand, collection of subnational waste statistics is generally left to the discretion of the local authorities, which depending on the available resources may have a data collection system in place or not. In general, it is often the case that waste data are collected at facilities and/or municipality level in order to feed national monitoring systems. However, due to the lack of a mandatory regulatory framework at subnational level, waste data are not *reorganised* at subnational levels, nor are they published in official statistical databases. This is the case in the Swedish regions, for which primary data on waste generation at the regional level could not be retrieved for any category. In the case of Norwegian regions, household waste by type of material and treatment was instead available in Norway statistics.

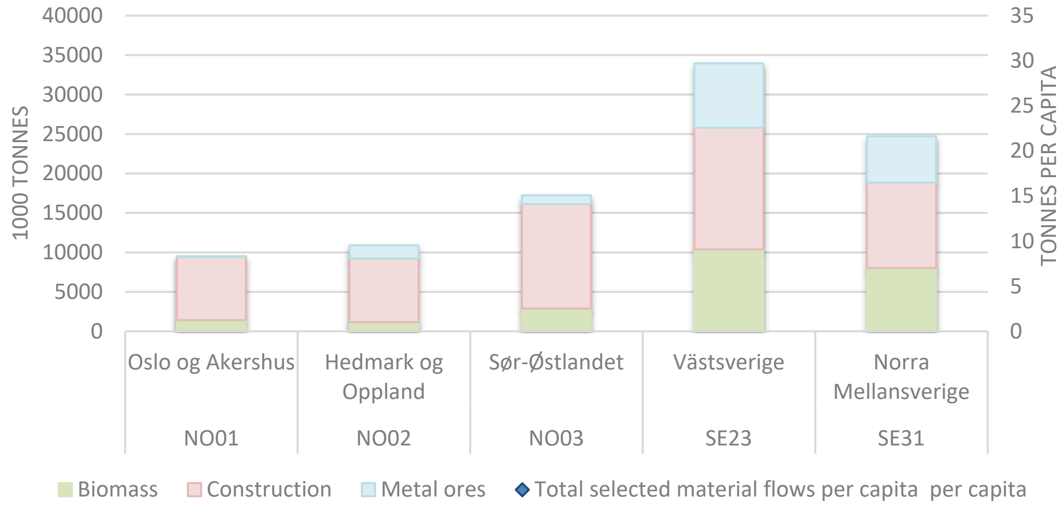
4.1 Material flows breakdown

Figure 4-1 show the breakdown structure of DMC, excluding the fossil energy materials category, which was not considered in the CIRCTER project. First, it can be seen the predominance of Sweden regions in metal ores consumption. This is not surprising as Sweden is one of the largest sources of iron ore in Europe, with approximately 92% of Europe's iron and 5% of the world's iron reserves (USGS, 2020). In particular, the region of North Middle Sweden (SE23) consumes among the highest amounts of metal ores (i.e. roughly 8 million tonnes). This is the fourth highest figure across all European regions (Upper Norrland (SE33) is first in the rank with 27 million tonnes[7]). This high estimate is also corroborated by the amount of employment in the industrial sector (except construction), as North Middle Sweden region (SE23) has more than twice as many employees in this sector than the other regions (137.000 thousand employees in 2019, source EUROSTAT). It follows Norra Mellansverige (SE31) with 6 million tonnes. Here, one of the most famous mines of Sweden, the copper Falun mine, which had (and still have) a significant contribution to the Swedish economy, is located in the cross-boundary county of Dalarna.

[6] At least to the authors knowledge. To note that respective statistical offices have been contacted to ask for potential available data and or studies dealing with these indicators. While some references were provided for waste statistics, regional material flows seem to be not assessed.

[7] Upper Norrland is a key mining region at the national and European levels, concentrating 9 of the 12 active mines in Sweden and providing 90% of the iron ore production in Europe (OECD, 2021).

Figure 4-1: Domestic material consumption breakdown: Biomass, Construction material, Metal ores (1.000 tonnes)

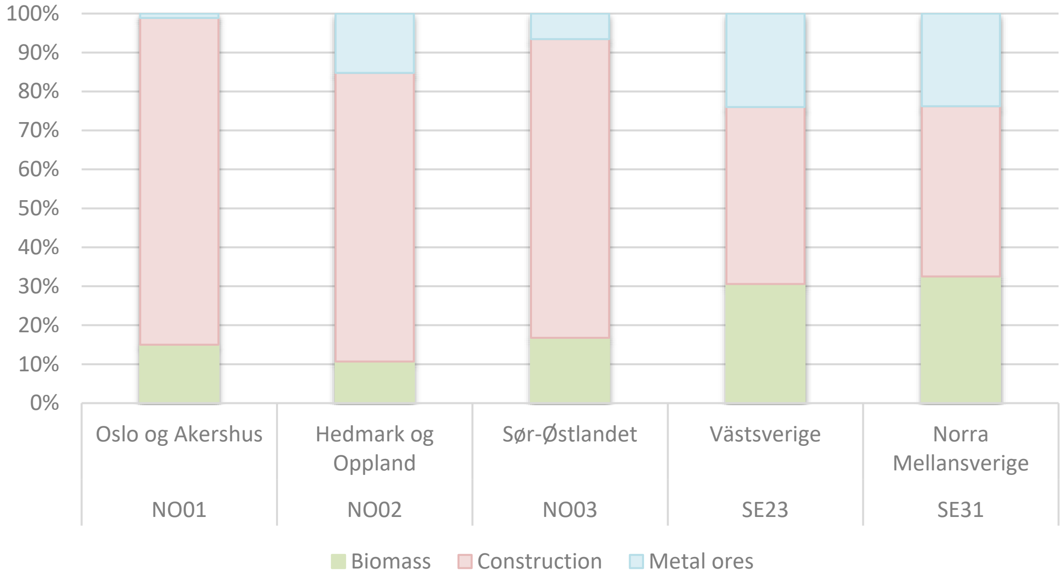


Source: own elaboration based on CIRCTER data

Same patterns can be observed for biomass and, to a letter extent, construction flows. Indeed, in absolute terms, North Middle Sweden (SE23) is the region consuming more materials across the three categories considered. In this sense, it might be the case that the presence of the Gothenburg port area *inflates* material consumption levels. In fact, in commercial harbour areas material flows tend to be overestimated due to trade exchanges and the difficult statistical allocation of transit goods (EUROSTAT, 2019). Notwithstanding, it should be highlighted that, the significantly higher amounts (in absolute terms) of biomass, metal ores and construction material consumption in Sweden regions might facilitate the achievement of critical masses in terms of e.g. organic residuals and/or rubble required to enable circular cascading flows or close technical cycles (see Section 5.2).

In relative terms, construction material seems to be the leading material flow across all regions (Figure 4-2). In the case of Oslo og Akershus (NO01), construction materials represent 85% of the material flows considered, followed by Hedmark og Oppland (NO02) and Sør-Østlandet (NO03), where the construction materials represent approximately 75%. On the other hand, the Swedish regions seem to have a more balanced subdivision of the flows of selected materials.

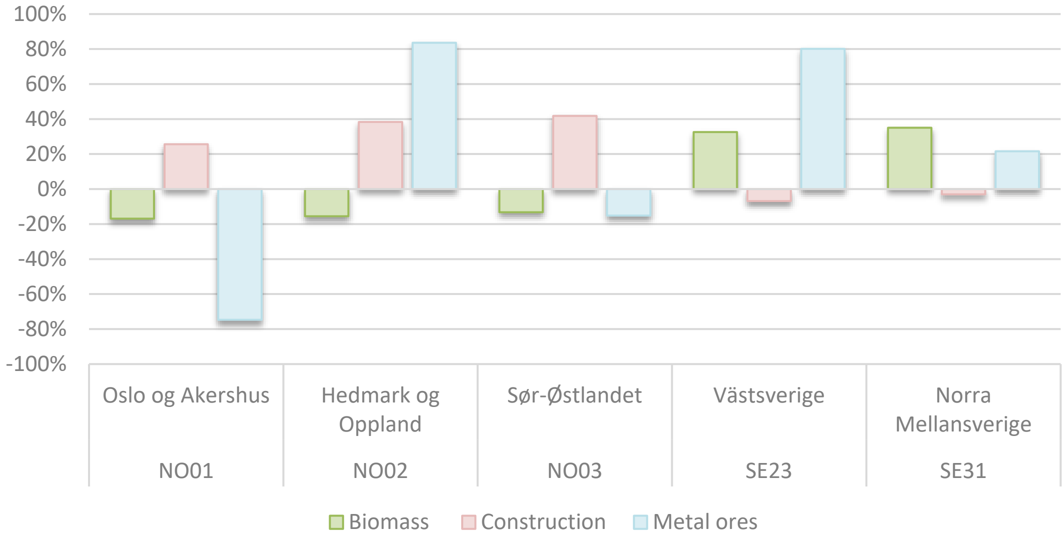
Figure 4-2: Relative shares of Biomass, Construction material and Metal ores (percentage)



Source: own elaboration based on CIRCTER data

Figure 4-3 shows the percentage change in selected material flows recorded between 2006 and 2014. According to the estimates, the greatest changes are observed in metal ores flows with Hedmark og Oppland (NO02) and North Middle Sweden (SE23), which increase the consumption of metal ores by roughly 80%. Opposite patterns, but with same magnitude, can be observed for Oslo og Akershus (NO01), i.e. -80%. However, it should be recalled that these estimates should be interpreted with caution as metal ores were one of the selected materials flows with lower data quality. This was mainly due to the different models employed to generate regional metal ores across 2006 and 2014 (see Circter project, Annex 2 for further details). Concerning biomass and construction material, opposite patterns can be observed between Norway and Swedish regions. While Oslo og Akershus (NO01), Hedmark og Oppland (NO02) and Sør-Østlandet (NO03) increased their construction material consumption by 20% and 40%, the Swedish regions slightly decreased their construction materials. On the contrary, North Middle Sweden (SE23) and Norra Mellansverige (SE31) seems to have increased the consumption of biomass (+30%), while the Norwegian regions have reduced the consumption of the latter (~ -20%).

Figure 4-3: Change in material consumption flows (2006-2014) – Biomass, Construction material, Metal ores



Source: own elaboration based on CIRCTER data

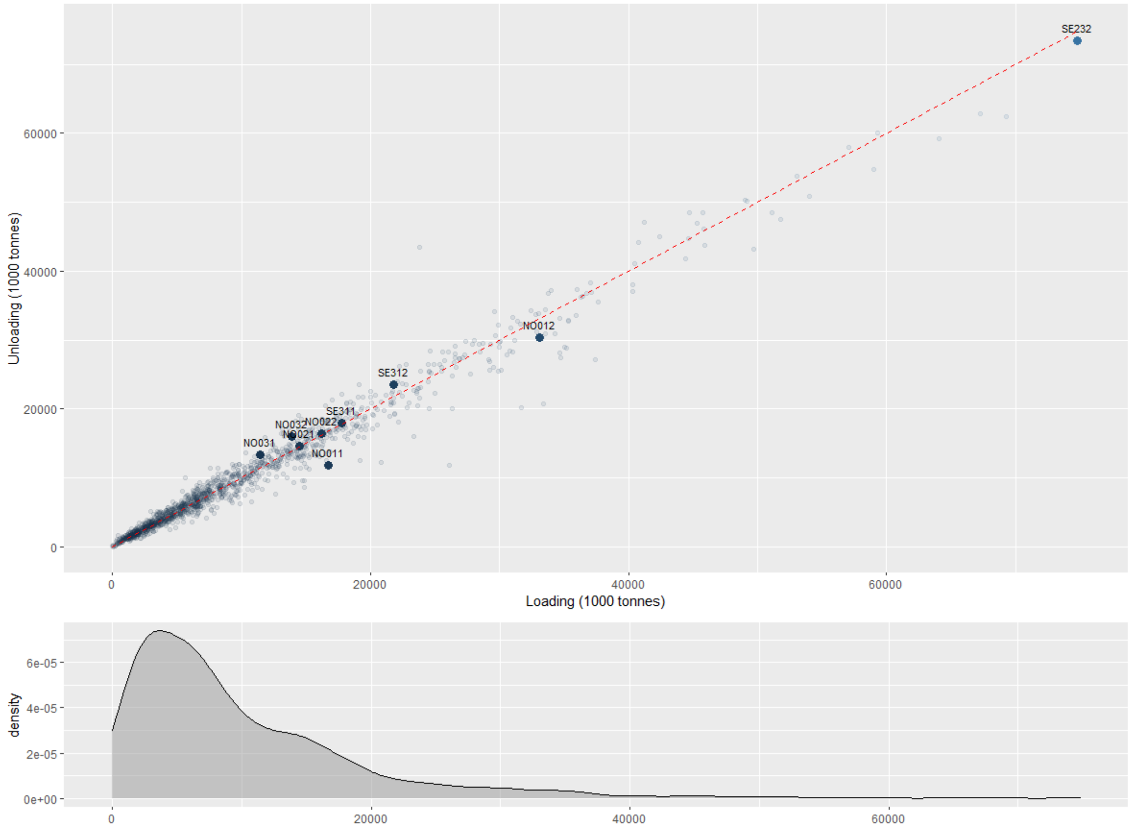
As mentioned above, excluding CIRCTER results, material flow data at subnational level are virtually inexistent. On the other hand, CIRCTER results should be interpreted with cautions because they rely on modelling assumptions and are not based on primary data. Therefore, in order to validate CIRCTER evidence, we refer to the road freight transport regional (NUTS-3) statistics (EUROSTAT: reg_road database). Namely, we present an overview of the amount of goods loaded and unloaded in the cross-border Scandinavian regions. These data represent a novel perspective on the main typology of goods traded/transported in selected regions and, similarly to the export/import figures employed to estimate economic-wide material flows, they constitute a primary input to calculate the amount of material consumed within a region[8].

Figure 4-4 shows the total annual road freight transport by region, comparing the amount of cargo vs amount of unloaded in thousand tonnes. The dashed red line indicates equals amounts of load and unload. Regions below the red line unload more than what they load (i.e. they are net importers in absolute physical terms). By contrary, regions that are above the red line load more than what they unload, i.e. they are net exporter. Oslo (NO011), Akershus (NO012) and Västra Gotaland County (SE232) seem to be the only net exporters regions, while all the other areas are, apparently, receiving more goods than what they are exporting. However, the difference in weight between goods loaded and unloaded could also depend on the type of goods considered (e.g. raw, intermediate, finished). Indeed, given the economic structure of these regions, which specialize mainly in material-intensive sectors, it is possible that they are receiving raw materials for further processing. Obviously, the weight of the incoming raw material is not comparable to the weight of the outgoing processed goods.

In addition to the comparison between goods loaded and goods unloaded, Figure 4-4 clearly shows that Scandinavian cross-border regions have among the highest quantities of goods traded among all European regions. Västra Gotaland County (SE232) represents an exceptional case being on the far right of the density curve, followed by Akershus (NO012) and Dalarna County (SE312). Following section will provide a granular overview of the main categories of traded goods.

[8] Theoretically, the DMC of a region should be equal to the domestic extracted material plus import less export. In this sense, the unloaded amount of goods in a region should represent the imports, while the loaded amount of good represent the exports. However, road freight represents only a part of regional import and export. In this sense, maritime and railway transport are excluded. Similarly, also domestic material extraction should be considered.

Figure 4-4: Total annual road freight transport by region (NUTS-3): amount of loading vs amount of unloading (thousand tonnes)



Source: own elaboration based on EUROSTAT data (“road_go_na_rl3g”, “road_go_na_ru3g”)

Figure 4-5 presents the ten first categories of goods by order of magnitude for the Scandinavian cross-border regions. To note that since transport statistics are available at the lower geographical level NUTS-3, it was possible to re-organise the data to fit exactly the area of study. This means that annual road freight transport is provided for Viken and Innlandet Norwegian counties and Västra Gotaland, Dalarna and Värmland Swedish counties. In addition, considering the close proximity with Viken, the Oslo county was also included in the analysis.

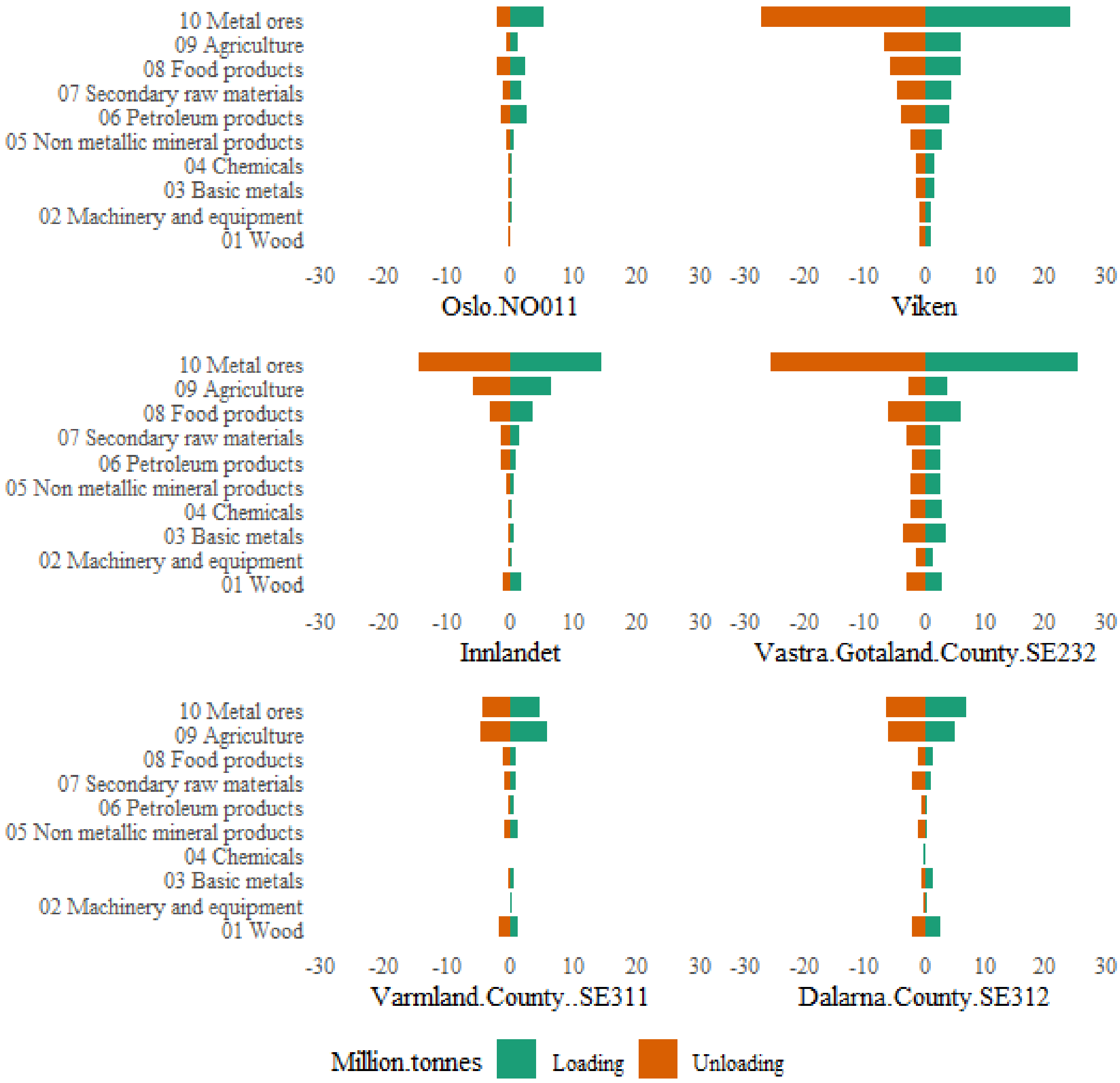
As anticipated by the CIRCTER results, metal ores, which mainly includes iron ores, non-ferrous metal ores and other mining and quarrying products[9], is by far the greatest category of goods for all the regions considered. Viken and Västra Gotaland have loading/unloading quantities of metal ores exceeding 24 thousand tonnes. These are among the biggest figures at European level. The second largest category of transported goods is related with agriculture (or primary) activities. Namely, loading of agricultural, hunting, forestry and fishing products counts over 6 thousand tonnes in Viken and Innlandet. Similar figures apply to unloading agricultural freight. Food products category (excluding food waste) ranks third in the list, being Viken and Västra Gotaland the counties having largest amounts for this type of goods.

To summarize, Scandinavian cross-border regions have an economy mostly specialized in resource-intensive activities, with metal ores and biomass-based products being the main types of traded commodities. The very high DMC and DE per capita suggest that these regions are mainly focused on upstream supply chain activities, namely the extraction of natural resources and the primary refining of raw materials. On the other hand, from a time perspective, it appears that resource consumption is increasing in all regions. In

[9] For further details see RAMON - Reference And Management Of Nomenclatures Standard goods classification for transport statistics https://ec.europa.eu/eurostat/ramon/index.cfm?TargetUrl=DSP_PUB_WELC

particular, the Swedish counties recorded an increase of between 20% and 80% in the consumption of metal ores, while the Norwegian regions show an increase of between 20% and 40% for building materials. These increasing trends are also supported by higher freight quantities for related commodity categories. Circular initiatives tailored to these territorial contexts are provided in section 5.2.

Figure 4-5: Annual road freight transport: amount of loading and unloading by group of goods (Million tonnes)



Source: own elaboration based on EUROSTAT data ("road_go_na_rl3g", "road_go_na_ru3g")

4.2 Waste flows breakdown

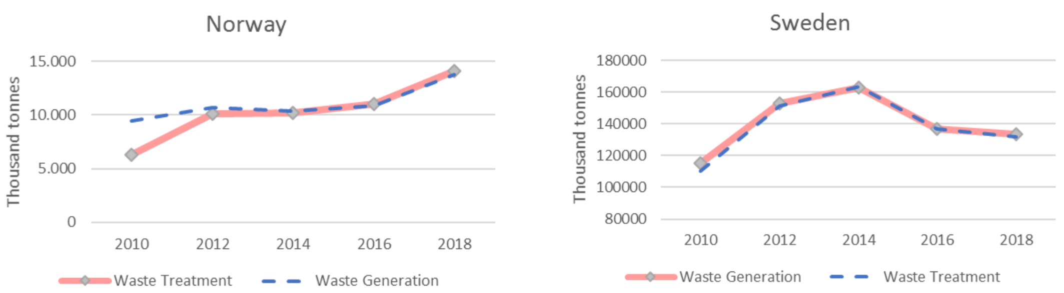
As mentioned above, waste statistics at subnational level is not available on regular basis. One of the few harmonised European databases available at regional (NUTS-2) level was the one compiled as part of a pilot project by means of an environmental questionnaire distributed among Member States . However, the time period of reference is quite outdated (2009-2013) and, most importantly, Sweden was not covered[10].

[10] However these data were mapped and analysed in CIRCTER project. The reader can refer to Annex 2 and Annex 3.

Therefore, in order to complement and support the evidence gathered by CIRCTER statistics in Section 3.2, in this case we will rely on the national waste figures. Indeed, although far from being an ideal solution, the analysis of national waste data can also be a realistic indicator of the most likely trends at the regional level, especially as regards the way waste is treated. Nonetheless, primary waste data are also provided in the case of Norway household waste.

Figure 4-6 shows the total waste generation and total waste treatment for Norway and Sweden recorded between 2010 and 2018. The two countries strongly differ in terms of overall magnitude and direction of the trend. Sweden produces much more waste, about 10 times the Norwegian amount. On the other hand, while Sweden significantly decreased the waste generation from the peak recorded in 2014, in Norway waste production appears to be increasing, missing the national goal to keep the increase in waste below the level of economic growth (Statistics Norway, 2018). Both countries seem treating most of the generated waste domestically, as the waste generation levels equals the waste treatment levels. This assumption was confirmed by checking the national material flow diagrams[11]. Indeed, Sweden only export 2 million tonnes of waste for recycling, while it imports 1.5 million tonnes. This is the 1.5% of total waste generated.

Figure 4-6: Waste generation and waste treatment levels in Norway and Sweden (thousand tonnes)



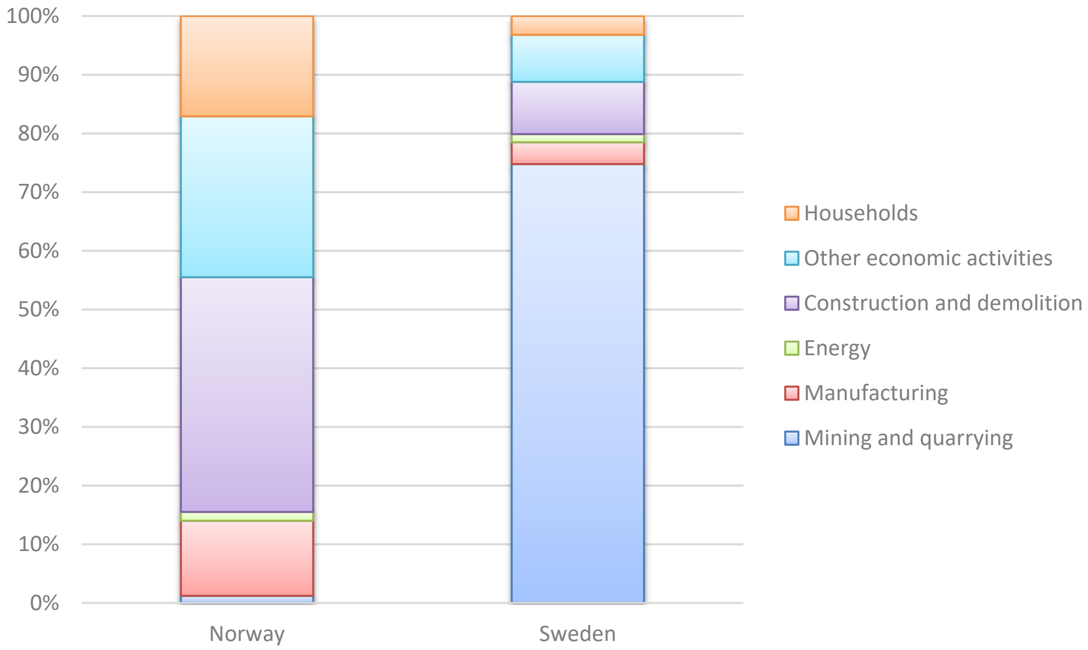
Data source: EUROSTAT: Waste generation **"**env_wasgen" & waste treatment "env_wastrt"

The stark difference between the two countries in the amount of waste generated is mainly due to the economic specialisation of Swedish regions, especially in the north of the country, in mining and quarrying activities. As Figure 4-7 shows, this sector is responsible for up to 75% of all waste generated in Sweden. On the other hand, Norway has a more balanced generation of waste across economic activities, being construction and demolition the leading sector (40%), followed by household (17%).

Since the inclusion of waste generated by mining and quarrying activities *dilutes* other waste flows, and considering that most of these activities are carried out outside the area of study, we present in Figure 4-8 the temporal evolution (2010-2018) of waste generation by selected economic activities, i.e. agriculture, manufacturing and construction, plus household. Waste generation increased among almost all sectors. The only exception is manufacturing, which appears to be the only economic activity that manages to reduce waste generation by around 30% in both countries. On the opposite side, the construction sector has the highest growth rate (260% in Norway ad 32% in Sweden), as well as being the biggest flow in terms of size. Household-generated waste also accounts for an important share of total waste and has increased in both countries (8% in Norway and 12% Sweden).

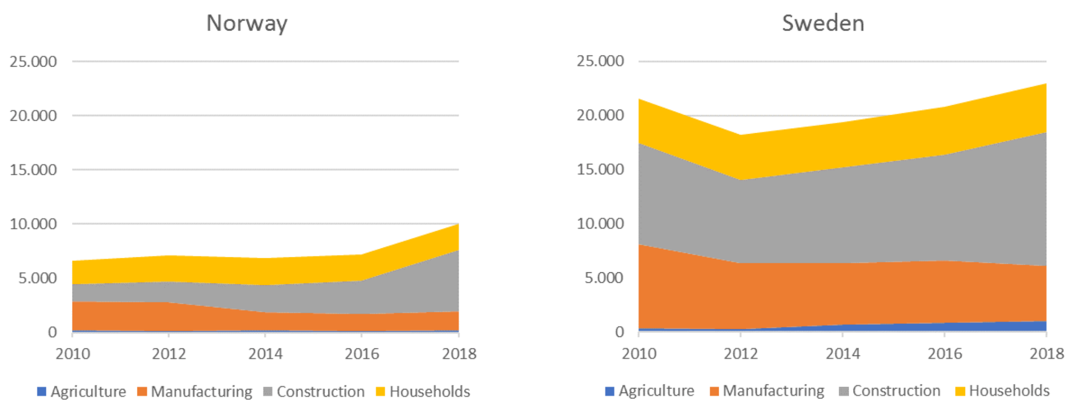
[11] https://ec.europa.eu/eurostat/web/circular-economy/material-flow-diagram

Figure 4-7: Waste generation by economic activity and households (% share of total waste) (2018)



Data source: EUROSTAT: Waste generation “env_wasgen”

Figure 4-8: Waste generation by economic activity and households (2010-2018)

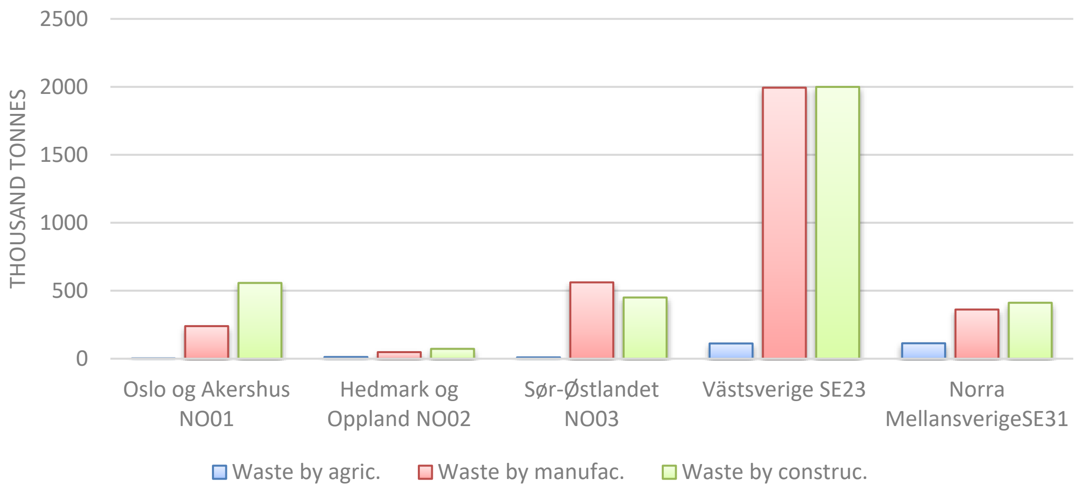


Data source: EUROSTAT: Waste generation “env_wasgen”

The CIRCTER project regionalised these national figures by means of socio-economic drivers (e.g. number of employees by economic activities, population density, gross value added (GVA) by economic activities etc.). The underlying assumption of this approach was that the regional allocation of waste generated by an economic activity should be based on the intensity level of such activity in each region. Therefore, agricultural, construction and manufacturing waste were allocated by means of respective employment and GVA levels. Figure 4-9 presents the regional results.

Similarly to what was observed for material consumption levels, Västsverige region (SE23) has the highest levels of waste generation in all economic activities, especially in manufacturing and construction. These data confirm the Västsverige Region as the industrial and productive nucleus of the Scandinavian cross-border area. Certainly helped by the presence of the port area of Gothenburg, this region concentrates the greatest flows of materials and waste among the regions analysed. In addition, being also a bridge between the Scandinavian cross-border area and the rest of Europe, Västsverige region might also be a critical node for circular initiatives oriented towards reverse logistic models or industrial symbiosis projects.

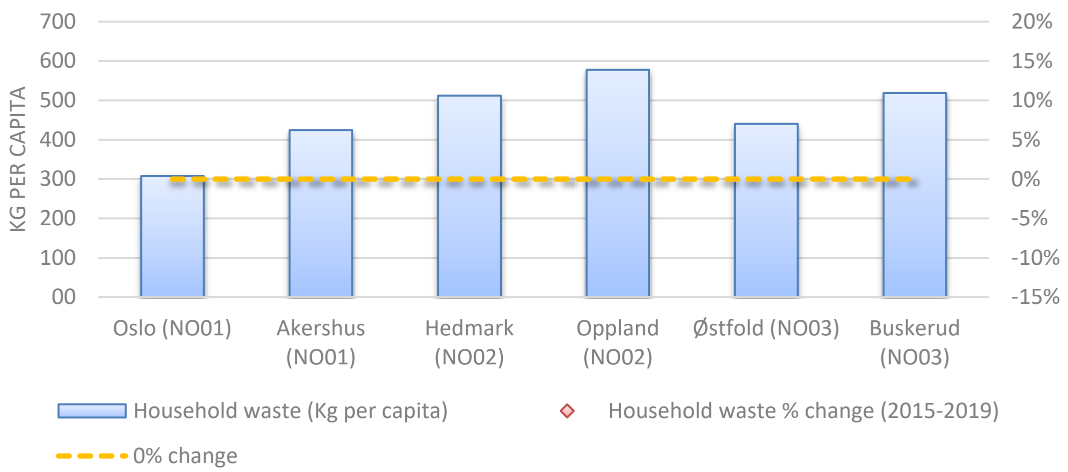
Figure 4-9: Regional waste by economic activity (2014) (thousand tonnes)



Source: own elaboration based on CIRCTER data

Figure 4-10 shows levels of household waste per capita and the change recorded between 2015 and 2019 for the Norwegian regions (NUTS-3)[12]. The Innlandet county (i.e. Hedmark and Oppland) presents the highest levels in household waste generation, more than 500 kg per capita. This is above the European average (425 kg per capita in 2018). Surprisingly, these regions are also the only ones to have a positive growth rate for household waste. In particular, Oppland recorded a net increase of 18%. On the other hand, Viken County (i.e. Akershus, Østfold and Buskerud) has overall levels of household waste in line with the European average and, more importantly, these are decreasing in all sub-regions. Also noteworthy is the Oslo region, the *best-in-class* with 300 kg per capita and a 10% reduction in the 2015-2019 period.

Figure 4-10: Regional household waste levels (kg per capita) and % change (2015-2019)



Data source: Statistics Norway

[12] Household waste for the Swedish regions was not regionalised in the CIRCTER project due to a lack of data. Likewise, primary data on household waste could not be retrieved from the official Swedish statistics.

It is interesting to note that the Akershus county, while showing a decreasing trend in terms of household waste per capita (-2%), has an increasing trend in terms of absolute production of household waste (+5%). This is probably due to the rapid demographic expansion that the region has had in recent years. Indeed, Akershus County, often referred to as “the green belt of Oslo”, has the highest level of net migration within Norway and attracts many people in the age group 30–39 years from both Oslo and abroad. Over the most recent 20 years, as a result of immigration from abroad and migration within Norway, the County has seen a 35.4% increase in population and a further increase of 200 000 is foreseen by 2040[13]. These demographic trends constitute (and will constitute) a significant pressure on the natural environment as they translate into long-lasting items such as infrastructure and buildings. Therefore, a purposeful design of the built environment including circular economy principles will be critical in these areas (see section 5.2.3).

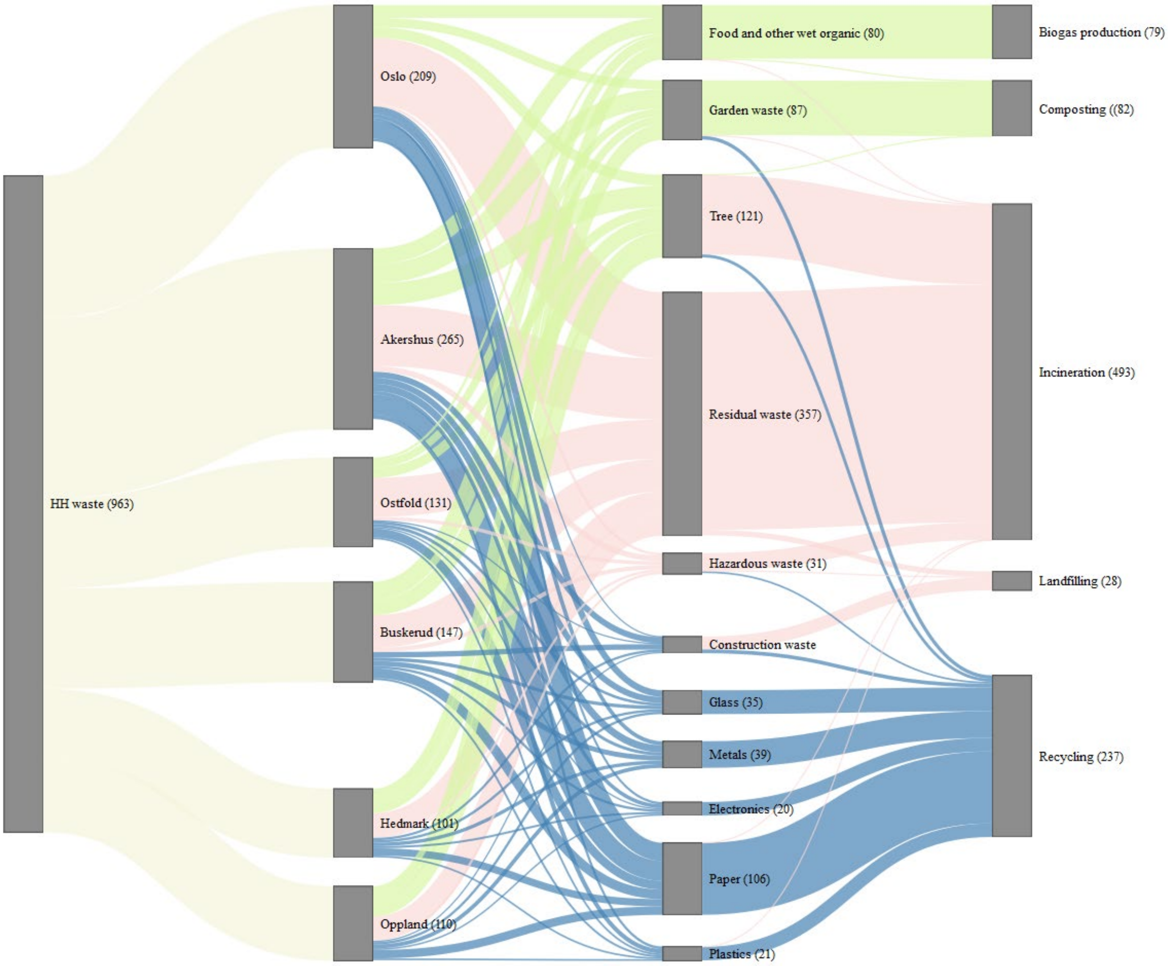
Figure 4-11 provides a Sankey diagram of household waste flows by selected Norwegian regions (NUTS-3), type of waste and type of treatment. Not surprisingly, the region generating more household waste is Akershus (265 thousand tonnes), followed by Oslo (209 thousand tonnes). Within each region, the biggest flow is generally constituted by residual waste, i.e. unsorted waste that ends up to incineration facilities. The total amount of residual waste is 357 thousand tonnes, which is almost 40% of total household waste generated. The overall treatment of household waste in selected regions is dominated by incineration, accounting, respectively, for 51% of household waste generated in 2019. Even if 80% of the waste sent for incineration is utilised for energy recovery, the current Norway over-reliance on incineration is a well-known issue that has contributed to a lock-in effect in waste management systems as it prevents proper recycling and compel municipalities to burn materials that could be recycled or composted.

Biotic flows of residuals are mainly recovered by superior options in the EU’s waste hierarchy, i.e. biogas production and/or composting. These account for the 17% of total household waste. However, it should be noted that a significant amount of organic material (tree) seems to be sent to waste-to-energy incineration facilities (12% of total household waste). On the other hand, paper, metal and glass are the biggest abiotic flows that are almost entirely recycled. However, it should be noted that these figures only reflect the actual materials correctly sorted. The potential for reducing such waste flows and achieving higher recovered amounts of these material is very high if actions are taken up-stream in the supply chain through e.g. eco-design and/or enhanced municipal waste collection systems.

Also noteworthy is the construction material waste generated by household, which remains one of the few waste flows still largely landfilled. This is particularly concerning, considering that also a large share of mineral waste generated by economic activities is still landfilled at the national level (31% in 2016). Sweden presents a similar situation, i.e. 24% of mineral waste is landfilled. These figures are well above European average (11%). In part, the larger availability of natural space in these countries may have limited the implementation of stricter regulations such as a ban on landfilling. Regulations that other countries such as Luxembourg have been forced to impose mostly due to the lack of space. Therefore, a range of interventions should be considered by local policymakers to facilitate the uptake of circular economy actions that will improve construction waste management, especially in those areas characterised by strong urban expansion.

[13] Akershusstatistikk nr 3-2016 – befolkningsprognoser for Akershus 2016–2031 [Akershus statistics no. 3-2016 –population prognoses for Akershus 2016–2031]. In: Statistikkhefter og grunnlagsdokumenter [Statistics and foundation documents] [website]

Figure 4-11: Household waste by region, material and treatment (thousands tonnes, 2019)



Note: colours reflect the type of flows: Household waste generation "beige"; Biotic circular flows "green"; Abiotic circular flows "blue"; Mixed waste -lost- flows "red". Data source: Statistics Norway;

A shift from composting to biogas production appears to be taking place in most counties, as more biogas plants have been installed, while some of the composting plants have been closed. The increased amount of waste for biogas production is not only explained by the waste diverted from the composting plant, but also by higher recovery levels of food waste and other wet organic waste. However, most food waste still goes with mixed waste, mainly for incineration.

Table 4-1 shows the evolution of household waste by treatments options observed in Norway regions between 2015 and 2019. As anticipated above, areas such as Akershus, which are going through a rapid urban expansion, should guarantee an effective management of waste in place in order to avoid last desirable options of waste treatment. Landfilling in this county increased 323% (from 4 to 17 thousand tonnes) in the 2015-2019 period. Similar figures can also be found in Oppland county albeit in smaller absolute terms. To note that while landfilling decreased significantly in the period 2009-2014 (EEA, 2016), from 2015 it seems to start growing again in all counties, with the exception of Oslo.

On the positive side, almost all counties increased waste levels sent for material recycling, Akershus and Oslo are the only exception in this case. Oppland achieved the highest increase (42%) in waste recycled, followed by Buskerud and Østfold, both 8%. A shift from composting to biogas production appears to be taking place in most counties, as more biogas plants have been installed, while some of the composting plants have been closed. The increased amount of waste for biogas production is not only explained by the waste diverted from the composting plant, but also by higher recovery levels of food waste and other wet organic waste. However, most food waste still goes with mixed waste, mainly for incineration.

Table 4-1: Household waste by treatment typology (thousand tonnes) (2015-2019)

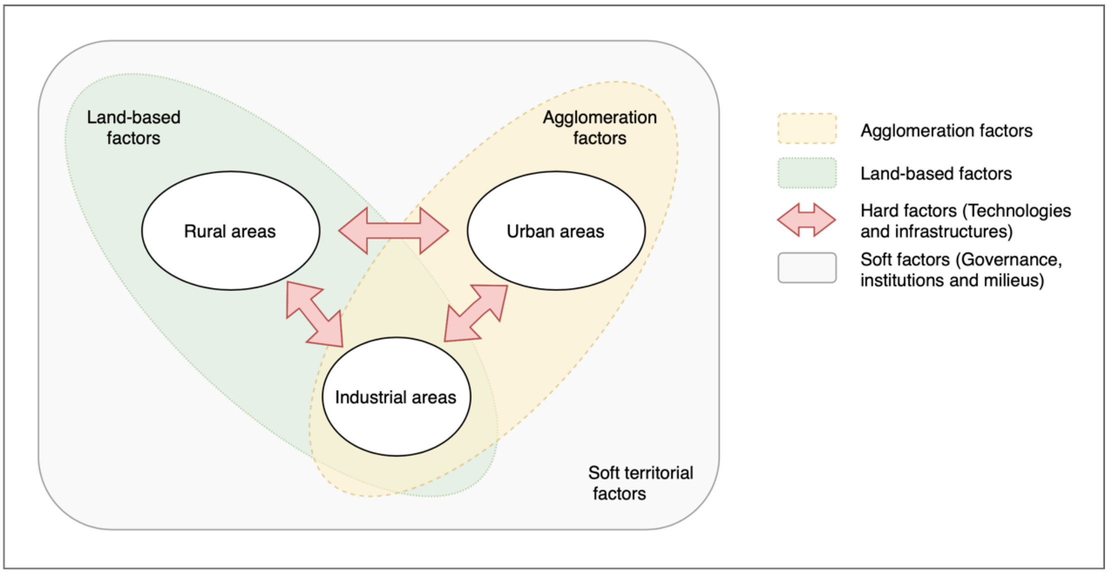
			2015	2016	2017	2018	2019	% change (2015-2019)
Oslo		total	221	218	218	213	209	-5%
		recycling	55	54	54	53	52	-4%
		incineration	128	126	126	125	119	-7%
		landfilling	7	7	7	6	6	-21%
		biogas production	16	17	17	16	19	18%
		composting	15	14	14	12	13	-14%
Viken	Østfold	total	138	136	121	127	131	-5%
		recycling	28	28	27	28	30	8%
		incineration	82	92	84	84	80	-2%
		landfilling	3	2	2	2	4	**37%**
		biogas production	3	3	2	3	4	7%
		composting	9	7	5	9	11	21%
	Akershus	total	253	258	243	243	265	**5%**
		recycling	67	67	63	64	66	-1%
		incineration	141	151	136	127	130	-8%
		landfilling	4	6	5	11	17	**323%**
		biogas production	9	12	15	22	23	156%
		composting	30	21	24	20	27	-10%
	Buskerud	in total	150	148	150	149	147	-2%
		recycling	36	37	38	39	39	8%
		incineration	85	81	80	80	77	-10%
		landfilling	3	4	6	5	4	**43%**
		biogas production	13	13	13	14	14	9%
		composting	13	12	12	11	12	-4%
Innlandet	Hedmark	total	99	97	101	102	101	3%
		recycling	26	26	26	26	26	3%
		incineration	50	49	50	52	51	3%
		landfilling	2	1	3	4	3	**58%**
		biogas production	8	9	9	9	9	9%
		composting	12	12	11	11	11	-9%
	Oppland	total	93	96	100	104	109	18%
		recycling	23	24	25	26	32	42%
		incineration	49	50	53	52	55	12%
		landfilling	1	2	2	4	4	**392%**
		biogas production	11	11	11	11	10	-4%
		composting	7	6	6	10	6	-5%

Data source: Statistics Norway

5 Circular Economy and the territorial perspective

In this chapter, we explore the role that territorial aspects identified in CIRCTER might have in the Central cross-border Scandinavia for the circular economy transition, besides being potential drivers of economic competitiveness and resilience. In CIRCTER project we focused on six factors that, according to the reviewed literature, show higher relevance from a circular economy perspective. These includes (Figure 5-1): (1) land-based resources, (2) agglomeration factors, (3) accessibility conditions, (4) technical and technological capacity, (5) knowledge-related factors, and (6) governance and institutional drivers. It follows a brief description for each of them, while section 5.2 will expand on the potential implications for the analysed territory.

Figure 5-1: Key territorial factor towards a Circular Economy.



Source: CIRCTER project

5.1 CIRCTER territorial factors

Land-based resources emphasise the relevance of natural endowment to satisfy the growing demand for raw materials and biomass feedstock for a circular economy. Unlike inert materials, which can be recovered and used in closed-loops, biotic materials can be used in cascades. This refers to the efficient utilisation of organic resources by using residues and recycled materials sequentially to extend total biomass availability within a given system. In general, circular economy frameworks emphasize the sustainable management of renewables feedstocks (e.g. in farming, fishing and harvesting activities), often linking land-based factors with rural areas, where the greater availability of land allows such activities. However, also urban areas play, indirectly, a key-role to close biotic loops. First of all, cities produce the largest amount of food waste. This means that they can take an active role in optimising consumption of food, reducing in the first instance the organic waste and re-directing the residuals to soil regeneration treatments. Second, available land is often the most valuable resource in cities. In general, cities depend on peripheric areas for the procurement of resources and assimilation of waste. The destination of land in cities for ecosystem services, aimed for example at producing food (e.g. urban agriculture) as well as tackling environmental hazards and the degradation of natural capital (e.g. urban forestry to absorb carbon dioxide, nature-based solutions to mitigate flooding), could potentially help reduce the consumption of inland resources and regenerate urban ecosystems (Williams, 2019).

Agglomeration factors refer to concentration of business, consumers and/or production means required to enable certain circular economic activities. Industrial agglomerations create the right conditions for all circular economy initiatives whenever diversity and complementarity are important enabling factors, such as for industrial symbiosis programmes (see for instance the Dunkirk case study in France (Beaurain et al., 2017; Morales and Diemer, 2019)). Furthermore, economies of scale in urban areas can also enable recovery of low-value materials that require significant volumes to ensure financial sustainability of the waste reclamation plants. In general, the lower the value of materials, the higher the quantities needed to enable profitable operation (Cucchiella et al., 2015; Wang et al., 2014). Economies of scale are not only important factors for recycling schemes. Urban agglomerations also increase resource use efficiency and create the right conditions for the development of business models that are based on product sharing, pooling and other forms of collaborative consumption (Brown et al., 2019; Cohen and Kietzmann, 2014). Frequently, urban areas are the only possible setting for profit-driven circular business models, as most of them require a certain 'critical mass' to become financially sustainable (Acquier et al., 2019).

Agglomeration and land-based factors mostly define optimal framework conditions for specific circular strategies. Still, they are not the only factors needed for a successful transition towards circular system. Closing material loops also require access to secondary materials and by-products for all economic actors. **Accessibility** to used products and secondary materials can greatly affect operational costs of firms adopting circular business models (Holgado and Aminoff, 2019) or participating in industrial symbiosis schemes (Domenech et al., 2019). In this sense, infrastructure enables the transportation and re-allocation of stocks in an efficient way. In general, areas located close to transportation hubs (like airports, ports, railway stations) and/or having in place effective intermodal transportation systems and logistic hubs can be significantly advantaged when it comes to triggering the economies of scale related, for instance, to the processing of secondary raw materials or the collection and recycling of low-value waste (Malinauskaite et al., 2017). This infrastructure is also required for the establishment of circular business models based on reverse logistics and take-back programmes (Dhakal et al., 2016).

Next to accessibility**, knowledge-base** and **technology capacity** factors also boost the development of circular economy in various ways. Technical knowledge, skills and information, including access to guidance and capacity to assemble and absorb knowledge are equally relevant at business, institutional and community levels. In the private sector, these factors become crucial for the development of more sustainable products and services through strategies such as eco-design, life cycle management and the adoption of circular business models. Equally, the role of emerging technologies triggering epochal shifts in industrial systems is widely recognised, particularly for digital technologies (Pagoropoulos et al., 2017) and the related concept of industry 4.0 (Nascimento et al., 2019). Technologies enable the implementation of circular economy processes not only along the value chain (e.g. cleaner production and eco-design) but also have a critical role for unlocking the market for secondary low-value material streams (Jawahir and Bradley, 2016). However, circular solutions and technologies like refurbishment and remanufacturing often compete with traditional, often cheaper, alternatives (Korhonen et al., 2018). Moreover, technologies may also create path dependences and lock-in effects in specific areas (Kalkuhl et al., 2012; Wilts and von Gries, 2015), including the bioeconomy (Marsden and Farioli, 2015).

Finally, **governance and institutional factors** contribute to create the necessary conditions for circular economy activities to root and materialise in concrete actions (Kanda et al., 2019). Governance and institutional arrangements not only promote circular economy principles, but also favour the establishment of other factors, such as knowledge diffusion and increased collaboration between firms (Niesten et al., 2017). Cultural and symbolic aspects of social elements, such as values, norms, cognitive repertoires, are also viewed as strategic assets affecting innovation because of their capacity to enhance small firms' action and to provide opportunities to compete in the knowledge economy (Fernández-Esquinas et al., 2017). Localised interactions between societal (value attitude, life-style, perceptions), institutional (regional policy context) and market components (networks, cooperation, etc.) have the capability to relate physical resources with local actors, facilitating the circulation of information and agent coordination within a region (Morretta et al., 2020). Such networks and connections can enable and promote circular economy transformations, as the latter require stronger collaboration between companies throughout the entire value chain (Lahti et al., 2018).

5.2 Territorial implications for the cross-border Scandinavian area

Understanding the territorial specificities of different areas becomes crucial to envisage a successful transition to a circular economy. Whereas agglomerations levels and land-based factors contribute to determine the framework conditions of circular transformations at the regional and local levels, accessibility and technologies might help to define the effectiveness of circular economy strategies, while 'soft' factors such as knowledge, governance and institutional factors ultimately contribute to *catalyse* this transformation (Tapia et al., 2021).

The cross-border Scandinavian area has good access to renewable resources, technical cutting-edge skills and industrial infrastructure. As suggested by EW-MFA indicators, these assets translated in economic structures mainly specialised in material-intensive activities. Domestic extraction and domestic consumption per capita are among the highest across European regions. Consequently, most of the regions are export-oriented, regularly trading raw material such as metal ores and wood, agriculture and food products. These territorial endowments offer excellent conditions for the development of a world-class circular and bio-based economy, as reflected by the most recent strategic objectives included in regional policy documents.

In terms of waste, Norway and Sweden are the European countries principally relying on incineration facilities with energy recovery. This is especially true for municipal waste where household waste accounts for the largest share. However, nowadays, this waste treatment option is increasingly contested because of its doubtful trade-off between energy-efficiency gains and environmental degradation (Abbasi, 2018). Furthermore, it seems that, perhaps favoured by the large availability of space in these areas, a relevant amount of construction waste is still sent to landfill instead of being adequately reused, recycled or recovered. Circular economy initiatives should be aimed therefore at exploring how to prevent in the first instance the production of waste, especially in those areas characterised by rapid urban expansion.

Next to waste prevention, the expansion of urban areas such as the Akershus region within the Viken county also calls for a development of the built environment encompassing circular principles. Even if the Viken county is far from being as densely populated as European urban regions, the lack of agglomeration factors should not be seen a limit. Rather, several circular-oriented proposals might support a balanced regional development across urban and rural areas, mitigating the increasing concerns over social cohesion and sustainable development.

Last but not least, the cross-boarder Scandinavian area benefits from a historical tradition of cooperation. High levels of collaboration between research-intensive industry, academia, research institutes and the public sector are already in place not only within regions, but also between cross-border regions. As an example, Innlandet (NO02) and Värmland (SE311) have recently established a strategic cooperation agreement within selected priority areas to promote joint regional development and growth. Through the collaboration, Innlandet and Värmland also wish to strengthen projects where both parties are involved for the best possible implementation of these. If any, the Scandinavian area exhibits one of the strongest *territorial milieus* at European level. This is a fundamental enabler for the implementation of circular solutions.

Following sections will elaborate further on each of these circular-focused strands.

5.2.1 Towards a circular and bio-based economy

As highlighted in the present study and by the on-going policy initiatives, the bioeconomy is an important sector for all regions of the cross-border Scandinavian area. Undoubtably, a major asset and opportunity for leading the transition towards a bio-based economy in the area lies in the abundance of natural assets and resources, including, agricultural land, forests, lakes and rivers. Viken has 20% of the agricultural land currently used in Norway, and 60% of the land used to grow wheat and oats. Agriculture and forestry are two important industries also in Innlandet (NO02), which produces 20% of Norway's agricultural production and about 40% of timber. The primary sector, including forestry, also plays a key role in the economies of Dalarna and Värmland, which, as shown in the transport statistics, trade very large quantities of this type of goods.

These assets give the area a particular strength to take advantage of green growth opportunities, above all because they are backed-up by a strong presence of innovation stakeholders, i.e. universities, R&D capacities in companies, economic hubs and skilled workforces in the science and technology sectors. According to CIRCTER statistics, rural regions such as Innlandet and Norra Mellansverige (the region within which Dalarna is located) already have among the highest levels of employment in activities related to the input-side of a circular economy (i.e. material providers). While the detail of available data does not permit to provide tailored recommendations on the specific bio-based streams, few considerations can be done at a more strategic level.

First, it is important to stress that a bioeconomy not necessarily represents a more sustainable option compared to business-as-usual (Kretschmer et al., 2013). In particular, when assessing the sustainability of bio-based products, two aspects should be addressed: the efficient use of biomass resources, including residues and waste, and the side-effects that such structural shifts might represent on the overall system. On the one hand, the environmental consequences of diverting residues from previous uses (straw and forest residues) must be considered (e.g. effects of greenhouse gas emission). On the other hand, a superior technological solution might also have unintended environmental consequences and lead to new path dependencies. For example, the massive deployment of advanced biofuels from forestry and agricultural residues often led to increased competition for land and water that could otherwise be used for food production. In this sense, a **"circular" bioeconomy** might help to ensure that the existing renewable bio-resources are used in an efficient and sustainable way, or that organic waste, co-products and by-products are treated as resources for the bioeconomy. The bioeconomy and circular economy can contribute in several ways to each other, including (Carus and Dammer, 2018):

- Utilisation of organic side and waste streams from agriculture, forestry, fishery, aquaculture, food & feed and organic process waste to applications such as aquaculture feed and all kinds of chemicals and materials;
- Biodegradable products being returned to the organic and nutrient cycles;
- Successful cascading of paper, other wood products, natural fibres textiles and many more;
- Innovative additives from oleo-chemicals enhancing recyclability of other materials;
- Collection and recycling of bioplastics (once the critical volume of new, bio-based polymers is reached);
- Linking different industrial sectors (food industries & chemical industry).

The cascading use of biomass and waste resources has become an important way in which to improve resource efficiency (European Commission, 2020, 2012), and it implies that burning such resources should be the last option, to be adopted only when no other use can be projected. Therefore, beyond the sound management of land use and improving the resource use efficiency, regional bioeconomy strategies should **envision** cascading flows based on: (1) the **measurement** of the specific material stocks associated with the characteristic of individual products in a system during their use phase, and (2) the **estimation** of the potential type and amount of materials that are available for the *recycling* infrastructure at a certain time. Another aspect is associated to the **quality of the material streams**. By providing a qualitative assessment of the material streams after the life cycle of a product, their technical and economic utilisation alternatives can be better understood. And this has a critical role in the definition and establishment of industrial concepts that close or at least improve the material loops within the productive system, as it is possible to define the highest value-added alternatives for the available resources.

The **spatial dimension** has also to be included in the decision-making process. As the technical concepts that drive the industrial networks to attain these strategies are implemented at production facilities, these facilities become part of a 'regional landscape' (O'Keeffe et al., 2016). Within this landscape, or geographical frame, these production facilities interact with each other either synergically (e.g. through coupled production) or in competition with each other (e.g. for using usually limited available local or regional resources). And they interact both individually and as a network with the environment, market and society, thus resulting, as anticipated above, in environmental, social and economic effects at different scales (local, regional, national and global). An optimal use of the available resources should be planned taking into account the overall effects of the implemented or desired productive system across all domains, i.e. economy, society and environment. Therefore, it will be imperative to consider the participation of representatives from the different sectors (i.e. society, markets (including consumers), industry (manufacturers), biomass suppliers and government), and from different scales (i.e. regional, national and international) into a common discussion. In this context, the engagement of all these relevant stakeholder groups might be eased by platforms with the objective of promoting dialogue and co-creation towards the development of action plans. As an example, the recently concluded Horizon 2020 BIOVOICES project created a **Mobilisation and Mutual Learning** (MML) platform in bio-based domain.

5.2.2 Decoupling waste generation from consumption

5.2.2.1 Prioritising waste prevention

As an ever-greater part of the world's population is living in urbanised areas, dealing with urban waste is becoming an increasingly prominent challenge for local authorities. In many places, local authorities are struggling to cope with growing amounts of waste annually, as cities grow and citizens' consumption rises. As shown in section 3.2 and 4.2, the regions of the cross-border Scandinavian area are not an exception to these macro-trends. Similar conclusion can be made looking at national figures: in 2016, Norway has generated more WEEE per capita than other country in the world; the amount of food wasted in Norway annually equates to the food consumption of 900,000 people; 41% of the household waste produced in Norway in 2018 was sent for recycling, 56% waste are incinerated, 0.8% goes to landfill.

On top of that, it is becoming increasingly clear that the generation of urban waste has consistently outpaced the overall efforts to dispose it cleanly. Strong efforts have been made to develop technologies for the recovery of energy from municipal waste by direct use as fuel (incineration) or by converting waste into gaseous or liquid fuels via landfilling, anaerobic digestion and other bioprocesses. However, such measures not only proved to be less-than-adequate over time but also disincentivised further efforts toward waste reduction. The Nordic countries are a prime example of this evidence. Sweden and Norway are among the top three European countries (Finland is the first) for waste incineration with energy recovery. Since these infrastructures require a stable amount of incoming material to be incinerated to be profitable, the very large capacity built in the Nordic countries caused a lock-in effect, which prevented the shift toward higher-level waste treatment options (Klitkou et al., 2019). For instance, the municipality of Oslo has been guided by political strategies aiming for a 50% recycling target. Such a target did not represent any incentive for waste prevention but represented a technical specification that translated in a lock-in of the recycling stage in the waste hierarchy. The development of a circular system for the recycling of household waste constitutes a value chain that can be seen as a disincentive to support efforts to reduce waste streams in the first place. Considering that landfill sites will be closed over time and that waste generation will likely continue to grow in these regions due to population growth (see Akershus and Innlandet), alternatives to reduce waste should be prioritized in the first place over end-of-pipe solutions, to avoid again technological lock-in traps.

To this aim, from a **systems perspective**, a sound dialogue between product designers and end-of-life materials managers (i.e. the waste industry) need to be at the heart of the discussion, as it will be a crucial step for the implementation of circularities within the production system. Otherwise, energy recovery alternatives will remain as the most adequate end-of-life treatment, without feasible options for waste management systems focused on material recovery. To allow for upward leaps in the waste hierarchy and, therefore, to separate waste generation from consumption, it seems more appropriate to operate with more **open and functional requirements** from the very early stages of product concept design rather than specify which sort of solutions are sought.

5.2.2.2 Circular business models and circular public procurement

Similarly, CE practitioners often emphasize circular strategies aiming at closing loops, that is, reuse and recycle. However, a challenge here is that initiatives aimed at reusing and recycling resources will only reduce primary production when secondary products/materials actually displace the primary production. In a reality of growing demands, secondary (reused/remanufactured/recycled) products are often sold in addition to primary (new) products, resulting in environmental impacts of both the primary and secondary production (Zink and Geyer, 2017). Thus, in order to ensure a net resource reduction, CE strategies based on reuse and recycle should confirm that actual "displacement" takes place. **Eco-design** and **product service/system** are often recognized as promising approaches to enhance the sustainability performance of traditional product/systems, due to its potential to improve resource efficiency by extending the product lifetime and decoupling value from the delivery of physical products (Kjaer et al., 2019). This change of paradigms in the current way of using resources can only be given by introducing the principles of circular economy thinking to the market and in the public procurement strategies and practices of cities and it should consider innovation from a multidimensional perspective – including involving products, processes and new business models and by exploiting the synergies between public authorities, research institutions, SMEs and non-profit organisations in this field.

From a territorial perspective, the industrial-economic fabric in the cross-border area appears already well developed. Regions such as Värmland and Västra Götaland, which have a clear orientation towards advanced manufacturing and technological innovation might be the natural places where such initiatives might take place. Västra Götaland presents a strong substrate of universities leaders in research and education and competitive industry. The region has the ambition to become a leading knowledge and industrial region, with research and innovation investments that should count for at least 5% of the Gross Regional Product. Priority sectors include textiles, furniture among other, with the aim of providing circular value chains. Värmland also offers an established system of schools and university that prepare on circular bio-based economy and innovation park, especially in the pulp and paper sector.

Local authorities have the capacity to promote businesses, non-profit organizations, and community groups with innovative solutions. As an example, they might stimulate the emergence of circular-oriented innovations by public procurement and capacity building initiatives. In this context, the **Circular Public Procurement** project funded by the Interreg Baltic Sea Region Programme 2014-2020 might serve as an inspiration for the future INTERREG programme 2021-2027. The main goal of this project is to develop an adequate framework for circular procurement, including (1) building the necessary capacity on circular procurement for all relevant stakeholders of the value supply chain, namely public procurers, SMEs and policy makers and (2) delivering call for tenders aligned with the defined priority areas to enable learning by doing and ensure the projects develops practical capacity building material.

5.2.2.3 Consumers' mindset change

People are at the centre of a cultural shift towards new business and governance models within a circular economy. Changing the practices and consumption habits of those living in cities will be critical to the delivery of resource decoupling. More specifically, if citizens do not ‘buy into’ consuming circular products (e.g. recycled goods, renewable energy) and services (e.g. renting, leasing, sharing) or adopt circular practices (e.g. repairing or upcycling goods, composting organic waste), then a circular society is undeliverable.

There is increasing evidence that municipalities as planning authorities have a leading role in enabling citizens to take an active role in a circular economy (Fratini et al., 2019). This is achieved through for instance the **provision of spaces** where people can come together to share items such as tolls, toys, clothes, or bring material for repair or reuse (e.g. repair café). As an example, the City of Malmö (Sweden) has captured this concept in the strategic vision for the municipality, with physical spaces identified to facilitate sharing. Under this model, the CE in cities is built up through relationships and networks, promoting local skills for the maintenance and repair of products. In turn, these initiatives may also help local governments to achieve broader goals, including social cohesion, capacity building and equal opportunities, by envisioning most precarious social groups as direct beneficiaries of reuse, repair and gift initiatives.

5.2.3 A circular economy for the built environment

Construction and demolition activities are responsible for 30% of all waste generated in Europe, making construction and demolition waste (CDW) the most significant stream in the EU. As shown in section 4.2, Norway and Sweden are not an exception, being the waste from construction activities the biggest waste flow and, more importantly, the only one still increasing at constant pace. At more local level, the increasing urbanisation and demands for housing, led urban areas to also become the hub for CDW. Remarkably, it seems that in several regions of the cross-border Scandinavian area a significant part of construction waste is still landfilled.

Differently from other waste stream such as WEEE, CDW generally has a lower residual value. This, combined with the size of this waste stream, often results in a critical bottleneck when trying to implement circular configurations of CDW at a larger (e.g. national) scale, as the greater distance between supply and demand often does not repay the value of the rubble. That is why addressing this issue at a local scale might be especially important in order to avoid such financial barriers. Several initiatives have recently been implemented as part of the Cityloops project (https://cityloops.eu/) to promote circularity in the construction and demolition waste sector at the local level. Many of them relate to the **urban mine** concept, that is the process of reclaiming raw materials from spent products, buildings and waste. In the case of CDW, the creation of *databanks* of construction materials from demolition sites in the area seems to be a cornerstone for creating a marketplace for recovered construction materials (see e.g. the BAMB project, https://www.bamb2020.eu/). These databases store information on materials such as volume, location, date available, material composition and basic characteristics, then, a web-platform facilitates the exchange of materials between (external) parties, giving the possibility for entities to search for specific material and solicit what they need. As an example, the city of Mikkeli (Finland) is currently developing a 3D tool for tracking CDW on-site and a databank & digital marketplace for recovered construction material.

CDW management and tools promoting urban mining might be seen as end-of-pipe solutions. However, the concept of circularity in the built environment should be integrated from the earliest stages of building design, introducing **flexible construction** techniques and enabling buildings to be used for multiple purposes (extending their life cycles) or disassembled (to facilitate reuse of materials). Designing buildings that can easily be deconstructed or transformed must become a necessary practice if we are to mitigate the building industry's negative environmental impacts. Recently, there has been an increasing effort to construct buildings that can be easily reconfigured or disassembled. For example, the CIRCUIT project (https://www.circuit-project.eu/) brings together several partners across the entire built environment chain in reduction of construction waste to bridge the implementation gap between theory, practice and policy and showcase how circular construction approaches can be scaled and replicated across Europe. Similar initiatives could also be sought in the cross-border Scandinavian area. Thanks to the technological capacity already installed in the territory (especially oriented towards advanced manufacturing), together with the well-established synergies between research institutions and the industry, this area can represent a successful testbed for these initiatives.

Last but not least, it should be kept in mind that the concept of circular economy applied to a territory goes far beyond the search for circular loops of materials and resources, as these latter often remain tied to a reduced economic perspective. Territories are complex ecosystems that require critical consideration during the development of circular strategies. As an example, land and infrastructure are important resources which should be integrated into the conceptualisation of a circular system. Similarly, the term “resources” not necessarily has to be interpreted as physical flows of materials. From a territorial perspective, human capital is also a resource which can contribute to generating positive impacts when their activities are better steered towards synergetic goals under a coherent integrated strategy. In this sense, the promotion of sustainable urban planning and **mixed-used zones** can strongly facilitate CE practices and, at the same time, mitigate social and environmental harms. Areas such as Viken, characterised by many municipalities of diverse size and characteristics and with significant commuting flows towards Oslo, can particularly benefit from a purposeful design of the built environment and reduce urban sprawl. The RiverCity Gothenburg project might be an example of how extensive dialogue and brainstorming involving local residents and representative of municipal administrations, companies, industry and academia converged towards a shared vision for a new and functional built environment.

5.2.4 The innovative ecosystem of the Scandinavian area: towards the definition of functional areas

As argued above, the cross-border Scandinavia area benefits from an established and innovative ecosystem characterized by a consolidated stakeholder network, including industrial clusters, science parks, large-scale research institutes and universities. Among others, this collaboration has been formalized through INTERREG Sweden-Norway programs under which in the recent past, cross-border cooperation has pursued the goal to boost development, innovation and competitiveness among the local economic actors. In this context, municipalities occupy a privileged position in comparison with the broader institutional context as they directly participate – to an increasing extent –in these local networks and collaborations. The increasing engagement of local public administration can partly be attributed to a growing necessity to draw on local resources, funding opportunities and expertise of a range of public, private and not-for-profit organizations in order to organize, fund and implement local policies (Mukhtar-Landgren et al., 2019). Municipalities should therefore take advantage of this position to channel local know-how and, therefore, the network of contacts of the ecosystem fabric towards innovative circular solutions.

The development of inter-sectoral linkages (i.e. between different industrial sectors, the public and private sectors, old industrial sectors and start-ups, etc.) should be the frame under which concrete projects and innovative business models might come to light. Building on the strong historical cross-border collaboration the implementation of new and focused partnerships facilitating communication and interaction across several actors of counties in both countries should aim at innovative circular collaboration schemes. For example, the creation of innovation platforms (see e.g. the Eco-Innovation Sicily(IT)) is a good illustration of a small-scale intervention for local companies and operators allowing to identify the symbiotic opportunities present in a region and, therefore, to activate transfers of resources between the productions of different sectors, in which waste of an operator's production process becomes raw material for the production process of others. A closer example is constituted by the Grenland district in the county of Vestfold og Telemark, which is the Norway's largest industrial area with complex large-scale export industry. The district is currently engaged as *industrial park case* within the Processes4Planet project[14] with the aim of mapping industrial side streams in the area and proposing realistic symbiotic projects. The initiative not only had positive clustering and motivation effects, which in turn led to openness and a willingness to share information, but it was also aligned and, thus contributed, to the Grenland roadmap for a climate positive region by 2040.

Since the spatial distribution of key actors is unlikely to respect the administrative boundaries of a region, the **identification of functional areas** will therefore be crucial to include all relevant players of a circular solution. Considering that the predominant existing definitions of functional area tend to focus on cities and their surrounding commuting zones (OECD, 2020b), the cross-border Scandinavian area, which is characterised predominantly by rural and sparsely populated areas, might represent an innovative application of this approach in rural contexts. Understanding the functional connectivity of rural areas can enable local policy makers to use a targeted and tailored approach to pressing challenges in those areas. The very nature of functional areas implies that they offer a crucial geographic perspective on key subnational policy issues that evolve around territorial linkages. For example, labour market policies can benefit from comprehensive analysis based on information on commuting, which defines people's access to jobs and economic opportunities. From a circular economy perspective, a functional area should reveal information on e.g. the geographic patterns of economic opportunities related with industrial symbiosis synergies or bio-based supply chains, and it can, therefore, also be used to address migration patterns between different labour market areas. Eventually, this functional approach might also represent an effective policy tool to address complex landscapes often characterised by several fragmented administrative borders not aligned among each other. In this sense, the functional areas can bring together (or cluster) smaller administrative units under a shared vision, facilitating service provision and planning functions.

[14] https://www.spire2030.eu/content/p4planet-roadmap-2050

6 Policy perspectives

The CIRCTER project provided an overview and analysis of several types of circular economy policies and initiatives, making a direct link between policy actions and territorial configurations and/or factors. On the other hand, this study sought to investigate the territorial resources of the Scandinavian cross-border area to better understand the local drivers and the barriers at play towards circular configurations. Based on the results of this study, this section summarizes and highlights the key messages for local policymakers for an effective implementation of circular economy strategies in the Scandinavian cross-border area.

First of all, the great momentum in terms of **financing and investment opportunities** currently underway should be underlined. Policymaker should seek to take advantage of the several financing sources, combining local public and private resources together with EU funding's (e.g. Cohesion funds, Horizon 2020, Green Deal etc.) on key strategic priority domains with high impact potentials in terms of circularity, climate change mitigation and ultimately sustainability. Thanks to their privileged position, local governments have the capacity to promote collaboration and increase engagement of private-sector actors alongside large research institutes and cluster agencies, acting as both: (1) enabler or partner of specific projects by applying for external funding (from the e.g. the state or EU-level); and (2) as promoter and facilitator of collaboration through e.g. policy instruments (public procurement) to actively promote change. Procurement has the potential to shift the market towards more circular products and business models. Local authorities can help accelerate this shift by using their procurement and investment budgets to drive demand for circular services and products, and by integrating standards for circular products and services in existing public procurement frameworks. In this context, **functional requirements** should be preferred to technical specifications in public tenders.

In addition to operating with functional requirements in their setting of the mission to be solved, the local policymaker should also guarantee the inclusion of a diverse and representative set of actors such as the private sector, social movements and lobby groups, into the identification and articulation of missions to be addressed and achieved. Such working practices will call for a more **networked and coordinated form of governance** that might contrast existing current bureaucratic, sectoral and silo-based municipal departments and working practices. It thus will be critical to supplement silo-based working practices with more networked governance to mobilize broader sets of societal actors into a joint reflection on possible alternative and viable ways forward towards increased circularity in existing socioeconomic systems. If any, the circular economy requires collaboration and concerted effort between new constellations of stakeholders, and the development of new business models, in particular, services which fulfil the functional requirements of public buyers. Therefore, initiatives facilitating exchange between buyers and sellers, such as market dialogues, will be particularly useful in driving transition to the circular economy. Not only because they will help buyers understand what is currently available on the market, but also because they provide suppliers (industry) a clear overview of the buyer's future direction, and so that it can begin preparing to meet these needs.

While it seems that in the past only limited attention has been paid to the notion of functional region when operationalizing European territorial cooperation, for the future, the Commission has prioritized the need to identify functional areas as enabler/vectors for Eu cohesion policies. Accordingly, the 2021-2027 INTERREG programme will likely support functional regions' strategies to become local drivers for development. It goes without saying, that given the systemic nature of circular configurations, the adoption of a **functional area approach** can be critical for identifying all the relevant stakeholder contributing to a circular solution. Where some regions have the most extensive forestry or agriculture industries in their respective jurisdiction (e.g. Innlandet in Norway or Värmland in Sweden), others host large clusters of industrial production (such as in Västra Gotaland, Sweden). Similarly, innovative capacity, education levels and skillsets among the inhabitants in remote areas are comparatively low compared with more centric ones. This heterogeneous distribution of territorial assets should translate into specific functional areas according to – thematic – circular solutions (e.g. circular bioeconomy, industrial symbiosis).

To conclude, it should be emphasized that the CE debate generally boil-down to an in-depth, large scale, and quick transformation of a socioeconomic system. Although this might be an attractive proposition for policymakers, this aim and its underlying assumptions often hinder the development of a coherent framework for governance-interventions to facilitate transformative change (Termeer and Metze, 2019). In addition, such radical changes can be daunting for smaller communities, which often lack both the industrial capacity and the human capital to support such transformations. There is increasing evidence that a "**small wins**" framework might be preferable in these cases, as it provides an alternative governance perspective by focusing on how transformational change can be shaped through accumulating series of small wins. Under this framework, local policymaker should, in a first instance, limit their intervention to setting a high ambition capable of mobilizing people and organise commitment towards a specific goal. Then, once identified small wins, they should activate mechanisms through which smalls wins can accumulate in transformative change.

The small wins framework also fits the ideas of grass-root or autonomous change, indicating that people, organisations, and networks are already involved in numerous adjustments to their social practices in response to ongoing sustainability challenges. Ultimately, this bottom-up perspective might represent an effective tool to support and complement the implementation of more strategic sectoral-management approaches, which often over-emphasize planned, well-ordered, and consensual processes.

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