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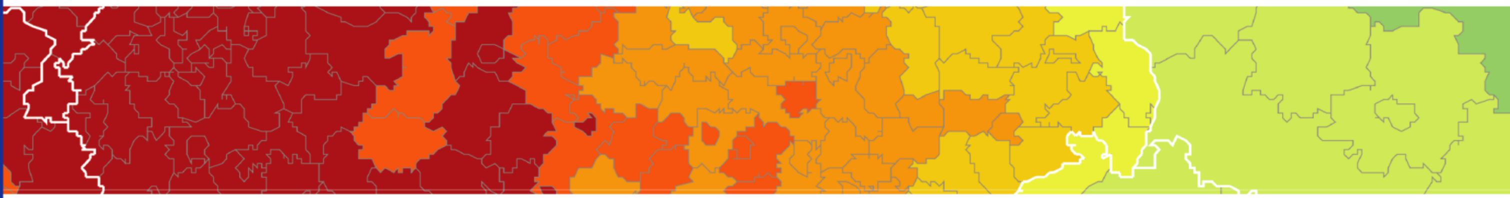

CIRCTER – Circular Economy and Territorial Consequences

Applied Research

Final Report

Annex 3

Material and waste patterns and flows in Europe:

A territorial analysis

Version 09/05/2019

Final Report

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Abbreviations

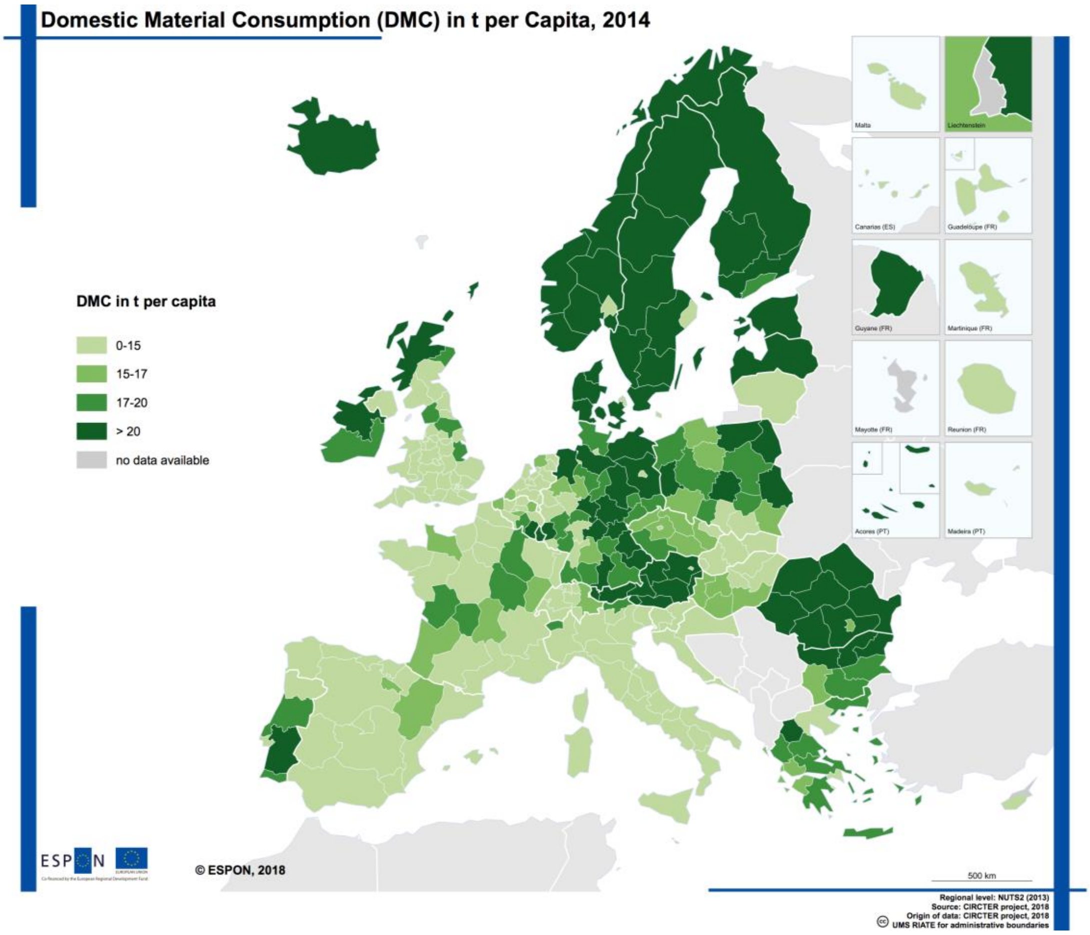
B2B	business-to-business
B2C	Business to Consumer
C2C	Consumer to Consumer
CBM	Circular Business Model
CDC	Caisse des dépôts et consignations
CE	Circular Economy
CEAP	Circular Economy Action Plan
CER	European Remanufacturing Council
CLD	Causal Loop Diagram
DE	Domestic Extraction
DMC	Domestic Material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

1 Material Consumption

Material resource use is usually measured in terms of Domestic Material Consumption (DMC) per capita. In 2014, the estimated DMC per capita of the European NUTS2 regions ranged from 5.6 t/capita to 52 t/capita. The median of all regions was about 16 t/capita and thus slightly above the EU28 average published by Eurostat (13.4 t/capita) (Eurostat, 2018).

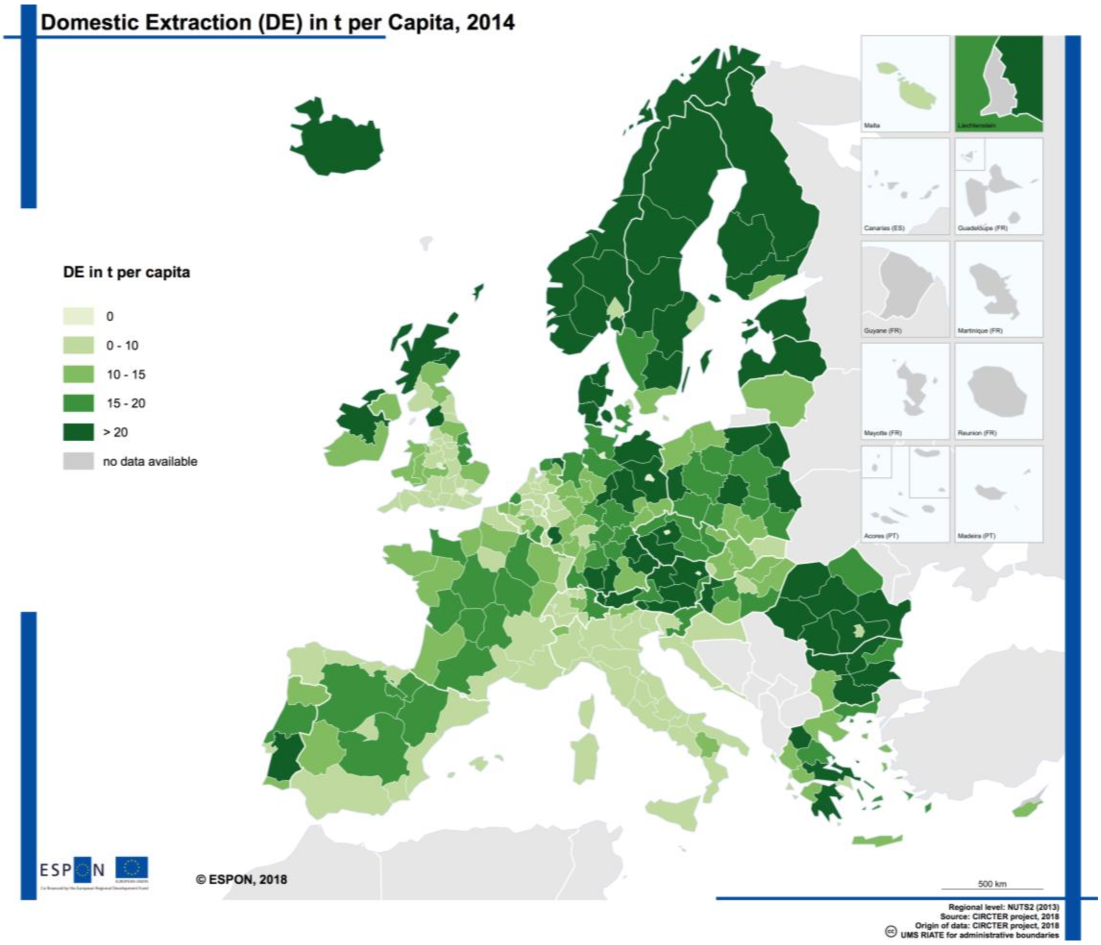
Map 1-1 shows that regions with a higher DMC per capita are often regions with a low population density like the Scandinavian regions or some regions of the British Isles. These regions are characterised by a high resource demand on a per capita base for infrastructure, e.g. road infrastructure or energy infrastructure. In addition, the Eastern European countries or regions often have a higher resource consumption per capita. In part, this can be explained by the higher importance of the primary sectors like mining and forestry and also by its downstream industries such as pulp production. The regional/national energy mix is another influencing factor regarding the level of the DMC: countries or regions with a high share on fossil energy sources for their electricity production, which is often the case in Eastern Europe regions, have rather high numbers in their domestic material consumption.

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



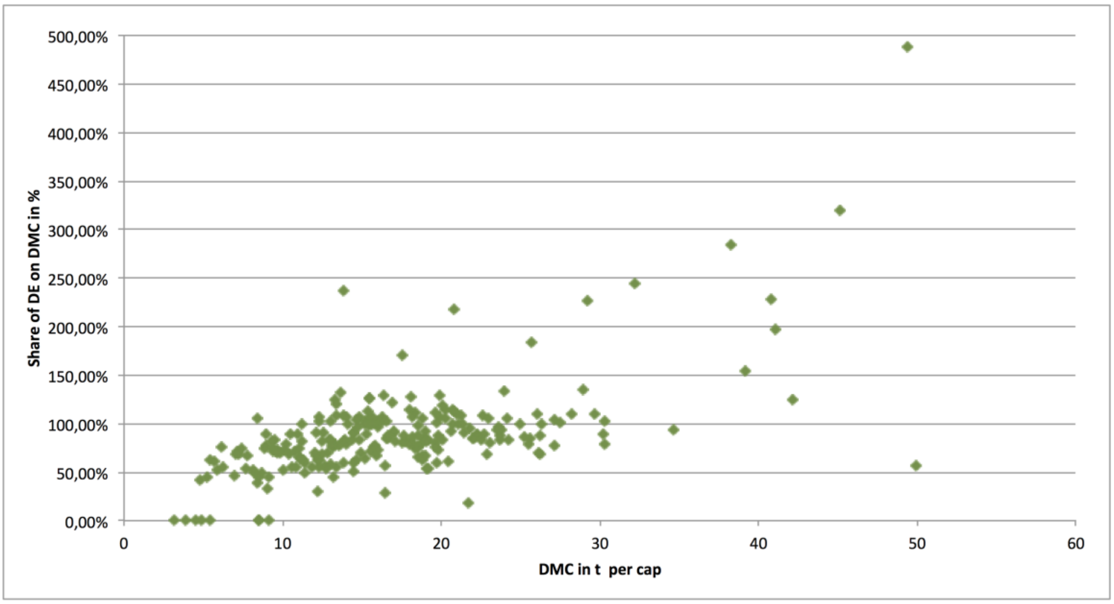
Although the DMC has a consumption perspective and exports are substracted, the DMC is not very suitable to depict the use of domestic resources for exports if these resources are further processed in the same region and later exported as semi-manufactured goods. With indicators like DMI and DMC, imports and exports are measured only with their own weights and therefore cannot reflect the amount of primary resources that is necessary to produce these goods. Countries or regions which import resource intensive goods from other countries or regions are often better off and have a smaller DMC per capita. Therefore, it is not surprising that the map for the Domestic Extraction per capita looks quite similar to the map for the DMC per capita.

Map 1-2: Domestic Extraction in tonnes per capita, 2014



However, if we combine these two indicators and scatter the DMC per capita with the share of DE on DMC in %, the picture is a little less definite (Figure 1-1): On the one hand, there are regions with a very low DMC per capita that also have a low share of DE in DMC. On the other hand, there are regions with a high DMC per capita whose DE values are mostly greater than 100%, suggesting that these regions are partly exploiting their natural resources for other regions. However, we can also see that in the range of DMC per capita where the majority of the analysed NUTS2 regions are located (12 – 23 t/capita), the spread of the share of DE in DMC is quite big. These differences could be explained by the different export structures of these regions (primary goods like hard coal vs. semi-manufacture and finished goods based on domestic resources like paper and steel).

Figure 1-1: Share of DE in DMC plotted against DMC per capita



Source: own elaboration

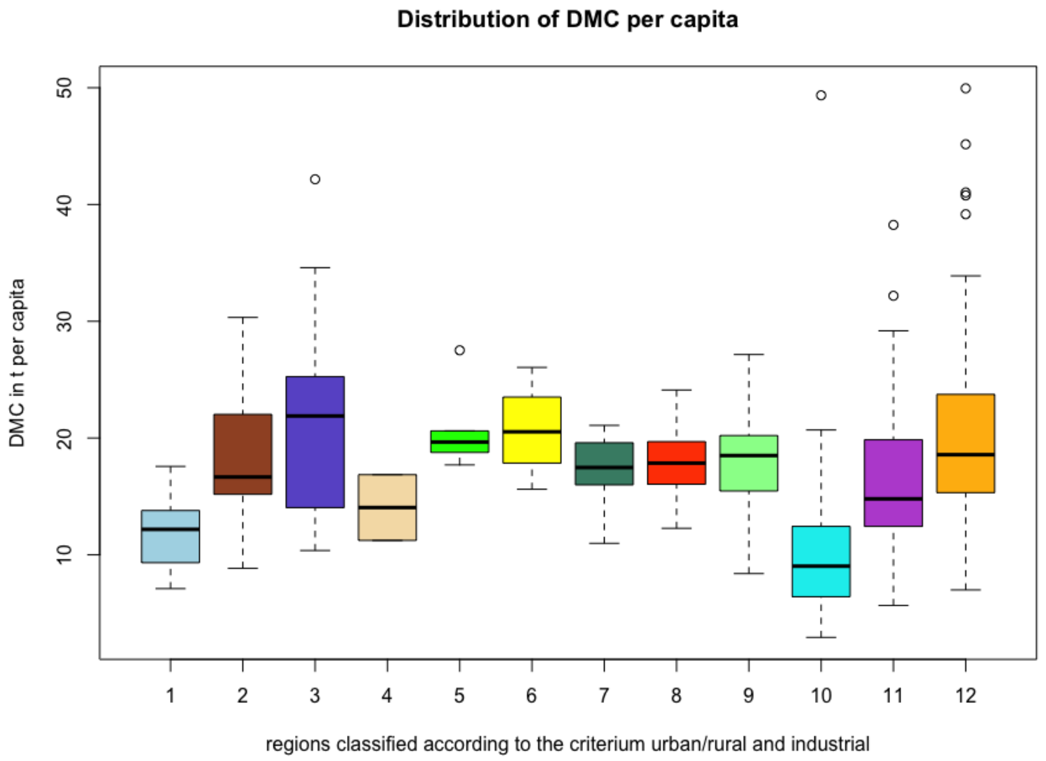
In another step, we aimed at answering the question whether there are differences between different types of regions in terms of their DMC per capita.

In order to do this, we used the Tercet urban-rural typology and the typology on regions in industrial transition developed by ESPON. Both typologies had to be adopted to our NUTS2 region approach. Both classifications are initially used on the level of NUTS3 regions. Therefore, we had to find a way to aggregate these NUTS3 classifications to the NUTS2 level. For the urban/rural typology, we weighted the individual NUTS3 regions which build a NUTS2 region by their population numbers. The criterion which represents the majority of the population living in the NUTS2 region was then selected, although the weighting over population biased the results in the direction of urban regions.

For the typologies on regions in industrial transition we used the same methodology as for NUTS3 regions but modified the threshold levels which define if a region is an industrial region or not. The reason for this is that NUTS3 urban centres with higher shares on jobs and GVA in the service sectors often dominate the NUTS2 regions as well. For example: the NUTS3 region “Milano” dominates the NUTS2 region “Lombardia” and ensures that the NUTS2 region Lombardia would be below the original threshold and therefore would be counted as a “no industrial region” although 8 of the 12 NUTS3 regions which make up the NUTS2 region of Lombardia are industrial regions. As a result, most of the NUTS2 regions would be counted as no industrial regions with the initial threshold (265 from 282). Therefore, we decreased the threshold levels from 25% share on GVA <u>and</u> Employment in manufacturing to 20% share of GVA <u>or</u> employment in manufacturing at the beginning of the reference period (in our case 2006)

Based on this typology, boxplot diagrams were created, showing the distribution of regions including every attribute for both typologies we analysed (Figure 1-2). The height of the bar indicates the range that covers 50 % of all regions per attribute. The whiskers indicate the area in which 97 % of the regions can be found and the dots represent the outliers per attribute.1

Figure 1-2: Box plot diagram for urban/rural and industrial typology of regions for DMC per cap



1 = predominantly urban/industrial region losing importance	7 = predominantly urban/industrial region mixed directions
2 = intermediate/industrial region losing importance	8 = intermediate/industrial region mixed directions
3 = predominantly rural/industrial region losing importance	9 = predominantly rural/industrial region mixed directions
4 = predominantly urban/industrial region gaining importance	10 = predominantly urban/no industrial region
5 = intermediate/industrial region gaining importance	11 = intermediate/no industrial region
6 = predominantly rural/industrial region gaining importance	12 = predominantly rural/no industrial region

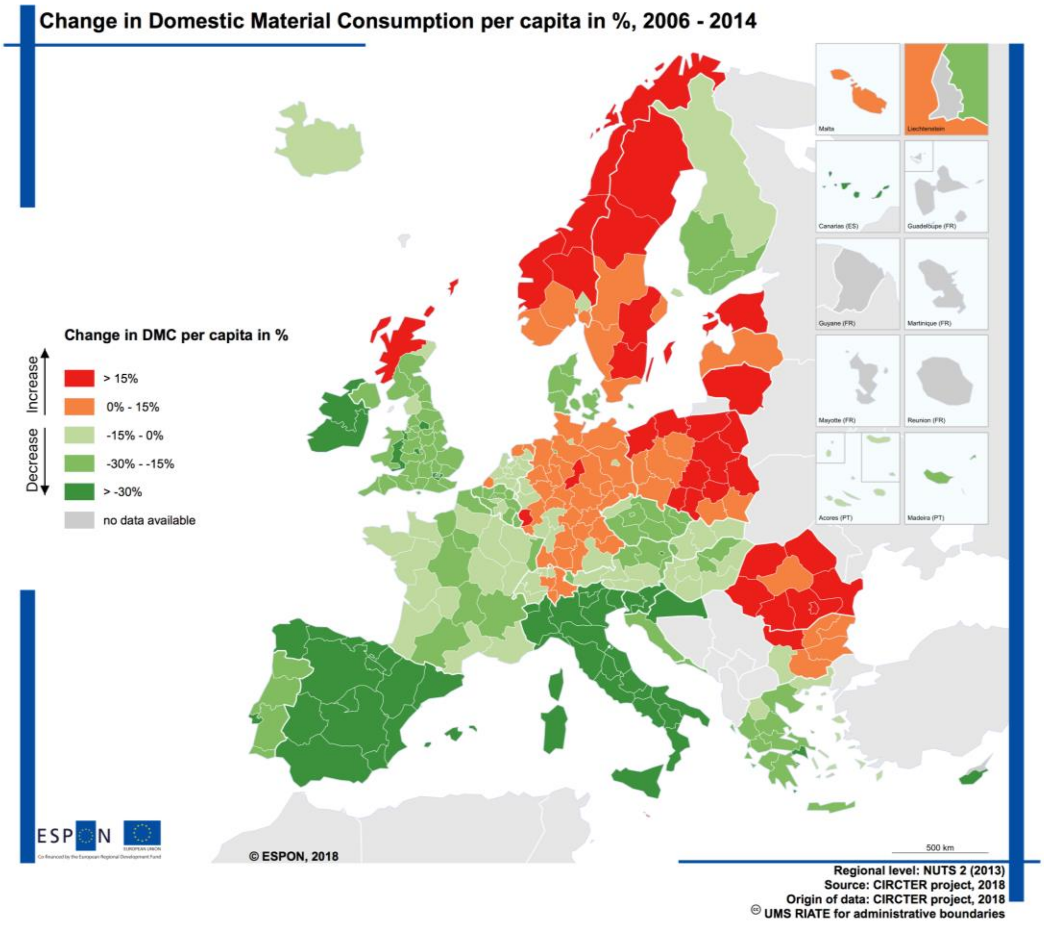
In the boxplot, the indicator DMC in tonnes per capita can be found on the y-axis while the values on the x-axis represent the respective attributes of the typologies. In Figure 1-2, we see a trend which indicates that urban regions are characterised by a lower material consumption per capita than rural regions. However, it can also be seen that there are outliers with high resource consumption per capita in each type of region. The differences between industrial regions and non industrial regions are less pronounced than the criterion urban vs. rural region, but the non industrial regions tend to have lower DMC values per cap. However, the number of

1 Mathematically, the area between the two ends of the bar is called interquartile range (IQR) because the upper limit of the bar is the third quartile, whereas the lower limit is the first quartile of the data set. The line inside the bar indicates the respective median of the data set. The whiskers are calculated as 1,5*IQR. Therefore, the data of the dots for outliers are above or below the value of 1,5*IQR.

regions for some criteria is very small, so that the distribution of the results depends strongly on the few individual regions that make up this group (e.g. the criterion 4 = predominantly urban regions which are also industrial regions with gaining importance only consists of two regions (which explains why the whiskers are identical with the limits of the bar). Especially for the typology of industrial regions with increasing importance, we only found 12 regions. Therefore, the boxplots of the criteria 4, 5 and 6 only contain few data points (2 regions, 6 regions and 4 regions respectively) and should therefore only be interpreted with caution.

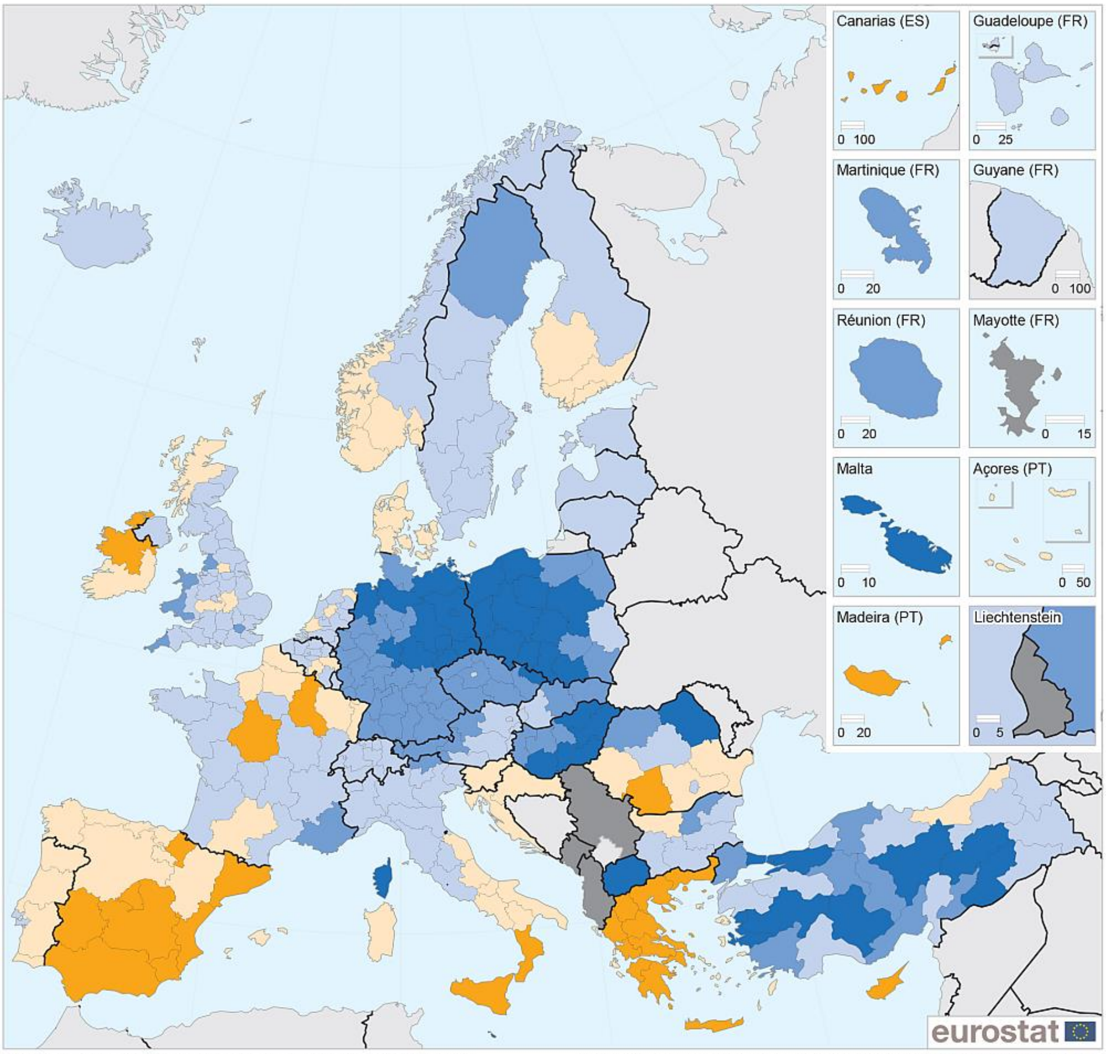
The change in the DMC per capita between 2006 and 2014 (Map 1-3) shows clear spatial patterns: the regions in Poland, the Baltic States and Sweden, but also several regions in Bulgaria and Romania are recording growing per capita figures for the DMC. The range extends from a decline of -69% to an increase of +44%, with a median for all regions of -14.8%. The two estimation models for the DMC in 2006 and 2014 are mainly determined by the number of employees and population density.

Map 1-3: Change in Domestic Material Consumption per capita in %, 2006-2014



Map 1-4: Change in the employment rate

Change in the employment rate, persons aged 20–64, by NUTS 2 regions, 2006–2016
(percentage points, difference between 2016 and 2006)



(percentage points, difference between 2016 and 2006)

Administrative boundaries: © EuroGeographics © UN-FAO © Turkstat
Cartography: Eurostat - GISCO, 07/2017

EU-28 = 2.2

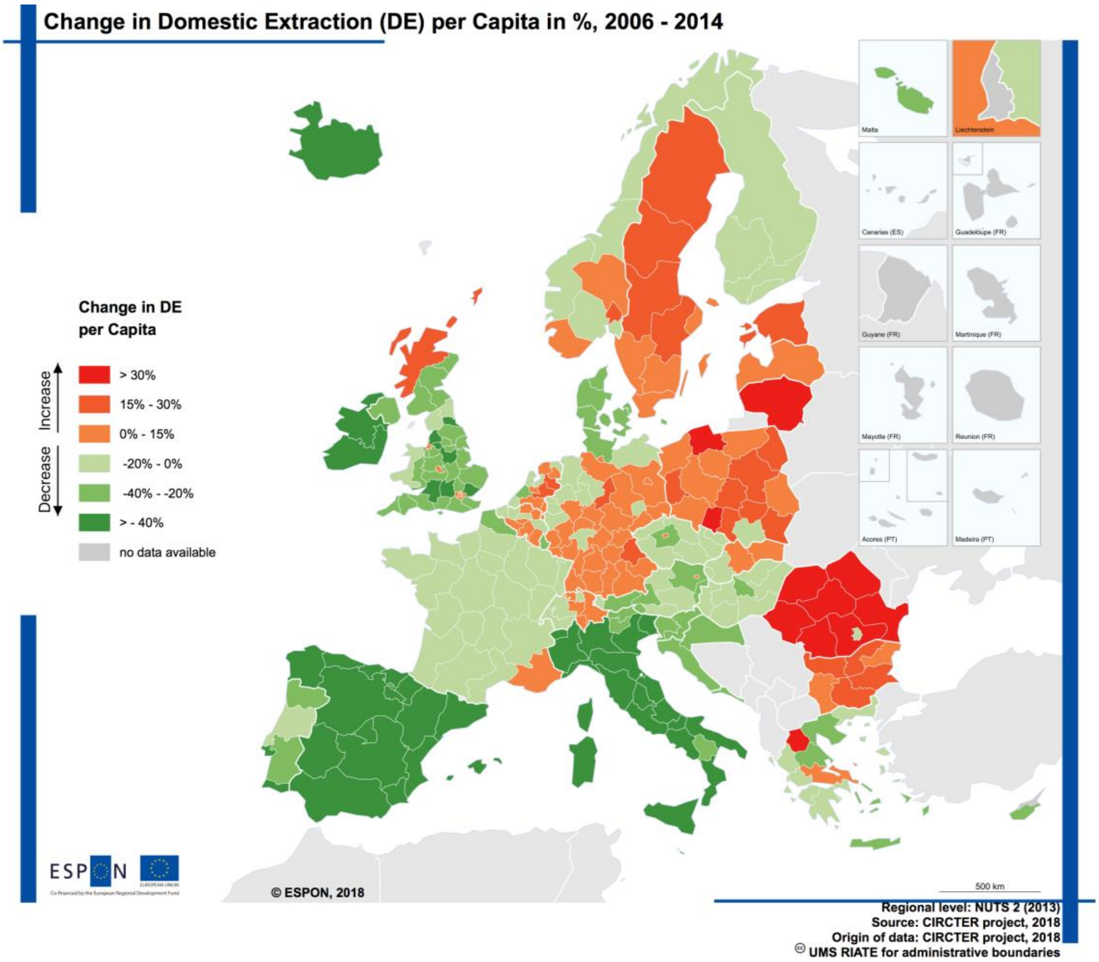
- < -4
- -4 – < 0
- 0 – < 4
- 4 – < 8
- >= 8
- Data not available

0 200 400 600 800 km

Note: London (UKI): NUTS level 1. Slovenia: national data. Denmark and Croatia: 2007–2016. Belgium, Bulgaria, the Czech Republic, Denmark, Germany, Ireland, Greece, Cyprus, Luxembourg, the Netherlands, Austria, Poland, Portugal, Romania, Slovakia, Finland, the United Kingdom and Turkey: break(s) in series.
Source: Eurostat (online data code: lfst_r_lfe2emprt)

Especially the Polish regions, but also regions in other Eastern European countries have caught up in their economic development during this period and show a corresponding increase in employment (see Map 1-4). Accordingly, the production volume was expanded. More resources are needed for its production. With rising employment, private demand for goods will also increase. By contrast, the declines in DMC per capita in Greece, Spain, Italy and Ireland are likely to be explained by below-average growth rates or even significant cuts in GDP and thus also in employment and disposable income. Spain and Ireland were characterised by a phase of above-average construction activity at the beginning of the observation period (and also before). This real estate bubble burst in 2008 as a result of the economic crisis and led to a partial collapse of the real estate market, with corresponding consequences for the demand for mineral raw materials.

Map 1-5: Change in Domestic Extraction (DE) per capita in %, 2006-2014



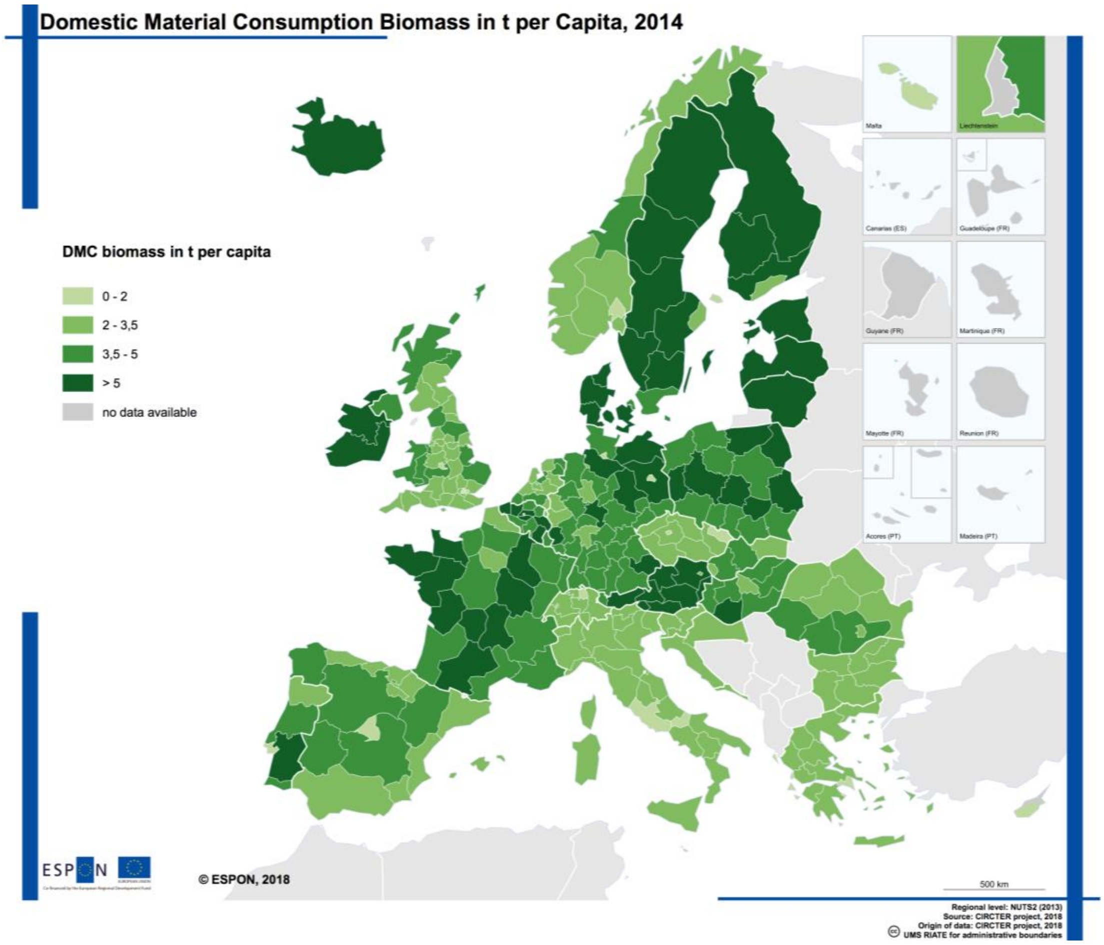
Given the close overlap between the DE and the DMC, it is not surprising that the trends in the development of the DMC per capita between 2006 and 2014 are also reflected in the development of the DE over the period under consideration: the regions with increasing DMC per capita are generally also those regions showing an increase in their domestic extraction per capita over time (see Map 1-5). The percentage range between the regions is accordingly similar to that for DMC per capita. It ranges from -68% to +55%, with a median for all regions of -10.7%.

1.1 Sub-categories of Domestic Material Consumption

The DMC biomass per capita for the NUTS2 regions is between 0,6 t/capita and 12.9 t/capita. The median across all regions is 3.5 t/capita. Regions that almost completely cover urban areas, such as Inner London or Berlin, are considered to have a very small DMC biomass, which tends to be underestimated, due to the estimation methods and the independent variables used there. These regions have no or only a very small proportion of extraction of biotic raw materials within their regions. At the same time, however, they are highly dependent on corresponding imports of biotic raw materials, intermediate products and processed goods, both in the food, construction timber and paper goods sectors. However, these inter-regional trade links cannot be represented by the chosen estimation model, as the independent variables mainly cover population, land use and a dummy variable for southern European regions. Basically, the estimation models of the input indicators represent the production side rather than the consumption side. If the estimations for urban regions tend to be too small for DMC biomass, other regions exporting corresponding shares of their DMC biomass tend to be overestimated.

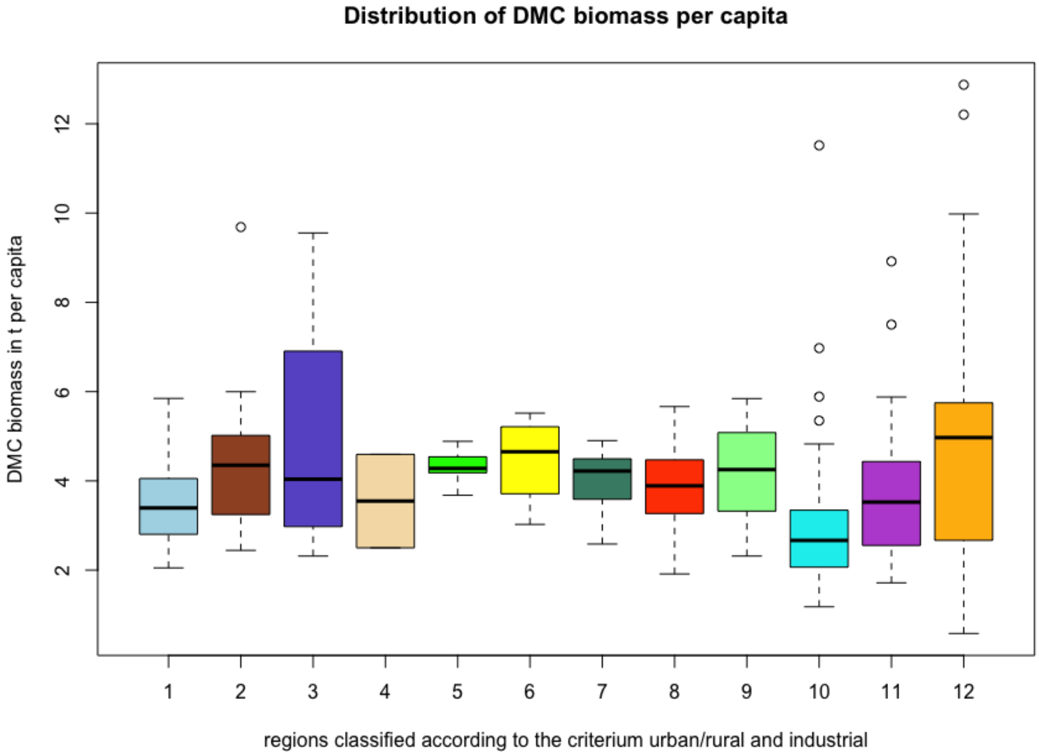
With these restrictions in mind, Map 1-6 shows that DMC biomass is above average, especially in the Scandinavian and Baltic regions, but Ireland and some regions in France also have relevant orders of magnitude for DMC biomass per capita. While the DMC biomass per capita in the Irish and Danish regions can mainly be explained on the production of animal agricultural goods. The high DMC biomass in the Scandinavian, Eastern Polish and Baltic regions, on the other hand, is probably determined by the use of forest products. In France, too, some regions have a DMC biomass of 6 t/capita or higher. This could possibly be due to the greater importance of viticulture in these regions.

Map 1-6: Domestic Material Consumption biomass per capita in tonnes



As for the DMC, a corresponding boxplot diagram was created for the regional typologies of urban/rural region in combination with regions in industrial transition or not (Figure 1-3). The diagram shows clearly that urban regions tend to have a lower DMC biomass per capita. Urban regions are often densely populated and therefore lacking of agricultural land for the production of biotic raw materials. And as with the DMC, the difference between industrial regions and non industrial regions seems to be less pronounced than between urban and rural regions. As already described, the DMC is not really able to map the imported indirect material flows, which are also important for food.

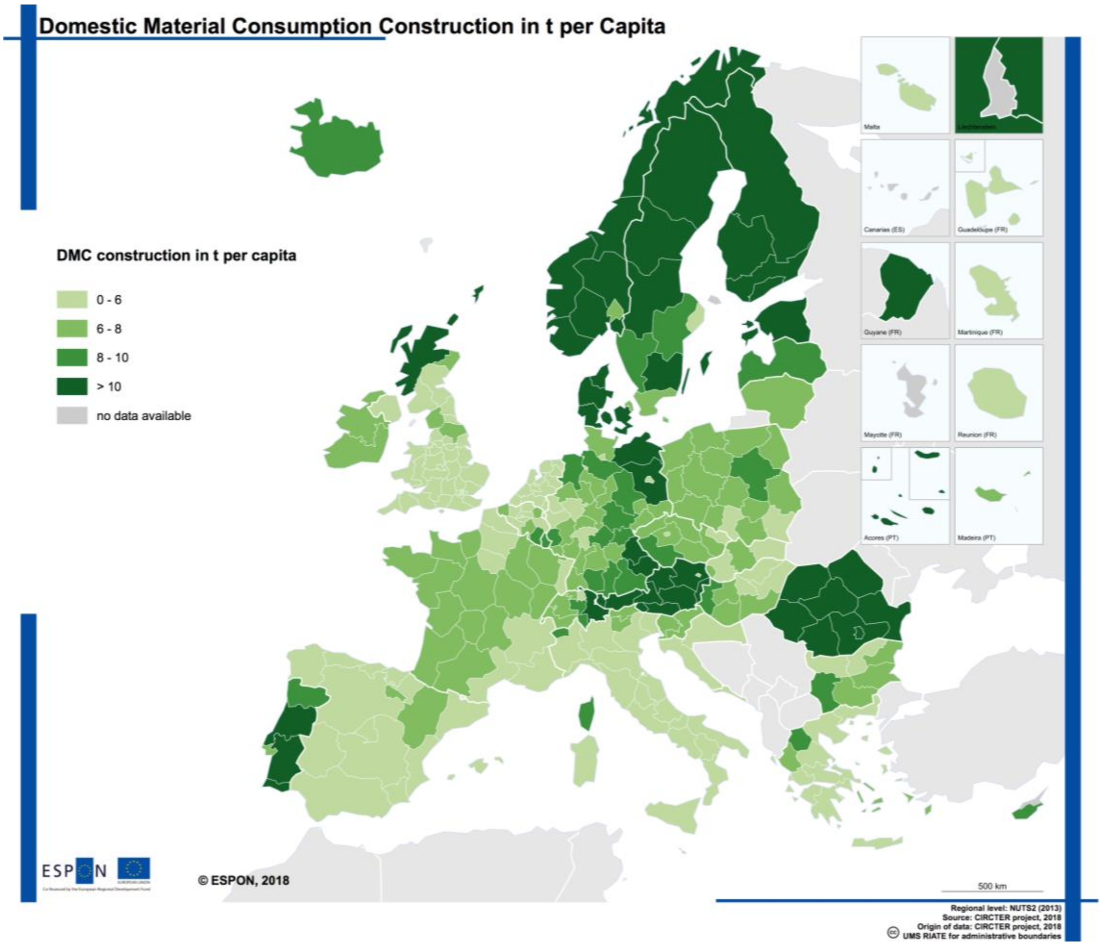
Figure 1-3: Boxplot Diagram for urban/rural and industrial transition of regions typologies for DMC biomass per cap



1 = predominantly urban/industrial region losing importance	7 = predominantly urban/industrial region mixed directions
2 = intermediate/industrial region losing importance	8 = intermediate/industrial region mixed directions
3 = predominantly rural/industrial region losing importance	9 = predominantly rural/industrial region mixed directions
4 = predominantly urban/industrial region gaining importance	10 = predominantly urban/no industrial region
5 = intermediate/industrial region gaining importance	11 = intermediate/no industrial region
6 = predominantly rural/industrial region gaining importance	12 = predominantly rural/no industrial region

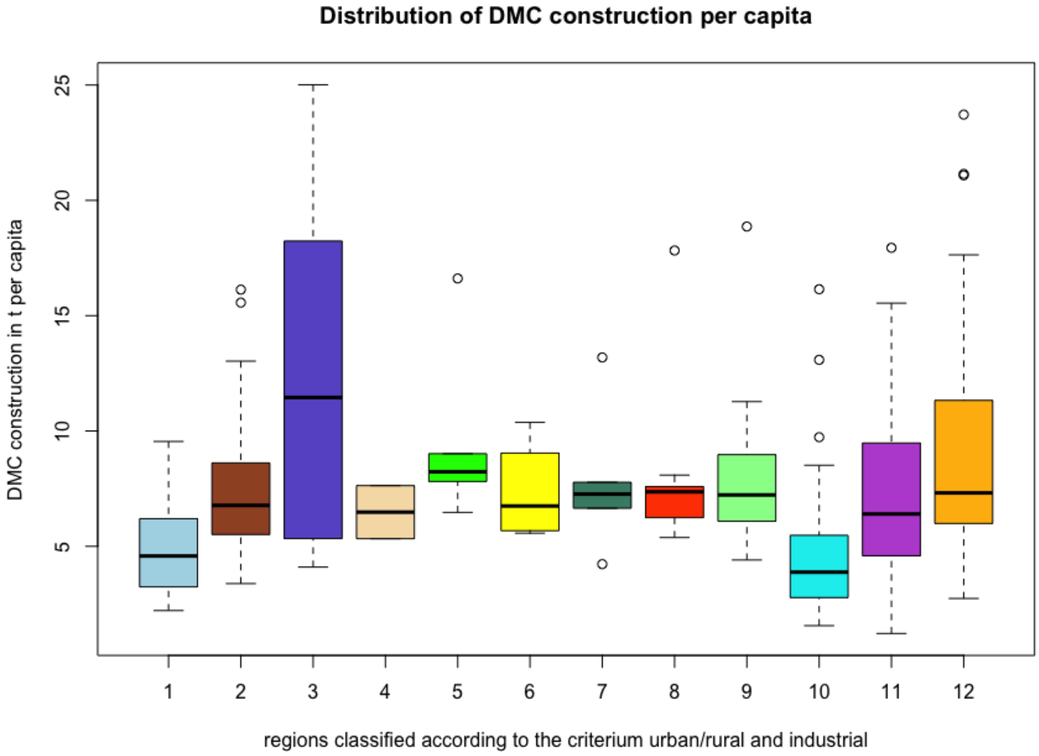
The DMC construction in tonnes per capita is between 1,2 t/capita and 25 t/capita in the regions studied. The median for all regions is 6.3 t/capita. We know from country analyses that construction activities are closely linked to GDP growth. At the same time, it is known that countries with a lower population density tend to have a higher DMC construction per capita. The reason for this is the higher resource use for infrastructures and the settlement structure with predominantly single-family houses in rural regions instead of apartment buildings, which increases the expenditure of construction materials. Additionally, infrastructures like roads, which are also a main driver for the use of construction materials, are used by less people in rural areas than in urban regions. Based on the Map 1-7, it can be assumed that the population density is more relevant in the estimation model than the number of employees in the construction sector. It might be because of the differences in population density between the regions being much more pronounced than in economic indicators such as the share of persons employed in the construction sector in total employment.

Map 1-7: Domestic Material Consumption construction per cap in tonnes



The boxplot diagram for the DMC construction (Figure 1-4) shows the expected pattern for the characteristic values: rural regions have a higher DMC construction per capita. But in most groups we also see a lot of outliers with high DMC construction values per capita. This is probably due to the different characteristics of individual regions: sometimes urban regions comprise almost completely the area of only a town, e.g. capitals like Berlin being surrounded by a separate region. In other cases, a town and its surrounding rural areas form an urban region. With the corresponding commuter structures and the normalisation of the high population density of the urban core with the surrounding, more rural areas, the hypothesis is well founded that urban regions which contain the surrounding rural area of a town have higher DMC construction values than urban regions without integrated surrounding areas, like Berlin or Vienna. It is interesting to note that there are no differences between industrial regions with mixed developments in employment and gross value added of their manufacture sector (Region 7, 8, and 9).

Figure 1-4: Boxplot Diagram for urban/rural and industrial transition typologies of regions for DMC construction per cap



1 = predominantly urban/industrial region losing importance	7 = predominantly urban/industrial region mixed directions
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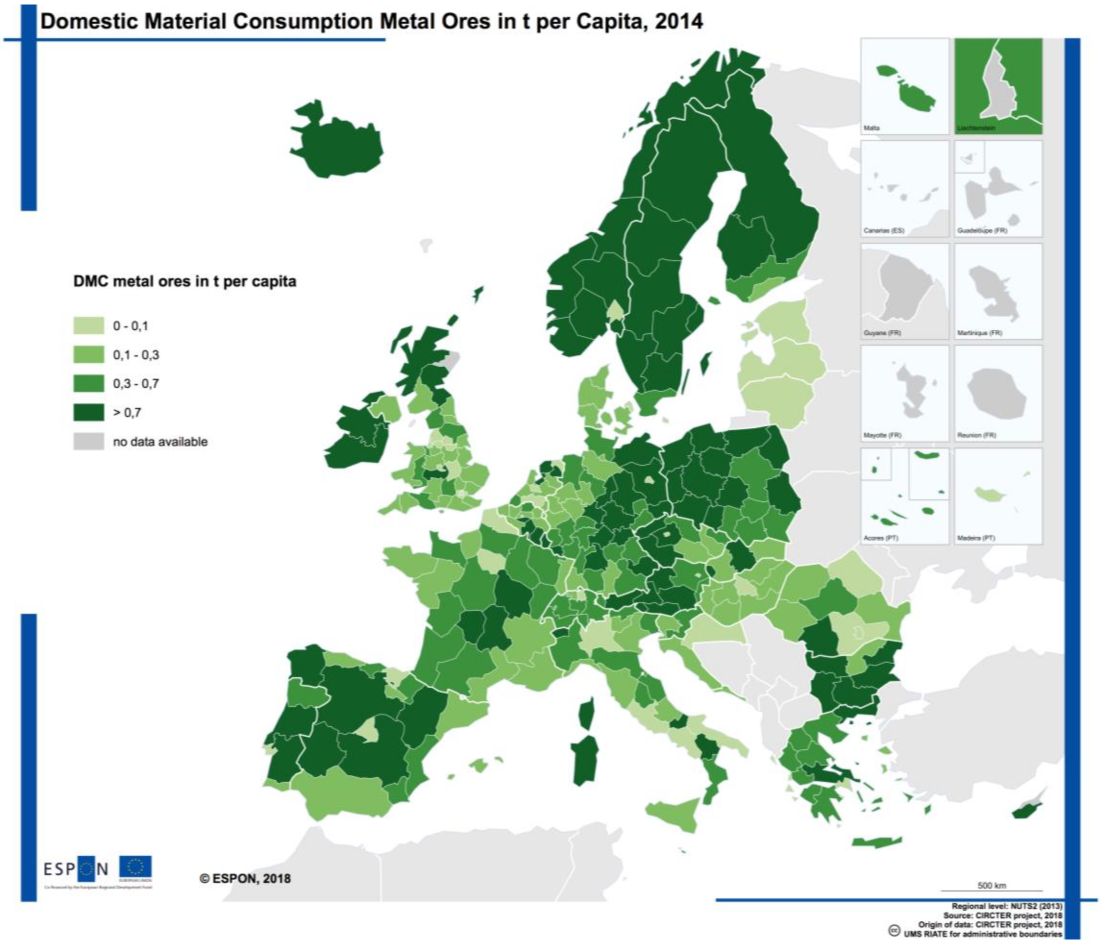
5 = intermediate/industrial region gaining importance	11 = intermediate/no industrial region
6 = predominantly rural/industrial region gaining importance	12 = predominantly rural/no industrial region

The estimated values for the DMC metal ores per capita seem to be less resilient than the other input indicators. With a few exceptions, the estimated DMC metal ores per capita is very low: the median across all regions is 0.35 t/capita. However, there are some enormous outliers of up to 54 t/capita for the region Övre Norrland in Sweden, where the largest iron ore underground mine in the world (Kiruna) is located.

Map 1-8: Domestic Material Consumption metal ores per capita



In all 12 categories of the typologies studied, it can be seen that 97% of the regions are at the near or below the 2 t/capita level and that outliers occur in almost every typology.2 Not surprisingly, urban regions show lower per capita value for the DMC metal ores than rural regions. But as also noted for the other DMC categories, the values for the DMC metal ores mainly show the production side and less the consumption perspective, which is also confirmed by the used estimation model.

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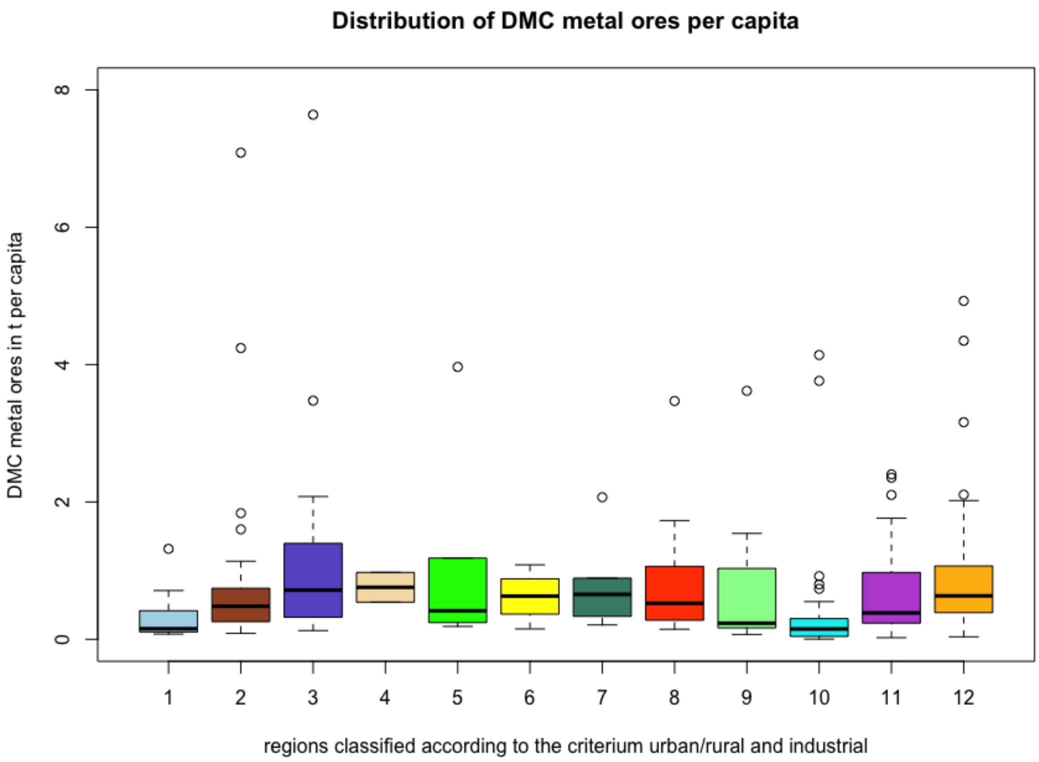
2 The largest outliers (> 8t/capita) have already been removed from the boxplot diagram in order to be able to create a meaningful boxplot diagram at all.

Figure 1-5:Boxplot Diagram for urban/rural and industrial transition typologies of regions for DMC construction per cap

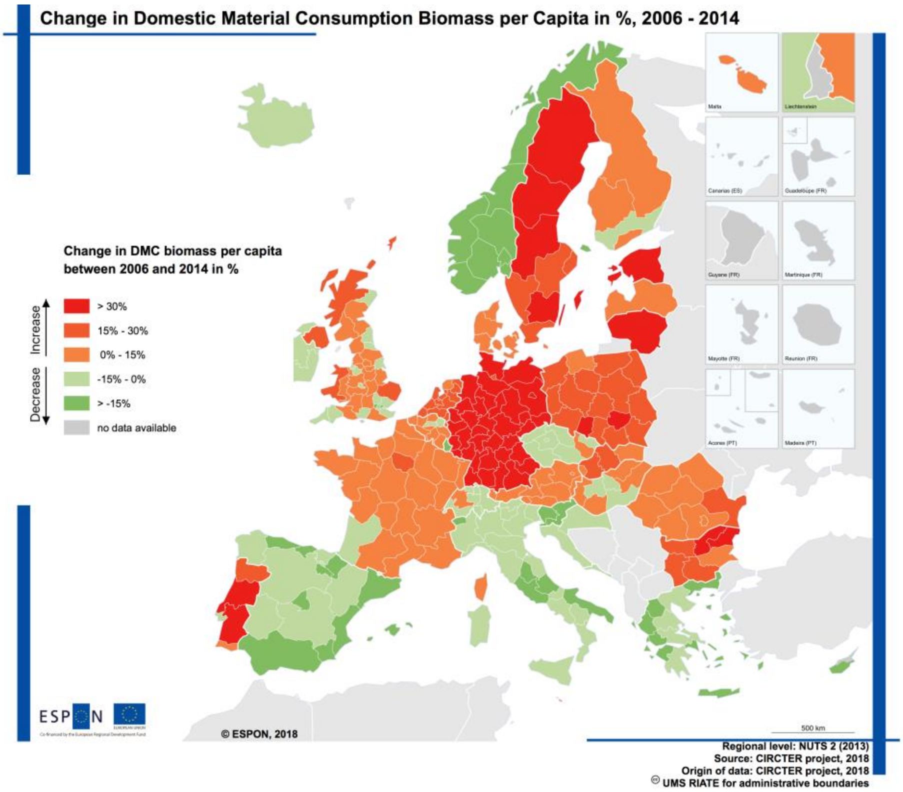


1 = predominantly urban/industrial region losing importance	7 = predominantly urban/industrial region mixed directions
2 = intermediate/industrial region losing importance	8 = intermediate/industrial region mixed directions
3 = predominantly rural/industrial region losing importance	9 = predominantly rural/industrial region mixed directions
4 = predominantly urban/industrial region gaining importance	10 = predominantly urban/no industrial region
5 = intermediate/industrial region gaining importance	11 = intermediate/no industrial region
6 = predominantly rural/industrial region gaining importance	12 = predominantly rural/no industrial region

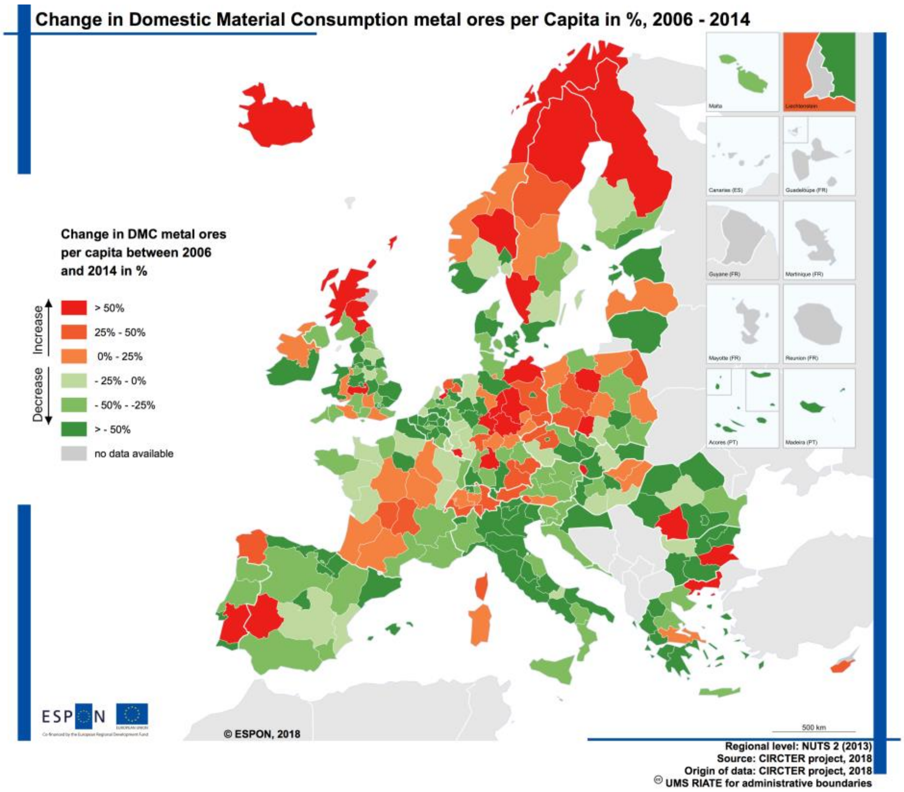
1.2 Change of the DMC subcategories between 2006 and 2014

For each indicator, we created a map for the percentage change between 2006 and 2014. However, the percentage change can sometimes lead to increases or decreases of 200% - 400% for very low baseline values and low absolute changes. Therefore, the subcategory of the DMC metal ores in particular is characterised by remarkably high percentage changes, although the absolute changes between 2006 and 2014 are often very small. With regard to the percentage change in DMC biomass, the consistently high increase in Germany of 30 - 40% in most German regions is surprising. One reason for the high increase could be the strong promotion of renewable energies based on biomass (bio-fuels and biogas), which led to a strong expansion of rapeseed and maize cultivation.

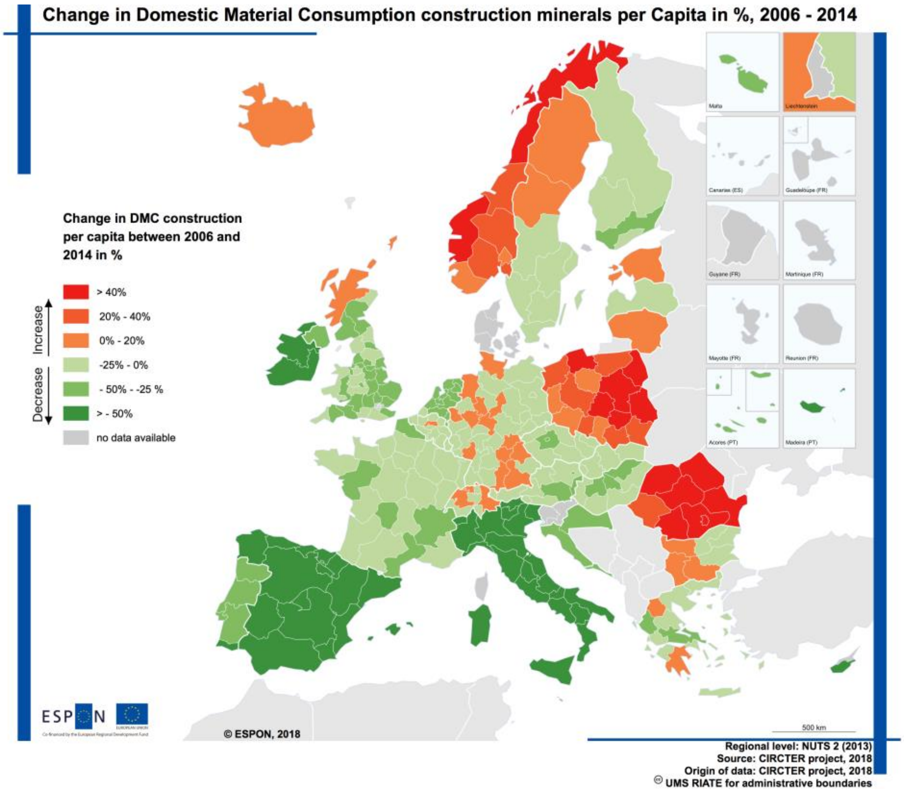
Map 1-9: Change in Domestic Material Consumption biomass per capita in %, 2006-2014



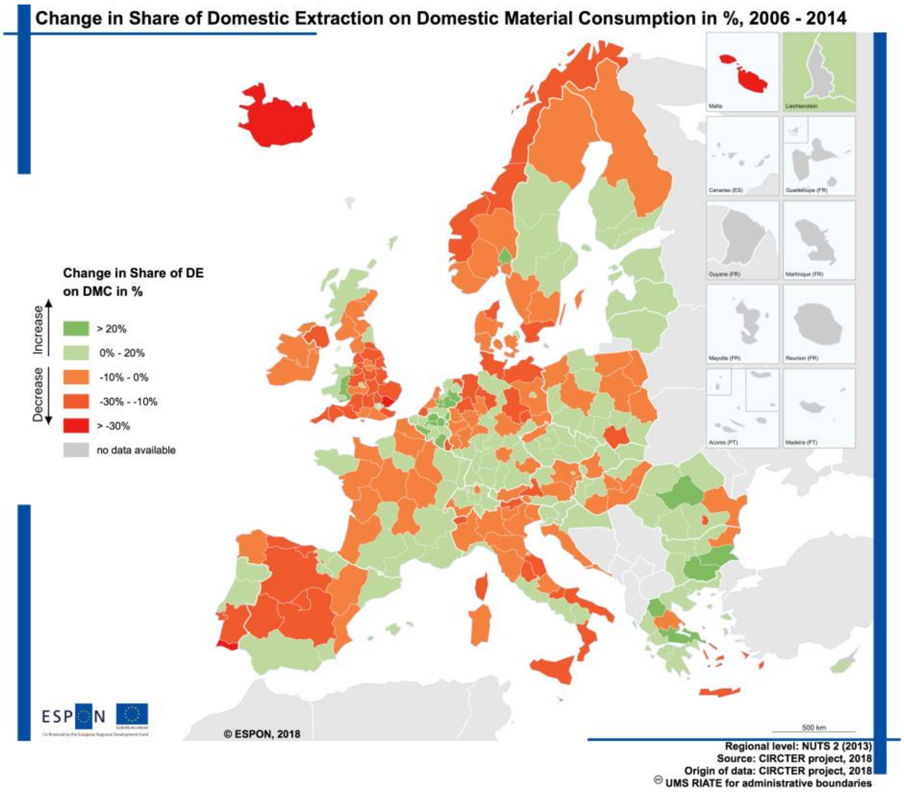
Map 1-10: Change in Domestic Material Consumption metal ores per capita in %, 2006 - 2014



Map 1-11: Change in Domestic Material Consumption construction per capita in %, 2006 - 2014



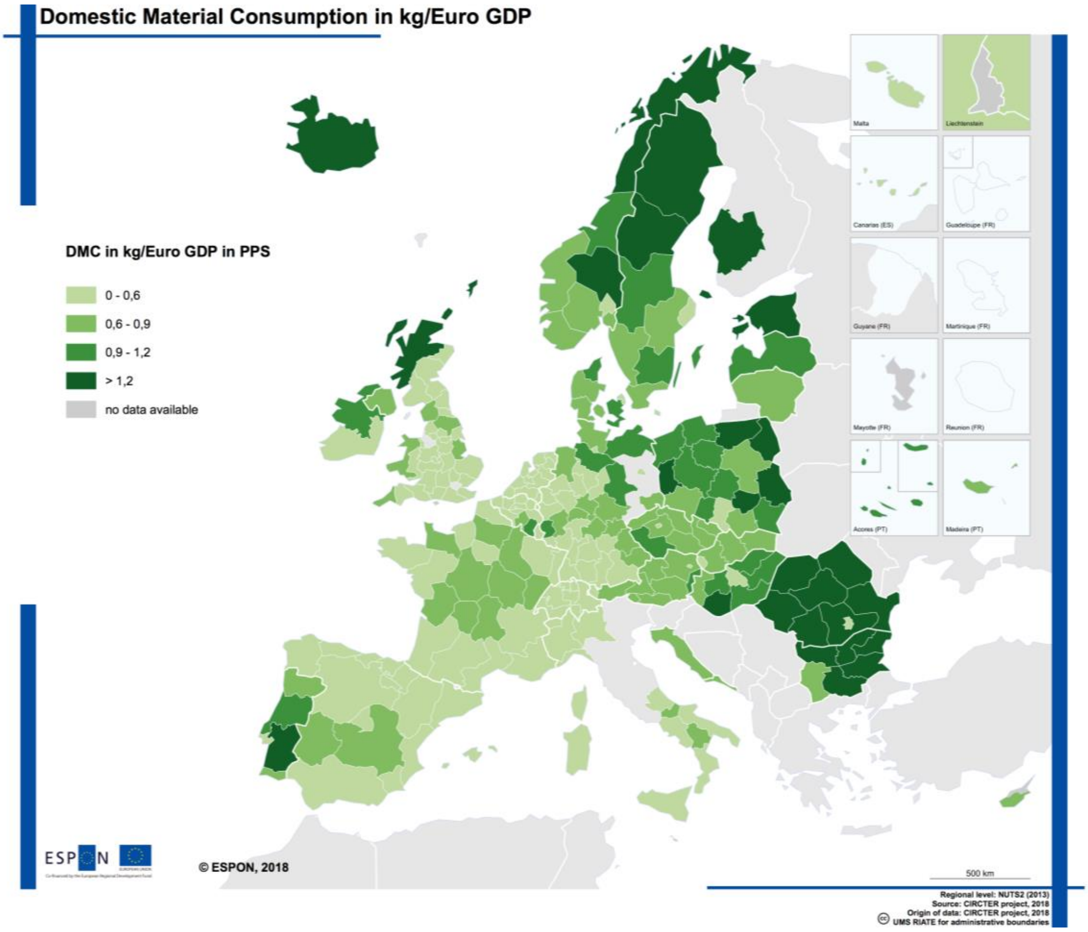
Map 1-12: Change in share of Domestic Extraction on DMC in %, 2006-2014



2 Material intensity

A high material use per capita does not necessarily mean that the material intensity[3] of this region is high as well. Regions with a high material consumption can be regions with high levels of GDP at the same time. As a result, these regions could have an average or above average material productivity (or less average material intensity). Examples for such regions can be found in Denmark or Austria. On the other hand, most of the regions in Romania and Bulgaria have a DMC per capita which is below 20 t/capita; however, the GDP of these regions is also low in comparison to other European regions. This leads to a higher material intensity of mostly above 1.5 kg/Euro GDP in PPS in these regions. In comparison, the median of all analysed regions is 0.59 kg/Euro GDP in PPS.

Map 2-1: Material Intensity, measured as DMC in kg/Euro GDP in PPS



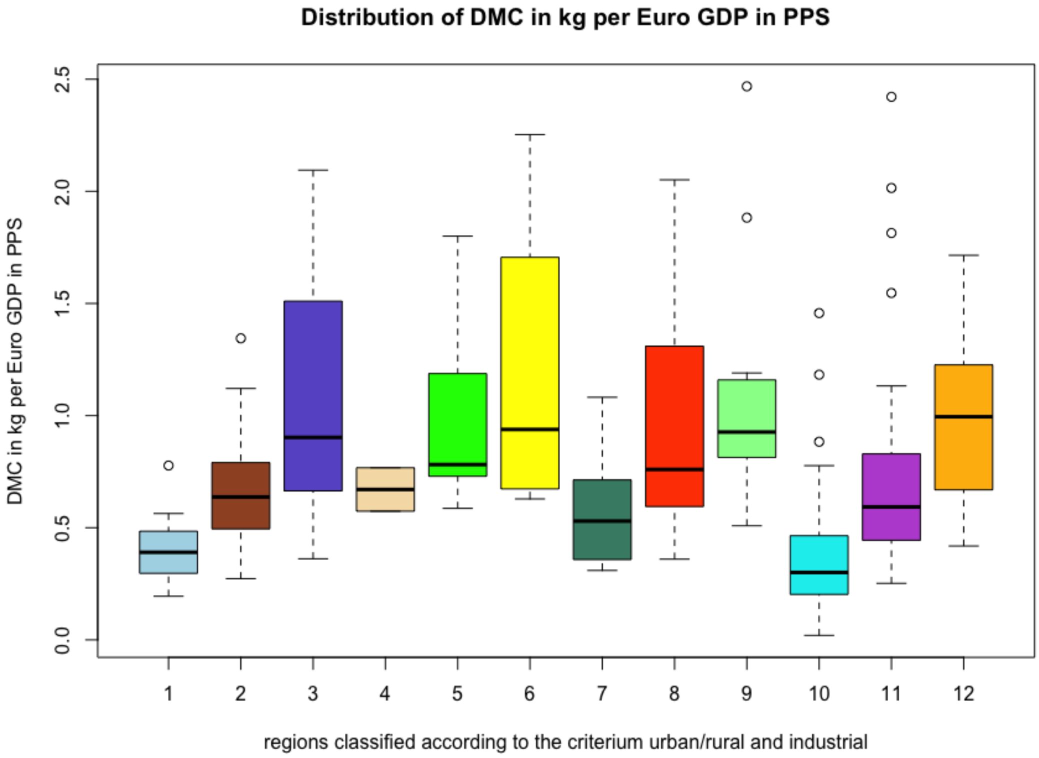
As we already know, urban regions are characterized by lower DMC per capita values. In addition, the GDP per capita is also higher in urban regions than in rural regions. As a consequence, the material intensity follows the same pattern as the distribution of the DMC per capita:

---

[3] Material intensity tells us how much material was necessary to produce one unit of GDP. Material intensity is the reciprocal of material productivity, which is more common in the literature. However, we decided to use the intensity instead of productivity value so that the indicators are methodically comparable to the waste indicators.

There is a clear tendency for urban regions to have a higher material productivity than rural regions. And analogous to the DMC and its subcategories, there is no difference in material intensity with regard to the differentiation whether a region is an industrial region or not or if the industrial sector has an increasing or decreasing importance.

Figure 2-1: Box plot diagrams for urban/rural and industrial transition typologies of regions for material intensity



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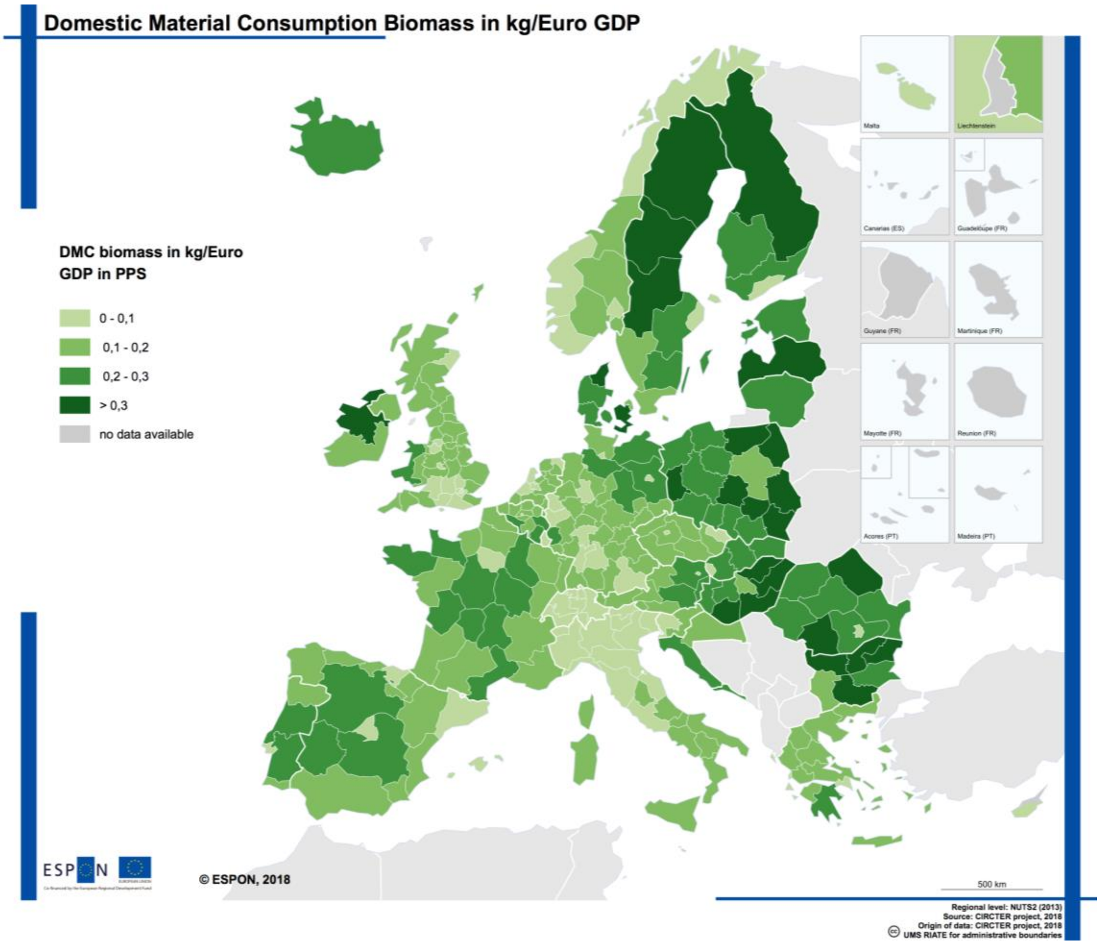
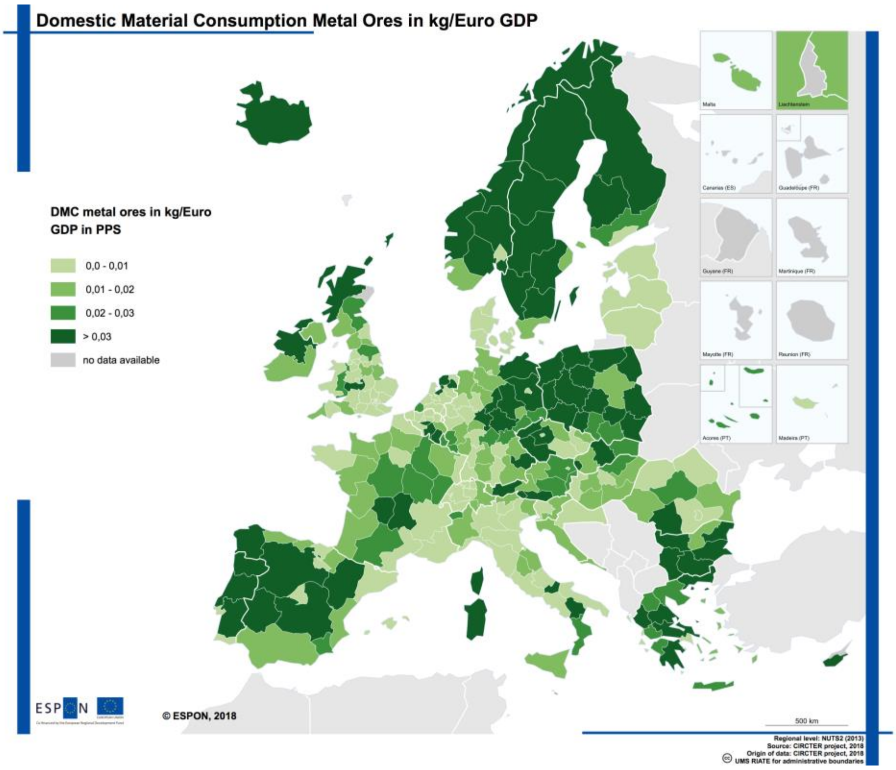
The material intensity of the individual subcategories of the DMC does not differ fundamentally in terms of spatial distribution from aggregated distribution of material intensity (DMC in kg per Euro GDP in PPS): The Scandinavian regions have above-average material intensities despite above-average GDP per capita due to their high DMC, which is also high in the subcategories. The Eastern European regions are characterised by high DMC, both in the DE per capita, and in DMC biomass, DMC metal ores and DMC construction per capita, and at the same time the level of per capita income is far from the level of the old EU15 member states. As a consequence, the material intensity of the Eastern European regions tends to be higher in all input categories than in many of the other regions examined. In Southern Ireland and Denmark, the difference between per capita material consumption and material intensity, which results from a high level of prosperity, is clearly visible: these regions have a high level of DMC biomass per capita and above-average per capita DMC construction. As a result, the per capita DMC in Southern Ireland and the Danish regions is also rather above average. However, this rmaterial use is linked to a high GDP per capita in both countries (and regions), which lowers the material intensity for the regions to a rather average to below average level.

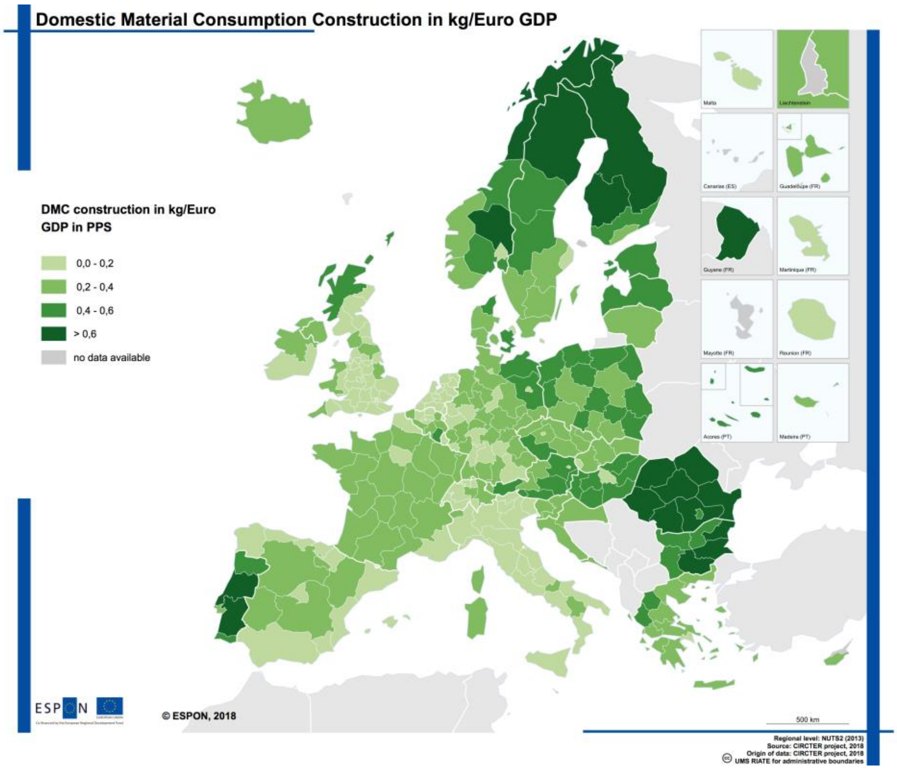
Map 2-2: Domestic Material Consumption biomass in kg/Euro GDP in PPS



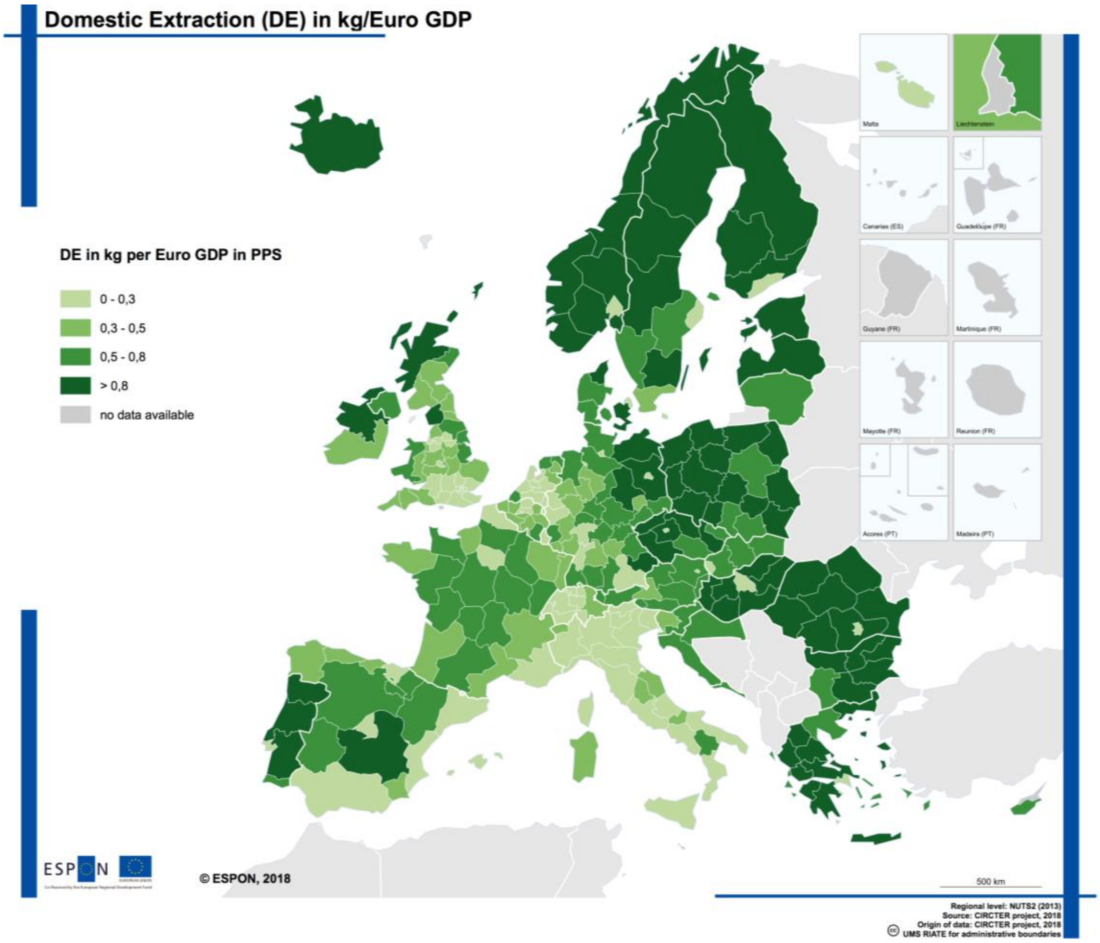
Map 2-3: Domestic Material Consumption metal ores in kg/Euro GDP in PPS



Map 2-4: Domestic Material Consumption construction in kg/Euro GDP in PPS



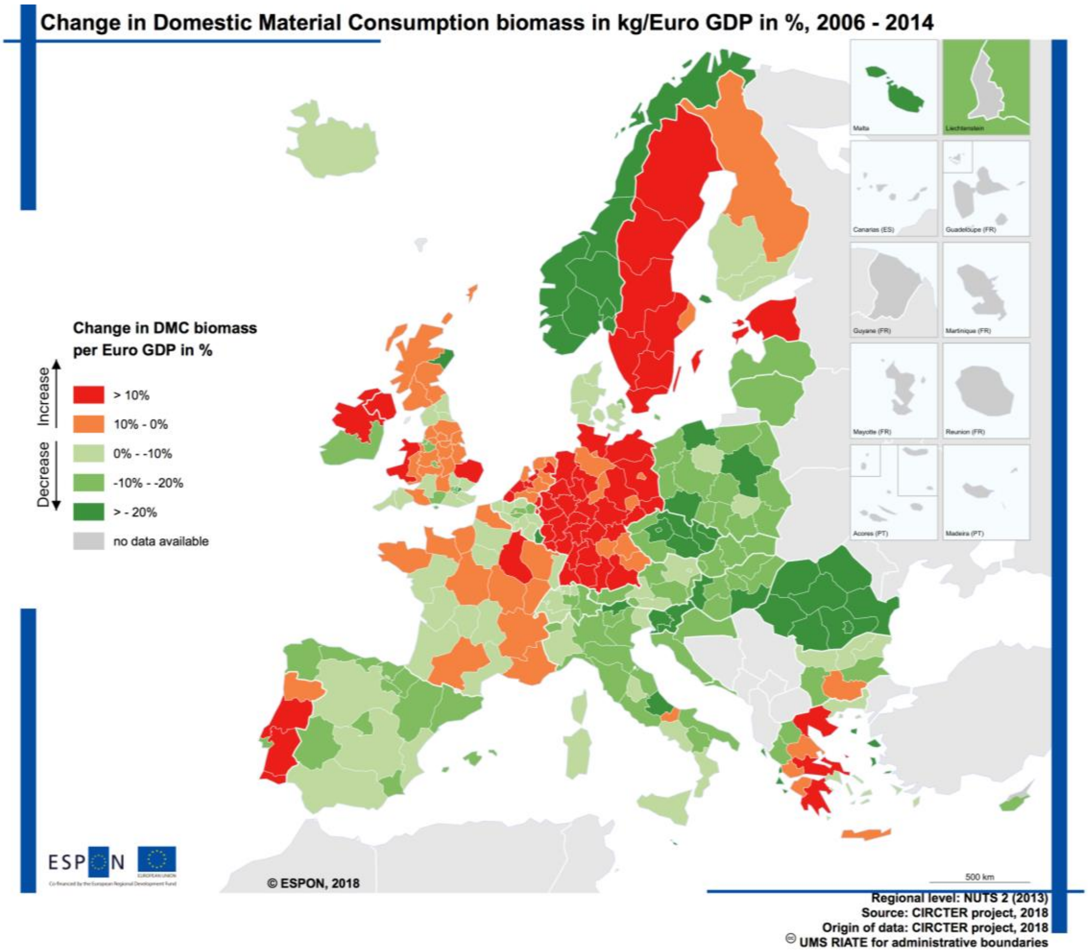
Map 2-5: Domestic Extraction in kg/Euro GDP in PPS



2.1 Change in material intensity of DMC subcategories

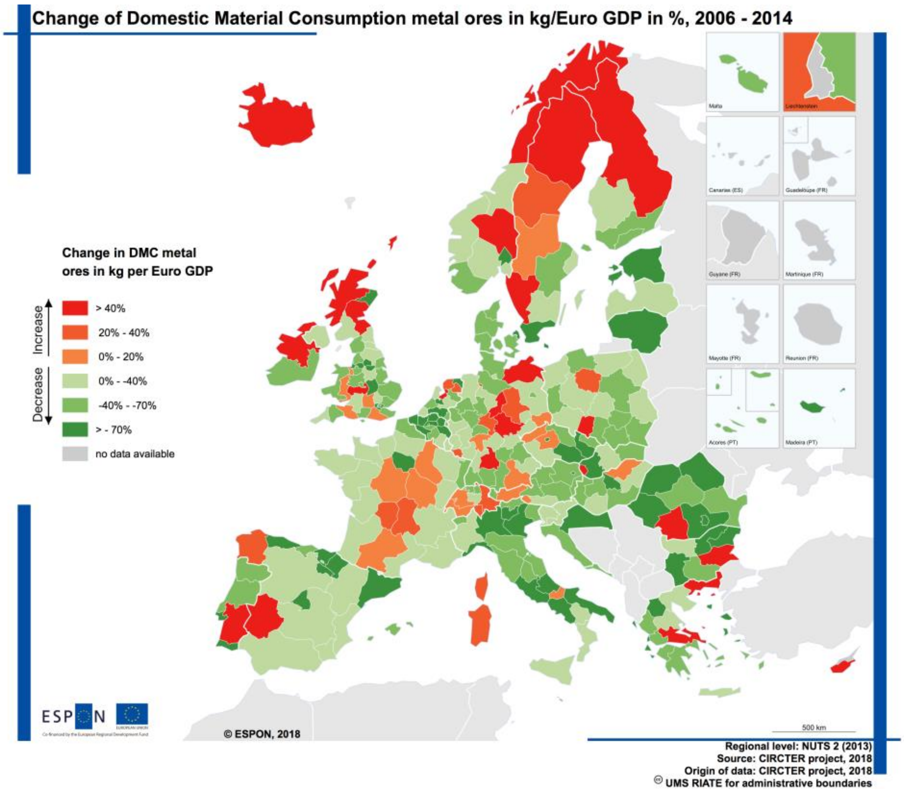
The example of the German and Polish regions in DMC biomass per Euro GDP in PPS shows the different patterns of different indicators of DMC subcategories: Both countries show an above average increase in DMC biomass per capita (see Map 1-9), whereas the increase in the German regions are significantly higher (41% on average between 2006 and 2014) than in the Polish regions (23% on average). But Germany still has a lower per capita level of DMC biomass (in 2014, 4,3 on average compared to 4,9 in Poland). And because of the lower GDP per capita in Poland, the material intensity for DMC biomass is also higher than in Germany (Polish regions: 0,29 kg/Euro GDP vs. 0,13 kg/Euro GDP on average in German regions). But the growth of GDP in the Polish regions between 2006 and 2014 is faster than the increase in DMC biomass, as well as the GDP increase in Germany. As a result, the material intensity in DMC biomass decreases in all Polish regions between 2006 and 2014, whereas the German regions have an increasing material intensity regarding the subcategory of DMC biomass.

Map 2-6: Change in DMC biomass in kg/Euro GDP in PPS in % between 2006 and 2014

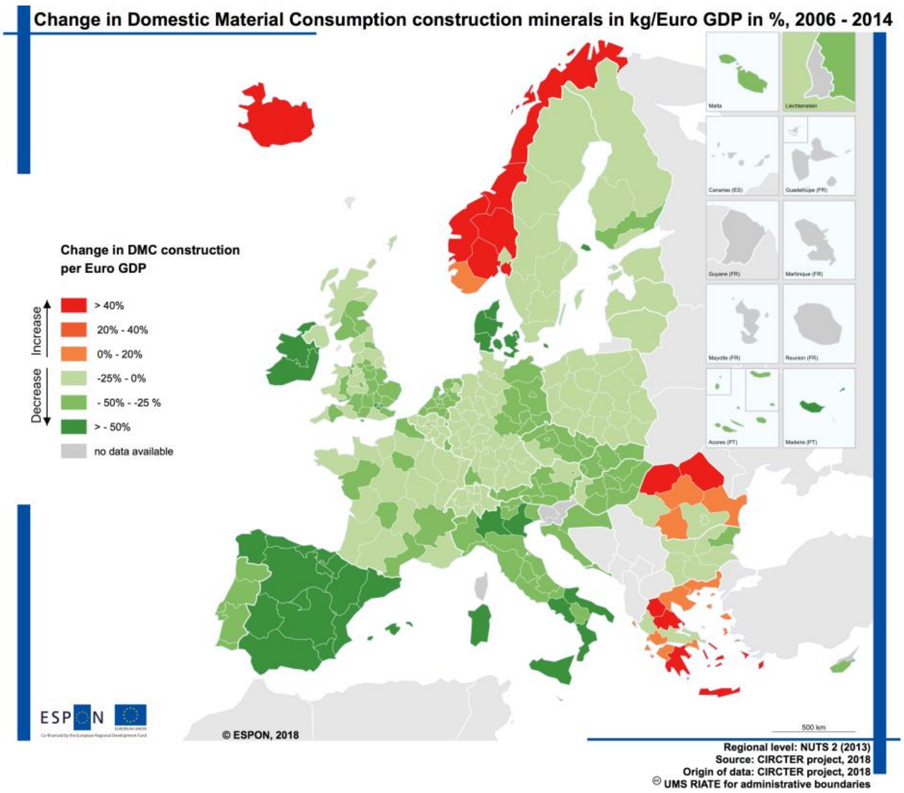


For the DMC metal ores, different regression models were used for 2006 and 2014. In addition, the per capita values are quite low in comparison to other subcategories of DMC. Together this results in an uncertainty about the reliability of the data and the low absolute values for the DMC metal ores provides high percentage changes of the DMC metal ores per capita, but also of the material intensity of this subcategory. The material intensity for minerals used for construction decreased in most regions between 2006 and 2014. On the one hand, this can be attributed to the decline in DMC construction per capita, which led to a decline in material intensity despite stagnating GDP, e.g. in Spain or Italy. In other countries/regions like some German or Baltic regions, the GDP growth was higher than the increase of the DMC construction per capita and thereby also led to a sinking material intensity measured as DMC construction in kg/Euro GDP. In some Greek regions, the opposite occurs: The GDP decreases more than the DMC construction per capita and therefore leads to an increasing material intensity, although the absolute consumption of building materials has fallen.

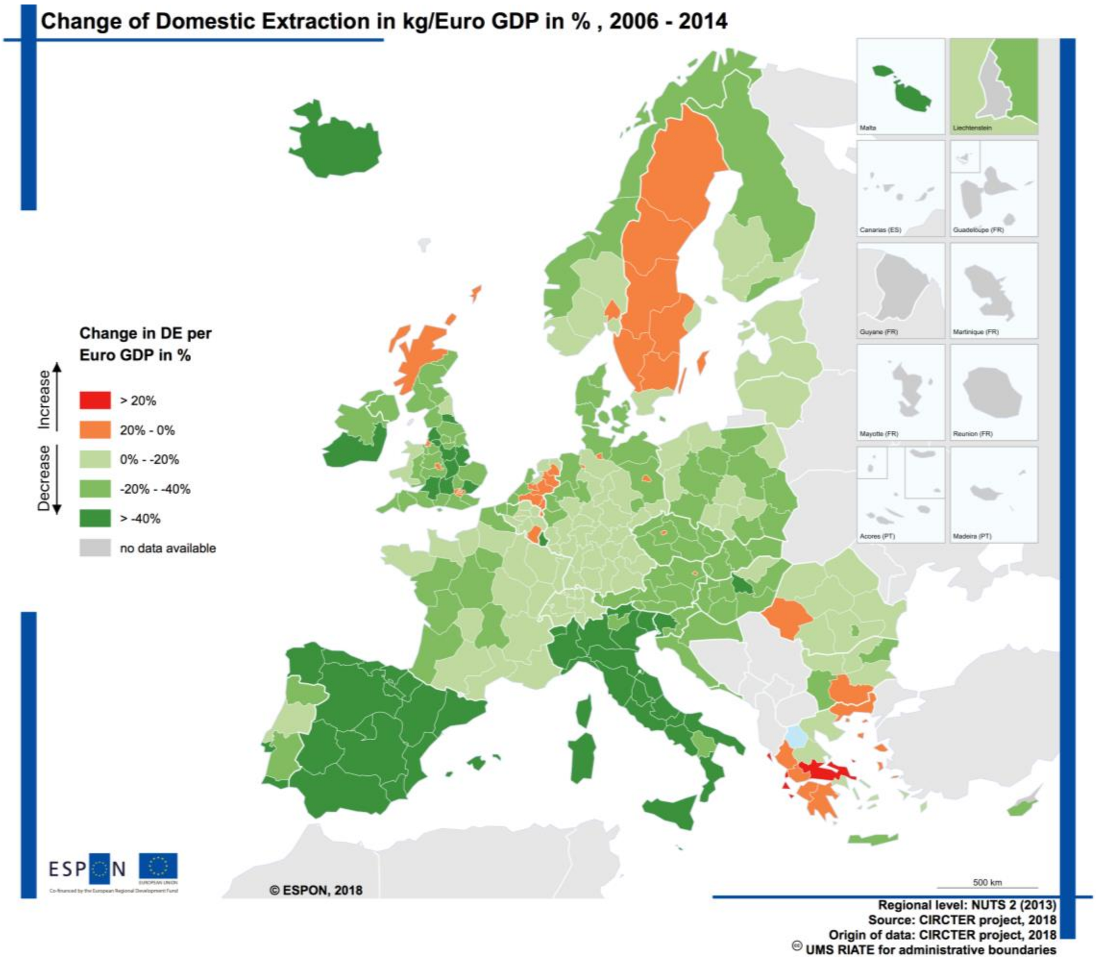
Map 2-7: Change in DMC metal ores in kg/Euro GDP in PPS in % between 2006 and 2014



Map 2-8: Change in DMC construction in kg/Euro GDP in PPS in % between 2006 and 2014



Map 2-9:Change in Domestic Extraction in kg/Euro GDP in PPS in % between 2006 and 2014



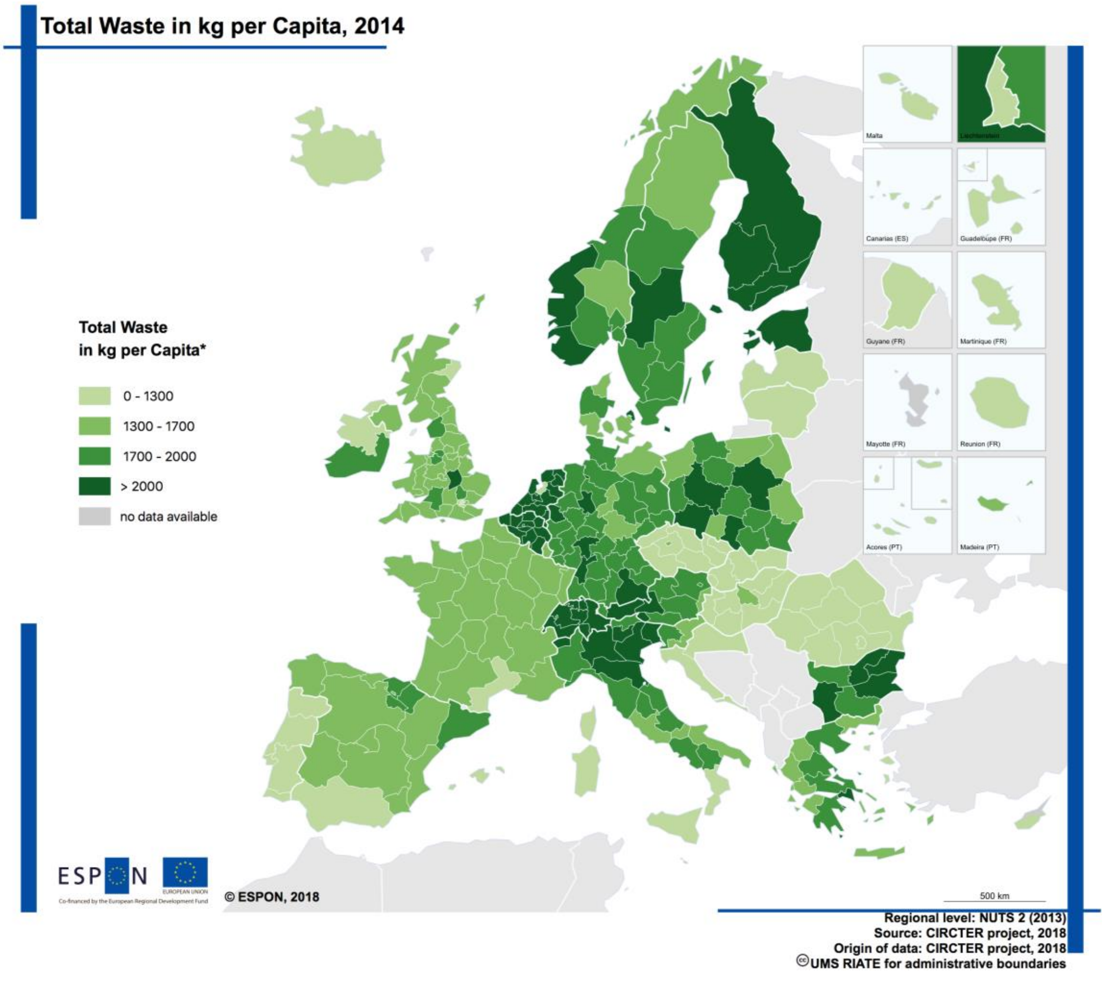
3 Total Waste per capita (excluding major mineral waste)

For the calculation of the waste indicators, two data sets are available. One data set containing data of waste generation is the result of the regionalisation approach in this project, the other data set including data for municipal waste and its treatment types was downloaded from the Eurostat website.

The waste generation data set includes data regarding the amount of total waste excluding major mineral waste and different subcategories of generated waste like plastic waste or food waste, as well as some data for waste streams by individual NACE sectors like construction waste or agriculture waste. For municipal waste, the data set contains data for the total amount of municipal waste and the share of different treatment options like landfill, incineration, recycling and composting/digestion. Therefore, it was also possible to calculate the recycling rate for municipal waste. In principle, waste statistics on a national level are already marked with some question marks, which inevitably have an impact on the disaggregation from national data to the NUTS2 levels. Some numbers in the regionalised waste statistics are extremely high, particularly for mining and quarrying waste, which also leads to very high per capita figures and waste intensity ratios.

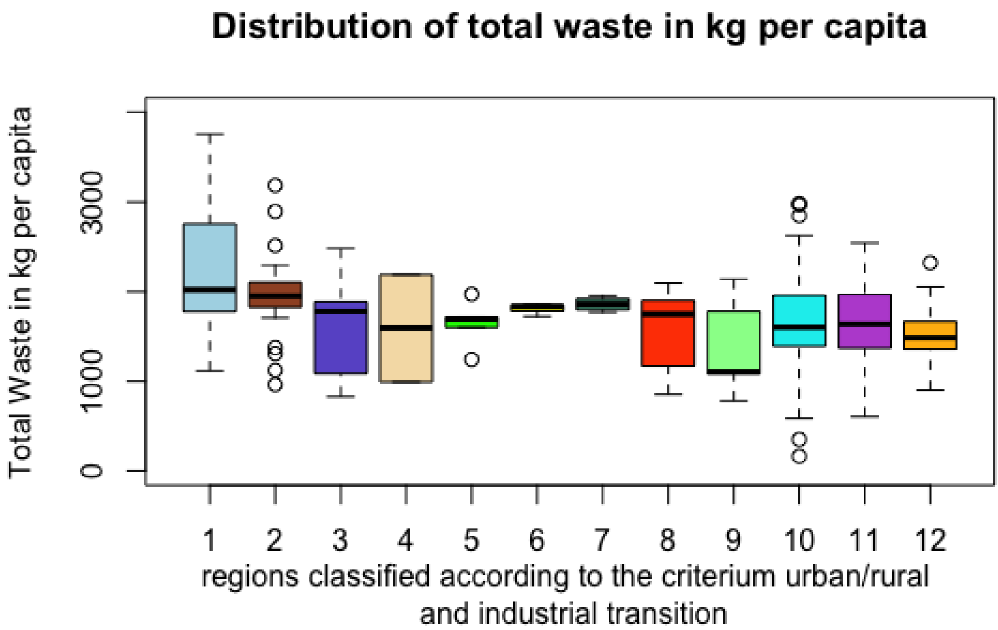
Map 3-1 shows the amount of total waste (excluding major mineral waste) generated in kg per capita. The range of data for total waste per capita is enormous: it reaches from 163 kg/capita to 9,500 kg/capita. The median is about 1,661 kg/capita, so the majority of the regions lie in the range of 1,200 kg/capita to 1,900 kg/capita. However, the value of 9,500 kg/capita is not necessarily an estimation error as this region satisfies much of its energy needs through the exploitation of oil shale. Based on the data, it can be seen that the amount of total waste per cap correlates well with the regional GDP: in regions with above-average GDP per capita, the volume of waste per capita is also above average.

Map 3-1: Total Waste (excluding major mineral waste) in kg per capita



The boxplot diagram (Figure 3-1) shows some interesting patterns in the analysed typologies. The rural regions tend to have smaller per capita numbers for total waste excluding major mineral waste. And surprisingly, industrial regions with decreasing importance have higher waste numbers than regions with increasing importance or mixed results as well as non-industrial regions. One explanation could be that regions where the industrial sector have a decreasing importance are regions which are characterized by more traditional industry branches like basic metal industry. But it should be noted that the boxplot diagram doesn’t include all data points for total waste per capita due to the enormous range of outliers. Therefore, we excluded all outliers above 4,000 kg/capita and set a limit for the y-axis at 4,000 kg/capita. Although sometimes, there are only a few differences in the distance of the quartiles for different classes (e.g. the group of regions in class 8 and 9 look quite similar at the first glance), but the median (marked as the line inside the bar) of both boxplots are different. This indicates that although 97% of the regions in both groups of regions are in the same range, the median of each group is quite different.

Figure 3-1: Box plot diagrams for urban/rural and industrial transition typologies of regions for total waste (excluding major mineral waste) per capita



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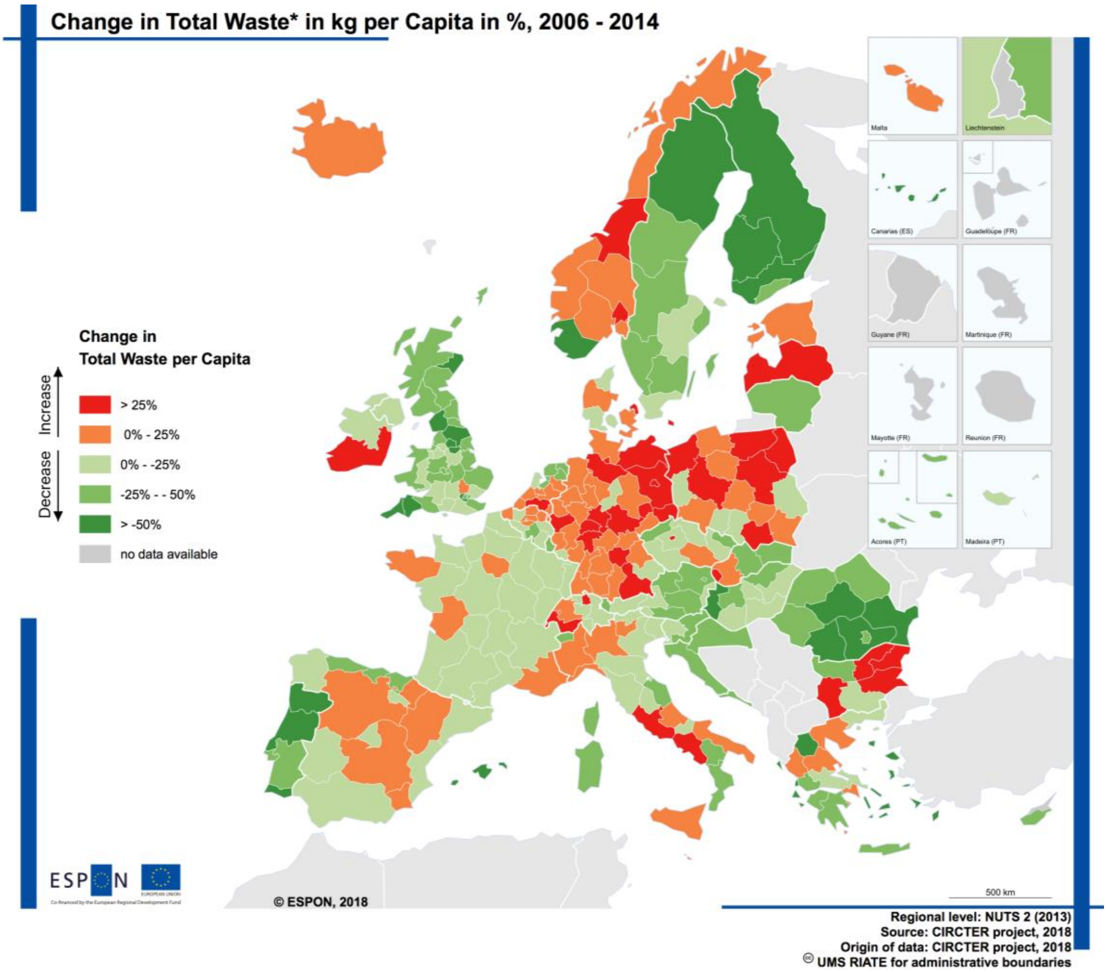
Between 2006 and 2014, total waste (excluding major mineral waste) per capita fell by around -20% on average (median across all regions: -21%). The range is between -99% and +113%. However, these rates of change should be viewed with caution, as the estimation models for total waste (excluding major mineral waste) in 2006 differ significantly from the 2014 estimation model. It can therefore not be excluded that one of the estimation models produces outliers (e.g. for the region *Dytiki Makedonia* in 2006 the amount of total waste seems to be clearly overestimated), which also converts the rate of change for these regions into outliers. With these methodological limits in mind, we see, that in most countries some regions decreased their total waste per capita and other regions increased the generation of total waste per capita, as in Spain or Italy. And by comparing the total waste levels per capita and the change in of this numbers between 2006 and 2014, you will find regions with high levels of per capita levels with decreasing trend (e.g. in Sweden and Finland) but also regions where the high numbers for total waste per capita in 2014 are the results of increasing values for total waste per capita between 2006 and 2014.

Map 3-2: Change of total waste (excluding major mineral waste) in kg per Capita in %



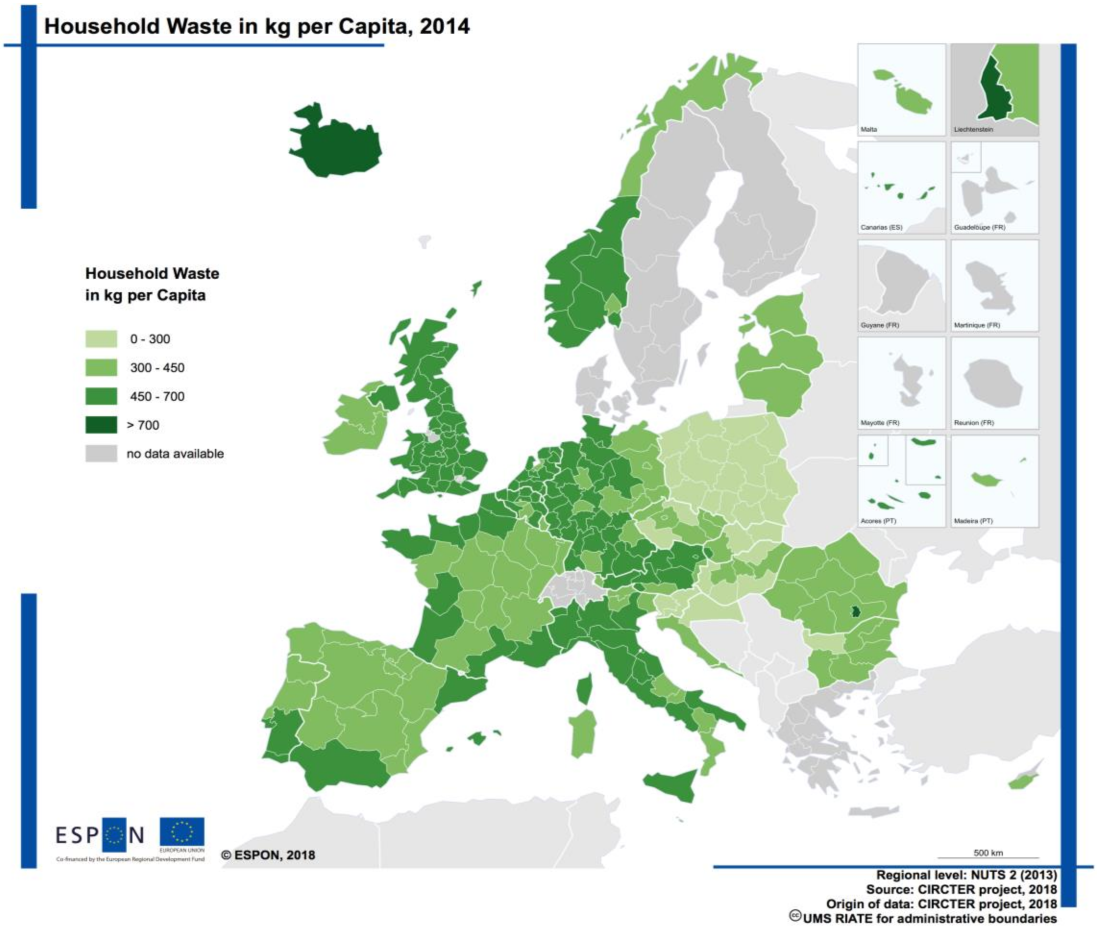
4 Sub-categories for waste generation

As independent variables, the estimation model for **household waste** mainly comprises the number of the population and the amount of municipal waste in which the household waste represents relevant proportions. Accordingly, the spatial patterns that can be taken from Map 7-1 and Map 4-1 are not very different. The range of household waste is between 147 kg/capita and 919 kg/capita. The median across all regions is 452 kg/capita.

One thing that stands out is the great homogeneity within national borders: there are only minor differences in the quantities of waste between the regions of one country: the quantities in the

German regions vary only between 359 kg/capita and 512 kg/capita. However, as the population is one of the two independent variables in the estimation model for household waste, the national homogeneity of this data is understandable because the population density between regions in one country differs less than between countries. At the same time, the homogeneous national distribution is explained by nationally uniform collection systems for household waste.

Map 4-1: Household Waste in kg per capita, 2014



An analysis of household waste per capita, sorted according to regional typology criteria (Figure 4-1), does not reveal any surprising patterns. With the exception of group 4, all urban regions tend to have higher per capita levels for household waste. However, as mentioned before, group 4 consists of only two regions, so this result is difficult to interpret and only reflects the specific criteria of these two regions. It is noticeable that the average amount of household waste per capita as well as the range of data, especially with regard to outliers, are much wider in non industrial regions. One reason could be that e.g. island regions which are normally no industrial regions often strongly depend on tourism and therefore harbour significantly more people who generate the corresponding municipal waste over a period of months.

The homogeneous development of regions within a country can be seen not only in the per capita values, but also in the percentage changes between 2006 and 2014. Map 4-2 shows that in most countries the amount of household waste in all regions has either increased or decreased. At the same time, countries with a high average amount of household waste are often also those regions with declining values between 2006 and 2014 and vice versa. One could therefore conclude that there is a convergence of the quantities of household waste between regions with low per capita values and regions with high per capita values.

Map 4-2: Change of Household Waste per Capita in % between 2006 and 2014

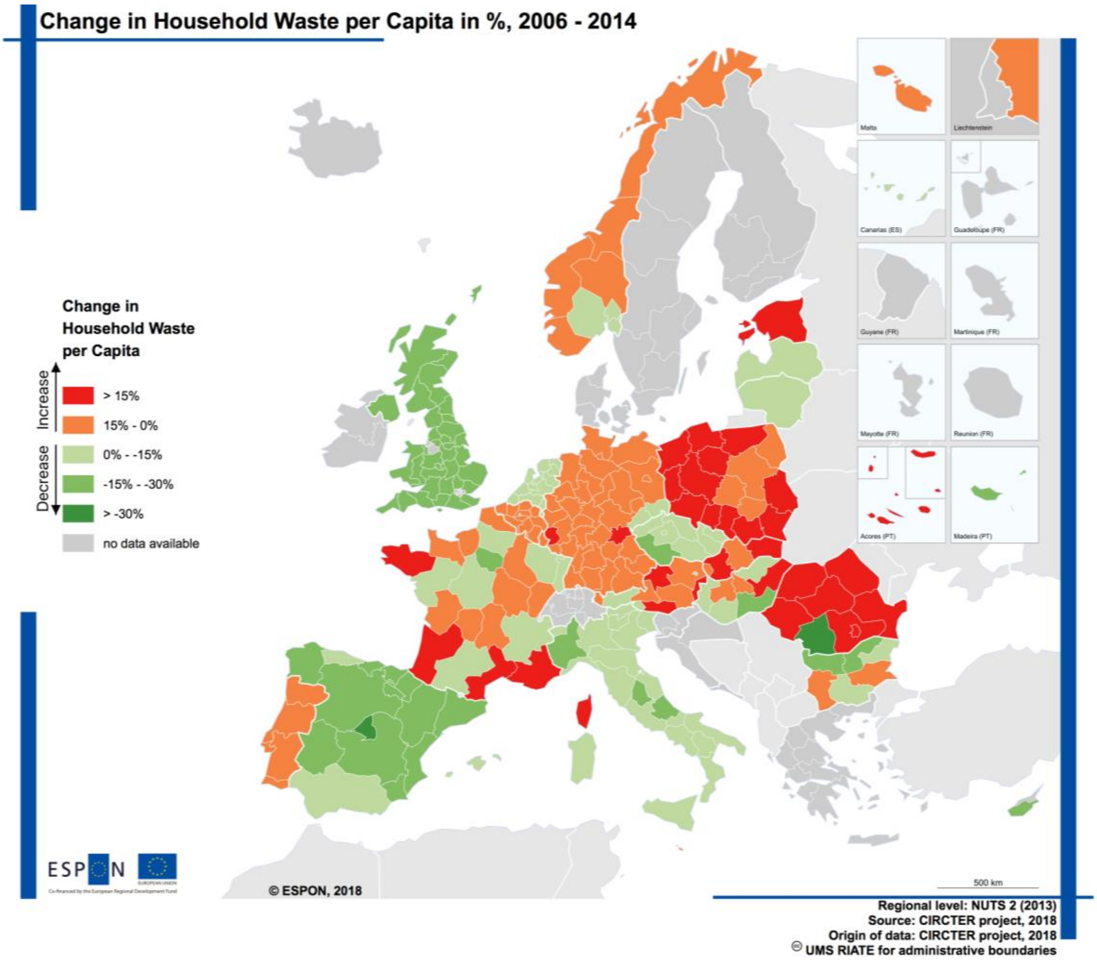
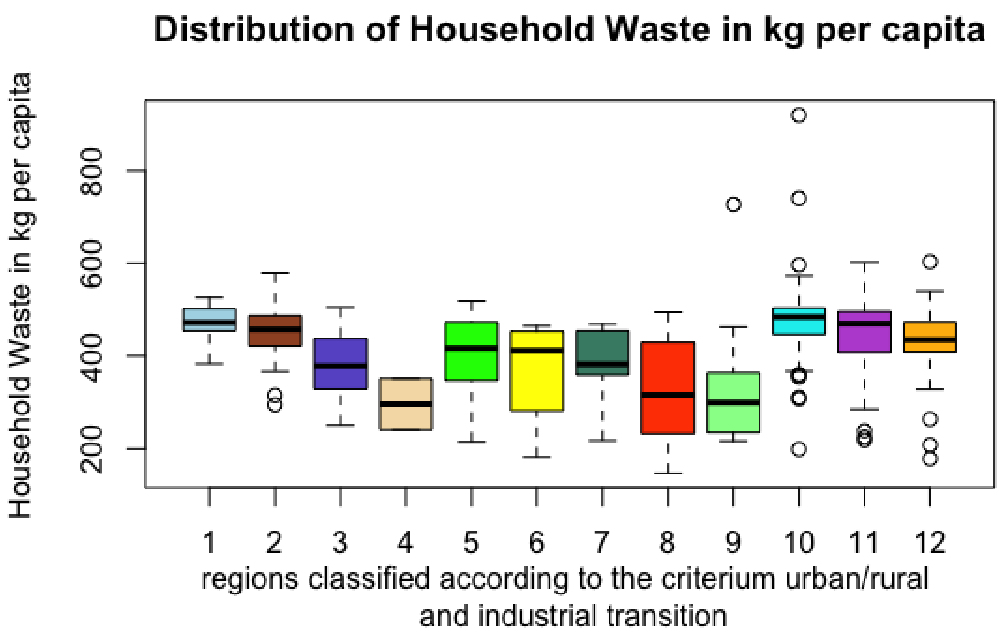


Figure 4-1: Boxplot Diagrams for urban/rural typology of regions for Household Waste in kg per cap



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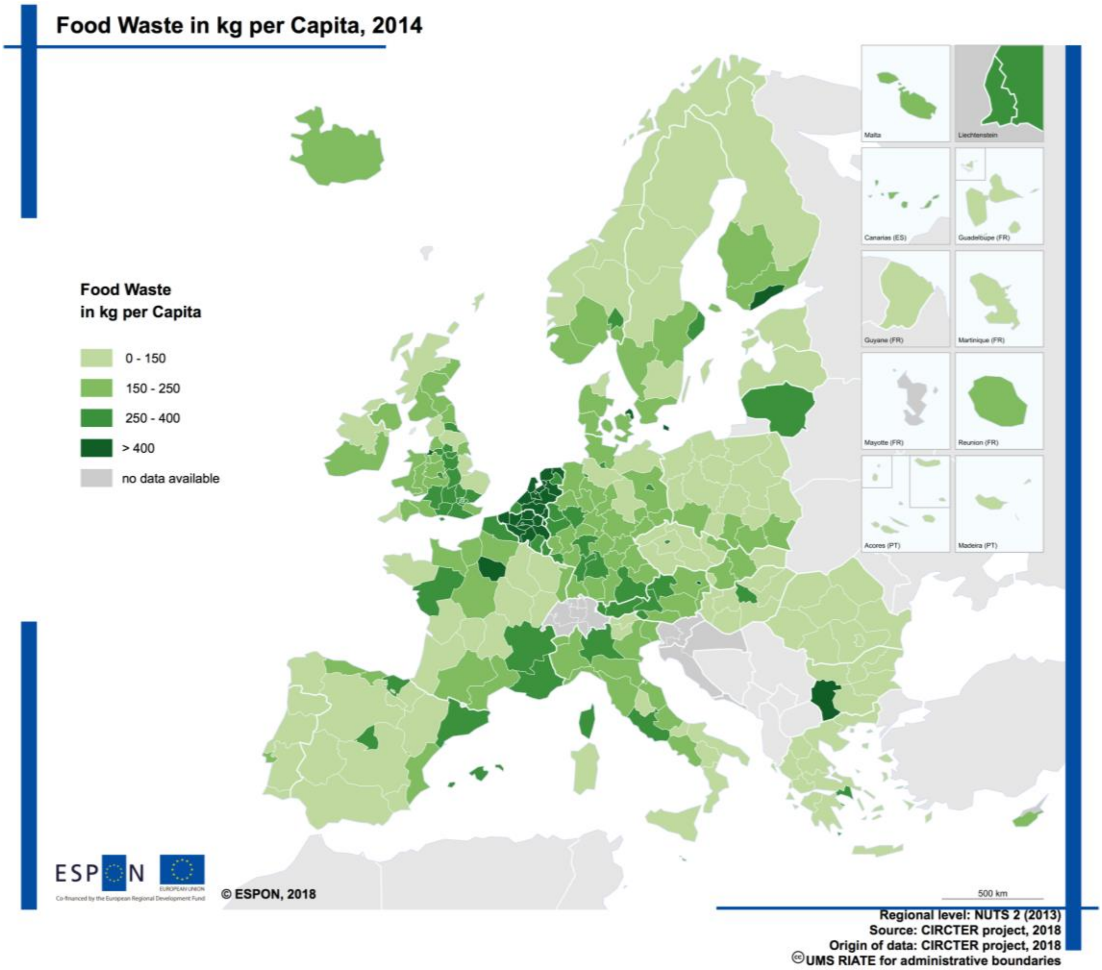
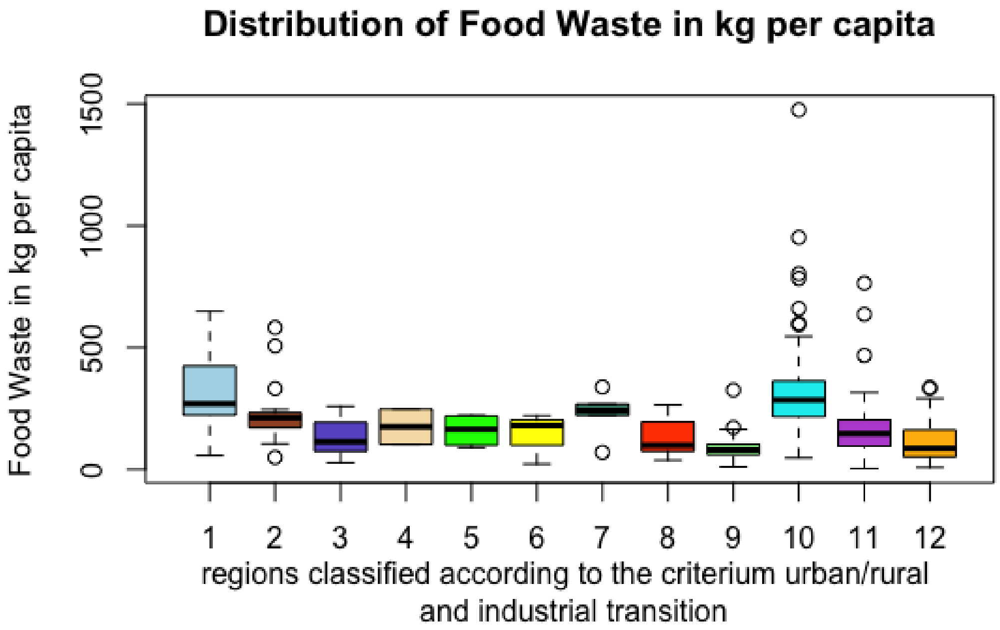
The height of **food waste in kg per capita** ranges from 3.45 kg/capita to 1,475 kg/capita. The median is 191 kg/capita. The comparatively low median already allows the assumption that the high per capita values for food waste are outliers. The estimation model for food waste is determined by the independent variables population density as the driving factor, the specialisation of the gross value added of the agricultural sector (the so-called location quotient (see task 1.1) as the braking factor and the available land area as the driving factor. The land area and population density, each with a positive sign, are contradictory variables: large regions with a large area often have a very low population density. Cities with a high population density are in turn regions with limited area expansion. However, the population density seems to be the more powerful of the two explanatory factors and the increase in population density by one person per square kilometre has a greater influence than the increase in area by one square kilometre. Accordingly, the smaller land area is less important for regions in the Netherlands and Belgium than the rather above-average population density. As a result, the per capita value for food waste is above 500 kg/capita in most of the Benelux regions compared to e.g. Italian regions, where the per capita value is often less than 100 kg, but also the population density is correspondingly lower.

Map 4-3: Food Waste in kg per capita, 2014



The analysis according to regional urban/rural and industrial transition typologies confirms the great influence of population density while at least slightly below average land area: the boxplot diagram below shows that urban regions have a significantly higher per capita value for food waste than rural regions or regions that have not been classified as intermediate regions. At the same time, the distinction between industrial and non-industrial regions does not seem to have a decisive impact on the level of food waste per capita.

Figure 4-2: Boxplot Diagram for urban/rural typology of regions for Food Waste per cap, 2014



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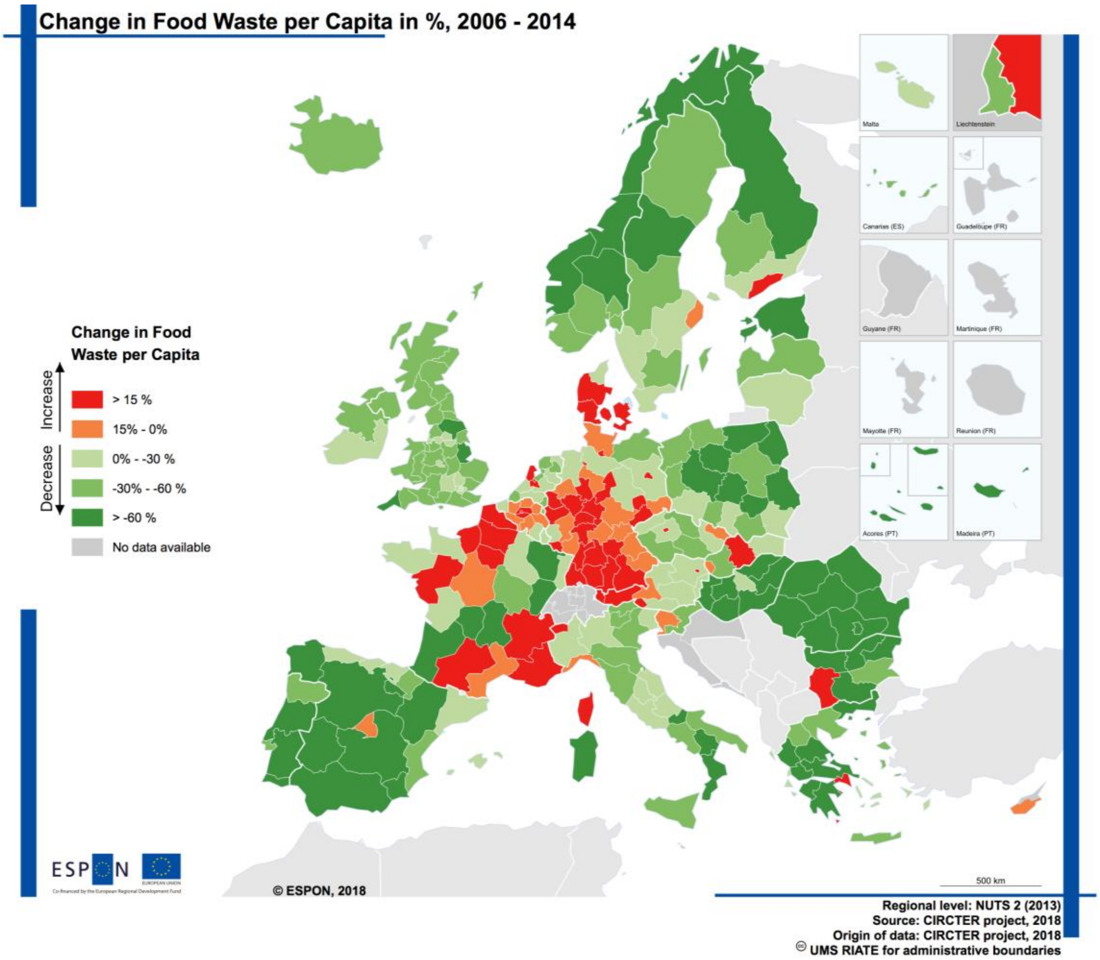
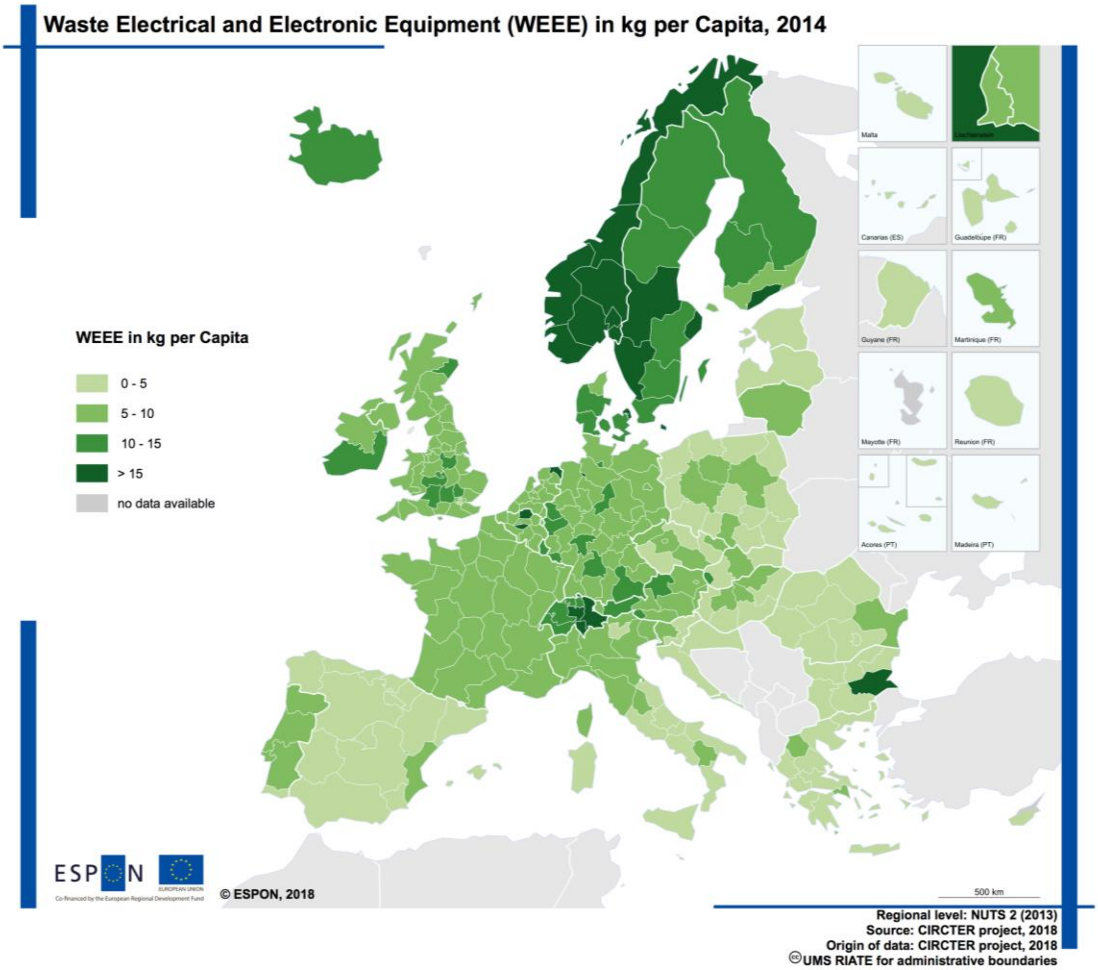
The change in per capita values of food waste between 2006 and 2014 shows increasing quantities of food waste in kg per capita for many regions in Germany, in France and the Benelux countries and also in capital regions like Madrid or Vienna (Map 4-4). Regions in Italy, but also in Portugal and the UK, on the other hand, have a declining amount of food waste per capita. However, the estimation model makes it difficult to justify these different development patterns: Both the land area and population density have not changed significantly in the period under review or have not changed at all in the case of land area. However, the increase in the capital regions in particular could indicate that the rising population density has led to an increase in per capita values of food waste, as the metropolitan regions/towns are in particular characterised by strong population growth. One reason for the higher per capita values in urban regions will be on the one hand an improved and separate collection of food waste in urban areas, but on the other hand also the fact that in rural regions, biotic waste is to a much greater extent composted in one's own property and therefore less food waste per household will be collected.

Map 4-4: Change of Food Waste per capita, 2006-2014



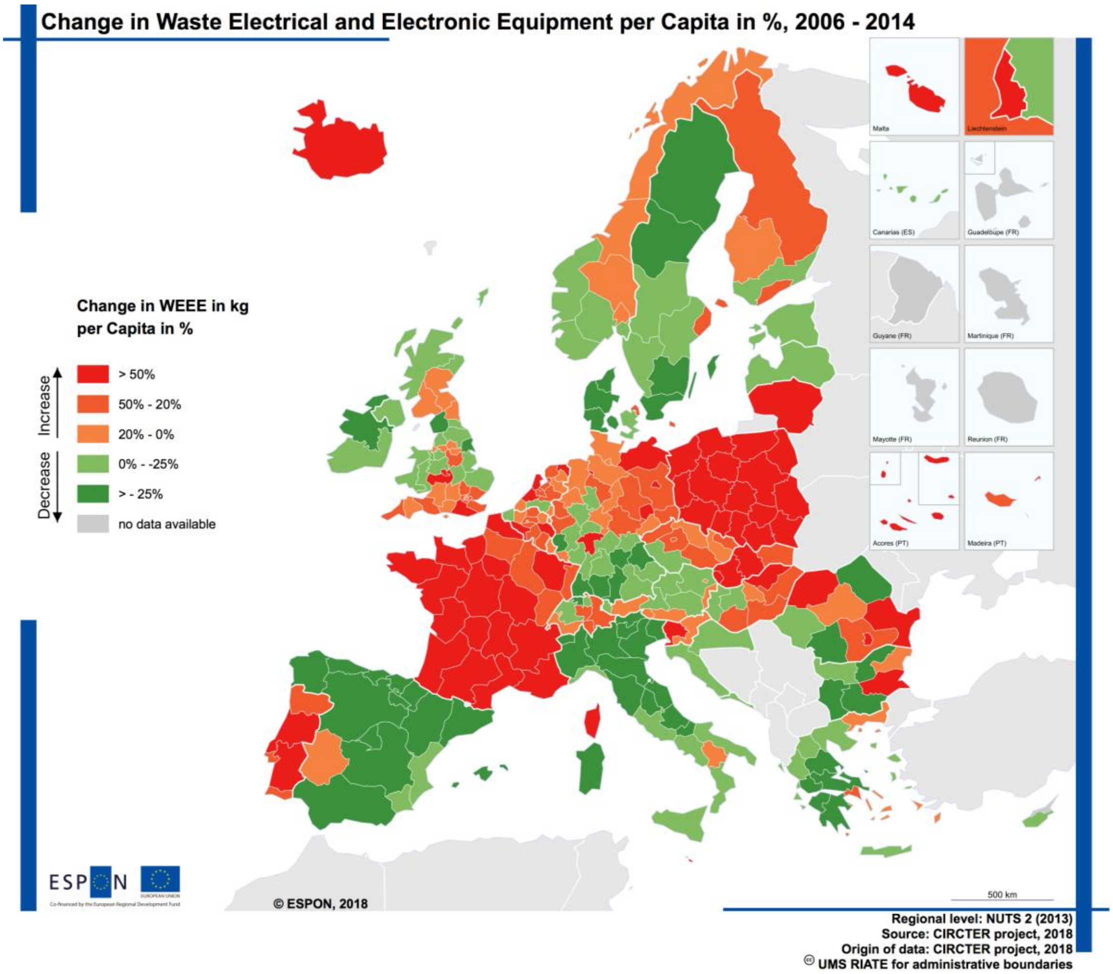
The estimation models for the level of **WEEE per capita** have several independent variables, which mainly emphasize the production perspective. In 2014, the location quotient for investment in the manufacturing sector was a driving factor, as was the gross value added (GVA) of the industrial sector, while at the same time the specialisation of GVA in the manufacturing sector is a braking factor. After all, the population is again a driving factor. WEEE per capita ranged from 0.05 kg/capita to 26 kg/capita in 2014. The median across all regions was 7 kg/capita. High rates of electrical and electronic waste are generated and collected in Sweden or Norway, with values well above 10 kg/capita in all regions. At the same time, the regions *Yugoiztochen* in Bulgaria and *Groningen* in the Netherlands are marked as outliers both in terms of the total panel of all regions and within the respective country, each with over 20 kg/capita, which is many times the average of all other regions of the respective country. The high volume of WEEE in the region *Yugoiztochen*, as well as in some Belgian or German regions with high per capita values for WEEE, can probably be explained by the high shares of manufacturing investment in total investment in these regions. However, this directly shows a problem with cross-panel regression without time dimension: investment in industry or manufacturing is undoubtedly a factor in the emergence of WEEE, but only with a certain time lag, as these investments only become WEEE after their use phase. However, investment rates in the manufacturing sector were also above average in these regions in 2006, so that it can be assumed that these regions represent industrial centres whose total gross fixed capital formations are continuously determined by high shares of the manufacturing sector. In the region *Groningen*, the share of manufacturing investment in total investment has been below average, although half of total gross value added in the *Groningen* region is determined by the industrial sector. This is a very high value for the Netherlands. On the other hand, the low levels of WEEE per capita in Greece or in the majority of Eastern European regions are explained accordingly by low investment in manufacturing and the low share of the industrial sector in regional gross value added as a result of the economic crisis in Greece.

Map 4-5: WEEE in kg per capita, 2014



Changes in WEEE volume per capita between 2006 and 2014 often show strong national patterns: While in France and Poland all regions have almost doubled their generated WEEE per capita, in Spain and Italy the opposite is the case. However, the absolute quantities of WEEE per capita are rather low, so that even small per capita changes can result in high percentage changes.

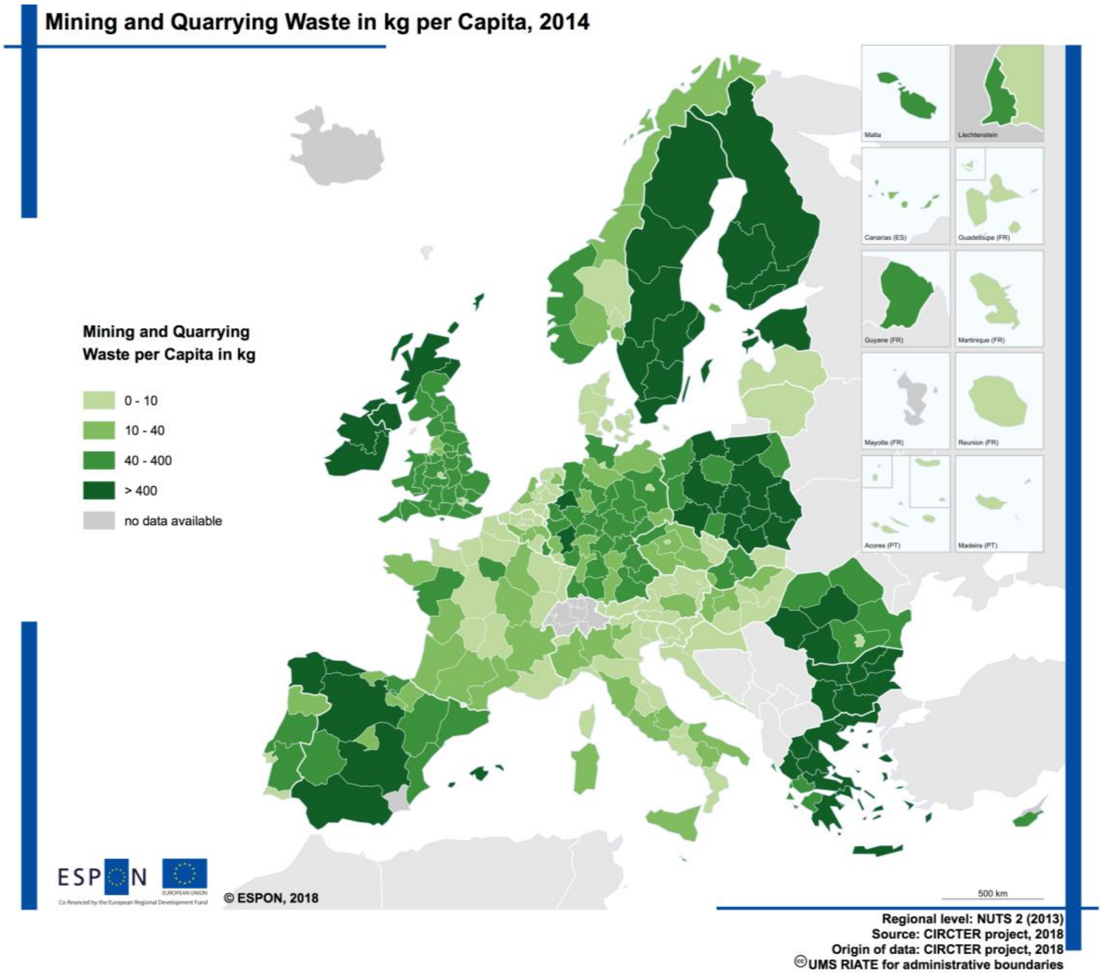
Map 4-6: Change in WEEE per Capita in %, 2006 – 2014



In contrast to the input and waste indicators presented so far, the regionalised data for the NACE sectors have not been estimated by a regression model but rather by the redistribution model for the regions. As a result, the sum of all regions of a country corresponds exactly to the national data published by Eurostat in the env_wasgen data set. However, as already been mentioned, some of the national statistics on certain categories of waste are unusually high, while other official figures are very low. These exceptional national data are even more reflected in the regional data as the national quantities of e.g. **mining and quarrying waste** are mainly allocated to the regions, that show corresponding mining and quarrying activities (in the form of number of companies and their employment). As a result, the spread of data at regional levels increases considerably: the range for mining and quarrying waste per capita for the regions studied is between 0 kg/capita and 144,000 kg/capita, i.e. 144 t/capita, with a median of 39 kg/capita. The low median compared to the upper limit of 144 t/capita indicates how exceptionally high this value of 144 t/capita is, compared to the whole panel.

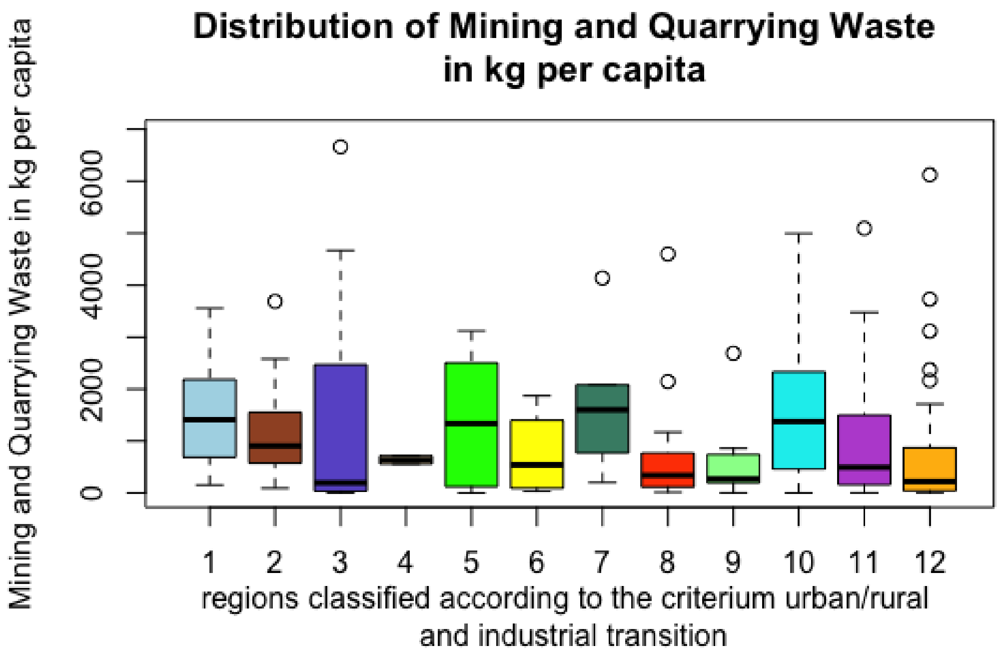
The results in Map 4-7 initially seem to reflect rather national patterns: France and Italy are characterised by low per capita values, other countries such as Sweden, Greece or Bulgaria rather by very high per capita values of mining and quarrying. However, the regional distribution within the states is enormous. This is mainly explained by the method of distributing the national quantities of waste among the regions: Mining (especially open-cast mining) often takes place in regions with low population density. In such cases, where the national mining and quarrying waste volumes are concentrated in sparsely populated regions, the per capita volumes of mining and quarrying waste are extraordinarily high. Additionally, in the several regions will be no significant share of the mining and quarrying sector in the total number of enterprises and their employees. As a result, the few regions with significant portions of mining are credited with the majority of mining and quarrying waste, while the several regions with no or less mining and quarrying activities are credited with almost none of the mining and quarrying waste. Mining is a labour-intensive sector, so that mining regions (especially historic mining regions) have often developed into industrial centres with a higher population density, such as the Ruhr area in Germany or the coal region in southern Poland.

Map 4-7: Mining and Quarrying Waste in kg per capita, 2014



In the boxplot diagrams for the distribution of mining and quarrying waste per capita according to the criterion of urban or rural areas and industrial transition, several outliers in the data can be observed. In order to be able to create meaningful boxplot diagrams at all, the largest outliers had to be cut off by limiting the Y-axis at 7,000 kg/capita. One result of the boxplot diagram is that outliers exist in almost all of the groups. Surprisingly, there is no clear pattern regarding the distribution of per capita values according to regional criteria or the importance of the industrial sector. Perhaps this is explained by the different regional conditions for quarrying and mining activities. As mentioned before, mining often takes place in less densely populated regions but also in regions with higher population density. Due to high transport costs, the demand for mineral resources in urban centres are met by companies in the surrounding area, which may still be part of an urban NUTS2 region. And in addition, the high level of building activities in Spain and Irland (Map 1-7) is reflected by higher numbers in quarrying waste in these regions.

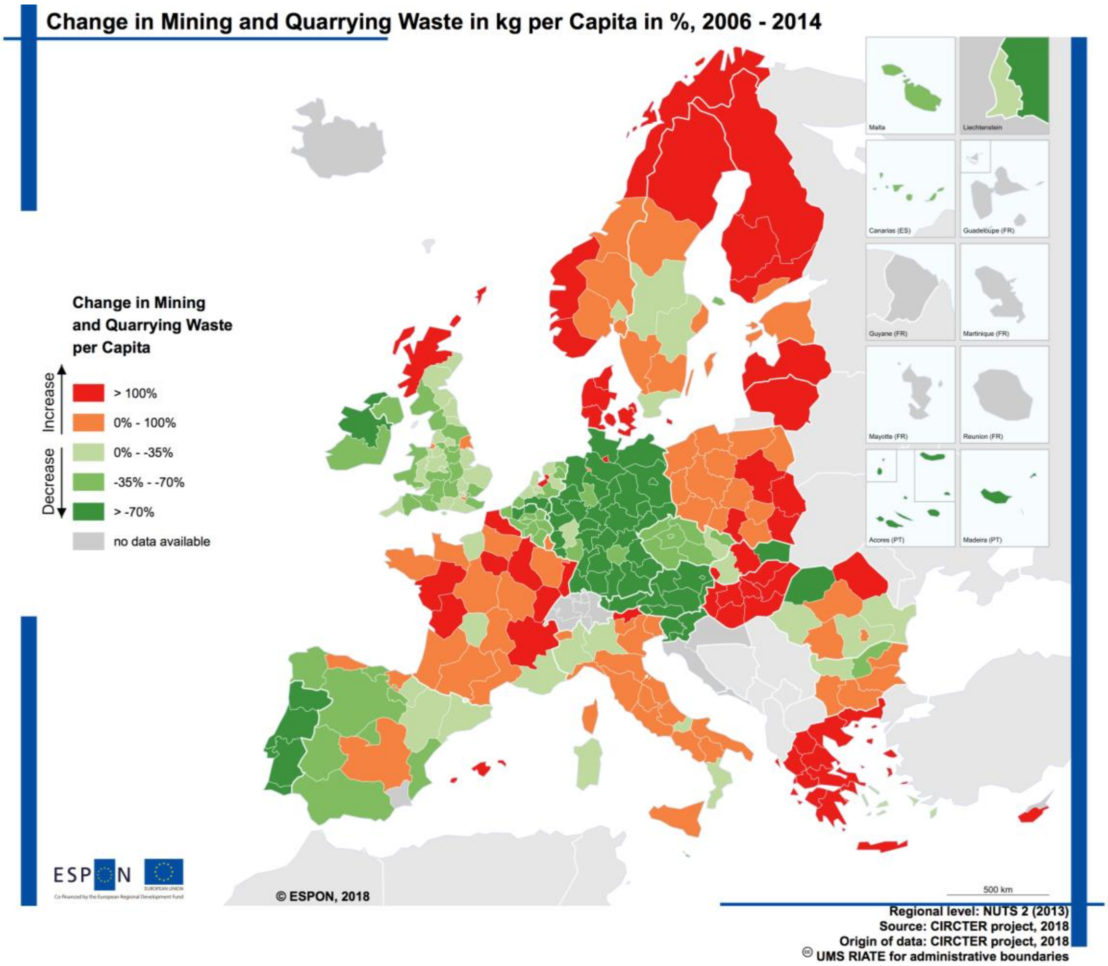
Figure 4-3: Boxplot-Diagram for urban/rural typology of regions for mining and quarrying waste, 2014



1 = predominantly urban/industrial region losing importance	7 = predominantly urban/industrial region mixed directions
2 = intermediate/industrial region losing importance	8 = intermediate/industrial region mixed directions
3 = predominantly rural/industrial region losing importance	9 = predominantly rural/industrial region mixed directions
4 = predominantly urban/industrial region gaining importance	10 = predominantly urban/no industrial region
5 = intermediate/industrial region gaining importance	11 = intermediate/no industrial region
6 = predominantly rural/industrial region gaining importance	12 = predominantly rural/no industrial region

For mining waste, too, the percentage changes between 2006 and 2014 mainly indicate national patterns. This is hardly surprising, as the regional changes result from national differences between 2006 and 2014. According to the distributional indicators, such as employment, not changing fundamentally, the national changes must be reflected evenly in the regions. This seems to be the case for Germany, where the regional decrease is quite similar. In addition, the range in the outer categories of the respective colour spectrum (dark green or red) is often very wide without this being apparent from the maps. Thus, the percentage increase of per capita values in Greece fluctuates between 150% and 440% and thus all above the threshold of +70% for this colour scheme, without these regional differences being recognizable from the maps.

Map 4-8: Change in Mining and Quarrying Waste per capita, 2006-2014



Agricultural waste includes all waste generated in NACE sector A (Agriculture, Forestry and Fishing). It is therefore to be expected that this waste will mainly be generated in agricultural or forestry regions or regions with relevant fishing fleets. A glance at Map Map 4-9 seems to confirm this. The distribution between the regions studied ranges from 0 kg/capita to 500 kg/capita, with a median of 9.7 kg/capita. This means that the 500 kg per capita is a clear outlier, which is confirmed in the box plot diagram. The box plot diagram shows further that outliers exist in almost all typology classifications, but also, that 75% of the respective regions are located below a per capita value of 100 kg/capita. Furthermore, the box plot diagram indicates that in 2 out of 4 typology clusters, the rural regions have a higher per capita value than urban or intermediated regions. However, these two clusters are also the ones with the lowest data points.

Map 4-9: Agricultural Waste in kg per capita, 2014

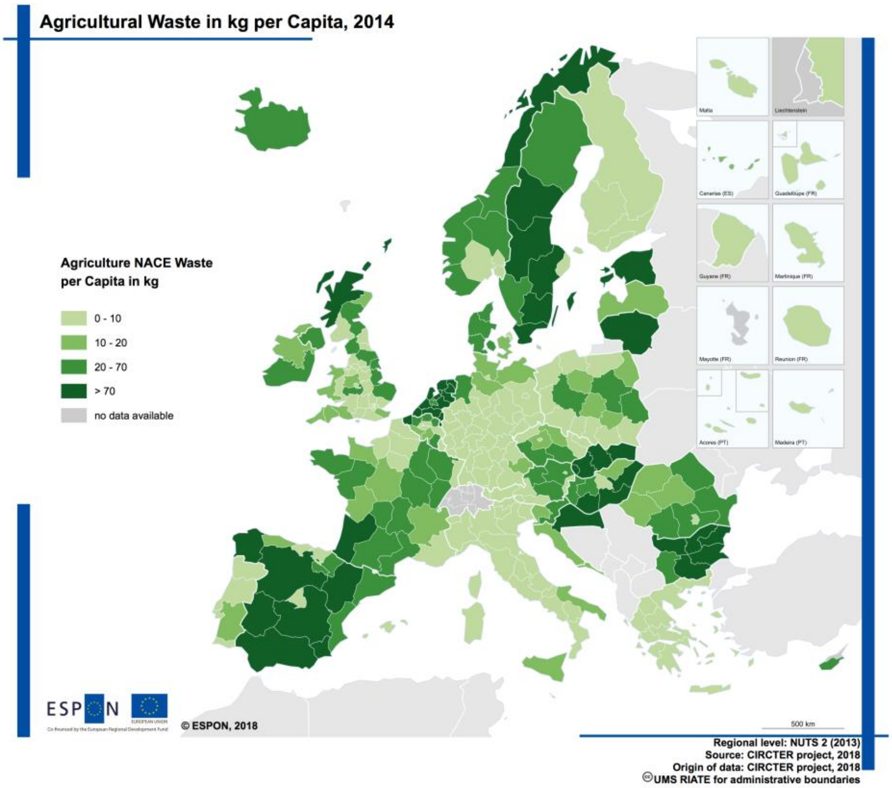
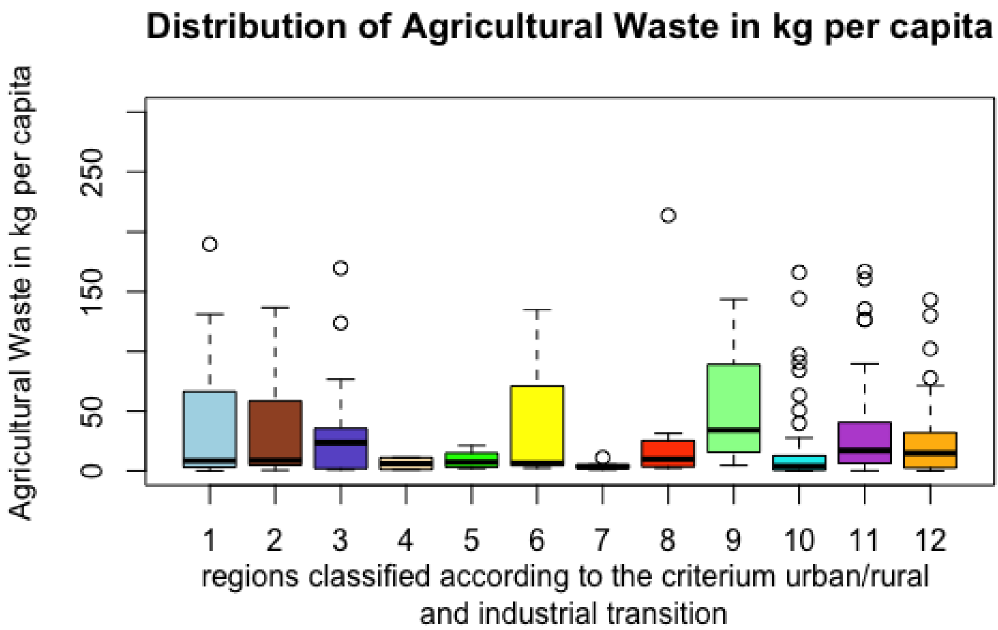


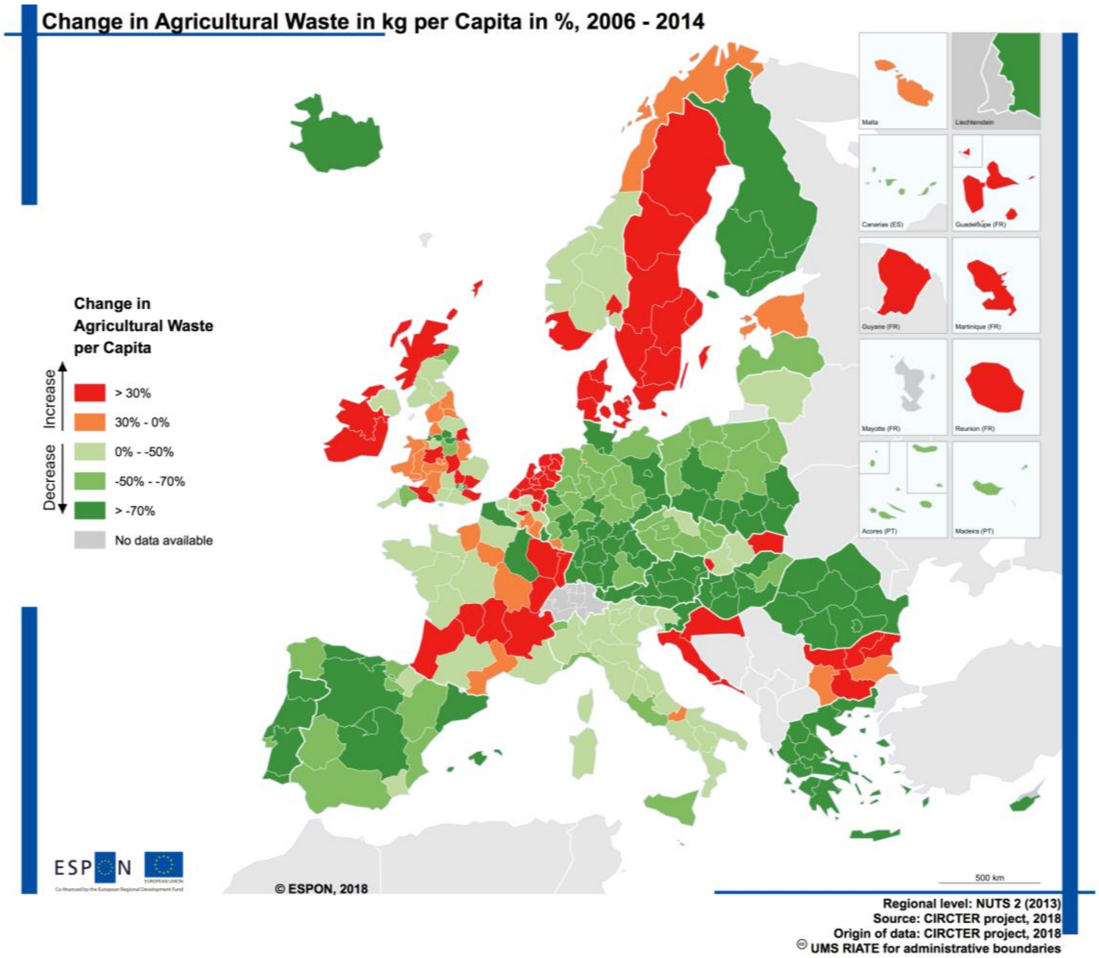
Figure 4-4:Boxplot-Diagram for urban/rural typology of regions for agricultural waste, 2014



1 = predominantly urban/industrial region losing importance	7 = predominantly urban/industrial region mixed directions
2 = intermediate/industrial region losing importance	8 = intermediate/industrial region mixed directions
3 = predominantly rural/industrial region losing importance	9 = predominantly rural/industrial region mixed directions
4 = predominantly urban/industrial region gaining importance	10 = predominantly urban/no industrial region
5 = intermediate/industrial region gaining importance	11 = intermediate/no industrial region
6 = predominantly rural/industrial region gaining importance	12 = predominantly rural/no industrial region

The change between 2006 and 2014 shows different patterns: On the one hand, there are regions with low per capita values in 2014, which have to register decreasing waste volumes between 2006 and 2014. One could therefore conclude here that the low per capita values in 2014 are a result of the declining volumes since 2006 (Greece, Finland). At the same time, however, there are also regions which, despite falling per capita values since 2006, still have high waste volumes in 2014 (Spain). On the other hand, regions can be identified that have high values in 2014 also due to increasing per capita volumes since 2006, for example, in Sweden, Ireland and the Benelux regions.

Map 4-10: Change of Agricultural Waste per capita in %, 2006-2014



The amount of **manufacturing waste** per capita ranges from 0.2 kg/capita to 3,350 kg/capita. The median is 235 kg/capita. And Map 4-11 indicates that the amount of manufacturing waste per capita is well above the average in industrially dominated regions: examples include regions in northern Italy, southern Germany and Catalonia. The boxplot diagram for the distribution of the regions according to the classifications of industrial transition and urban or rural region (Figure 4-5) also confirms the correlation between the level of manufacturing waste per capita and the importance of the industry sector. At the same time, no differences can be observed between urban and non-urban regions. This suggests that regions with above-average importance of the industrial sector are often regions characterised by small towns and small and medium-sized enterprises.

Map 4-11: Manufacturing Waste in kg per capita, 2014

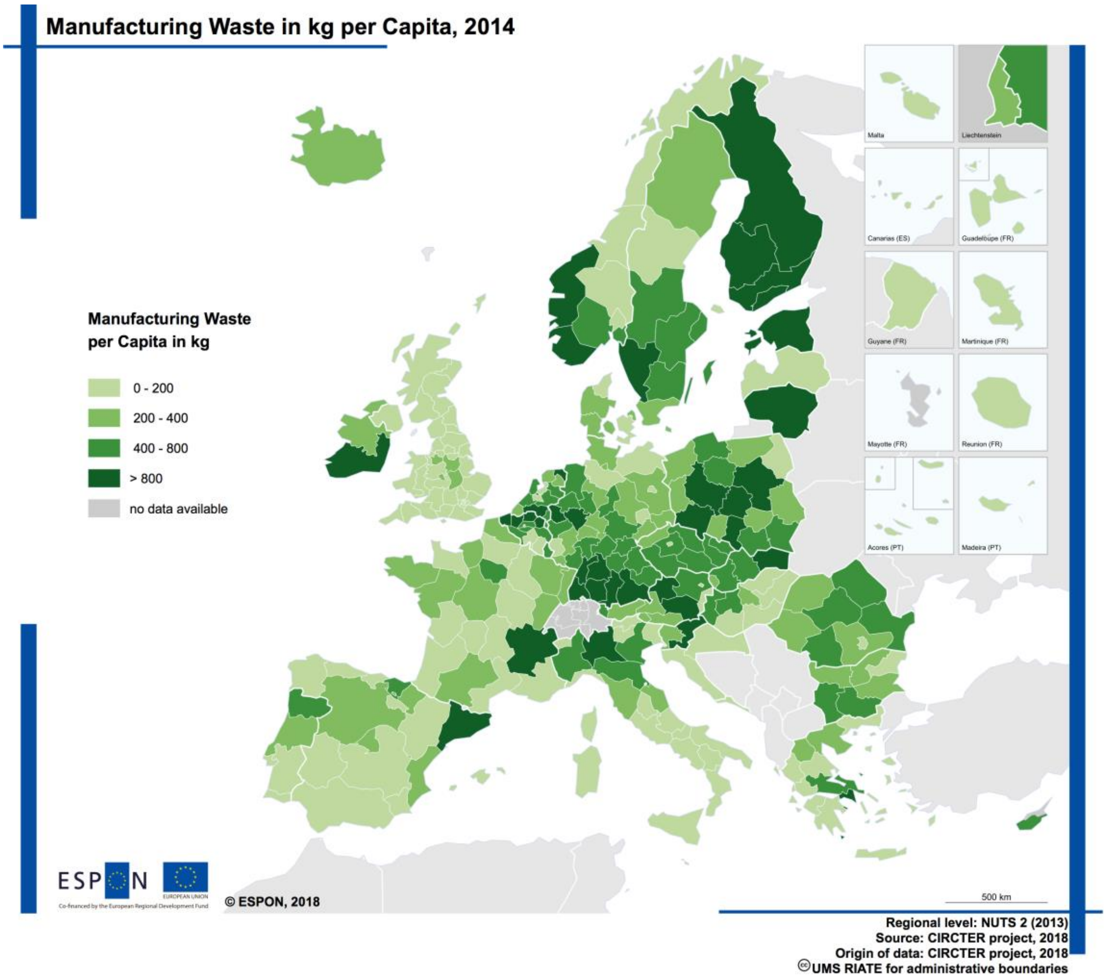
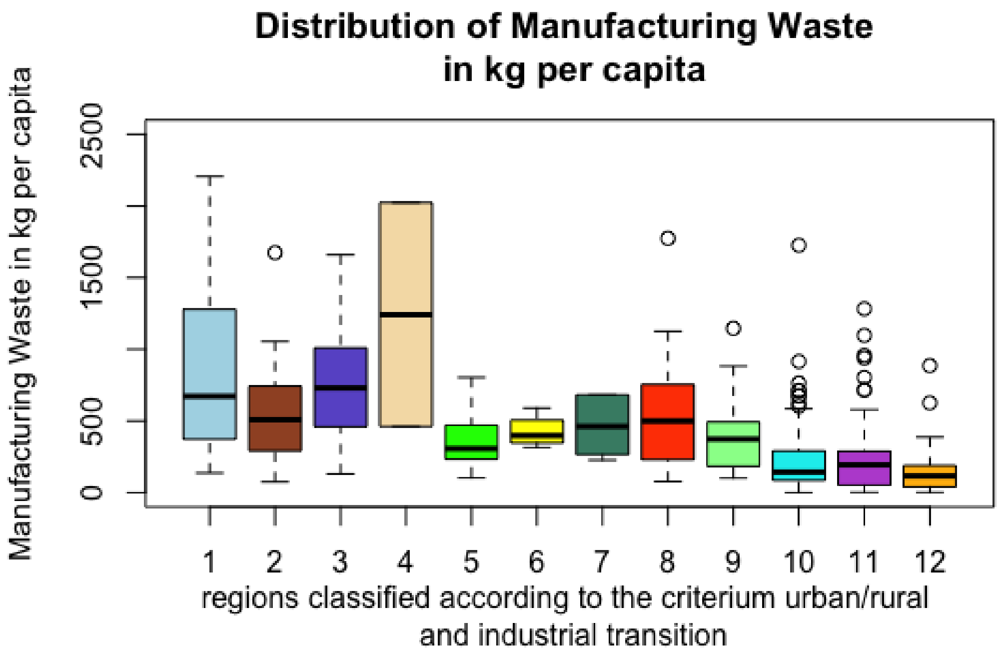


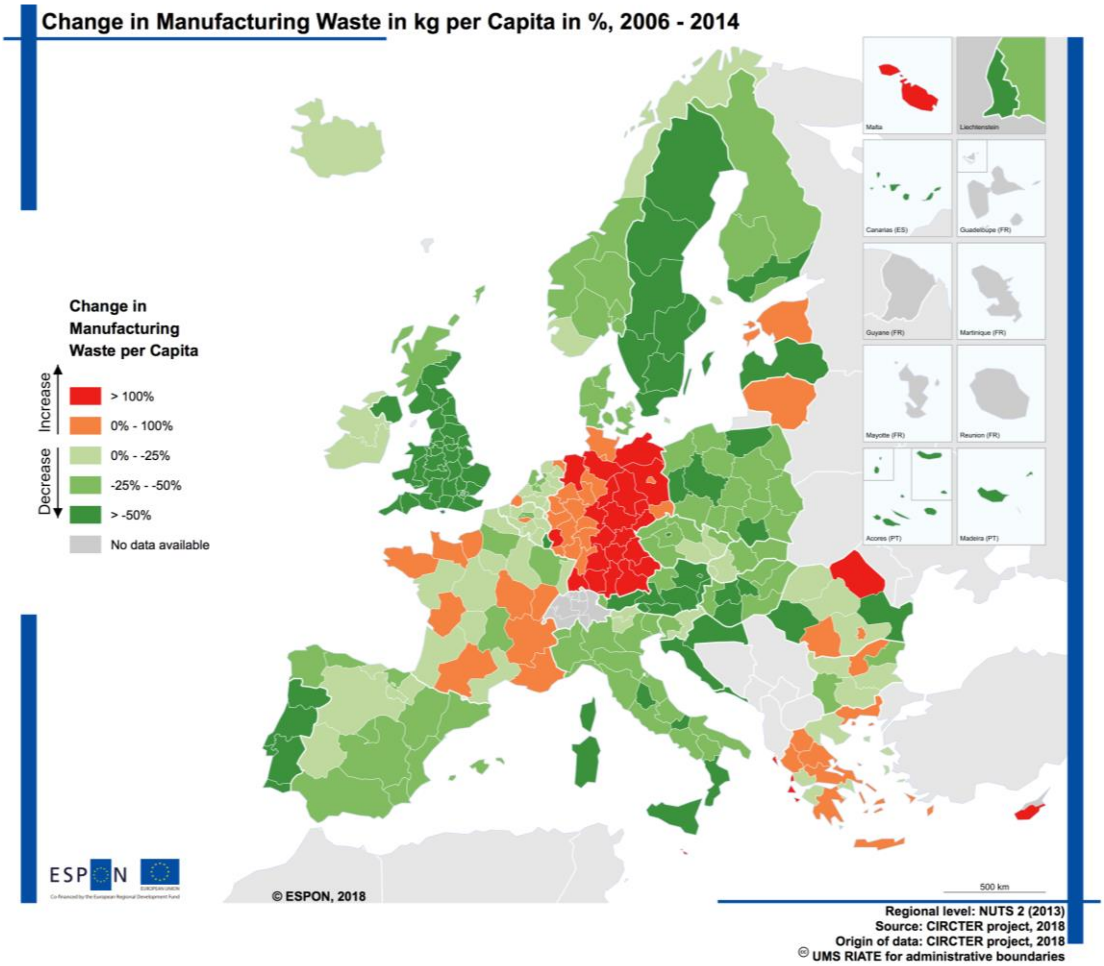
Figure 4-5: Boxplot-Diagram for urban/rural typology of regions manufacturing waste, 2014



1 = predominantly urban/industrial region losing importance	7 = predominantly urban/industrial region mixed directions
2 = intermediate/industrial region losing importance	8 = intermediate/industrial region mixed directions
3 = predominantly rural/industrial region losing importance	9 = predominantly rural/industrial region mixed directions
4 = predominantly urban/industrial region gaining importance	10 = predominantly urban/no industrial region
5 = intermediate/industrial region gaining importance	11 = intermediate/no industrial region
6 = predominantly rural/industrial region gaining importance	12 = predominantly rural/no industrial region

Surprisingly, Germany is almost the only country in which the amount of manufacturing waste per capita has increased (and often by more than 100%). This may in parts be explained by the continuing importance of the industrial sector in Germany. Although the majority of German regions are not regions with an increasing importance of the industrial sector (see the groups 4 - 6 of the typologies), deindustrialisation in Germany is much less pronounced than in other countries and the manufacturing sector is still one of the growth engines of the German economy.

Map 4-12: Change in Manufacturing Waste in kg/Capita in %, 2006 - 2014



The amount of **mineral and solidified waste generated by the construction sector** varies between 0 kg/cap and 13,900 kg per capita in the investigated regions. The median is 711 kg/capita. The regional quantities for this waste category methodically results from the national waste quantities (due to the method described above). And in Eurostat's national statistics, there are also massive differences between the countries. The assumption is that the national numbers are already underestimated in some of the countries studied. For example, for Romania only 235,000 tonnes of waste are reported in this category in 2014. This is one sixth of the amount reported by Eurostat for Malta. If these (too) small national quantities are then distributed among the Romanian regions, the per capita value for all Romanian regions are very low. The Greek regions and some Bulgarian regions show similar characteristics, where it can be assumed that not all mineral and solidified waste from the construction sector is recorded as corresponding waste categories and reported accordingly.

Therefore, the maps for the per capita level, as well as the change over time, and also the boxplot diagrams, are based on national data from Eurostat, for which it can be assumed that the data are not collected according to the same methodology in all countries and therefore are difficult to interpret.

Map 4-13: Mineral and Solidfied Waste in kg per capita, 2014

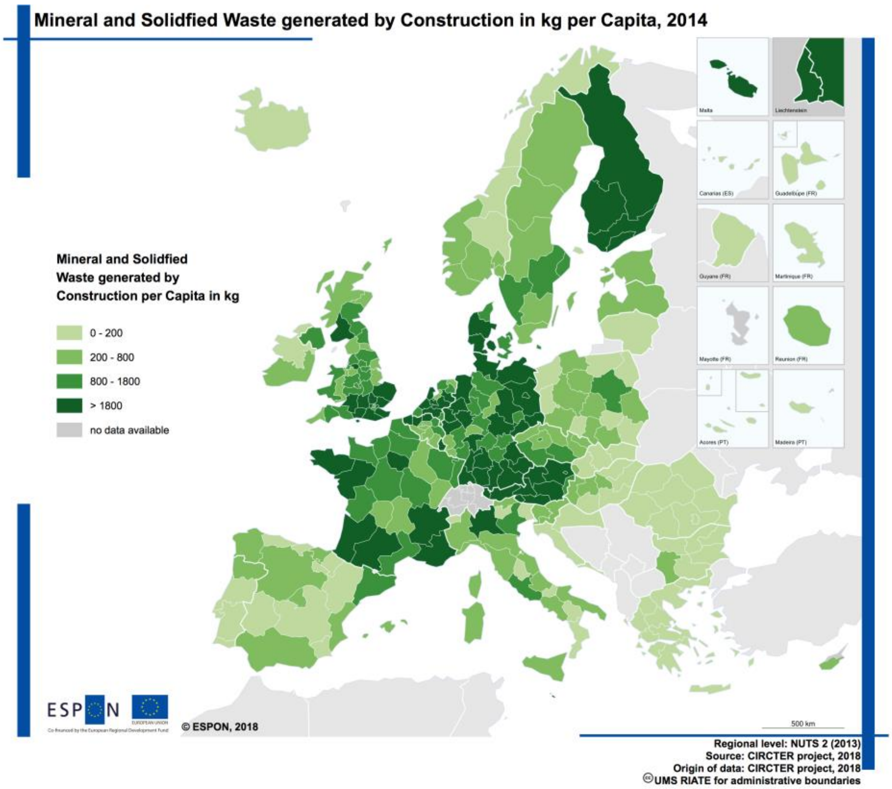
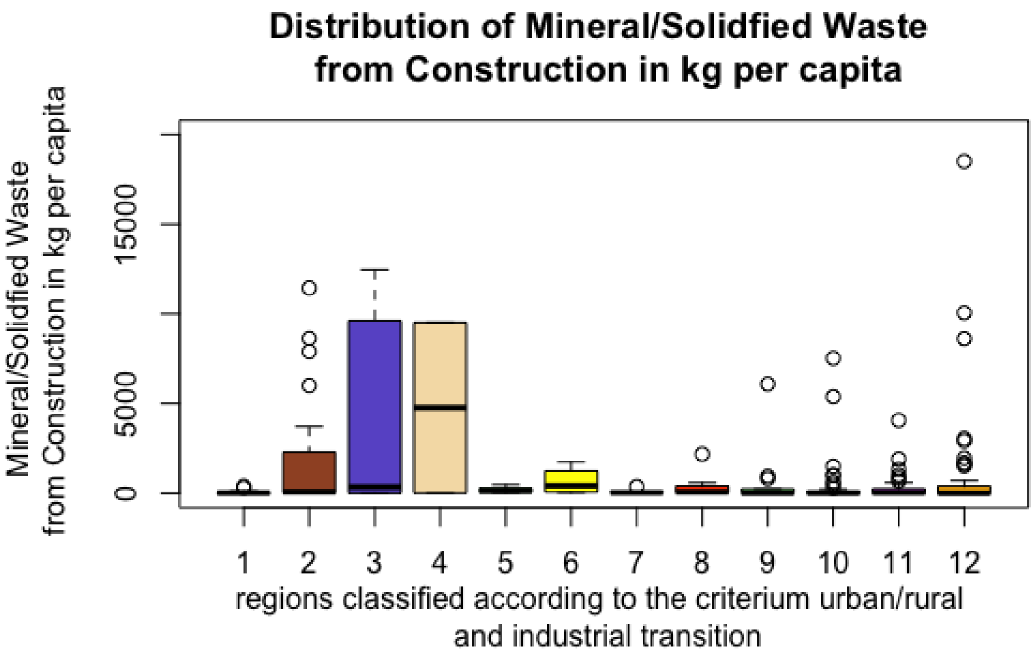
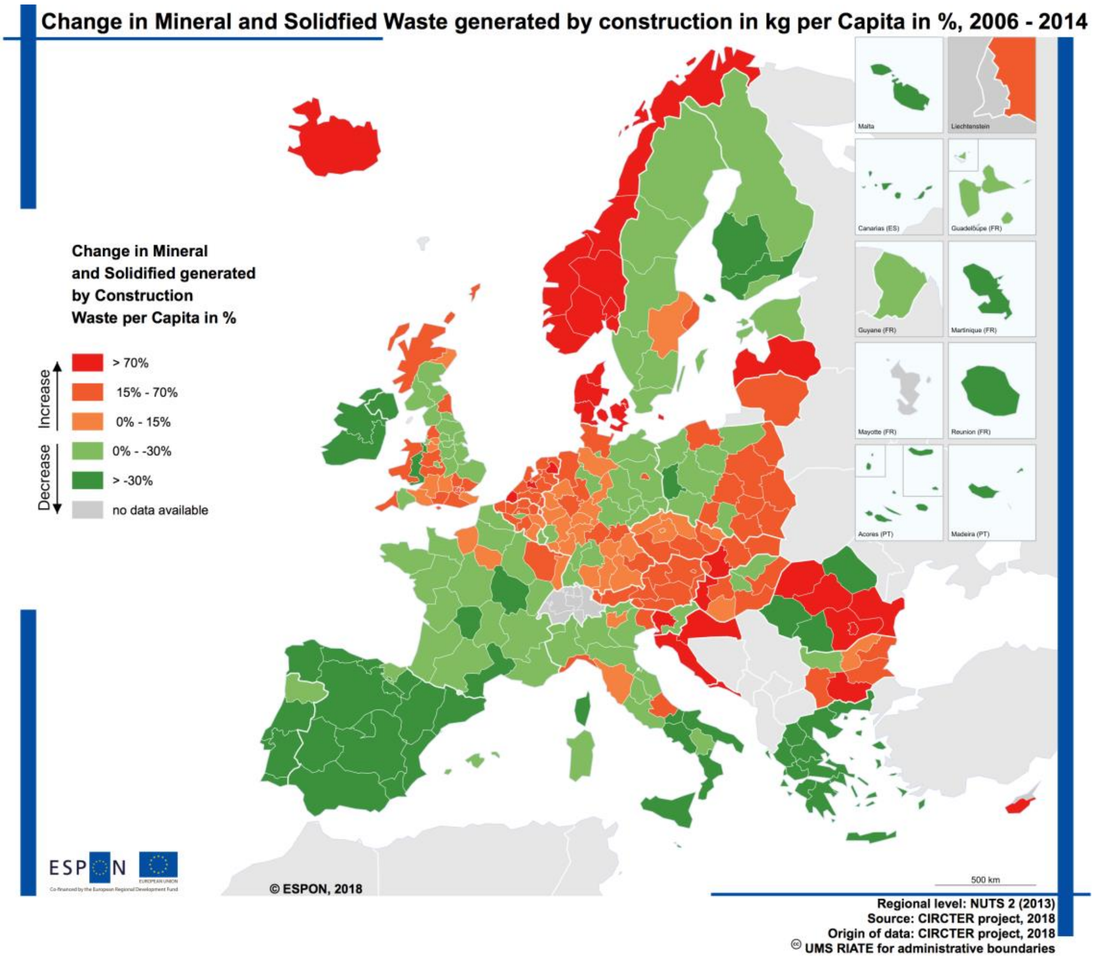


Figure 4-6: Box plot diagrams for urban/rural typologiy of regions for mineral and solidfied waste generated by construction in kg per capita



1 = predominantly urban/industrial region losing importance	7 = predominantly urban/industrial region mixed directions
2 = intermediate/industrial region losing importance	8 = intermediate/industrial region mixed directions
3 = predominantly rural/industrial region losing importance	9 = predominantly rural/industrial region mixed directions
4 = predominantly urban/industrial region gaining importance	10 = predominantly urban/no industrial region
5 = intermediate/industrial region gaining importance	11 = intermediate/no industrial region
6 = predominantly rural/industrial region gaining importance	12 = predominantly rural/no industrial region

Map 4-14: Change in Mineral and Solidfied Waste in kg per cap in %, 2006-2014



The amount of national **plastic waste** has also been regionalised using a redistribution model, but in contrast to the waste flows of individual NACE sectors for plastic waste, socio indicators such as population and income (together with the economic indicators total employment and total GVA) have been used as allocation criteria. This assignment produces a map that does not show any distinct spatial patterns, as is the case with household waste, for example. However, it becomes apparent that urban centres, especially capitals, have higher per capita plastic waste than rural regions. This is not surprising, because the variables used for redistribution, as both the population and income, are above average in urban centres and the often high concentration of service industries in urban regions leads to a higher the number of employees and gross value added in the region.

Map 4-15: Plastic Waste in kg per capita, 2014

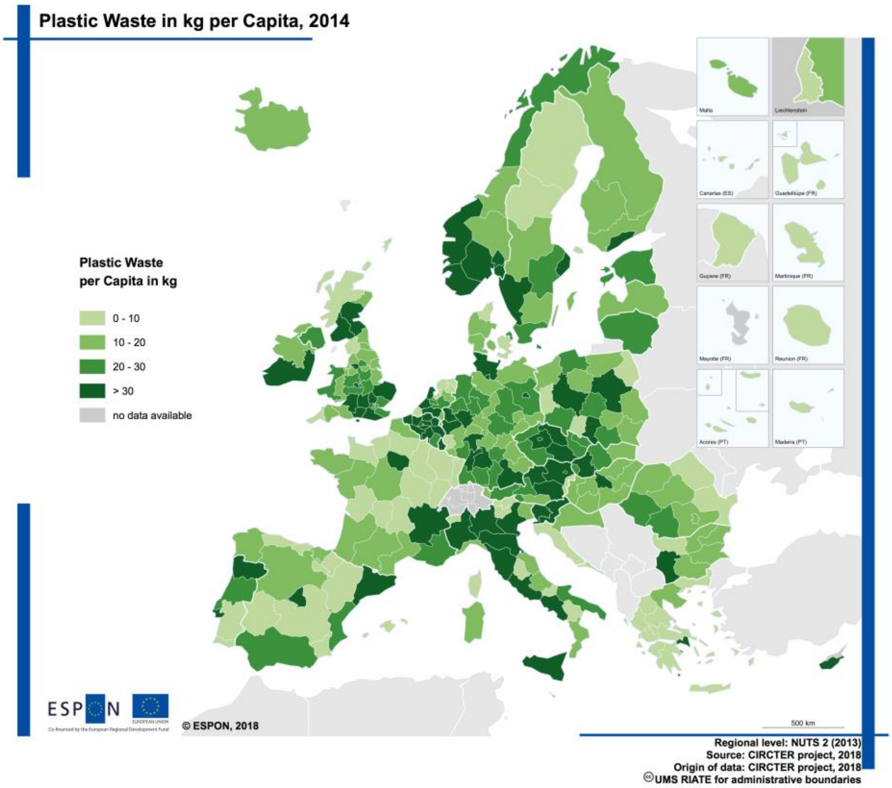
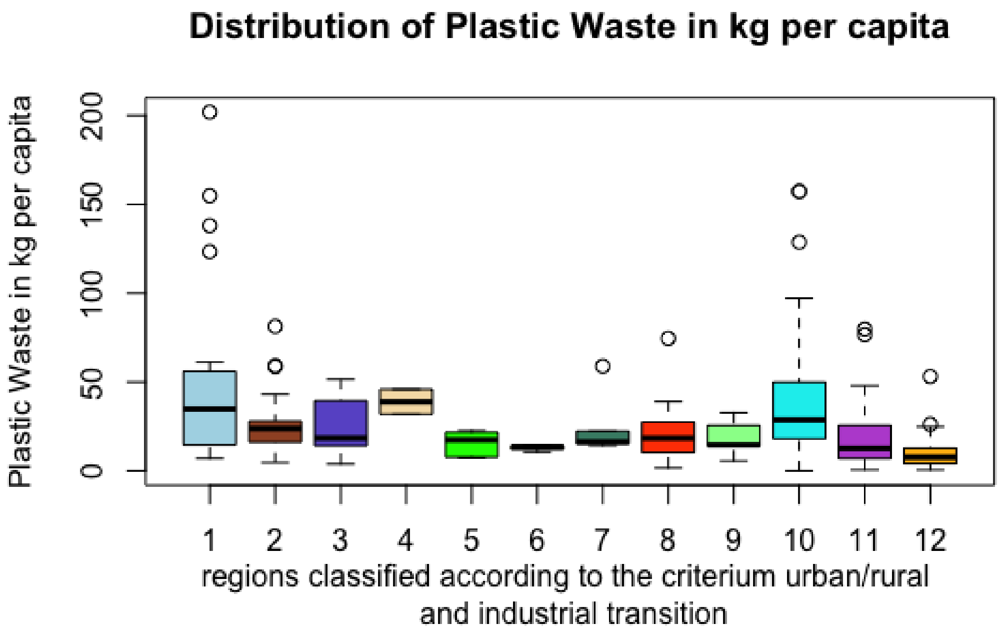


Figure 4-7: Box plot diagrams for urban/rural typologiy of regions for plastic waste in kg per capita



1 = predominantly urban/industrial region losing importance	7 = predominantly urban/industrial region mixed directions
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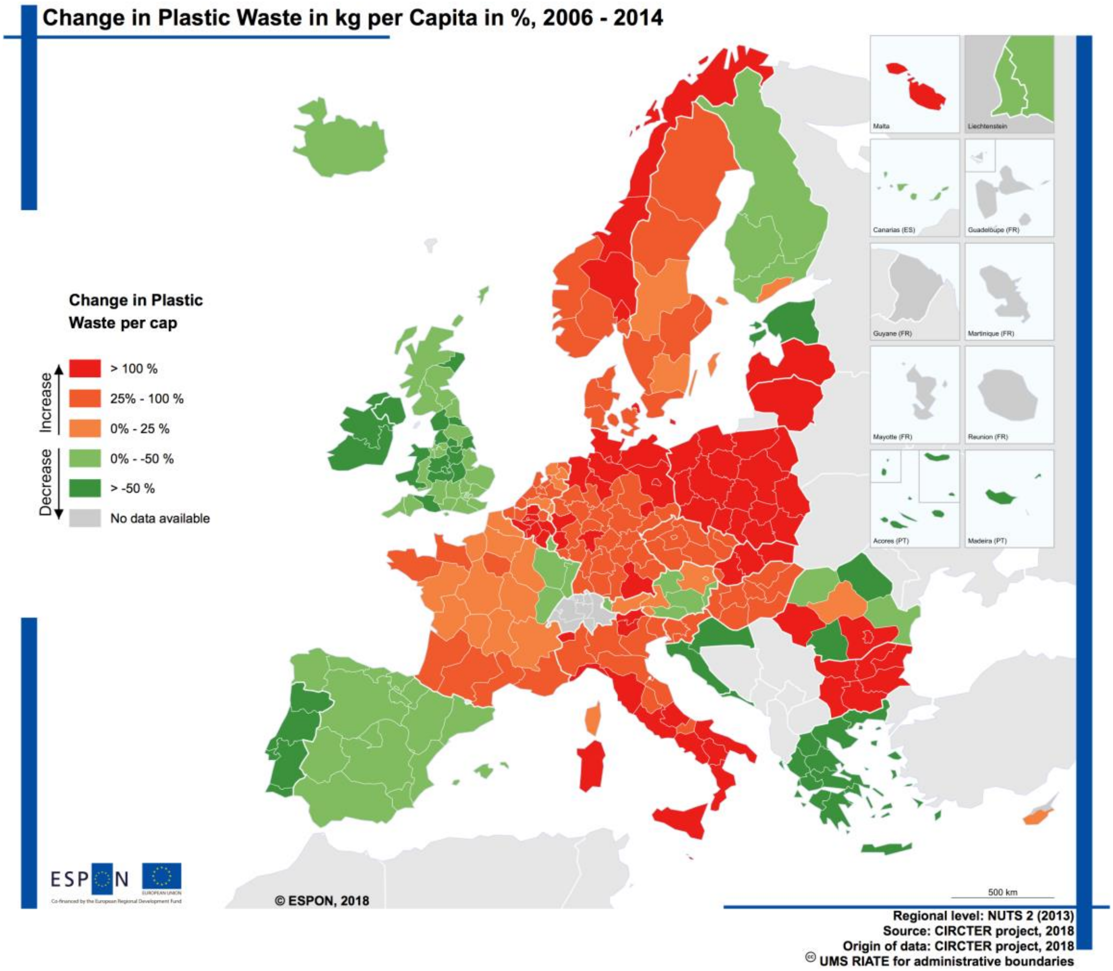
3 = predominantly rural/industrial region losing importance	9 = predominantly rural/industrial region mixed directions
4 = predominantly urban/industrial region gaining importance	10 = predominantly urban/no industrial region
5 = intermediate/industrial region gaining importance	11 = intermediate/no industrial region
6 = predominantly rural/industrial region gaining importance	12 = predominantly rural/no industrial region

The change in plastic waste per capita between 2006 and 2014 shows clear national patterns. Due to the redistribution method, these patterns are not surprising: the decline or increase in national values for plastic waste is redistributed accordingly among the individual regions of a country. It is therefore expectable that there are almost no countries including regions with increasing and decreasing plastic waste.

Map 4-16: Change in Plastic Waste per capita in %, 2006-2014

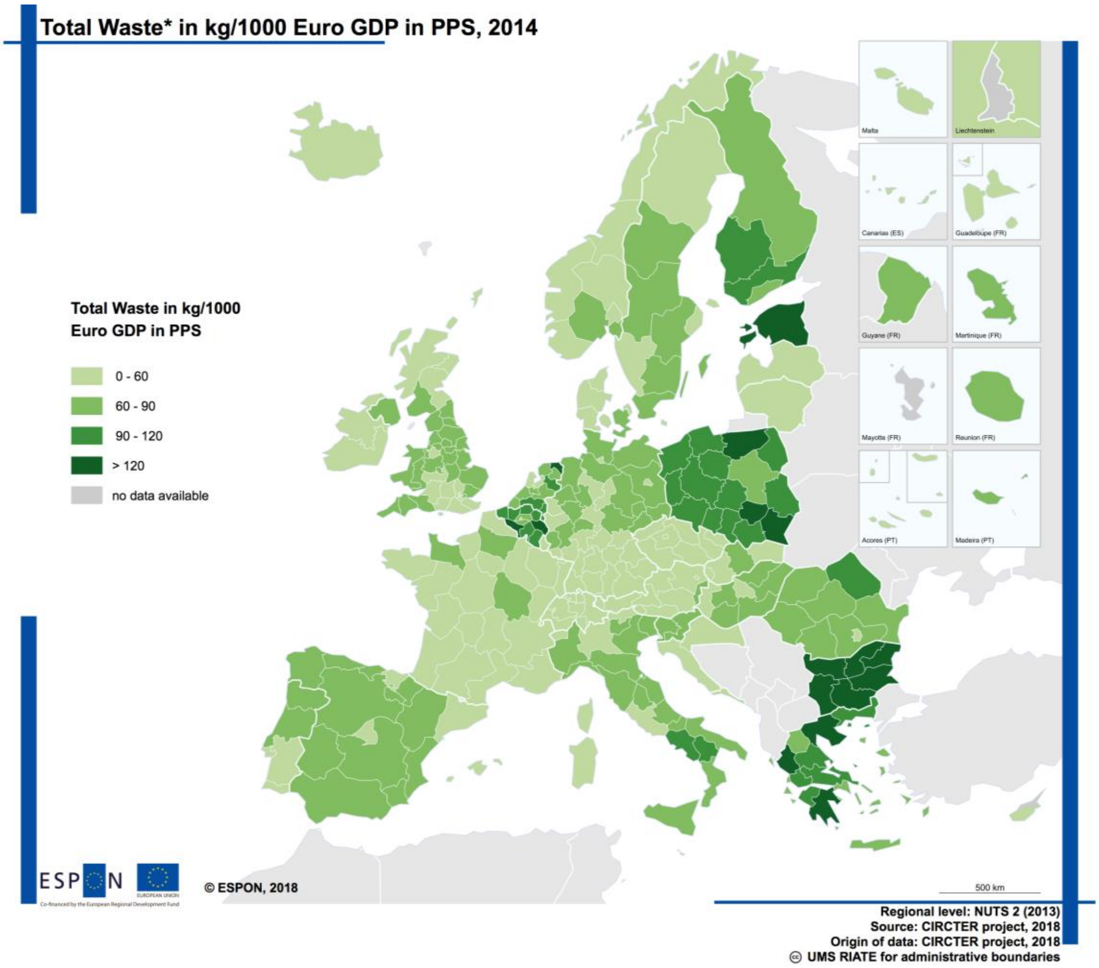


5 Waste Intensity

In principle, it should be noted that for many waste intensity indicators, both the maps and the distribution of data based on the typologies studied as well as the changes over time do not differ fundamentally from the evaluation of the waste indicators and their per capita values in 2014. In order to avoid redundancies, the waste intensity chapter will not cover each indicator with the same level of detail, as was the case in the previous chapter (especially for the subcategories), but will rather focus on differences in the interpretation of the per capita values and their change.

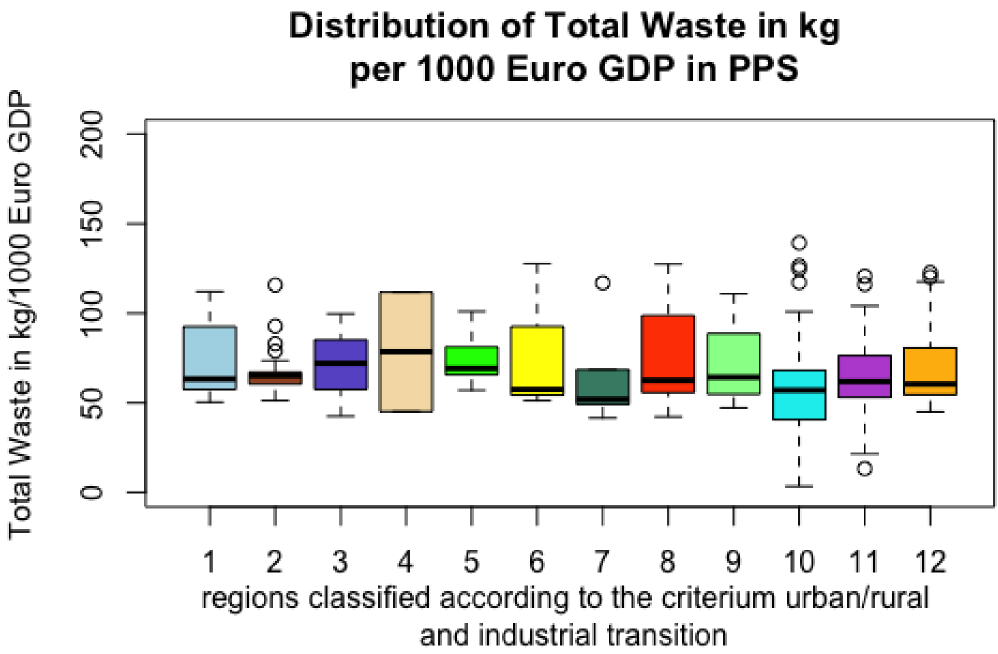
Most of the regions have a total waste intensity between 50 kg/1000 Euro GDP in PPS and 70 kg/1000 Euro GDP in PPS, with a median of 63 kg/1000 Euro GDP in PPS. However, similar to the data for the DMC and the subcategories (and their intensities), high volumes of waste per capita do not necessarily mean high waste intensities. The regions in Eastern Europe mostly have higher than average levels of waste intensity, despite their low per capita values. On the other hand, in regions characterised mainly as metropolitan regions (e.g. Hamburg, London, Bucharest), the waste intensity lies below the level of the surrounding regions. Although, there the per capita amount of waste is mostly higher.

Map 5-1: Waste Intensity (Total Waste)



The region with a total waste per cap of 9.500 kg is also an outlier in the data set for waste intensity. Its waste intensity is about 450 kg/1000 Euro GDP in PPS, which is nearly the threefold of the next two outliers with levels around 163 kg/1000 Euro GDP in PPS. For a better visualization, the 450 kg/1000 Euro outlier were again excluded from the boxplot diagram for the waste intensity (Figure 5-1). The distribution of waste intensity data for the urban/rural and industrial transition typologies of regions again shows no clear picture. Similar to other boxplot diagrams there are no real differences with respect to the criteria of urban vs rural or industrial transition. Neither the height of the bar nor the position of the median in the box plot indicates a pattern: If there seems to be a trend among regions without an industrial focus that rural regions have a higher volume of waste than urban regions, the picture is much less clear for industrial regions.

Figure 5-1: Box plot diagrams for urban/rural typologiy of regions for total waste intensity in kg/1000 Euro GDP in PPS



1 = predominantly urban/industrial region losing importance	7 = predominantly urban/industrial region mixed directions
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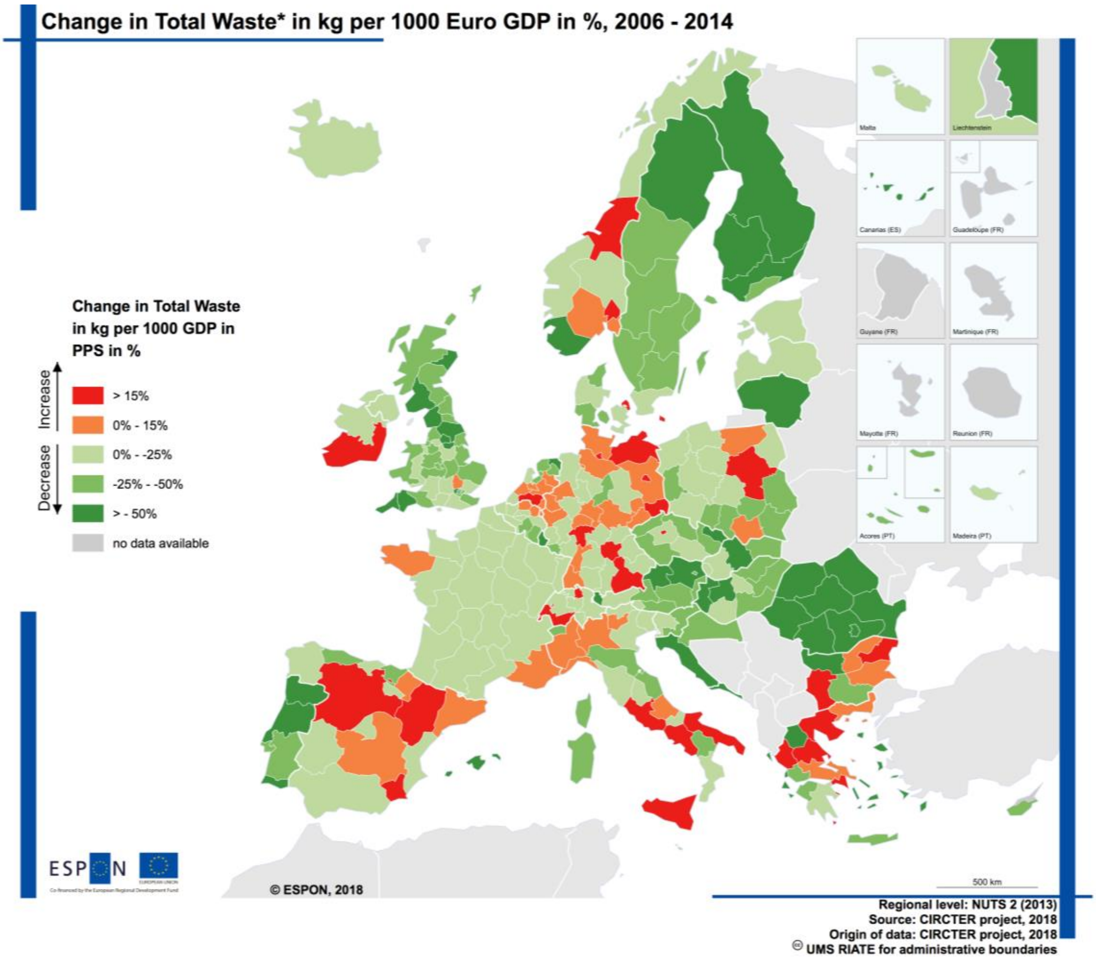
4 = predominantly urban/industrial region gaining importance	10 = predominantly urban/no industrial region
5 = intermediate/industrial region gaining importance	11 = intermediate/no industrial region
6 = predominantly rural/industrial region gaining importance	12 = predominantly rural/no industrial region

The pattern of change in waste intensity between 2006 and 2014 is not fundamentally different from the evolution of per capita total waste values: Regions with rising per capita values often have rising waste intensities for total waste as well, excluding major mineral waste.

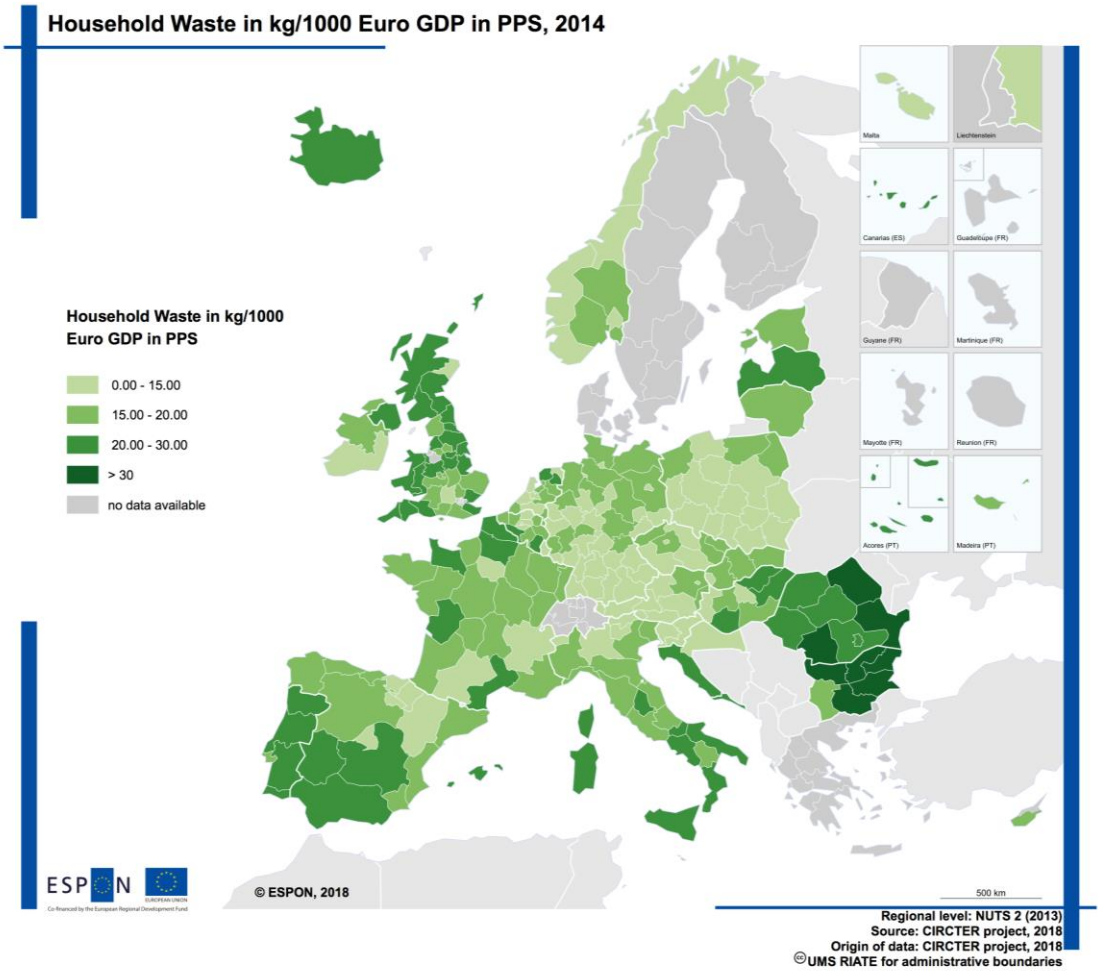
Map 5-2: Change in Total Waste Intensity



5.1 Waste Intensity of subcategories

The low GDP per capita in Romania and Bulgaria transforms the actual average values at household waste per capita into above-average household waste intensities per 1000 Euro GDP. The development in Germany or the Benelux countries is the opposite: High per capita values in the regions of these countries, but measured by the amount of waste per 1000 Euro GDP, the values are below average. For the per capita values of household waste, we have noted above that there are national patterns. In other words: the regional distribution within a country is rather small. Based on the intensity of household waste quantities per 1000 Euro GDP, the different per capita GDP levels can be seen in many countries: poorer regions within a country have a higher waste intensity (southern Italy, southern Spain, northern UK).

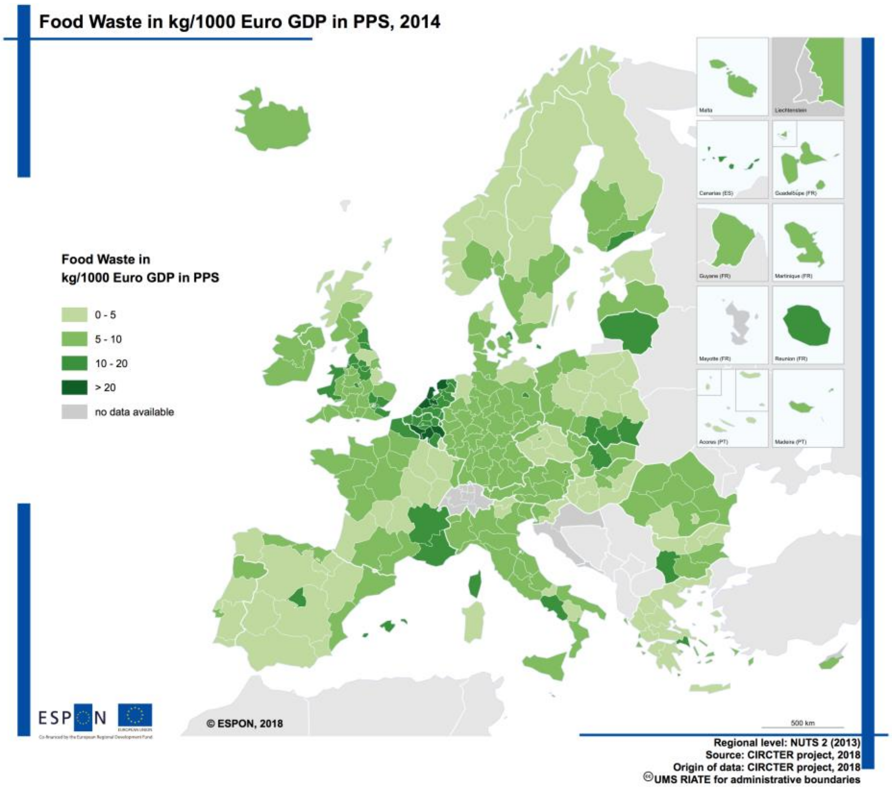
Map 5-3: Household Waste in kg per 1000 Euro GDP in PPS, 2014



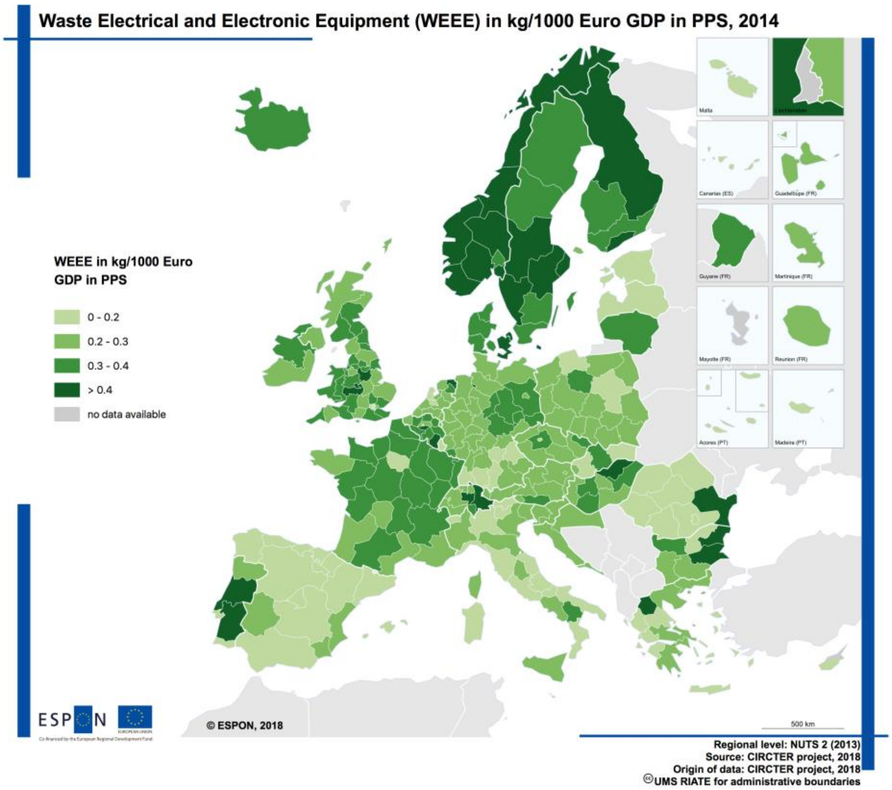
In many regions of the Benelux countries, the high per capita values for food waste can still be seen in the food waste intensity map, despite above-average per capita income. Due to the differences in per capita income, there is an alignment between regions with high per capita income (tending to high per capita values for food waste per capita) and regions with low per capita income (tending to low per capita quantities of food waste): the regional differences in waste intensities are smaller than those in per capita values.

The waste intensity for WEEE shows the same regional patterns as the per capita values. Scandinavian regions have both high per capita values of collected WEEE and above average values in relation to GDP. And despite low per capita income in Eastern European regions, the waste intensity for WEEE remains below average in the majority of these regions.

Map 5-4: Food Waste in kg per 1000 Euro GDP in PPS, 2014

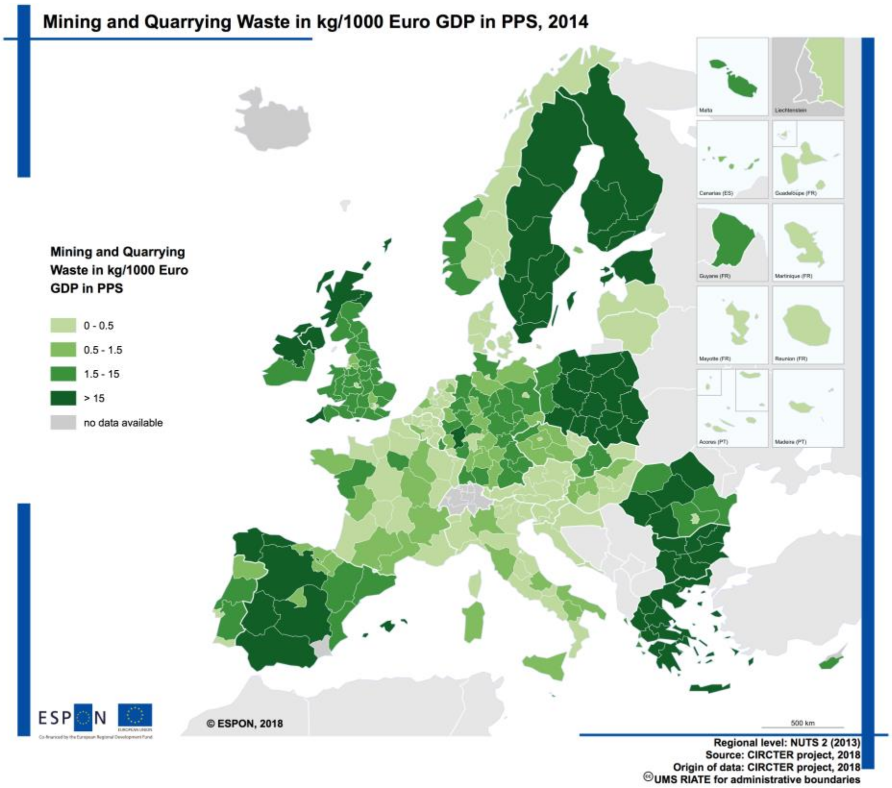


Map 5-5: WEEE in kg per 1000 Euro GDP in PPS, 2014

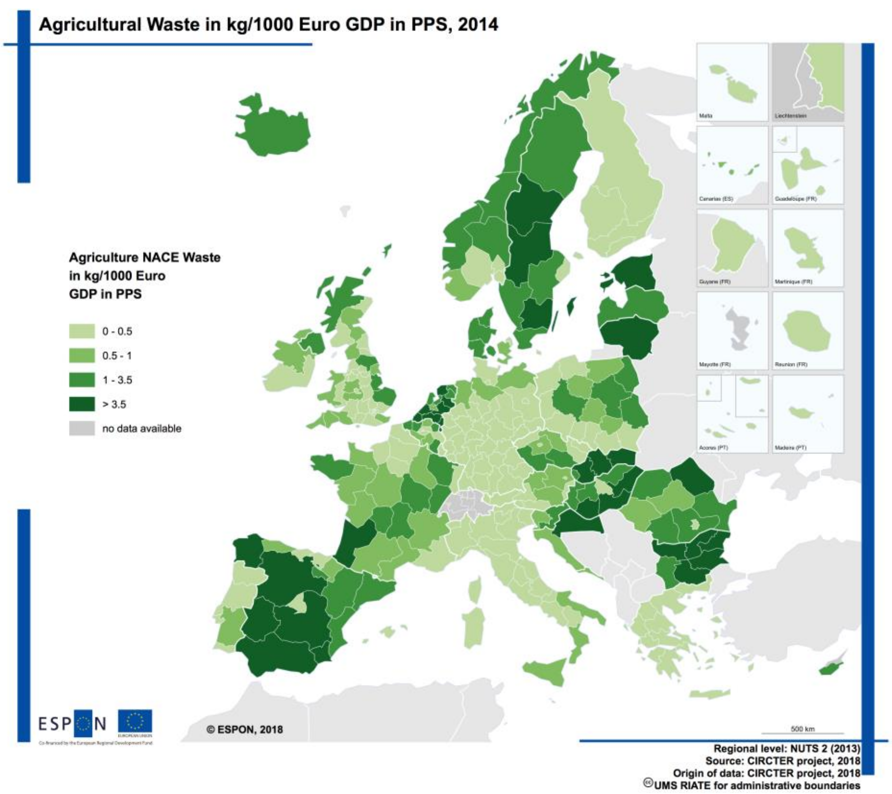


The four maps (Map 5-6 to Map 5-9) for waste intensity by NACE categories are almost identical to the maps for per capita waste quantities in the corresponding NACE categories. If you place the map for the per capita value with the corresponding intensity per 1000 Euro GDP next to each other, you could get the impression that both maps are identical because only a few regions have changed to a higher and lower colour spectrum: Regions with high per capita waste levels also remain regions with high waste intensities. The high per capita values for mining and quarrying waste and agricultural waste are concentrated in regions with low or average per capita income, so that the intensities must remain high. And in manufacturing waste and waste generated by construction activities, the differences in per capita waste volumes seems to be greater than the differences in GDP per capita, so that even regions with a high per capita income still have higher waste intensities than regions with a low per capita income, but also low waste volumes per capita. The almost identical pattern in per capita quantities and associated intensities is also reflected in very similar boxplot diagrams for the four waste categories. A presentation and evaluation of the distribution of the regions in terms of waste intensity by NACE economic sectors would therefore not offer any new insights or explanations and are therefore omitted here. The same applies to the percentage change in per capita values and intensities of the NACE waste categories: apart from a few exceptions, regions with increasing or decreasing per capita values also show increasing or decreasing intensities. In other words: red coloured regions with increasing per capita values in the Map 4-8, Map 4-10, Map 4-12 and Map 4-14 are also coloured red in the maps for the change of waste intensity. And vice versa, green marked regions in the maps about per capita change remain green marked regions in the maps about the change of the waste intensity in the examined NACE sectors. Accordingly, the interpretations of regional patterns of per capita data also apply here.

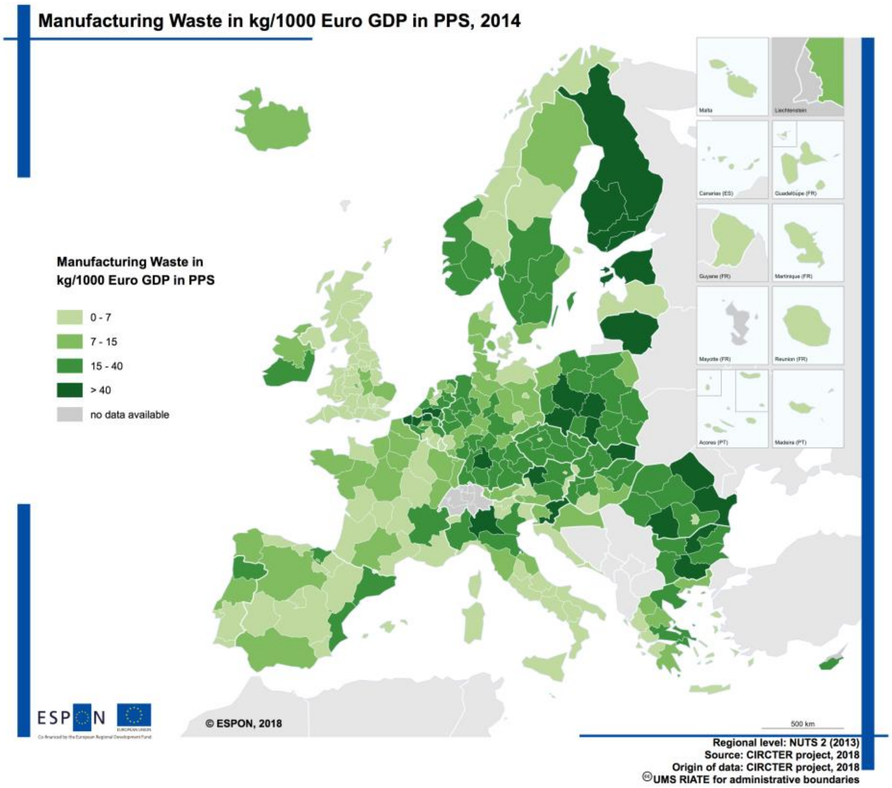
Map 5-6: Mining and Quarrying Waste in kg per 1000 Euro GDP in PPS, 2014



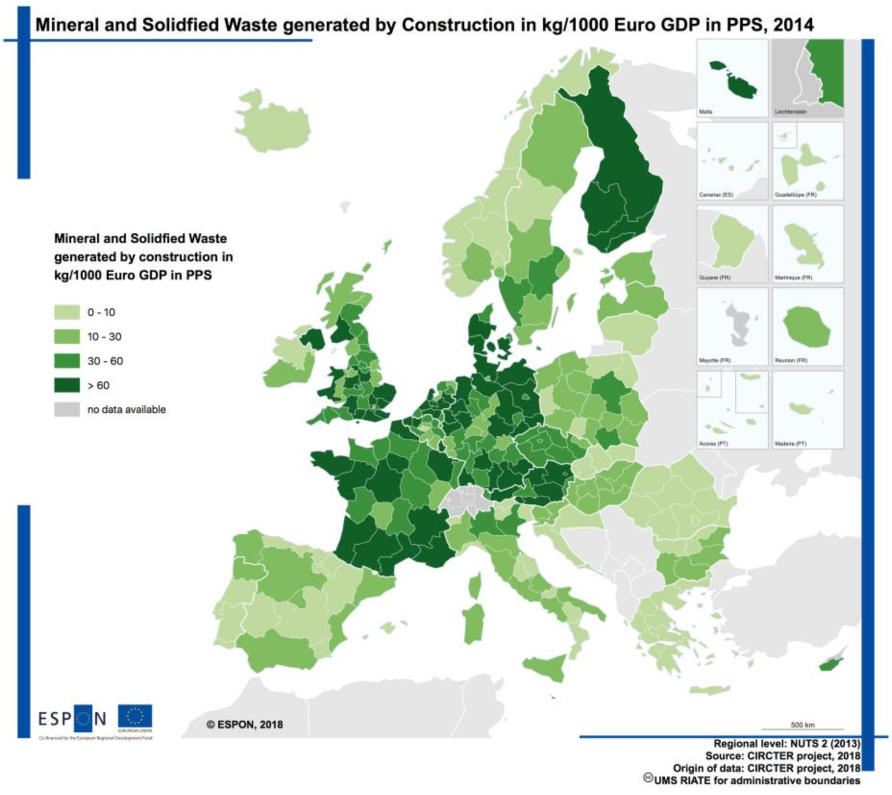
Map 5-7: Agricultural Waste in kg/1000 Euro GDP in PPS, 2014



Map 5-8: Manufacturing Waste in kg/1000 Euro GDP in PPS, 2014

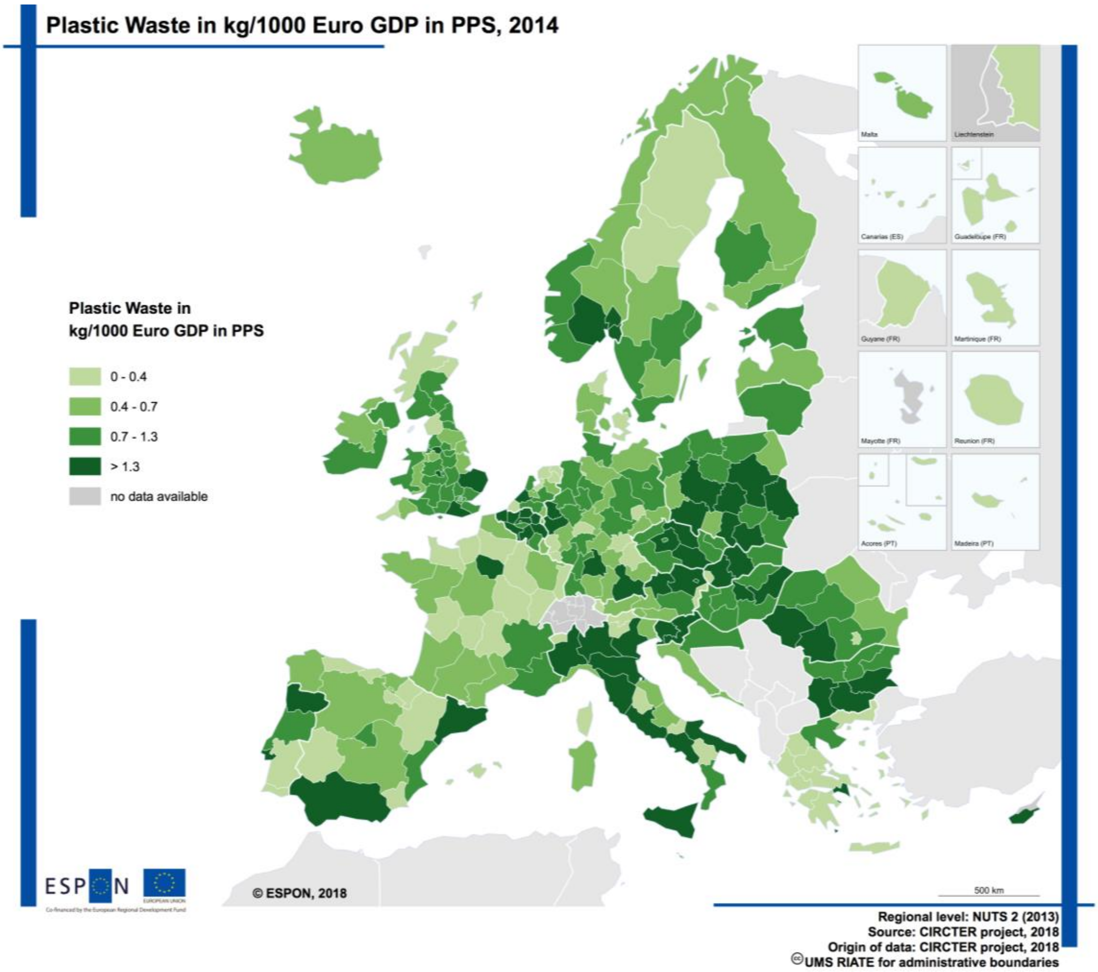


Map 5-9: Mineral and Solidfied Waste generated by construction in kg/1000 Euro GDP in PPS, 2014



Since the regional distribution of national GDP is a factor in the distribution model for plastic waste, it can also be expected that the regional differences between the per capita values and the intensities will not differ significantly. Furthermore, it was found above that the per capita values of plastic waste are particularly high in urban centres and that these are also regions with above-average per capita incomes. As a result, urban centres should be less conspicuous in terms of intensities than in terms of per capita values. However, only the latter assumption is confirmed, while the basic regional patterns between the per capita values of plastic waste and the intensities differ. While many regions in the UK and the Irish regions have the highest per capita levels of plastic waste, the emphasis of the high intensity regions is shifting to Eastern Europe, where the low per capita income is dominant. The Spanish regions with high per capita values remain, with the exception of the Comunidad de Madrid, also regions with high intensities. The reason lies in the comparatively low per capita income, which has hardly grown since 2006 due to the economic crisis.

Map 5-10: Plastic Waste in kg/1000 Euro GDP in PPS, 2014

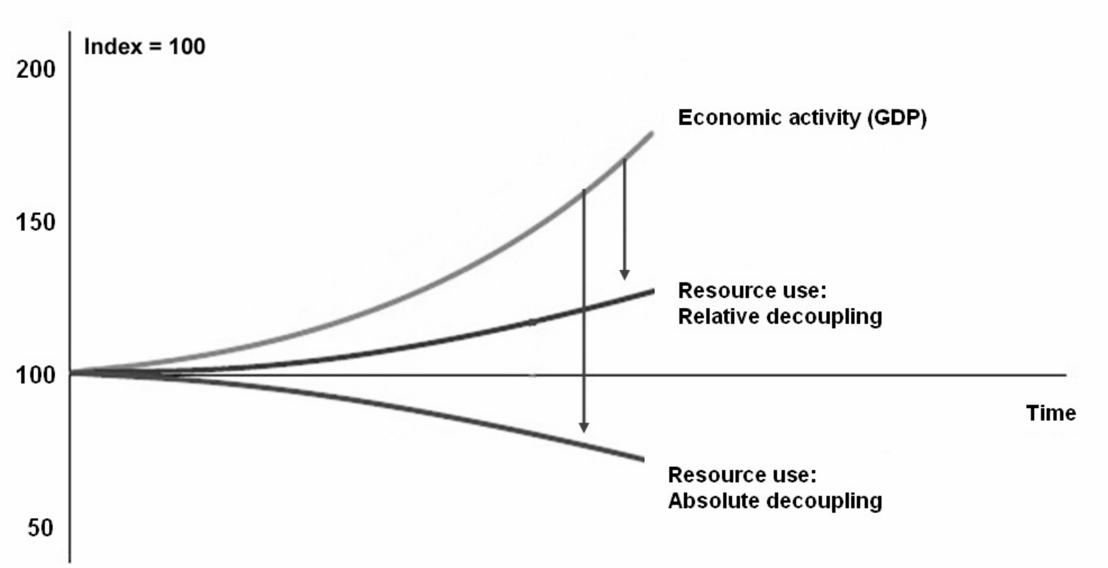


6 Decoupling analysis

6.1 Decoupling Domestic Material Consumption from GDP

The term *decoupling* – or *delinking* – mostly refers to the different dynamics of the development of GDP (or other economic indicators) on the one hand compared to indicators of resource or energy use or indicators of environmental impacts on the other hand. The idea behind decoupling is, that economic growth is possible without harming the environment or with lowering the negative environmental effects of growth. The concept of "green growth" is based on the idea of decoupling. The literature distinguishes between absolute and relative decoupling, whereas the first is described as economic growth with decreasing resource use at the same time. Relative decoupling, on the other hand, is a development in which both indicators grow, but the growth rate of the GDP is higher than that of resource use (see Figure 6-1).

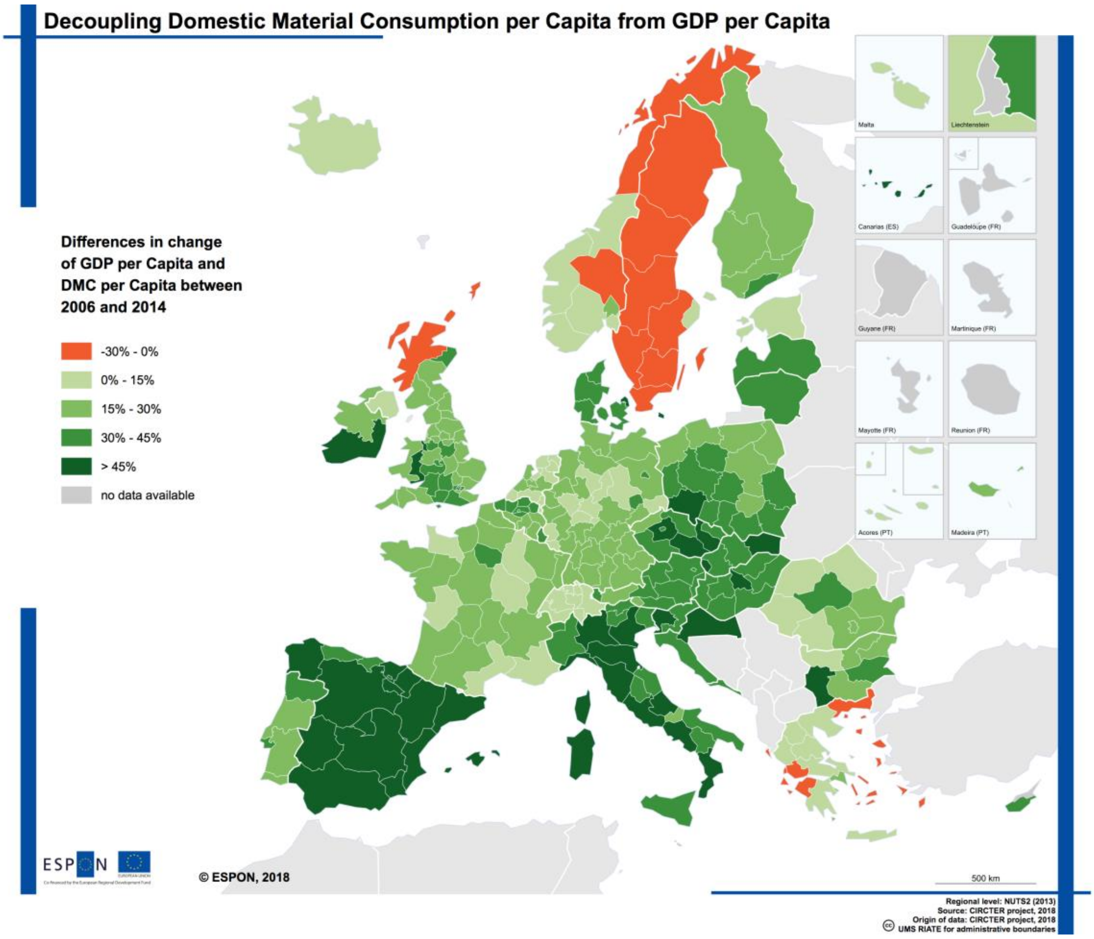
Figure 6-1: Absolute vs relative decoupling of Economic growth from resource use



source: https://oxfamblogs.org/fp2p/hunting-for-green-growth-in-the-g20/

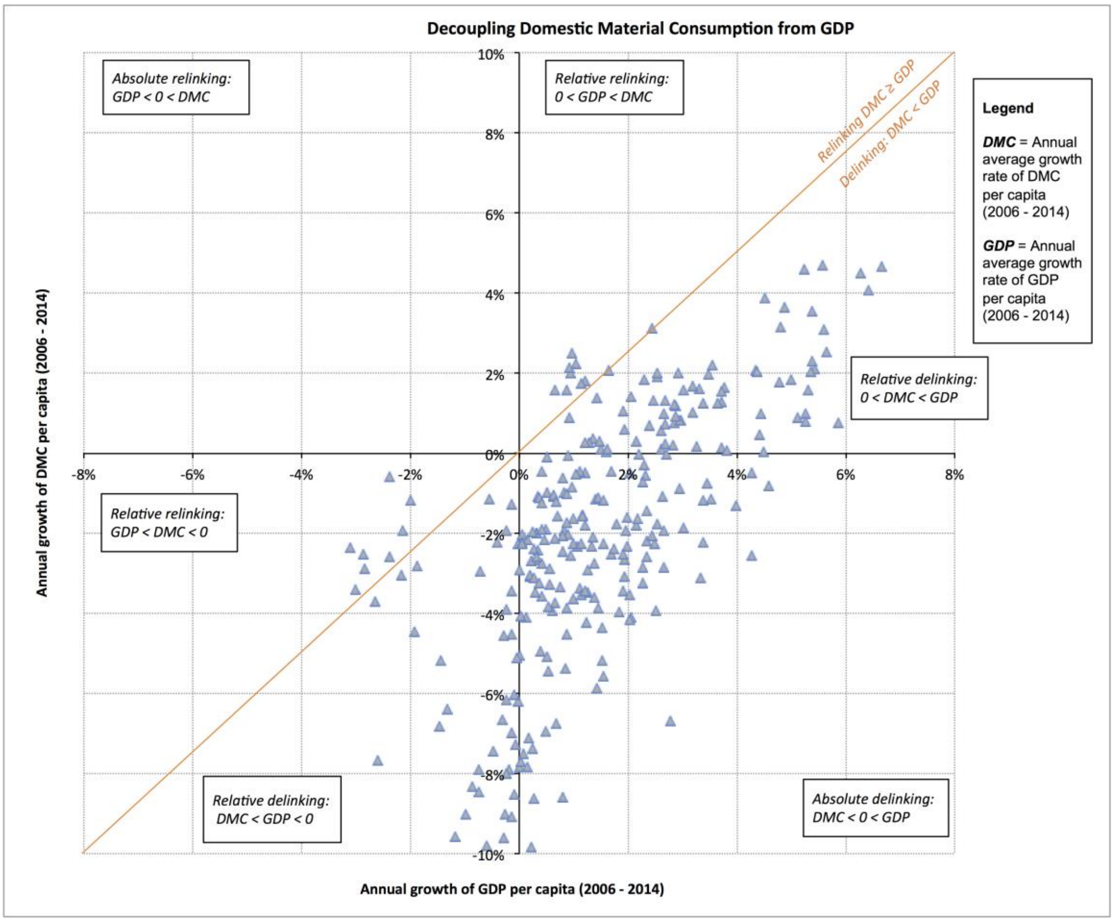
We were also interested in whether there was a decoupling between material consumption and GDP at the regional level we have studied. Normally, a graphical representation of the decoupling would mostly be represented as a line diagram (see figure above). But this is not a useful approach for over 300 regions. Therefore, we illustrated the different dynamics of the percentage change in GDP per capita and DMC per capita between 2006 and 2014 as a map (see Map 6-1) as well as in a data point diagram (Figure 6-2). The advantage of Map 6-1 is that readers get a first glance at the regional patterns of decoupling the material consumption from GDP growth, but it does not show if a relative or an absolute decoupling occurred, neither does the map show us whether the development between 2006 and 2014 is associated with increasing or decreasing values. For example, in the year 2014, in most countries the GDP per capita were higher than in 2006. But there are some countries, where the 2008/2009 economic crisis is still measurable in the GDP per capita values of 2014: in 2014, the GDP per capita was still lower than in 2006. This is the case, for example, for all regions in Greece and most regions in Spain. But the green colour for all the Spanish regions in Map 6-1 indicated, that the DMC per capita decreased in these regions even further between 2006 and 2014. Therefore, we have a decoupling, although both indicators decreased during the period under review, whereas in some of the Greek regions the decrease of DMC per capita was lower than the decrease of GDP per capita and therefore the opposite of a decoupling took place. In other words: in the red coloured regions of Map 6-1 no decoupling took place, whereas the green coloured regions some decoupling happened, but this could be a regular relative decoupling with a higher growth rate for the GDP per capita compared to the growth of DMC per capita (often in Eastern Europe regions, see Map 1-3 Change in DMC per capita in %), or an absolute decoupling with increasing GDP per capita and decreasing DMC per cap (for example all regions in Belgium, but as mentioned, also regions with decreasing GDP per capita and also with an even bigger decrease in DMC per capita.

Map 6-1: Decoupling Domestic Material Consumption per capita from GDP per capita



For getting a clearer picture about the magnitude of the NUTS2 region, we plotted the annual growth rate of GDP vs. DMC together. In this scatterplot diagram, you see six areas, which are defined by the different growth rates of GDP per capita and DMC per capita. All areas to the left of the diagnostic axis, which is coloured orange, are areas that show a relinking, i.e. the growth of the GDP is lower than the growth of the DMC. In all fields to the right of the orange diagonal, the GDP growths more than the DMC. The quadrant bottom right shows all regions with an absolute decoupling where the DMC per capita decreased over time and the GDP increased. We can therefore conclude that around half of all regions have an absolute decoupling of material consumption, measured as DMC per capita, from GDP per capita between 2006 and 2014.

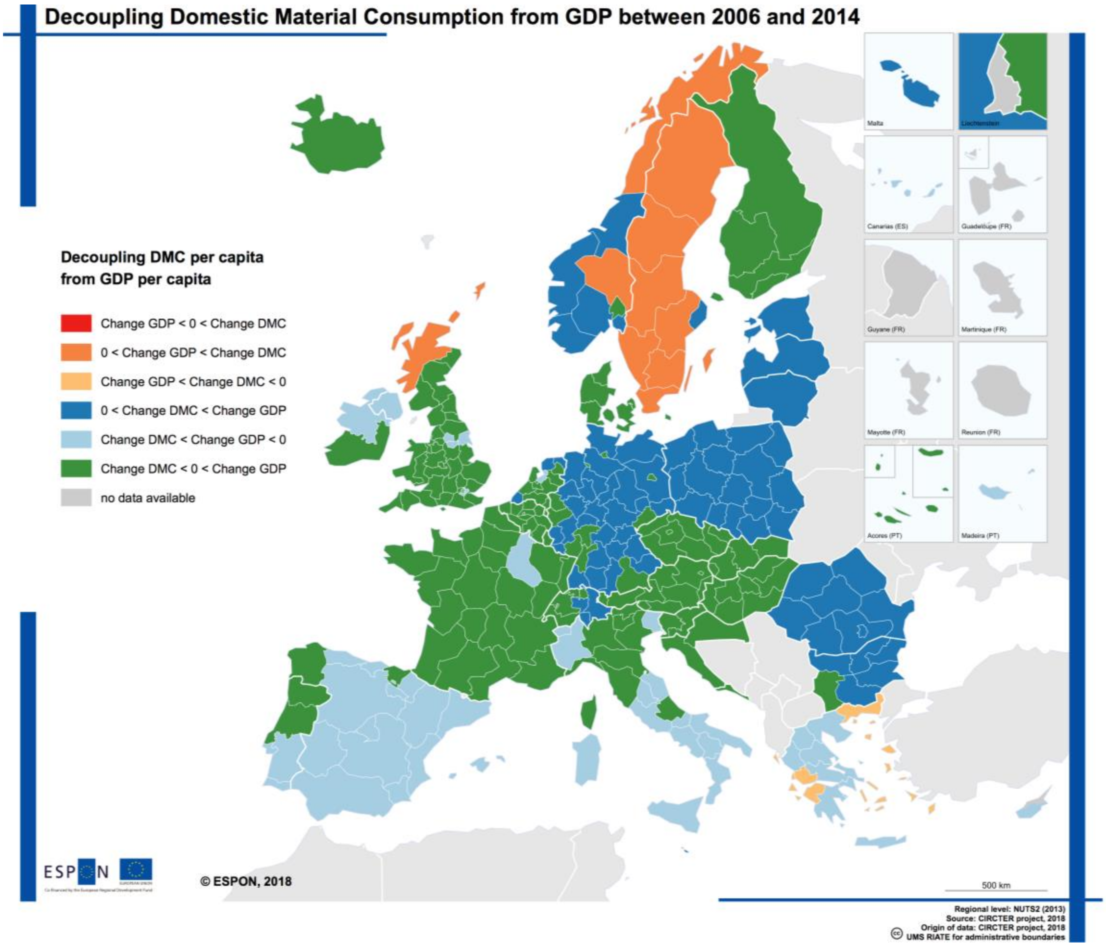
Figure 6-2: Scatterplot Diagram for Decoupling DMC per capita from GDP per capita, annual growth rate



If you translate this diagram into a map, you get the following picture (Map 6-2). The legend shows the different growth dynamics of the GDP per capita and the DMC per capita in comparison to each other and at the same time in relation to the zero point, in other words, with which sign the annual changes are provided. Regions coloured red would therefore be regions with a decreasing GDP and an increasing DMC. As you can see, none of the investigated regions follows this path between 2006 and 2014. An absolute relinking has thus not taken place in any region. The orange and yellow regions, on the other hand, are regions where relative relinking took place. In the case of the yellow regions with a negative trend, i.e. GDP per capita decreased more strongly than the decline of the DMC per capita, while in the orange regions exactly the opposite occurred: the GDP per capita growth was weaker than the increase of the DMC per capita.

In the green regions, there was an absolute decoupling of material consumption from economic growth. In other words, here the DMC per capita decreased with simultaneous GDP growth per capita. In the two blue regions, at least a relative decoupling took place between 2006 and 2014: in the dark blue regions, the GDP grew faster than the DMC per capita, while in the light blue regions, the DMC per capita decreased more than the GDP per capita at the same time.

Map 6-2: Decoupling DMC per Capita from GDP per capita, closer look

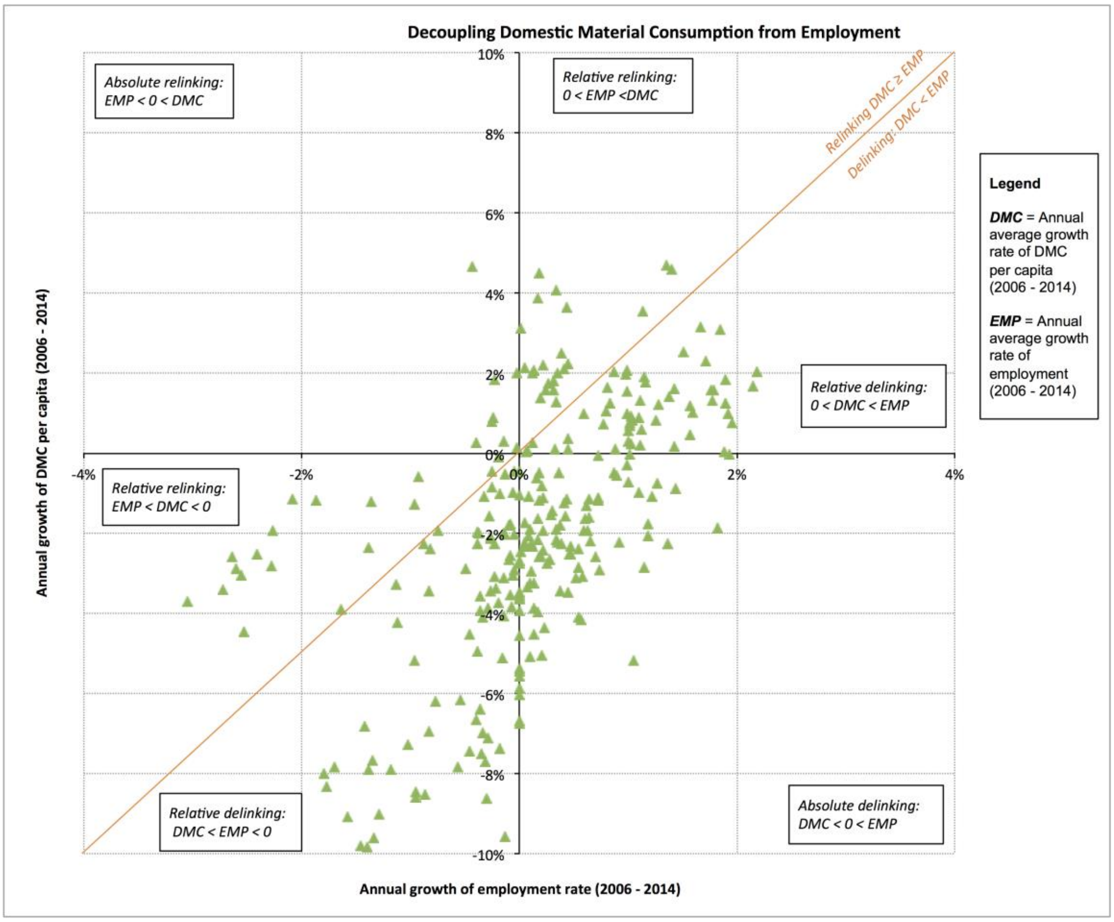


6.2 Decoupling Domestic Material Consumption from employment

In addition to GDP, we have also linked the two main indicators DMC and Total Waste with the economic indicator of the annual average growth rate of employment. The aim is to examine whether decreasing material consumption is rather associated with decreasing employment or whether prosperous regions can achieve increasing employment numbers with less material input. Figure 6-3 shows that between 2006 and 2014 several regions were able to achieve increasing employment with less material input (the data points in the quadrant bottom right).

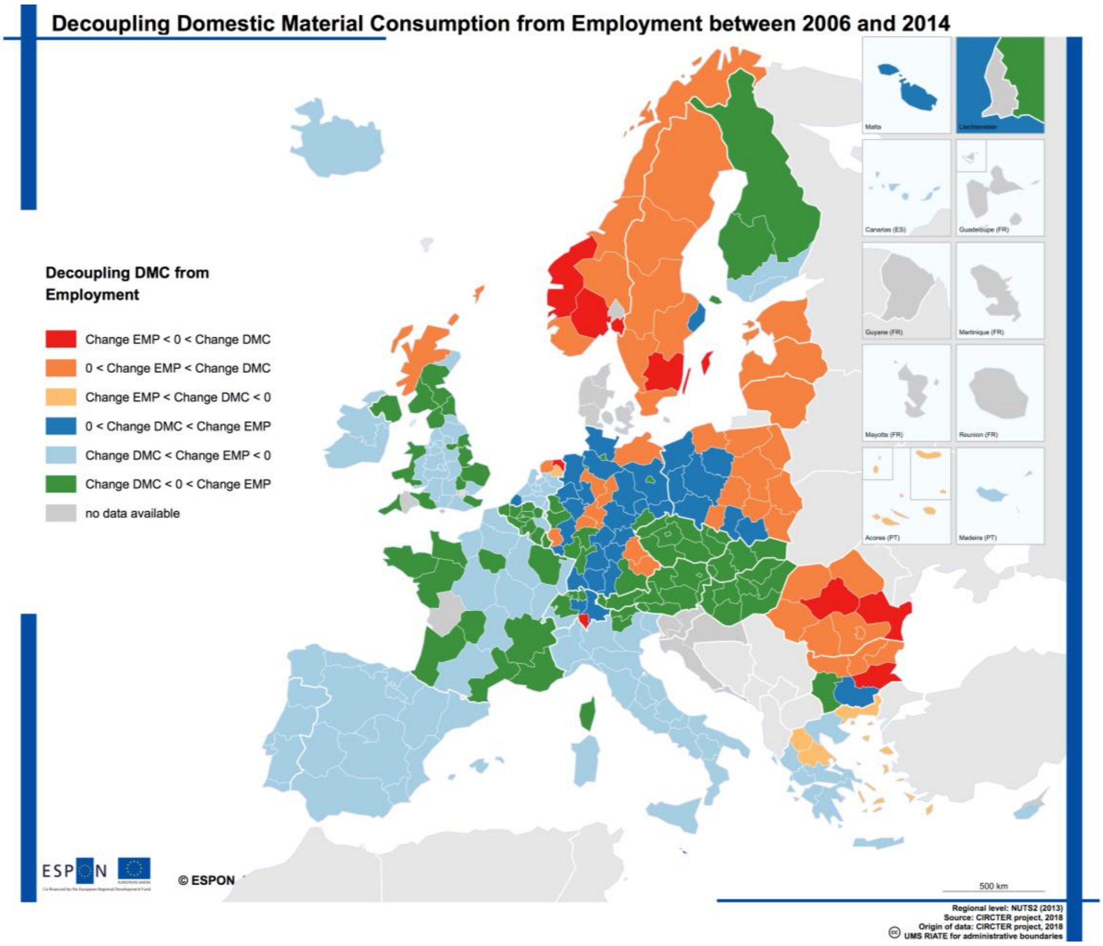
At the same time, however, just as many regions can be identified in which declining material consumption is associated with simultaneously declining employment (quadrant bottom left), which is more likely to be a consequence of economic crises than of regions that converted their mode of production to new and circular value chains.

Figure 6-3: Scatterplot Diagram for Decoupling Change of DMC per capita from change of Employment, annual growth rate



Map 6-3 shows strong national patterns: In Austria, Czech Republic, Slovakia and Hungary all regions are characterised by declining DMC and rising employment. Equally many regions in France, Finland and the UK. Portugal, Spain, Italy and Greece are characterised above all by falling DMCs and employment figures. Many German regions and the western plenary, on the other hand, are characterised by rising employment and simultaneously rising material consumption. Norway, Sweden, the Baltic regions as well as the majority of the Romanian and Bulgarian regions are coloured red or orange, which means that either the material consumption increased although employment even decreased (red) or material consumption grew faster than employment (orange).

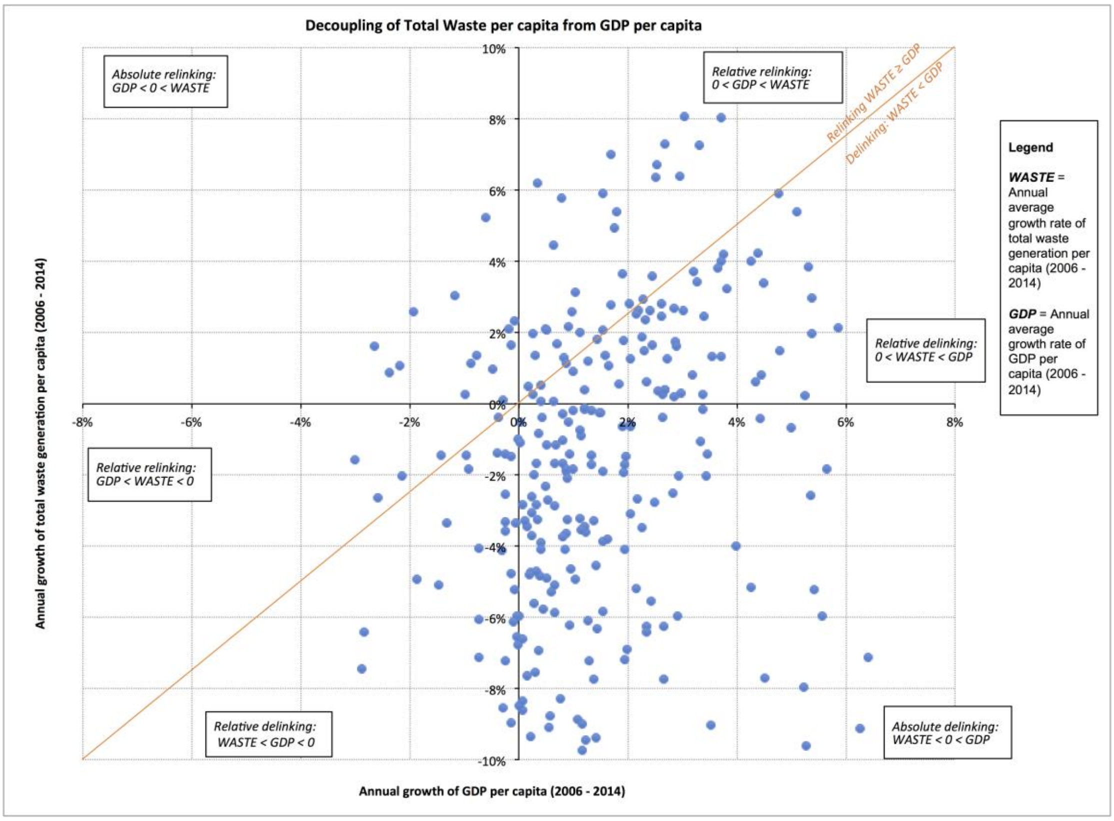
Map 6-3: Decoupling annual change of DMC per Capita from annual change of Employment, closer look



6.3 Decoupling waste generation from GDP

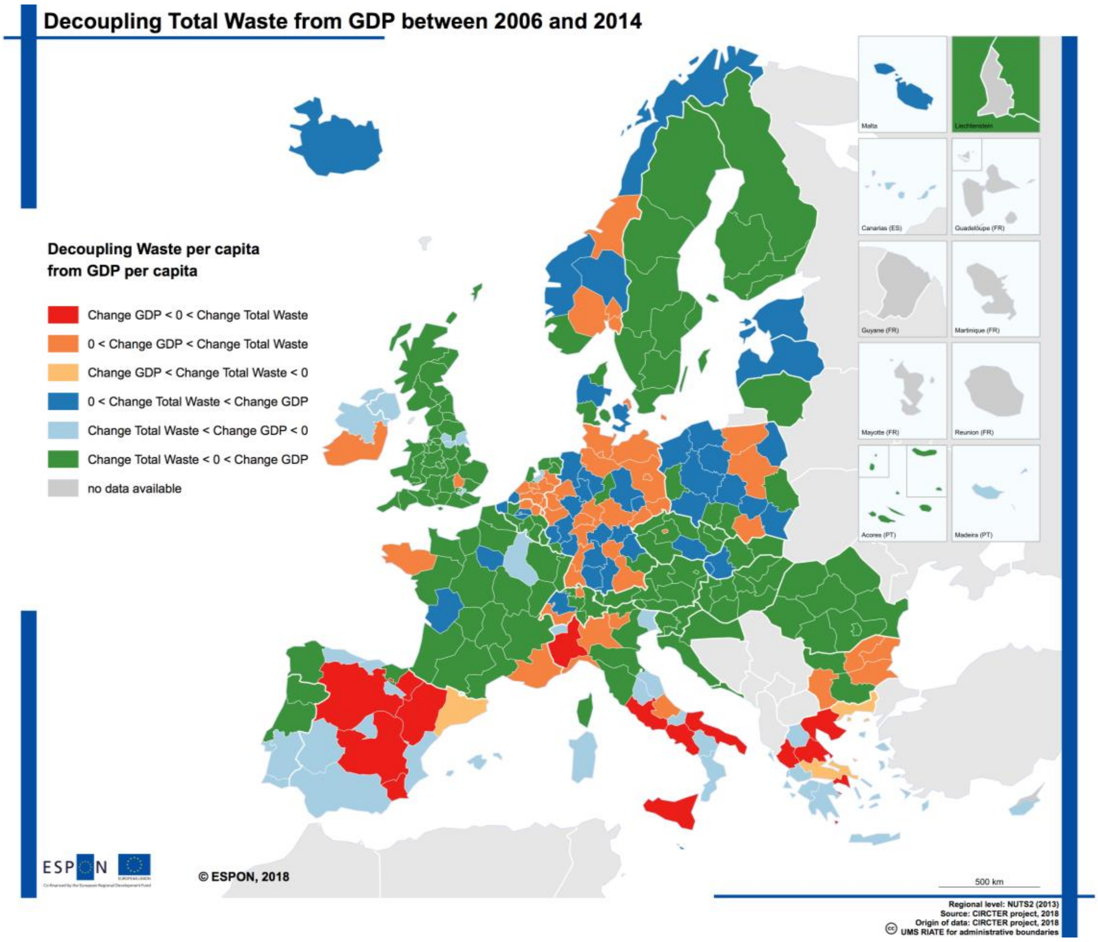
We did the same analyses for the decoupling of Total Waste per capita from GDP per capita (Figure 6-4). Clear differences can be seen to the decoupling of the DMC per head from the GDP per head. When comparing the growth rate of total waste per capita and GDP per capita, there are significantly more regions to the left of the orange diagonal, which means that in these regions there was a relink of the amount of waste per capita from GDP. In addition, the scatter-plot diagram also shows regions in the upper right quarter. Regions in this field show absolute relinking, i.e. GDP per capita decreased between 2006 and 2013, while the amount of total waste per capita increased at the same time.

Figure 6-4: Scatterplot Diagram for Decoupling Total Waste per capita from GDP per capita, annual growth rate



Map Map 6-4 shows the exact growth dynamics of waste generation and GDP per capita for all regions investigated. You can see that the regions with an absolute relink are in exactly three countries: Spain, Greece and Italy. All three countries show negative or stagnating GDP growth rates. Spain and Greece in particular were strongly affected by the global economic crisis after 2008. And while material input per capita in these regions fell more sharply than GDP per capita (see Map 6-2), this was not the case in some of the regions of these three countries in terms of total waste generation per capita. In the majority of the remaining Mediterranean regions, as with the DMC per capita, a relative decoupling took place with negative growth rates for both GDP and total waste.

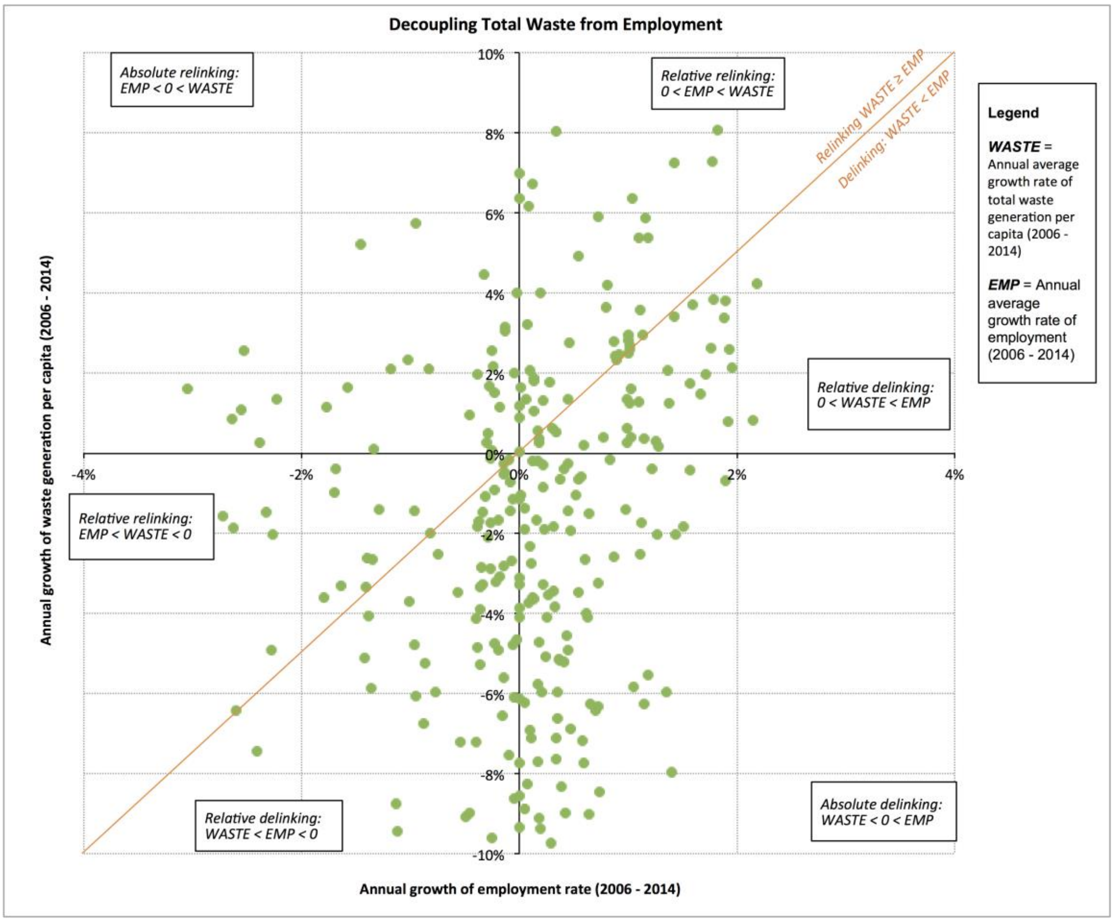
Map 6-4: Decoupling Total Waste per Capita from GDP per capita



6.4 Decoupling waste generation from employment

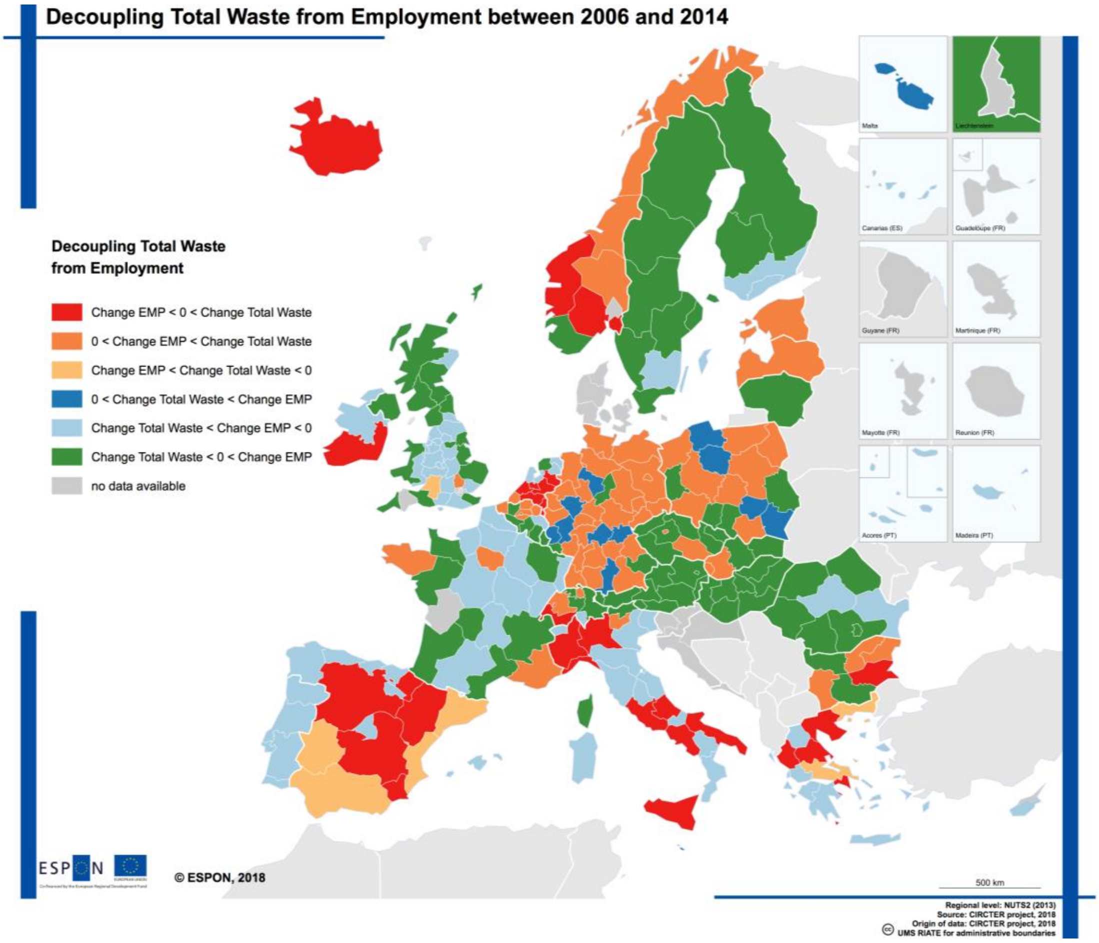
As the fourth variant of a possible decoupling, the development of the annual change in waste production was examined in relation to the change in employment. Figure 6-5 shows the combinations of different growth rates for each region. It can be seen that in each of the six possible combinations there is a large number of regions and therefore there does not seem to be a clear correlation between the development of employment and waste generation. While in the decoupling analyses with GDP hardly any regions can be found to the left of the orange diagonal (relinking), the number of regions to the left of the diagonal is significantly higher in the analysis of the indicators DMC and Total Waste with the development of employment. And in connection with Total Waste, it is once again much more pronounced than in comparison with the ratio DMC - employment. This means that the change of total waste generated over time appears to be less influenced by economic indicators such as employment and GDP than the change of DMC (or the differences of per capita values) and other factors influencing the change of total waste volumes appear to have a greater influence.

Figure 6-5: Scatterplot Diagram for Decoupling Total Waste per capita from Employment, annual growth rate



If the data points in Figure 6-5 are converted into a map (Map 6-5), we observe a more random pattern: Regions with decreasing total waste generation over time and increasing employment borders on regions with decreasing employment and increasing waste generation. Even a comparison of the various decoupling results with the regional typologies considered in this work does not provide a picture where a trend could be observed: e.g. almost all Czech regions are characterised by absolute decoupling in each of the four explored possibilities and at the same time they are some of the few regions with increasing importance of the industrial sector and urban character.

Map 6-5: Decoupling Total Waste per Capita from Employment

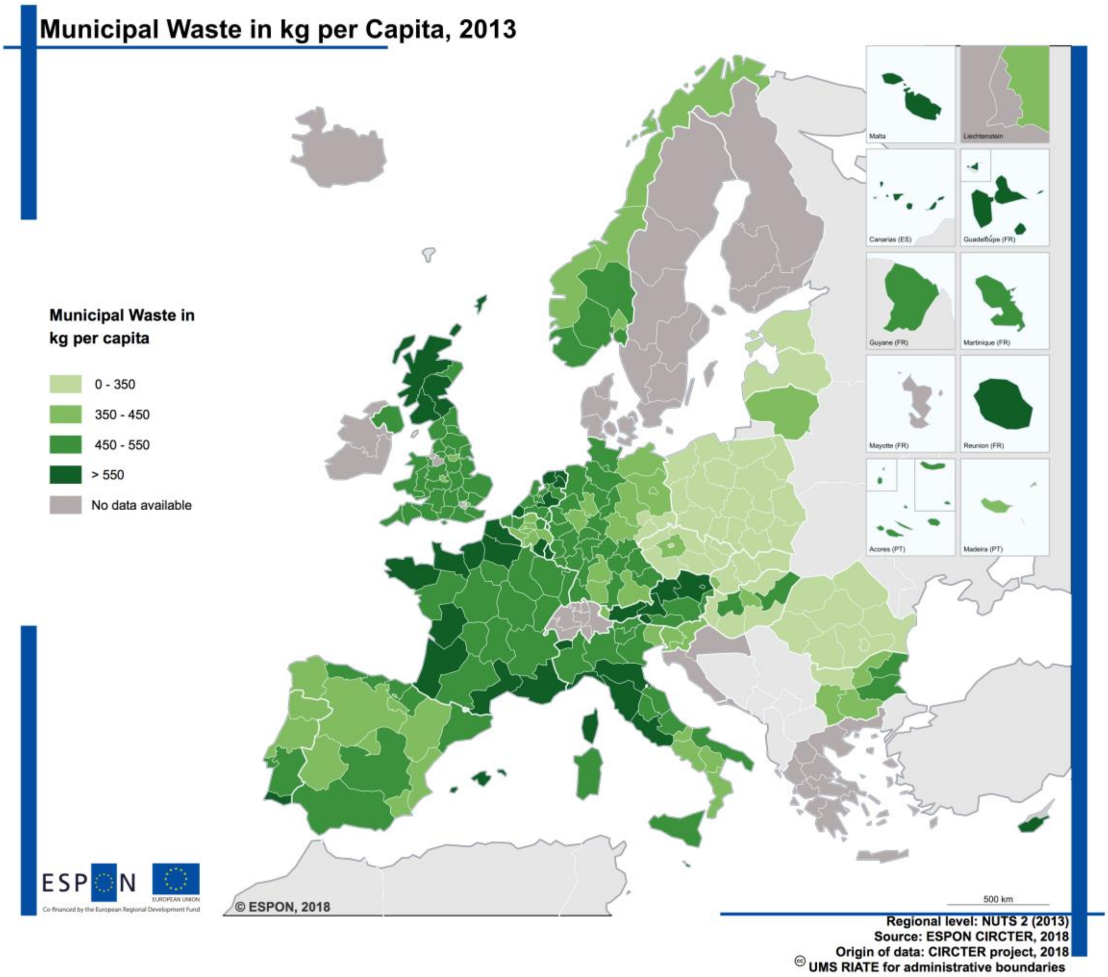


7 Treatment of Municipal Waste

The data set for the treatment of municipal waste includes less data points than the estimated data for the generation of different waste streams. As the data is published by Eurostat, we can expect that both years (2006 and 2013) are compiled with the same methodology and therefore are comparable over time.

The municipal waste values for the NUTS2 regions in kg per capita range between 165 kg/capita to 763 kg/capita, with a median of 459 kg/capita. In some ways, the data for municipal waste per cap follows similar patterns like the total waste per cap: the Eastern Europe regions have lower numbers than the core regions of the EU15 countries. However, there are also differences, as e.g. most French regions have high levels of per capita ratios for municipal waste (often above 600 kg/capita), whereas in all French regions, with the exception of *Île de France*, the estimated numbers for total waste, excluding major mineral waste, lie below the median of all regions. The opposite is evident for the Benelux regions and some regions in Poland and Norway (and also in other countries) where the per capita value for municipal waste is lower than the average, whereas the numbers for total waste per cap for the same regions are well above the median. If the total waste of a region is mostly driven by waste streams like mining and quarrying waste or waste generated by the agricultural sector (e.g. through forestry), this could explain the difference between total waste and municipal waste. Another explanation could be that in these regions/countries, appropriate collection schemes for municipal waste streams are established, even though the total waste values are above average because e.g. the energy supply is largely based on fossil fuels or resource intensive sectors like forestry.

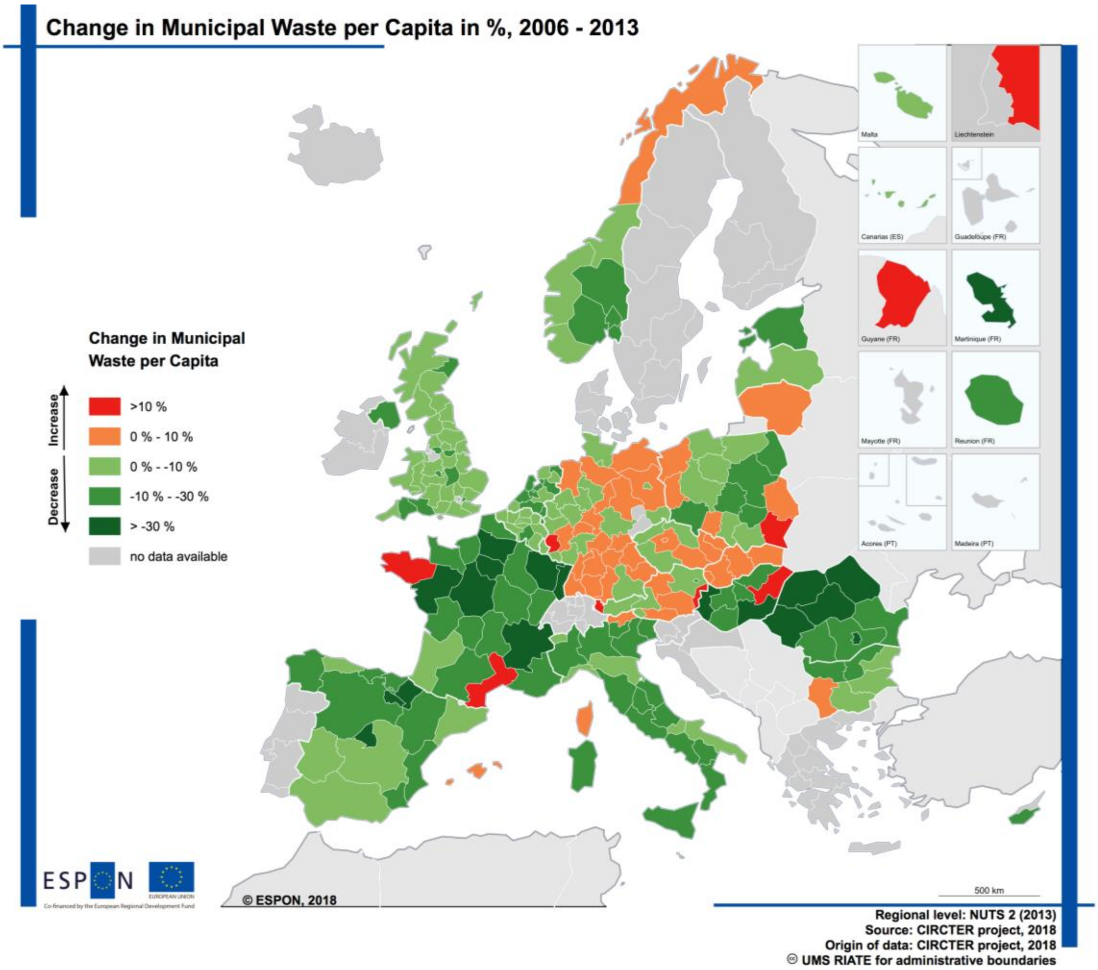
Map 7-1: Municipal Waste in kg per capita



Another aspect of interest is how the amount of municipal waste per capita has evolved over time. For this purpose, we have determined the growth rate for the period 2006 to 2013 (Map 7-2). All green coloured regions represent decreasing numbers in municipal waste per cap, whereas the red regions denote increasing values in municipal waste per capita.

The regional mapping of growth rate shows no clear picture: regions with high as well as low municipal waste values per capita (regions in France and Romania, respectively) have been able to reduce their municipal waste per capita by more than 30% between 2006 and 2013. And vice versa, we also have an increase of more than 10% between 2006 and 2013 for regions with high levels of municipal waste per capita as well as for regions with low per capita numbers for municipal waste.

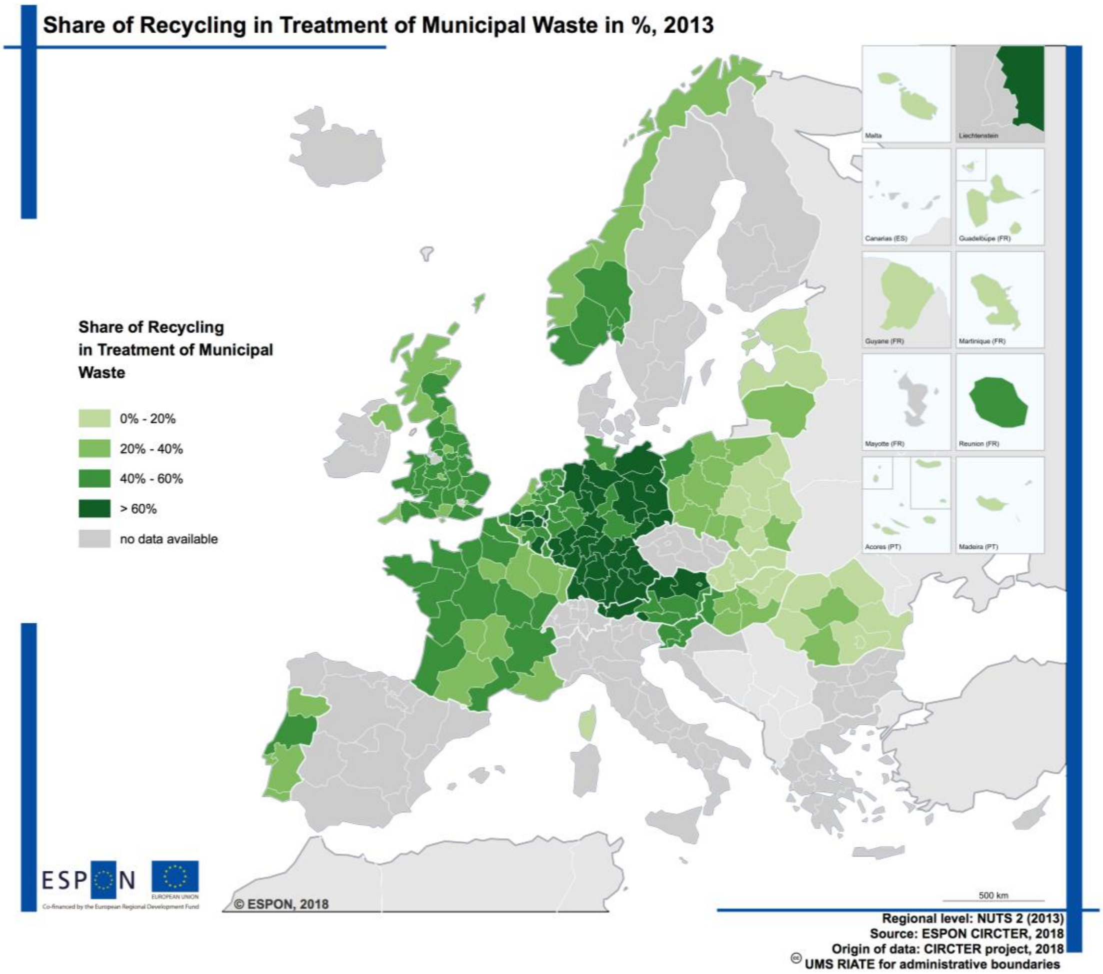
Map 7-2: Change in municipal waste per capita in %



Another interesting characteristic we have analysed is the question of how the municipal waste is treated after the collection. Eurostat distinguishes between landfilling, incineration (with or without energy recovering) and recycling. Recycling rate for municipal waste is defined by Eurostat as the share of municipal waste which is treated as material recycling and composting/digestions on total municipal waste. Therefore, the amount of municipal waste which goes directly to incineration (regardless of using energy recovery or not) is not considered as recycling.

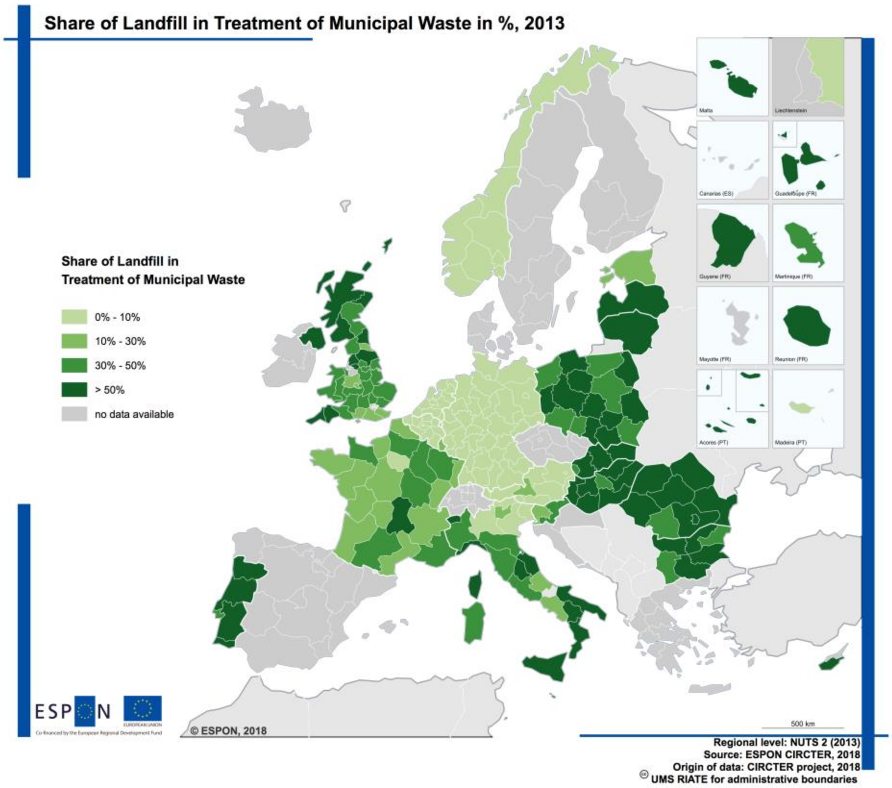
As can be seen, the data situation for single treatment fractions regarding municipal waste is much worse than for total municipal waste, therefore the data for countries/regions where no data is available increased sharply in comparison to the maps presented before. For all regions with available data, the recycling rates cover the full range from 0% to 100% with a median of 44%. As Map 7-3 shows, the German regions have appreciable higher recycling rates of often nearly 100%. As in the Eurostat metadata documented, the treatment data are the input quantity to the corresponding treatment facility. If a region has no incineration capacity, their incinerated part of municipal waste could be exported to other regions which could explain their exceptional high portion of recycling. However, a closer look at the data shows that the German regions with very low incineration rates (see Map 7-5) are mostly concentrated in the southwest of Germany and also form federal states with large areas such as Hesse or Baden-Wuerttemberg. However, it is unlikely that nearly no municipal waste will be incinerated throughout Hesse or Baden-Wuerttemberg. A comparison with the official waste statistics of the federal state of Hesse (Hessian Ministry for the Environment, Climate Protection, Agriculture and Consumer Protection (HMUKLV), 2015) confirms this assumption. Although the total amounts of municipal waste in 2013 for Hesse (NUTS1 level) largely correspond to the totals for the regions of Gießen, Darmstadt and Kassel (NUTS2 regions of Hesse) (2.79 million tonnes in Eurostat, 2.84 million tonnes in HMUKLV 2015), the treatment data for the regions of Giessen, Darmstadt and Kassel (NUTS2 regions of Hesse) in Eurostat are very different to the data for Hesse, published by the official authorities in Hesse. In HMUKLV (2015) it becomes apparent that only 56.7% of municipal waste in Hesse are recycled, while 33% is energetically used. A further 10.3% of municipal waste was treated in a mechanical-biological waste treatment plant (MBT), where only part of it can subsequently be recycled. However, according to Eurostat data for the three NUTS2 regions of Hesse, the incineration share is only 0.09%, although four waste-to-energy plants and four plants for the mechanical-biological treatment of municipal waste are in operation in Hesse. Obviously, Eurostat data on the treatment of municipal waste are not identical, at least in part, to those of the state environment ministries in terms of their definitions. It is therefore almost impossible to interpret the regional treatment data, as obviously identical definitions have not been used in all regions and we cannot estimate how the data quality affects the results. Rather, we must limit ourselves to the mere presentation of the results available to us.

Map 7-3: Share of Recycling of municipal waste

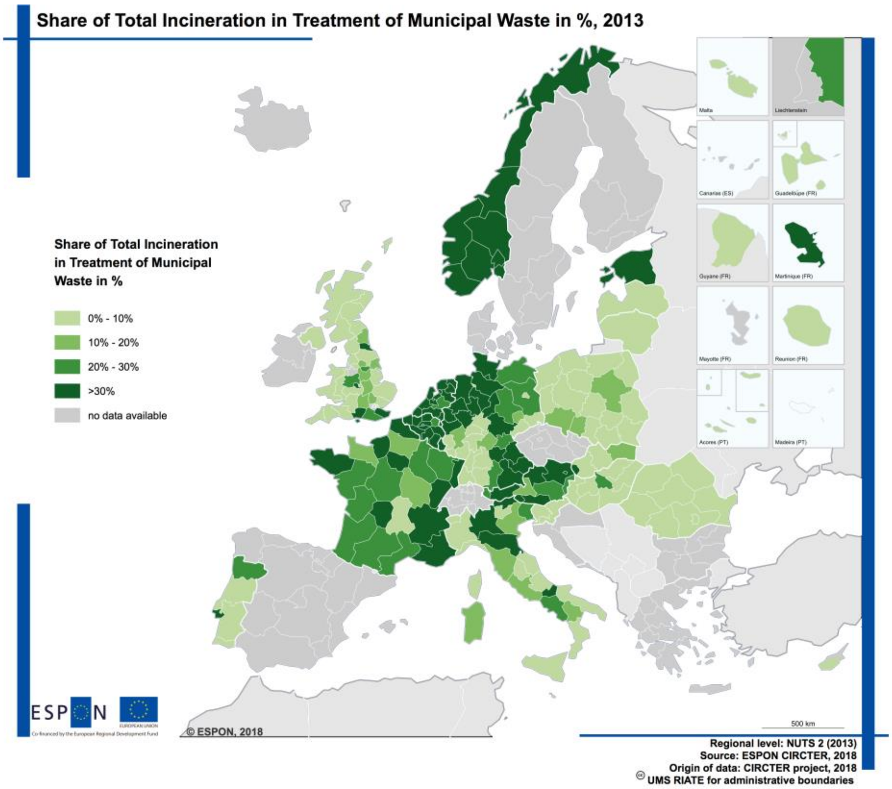


In contrast to the share of recycling in the municipal waste collected, the share of landfill is still quite high, especially in Eastern Europe, also in Portugal and southern Italy. The light green coloured regions in Germany are exactly those below the limit of the colour spectrum, i.e. zero tonnes. According to Eurostat statistics, all municipal waste in Germany is either recycled or incinerated. There is no landfilling. However, these data are inputs to the recovery facilities and not outputs after recovery. It can therefore be realistically assumed that residues of municipal waste in form of slag/ash from incineration or residues after recycling will still be landfilled in Germany. The share of landfill is surprisingly high in some regions of Great Britain. In regions where the share of landfill is high, combustion capacity for municipal waste appears to be low. The map of the share of incineration of municipal waste in many ways defines the counterpart to the map of share of landfill: if the incineration share is high, the landfill share is low and vice versa.

Map 7-4: Share of Deposition of municipal waste

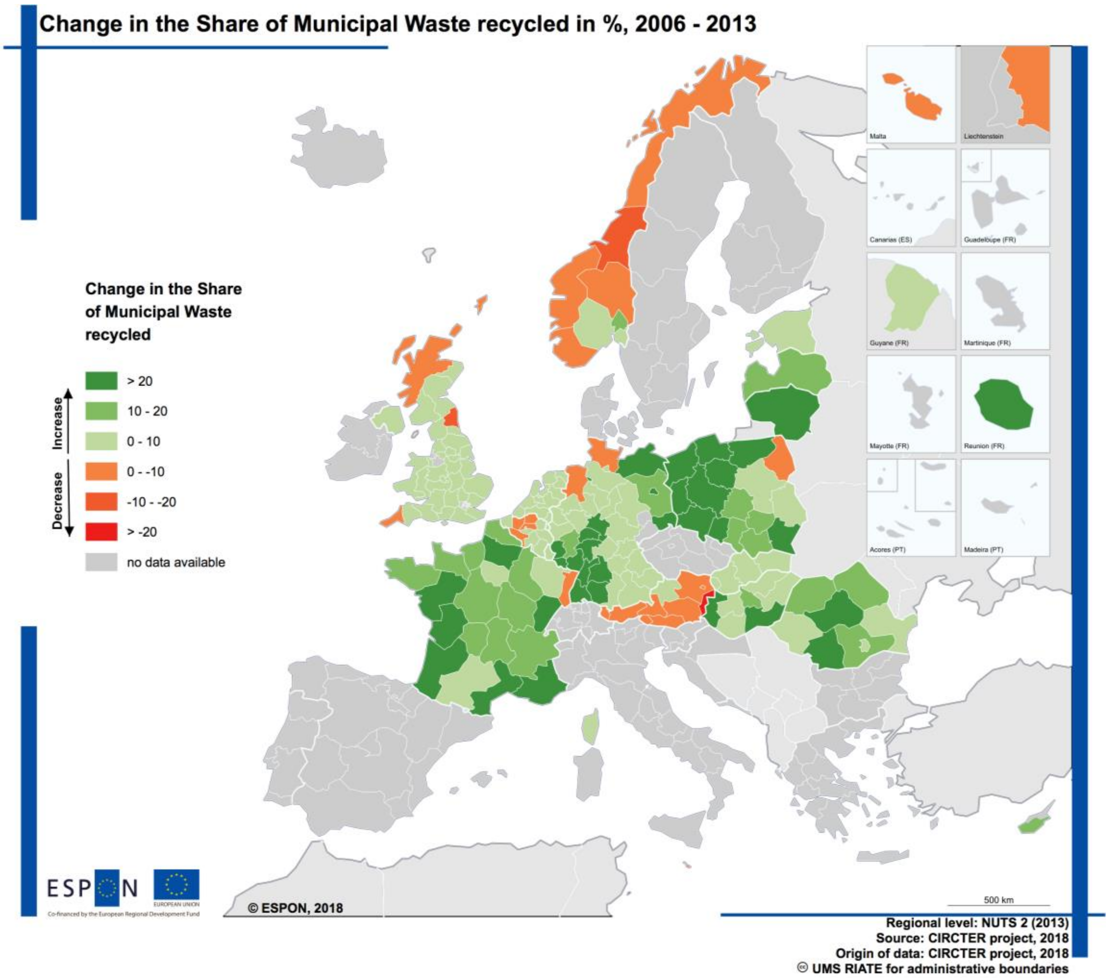


Map 7-5: Share of Incineration of municipal waste

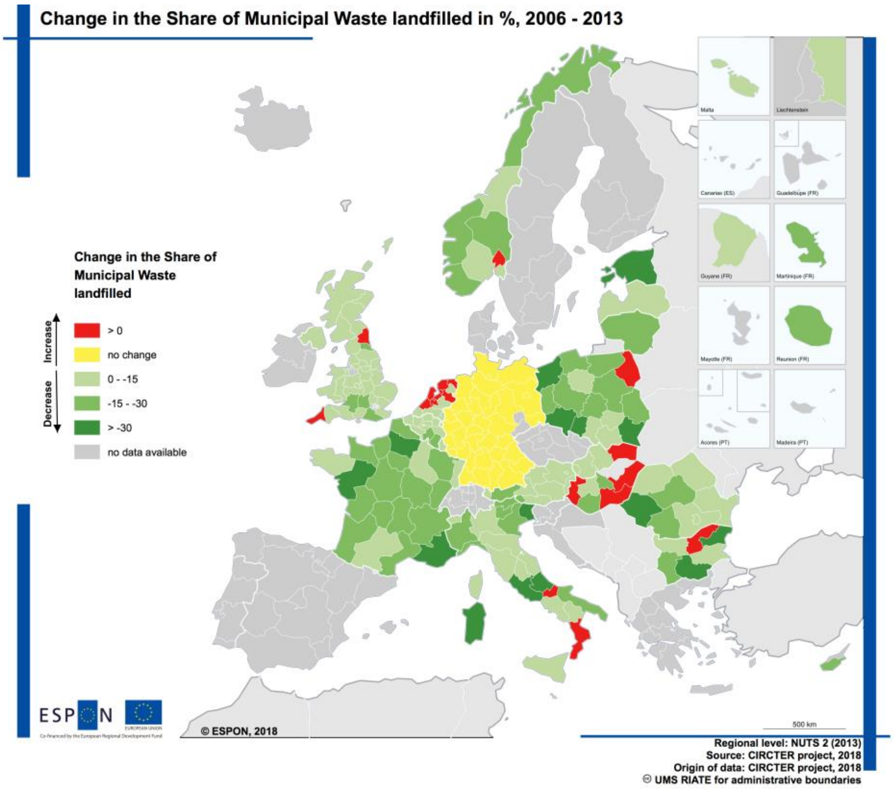


For the treatment of municipal waste in 2006, fewer data are available than for the period 2013. Therefore, the number of regions, for which the change in the shares of the various treatment options can be shown, is reduced again. As can be seen, in Germany the share of recycling has increased in most regions at the expense of incineration. In France, the share of landfill has decreased and leads to higher share of recycling as well as an increase in the majority of French regions in the incineration of municipal waste. The red regions in Map 7-7 in Great Britain show slightly increasing shares, but are due to the fact that the total amount of municipal waste has decreased even more than the amount of municipal waste which has been landfilled. Only in handful of regions has higher quantities of landfilled municipal waste per capita in 2013 in comparison to 2006. In the case of the Netherlands, however, this is the case at very small absolute quantities and therefore also at very low share at total municipal waste.

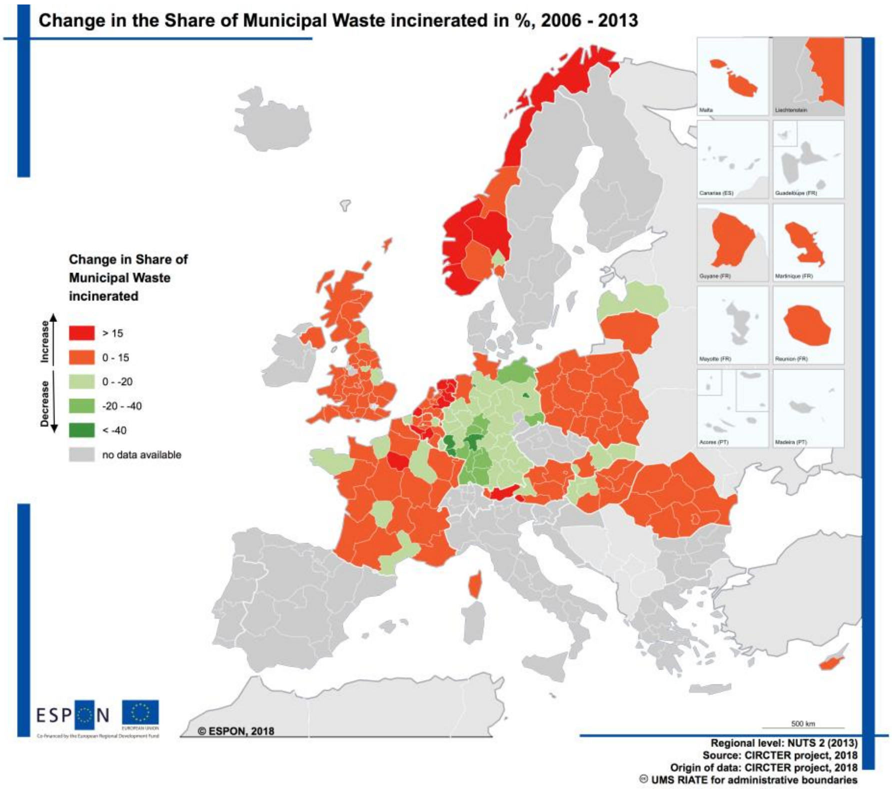
Map 7-6: Change in recycling of municipal waste



Map 7-7: Change in deposition of municipal waste



Map 7-8: Change in Incineration of municipal waste



8 Conclusions

The CIRCTER project investigates how regions differ in their ability to establish approaches of a circular economy and how they have developed on the way to a circular economy. As described in Annex 2 to this report, currently there is no totally established set of indicators on how this performance can be measured and presented by countries and regions. As described above, a number of indicators have therefore been selected in this project which are suitable for measuring some specific aspects of a circular economy. The choice of indicators depends on the data availability allowing a regionalisation of the data and whether they can be found at Eurostat at the corresponding NUTS2 level.

However, this data availability is also a limitation of the interpretability of the results, since only certain aspects could be analysed, or the existing indicators are only proxy indicators. Those would be more suitable for measuring circular economy, but the corresponding data are missing. Further difficulties for the interpretation of the results lie in the uncertainty about the quality of the data regionalised in the project and the quality of official data at the NUTS2 level, as explained in the section on treatment of municipal waste.

For example, the indicator *DMC per capita* as such does not say much about a circular economy. This would require much more information about the share of secondary material of the DMC. However, this information is not available. In a project for the German Federal Environmental Agency, this ratio was determined in relation to the Direct Material Input (DMI) for Germany. According to this, the share of secondary material in the DMI was around 14% (Steger et al., 2018). It can be assumed that also in other countries the share of secondary materials in the direct material input (and consumption) is not much higher. This in turn means that the DMC per capita is a suitable proxy indicator for the “openness” of a circular economy. In other words, because the secondary share in the DMC is probably low in all countries, the DMC indicates how much primary material input flows into the material cycle of a circular economy. Thus, the lower the per capita value of the DMC, the less primary material input flowed into the system.

At the end of the production and usage phase, waste is generated which should be recycled in a circular economy. This represents stage 3 of the waste hierarchy. Levels 1 and 2 of the waste hierarchy contain the approaches of waste prevention and the preparation for the reuse of waste. All three relevant stages of the waste hierarchy for a circular economy are regionally difficult to measure. Defining appropriate indicators for waste prevention is currently an important topic in research on the circular economy. At present, practicable suggestions are often limited to plain waste quantities and their development over time, being the only feasible indicators with corresponding data availablity. However, it is often unclear how a reduction in waste quantities can be associated with possible waste prevention measures and initiatives. For the second stage of the waste hierarchy, the preparation for reuse, there are suitable indicators, such as the number of repair cafes or similar, which, however, are only sporadically available for regions. Data on recycling, the 3rd stage of the waste hierarchy, are also available at regional levels only for municipal waste but not for other waste categories.

The quantities of different waste categories produced do not allow any conclusions to be drawn about the recycled proportion of these quantities. However, if a region/country does not recycle 50-60% of its municipal waste but landfills it, it is unlikely that this region/country has correspondingly high recycling rates for other waste categories.

Despite these limitations of the existing indicators for measuring certain aspects of a circular economy, the analyses of available data provide valuable information on the spatial patterns.

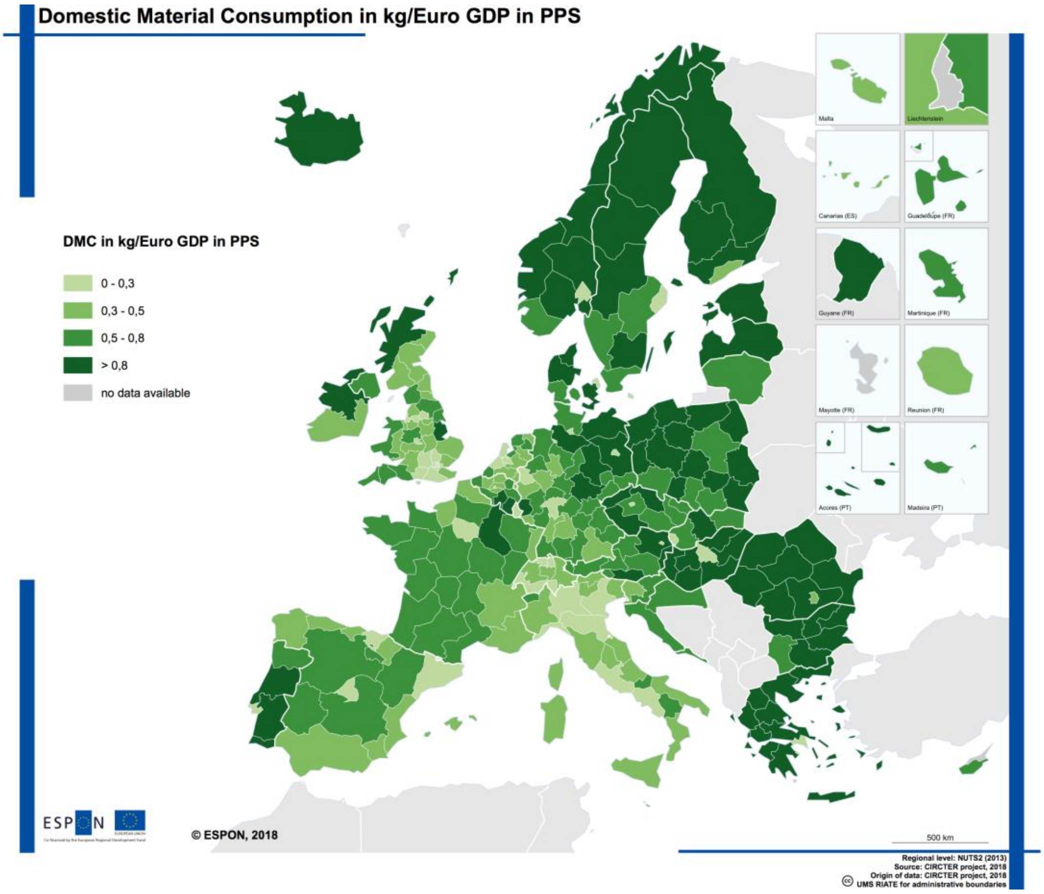
From these conclusions the following aspects can be derived, which should be taken up by future research projects and/or which represent political recommendations for action for further activities:

- Definition of a uniform set of indicators to measure the progress of a circular economy. Eurostat has proposed a first set which represent a good starting point.
- It follows, however, that the data situation for this set of indicators must be improved both nationally and regionally/local. In this project most of the Eurostat indicators could not be taken up, as no corresponding data are available, neither up-to-date nor in time series.
- Even with official data avaiable from Eurostat at NUTS2 level, there are large question marks regarding comparability, as the national statistical institutes seem to work with different methodological approaches.
- The limitation of the available indicators, the partly questionable data quality and the methodological limitations of the regionalisation approach made the interpretation of the results more difficult. A more regionally limited and rather bottom-up analyses could on the one hand validate the results of this project for individual regions and, on the other hand, more specific individual influencing factors could myay found an analyse than it was possible with the top-down approach chosen in this project.

8.1 Material input

The Domestic Material Consumption (DMC) per capita is above average, especially in some regions of Eastern Europe and Scandinavia, but also in the regions of Austria, Iceland, Ireland and some regions of Germany. Two factors seem to determine the DMC per capita: First, a high DMC per capita values are often due to the use of local natural resources, e.g. through forestry and mining in Scandinavia. Secondly, the level of DMC per capita is strongly influenced by population density. In less densely populated regions, the necessary materials for buildings or infrastructure are distributed among significantly fewer people, so that material consumption per capita increases. This is particularly evident in Norwegen and Sweden. The high level of DMC construction in the Romanian regions can probably also be explained by this.

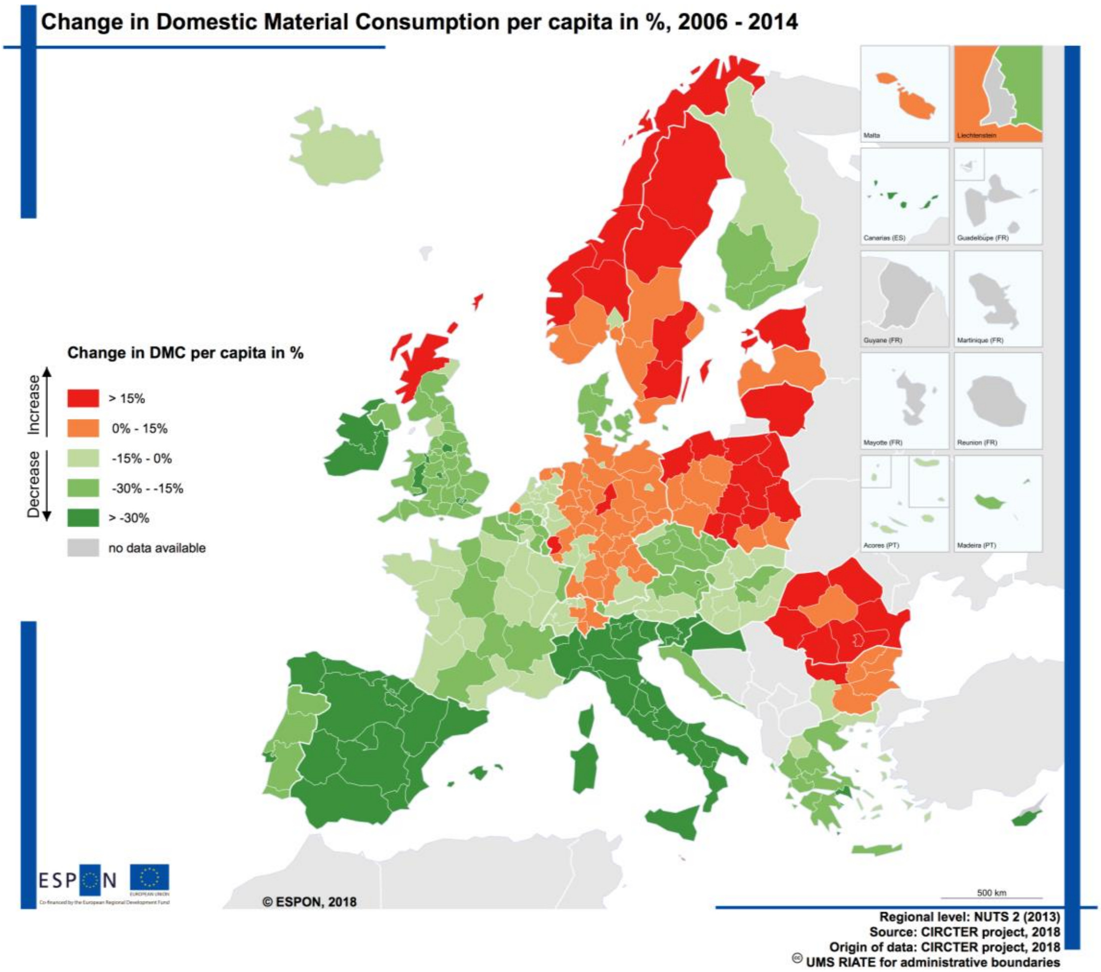
Map 8-1: DMC per capita in 2014



This spatial aspect of population density is also clearly reflected in the studied typologies and their distribution analyses. In principle, the box plot diagrams have shown that the distinction between urban and rural regions is more relevant than the differentiation of regions according to whether a region is industrial or not, both for material input and for waste indicators.

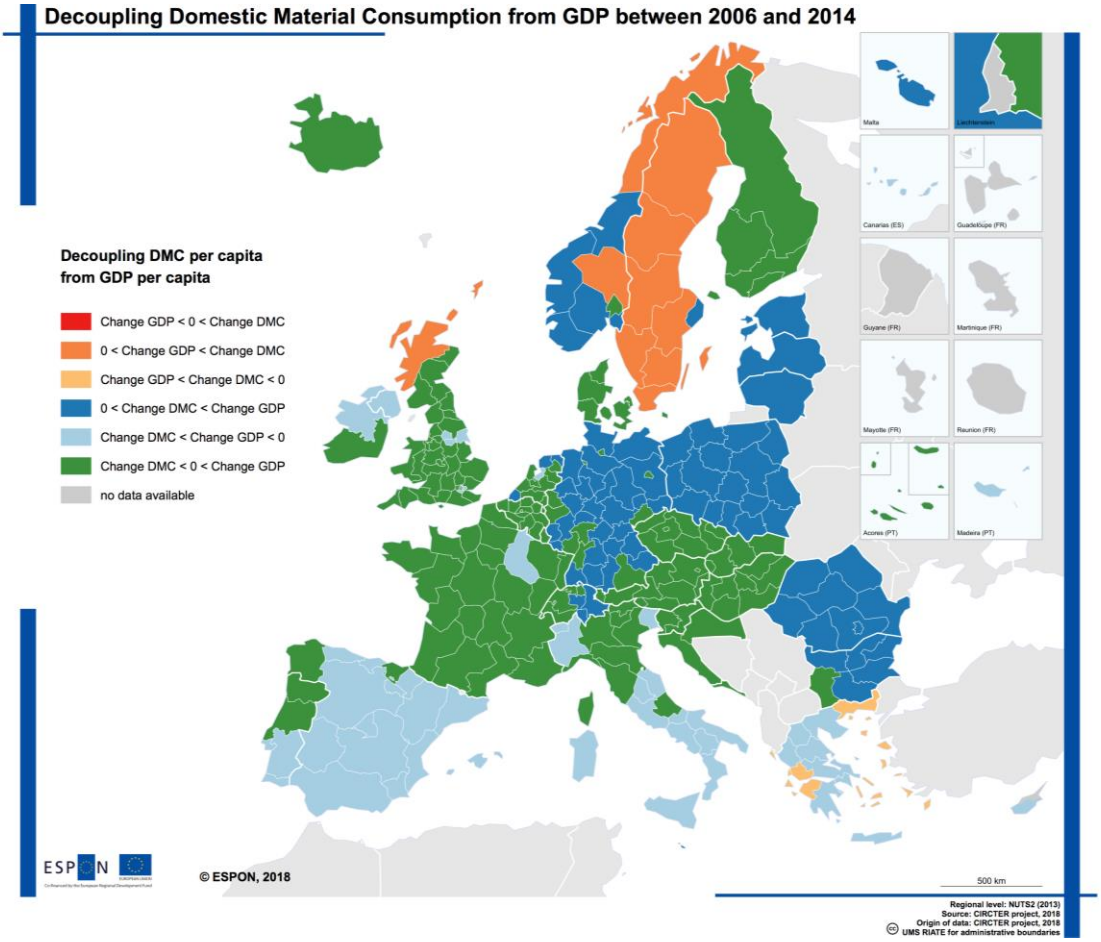
The change in the DMC per capita between 2006 and 2014 again shows the link between material consumption and GDP dynamics: on the one hand, regions with low resource consumption in 2014 are also the regions with declining DMC per capita since 2006. At the same time, the regions with the strongest declines between 2006 and 2014 are also those hit hardest by the global economic crisis in 2008 and therefore show not only strongly declining DMC per capita values in the period 2006 to 2014, but also declining or stagnating GDP per capita levels. This observation applies to Spain, Italy, Ireland and Greece.

Map 8-2: Change in DMC per capita in %, 2006-2014



The link between the change in GDP per capita and the change in material consumption per capita also leads to the fact that in regions with strongly declining DMC per capita often no decoupling of the DMC from GDP took place. But rather a relative negative delinking or in the case of some regions in Greece, with lower decline in the DMC per capita, even a relinking of the DMC per capita with the change of GDP can be identified. Regions with an absolute decoupling were rather regions with a moderate decrease of the DMC per capita.

Map 8-3: Decoupling DMC per Capita from GDP per capita



The DMC is mainly characterized by the subcategory of DMC construction, followed by DMC Biomass. The DMC metal does not play a major role in most regions, as there is no significant mining of metallic raw materials in most regions. Accordingly, the change in the DMC over the period 2006 to 2014 will also be very much adapted to the dynamic changes in the DMC Construction.

The Eastern European regions with an above-average DMC per capita also have a high material intensity (or reciprocally a low material productivity) due to the comparatively low per capita income in Eastern Europe. In the Scandinavian and German regions with high material consumption, the high per capita income helps to reduce material intensity to an average level. However, they don´t reach the high material productivity in the French, Italian or British regions, which results from the low DMC per capita and the also relatively high income per capita.

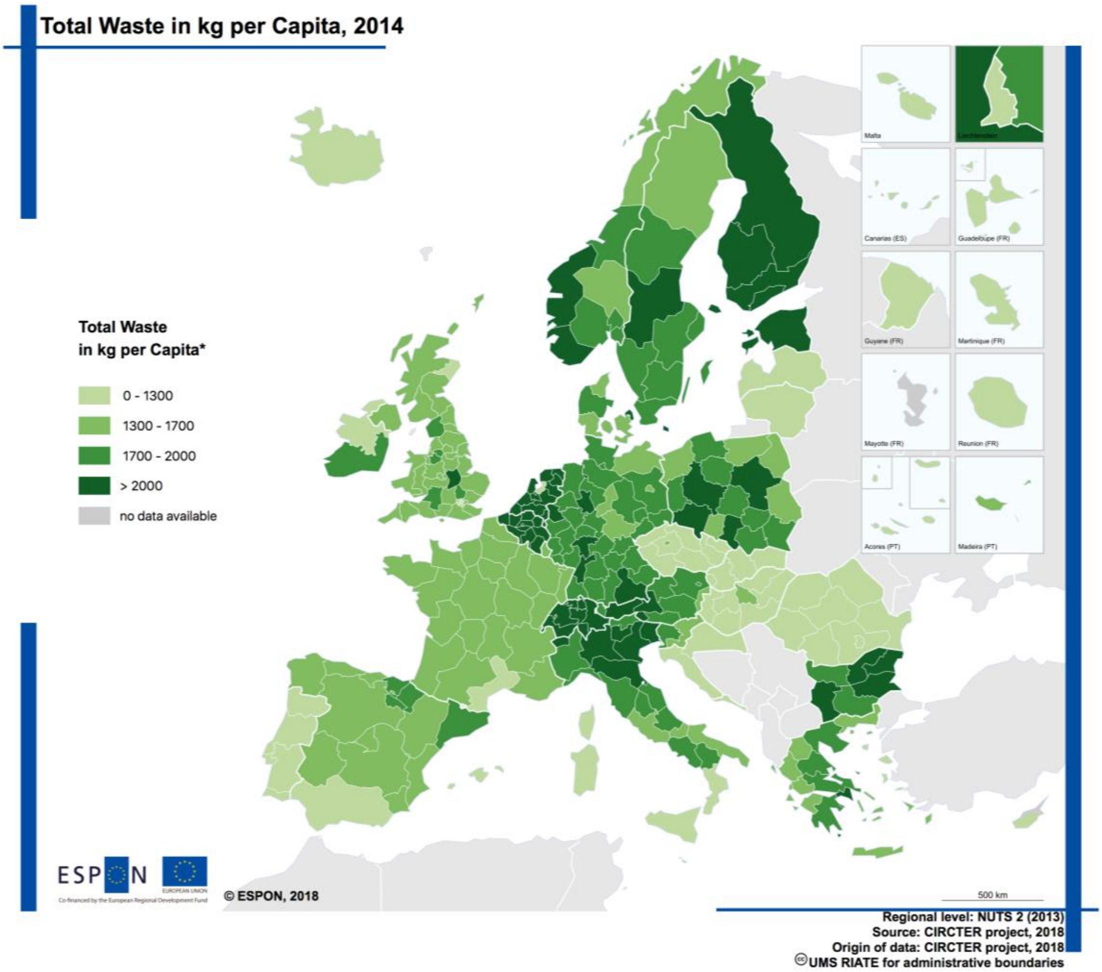
8.2 Waste

The amount of total waste excluding major mineral waste is also strongly determined by per capita income or in other words, regions with high per capita income tend to generate higher amounts of total waste excluding major mineral waste. This is also confirmed by the pattern that urban regions tend to generate higher quantities of total waste than rural regions. Looking at the different waste categories that determine total waste, it can be seen that these differences are mainly defined by household and food waste. In urban regions, however, the collection infrastructure may simply be better developed, allowing more waste to be collected and treated, thus explaining at least in parts the higher values of food waste and household waste.

At the same time, however, national patterns seem to play a role in influencing per capita total waste levels, which are likely to be caused by different national waste legislation or other national regulations/standards. In the per capita levels as well as in the dynamics of individual waste categories, national patterns seem to become visible again.

In addition, regions with higher per capita incomes are also industrial centres. At the very least, the quantity of manufacturing waste often makes it possible to identify the respective industrial centres of the individual countries: be it Cataluña in Spain, Lombardia in Italy or Noord-Brabant in the Netherlands. With a few exceptions, the other waste categories (WEEE, Plastic, Agriculture or Mining) play only a minor role for the differences in the regional total waste quantities as their shares of total waste are too low.

Map 8-4: Total Waste (excluding major mineral waste) in kg per capita



The dynamics of the change in per capita values in total waste are difficult to interpret. For methodological reasons, different regression models were used for regionalisation of the 2006 and 2014 data, which in some regions led to data that cannot be meaningfully interpreted. There are a few Spanish regions whose total waste per capita increased between 2006 and 2014, although all other waste categories decreased in the same period. These implausible dynamics are then also reflected in the map of the decoupling of waste quantities per capita from per capita income, in which two adjacent regions can exhibit absolute decoupling and absolute re-linking, although their respective changes in per capita income show similar dynamics.

In addition to the plain amount of waste generated, an equally important criterion for the assessment of whether a region follows a linear or circular production and consumption model is, the question how these quantities are handled. Is it more ecological if the per capita value of waste is lower, but large parts of it are landfilled and thus lost for a circular economy? Or are higher per capita values more tolerable if, in contrast, a higher proportion of waste is recycled or used as an energy source? However, data for the treatment of waste are only available for municipal waste until 2013. These data are produced by Eurostat as part of a pilot project and therefore do not constitute a regular data set. These data are provided on a voluntary basis by the national statistical offices and partly differ in their methodology. As documented in the Eurostat metadata, the German and French regional data are not comparable with the data of the other countries. But without considering the German and French data plus the many data gaps where the national statistical offices have not documented any data, the number of NUTS2 regions with information about the type of treatment is significantly reduced and the majority of regions on the ESPON map would be grey.

These data constraints illustrate the need for an improved data situation at NUTS2 level in order to be able to make better assertions about how a region has made progress towards a circular economy. At the moment, the information value is very limited due to the availability of the existing indicators, the general data quality already with the initial national data and the methodically difficulties of the regionalisation approaches.

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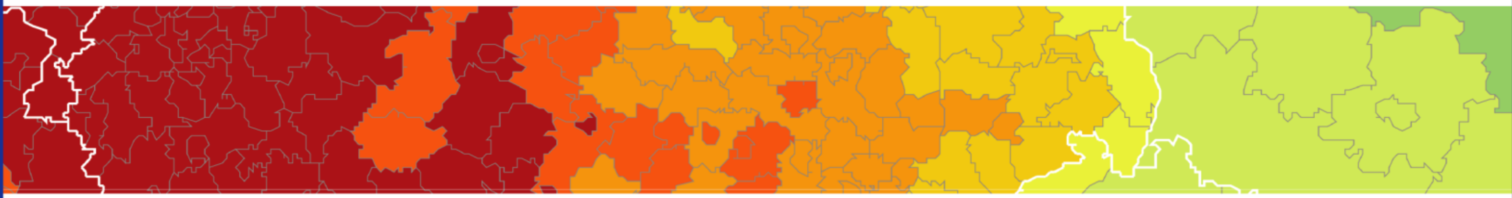

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