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Inspire Policy Making with Territorial Evidence

CIRCTER SPIN-OFF //

Switzerland and Liechtenstein Case study

Final Report // August 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
FOEN	Swiss Federal Office for the Environment
FSO	Swiss Federal Statistical Office
GDP	Gross Domestic Product
GVA	Gross Value Added
IOT	Input-Output tables
LCA	Life cycle Assessment
MFA	Material Flow Analysis
MSW	Municipal solid waste
NACE	Nomenclature of Economic Activities
NUTS	Nomenclature of Territorial Units for Statistics
PPS	Purchasing Power Standards
PU	Potential Users
RIS	Regional Innovation Scoreboard
RMC	Raw Material Consumption
SME	Small and Medium enterprises
ToR	Terms of Reference
WEEE	Waste from Electrical and Electronic Equipment

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 a 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[1], 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, including land-based sources, agglomeration economies, accessibility conditions, knowledge and technology-based enablers, governance and institutional contexts, which ultimately affect the distribution and manifestation of circular economies at subnational levels. 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 more likely adopt or demand new circular business processes, products and technologies. Likewise, the supply-side is defined by the providers 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 of Luxembourg, Norway, Switzerland and Liechtenstein. These case studies aim to increase and better adapt CIRCTER's evidence to specific territorial contexts and, ultimately, to support the definition of policies and territorial developments towards circular systems. 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 SPINOFF focusses on Switzerland and Liechtenstein countries** and it seeks to provide critical insights for a transition to a circular economy tailored to these territories. 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 of the interested areas.

[1] https://ec.europa.eu/eurostat/web/circular-economy/indicators/monitoring-framework

1.2 Structure of the report

The report is organised as it follows. After this introduction, Chapter 2 presents the area of study, including main territorial characteristics of selected regions and the overall policy context. Chapter 3 provide an overview of CIRCTER estimates focusing on a selected set of indicators spanning from material consumption and waste generation to sectoral indicators. The objective of this chapter is to benchmark Switzerland regions and Liechtenstein with the broader European context, identifying the key aspects that differentiate these territories from the rest of the European regions.

Chapter 4 complements CIRCTER data with additional primary data retrieved predominantly by EUROSTAT and official statistical databases sources. The objective of this chapter is to support CIRCTER evidence by providing a granular analysis of material and waste streams and their evolution over time.

Basing on the findings generated in previous chapters, Chapter 5 elaborates on the territorial implications for transitioning towards circular configurations in these territories. To this aim, the taxonomy of territorial factors developed in CIRCTER is first presented, then specific lessons and/or input towards a comprehensive circular economy strategy are provided accordingly to the territorial strength of Switzerland and Liechtenstein.

Finally, Chapter 6 concludes the report by delivering CIRCTER key messages adapted to Switzerland and Liechtenstein context along with new lessons produced by the work done.

2 Switzerland and Liechtenstein: a regional overview

2.1 Socio-economic and territorial characteristics

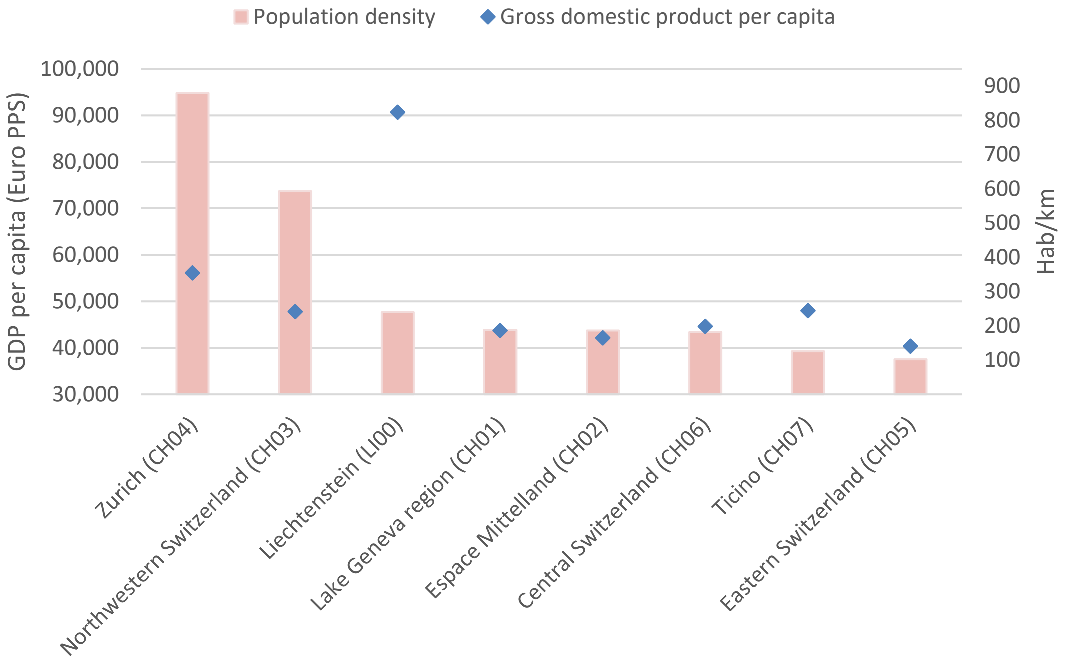
Located in the heart of the European continent, Switzerland and Liechtenstein features a set of socio-economic characteristics that situate the countries among the most performant in terms of productivity, innovation and infrastructures around the world. Both countries have among the highest GPD per capita in Europe – Liechtenstein is second in the world ranking only behind Monaco –, and present a prosperous and modern market economy with low unemployment and a highly skilled labour-force. Even though the two countries do not count with significant domestic natural resources, they have managed to create a cutting-edge and prosperous manufacturing industry specializing in high-tech, knowledge-based manufacturing. The economies of both Switzerland and Liechtenstein are significantly based on the tertiary sector. Besides that, Switzerland strength is specially marked in sectors like pharmaceutical industry, watchmaking, machines and electronics, whereas the Liechtenstein economy is widely diversified in small and medium-sized businesses. The economic competitiveness of Switzerland and Liechtenstein is also due to their very low corporate taxes, which, together with political stability and transparent legal systems, have led many holding companies to establish nominal offices in these regions.

The strategic location in the centre of Europe, the quality of life and working conditions, the relatively moderate size of these countries and the very developed transport infrastructure in place make Switzerland and Liechtenstein also an appreciated destination for cross-border commuters. According to most recent statistics, over 341.000 cross-border commuters work within Switzerland. Their origins are (in order of importance) from France (more than 180.000), Italy (around 80.000), Germany (around 60.000) and Austria (around 10.000). The number of cross-border workers is equivalent to 4% of the resident population and approximately 7% of the total workforce. In relative terms, the number of cross-border commuters working in Liechtenstein is much higher as they make up 57% of the national labour force (Liechtenstein - Office of Statistics, 2019). Interestingly, the number of employees in Liechtenstein is even higher than the resident population (38.660 employee vs. 38.378 inhabitants).

Besides the fact that these socioeconomic aspects are important for the understanding of the territorial strengths of these countries, it is very important to stress that they also are critical for a correct interpretation of circular economy indicators, being these referring to material consumption and/or waste patterns. In fact, in the case of Liechtenstein, the very high commuters in-flow will strongly influence "per capita" figures, eventually worsening the performance of the country. This is because cross-borders commuters are not counted in the population, even if they contribute to material consumption and waste production. Conversely, waste or material intensity indicators (i.e. waste/GDP and DMC/GDP) might benefit from these distinctive features since, as explained above, the favourable tax environment induced many companies to establish headquarters in Switzerland and Liechtenstein, even though the economic activity generating waste or consuming material could be carried out outside the national territory. Although these aspects affect all national / regional statistics to a lesser or greater extent, they can become particularly relevant, and thus lead to misleading conclusions, for small territorial areas such as Liechtenstein. Therefore, caution is needed when interpreting these figures.

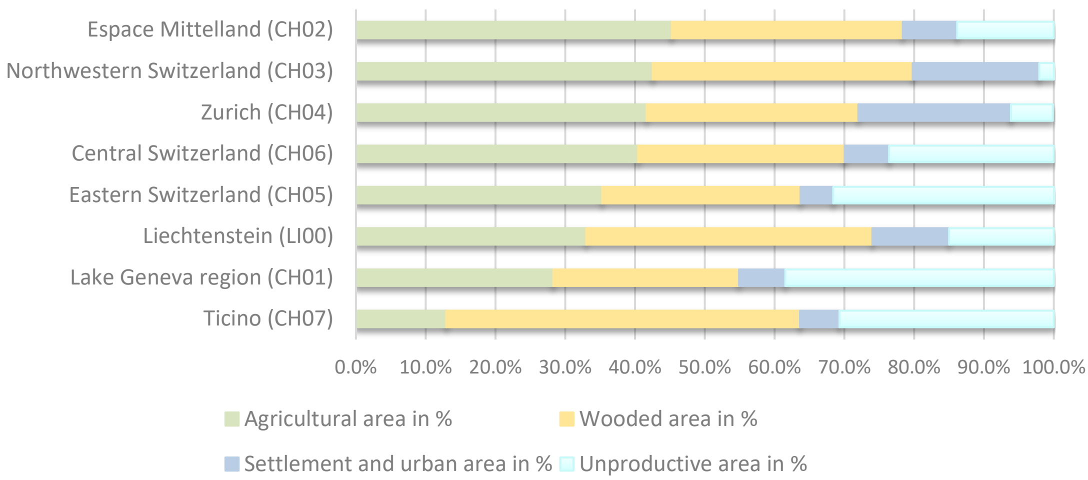
Figure 2-1 presents a granular overview of population density and GDP per capita in Switzerland regions (NUTS 2) and Liechtenstein. In Switzerland, the Zurich region presents the highest population density (879 Hab/km2) followed by the Northwestern Switzerland region (593 Hab/km2). Not surprisingly, these two regions also have the largest share of settlement and urban areas in their territory (~20%) (Figure 2-2), and very specialised economies in the tertiary sector (~80% in Zurich, as share of employment by sectors). On the other side, Eastern Switzerland and Ticino are the less urbanised regions, with roughly 100 hab/km2. In general, less urbanised territories feature greater availability of natural endowments. This, in turn, results in relatively higher specialisation in the primary and secondary sectors. This is the case for Ticino, which has the largest share of wooded area (Figure 2-2), and Eastern Switzerland, which is the most specialised in primary and secondary sectors among the Swiss regions (Figure 2-3). As said earlier, Liechtenstein instead has a low population density, the highest GDP per capita and a strong secondary sector. Its land use share is comparable with that of less populated Swiss regions.

Figure 2-1: Population density and GDP per capita in Switzerland (NUTS 2) regions and Liechtenstein



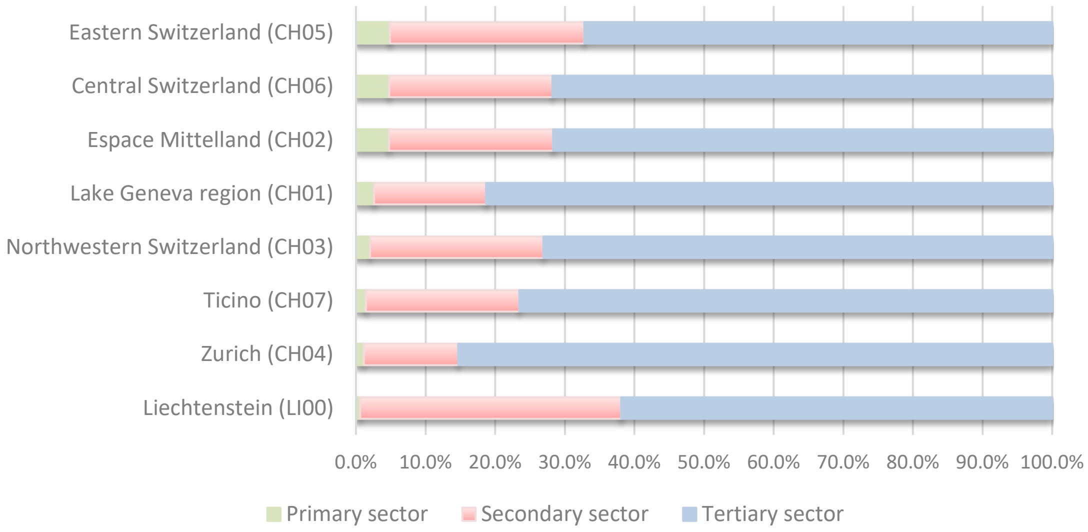
Source: own elaboration based on Switzerland FSO data and Office of Statistics of the Principality of Liechtenstein data

Figure 2-2: Land use shares (%) in Switzerland (NUTS 2) regions and Liechtenstein



Source: own elaboration based on Switzerland FSO data and Office of Statistics of the Principality of Liechtenstein data

Figure 2-3: Share of employment (%) by sectors in Switzerland (NUTS 2) regions and Liechtenstein



Source: own elaboration based on Switzerland FSO data and Office of Statistics of the Principality of Liechtenstein data

2.2 Policy framework

Due to very similar territorial contexts and highly interconnected socio-economic systems, Switzerland and Liechtenstein have almost equal priorities when it comes to the transition to a circular and resource-efficient economy. In fact, according to the European Environment Agency (EEA) reports on "Resource efficiency and the circular economy in Europe 2019" (EEA, 2019) the main drivers of the two countries include:

- the scarcity of raw materials and, therefore, the goal of increasing independence from foreign countries;
- the growing production of household waste, despite relatively high recycling rates; and
- a gradual elimination of landfill sites and, therefore, a better use of waste resources and the territory.

More specifically, Switzerland seems committed to reduce material consumption footprints within planetary boundaries by considering the whole supply chain of products[2]. For this, rising consumer awareness on circular economy issues (e.g. product lifespans), as well as increasing competitiveness through circular economy business models, taking advantage of installed technological know-how, represent critical levers.

In order to create favorable framework conditions to support circular economy deployment in Switzerland, several key legislative initiatives have been launched in the past few years. For example, the "Loi pour la Protection de l'Environnement, LPE" has been amended to address key issues such as:

- Conservation of resources taking into account the impact of Swiss consumption on the environment abroad (art. 10h, para. 1, LPE).
- Creation of a platform on the circular economy (art. 10h, para. 2, LPE).
- Deepening of exchanges between the Confederation and the private sector in the case of sectoral initiatives (art. 41a LPE).

[2] See e.g. Switzerland 2030 Sustainable Development Strategy https://www.are.admin.ch/are/en/home/sustainable-development/strategy-and-planning/sustainable-development-strategy-2016-2019.html

- Creation of better framework conditions for recovering waste (e.g., art. 30d LPE).

Another key-policy addressing material resource efficiency and circular economy in Switzerland is the Green Economy Action Plan (GEAP). Adopted in 2013, the GEAP focuses on three priority areas: consumption and production, waste and raw materials, and cross-cutting instruments. Further, the “2016–2019 measures” complemented existing legislation to support the voluntary commitment of the actors concerned and to create potential for resource efficiency and conservation.

Other initiatives at national level which are relevant to circular economy are the following:

- The New Regional Policy (NRP) is an instrument for regional economic development with a focus on mountain and rural as well as border regions. While the NRP focuses on entrepreneurship, innovation and value creation first, it places sustainability as an overall framework of the policy
- The Sustainable Development Strategy, mentioning the need to stay within the planet boundaries.

At sub-national level, the following initiative may be mentioned:

- The action plan of the Canton of Zürich for its waste and resource industries, which considers measures and strategies for seven challenges (i.e. urban mining, reduction of barriers to trade concerning waste and recycled products, resource efficiency in production and consumption, innovation, risks related to new products and technologies, quality of waste management, and safety of disposal sites).

On the other hand, mainly due to the reduced geographical extension and limited availability of raw material, Liechtenstein does not have a dedicated national resource efficiency strategy or action plan. Because of the strong proximity with Switzerland, Liechtenstein not only is part of the Swiss waste economy[3], but it has also adopted the waste legislation and raw material strategy of Switzerland. Legislative efforts made by Liechtenstein in the recent past in the field of environmental protection have had a special focus on the improvement of waste management practices and “end of pipe” solutions, especially in the construction sector. As an example:

- In 2010, the Implementation Plan for the Use of Recycled Building Materials in Public Buildings was presented to look at ways to increase the use of recycled building materials in local construction.
- In 2012, the Liechtenstein Waste Management Plan 2012-2070, was outlined describing measures to deal with the disposal of different types of waste generated in the long term.
- In 2012, the National Energy Strategy was released to support the further reduction of emissions via policy and measures in energy conservation, energy efficiency, and renewable energy production, and in particular the renovation of older buildings and the generation of biogas from waste.

Besides the recycling of building materials, building renovation and waste-to-energy measures, the strategies and plans of the past have placed little emphasis on the re-use and revalorisation of waste as part of a green circular economy. Today, given the growing trends in waste and wastewater production, Liechtenstein is willing to re-think its waste strategies on principles of waste reduction, reuse and recovery, reducing less-efficient waste management routes such as incineration. To this aim, Liechtenstein is currently developing its own Circular Economy strategy (LISD, 2020), defining 4 broad strategic objectives disaggregated in 20 concrete actions. The strategy greatly focuses on the objective of closing product and materials cycles with support of technological innovations (e.g. collection systems, reverse logistics, separation), commitment of all actors along the value chains (i.e. support re-use networks, hence, implication of citizens) and the administration (creation of an online registry for waste prevention and resource recovery data). It is expected that this paradigm shift will allow Liechtenstein to reduce emissions coming from waste, lower the dependence on new materials, improve environmental safeguards and generate additional economic growth, employment and deliver savings to consumers and residents.

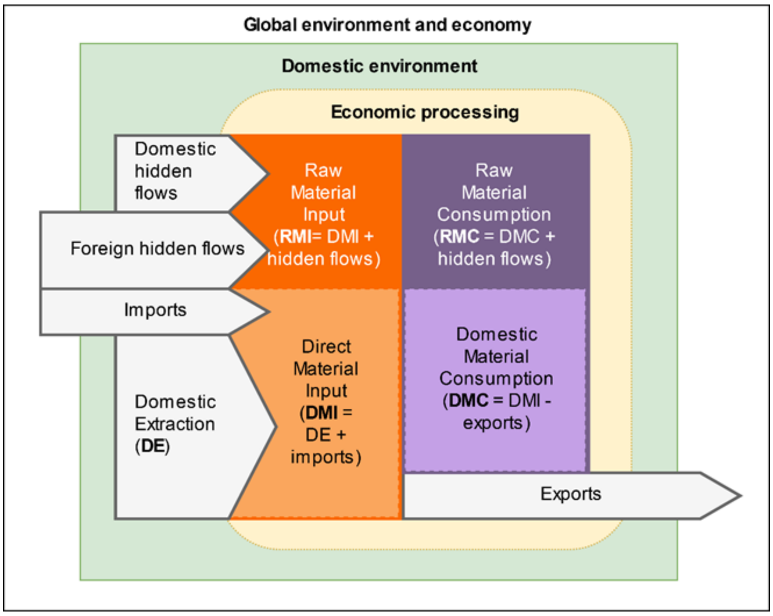
[3] For the management of waste, Liechtenstein currently relies to a great extent on the Swiss incineration facility of Buchs

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). Since estimates of RMC are only available at the aggregated EU economy and for few countries – including Switzerland (see Box 3-1), 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.

Unfortunately, Economic-Wide Material Flows Accounting (EW-MFA) statistics for Liechtenstein are not available. This shortcoming prevented the displaying of Liechtenstein from all the maps related with material flows in the CIRCTER project. However, in order to provide an analysis as comprehensive as possible, this study endeavoured to providing some first estimate of Liechtenstein's DMC for the year 2006 and 2014. This calculation relied on the assumption that, given the spatial proximity and similar socioeconomic structures of Liechtenstein and Switzerland, the drivers of DMC should also be similar among the two countries. Therefore, we employed the Switzerland DMC elasticities computed in the CIRCTER project, namely GDP per capita and population density, as parameters to predict the DMC for Liechtenstein. This approach has only been possible for DMC, as other material flows indicators relied on a wider set of predictors, for which data are not directly available for Liechtenstein.

Box 3-1: Comparing Swiss patterns of DMC and RMC

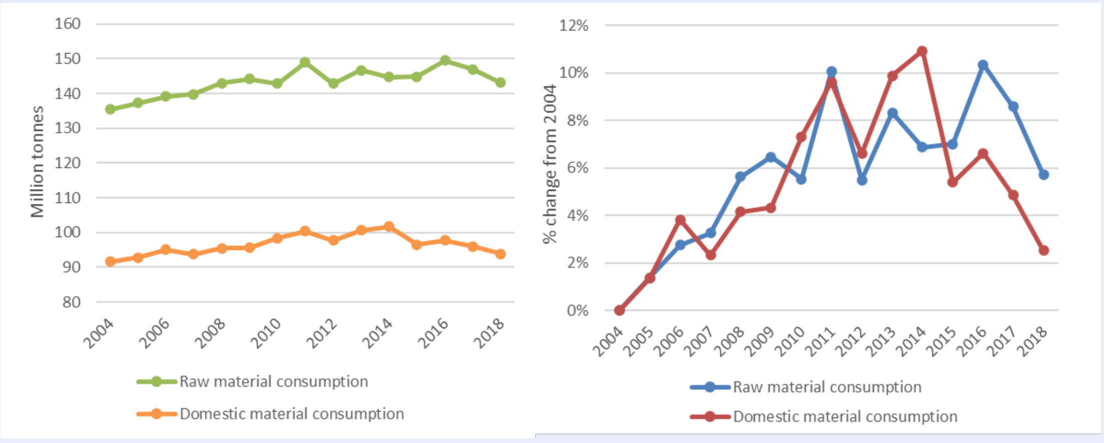
Historical evolution of Raw Material Consumption and Domestic Material Consumption in Switzerland

Switzerland is one of the few countries worldwide producing on regular basis RMC estimates. The data on domestic raw material consumption are collected as part of the environmental accounting of the Federal Statistical Office (FSO). The indicator is calculated based on a method developed by the EUROSTAT. This method is used to convert the imports and exports of a country into raw material equivalents (RME) and it involves a hybrid approach that combines environmentally extended input-output tables (IOT) with life cycle assessments (LCA). It should be noted that since the calculation of raw material equivalents is based on a model, it is subject to much more uncertainty than the calculation based on direct flows (i.e. DMC).

RMC, also called **material footprint**, indicates the total quantity of raw materials that are required in Switzerland or abroad to cover Swiss demand for goods and services. All materials that are consumed in the product life cycle are included in this indicator. Since the extraction, transport, processing, use and disposal of material exert negative impacts on the environment, due to e.g. land use and emissions, a reduction of the material footprint is critical. A RMC greater than DMC indicates that the Swiss demand for goods and services requires a consumption of materials higher than those actually consumed in the national territory. Conversely, a DMC greater than RMC might indicate that the material consumed internally is directed to a greater extent to satisfy foreign demand for goods and services. Figure 3-2 compares the evolution of DMC and RMC in Switzerland over the last years. Switzerland exhibits a significantly higher RMC than DMC, namely 143 million tonnes vs. 94 million tonnes in 2018. This pattern reflects the scarce raw material endowments of Switzerland territory and, therefore, the consolidated economic structure of this country mostly focused on advanced manufacturing and the tertiary/services sector.

Interestingly, it can be noted that despite DMC-RMC had – in relative terms – similar increasing patterns from 2004 to 2014, it appears that in more recent years, Switzerland's dependence on imported goods has increased. In fact, as the graph to the right of Figure 3-2 shows, RMC levels decreased at a slower rate than the DMC levels.

Figure 3-2: Historical evolution of DMC and RMC in Switzerland

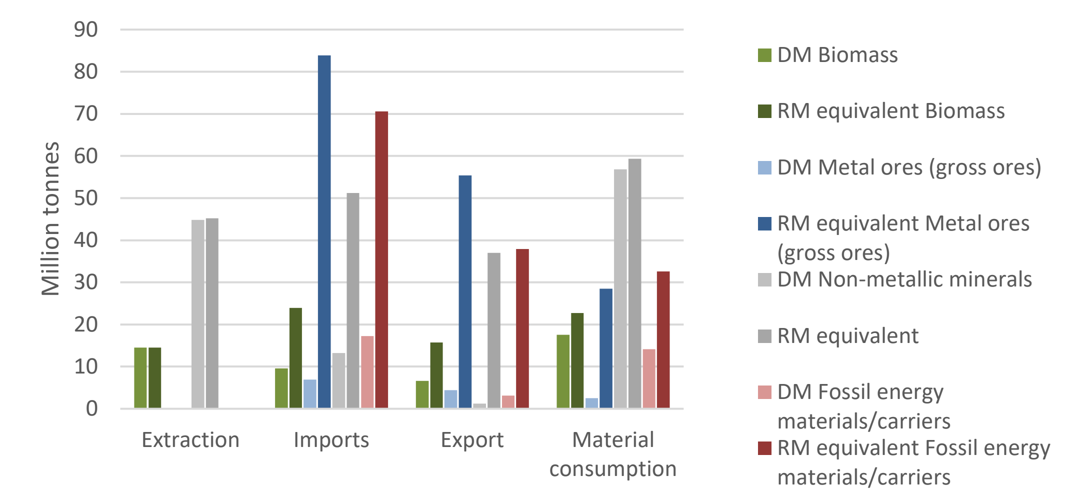


Source: own elaboration based on Federal Office for the Environment (FOEN) data

[continued]

Figure 3-3, which shows RMC and DMC levels by type of material flows in 2018, clearly explains the reason of the observed gap between RMC and DMC for the Swiss case. While biomass and construction material consumption have similar values between DMC and equivalent RMC, metallic and fossil energy materials/carriers present a stark difference between the two categories. Switzerland does not have extraction activities related with these material flows; therefore, these are entirely imported (note that they constitute the higher amounts among all material imports). However, differently from DMC which allocates to the importing country only the weight of the exported materials, in equivalent RMC the ore extraction needed to produce a specific metal is also allocated to the importing country. The same applies to fossil energy materials /carriers. In this context, it will be critical to identify those circular-oriented practices that might mitigate Swiss's high – and growing – dependence on imports of metal ores.

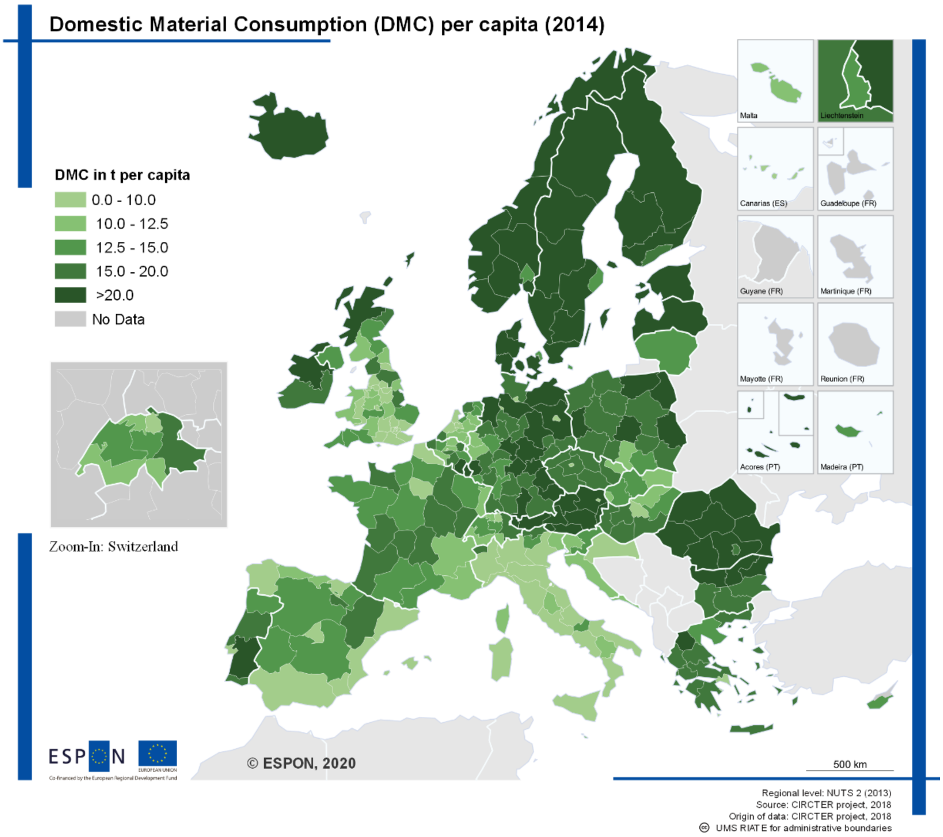
Figure 3-3: RMC and DMC by material flows (year 2018)



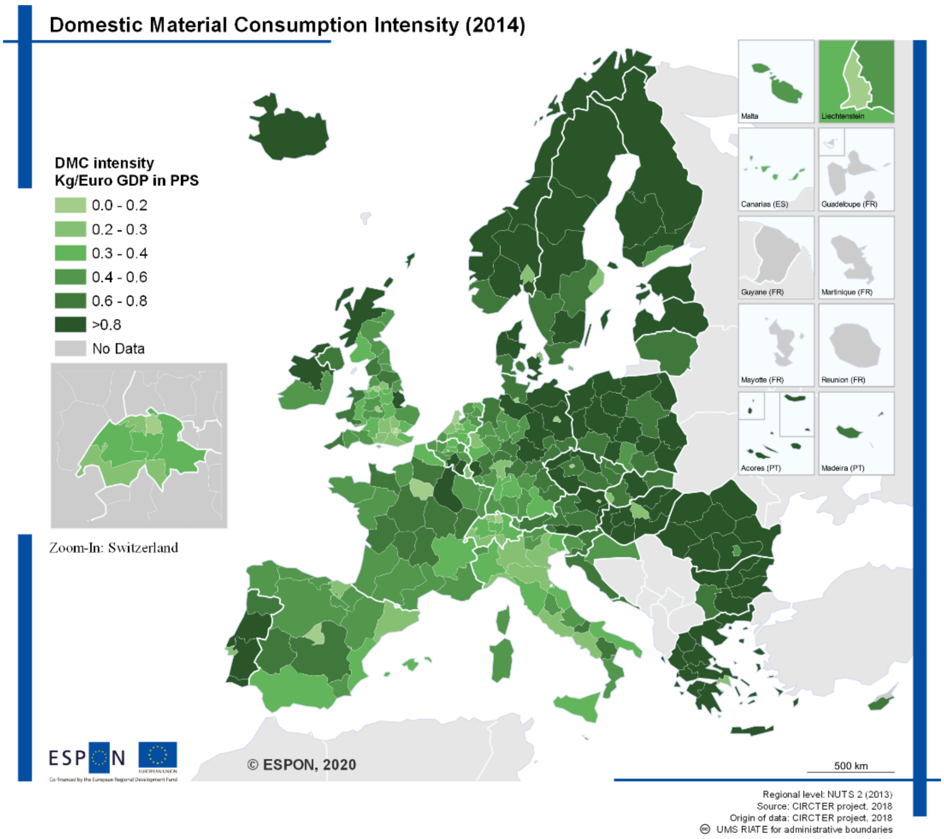
Source: own elaboration based on Federal Office for the Environment (FOEN) data

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. As a consequence, 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 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 and Map 3-2 show DMC per capita and DMC intensity in 2014, respectively.

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



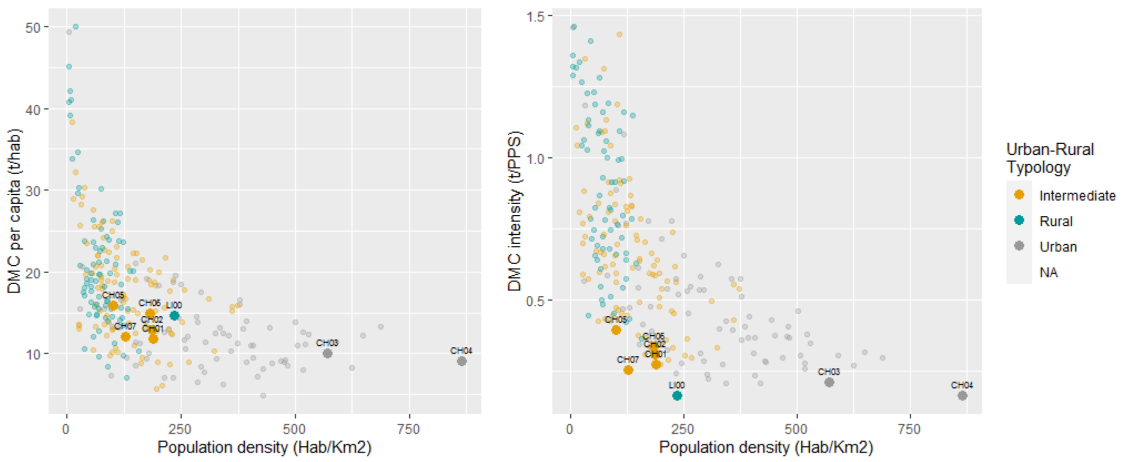
Map 3-2: Material Intensity in kg/Euro GDP in PPS (2014)



All analysed territories have a relatively low DMC per capita when compared to the European regional (NUTS-2) average, which is 16.09 tonnes per capita. Zurich (CH04), Northwestern Switzerland (CH03) and Lake Geneve region (CH01) are the regions performing better, having a DMC per capita equals to 9.03, 10.04 and 11.87 tonnes per capita, respectively. Similar patterns can also be observed when focusing on DMC intensity, i.e. Swiss regions and Liechtenstein have DMC intensity significantly lower than the European average, which is 0.69 kg/PPS. Interestingly, one difference can be observed when comparing DMC per capita and DMC intensity figures across the considered regions, i.e. Liechtenstein's superior performance when considering the material intensity perspective. This can be visualised even better in Figure 3-4. While in DMC per capita terms, Liechtenstein figures in the middle rank (left side plot), in DMC intensity terms (right side plot), Liechtenstein leads the ranking together with Zurich, both with a material intensity of 0.16 kg/PPS, among the lowest in Europe.

This particular pattern was also observed for the Luxembourg case study and it is mostly explained by (1) the socioeconomic structure of the interested territories along with (2) their commuting flows. Concerning aspect (1), the strong specialisation of these regions in economic activities with very high added values such as advanced manufacturing, financial and service activities, clearly boost the GDP. Further, these activities also require much lower amounts of raw materials compared to primary and secondary sectors. On the other hand, very high commuting flows such as in Luxembourg and Liechtenstein might *inflate* material consumption statistics. Indeed, Liechtenstein commuting workforce (which accounts the 57% of total workforce) does not reside in Liechtenstein territory, but it influences the overall consumption of resources and contribute to GDP generation. Therefore, when considering DMC per capita, the impact of this share of workforce is accounted only from the consumption side, as the denominator population only consider "residents". Contrarywise, the DMC intensity indicator accounts both impacts related with resident and commuting workforce, namely the amount of material consumption and the GDP generation. In this sense, the performance of Liechtenstein DMC could best be described by the "intensive" form of material consumption, otherwise the commuting workforce would have to be added to the residential population when considering the per capita DMC.

Figure 3-4: DMC per capita vs DMC intensity scatterplots (2014)



Source: own elaboration based on CIRCTER data

Figure 3-4 also relates the type of territorial configuration (i.e. urban vs rural) with DMC levels. Agglomerated, urban areas having economic structures mostly specialised in tertiary sector are those to the bottom right of the scatterplot. In this area we can find in fact Zurich (CH04) and Northwestern Switzerland (CH03), the two regions having the highest population density in the analysed regional sample (see also Figure 2-1). 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. In turn, these latter, which generally coincide with rural areas, present higher DMC values and are displayed in the upper left area of scatterplots. Eastern Switzerland (CH05) is the region within the sample having territorial characteristics closer to the rural typology, i.e. lower population density and a stronger specialisation in the agricultural sector, even if it still remains far from being considered a fullfledged rural area. Liechtenstein, which is classified as a rural region, represent an exception to these general patterns, mostly because of the socioeconomic phenomena described above.

Map 3-3 shows the Domestic Extraction (DE) per capita. In this case, data for Liechtenstein was not available. As a country with relatively few raw materials, Switzerland does not have high amounts of material extraction. As explained above in Box 3-1, metal ores and fossil energy materials/carriers are entirely imported from abroad. Therefore, material extraction is limited to biomass and non-mineral ores (i.e. construction material). According with the estimated data, Eastern Switzerland (CH05) seems to concentrate most of material extraction activities, being its DE 18 million tonnes, or 16 tonnes per capita. This is in line with European average, that is 16.30 tonnes per capita in 2014. More urbanised territories such as Zurich (CH04), Northwestern Switzerland (CH03), which have reduced availability of land for extraction activities, present in turn significantly less amounts of DE, being in the range of 3-5 tonnes per capita.

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

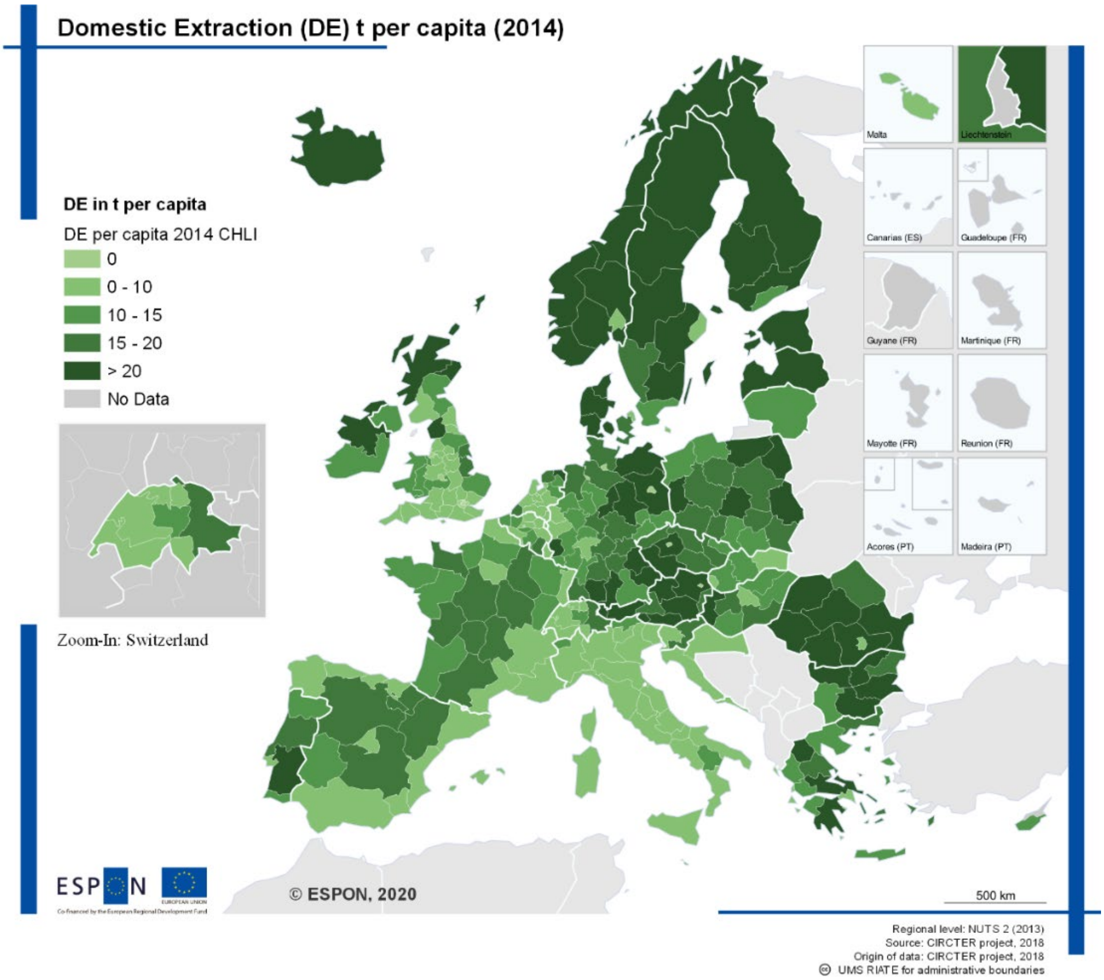
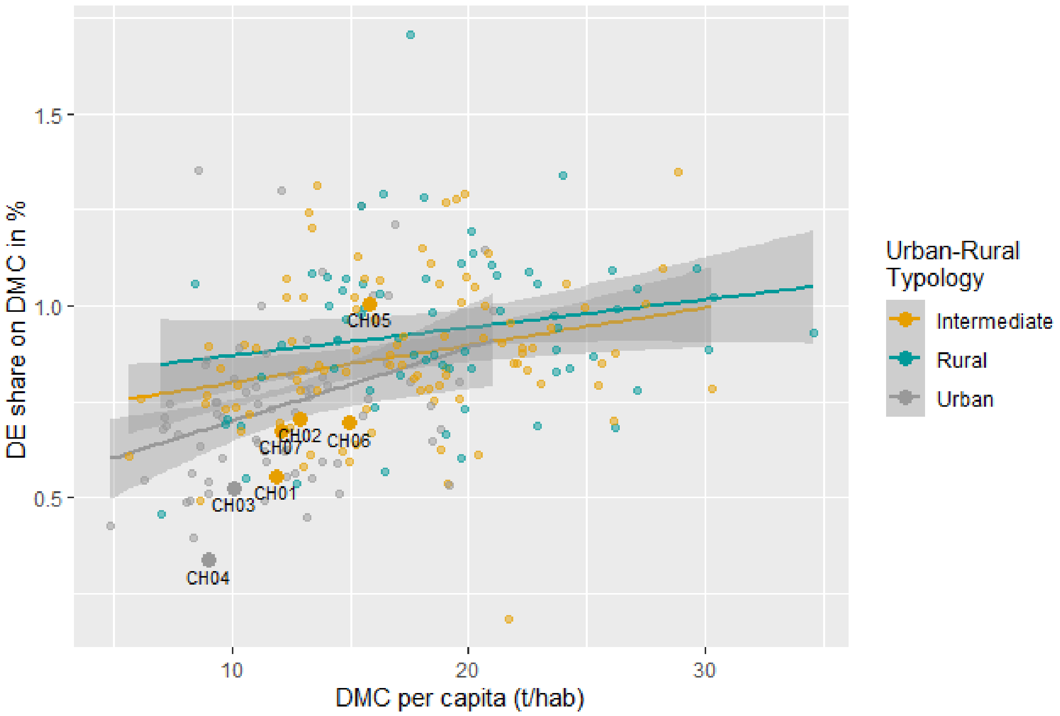


Figure 3-5 shows the relationship between DE share of DMC and DMC per capita. In general, it can be appreciated a linear relationship, with a very similar pace across the urban-rural territorial typologies, between the reliance of an economy on local natural resources and its overall consumption of material. Increasing resilience on local resource extraction translates, on average, in higher DMC per capita. Areas featuring a DE share over 100% DMC are generally exporting regions, which extract and exploit natural resource for foreign markets. Conversely, those areas having very small DE shares generally correspond to importing-oriented regions. These latter generally undergo very limited availability of local natural resources, hence relying mostly on imports from other areas. Except for Eastern Switzerland (CH05), all Swiss regions have a domestic extraction lower than material consumption. As said above, this confirm the significant reliance of Switzerland on imported goods. Zurich (CH04), which is highly specialised in the service sectors, seems to be the regions relying the most on imported goods, as DE accounts for only 33% of the total material consumed. Contrarywise, Eastern Switzerland (CH05) recorded same amounts for DE and DMC, therefore suggesting the relatively higher concentration of primary sector activities in this area.

Figure 3-5: DE share of DMC plotted against DMC per capita

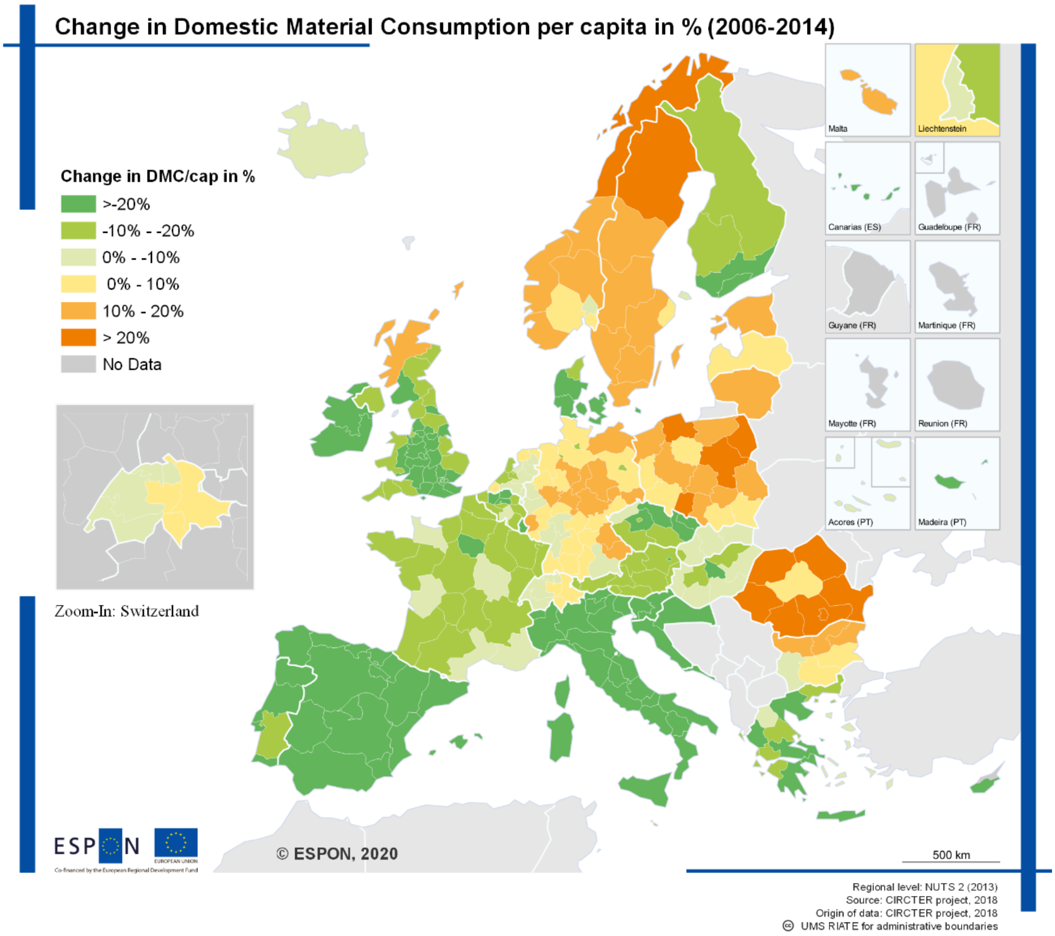


Source: own elaboration based on CIRCTER data

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, or conversely, it mostly relies on imported goods. 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 burden as less consumption of resources would translate in fewer environmental impacts (e.g. emissions, biodiversity loss, soil degradation). In this context, Map 3-4 shows the percentage change in DMC per capita observed between 2006 and 2014. DMC per capita slightly decreased in western regions of Switzerland, especially in Zurich (CH04) and Lake Geneve region (CH01) DMC decreased by more than 8%. To the contrary, DMC per capita increased in Ticino (CH07) and Central Switzerland (CH06) region by 3.2% and 2.6%, respectively. Liechtenstein did not show significant changes between the two periods.

While focusing on DMC per capita or material intensity indicators is important to assess and enable comparison between the overall performance and type of regional socioeconomic metabolisms, it is also critical to keep in mind the absolute trend of material consumption. In the end, the environmental hazards related to the extraction, processing and disposal of goods are directly proportional to the quantity of these, so final goals should be aimed at reducing the consumption of material in absolute terms. In this context, absolute DMC actually increased in all the regions considered for the time period considered (2006-2014). As Figure 3-2 showed, absolute DMC in Switzerland went from roughly 95 million tonnes in 2006 to more than 100 million tonnes in 2014. Further, 2014 seems to be the turning point in which DMC begins to decline in absolute values. The reason why material consumption per capita and material consumption in absolute terms show opposite patterns is due to the underlying demographic evolution. Regions such as Zurich (CH04) and Lake Geneve region (CH01) experienced demographic increases (i.e. +12%) much higher than the increase observed for DMC (i.e.3%). As a result, DMC per capita decreased over the period analysed. In contrast, regions where population growth has occurred at a slower rate than the increase in DMC, showed increasing or unchanged per capita DMC levels.

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

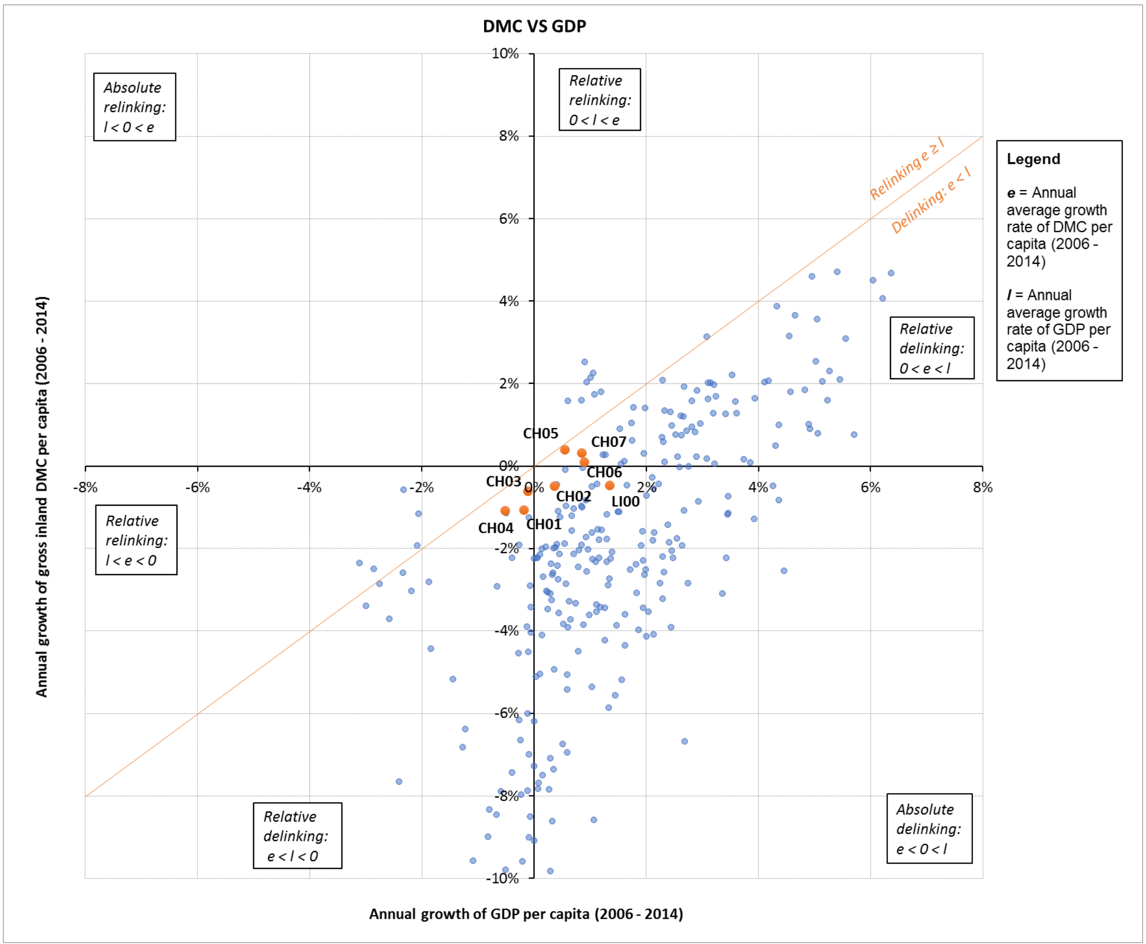


One of the most prominent concepts to harmonize economic and environmental goals is to decrease the requirement of natural resources for ongoing economic performance. In other words, to break the link between "environmental bad" and the "economic good". Ideally, this "decoupling" process would allow economic prosperity while reducing environmental pressures and impacts and, furthermore, would enable human development in accordance with planetary restrictions. Currently, the concept of decoupling is operationalised into breaking the link between economic growth and resource use (resource decoupling), or in other words increasing resource efficiency, following the assumption that by that means also environmental impacts will be lessened. When evaluating decoupling trends, two types of decoupling can be distinguished: relative delinking is achieved when economic growth is exceeding growth in material use. In contrast, achieving economic growth while at the same time decreasing material use is called absolute delinking. While both cases entail an increase in efficiency in raw material use, only the latter can be seen as a means towards lowering the pressures on the environment.

Figure 3-6 and Figure 3-7 shows the decoupling analysis carried out in the CIRCTER project, highlighting the performance of Swiss and Liechtenstein regions. 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 relative 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, only Liechtenstein and Espace Mittelland (CH02) achieved an absolute decoupling. This is surprising as Espace Mittelland (CH02) was not previously depicted among the Swiss regions that had reduced the volume of DMC the most. Nonetheless, Espace Mittelland (CH02) is the unique Swiss region succeeding in reducing DMC while still increasing GDP over the selected period. In fact, the largest decrease in DMC recorded in Zurich (CH04), in Northwestern Switzerland (CH03) and in the Lake Geneva region (CH01) occurred in parallel with a contraction in GDP. This explains why these regions only achieved a relative delinking pattern. Similar relative delinking patterns are also observed for Eastern Switzerland (CH05), Central Switzerland (CH06) and Ticino (CH07), even if in this case GDP increased more than DMC.

Figure 3-6: DMC Annual average growth Vs. GDP annual average growth



Source: own elaboration based on CIRCTER data

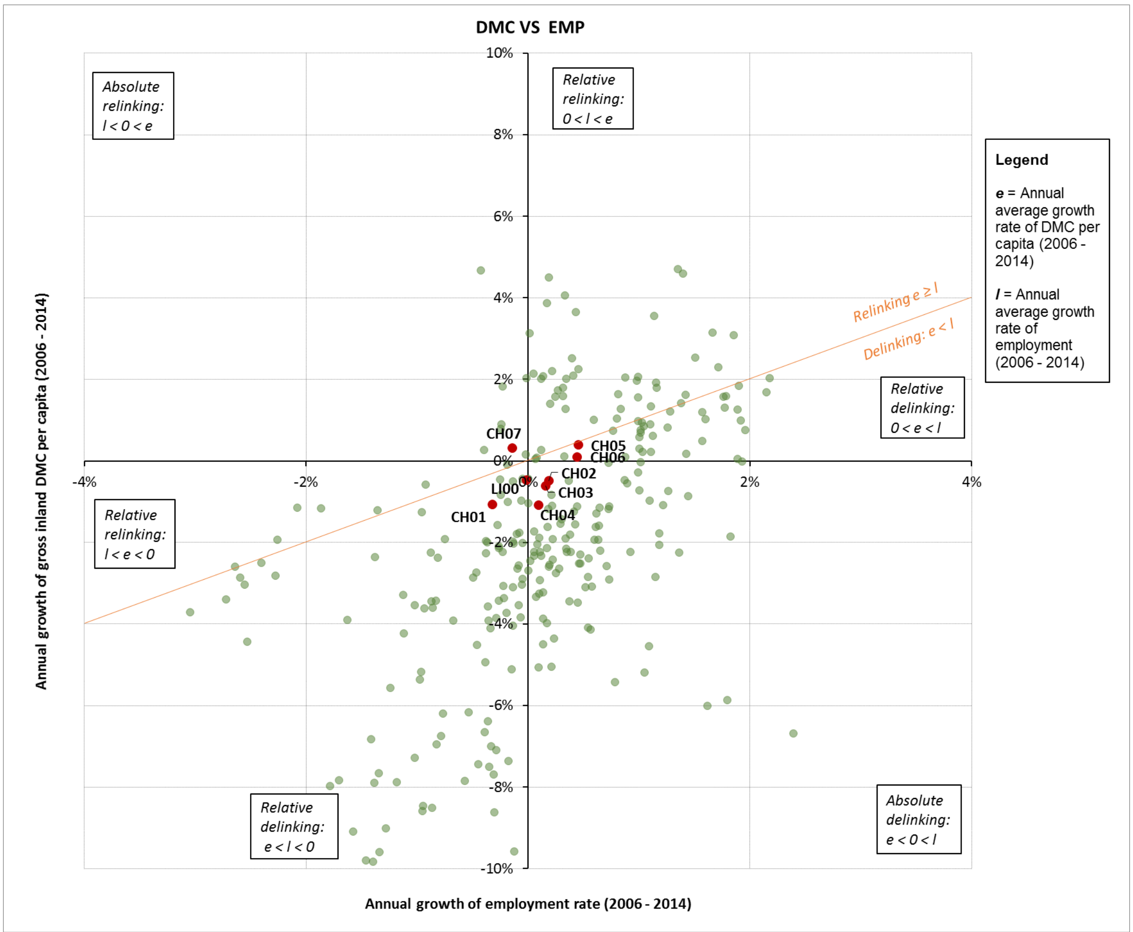
Figure 3-7 shows the same type of scatterplot, but with a different social indicator, i.e. employment growth. Employment might be considered a more inclusive social indicator than GDP, as this latter is often criticised for its weak link with sustainable growth[4]. Interestingly, several regions changed their "delinking" status. Remarkably, the region of Ticino (CH07) worsened its performance by displaying an absolute relinking pattern. In other words, when comparing employment with resource consumption it seems that the region increased material consumption despite the decline in employment rates. On the other hand, Zurich (CH04) and Northwestern Switzerland (CH03) shifted to the absolute delinking area, thanks to a positive employment rate compared with the negative material consumption rate.

According to FSO statistics, the Ticino region (CH07) and in particular the Lake Geneva region (CH01), still seem to be those areas struggling the most to retain employment. Unemployment in Ticino was 7.6% in 2019, while in Geneve it reached 10.09%, the highest rate among all Swiss cantons. Clearly, these regions

[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).

should aspire to, and benefit from, circular economy initiatives capable of boosting job creation. An example of these initiatives will be delivered in section 5.2.

Figure 3-7: DMC Annual average growth Vs. Employment annual average growth



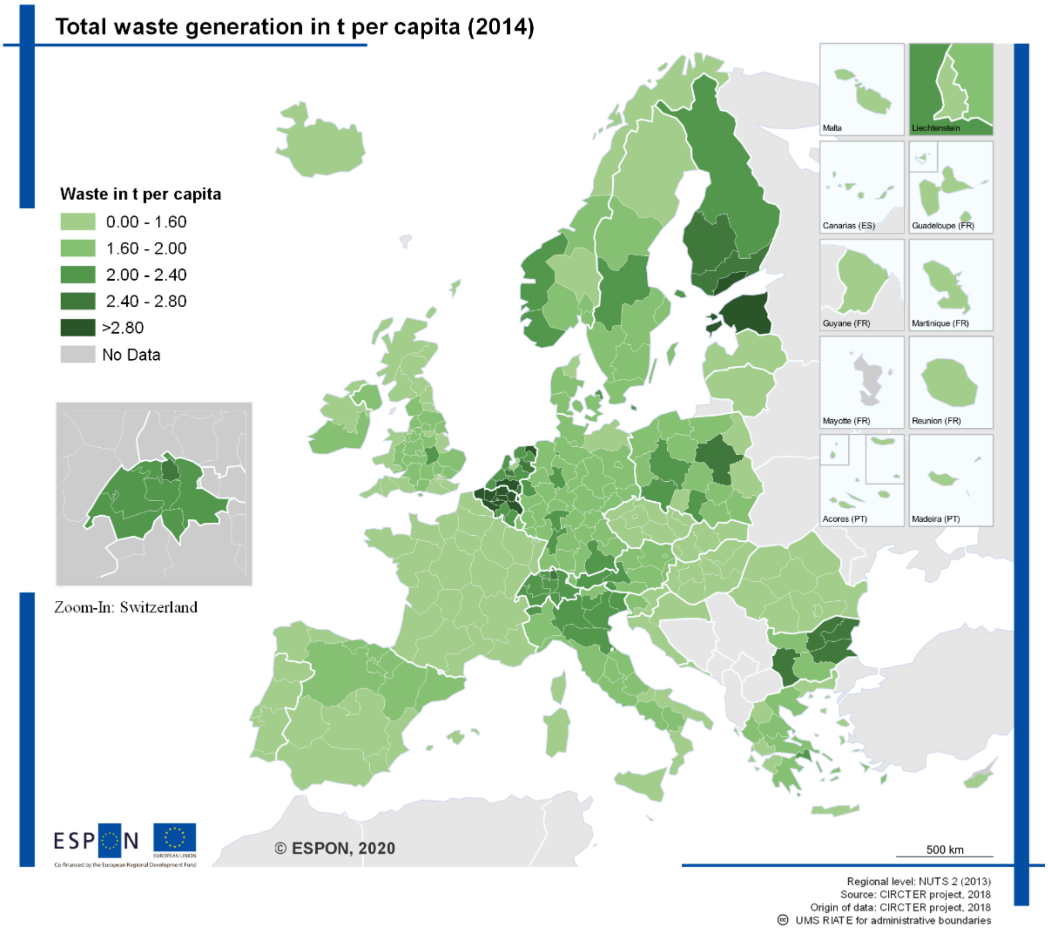
Source: own elaboration based on CIRCTER data

3.2 Waste generation patterns

As highlighted in the 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. A higher level of mindfulness is therefore required when comparing waste indicators between regions belonging to different countries.

Map 3-5 shows the total waste (excluding major mineral waste) in tonnes per capita in 2014. According to CIRCTER statistics, Swiss regions show, overall, waste per capita values above the European average (i.e. >1.7 t/cap), while Liechtenstein waste per capita is 1.15 t/cap, therefore below European average. Zurich (CH04) seems to be the Swiss region that generates the most waste per capita (2.5 t/cap), while in absolute terms Espace Mittelland region generates the highest amount, i.e. almost 4 million tons, followed by the Lake Geneve and Zurich regions with more than 3.5 million tons.

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



Likewise DMC, an analysis is also provided for waste intensity, i.e. the generation of waste – excluding major mineral wastes – per GDP unit (kg per thousand euro in purchasing power standard (PPS)). This indicator is particularly relevant within the circular economy framework as it indicates the ability of territories to decrease the generation of waste while maintaining or increasing economic output. Not surprisingly, waste intensity indicator is also included in the CE monitoring framework provided by the European Commission. Map 3-6 shows the waste intensity across European regions in 2014.

According to CIRCTER statistics, the regional European average of waste intensity was 71 kg per thousand euro, in 2014. On the other hand, the waste intensity average measured at the national level provided by EUROSTAT seems to be slightly lower, i.e. 68 kg per thousand euro. In this context, the Swiss regions were well below the European averages having waste intensity values ranging from a maximum value of 53 kg per thousand euro in Eastern Switzerland (CH05) to a minimum of 43 kg per thousand euro in Ticino (CH07). Notably, Liechtenstein is in the top three European regions – along with Inner London and North Eastern Scotland – with a waste intensity of 12.6 kg per thousand euro.

Once again, depending on the type of denominator (i.e. population or GDP) the resulting picture is very different. Whereas, the waste intensity indicator positions the analysed regions among the best performer European regions, the per capita indicator shows a rather worse situation. Figure 3-8 exemplifies this stark difference: Swiss regions appear at the top of the scatterplot on the left side (i.e. higher per capita waste) while occupying the lower area of the scatterplot on the right side (i.e. lower waste intensity). Obviously, none of the selected indicators should be interpreted as the “ultimate truth”. Instead, they provide complementary perspectives of Swiss and Liechtenstein socio-economic metabolisms. On the one hand, the economic structures of these territories and their specialization in high value services such as finance or IT sectors, mitigate the amount of waste produced when normalised by economic output. From the point of view of the circular economy this is positive, as it reflects the ability of these regions to retain the value of products, materials and resources in the economy, or *vice versa*, to optimize the consumption of resources in activities with higher added value. However, referring to the Swiss regions, it remains clear that the amount of waste generated remains very high. Perhaps this is also due to commuter flows that contribute to the production of waste but are not accounted for within the population. In this sense, it may be worth considering per capita waste indicators that include the commuter workforce.

Map 3-6: Waste intensity in kg/1000 Euro GDP (PPS) (2014)

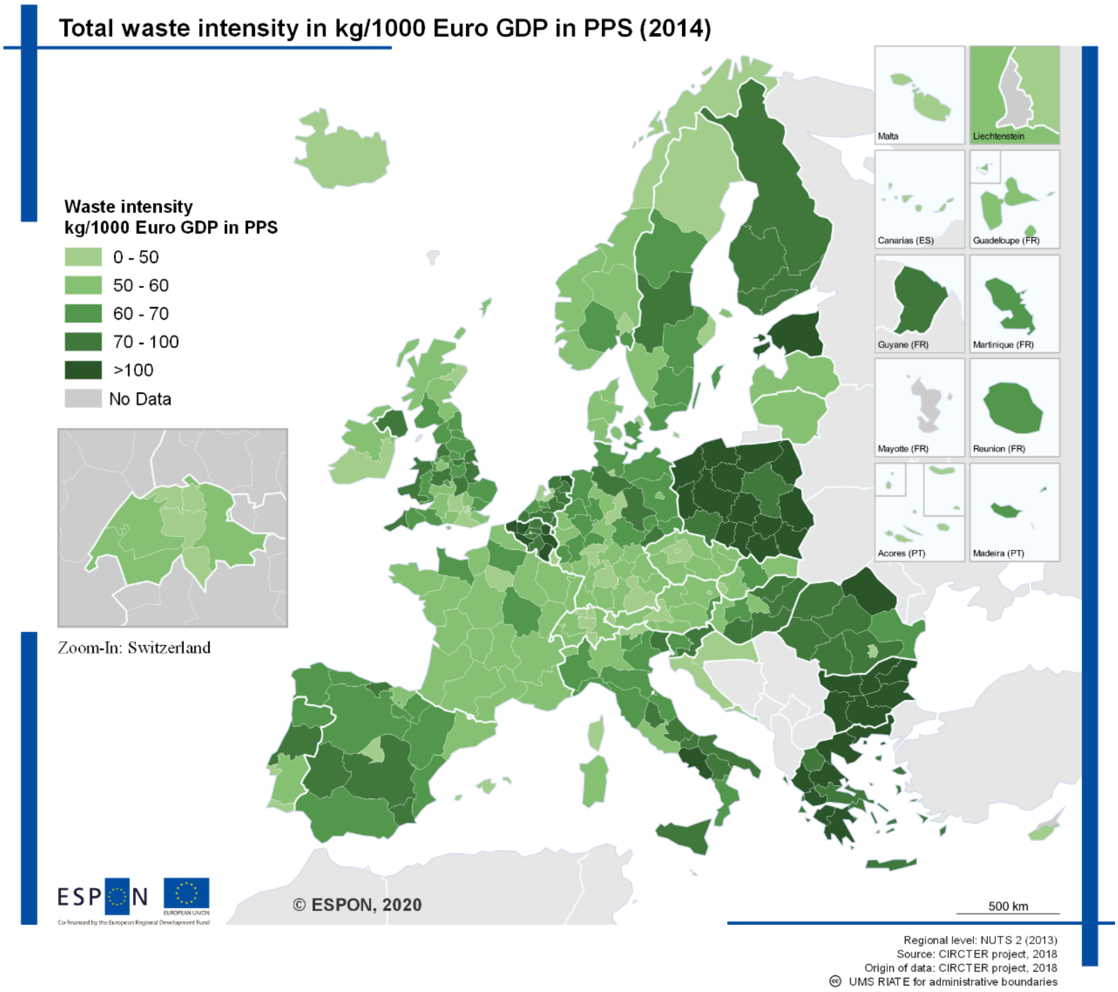
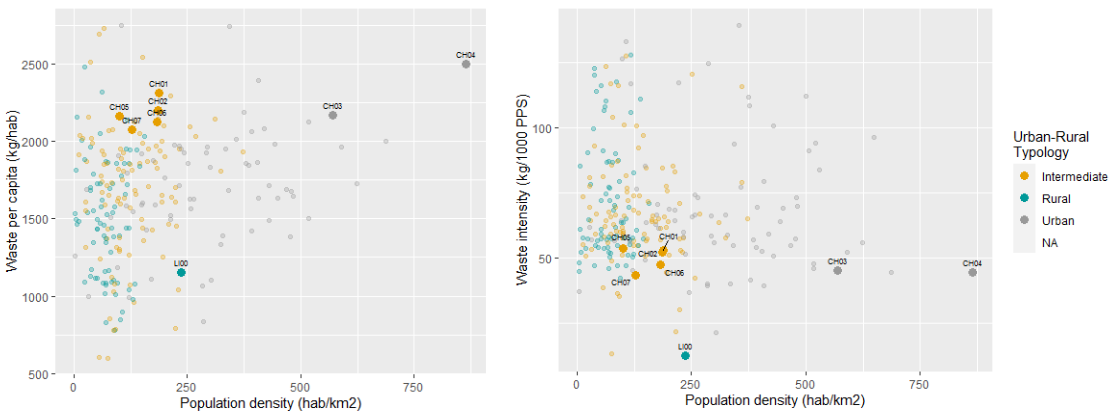


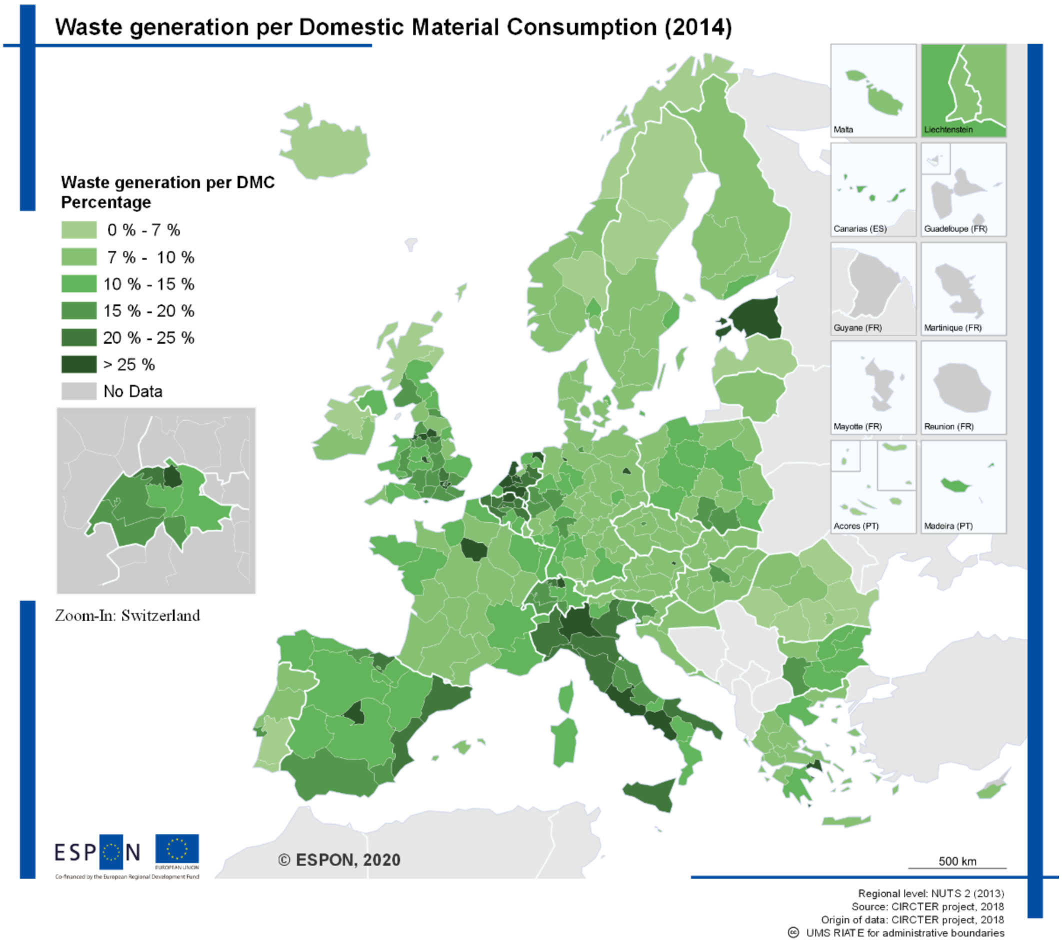
Figure 3-8: Waste per capita vs. Waste intensity (2014)



Source: own elaboration based on CIRCTER data

Due to the limited availability of data, the remaining waste-related indicators were not calculated for the Swiss regions[5] in the CIRCTER project. However, the availability of DMC and waste allowed the estimation of an additional Circular Economy indicator included in the EC monitoring framework, that is the generation of waste excluding major mineral wastes per domestic material consumption (later referred to as "waste per DMC"). This indicator, which is expressed in percentage (%) as both terms are measured in the same unit (tonnes), monitors the efficiency of regional material consumption by comparing the tonnes of waste generated to domestic material consumption (DMC). Therefore, just as waste intensity, this ratio is relevant as an index of relative intensity of raw material and waste "pressures" of an economy as it reflects the share of waste in inputs used for production. Map 3-7 shows the waste generation per DMC across European regions.

Map 3-7: Generation of waste (excluding major mineral wastes) per domestic material consumption



Since this map was not delivered in CIRCTER, and it probably represents a first example of this indicator at the regional (NUTS-2) level, a broader interpretation is required. First, it can be seen that the very urbanised areas, or capital regions (see for instance Ile de France (FR), Madrid (ES), Berlin (DE)), present, overall, the higher shares of waste per DMC (i.e. > 25%). In the Swiss case, this only applies to the Zurich region (CH04) (28%). On the contrary, rural and more peripheric areas shows, overall, shares of waste per DMC significantly lower, ranging from the minimum of 3 % in Iceland (IS00) and North Eastern Scotland (UKM5) to roughly 10% across several regions. This is somehow contrasting with material and waste intensity indicators showed before, which presented urban areas clearly as the better-off regions thanks to, *inter alia*, the type of economies and agglomeration synergies. This evidence might be explained by the nature itself of

[5] To note that electronic and electrical equipment waste (WEEE) was also calculated in the CIRCTER project. However, due to the low robustness of these estimates we preferred to omit these results from the present analysis.

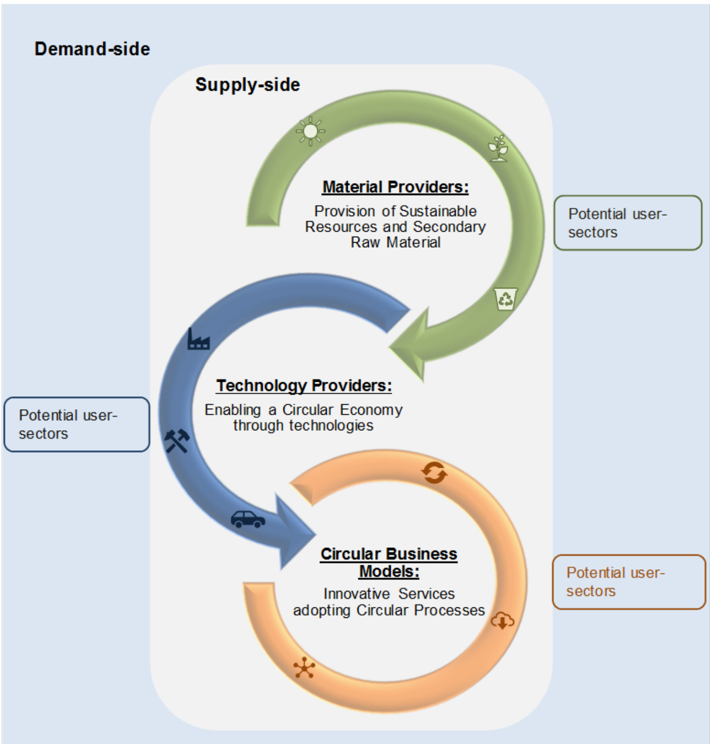
the indicator, which relates two physical flows (material and waste) and their underlying patterns. On the one hand, rural areas concentrate most of material intensive activities which, in turn, boost DMC. Comparatively, the waste generation will be much lower as they will not shoulder the waste related to final consumption, as most of the produced goods will be exported. Conversely, urban areas, which concentrate most of the total social demand for goods, not only import most of these, but they are also recipients of the waste generated by final consumption. Consequently, urban areas will have, on average, a reduced DMC (denominator) compared to the production of waste (numerator).

As for the Swiss regions, although many of them have rather similar facets to intermediate and / or rural European regions (e.g. Eastern Switzerland (CH05), Central Switzerland (CH06) or Ticino (CH07)), they all have a waste to DMC ratio above the European average (> 13%). On the positive side, Liechtenstein presents a performance superior to European average, i.e. 0.08%. These results confirm the critical need for Switzerland to direct circular economy strategies to reduce waste in the first place.

3.3 Sectoral perspective of Circular Economy: Potential Users of circular innovations and products

Next to the indicators concerning material and waste patterns commonly used to measure the progress towards resource-efficient systems, the CIRCTER project developed a new set of indicators related to the current uptake of economic activities promoting circular businesses and, in turn, to the potential diffusion they could have in the economic fabric of European territories. The sectoral definition established in the CIRCTER project distinguishes between the supply-side and demand-side of the economy (Figure 3-9). 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 by selected industries that are more likely to adopt, or rather require, new circular business processes, products and/or technologies. These are referred to as Potential Users (ESPON CIRCTER, 2019). Since figures for Material Providers, Technology Providers and Circular Business Models (CBM) are not available for the Swiss regions, nor for Liechtenstein, this report focusses only on Potential Users.

Figure 3-9: A conceptual visualisation of the four pillars of a Circular Economy and their respective sectors

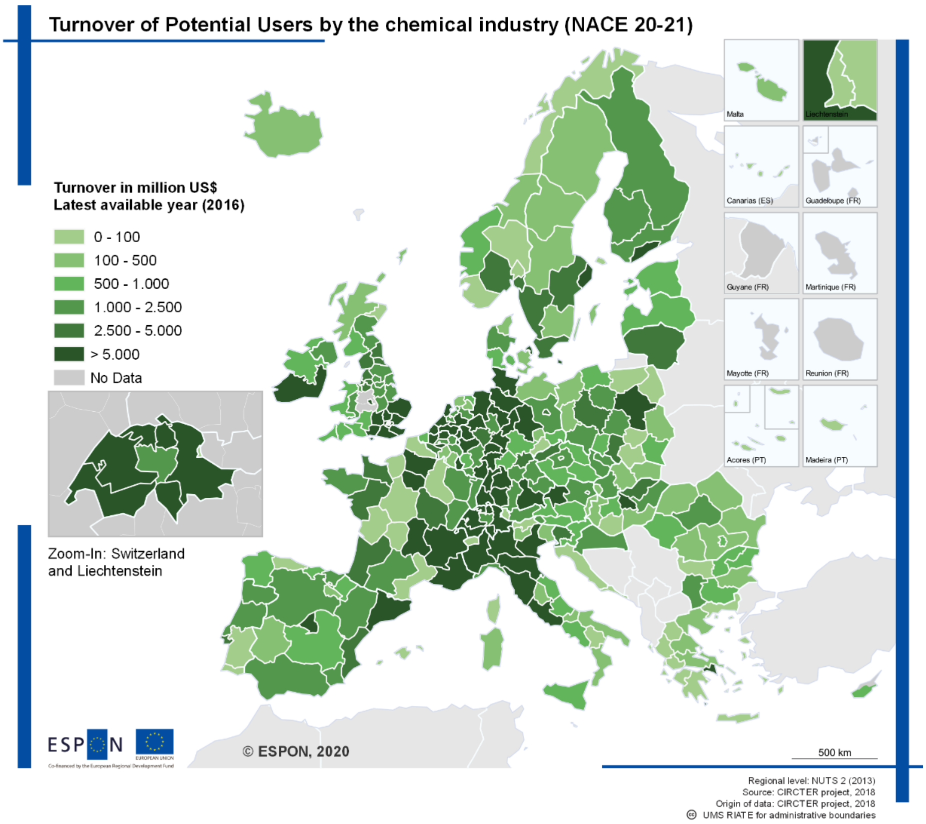


Source: CIRCTER project 2019.

Monitoring Potential Users can provide important insights on those territories having a greater potential for the implementation of circular innovative processes and products into underlying value chains. In this sense, the CIRCTER project identified as relevant sectors the automotive industry, the chemical industry, the metal industry, the electronics industry and the construction sector. These industries were found to be more related with established CE practices, namely: using fewer primary resources (e.g. recycling, efficient use of resources, use of renewable resources), maintaining highest value of materials & product (e.g. refurbishment, remanufacturing, reusing) and changing consumption patterns (e.g. product as a service, sharing models, consumption shifts toward more sustainable modes). Therefore, the following sectors were selected for Potential Users monitoring: chemical and pharmaceutical industry (NACE 20 and 21), manufacture of basic metals (NACE 24), manufacture of fabricated metal products, except machinery and equipment (NACE 25), electronics industry (NACE 26 and 27), automotive industries (NACE 29 and 30) and the construction sector (NACE 41 to 43). Automotive industry and the construction sector are excluded from the present analysis because not critical for the Swiss regions and Liechtenstein[6].

Map 3-8 shows the turnover generated by the –energy intensive– chemical and pharmaceutical industry (NACE 20-21). Circular business initiatives oriented to renewable energy use and secondary raw materials utilization (like solvents, waste oils, but also plastics) could have a rather fertile ground in areas specialized in this sector. This is the case in most of the Swiss regions, whose turnover generated by the chemical industry is among the highest in the European regions. Namely, Northwestern Switzerland (CH03) seems to be the second region, just after Ile de France, with the highest turnover in Europe (i.e. >150 billion US$). It follows Espace Mittelland (CH02), Zurich (CH04), Lake Geneve (CH01) and Ticino (CH07), which, even if with significantly lower figures (from 25 to 11 billion US$), still rank at the top of Europe.

Map 3-8: Turnover of Potential Users by the chemical industry (2016)

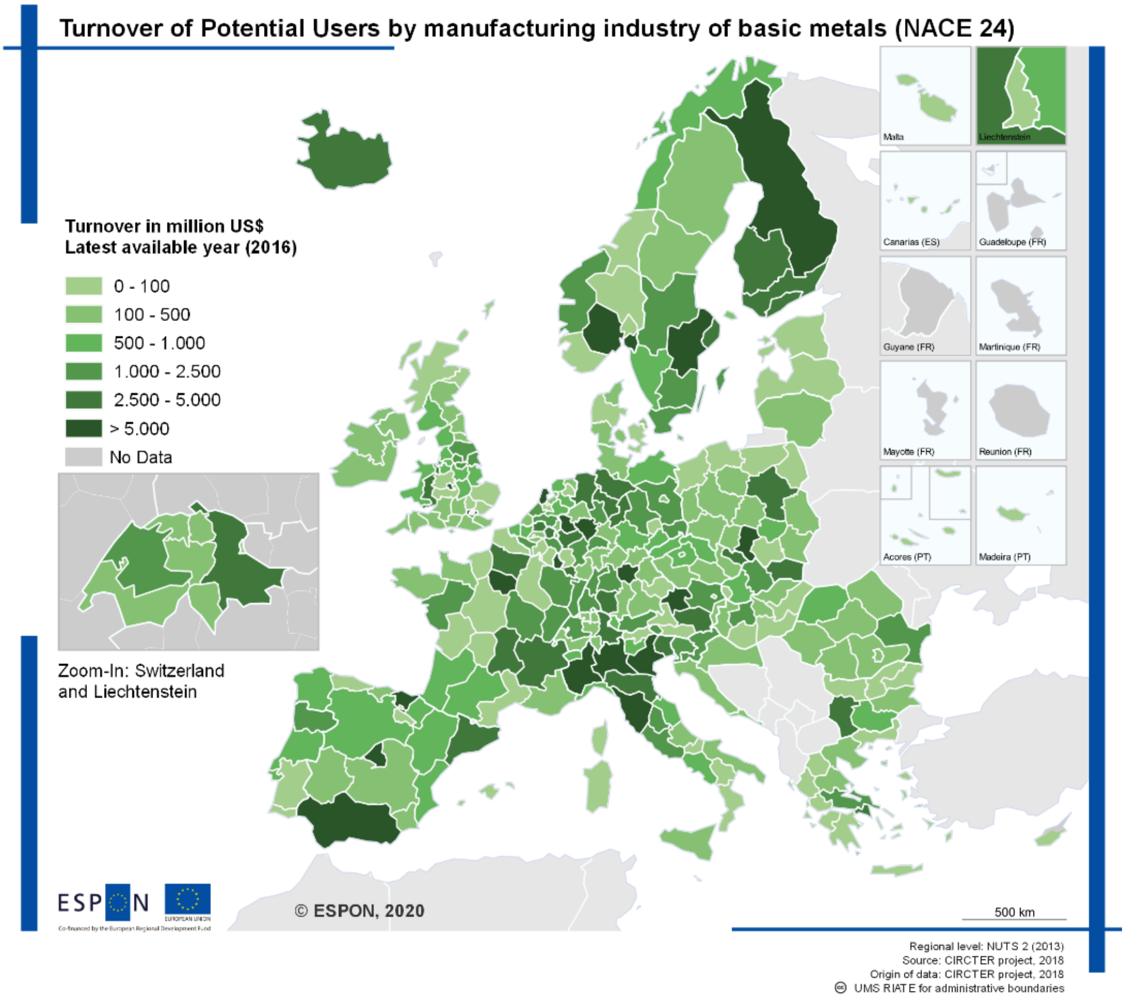


[6] According to CIRCTER data, the Swiss regions and Liechtenstein have among the lowest European turnover in the automotive and construction sector

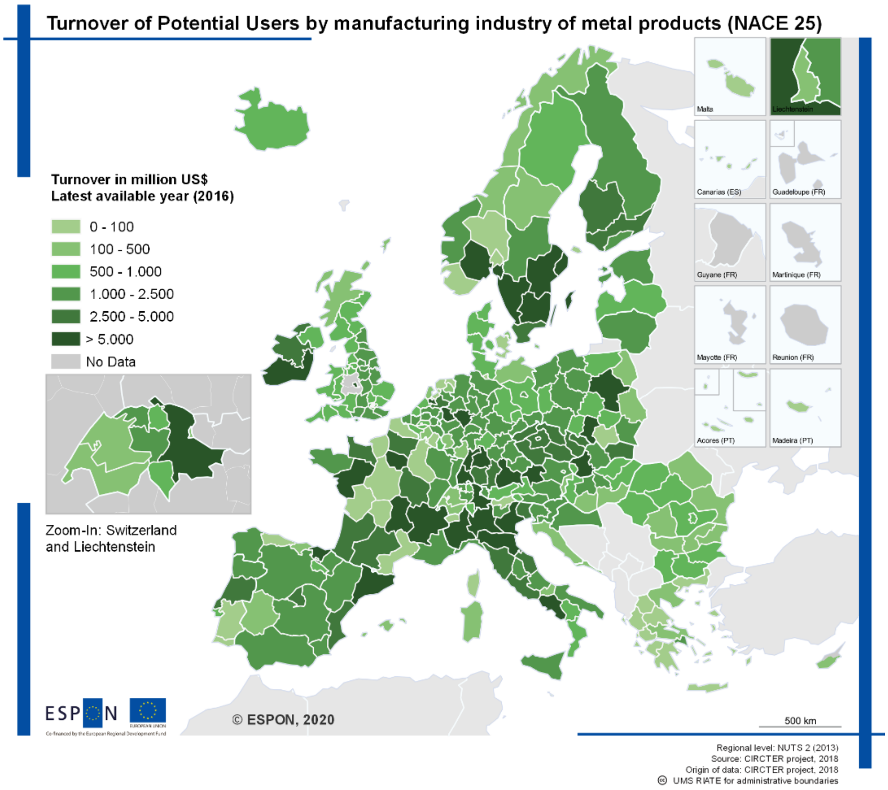
Map 3-9 and Map 3-10 show the turnover generated by the manufacturing industry of basic metals and metals products. Circular approaches to manufacturing and resource management are particularly well suited to the mining and metals industry. On the whole, metals are infinitely recyclable, while their inherent durability, strength and anti-corrosive properties help to enhance the longevity of products in which they're used. The high value of many metals and minerals also incentivises the recovery of such materials at the end of a product's life cycle. As an example, countries like Luxembourg have made "recycling and reuse of metal waste" a cornerstone of their domestic supply chain, as they import roughly 2 Gigatons of iron and steel waste per year (Luxembourg SPIN-OFF report). Regarding the area of study, Eastern Switzerland (CH05) is the region generating the highest turnover in both, manufacturing of basic metals and manufacturing of metals products with 4.300 million US$ and 7.600 million US$, respectively. This was somewhat to be expected as this region is, indeed, the most specialized in the secondary sector between those analysed (see Figure 2-3).

To conclude, Map 3-11 shows the turnover generated by the manufacturing industry of computers and electrical equipment. The relevance of consumer electronic product for a transition to a Circular Economy is well known. On the one hand, the persistent increase in electronic waste require a "rethink" in design strategies in order to keep the value of entire products or components as long as possible in the economy. On the other hand, the value of the critical raw materials incorporated in e-waste is increasingly seen as a real mine to be exploited. According to CIRCTER data, Zurich (CH04) seems to be the better placed region to take advantage of circular consumer electronics. With a turnover of 44 billion US $, Zurich is not only the leading area within the regional sample considered, but also one of the first European regions in this sector.

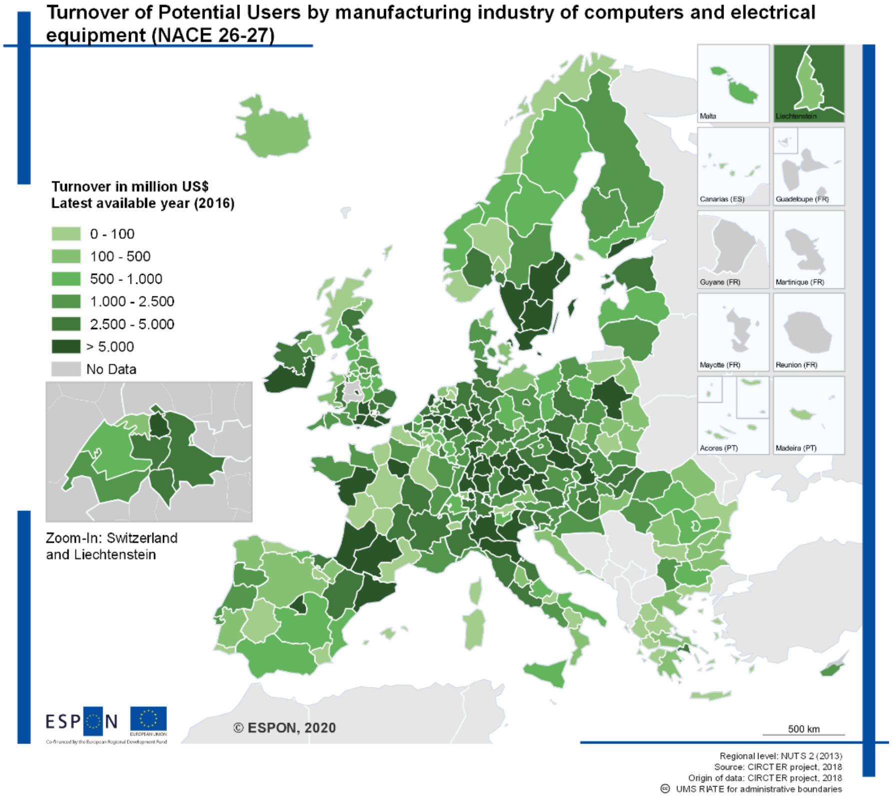
Map 3-9: Turnover of Potential Users by manufacturing industry of basic metals (2016)



Map 3-10: Turnover of Potential Users by manufacturing industry of metal products 2016)



Map 3-11: Turnover of Potential Users by manufacturing industry of computers and electrical equipment (2016)



4 The territorial metabolism of Switzerland and Liechtenstein

This chapter takes a closer view on the material and waste flows previously mapped in order to provide additional insights on Switzerland and Liechtenstein territorial metabolism, and hence, a better understanding of the more incipient challenges towards closed-loop systems. In order to complement CIRCTER evidence, additional data sources were explored. These mainly refer to the Federal Office for the Environment (FOEN) and the Federal Statistical Office (FSO) for Switzerland and the Office of Statistics of the Principality of Liechtenstein. To note that data for the thematic areas of waste and material flows are generally only available at the country level, therefore a granular analysis at the regional level – in the Swiss case – was not possible in this case. However, given the small territorial extent of Switzerland and the relatively close spatial proximity between Swiss regions, national values could still offer important insights which, taking the necessary precautions, can translate into tailored regional implications. Furthermore, as the data sources between Switzerland and Liechtenstein differ and, therefore, the classification of the indicators and the underlying approaches to estimate them are not the same, a direct comparison between these two countries was not possible. Therefore, the analyses for Switzerland and Liechtenstein are presented in separate sections. Also note that while details on material flows are provided for Switzerland, they are not provided for Liechtenstein, as this country does not have environmental accounting statistics.

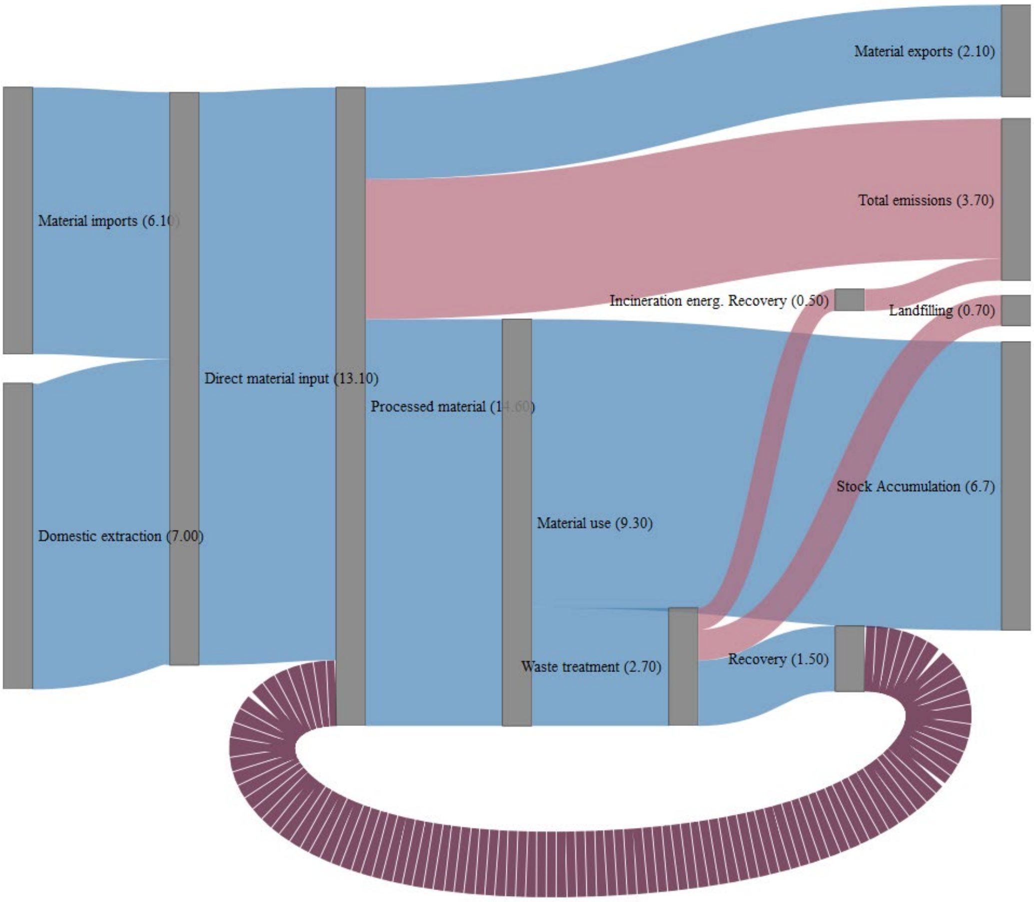
4.1 Swiss material flows patterns

Figure 4-1 shows a Sankey diagram of the aggregated flows of material and waste in Switzerland in 2018. The diagram shows that in 2018, 48% of the materials processed by the economy came from domestic extraction, 42% from imports and 10% from waste recovery. 64% of these materials are used to manufacture products or infrastructure, the rest is exported (14%) or released into the environment (22%) mainly as emissions into the air. The total waste treated (excluding exports) was about 2.7 tonnes per person in 2018. 55% of this waste was recovered as materials and could thus be re-injected into the economic system (circular loop). 25% was landfilled and the remaining 20% recovered as energy and thus returned to the environment as emissions into the air. Finally, 6.7 tonnes per person are added annually to the society's material stock, which consists mainly of buildings and infrastructure.

The Circular Material Use (CMU) rate (Eurostat, 2018), which corresponds to the share of the quantities of materials recovered in the total of materials consumed, is estimated to be around 13% in 2018 (i.e. 1.5 tonnes per capita) and has been rising steadily since 2000 (CMU ~8 % in 2000). Even if the Swiss CMU is above the European average of 12.1%, Switzerland still seem to have much room for improvement. In fact, just under half of the total residues generated are still directed to less preferable treatments options (i.e. incineration and/or landfilling).

Figure 4-1 also shows that the flow of recovered materials is small in relation to the total material inputs required by the Swiss economy. This is so despite some recovery rates are very high in Switzerland (such as, according to the Federal Office for the Environment (FOEN), over 80% for paper and almost 94% for glass). Therefore, even in an ideal scenario where all waste streams would have been recovered, these secondary material flows (from recycling) would only partially replace raw material flows (specifically just one fifth). This evidence highlights once again that the absolute priority for the Swiss regions should remain the diminution in the consumption of materials and/or goods, and the consequent reduction in waste generation.

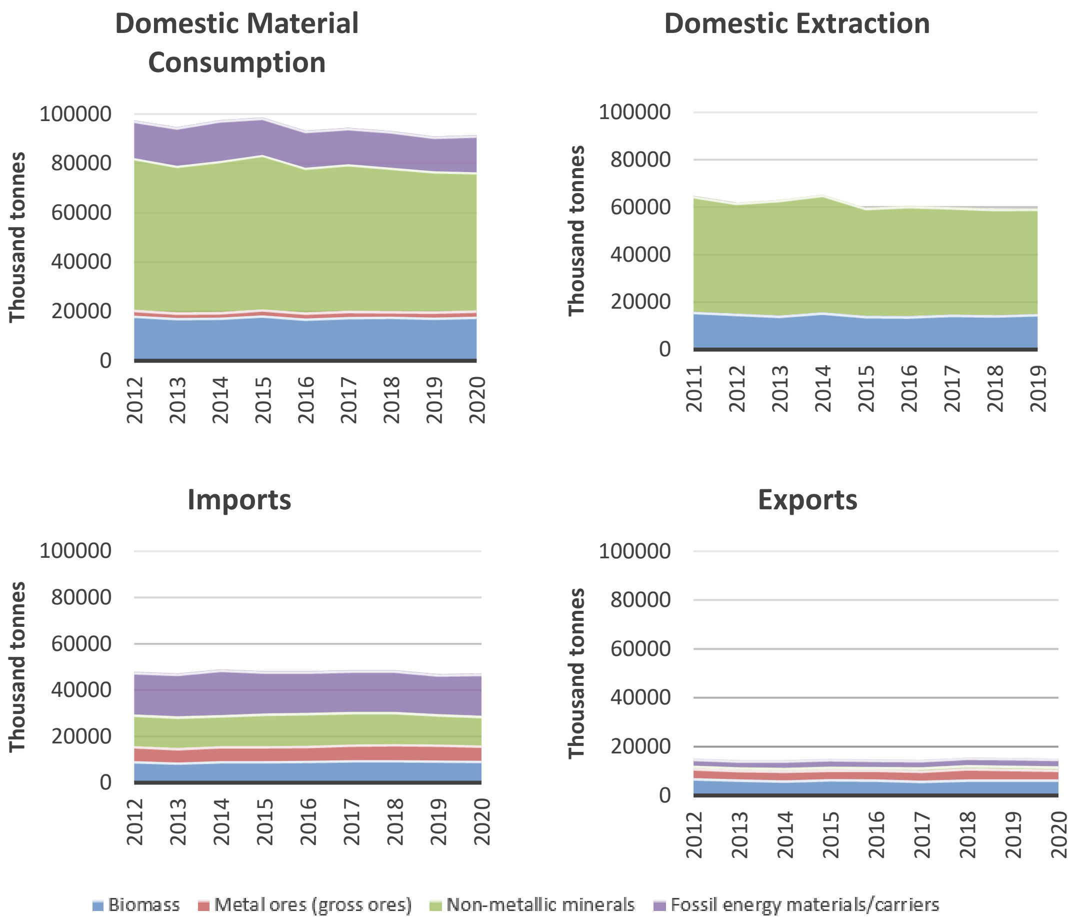
Figure 4-1: Switzerland Sankey diagram: aggregated material and waste flows in tonnes per person, 2018



Source: own elaboration based on FSO (2020) – Environmental accounts. Note that for reasons of readability, balancing items that allow for the consideration of e.g., air exchange during the combustion process, are not shown here. In order to ensure the consistency of the diagram, the mass of emissions to nature is deduced from the other flows and does not correspond to the actual mass published in the material flow accounts (6.5 tonnes per person). In addition, due to methodological reasons, "soils waste", i.e. soils and stones that originate mainly from construction activities, the excavation of contaminated sites and soil remediation, have been excluded since they are not considered within material flows accounting.

Figure 4-2 shows the evolution of Swiss aggregated material flows during the 2012-2020 period, while Figure 4-3 provides granular details on the type of materials within each material flow in 2018. As anticipated in section 3.1, the Swiss DMC appears to have embarked on a downward trend, having decreased by 8% from the peak recorded in 2014. Similar patterns can also be observed for domestic extraction flows. Here the only types of material extracted in the domestic territory are constituted by biomass (especially crops) and minerals such as sand and gravel. Both recorded decreasing patterns since 2014: biomass extraction decreased by 5%, while minerals by 10%. Import and export material flows remained quite stationary within the decade analysed. The steady influx of imports could be one of the reasons why the consumption of equivalent raw materials in Switzerland has decreased to a lesser extent than in the DMC.

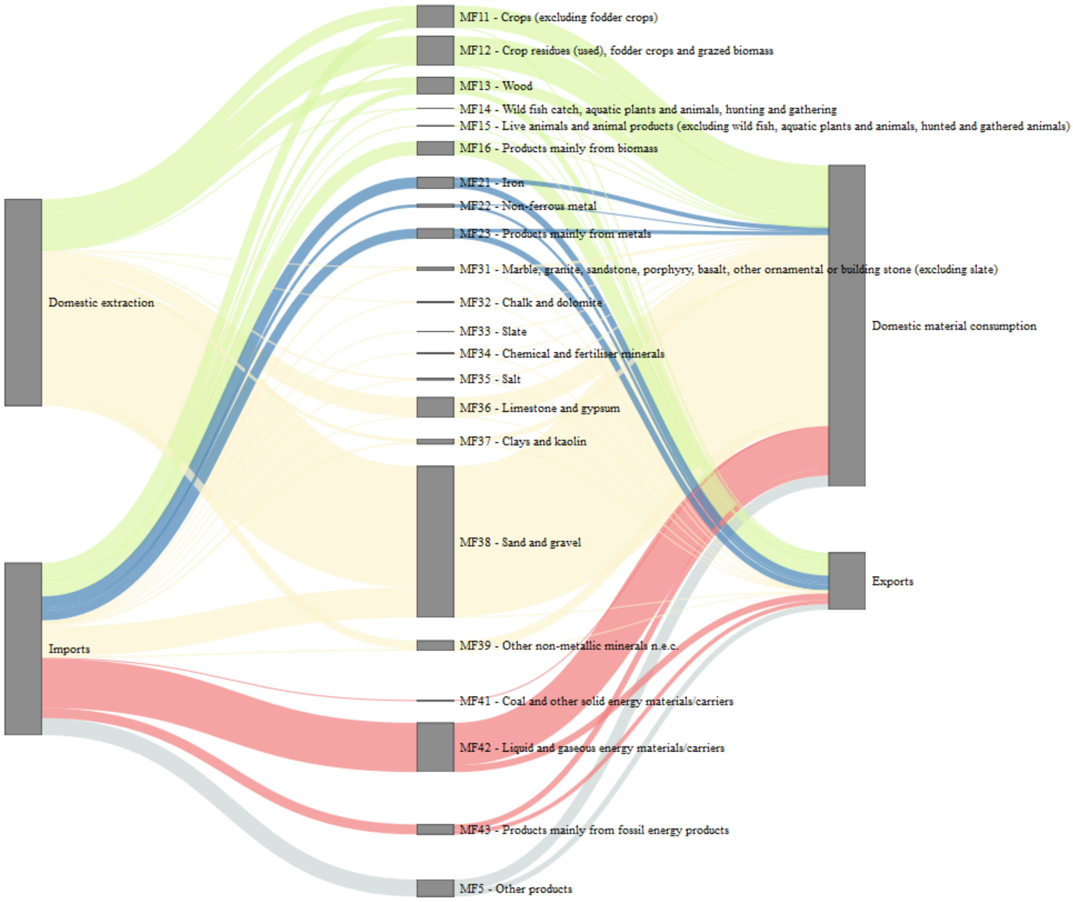
Figure 4-2: Evolution of DMC, DE, Import and Export by material flow typology



Source: own elaboration based on EUROSTAT “env_ac_mfa” database

Overall, domestic extraction is significantly low compared to DMC. Indeed, while the European average measures a DE of 11.44 tonnes per capita, Switzerland extracts only 6.9 tonnes per capita. This pattern reflects the relatively scarce availability of natural resources and, consequently, Switzerland's specialization in advanced manufacturing and the tertiary sector on the one hand, while on the other hand the country's important dependence on imports. The biggest flows of imports include liquid and gaseous energy materials/carriers (14 million tonnes), sand and gravel (8.6 million tonnes) and iron (3.2 million tonnes). All of these are primarily required to meet domestic demand as export material flows are far smaller in scale.

Figure 4-3: Sankey diagram of economic-wide material flows (2018)



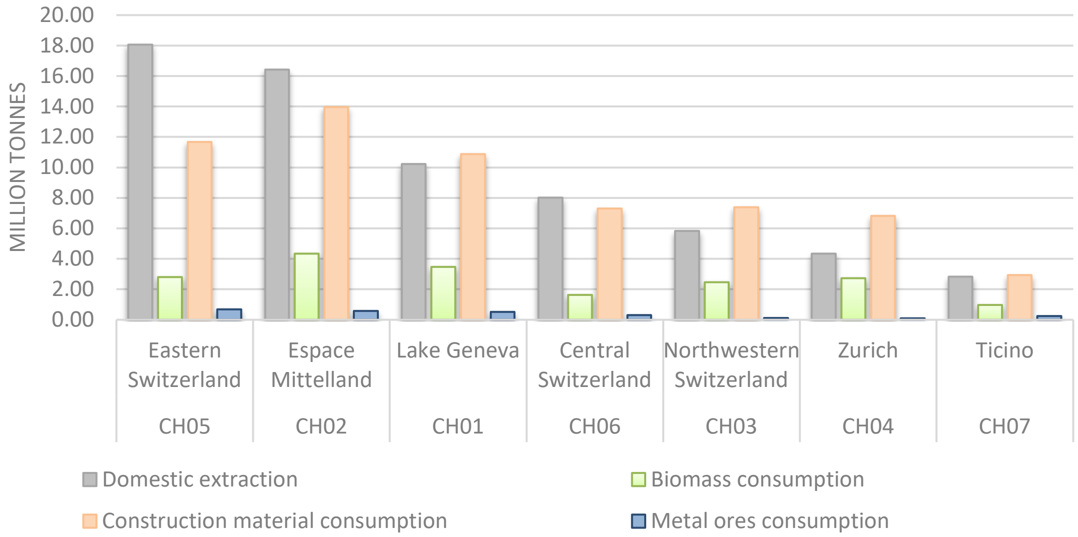
Source: own elaboration based on EUROSTAT “env_ac_mfa” database

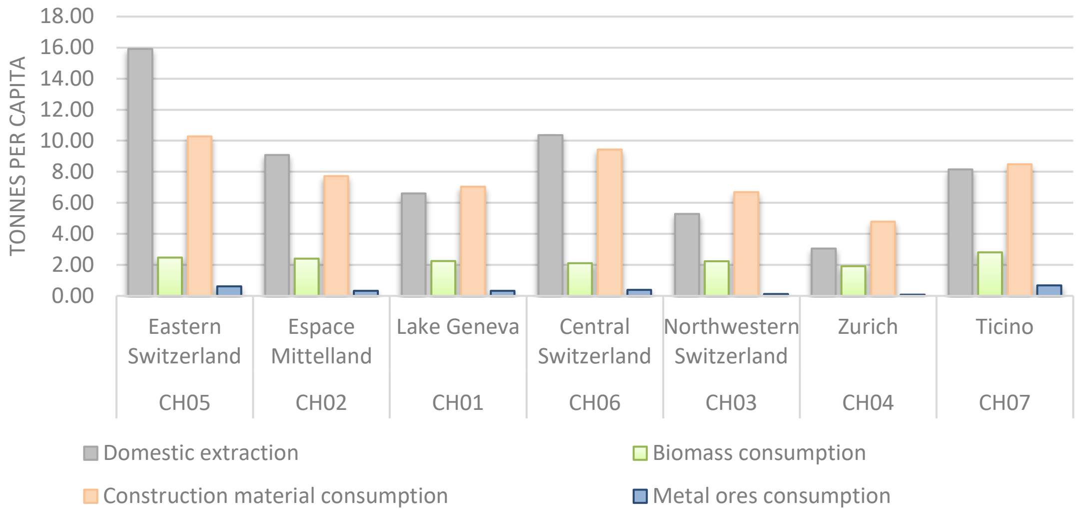
Figure 4-4 provides an estimate of how these material flows might be distributed across Swiss regions. The regional data were assessed in the CIRCTER project. Eastern Switzerland (CH05) and Espace Mittelland (CH02) likely concentrate most of Swiss extraction activities, i.e. non-metallic minerals (sand and gravel) and biomass (crops). Not surprisingly, these two regions also have the highest consumption level for construction material, more than 11 million tonnes, and, in the case of Espace Mittelland, also biomass consumption (> 4 million tonnes). Therefore, according to this evidence, Eastern Switzerland (CH05), Espace Mittelland (CH02) and, to a less extent, also the Lake Geneva region (CH01) are the territories where most of (raw) materials are extracted and/or processed. This suggests that these regions could reap higher benefits in term of resource efficiency through an improvement of their productive means – not only meant as technological progress, but also as better resource management – in extracting, primary processing, construction, as well as design activities.

Furthermore, resources used for the construction of buildings and large transport and protection infrastructure (e.g. tunnels, bridges, roads on pillars, protections against avalanches and crumbling) constitute a great amounts of materials that are “captured/locked” for several decades (and up to century). The reuse and recycle of construction and demolition waste generated within the country’s boundaries might partly supply secondary raw materials to the Swiss construction sector. Other alternative means of supplying the Swiss sector with secondary raw materials may come from abroad neighbouring regions, in case a surplus of unused waste were to be handled (see e.g. the recent case study of industrial symbiosis to manage construction and demolition waste between the Swiss region of Ticino and the Italian region of Lombardy (Borbon-Galvez et al. 2021)). Switzerland may take advantage of (1) its central location in the heart of Europe where goods are transitioning and (2) its very developed infrastructures for transport of goods (up to 70% of goods are transported in Switzerland by rail). Such new collaborations with neighbouring countries could be supported in their initiation with Interreg programmes (see e.g. WINPOL and CONDEREFF Interreg projects), at least to explore the viability of such solution and test it under real market conditions.

On the right side of Figure 4-4, regions such as Ticino (CH07), Zurich (CH04) and Northern Switzerland (CH03) have significantly lower quantities of material extraction and / or consumption. This is mainly due, with the exception of the case of Ticino, to the higher degree of urbanization of these areas which on the one hand limits material-intensive activities such as extraction and / or primary processing, and on the other brings these areas to depend mainly on the import of intermediate products and finished goods, thus avoiding the consumption of material necessary for their processing. Circular initiatives geared at the organisation and optimisation of urban life might be therefore more relevant in Zurich (CH04) and Northern Switzerland (CH03), which have the greatest concentration of population. In particular, changing consumer habits in these areas could be a key milestone in paving the way for decoupling economic growth from resource consumption.

Figure 4-4: Regional comparison of domestic extraction and material consumption by type of flows (2014)





Source: own elaboration based on CIRCTER data

4.2 Swiss waste patterns

With roughly 6 million tonnes of municipal waste generated annually, Switzerland is one of the countries with the highest per capita waste production in the world and, considering the steady growth of the population and increasing prosperity of this country, these figures are expected to increase in the future. On the positive side, thanks to the waste management policies adopted and the long-standing tradition of developing and using environmental technologies especially for waste management, Switzerland is also one of the countries with the highest recycling rates for municipal waste.

Figure 4-5 shows the municipal solid waste (MSW) trend between 2004 and 2019, while Figure 4-6 compares the management of MSW between Switzerland and the European average in 2018[7]. First, it should be noted that despite a rather stable MSW generation per capita and a recycling rate very high since 2004, the absolute amount of MSW has not stopped growing. Namely, it increased by more than 1 million ton, which is equal to a 23% increase compared to 2004 levels. Concerning the management perspective, more than half of municipal solid waste is recovered in Switzerland, unlike the European average which is 47%. It also stands out that, thanks to the introduction of the ban on landfilling in Switzerland on 1 January 2000, this treatment option has been eliminated since 2003, contrary to the European experience that still redirects a considerable amount of MSW to landfills (i.e. 23%).

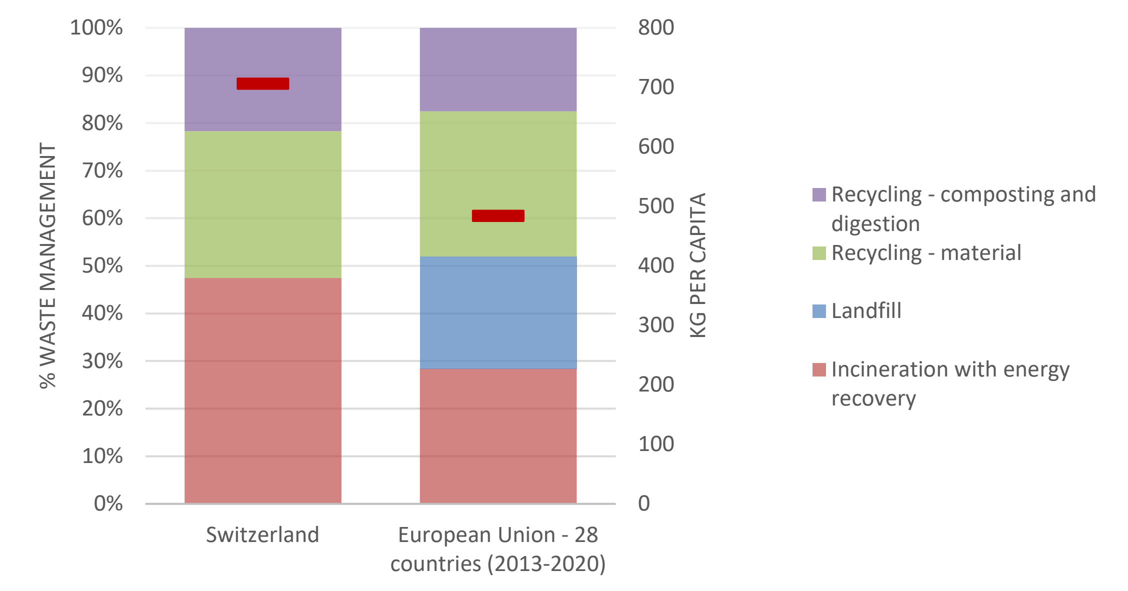
Typically, the production of municipal waste is closely related to the number of inhabitants and their economic well-being. The higher the population, the more waste is produced. Likewise, the greater the economic well-being, the greater the waste. Therefore, not surprisingly, Figure 4-6 also shows a stark difference between Swiss MSW per capita (706 kg/cap) and European average of MSW generation per capita (484 kg/cap). Notably, despite, the MSW has grown overtime, the amount of waste directed to incineration seems to remain stable, suggesting therefore the prioritization of Switzerland towards higher-level waste treatment options.

Figure 4-5: Swiss municipal waste generation (2004-2019)

Source: own elaboration based on FSO statistics

[7] European average refers to the European Union in the period 2013-2020, based on 28 countries.

Figure 4-6: Municipal waste management: Switzerland vs EU average (2018)

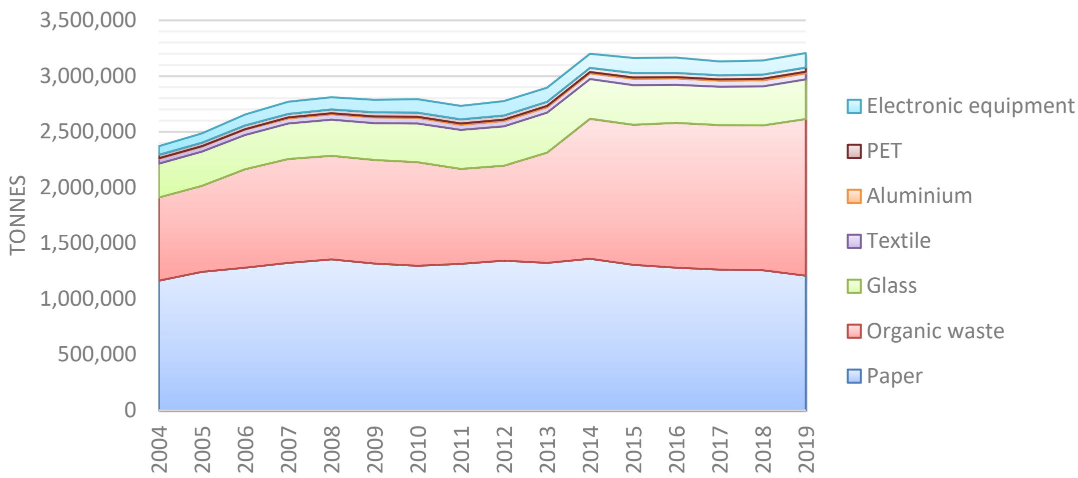


Source: own elaboration based on EUROSTAT data

Figure 4-7 shows the evolution of separately collected municipal waste by type of waste. In 2019, 373 kg of urban waste per person or 3.2 million tons, were collected separately for recycling, i.e. around 53% of total urban waste. Paper, glass and green waste make up the largest share. The streams of collected waste that experienced major increases over the selected period are aluminium (+68%), organic waste (+47%) and electronic equipment (+41%). While the population growth and the evolution of consumption habits are arguably at the roots of these trends –especially for organic waste and electronic equipment, waste management improvements can also partly explain the increasing amount of separately collected waste. Indeed, they may have gradually increased the amount of separately collected waste to the detriment of mixed waste. As mentioned above, when it is about recycling rates, Switzerland is among the best European countries. According to the Office Fédéral de l'Environnement (OFS), recycling rate in 2019 were 82% for paper and cardboard, 94% for glass and aluminium, 81% for PET.

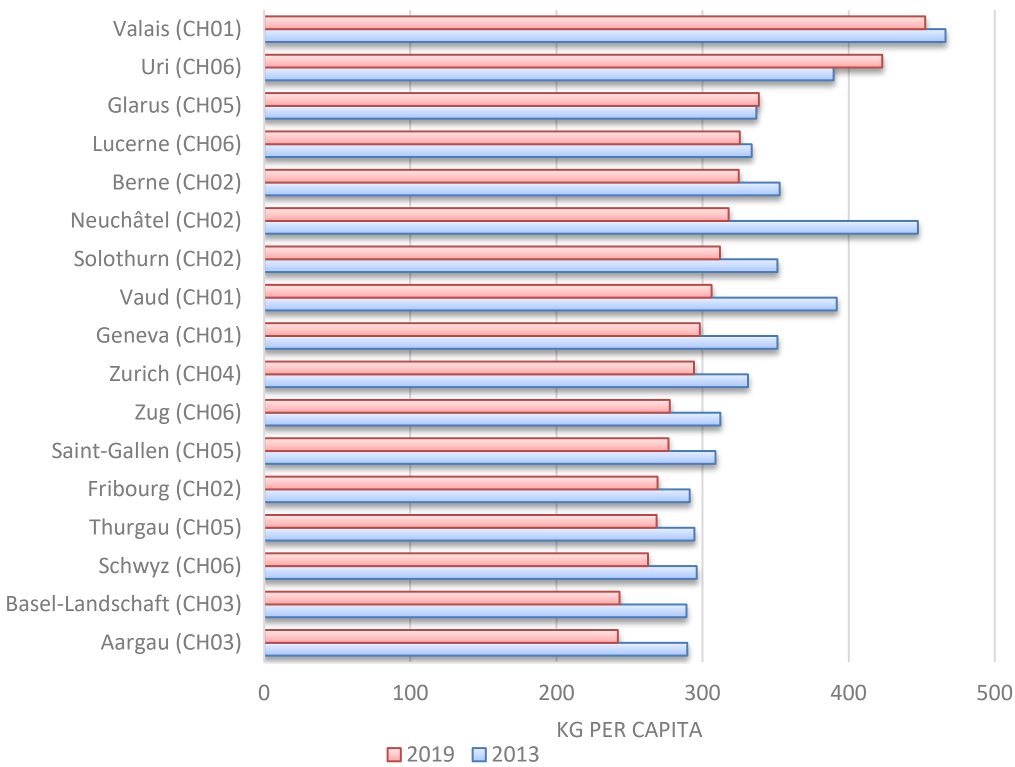
Figure 4-8 presents a comparative overview of municipal waste generation at the canton level. In this case, municipal waste only considers following categories of used materials collected separately; i) old paper + cardboard (together), ii) glass and iii) aluminium + sheet + other metals (together). The data have been collected within the national framework "Cercle Indicateurs", which has been designed to measure sustainable development in townships and cities. The cantons participate to the initiative on voluntary basis. In general, a reduction of municipal waste can be observed between 2013 and 2019. The only exceptions are Uri in Central Switzerland (CH06) and Glarus in Eastern Switzerland (CH05). These cantons not only increased waste generation in the selected period, but also have among the highest figures in municipal waste per capita. Valais canton in Lake Geneve region generated the highest amount of waste in 2019, i.e. 452 kg per capita. By contrary, Aargau and Basel-Landschaft in Northwestern Switzerland (CH03) are the cantons with the lowest amounts of municipal waste (240 kg per capita).

Figure 4-7: Swiss municipal solid waste generation by type of waste



Source: own elaboration based on FOEN statistics

Figure 4-8: Municipal waste* generation per capita (2013 vs 2019)

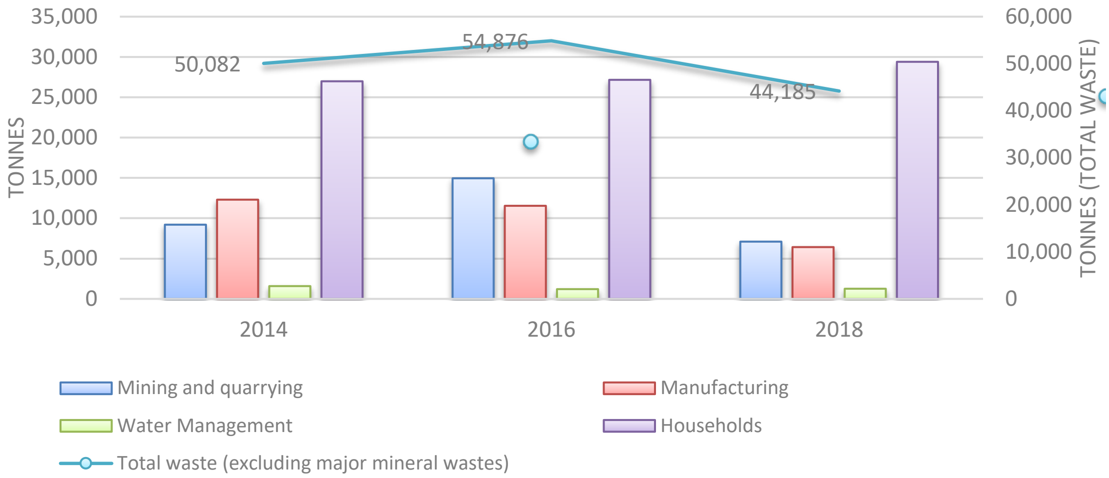


Source: own elaboration based on OFS – Statistique de la population et des ménages (STATPOP), Statistique de l'état annuel de la population (ESPOP); Données des cantons; *municipal waste in this case only includes paper, glass and metallic packaging.

4.3 Liechtenstein waste patterns

In 2018, Liechtenstein generated 44 thousand tonnes of municipal waste, excluding the soil waste generated by the construction industry (i.e. 388 thousand tonnes). Since soil waste generally accounts for a huge share of total waste (in this case it represents 89% of total waste), it is often kept separate when analysing waste streams, in order to avoid diluting the other categories. Figure 4-9 shows the evolution of total waste and waste generated by NACE activities and households during the period 2014-2018. Total waste in 2018 decreased by 12% compared to 2014. Apparently, this reduction has been due to the less amount of wastes generated by the mining and quarrying sector (-23%) and the manufacturing sector (-48%). To note that soil waste also decreased by 25%, from 516 thousand tonnes in 2014 to 387 thousand tonnes in 2018. On the contrary, the waste generated by household seems to grow constantly, as it increased by 9% in the selected period. This trend is very similar to that observed in Switzerland and mainly explained by two factors at play: population growth and economic prosperity. In this context, the shift of consumption behaviours towards more sustainable and circular models will be fundamental not only to decouple these trends, but also and above all to significantly reduce the amount of household waste, given that it represent more than half of the total waste produced.

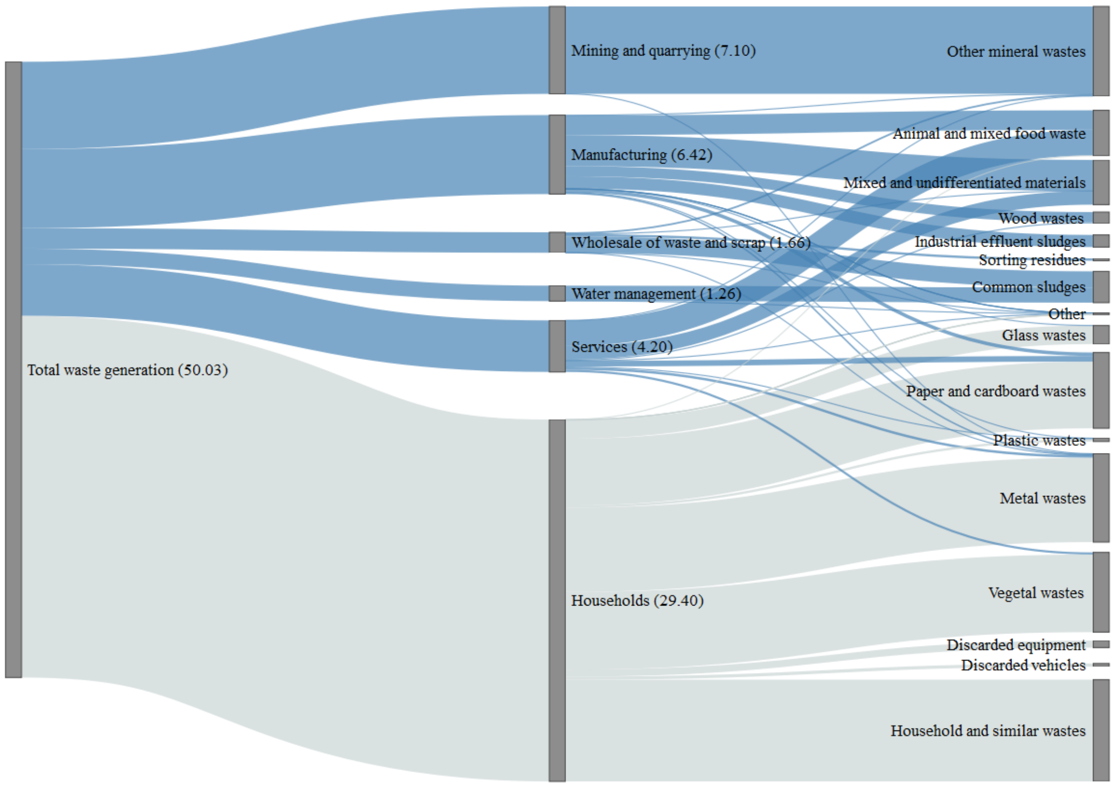
Figure 4-9: Total waste generation (excluding major mineral wastes)



Source: own elaboration based on EUROSTAT data [env_wasgen]. Note: only waste activities available for 2014, 2016 and 2018 are showed.

The relevance of household waste is clearly visible in Figure 4-10, which shows the breakdown of total waste (excluding the main mineral waste produced by construction activity) by type of economic activity and, consequently, by type of waste. Domestic waste amounts to 29 thousand tons, equal to 67% of the total waste produced. Concerning the economic activities, mining and quarrying represents the second larger stream (14%), followed by manufacturing (13%) and services (8%). In terms of types of waste, household and similar wastes represent the biggest amount, i.e. more than 8 thousand tonnes (17%). This category is constituted principally by mixed municipal waste, bulky waste, street cleaning waste and household equipment, and the main amount comes from private household. Importantly, it should be noted that it excludes specific categories of waste fractions like glass, paper, metal or plastic. While these latter are, in general, soundly managed, i.e. separately collected and recycled whenever possible, mixed municipal waste is generally incinerated. However, data on treatment of total waste generated is not available in EUROSTAT statistics for Liechtenstein. Data referring to the treatment of municipal waste, as provided by the Office of Statistics of the Principality of Liechtenstein, was instead considered.

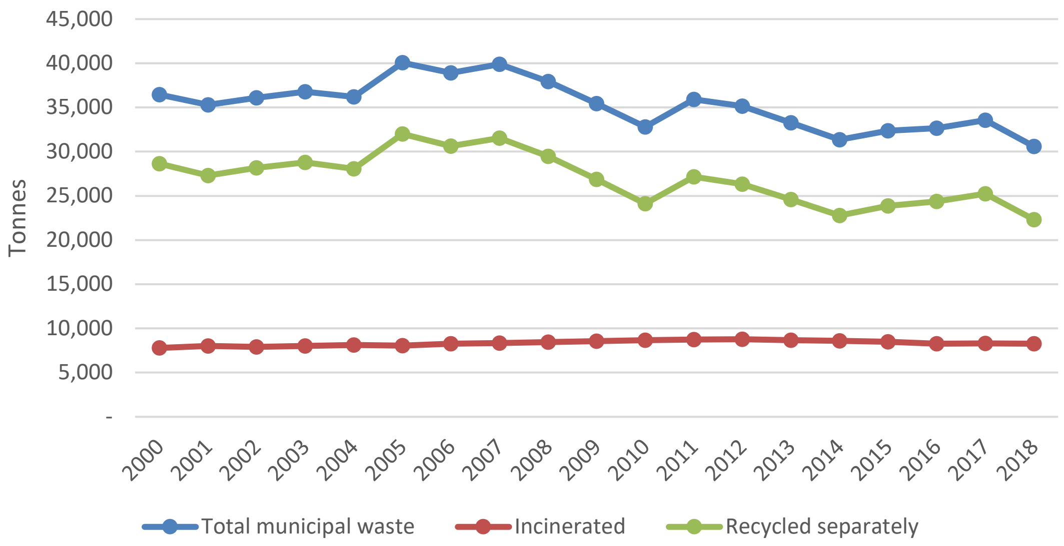
Figure 4-10: Waste generation breakdown by NACE activities and type of waste (thousand tonnes)



Source: own elaboration based on EUROSTAT data [env_wasgen]

Figure 4-11 presents the evolution of municipal waste generated in Liechtenstein during the last two decades, along with the treatment modes, i.e. incineration and recycling. Note that in this case municipal waste should equal, to a great extent to “waste generated by household” as defined by the EUROSTAT statistic nomenclature. While the difference between the two indicators is very small in 2018 (29.4 thousand tonnes vs. 30.6 thousand tonnes), it seems that the two indicators follow opposite trends. Namely, increasing waste is generated by household, while municipal waste generation is decreasing. The reason of this inconsistency might be double. On the one hand, it should be recalled that the municipal waste consists of waste collected by or on behalf of municipal authorities and disposed of through the waste management system. Therefore, next to waste generated by household, municipal waste also includes similar waste produced by sources like commerce, offices and public institutions. Therefore, it may be the case that these different sources have either been progressively decreasing the waste generated or, have taken on the direct responsibility for the collection and disposal of waste, therefore accounted for as *industrial* waste. On the other hand, the second factor that may cause this divergence may be a pure technicity, or in other words a difference between how the two institutions estimate these indicators.

Figure 4-11: Liechtenstein municipal waste generation (2000-2018)



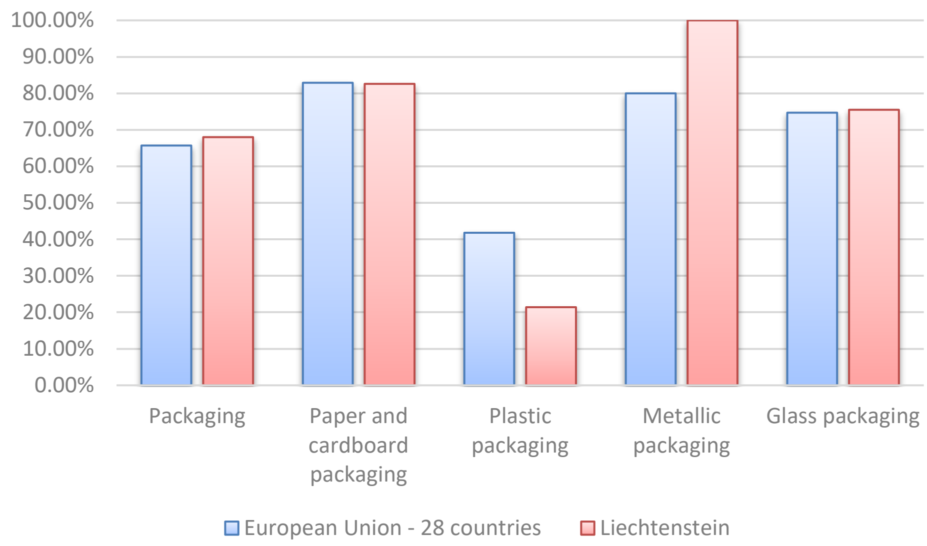
Source: own elaboration based on Office of Statistics of the Principality of Liechtenstein data

Overall, Liechtenstein has a good recovering rate of municipal waste, that is above the 70%, or 22 thousand tonnes in 2018. More than half of this amount was constituted by recyclable material, while a lower share was constituted by compostable and/or green waste. If any, it would be important to draw attention to the high level of MSW generation per capita, which is even greater than Switzerland, i.e. 800 kg per capita. Although, as mentioned above, such a high level could also be due to the extraordinary flows of commuters that characterize Liechtenstein, the decrease in MSW should remain a critical priority for the country.

Although there are no waste incineration plants operating in Liechtenstein, slightly more than 8 thousand tonnes are exported annually to Switzerland for incineration. This waste treatment option is increasingly contested nowadays because of its doubtful trade-off between energy-efficiency gains and environmental degradation (Abbasi, 2018). While in the short term it will be rather difficult for Liechtenstein to shift away from this waste treatment option due to long-term contracts in place, it will be important to not increase the amount of future waste incinerated. Especially given the rise in household waste rates.

On the bright side, thanks to the very efficient recycling infrastructure and collection system in place, Liechtenstein went already beyond some of the most ambitious targets set by the European Union in terms of recycling. As a sort of best-practice benchmark, we present in Figure 4-12 the Liechtenstein recycling rates of packaging waste with the European Union average in 2018, and we contextualise these recycling rate with the most recent targets set by EU waste directives. Under the revised Waste Framework Directive, households and business will have to recycle at least 55% of their municipal waste by 2025, and to reach 65% in 2035. Liechtenstein already achieved this target with a recycling rate of 68%. Regarding the Packaging Waste Directive, it requires governments to ensure specific recycling targets by type of packaging by the end of 2025. These are 55% for plastic, 75% for glass and 85% for paper. According to Figure 4-12, Liechtenstein is well on track for paper and glass packaging (recycling rates of 82% and 75%, respectively). However, it seems to be lagging behind for plastics as it only recycled 21% of plastic packaging compared to the EU average of 42%. Notably, Liechtenstein recycles 100% of metal packaging.

Figure 4-12: Recycling rates of packaging waste: Liechtenstein vs European Union

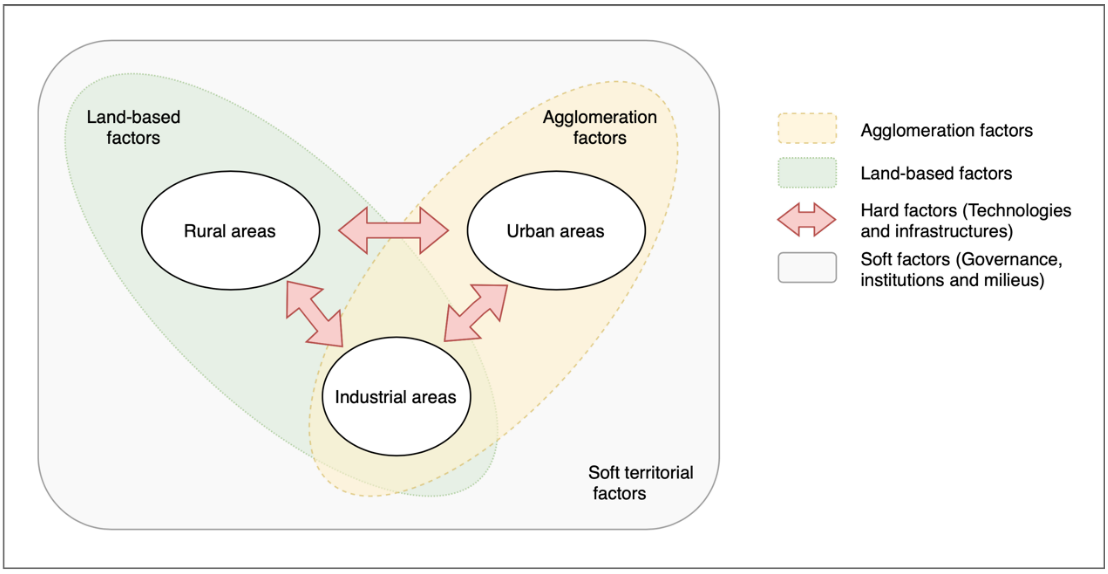


Source: own elaboration based on EUROSTAT data [env_waspacr].

5 Circular Economy and the territorial perspective

In this chapter, we explore the role that territorial aspects identified in CIRCTER might have in Switzerland and Liechtenstein for the circular economy transition, besides being potential drivers of economic competitiveness and resilience. In the 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 Taking stock of territorial strengths to boost transition towards circularity

Understanding the territorial specificities of different areas becomes crucial to envisage a successful transition towards a circular economy. As a general rule, the distribution and combination of socioeconomic factors (e.g. population, businesses), along with the availability of natural endowments, often determine the framework conditions of circular configurations. The presence of large stocks of biomass resources might, for example, drives the uptake of circular solutions based on a bioeconomy (e.g. as in the SPINOFF case study for Scandinavian regions). Differently, the presence of a dense socio-economic fabric and the lack of primary raw materials might favour the deployment of circular strategies based on the valorisation of produced waste (e.g. as in the SPINOFF case study for Luxembourg). While the identification of these "hard" factors is important to envisage overall goals, a sound understanding of circular enablers, like the installed technological or R&D capacity, the level of accessibility (i.e. transport infrastructure) and the governance and institutional systems in place, is critical to guarantee a successful deployment of circular strategies (Tapia et al., 2021). The following SWOT table provides an overview of the main strength, weakness, opportunities and threats of Switzerland and Liechtenstein, from the perspective of circular economy transition. The SWOT results are based on the territorial analyses conducted in chapter 3 and 4.

Table 5-1: Switzerland and Liechtenstein SWOT analysis

Strengths	**Weaknesses**
• Highly efficient collection and recycling systems • Well-established industry in advanced manufacturing (chemical products, metal-based products, computer and electrical equipment) • Industry and key areas supported strongly by education and research institutes • Platforms and networks help sharing experiences and disseminate innovations across the country and internationally • High economic prosperity • Cutting-edge take-back system • Favourable financial and business environment • Transport logistic node with important corridors running through Europe • Public awareness and institutional commitment on environmental/sustainability issues.	• High municipal waste generation per capita • Lack of natural resources and consequent dependence on foreign countries • Shrinking employment in some regions (e.g. Ticino or Lake Geneve region) • Different/'mismatched' geography for waste management initiatives at the local level
Opportunities	**Threats**
• Capability to adopt smart technological sustainable solutions • Building closer collaboration of business innovation and research for circular-designed products • Smart public solutions and competitive advantage for business through innovative public procurements • Sustainable industry including production, new materials, digitalisation and circular business models. • Active participation in European collaborations/initiatives	• Increasing generation of municipal waste • Increasing dependence from foreign countries • Incineration lock-in effect • Increasing urban-rural disparities and intra-regional centralisation • Non-comprehensive planning for attractive rural areas • Potentially neglected opportunities for industrial symbiosis due to reduced material-intensive economic activities

Source: own elaboration

5.2.1 Decoupling waste generation from consumption: eco- and functional design

Thanks to the waste management policies adopted in the past and the very efficient collection and recycling system in place, Switzerland and Liechtenstein are among the countries with the highest recycling rates. However, Switzerland and Liechtenstein high recycling rate stands alongside a huge volume of waste. Hardly any other country generates as much municipal waste in relation to the resident population. In this context, the emphasis should be placed first on avoiding the generation of waste and, secondly, transforming waste into secondary resources of high quality.

For the first prospect, the local governments shall play a critical role by ensuring competitive environments for developing, testing and demonstrating new business models. **Boosting green procurement and eco-design principles** constitute some examples of strategies which can contribute to accelerate a shift towards the circular economy by introducing products and services presenting improved reparability, durability and recyclability in addition to energy efficiency. Public authorities, since the national down to the local level should therefore stimulate value chain actors through different instruments (e.g. economic incentives, standards, legislation) to bring more circular and sustainable products to the market. Such collaborations should bring industry (including entrepreneurs), knowledge centres, investors and public authorities together for creating enabling environments for innovation.

A rigorous adoption of eco-design principles could be particularly relevant in those forefront sectors with high circular potential. In this sense, as showed by the sectoral perspective in Section 3.3, most of Swiss regions are very specialised in chemical products and electrical equipment. The last report "Support for the upcoming Commission initiative towards an EU product policy framework supportive of circular economy" (European Commission, 2019) identifies several possibilities for designing these products for circularity. For example, reducing use for chemicals could be achieved through design requiring less re-paint or capable of "self-healing" for paints, capsule design for minimising use for detergents, and so on. Similarly, increasing circularity is possible via *reuse or* repurposing *network* (see e.g. *rreuse*[8]*,* an International network **representing social enterprises active in re-use, repair and recycling**). Differently, for Electronics and ICT equipment value retention and waste generation are more dependent on changes in technology and associated obsolescence, rather than durability, although reliability, reparability and upgradability are still important to allow reuse, for example by less-demanding users. Circular/sustainable design is increasingly gaining ground in Europe. As an example, in UK the Center for Sustainable Design[9] and the UK agency of Design[10] are active promoters of the concept. Similarly, in Switzerland, the Swiss government supports the Reffnet.ch network of experts offering advice to companies, especially SMEs, on increasing the material and energy efficiency in their products and production processes and therefore reduce costs and environmental impacts throughout their value chain. Enterprises can get targeted advice and audits.

Furthermore, as a general rule, eco-design activities should also **refer to the functionalities** that a product delivers, in terms of the services it provides to customers. By focusing on the functions that a product delivers rather than the form that it takes, the team can innovate more broadly and consider a wide range of possible options. For example, with respect to the use of chemicals, the guidance from the OECD on key considerations for identifying and selecting safer chemical alternatives can be used to structure an assessment of the safety profile of a product with regard to the chemicals used and emitted throughout the product's life cycle (OECD, 2021). The guidance provides a decision-making process focusing on minimum assessment criteria and recommended assessment practices for substituting hazardous substances with less harmful substances. Under the process, the two dimensions of chemical risk — comparative hazard and exposure — are assessed and scored and the scores combined to give an overall score for safety. The guidance also includes recommendations for moving beyond the minimum chemical safety criteria and assessment practices.

In terms of opportunities, the next European Commission's research and innovation framework, Horizon Europe, will support the development and adoption of approaches that are safe and sustainable by definition.

[8] https://www.rreuse.org/
[9] https://cfsd.org.uk/
[10] https://agencyofdesign.co.uk/projects/

This may include the development and validation of guidance materials, interdisciplinary exchanges of good practice and the creation of pilot projects in key industrial sectors. In this context, Switzerland and Liechtenstein may showcase domestic best-practice or, equally, be-trained through technical support centers on approaches and methods for upstream design of safe and sustainable products. This will help foster innovation and ensure the alignment of quality and safe requirements of products to use in Europe.

5.2.2 Reducing raw material dependence by fostering markets for secondary materials

As claimed in several parts of this report, Switzerland and Liechtenstein do not benefit from abundant natural resources. Instead, they are increasingly reliant on imports from foreign countries. On the top of that, too much municipal solid waste is generated and incinerated. In this context, **enhancing markets for secondary raw materials** might reduce the dependencies and risks in global supply chains of Switzerland and Liechtenstein (especially for certain critical raw materials), besides boosting regional value and jobs creation.

In this respect, one key challenge is enabling well-functioning market conditions. Procurement rules, fiscal and other financial instruments should be better calibrated to incentivize the supply and use of secondary raw material or circular products. Governments should introduce ambitious **green – circular – requirements in public procurement.** As an example, in France, according to Law No. 2015–992 by 2020 at least 40% of paper products, fiber-based stationery and printed materials acquired by the state services and by local authorities and their groups should be made from recycled paper. The law also provides similar requirements for the procurement of road construction and maintenance. Obviously, the introduction of green requirements should take the characteristics of SMEs into account. Several Interreg Europe projects (GPP4Growth, CircPro and GPP-STREAM) address the use of Green Public Procurement).

Regarding tax-based tools, the example of Sweden can be taken. Sweden has tax rules that incentivize repair and longer product life spans, thereby fostering a reduction of new products, as well as the associated use of materials and generation of waste. These incentives are helping to steer the Swedish economy from a linear to a circular model and to redeploy parts of the workforce from production and waste management to design, repair and maintenance.

Given the long tradition of Switzerland and Liechtenstein in high environmental standards, more ambitious targets can also be pursued by **shifting taxation from labor to resources**. This idea is based on the theory that increasing resource taxes will incentivize a reduction of their use and decreasing labor taxes will reduce unemployment as well as stimulate economic growth. Furthermore, a reduction in labor taxes can facilitate the transition to a circular economy by improving the competitiveness of labor-intensive activities, such as maintenance and repair of products, as well as R&D efforts. Not surprising, the EU has repeatedly advocated such a tax shift, *inter alia*, in its 7th Environmental Action Programme[11] and in the Roadmap for a Resource Efficient Europe (European Commission, 2011). Given the increasing reliance on imports and the reiterated Swiss goal of reducing its footprints to within planetary boundaries, Switzerland may represent an optimal testbed to experiment “third type” of resource tax, i.e. based on consumption (ETC/SCP and ETC/WMGE, 2015). Even if the determination of the tax base may be difficult particularly for products with a complex composition of resources, exploring the introduction of a resource tax is nevertheless recommended, at least for those products/resources particularly critical for Swiss economy, to steer the economy towards a more sustainable and resilient model.

One of the biggest issues in terms of material circularity remains the management of non-metallic mineral flows and, thereby, construction and demolition waste (CDW). Non-metallic minerals and CDW comprise the largest material streams in Europe. Switzerland and Liechtenstein are not an exception. As shown in section 4.1, non-metallic minerals represent more than 60% of material domestically consumed in Switzerland (i.e. 56 million tons in 2019). Most of these (i.e. 80%) are directly extracted from the domestic territory. On the other hand, 84% of the Swiss industrial waste volume comes from the construction industry[12], which

[11] See Decision No. 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on a General Union Environment Action Programme to 2020 ‘Living well, within the limits of our planet’, OJ L 354/171.

[12] https://sps.swiss/en/stories/story-detail/the-circular-economy-is-more-than-just-recycling

also accounts for 40% of domestic energy consumption and 50% of the consumption of natural resources. In Liechtenstein, CDW represented almost the 90% of total waste in 2016 (LISD, 2020). Almost a third of this was landfilled. In this context, a reduction of CDW can be achieved at first instance through better design and construction management practices. Complementarily, the adoption of circular economy-inspired actions can help not only to optimize CDW flows by reintroducing them into the economy, but they would also mitigate the environmental burden that mineral extraction activities represent. Circular economy-inspired interventions should go beyond simply increasing the quantity of recycling[13], but should try to keep materials in the economy for as long as possible while keeping their intrinsic value / quality as high as possible. Several circular actions are currently being implemented across Europe ranging from the design of high-grade products with high-recycled content and the consideration of design for disassembly principles, to selective demolition or deconstruction. For this latter, a good example is provided by the city of Paris, which is developing a deconstruction/demolition framework agreement that establishes a deconstruction methodology for construction waste management (OECD, 2020) or the CIRCUIT project (https://www.circuit-project.eu/), which brings together several partners across the entire built environment chain to showcase how circular construction approaches can be scaled and replicated across Europe. Similarly, public and private procurement processes might include selection criteria such as: sorting organization internally on site; transport of waste to a recycling platform, traceability of the disposal of construction waste; the rate of recovery of construction waste specifying the nature of waste, the sectors and suppliers.

In general, the main barriers to the uptake of circular economy actions relevant for the management of C&DW mainly concern the price competition with virgin cheaper minerals, which also have guaranteed quality through warranties and standards. Therefore, also in this case, enabling effective and competitive markets for secondary raw material is critical. Engaging in the **development of standards for secondary raw materials** would increase the trust in their properties and quality. Several initiatives have been recently implemented, also relating 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/ or the Cityloops project https://cityloops.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.

Finally, the study revealed that the generation of municipal waste is outpacing the overall efforts to dispose it cleanly. Switzerland tradition on developing and using environmental technologies especially for waste management has existed since the 1960s, and today the country is a pioneer in this domain by rigorously installing treatment and incineration plants with stringent emission standards. However, incineration not only proved to be less-than-adequate over time, but also disincentivise further efforts towards waste reduction or higher-level waste treatment options (Klitkou et al., 2019). As these infrastructures require a stable amount of incoming material to be profitable, installed capacity on Swiss territory can cause a lock-in effect, not only for Switzerland but also for Liechtenstein, as the country has ensured the supply of domestic municipal waste through long-term agreements[14]. Considering that waste generation will likely continue to grow in these regions, **alternatives to reduce waste should be prioritized in the first place over end-of-pipe solutions**, to avoid potential technological lock-in traps.

To this aim, 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-consumption-disposal system. However, according to Economiesuisse[15], the Swiss waste management system, which is largely in the hands of the State or public bodies, seems sometimes to disincentive or hinder private initiatives. In many cases, private companies are just partners in waste management (especially in the cement industry or for waste electrical and electronic equipment), and

[13] The high recovery of C&DW in Europe is based, to a large extent, on backfilling or on low-grade recovery, e.g. using recycled aggregates from the mineral part of C&DW on applications such as road sub-bases. Therefore, the inherent value of the materials composing C&DW is eroded, qualitative aspects of recycling are not systematically addressed and recycling is not performed in closed loops (EEA, 2020)

[14] Almost a third of Liechtenstein municipal solid waste is exported to Switzerland yearly.

[15] https://www.economiesuisse.ch/fr/dossier-politik/%C3%A9conomie-circulaire-d%C3%A9finition-et-situation-en-suisse

the state framework conditions often do not allow them to play a more active role. By its very systemic nature, cooperation among authorities, municipalities, academia and businesses and across sectors is critical in the circular economy. Therefore, a more **integrated stakeholder-based approach** is crucial for ensuring progresses towards circular systems. In this sense, the Swiss initiative "RESSOURCEN TRIALOG[16]" might offer a good example of developing a common understanding on complex issues like optimal handling of waste and resources by involving actors from a broad spectrum of science, business and society.

5.2.3 Leveraging collaboration among business actors to stimulate innovations for circularity

Switzerland and Liechtenstein are among the European territories best positioned to take advantage of installed technological know-how for the deployment of circular systems. According to the Regional Innovation Scoreboard (RIS) (European Commission, 2019), all Swiss regions are "innovation leaders", i.e. they have an overall innovation performance 40% above the EU average. In particular, Zurich (CH04) and Ticino (CH07) are the first and second most innovative regions across the European countries analysed. To note that performance has significantly increased for Ticino between 2017 and 2019 (in 2017 Ticino scored 8th in the RIS rank). For what concerns the potential for circular-oriented innovations, Swiss regions like Ticino (CH07) and Northwestern Switzerland (CH03) seem to be better placed as they were those introducing an higher number of new products (goods or services) and processes compared to other Swiss or European regions. The same goes for organisational innovations. Ticino (CH07), Espace Mittelland (CH02), Eastern Switzerland (CH05) and Zurich (CH04) have the highest share of SMEs innovating through non-technological innovations across Europe.

However, despite the high level of innovation, there seems to be a rather scarce collaboration between SMEs in Switzerland. Indeed, none of the Swiss regions appear among the top 40 regions with the highest share of SMEs engaged in cooperation agreement geared at innovation. Complex innovations such as circular products often depend on companies' ability to draw on diverse sources of information and knowledge, or to collaborate on the development of an innovation. Therefore, **new forms of cooperation** are essential to steer an economic sector towards a circular economy. Efficiency will be maximised if the know-how needed to implement resource-saving business models is developed in partnership. This strengthens the sector as a whole and at the same time favours individual companies. In this context, the creation of collaborative platforms involving all industry actors across value chains might be an important means of promoting cooperation. For example, the Swiss Circular Economy[17] platform promotes knowledge exchanges between different actors by collecting and making available relevant information and offering the possibility of developing industrial networks. A similar aim is pursued by the Circular Hub[18], a Swiss knowledge and networking platform to build and exchange application-oriented knowledge and practical experience in circular business. "Circado", a cross-industrial trading platform for industrial side-streams has been instead developed by the swiss Re-think Resources. This platform promotes the upcycling of material for new products of higher value.

In general, the prospects for information sharing are promising, but several barriers still remain to be addressed: access to relevant, reliable and standardised data; ensuring trust between stakeholders across the value chain; and finding a fair balance between enabling access to and the sharing of data are some of these challenges. In the short-term, policymakers should encourage 'coalitions of the willing' in the private sector to improve information sharing on the principle of freedom of contract (i.e. parties agree on the terms and conditions). However, long-term goals should aim at establishing a **standardised European system for information sharing** across value chains that ensures both 'data sharing' and 'data protection' in B2B and B2C markets (see "The circular economy: Going digital" by the European Policy center for further details on the linkages between digitalisation and the circular economy (EPC, 2020).

[16] http://www.ressourcentrialog.ch/welche-ziele-werden-angestrebt/

[17] https://www.economie-circulaire.swiss/

[18] https://circular-economy-switzerland.ch/projekt/circular-hub/?lang=en

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 Switzerland and Liechtenstein 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 these countries.

The high waste management standards together with the highly efficient infrastructure in place, have made Switzerland and Liechtenstein two of the European countries with the best waste management system in place. Nonetheless, even highly effective waste management is in itself insufficient to reduce countries' overall consumption of resources and waste generation. Indeed, the two countries are undergoing continuous growth in the total volume of MSW, while increasing the reliance on imported goods. In this context, moving towards a circular economy should be seen as a priority for the countries, not only to improve the waste and material patterns mentioned above, but also because the implementation of circular solutions might help some of the analysed regions like Ticino and Lake Geneve to counteract the shrinkage of employment.

If the final goal is to reduce consumption footprints – i.e. looking to impacts occurring along the global supply chain, a more **systemic approach to resources management should be adopted though the collaboration of different actors.** Governments should go beyond traditional waste policies and narrow end-of-life perspectives. The idea of circular business models is that not one company closes the loop, but the ecosystem does. New alliances should be sought within businesses, across the supply chain and between the private and the public sector. **Long-term strategic cooperation** should be at the heart of the Switzerland and Liechtenstein circular models. More ambitious waste management policy objectives with a focus on management quality, such as the introduction of requirements for re-use of CDW, would reorient current waste management practices to a more circular approach. In a digitally powered circular economy, policymakers can support the development of a functioning digital ecosystem that effectively generates data for circular economy business models through (1) incentivising the creation of cross-industry collaboration platforms, (2) developing business support schemes and programmes, and (3) introducing regulatory frameworks that address the issues of data privacy and ownership.

As countries with few raw materials but with a very innovative and flourishing business environment, Switzerland and Liechtenstein should take up the challenge to create **a language and an agenda for business-driven circular transition**. First and foremost, the circular paradigm can and should be seen as an opportunity to create new markets on which Swiss and Liechtenstein companies can thrive and compete for secondary resources, for the supply of more circular products and the protection of ecosystem services. Both, government and businesses, will have their part to play to bring these new markets to life.

On the one hand, regional and local authorities should deploy, whenever possible, fiscal, financial, economic and regulatory instruments to **enable markets for secondary materials**, incentivising the use of recycled materials and penalising undesirable waste management options (such as landfilling). Besides the already implemented pay-as-you-throw schemes, implementation of resource-based tax should be explored. In addition, efforts towards **standardisation** of secondary raw materials would help alleviate the lack of credibility of these materials. Measures like **Green Public Procurement** (GPP) or supply chain approaches that provide collective solutions to logistical difficulties[19] can also be helpful and boost the required market demand for circular products and secondary materials. On the other hand, business players and multinationals can play an important role in improving the consumer footprint by introducing (1) transparent requirements in global supply chains and (2) eco- and functional principles in early-stage design of products. These measures would promote a more efficient use of natural resources and the responsible use of ecologically sensitive materials such as peat, cocoa, soy and gold.

[19] E.g. reverse logistic systems would benefit from voluntary protocols in which a number of companies or a circular supply chains commit to a specific treatment and recovery system.

To conclude, an active role should also be foreseen for citizens. In particular, citizens should be *incentivised* to "buy into" consuming circular products (e.g. recycled goods, renewable energy etc.) and services (e.g. renting, leasing, sharing etc.) or adopt circular practices (e.g. repairing or upcycling goods, composting organic waste). All in all, the entire society can be a major catalyst for radical changes towards more sustainable consumption. In this sense, policymakers might complement awareness campaigns with direct **consumer empowerment** initiatives. For example, by requiring business to provide reliable and transparent information on issues such as repairability and durability of products to help consumers make environmentally friendly choices; as well as, by facilitating the design of strategic spaces that integrate CE practices into the built environment (e.g. repair cafes) to make circular resource management visible and accessible to citizens.

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