REPAiR

REsource Management in Peri-urban AReas: Going Beyond Urban Metabolism

D3.1 Introduction to methodology for integrated spatial, material flow and social analyses

Version Final, October 3rd 2017

Authors: Bob Geldermans (TUD), Carolin Bellstedt (TUD), Enrico Formato (UNINA), Viktor Varju (RKI), Zoltan Grunhut (RKI), Maria Cerreta (UNINA), Libera Amenta (UNINA/TUD), Pasquale Inglese (UNINA), Janneke van der Leer (TUD), Alexander Wandl (TUD)

Contributors: Sue Ellen Taelman (UGent), Davide Tonini (JRC), Fortuna de Rosa (UNINA)

Grant Agreement No.:	688920
Programme call:	H2020-WASTE-2015-two-stage
Type of action:	RIA – Research & Innovation Action
Project Start Date:	01-09-2016
Duration:	48 months
Deliverable Lead Beneficiary:	TUD
Dissemination Level:	PU
Contact of responsible author:	r.j.geldermans@tudelft.nl

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 688920.

Dissemination level:
- PU = Public
- CO = Confidential, only for members of the consortium (including the Commission Services)

Change control

Version	Date	Author	Organisation	Description / Comments
1.0	07-02-2017	Bob Geldermans	TUD	First draft version
1.1	23-03-2017	Alex Wandl	TUD	Task 2.1 delineation of focus area
1.2	03-07-2017	Carolin Bellstedt	TUD	Refine structure of 2.2, add list of abbreviations and acronyms
1.3	05-07-2017	Libera Amenta, Enrico Formato	UNINA	Mapping Wastescape methodology chapter n. 2.1.2
1.4	04-09-2017	Carolin Bellstedt	TUD	Updating the AS-MFA steps
1.5	17-09-2017	Maria Cerreta, Fortuna De Rosa, Pasquale Inglese	UNINA	System boundaries Spatial Analysis Wastescapes classification and analysis
1.6	18-09-2017	Libera Amenta, Enrico Formato	UNINA	Update Analysis and Mapping Wastescape methodology
1.7	19-09-2017	Sue Ellen Taelman	UGent	Comments and input throughout the deliverable
1.8	25-09-2017	Zoltán Grünhut	RKI	Updating Socio-cultural analysis
1.9	27-09-2017	Gustavo Arciniegas	Geo-Col	General comments on Version 1.8
2.0	29-09-2017	Carolin Bellstedt	TUD	Addressed and/or implemented all comments for T3.2; added all references
2.1	30-09-2017	Libera Amenta, Enrico Formato	UNINA	Update chapter 2.1; General Introduction Task 3.1; T3.1 and Wastescapes definition.
2.2	01-10-2017	Maria Cerreta, Pasquale Inglese	UNINA	Update chapter Task 3.1 | Spatial analysis; added new references
2.3	02-10-2017	Bob Geldermans, Carolin Bellstedt,	TUD	Publishable summary, Conclusion, Final edit
2.4	03-10-2017	Bob Geldermans,	TUD	Finalising D3.1

Acronyms and Abbreviations

AS-MFA	Activity-based Spatial Material Flow Analysis
CE	Circular Economy
CDW	Construction and Demolition Waste
EC	European Commission
EoW	End-of-Waste
ESS	European Social Survey
EW-MFA	Economy-wide MFA
FA	Focus Area
GDSE	Geodesign Decision Support Environment
GG	General Geography
HG	Human Geography
LCA	Life Cycle Assessment
MFA	Material Flow Analysis
MSW	Municipal Solid Waste
OW	Organic Waste
PCPW	Post-consumer Plastic Waste
PG	Physical Geography
PSCA	Primer Sociocultural Analysi
PULL	Peri-urban Living Lab
SC	Supply Chain
SEA	Socioeconomic Analysis
SSCA	Secondary Sociocultural Analysis
UM	Urban Metabolism
WEEE	Waste Electrical and Electronic Equipment
WM	Waste Management
WP	Work Package
WVS	World Value Survey

Table of Contents

Publishable Summary

The role of Work Package 3 within the REPAiR project is to develop and implement territorial metabolism models. The aim is to analyse, describe and model the case study areas with their subsystems and processes that define the area's current metabolic patterns, from the vantage point of waste production and waste management. The interrelated domains place, flow & stocks, and behaviour & governance are taken into account with regard to spatial (*where?*), contextual (*what, why, who and how?*) and temporal (*when?*) dimensions. This deliverable – D3.1 – provides an introduction to the methodology for integrated spatial (Task 3.1), material flows (Task 3.2) and social (Task 3.3) analyses. It explains methodological considerations and choices, whilst laying out the approach, developed in close conjunction with the two main pilot case studies Amsterdam and Naples. Subsequently, this handbook provides guidelines for application in the four other case study areas. Task 3.1, concerning the spatial analysis, is located between the investigation of the flows that cross, and are processed within, our urban and peri-urban territories on the one hand, and the study of the spatial effects that these 'metabolisms' have on the territory, on the other. A core aspect of Task 3.1 is related to the identification of what REPAiR defines as 'Wastescapes'. In Task 3.2 of WP3, Material Flow Analysis is used as a tool to study the material flows and stocks of the subsystems of the six case studies, based on consumption patterns and waste production. By introducing a new method for MFA, "Activity-based Spatial Material Flow Analysis" (AS-MFA), specific activities relating to material flows and stocks from waste production in subsystems, the involved actors and their interrelations can be identified. The AS-MFA aims to connect the spatial, material and social analyses in REPAiR. Task 3.3, on social analysis, is dealing with the linkages between sociocultural features and social sensitiveness about general environmental issues, and particularly about waste and resource management. Task 3.3 has a multilevel scope: secondary sociocultural inquiries are focusing on national level specificities, while the primer sociocultural stage of the research and the socioeconomic investigation is done on a local level. The representation and process models developed in WP3 have strong ties with WP4, regarding sustainability impact assessment and evaluation models, and with WP5 concerning eco-innovative solutions and change strategies. Moreover, the models are used as input to the GDSE (WP2) and inform – and are informed by – WP6 with regard to decision models. These interrelations accentuate the importance of common agreements regarding e.g. delineations, data sourcing and processing. Such issues are dealt with in this handbook, whilst underlining the necessity for continuing alignment between work packages of the REPAiR project.

1 Introduction

The core objective of REPAiR is to provide local and regional authorities with an innovative trans-disciplinary and open source Geodesign Decision Support Environment (GDSE), developed and implemented in six metropolitan 'living labs'. The GDSE allows the creation of integrated, place-based eco-innovative spatial development strategies aiming at a quantitative reduction of waste flows in the strategic interface of peri-urban areas. These strategies will promote the notion of waste as a "resource", whilst supporting the on-going initiatives of the European Commission towards establishing a strong Circular Economy (CE). However, there is no consensus regarding what exactly a "strong circular economy" entails. This accommodates interpretations to depart from a traditional understanding of how to optimize – rather than radically alter or avoid – current processes, in social as well as industrial and governmental contexts. Ghisselini et al. (2016) point out that CE has often been considered as an approach to more appropriate waste management. However, "such very limited point of view may lead CE to fail" (Ghisselini et al., 2016, p. 12), as it will result in a narrow approach of 'end-of-pipe' potential and solutions. REPAiR adheres to a more systemic perspective on the phenomenon of waste, which resonates in the definition of CE utilized (see Geldermans and Taelman, 2016):

Circular Economy (REPAiR-specific): An economy that accommodates resources to flow through man-made and natural systems in renewable ways, creating or retaining value through "slowed, closed or narrowed loops/flows", rather than rapidly destructing value through the creation of waste (cfr. linear economy). This value can manifest itself in monetary principles as well as other social, ecological or economic principles, taking account of potential trade offs. Important in this notion is the establishment of production-consumption-use systems built on restorative resources in optimal flows. Optimal flows imply that cycles are closed or connected at spatially and temporally favourable conditions, i.e. where and when most appropriate (highest possible value, possibly via cascade loops). Moreover, changes in one part of the system should not incite negative externalities. Of particular interest for REPAiR in this respect are impacts on spatial quality. From that perspective REPAiR also takes the notion of wastescapes (open spaces as well as built form) into consideration.

Systems thinking, as advocated in the definition above, implies that rather than looking at materials when they (have) become waste and focus on improved treatment processes, we need to determine why, how, where, when and by whom this waste was generated. Such a comprehensive approach increases the analytical complexity, but allows for more meaningful insights in production and consumption systems, their impacts, as well as possible intervention points for an improved management of resources and waste.

WP3 thus strives for a systemic representation of waste-related activities, flows, social attitudes and relations, and spatial significance. Both, downstream and upstream activities in production consumption/use discharge systems that cause specific waste flows may need to be taken into account. This realization forms the heart of WP3 and its objective to analyse and describe an area's metabolic patterns, from the vantage point of waste production and waste management. Alternating between reductionist approaches (zooming in, narrowing down) and holistic approaches (zooming out, widening up) became a leading theme in the research, necessitating many discussions between the tasks of WP3, as well as with other WPs: in particular WP4 regarding sustainable impact assessment, WP5 concerning eco-innovative solutions and WP2 for developing the GDSE environment. These discussions are ongoing, as it remains work in progress. That said, based on the two main pilot case-study areas, Amsterdam and Naples, methodological choices have been made and are described in this handbook.

1.2 The purpose of this handbook

This handbook - Deliverable 3.1 - provides an introduction to the methodology for integrated spatial, material flows and social analyses. It explains methodological considerations and choices, whilst laying out the approach, developed in close conjunction with the two main pilot case studies Amsterdam and Naples. As such, it provides a toolbox for application – and further fine-tuning – in the four other case study areas. After positioning WP3 within the overall REPAiR project structure and an introduction into the system boundaries, the three tasks that comprise WP3 lay out their methodologies: Spatial Analysis (Chapter 2.1), Material Flow Analysis (Chapter 2.2), and Social Analysis (Chapter 2.3). At the end of the handbook we briefly reflect on the work thus far and next steps.

1.3 WP3 in the REPAiR project structure

REPAiR follows in its structure six questions and models of the Geodesign framework (Steinitz, 2012) and is organized in two levels. WPs 3 to 6 develop the six models of the Geodesign framework for each study area, whereas WPs 1, 2, 7 and 8 manage different aspects across the cases and coordinate activities related to knowledge dissemination and data management (Figure 1).

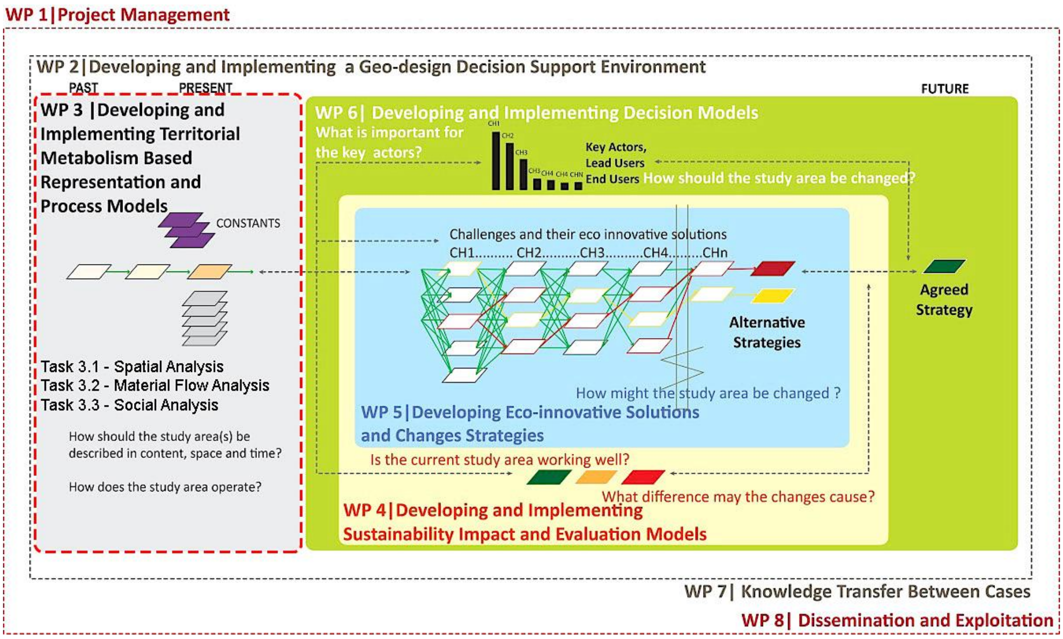


Figure 1: REPAiR Work Package structure.

REPAiR's approach to developing strategies that strengthen a CE builds on the collaboration of several expert teams from industrial ecology, economy, sustainability analysis, spatial planning, environmental policies and other relevant fields and stakeholders from particular regions. This approach calls for a methodology facilitating regular inter-team interaction in a real-world environment. Accordingly, the REPAiR team needs to:

- Understand the decision needs of key actors in the study areas;
- Specify the concept of urban metabolism to describe crucial processes in the study area;
- Generate manifold ideas for possible changes and engage future users, local stakeholders as well as thematic experts in strategy development;
- Develop a sustainability framework of indicators to assess these ideas against the current situation;
- Develop a framework of knowledge transfer;

- Develop data management structures and user interfaces for the Geodesign Decision Support Environment (GDSE) to enable decision makers to assess their decision alternatives quickly.

There are four types of activities in the project, namely: research activities, technological innovation, Peri-Urban Living Labs (PULLs), and promotion/dissemination activities. These are tightly interlinked to ensure a quick market uptake of the GDSE, which will foster change and improvement in resource management, and thereby prevent waste generation and promote waste as a resource.

WP3 is focused on research activities, with the goal to develop and implement territorial metabolism models. The aim is thus to analyse, describe and model the case study areas with their subsystems and processes that define the area's metabolic patterns, from the vantage point of waste production and waste management. The interrelated domains place, flow & stocks, and behaviour & governance are taken into account with regard to spatial (*where?*), contextual (*what, why, who and how?*) and temporal (*when?*) dimensions. The representation and process models developed in WP3 have strong ties with WP4, regarding sustainability impact assessment and evaluation models, and with WP5 concerning eco-innovative solutions and change strategies. Moreover, the representation and process models are used as input to the GDSE (WP2) and inform – and are informed by – WP6 with regard to decision models. These interrelations accentuate the importance of common agreements regarding e.g. delineations, data sourcing and processing. This is addressed in the following sections and chapters.

1.4 System boundaries

Identifying a meaningful and operational definition of "boundaries" for urban areas is a significant problem that remains to be solved (Potere and Schneider, 2007). Indeed, national governments and municipalities define urban areas in numerous ways and the boundaries of these areas can change for political, demographic or economic reasons (UNFPA, 2011).

Uchiyama and Mori (2017) consider that urban populations may be counted in different ways depending on which definition of urban areas is used. At the same time, different definitions and methods for delineating a system spatial boundaries underline that dividing lines do not necessarily coincide with administrative borders. The definition of city boundaries differs among researchers and academic fields. Uchiyama and Mori (2017) highlight how urban areas are delineated by built-up areas, impervious surface, built environment, or developed area; if urban areas are analysed by the perspective of urban ecology, they are defined qualitatively, considering areas under human influence (Marcotullio and Solecki, 2013). If the point of view is social, the term 'urban' is referred to areas with high human population density (Mcintyre et al., 2000), including size of population, density, and heterogeneity as relevant factors (Wirth, 1938).

Different definitions and identification methods provide different boundaries for the same cities or urban areas, and thus population size, population density, and components of land cover will differ considerably depending on the methodology or definition used to determine the boundary. Therefore, the identification of the spatial boundaries, based on a definition that is appropriate for a specific purpose of research, is an essential premise for the spatial analysis.

Boundaries match with geographical differences; socio-economic differences; and morphological differences. At the same time, boundaries coincide with main infrastructural paths (railroads, highways, etc.); precincts and dikes (wall, fences, etc.).

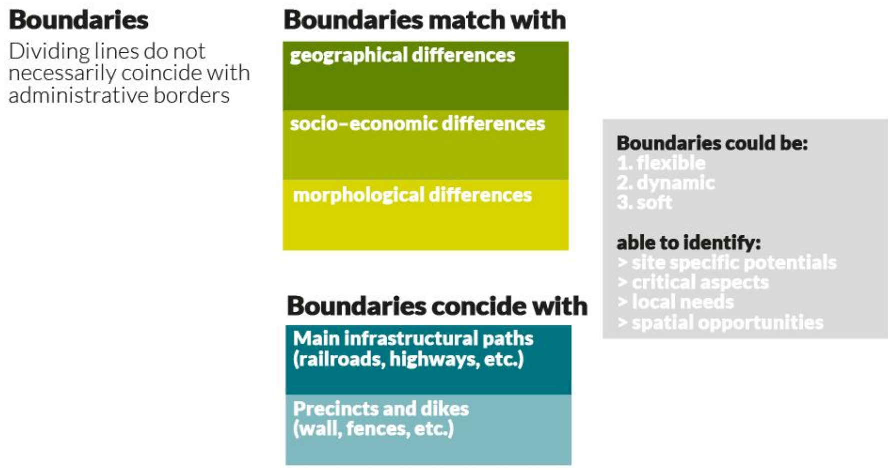


Figure 2: Boundaries interpretation

According to a dynamic perspective, the boundaries could be flexible and soft, in order to be able to identify site-specific potential, critical aspects, local needs, and spatial opportunities. Indeed, many studies have recognized that the social and biophysical components of the social-ecological systems (SES) can interact at multiple temporal and spatial scales (Liu et al., 2007), where ecological, biophysical, and socio-economic components define specific units used to operationalize the delineation of social-ecological systems (SES) (Martín-López et al., 2017), interacting across spatial scales.

The spatial boundary setting is related to the analysis scale and is relevant to understand how the spatial boundaries contribute to identify the central issues, considering ecosystem-centred spatial boundaries, activity-centred spatial boundaries and administrative, political, or other human-made spatial boundaries.
Within the REPAiR project the following five spatial boundaries have been defined: Global, Europe, Country, Region and Focus Area.

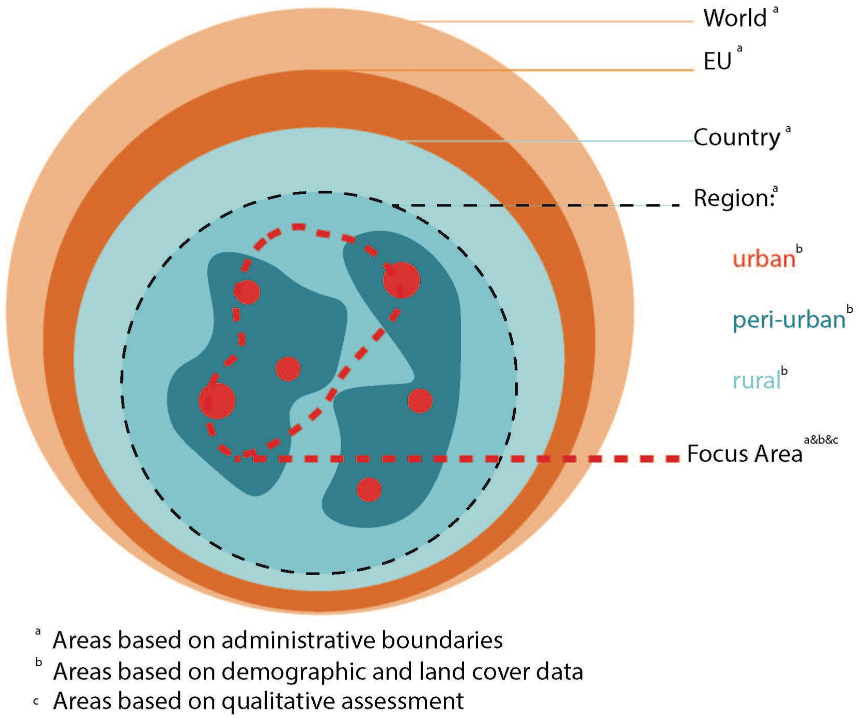


Figure 3: Illustration of the five spatial boundaries used in REPAiR

Figure 4: Examples of spatial boundaries for the Italian case-study

World and **Country** borders are self-explanatory; as **EU** we understand the EU 28 including the UK, as we assume that the UK will be member of the EU during the majority of the project period. As **Region** we understand the administrative region (more than one municipality) of relevance, which means it is on the one hand a relevant governance body for waste management and spatial planning. On the other hand, significant parts of the process chain of the key waste flows under investigation in the case study are taking place within the region. The region is therefore the key boundary for the MFA (see Chapter 2.2). The following aspects determine the **Focus area**:

1. A representative sample of the Region area, containing:
    a. A mix of urban, rural and peri-urban areas, with a dominant share of peri-urban areas;

   b. Wastescapes (in both the meaning of Drosscape and Operational Landscape of Waste, see section 2.1.3);
   c. Large infrastructure networks where there is an active interaction between the city and its surroundings;
   d. Productive areas and logistic platforms.
2. A problematic "paradigmatic" area; i.e. having the value of a model for investigating the problems and challenges and starting to experiment the solutions.
3. Defined based on administrative borders, socio-economic and land cover data as well as on qualitative assessments, where the kind of relationships and movements contributes to identify density gradients of population and uses.

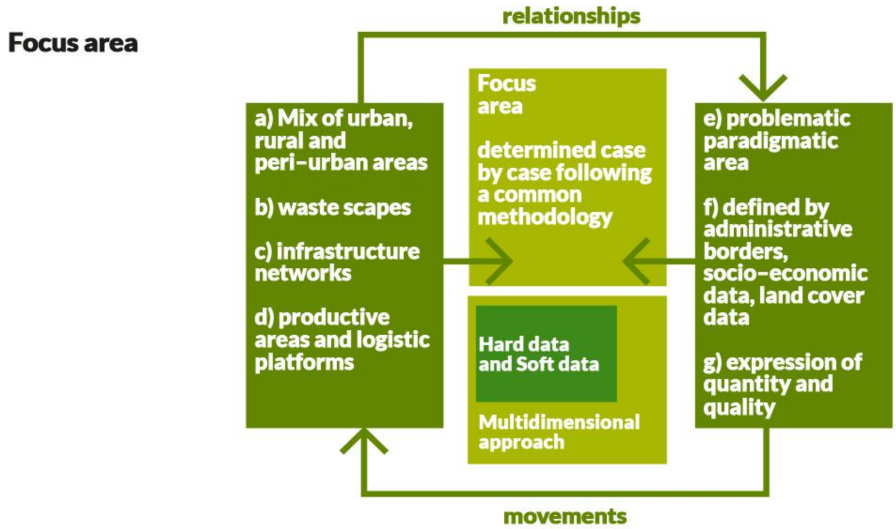


Figure 5: Components for the focus area identification

The objective of the identification of the focus area is to co-create and test the Eco-innovative Solutions in defined and manageable boundaries, even if their effects may be spread over larger areas. For the method of delineation of the focus area we refer to chapter 2.1.

The relevant spatial scales for Task 3.1 are the focus area, while Task 3.2 focuses on the regional scale. Task 3.3 has a multilevel scope, taking into account national level specificities as well as input from the local (focus area) level.

2 WP3 TASKS

2.1 Task 3.1 | Spatial analysis

2.1.1 General Introduction

"*We can say that spatial (geographic) data link place (location), time and an attribute [...]. Attributes come in many forms. Some are physical or environmental in nature, while others are social or economic. Some simply identify a location such as postal addresses or parcel identifiers used for recording land ownership. Other attributes measure something at a location (examples include atmospheric temperature and income), while others classify into categories such as, for example, land use classes that differentiate between agriculture, residential land and industry. […] Spatial data analysis requires an underlying spatial framework on which to locate the spatial phenomena under study*" (Fischer and Wang, 2011, p. 2.).

According to Pumain (2005), the spatial analysis consists in proposing a partial explanation as well as prediction possibilities about the state and probable evolution of geographical objects or entities, on basis of knowledge of their situation with respect to other geographical objects. At the same time, the spatial analysis can be considered mixing the reflections related to a theory of concentrations, of spacing, of spatial structures and of evolution of spatial systems, relying on knowledge of behaviours in space and of spatial representations. In this perspective, many theories which attempt to explain location and distribution of human activities, refer to the major role played by distance, which on the one hand slows down interactions and on the other makes value of places vary in function of their relative geographical situation (for examples the centre/periphery theory, the central places theory, and the theory of spatial diffusion of innovations, etc.). In several cases, distances-times and/or distances-costs tend to regulate interactions. Differentiation of space can be observed at different geographic scales, and a multi-scalar organisation can be relevant to explore the evolutionary processes that generate the different configurations of places and their interactions.

Task 3.1 of REPAiR WP3 could be considered as an intermediary task between the project activities of the PULLs, developed within WP5 of REPAiR, and the research about material flows of WP3 Task 3.2. Indeed, conceptually, it is located somewhere in between the investigation of the flows that cross our territories, and the study of the spatial effects that these metabolisms have on the territory. Moreover, Task 3.1 examines in depth the spatial implications of solutions identified within WP5 with the utilization of the GDSE developed by WP2.

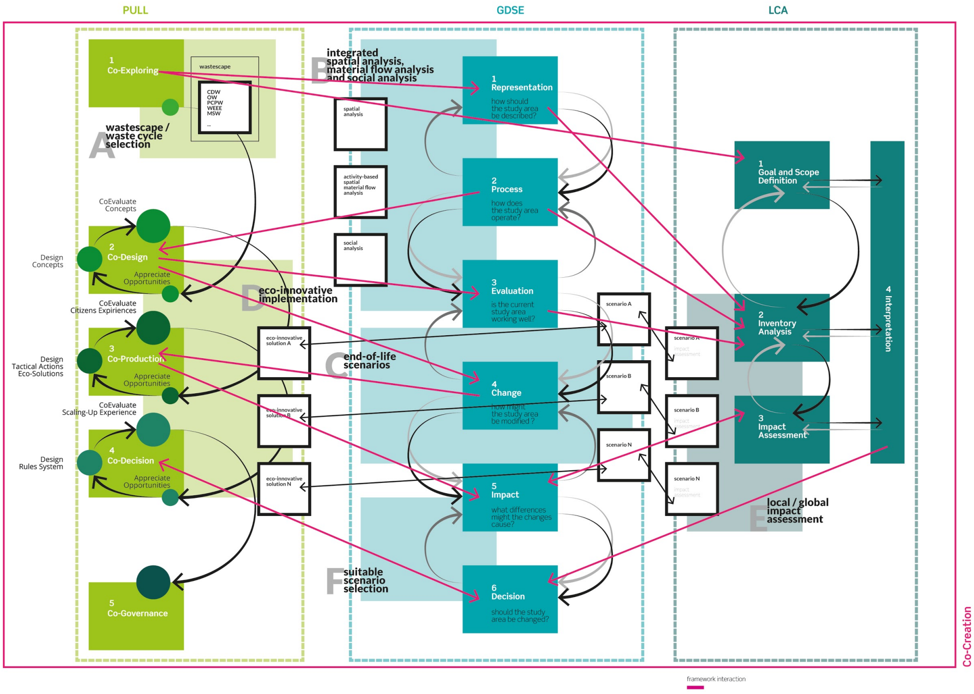


Figure 6: Integrated Spatial Analysis, Material Flow Analysis and Social Analysis in the methodological framework where PULL, GDSE and LCA interact

The spatial analysis aims to identify the boundaries, the geographies, the Wastescapes, and the policies and planning instruments of the focus areas of the 6 case studies of REPAiR. The activity is carried out in relation to the strategies developed in the Peri-Urban Living Labs (PULLs), so it does not only deal with the analysis of current conditions but it is supportive for the definition of eco-innovative solutions. At the same time, it supports the GDSE process and the interaction with LCA model implementation (Figure 6).

2.1.2 Goal & Scope

The aim of this chapter is to provide an approach as well as a set of methods in order to:

1. Define the relevant spatial boundaries of the areas.
2. Represent the case study area in a way that allows better understanding the relation between morphology and physiology of the focus area and region, and thereby allows extending the concept of urban metabolism.
3. Describe the specific, physical, human and waste geography of the focus area and region in order to identify challenges, problems and solutions for and towards a more circular economy, on the one hand, and provide input for the sustainability assessment on the other.
4. Facilitate the work developed within the different PULLs, while addressing questions that arise during the Living Lab activities. I.e.: both going deeper in the analysis of pilot cases, and exploring alternative strategies (scenarios) to be implemented.
5. Support the elaboration of the GDSE framework and the assessment of the scenarios' impacts.

2.1.3 Task 3.1 and Wastescapes definition

Considering that a shared and clear understanding of Wastescapes is missing in the literature, Task 3.1 of REPAiR aims to fill this gap. Specifically, its goal is to provide a more precise definition of the Wastescapes set, in relation to the first one, which was presented in Deliverable D5.1 (Russo et al., 2017). Wastescapes sets are composed by: Drosscape

(Berger, 2006) and Operational landscape of Waste (Brenner, 2014). For REPAiR WP3 they are to be analysed only in the focus areas of the six case studies, in close collaboration with local stakeholders.

With the aim to identify Wastescapes, the REPAiR WP3 team provides a first draft mapping of Wastescapes in the focus areas. Successively, during the PULLs workshops, but also during the PULLs meetings in general, the first draft mapping of Wastescapes is discussed and consequently updated by mixed teams of researchers and local stakeholders, specific to the different case studies. In other words, Task 3.1 in WP3 can be understood as a recursive process in which WP3-teams define draft maps based on data provided by PULLs. Then, the drafts are reflected on in the PULLs, and WP3-teams collect feedback to improve them. This process can be replied more times.
The Wastescapes identified in the focus areas will be taken into consideration even if they are located in zones subject to a planning instrument. For instance, sometimes the process towards the actual implementation of a plan takes long time; in this case, temporary uses can be imagined in the selected areas.
According to the definition of Shannon (2006), drosscapes are large tracts of abused land on the peripheries of cities and beyond, where urban sprawl meets urban dereliction, also described as landscapes of wasted land. They include contaminated former industrial sites, mineral workings, garbage dumps, container stores, polluted river banks, sewage works and expanses of tarmac used for airport parking lots and military compounds. At the same time, Berger (2006) identifies drosscape as integral to the essence of the urban landscape, not the void between bits of the urban landscape.

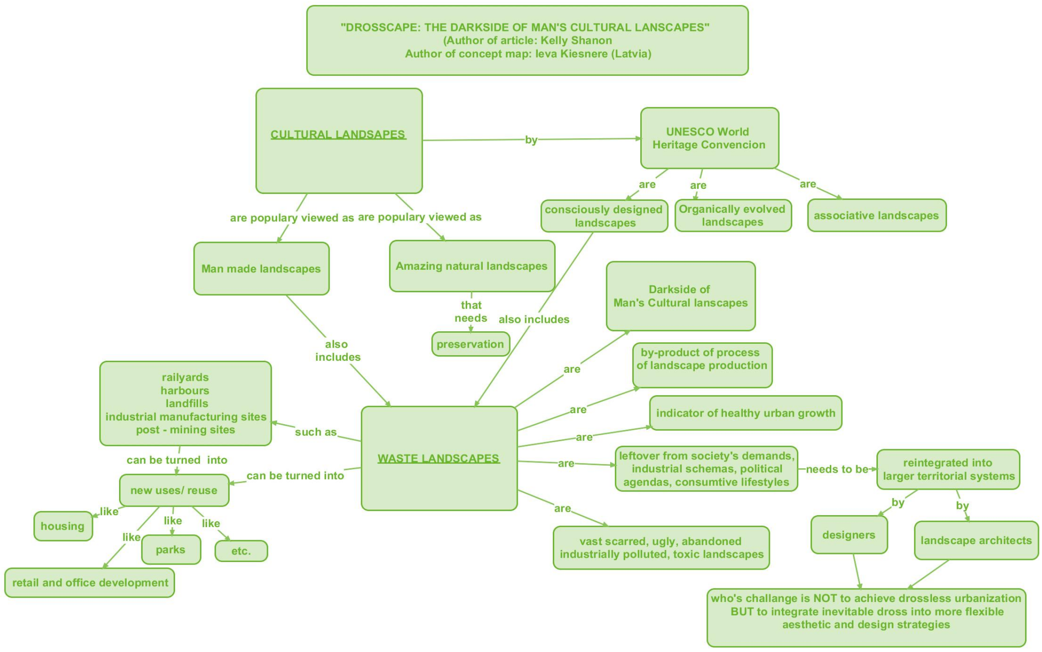


Figure 7: Concept map of Waste Landscapes definition (source: https://fluswikien.hfwu.de)

15

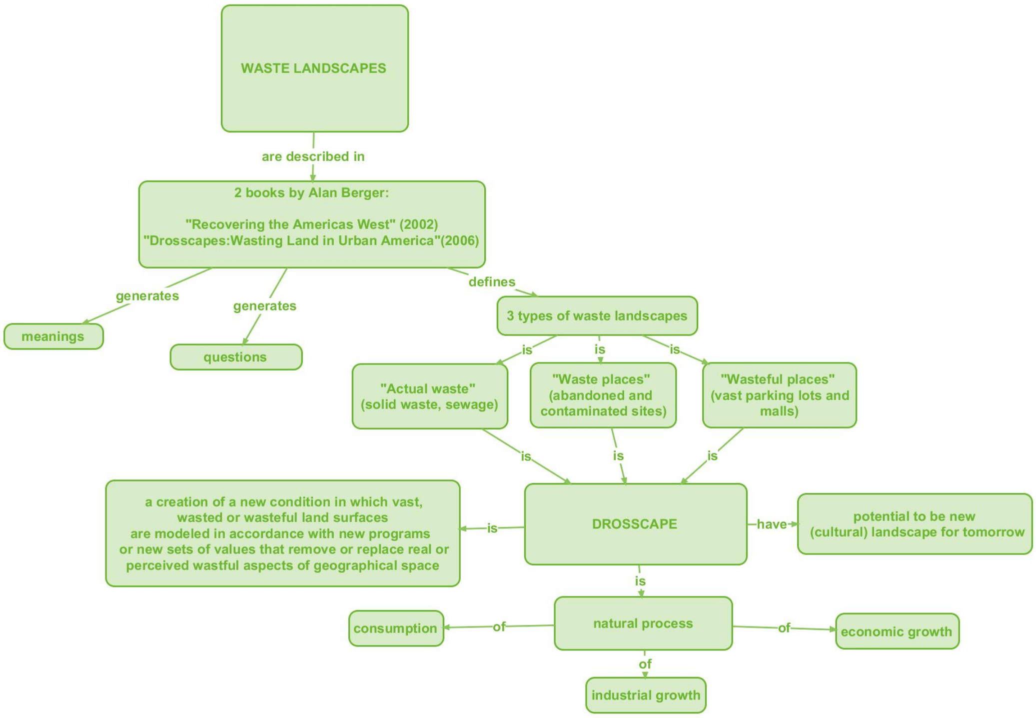


Figure 8: Concept map of Waste Landscapes definition (source: https://fluswikien.hfwu.de)

The concept maps (Figures 7 and 8) synthesize the descriptions of drosscapes and waste landscapes already in the literature, linked to the concept of "uses", distinguishing between use in the past, current use, and possible use in the future, and the concept of "relations", considering tangible and intangible relations. Uses and relations take into account transformation process and production model, and the effects on the quality of life, wellness and health.

Economic growth, industrial growth and consumption contribute to drosscape creation and the identification of three main types of wastes landscapes: actual wastes (solid waste, sewage); waste places (abandoned and contaminated sites); and wasteful places (vast parking lots and malls).

Starting from the above considerations, a more articulated definition of Wastescapes has been elaborated in the REPAiR project, see also the next section, with regards to 'Analysis and Mapping Wastescapes methodology'.

2.1.4 Concepts & Tools

Delineation of the focus area

The delineation of the focus area is obtained by the superposition of the different maps/data, considering the different 'geographies' (Steinitz, 2012; Haining et al., 2010) that characterise the focus area; General Geography (GG), Physical Geography (PG, and Human Geography (HG), able to identify:

1. Maps for the classification of urban, rural, and peri-urban areas.
2. Maps to identify those areas, informed by relevant policy documents as well as earlier research and ongoing initiatives as crucial for the development of a circular economy respectively an improvement of waste management.
3. Maps identifying the Wastescapes, which are patches of landscape related to waste-cycles both by functional relations and because they are 'wasted lands' i.e. neglected/discarded spaces.
4. Maps representing the assessment of the key areas for the establishment of a CE by experts and stakeholders of the case study, obtained by the analysis of interviews (WP 6, D6.1 and D6.2) and during PULL workshops.

5. Maps identifying the location of the generation, processing and treatment (processes) of the key waste flows identified for the case study.
6. Maps with the smallest spatial statistical units for which basic demographic data are available.

In particular, the General Geography (GG) is the repartition of physical environment, expression of territorial system relations, and can be articulated into two sub-fields, as follows: administrative and not administrative boundaries.
The Physical Geography (PG) is the features of the physical environment, expression of ecosystems relations, and can be divided into the following sub-fields: air, water, nature, land.
The Human Geography (HG) is the study of the spatial organization of human activity and human interaction with the physical environment, expression of socio-economic systems relations, and can be analysed considering the following subfields: culture, development, economics, health, governance, population, urban features.

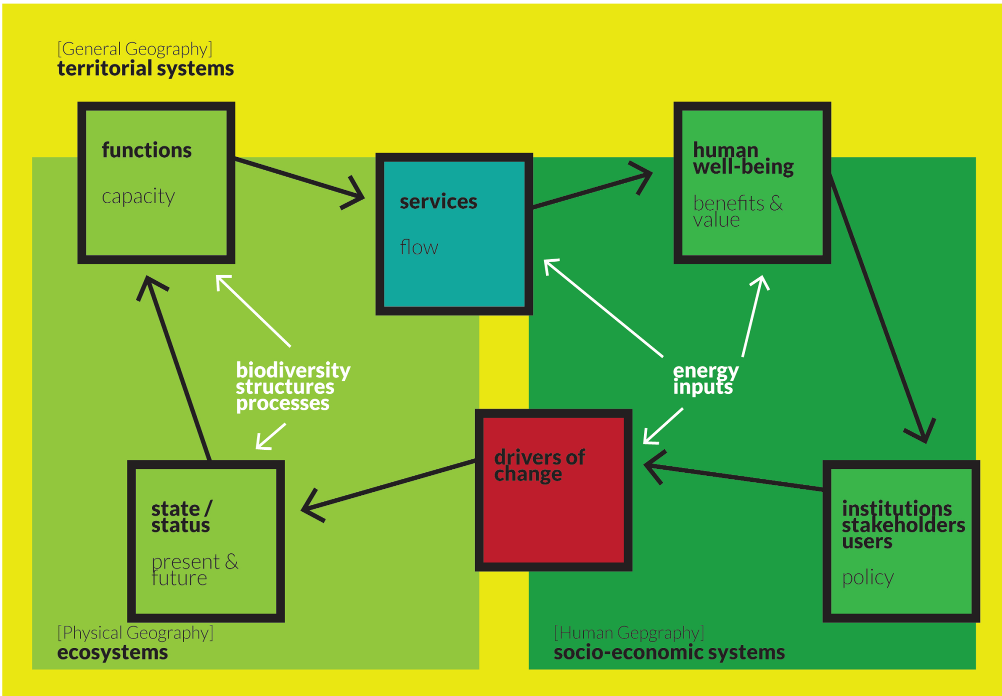


Figure 9: General Geography (GG), Physical Geography (PG) and Human Geography (HG): interaction of ecosystems and socio-economic systems

Delineation of the urban, rural and peri-urban areas

The delineation of urban, rural and peri-urban areas in the region follows the methodology described by Wandl et al. (2014): The method is based on population density, land use and intermingling of built and un-built features. In summary, the spatial delineation method can be described in the following four steps:

- Dividing the area into 500m x 500m grid cells;
- Selecting those grid cells with a population between 38 and 1,250 inhabitants;
- Adding grid cells, with a rural density of maximum population density that overlap with areas of the CORINE land cover[1] classes industrial or commercial units, port areas, airports, mineral extraction sites, waste sites, port and leisure facilities, and all major roads and railway tracks and associated land;

[1] CORINE Land Cover, see: http://land.copernicus.eu/pan-european/corine-land-cover

- Subtracting all cells that are classified continuous urban fabric according to the CORINE land cover classification.

For some cases, data in this specific spatial resolution may not be available; in this case the most detailed data available should be used, allowing for a clear definition of the focus area and a substantive understanding of its characteristics.

Geographies: classification of information, composite indicators and spatial representation

The identification of the system boundaries of the focus area with GIS-based data and maps needs the selection of suitable criteria and indicators able to describe the main relevant characteristics and analyse urban, peri-urban and rural peculiarities (Haining, 2003, 2009; Haining et al., 2010). Each focus area can be explored considering three main categories of Geographies:

1. General Geography (GG), that identifies boundaries, administrative and census;
2. Physical Geography (PG), related to air, land, nature and water;
3. Human Geography (HG) related to culture, economics, health, governance, social, settlements and infrastructures..

The sources of data to define the Geographies described above are composed by: statistical data (local and European data as Eurostat and EEA), planning instruments, public policies, and administrative documents.
The articulation of the Sharing Knowledge Base (SKB) (Figure 10) can be declined according to a hierarchical framework, from the general level to specific one, selecting suitable criteria and indicators useful to analyse each geography level.

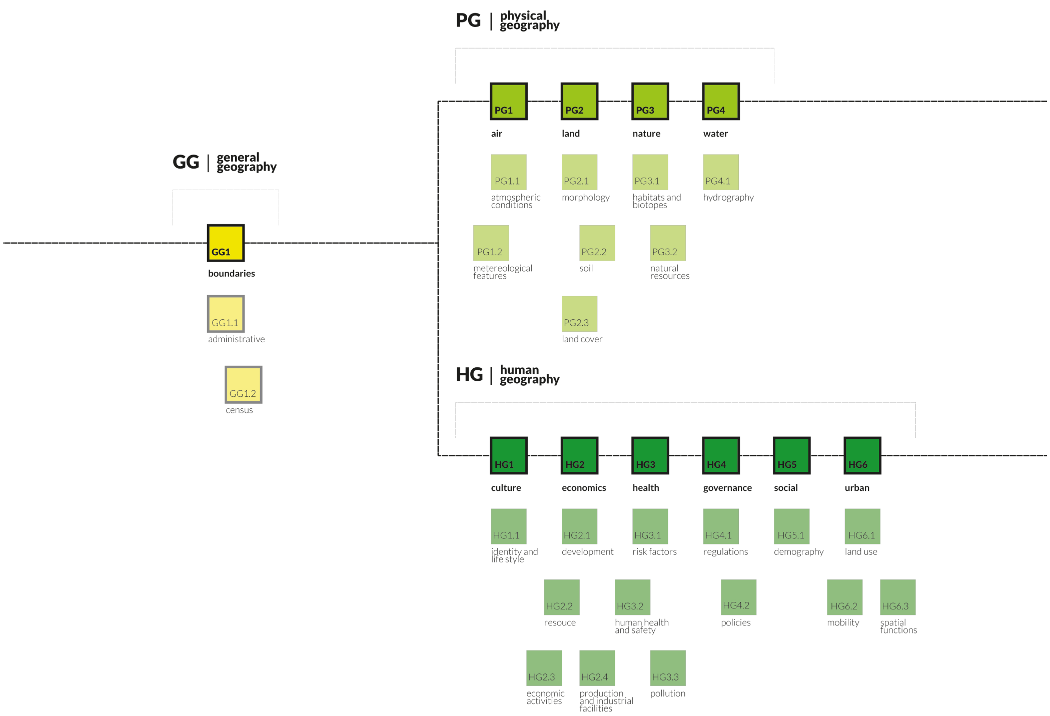


Figure 10: Sharing Knowledge Base (SKB): Geographies decision tree

Peri-urban areas have no clear boundaries, and the identification of the different typologies can be based on the assumptions that more than one type of peri-urban areas can exist. Indeed, a multidimensional approach, able to link the physical, economic, social and personal aspects, is needed to capture the variability and the complexity of the peri-urban character.

The "peri-urban character" can be considered as a mixture of multiple disciplinary aspects including settlement patterns, accessibility of infrastructure, diversification of the economy, territorial impacts of structural change in land use, conservation and enhancement of the natural capital (Hornis and Eck, 2008), cultural heritage, cooperation between rural and urban authorities at the local administration level (Korcelli et al., 2008), underlying urbanization processes (Iaquinta and Drescher, 2000) or mobility patterns (Allen, 2003).
Some recent studies of the Technical University of Lisbon 2013–2016 (Moreira et al., 2016; Gonc¸alves et al., 2017) underline that both peri–urban areas identification and assessment need transdisciplinary indicators, and their selection can be articulated considering sectorialiation and interdisciplinarity of problems; Quadruple Helix[2] actors' roles; integration (inter / trans) process; and transdisciplinary assessment of integrated outputs results.
If we consider that there are many types of homogenous peri-urban area, each with distinguishable features, multiple dimensions have to be taken into account to describe the complexity of the peri-urban character, requiring a transdisciplinary approach linking the physical, economic, social and cultural aspects, and taking into account the views of local and regional stakeholder. The Quadruple Helix (QH), with its emphasis on broad cooperation in innovation, represents a shift towards systemic, open and user-centric innovation policy, able to activate different levels of co-production with consumers, customers and citizens. QH also sets a challenge for public authorities and the production of public services (Arnkil et al., 2010) in PULL decision context.
In order to implement a transdisciplinary approach it could be useful to identify some composite indicators, according to the Handbook on Constructing Composite Indicators of Organization for Economic Cooperation and Development (OECD, 2008), that defines an indicator as a quantitative or a qualitative measure derived from a series of observed facts that can reveal relative positions in a given area. When evaluated at regular intervals, an indicator can point out the direction of change across different units and through time. Indicators are useful in identifying trends and drawing attention to particular issues, in setting policy priorities and in benchmarking or monitoring performance.
In particular, a composite indicator is formed when individual indicators are compiled into a single index on the basis of an underlying model. The composite indicator should ideally measure multidimensional concepts that cannot be captured by a single indicator.
In general terms, the construction of composite indicators considers the following steps:

1. Theoretical framework for the selection and combination of single indicators into a meaningful composite indicator;
2. Data selection, on the basis of their analytical soundness, measurability, country coverage, relevance to the phenomenon being measured and relationship to each other;
3. Imputation of missing data, considering different approaches for imputing missing values;
4. Multivariate analysis, able to investigate the overall structure of the indicators, assess the suitability of the data set and explain the methodological choices;
5. Normalisation of indicators to render them comparable;
6. Weighting and aggregation of indicators according to the theoretical framework, including correlation and compensability issues, also with the support of Multi-Criteria Analysis and/or Multi-Group Analysis;
7. Robustness and sensitivity in order to assess the relevance of the composite indicators, and the choice of weights and the aggregation method;
8. Back to the real data, considering that composite indicators should be transparent and fit to be decomposed into their underlying indicators or values;
9. Links to other variables, correlating the composite indicator with other indicators, or identifying linkages through regressions analysis;

[2] Quadruple Helix: innovation cooperation model or innovation environment in which users, firms, universities and public authorities cooperate in order to produce innovations (Arnkil et al. 2010).

10. Presentation and visualisation of composite indicators can be a relevant factor that influences their interpretation. Spatial representation by maps is particularly effective for urban and regional studies.

Taking into account the previous considerations, the methodological framework able to describe the articulation of geographies (General Geography, Physical Geography and Human Geography) in the SKB (Figure 10) considers the following main steps:

1. Data collections, including the different national and international sources;
2. Missing data, analysing the critical aspects;
3. Define geography layers and indicators tree, selecting the relevant criteria for the specific case study;
4. Multivariate analysis, exploring the phenomena linked to each indicator;
5. Geography maps, elaborating a spatial representation of the different indicators;
6. Data normalization for the different typologies of indicators;
7. Geography indicators, representing every component of each geography (General Geography, Physical Geography and Human Geography);
8. Composite indicators, as aggregation of weighted simple ones; the weighting process also takes into account the interaction with stakeholders through Multi-Criteria and Multi-Group Analysis;
9. Composite indicators, elaborating spatial representation of specific issues related to each geography component.

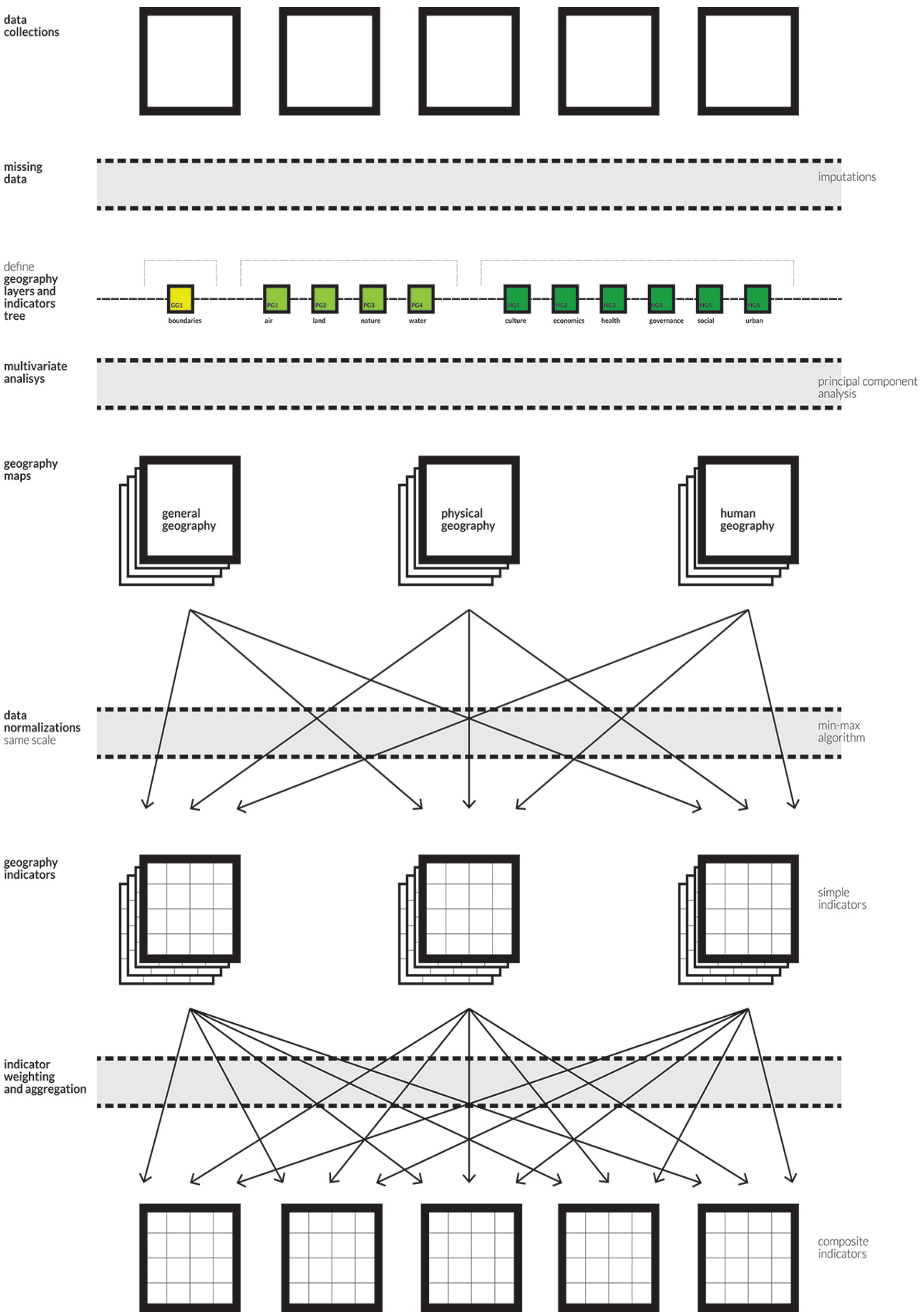


Figure 11: Framework for geographies knowledge

In Figure 12, the decision tree related to each geography identifies the different levels: Geography, Thematic area, Topic, Sub-topic, Layer, Indicator (see also [Table Integrated_Indicators_v2_Rev](#) for a [Dataset list](#)).

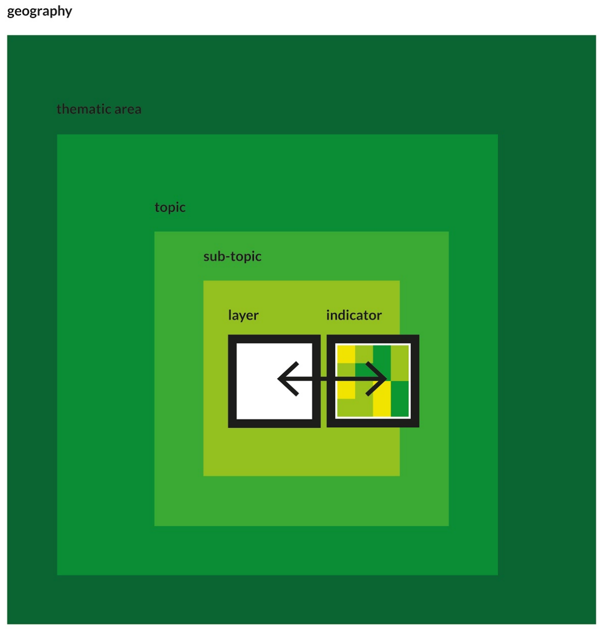


Figure 12: From geography to indicators: the hierarchy of levels

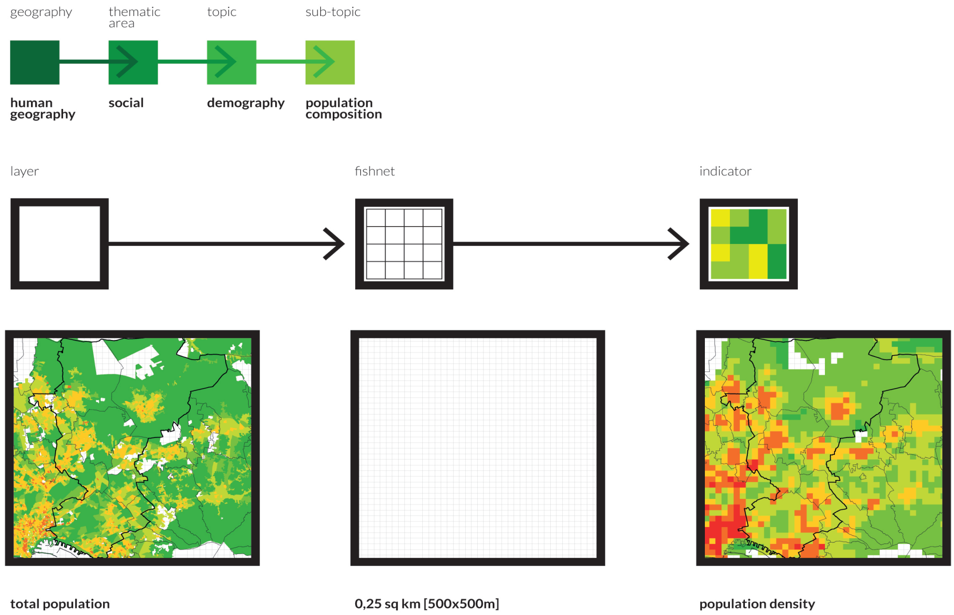


Figure 13: From geography to indicators: an example

The methodological process described above is part of a more complex context, where territorial system, spatial system and stakeholders system interact and characterise the specific Wastescapes (Figure 14).

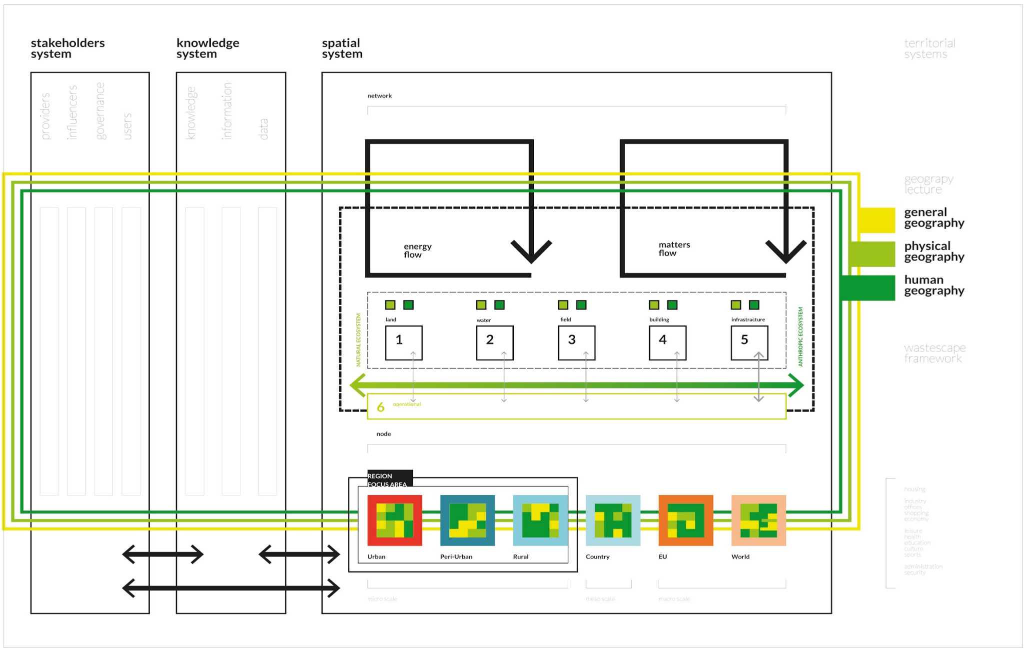


Figure 14: Interaction among the different systems: Methodological framework for spatial analysis

A methodological framework for a comprehensive Wastescapes characterisation, focusing on the material and immaterial relations, is consistent with the need to identify how the interaction of different geographies can be observed, understood, evaluated and monitored.

The scope of characterisation methods however, is by and large limited to the Wastescapes, expression of new 'hybrid' types of space that fall outside existing characterisation methods. Indeed, the project's aim is to produce a comprehensive Wastescapes characterisation approach for peri-urban areas in order to understand, evaluate and monitor their critical aspects and potentials. The methodological process is articulated considering three main steps (Figure 15):

1. The identification of knowledge base, where the geographies layers are selected, distinguishing among the General Geography (GG), that identifies the repartition of physical environment, the Physical Geography (PG), that expresses the features of the physical environment, the Human Geography (HG), that describes the spatial organization of human activity and human interaction with the physical environment;
2. The implementation of a checklist analysis, able to identify real features (objective, hard data, as erosion, pollution, deforestation, underuse, dereliction, over-harvesting, etc.) and perceived features (subjective, soft data, as dirtiness, smell, noise, useless, inaccessibility, risky, etc.) that characterise each Wastescape, expressed by the geography composite indicators;
3. The elaboration of Wastescapes categories, considers a cluster including a hybrid combination of both natural and anthropic ecosystems, formed by soil (1), water (2), field (3), building (4) and infrastructure (5). The interaction of the five main categories is represented by the operational infrastructure of waste (6). Each category of Wastescape can be identified on a map, resulting from an aggregation of composite indicators.

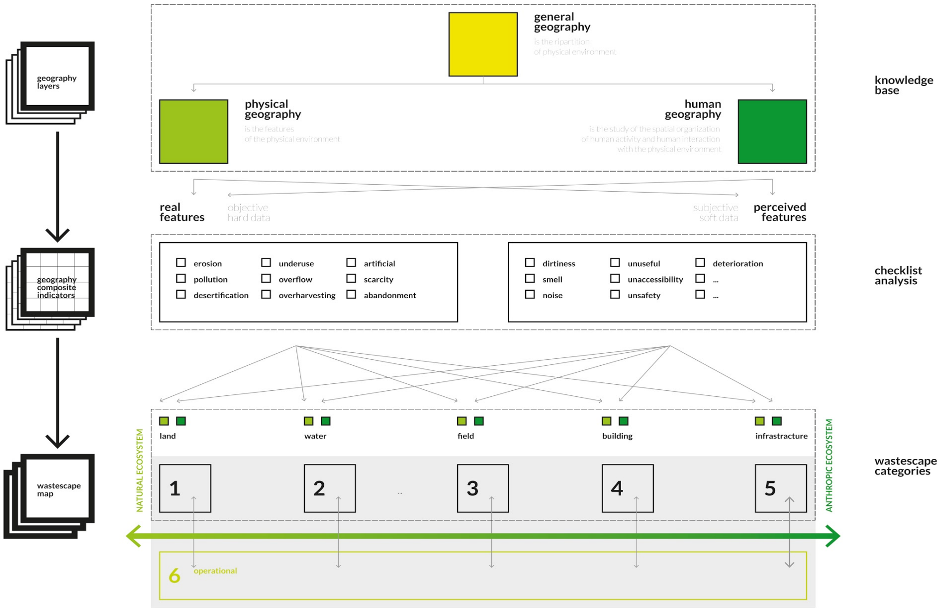


Figure 15: From geographies to wastescapes classification and maps

Spatial information data relating to focus area are the basis of general, physical and human geographies. Spatial information in Europe can be described as fragmentations of datasets and sources, with gaps in availability, lack of interoperability or harmonization between datasets at different geographical scales and duplication of information collection. This generates a need for a unified and standardized framework to support seamless integration of geographic data from different sources. At national and at EU level awareness has grown about the need for quality geo-referenced information to support the understanding of the complexity and interactions between human activities and environmental pressures and impacts.

Data for spatial analysis must contain two classes of information:

1. The 1st class includes attributes of spatial features measured in interval or ratio variables;
2. The 2nd class involves the location of a spatial feature described by position on a map measured in one of many geographic coordinate or referencing systems.

Data are extracted from each dataset to compose the layers of the spatial knowledge. Each layer contributes to the construction of integrated territorial interpretation related to the spatial investigation objective. For each data identification card we consider:

- Type of Geography
- Thematic area
- Topic
- Sub-topic
- Layer
- Indicator
- Data references
- Source
- Map and/or picture

The Atlas of data identification cards will be elaborated taking into account the decision tree of Figure 10 and selecting the most relevant information and the related map and/or picture.

Analysis and Mapping Wastescapes methodology

Going beyond the material dimension of waste flows, REPAiR includes in its experimentations the category of Wastescapes, that embrace the spatial effects of waste flows on the landscape, as well as all the residual spaces scattered in the peri-urban areas object of the study.

Wastescapes are fragmented spaces of contemporary peri-urban European territories. They are related to the spatial effect of the material waste flows on the territories, and to the configurations of the infrastructures for their management. From a spatial, environmental, and social point of view, Wastescapes could represent challenging areas. Therefore, in order to be spatially connected with the surrounding settlements and become accessible areas as public spaces, they need to be transformed and regenerated.

As stated in the Spatial Analysis Glossary of the Deliverable 5.1 PULLS Handbook (Russo et al. 2017), Wastescapes are: 'patches of landscape related to waste-cycles both by functional relations and because they are "wasted-lands": areas not included in the peri-urban development scenarios, becoming neglected spaces. According to Berger (Berger, 2006) we define drosscape as accumulation "in the wake of the socio – and spatio – economic processes of deindustrialization, post- Fordism and technological innovation. [They] are located in the declining, neglected and deindustrializing areas of cities". The notion of drosscape emphasizes the opportunity to reuse the material scrapes of the city, as in-between areas and abandoned spaces, going beyond the mere spatial reference of soils and fields and embracing the wider and multidisciplinary field of landscape. In the REPAiR research focus, the Wastescapes involve also the spaces that enable the urban system to be efficient. According to Brenner (Brenner 2014) the operational landscapes, like mines and infrastructures, are not perceived as part of the city because of the lack of relations with the urban settlements and the gap with the human dimension. Nevertheless, these new geographies of the urbanization phenomena are the working engines of the system and should be considered as urban spaces involved in the urban policies and strategies. What we call "operational infra of waste" are areas related to waste management function as incinerators, landfills, big waste treatment and waste disposal plants, waste-recycling plants, waste-water processing plants and even former industrial areas waiting for reclamation by the State. Territories in-between belonging to our case study host these infrastructures for waste-disposal, which shaped peri-urban areas and are managed by national and local policies.

REPAiR defines 5+1 categories of Wastescapes that are considered as innovative resources to be reintegrated in the metabolic dynamics for an improved quality of the peri-urban areas investigated. These 5+1 categories are grouped in DROSSCAPES and OPERATIONAL INFRASTRUCTURE OF WASTE.

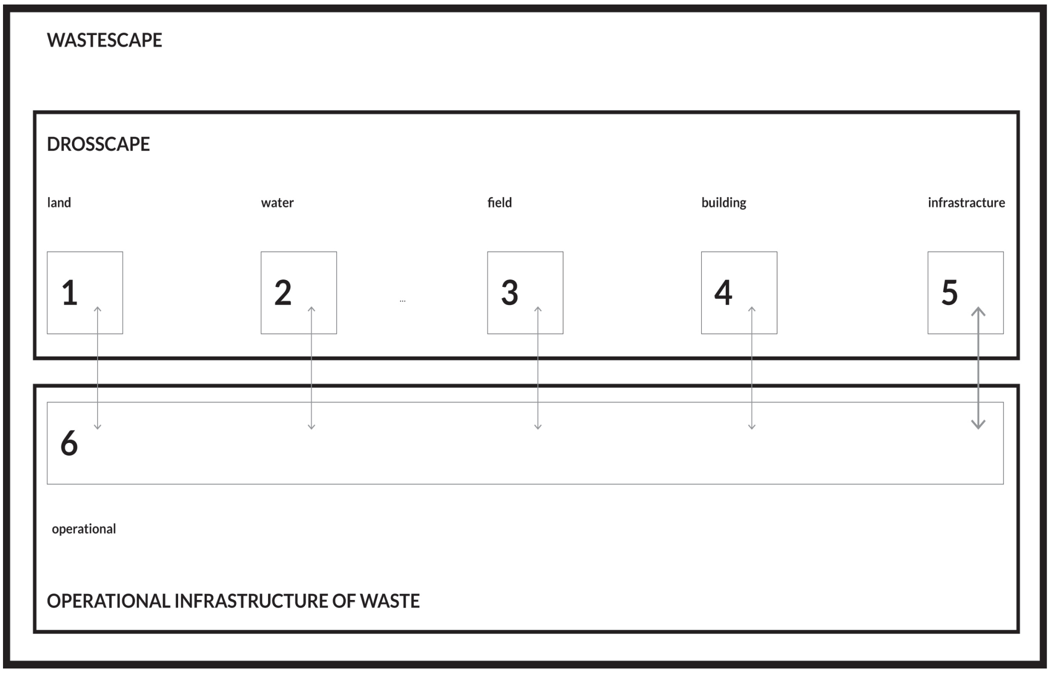


Figure 16: Wastescape set

DROSSCAPES

1. Degraded land (W1)
2. Degraded water and connected areas (W2)
3. Declining fields (W3)
4. Settlements and buildings in crisis (W4)
5. "Dross" of facilities and infrastructures (W5)

+

6. OPERATIONAL INFRASTRUCTURE OF WASTE (W6)

For a better understanding about how to identify Wastescapes in the REPAiR focus areas, a description of the 5+1 categories s is provided below.

Within the category of DROSSCAPES there are:

1 Degraded lands (W1)

Lands that have lost some degree of their natural productivity due to human-caused processes, this category includes: polluted (W1.1), bare (W1.2) and artificial soils (W1.3).

Polluted soils (W1.1) are marked by the presence of significant quantity - as defined by the reference indicators - of xenobiotic chemicals or other human-made drosses (Panagos et al., 2013). This kind of land can be found in proximity of industrial/port areas, main infrastructures (mostly pipelines) and facilities (e.g. wastewater treatment plants), as well as in areas close to landfills and other waste treatment plants. Contamination can also be the product of industrial agriculture, due to the massive use of pesticides, herbicides and other chemicals. In order to identify polluted soils, it is necessary to investigate the availability of data about the presence of pollutants in the ground. Generally, the most common chemicals involved as polluting are: petroleum hydrocarbons, polynuclear aromatic hydrocarbons, solvents, pesticides, and heavy metals (lead and others). For instance, in the case of Amsterdam, polluted lands contamination depends mainly on the presence of lead in the soil. (Omgevingsdienst Noordzeekanaal:

https://gisviewer.odnzkg.nl/?@Lood). In the case of Naples, the most polluted site is close to former oil refinery plants, near the commercial port, where the amount of hydrocarbons is very high. Also former landfills between Casoria and Afragola have been mapped as degraded-land.

They are ***bare soils*** (W1.2) when damaged: their eco-nat value is low or decreasing, not anymore in equilibrium, becoming increasingly arid, losing vegetation and wildlife. The presence of vegetation is essential for the biological composition of the soil, since the rate of erosion and runoff decreases exponentially when vegetation cover is not adequate. If unprotected, dry soil surfaces blow away with the wind or flash floods, leaving infertile lower layers that bake in the sun and become an unproductive hardpan. Desertification of land is caused generally by over harvesting through human activity. Even the rise of the salt water (near the coast) may lead to the desertification of former agricultural areas. At macro level, climate change, contributes to land desertification. Bare soils are not suitable anymore for agricultural purposes, due to a dramatic depletion of nutrients in soil that are essential for it to remain arable. This phenomenon, in general, produces serious threats to biodiversity: that is why it is directly linked to the ecological value of the site.

Finally, ***artificial soils*** (W1.3) are degraded lands because of significant morphological transformations, like quarries, digs and artificial dams.

2 Degraded water and connected areas (W2)

This category includes both properly degraded water bodies; elements functionally related to them; and territories in crisis for hydraulic reasons. The following subcategories are distinguished:

W2.1: water bodies, degraded for quantitative or qualitative reasons (i.e.: polluted, draining up, overflowing, etc.): rivers, canals, basins, streams, ditches, water pipes, culverts, wells, etc.
W2.2: banks, shores, tanks, plants, and other elements linked to W2.1
W2.3: flooding zones.

Water degradation depends on both qualitative and quantitative issues. Water quality degradation is mostly a result of contaminants directly or indirectly discharged into water bodies. It may be the product of a single source, such as a pipe or a ditch. For instance, it depends on inadequate treatments of sewage outfalls.
Moreover, degradation of water can be the result of diffuse contamination, generally caused by intensive agriculture and farming - based on the use of pesticides and other chemicals (Moss, 2008). Sometimes, diffuse contamination of water-drains comes from the presence of chemicals used decades ago, especially during the 1940s and 50s: DDT and other pesticides now banned with a long decay time.
The assessment of water quality is generally carried out through the measurement of nitrogen and phosphorus, sensors of the presence of plants, algae, microbes and other biological elements necessary for aquatic ecosystems.
As said, degradation is also linked to *quantitative* issues.
For the effect of reductions of flows (of rivers and canals), the network of secondary conduits and ditches can dry up, all year long or only for certain periods. So, some former water bodies become unused or underused and the landscape of their surroundings, drained up, loss the riparian vegetation.
On the other hand, for the effect of peaks of overflow, some lands are vulnerable to flooding. Furthermore, there are areas susceptible to flooding just because the water table is almost at the surface and also a sudden storm can cause difficulties

and disruption for people and things (groundwater outcrop). The origin of the hydraulic crisis can result from human actions: conversion of canals and rivers in pipelines; spread of water wells; concreting of banks and shores; etc.

3 Declining fields (W3)
This category addresses vacant/under-used fields, vacant parcels, and vulnerable soils. The subcategories are: Abandoned fields and parcels (W3.1), and Vulnerable lands (W3.2)

Abandoned fields and parcels (W3.1) are areas that are not used anymore for the function they were planned or long-time used; they are essentially out of their expected life-cycle, in a waiting condition, ready to be used in alternative ways. Sometimes soils are abandoned because of pollutants present in the ground, therefore not suitable anymore for residential or agricultural uses, for example.
Fields are open land areas, free of woods and buildings. Generally, they are included in rural environments and in fringes with a low rate of buildings. Vacant and underused fields are often former agricultural ones. Nowadays, the soil can be yet natural or compromised by concreting and asphalting of surface. Parcels are sections or areas of land dedicated (by plans) for buildings. They can be in a condition of "suspension", since, as effect of financial crisis, demand for new building has plummeted.
In the case of Amsterdam, many abandoned areas are located in the industrial port area. In the Neapolitan one, large former agricultural fields are located close big infrastructures, like the new High-speed rail station for Napoli-.Afragola.

Vulnerable lands (W3.2) are characterised by hydrogeological and/or seismic criticality, such as landslide or instability risk. The international scientific community has adopted a common point of view regarding risk - "vulnerability" - that is a result of two interacting factors: natural hazard and human presence. So, the industrialized and economically advanced territories, with high density of population, are generally more vulnerable than lower anthropic pressure ones. These phenomena need to be mapped in order to intervene in such areas, that can be understood as potential Wastescapes, because vulnerable spaces, that means more exposed and sensitive to disturbances.

4 Settlements and buildings in crisis (W4)
The subcategories are: Vacant/underused, neglected or obsolescent buildings and settlements (W4.1), and Unauthorized, confiscated, buildings and informal settlements (W4.2).

Vacancy and underusing of buildings and settlements (W4.1) can be the direct consequences of phenomenon of urban decline, due to several factors in the organisation of the territory. Economic changes/crisis could also cause abandonment of settlements, or of some parts of them. Abandonment and underusing are often accompanied by the degradation of building finishing (plasters, fixtures and windows, etc.) and, when the underutilisation has spread to neighbouring buildings, abandonment and depletion of public space. Economic changes/crisis could also cause abandonment of settlements of their portions.
Sometimes, underutilisation and vacancy of some parts of a buildings push filtering down of the neighbourhood, as degrading dwellings can be used by weak groups: immigrants, refugees, low-income and low-educated people.
In this category abandoned, vacant, underused, dismissed industrial, commercial, military buildings are also included.
In the peri-urban areas of Amsterdam and Naples, also unused or underused former rural buildings and structures (farm as well as greenhouses), are often

found. Furthermore, since the financial crisis, many commercial malls along the main roads are stuffed, as well as productive 'big boxes' and settlements. In the city cores of the neapolitan conurbation many dwellings and commercial properties are vacant. In the Amsterdam case there is a huge problem of office vacancy, that are now in a 'waiting condition' to be reused in creative ways. Vacant culture, hotel, restaurant, cafè are also present in the Amsterdam case.

Unauthorized, confiscated, buildings and informal settlements (W4.2)
In Naples peri-urban area many buildings and settlements are built-up without permission. That is a condition of informality common all over Southern Italy: in the Naples case, several hundred thousands of buildings are unauthorized. In Italy, all the unauthorized buildings after 2004 are not legal: they are to be confiscated by municipalities that can decide if reusing or demolishing them.
Finally, another category of confiscated buildings and areas are those subtracted for judicial reasons: confiscated as result of bankruptcy, scams, corruption or because owners are affiliated with criminal organization (in the case of Naples confiscated to mafia organizations).

5 'Dross' of facilities and infrastructures (W5)
This category includes: dismissed or underused Infrastructures (W5.1) and Facilities (W5.2) as well as - both active and dismissed - areas connected to them (W5.3).

In peri-urban areas there are neglected - dismissed or underused - infrastructures as roads, railways, pipelines, power lines, sewerage, etc. (W5.1). Also, dismissed or underused facilities, like parking areas, petrol stations, service areas, plants, etc., are included (W5.2). Moreover, interstitial spaces of infrastructure networks, both active and neglected ones, are also to map (because they are often public owned and lack of use): road intersections and slopes, areas under viaducts, railway embankments, buffer zones of pipelines, aqueducts, power lines, and plants (W5.3).

This category includes some intangible Wastescapes that can be mapped and are not immediately recognized spatially: the noise and the odour landscapes. For instance, in the case of Amsterdam, the noise landscape is mainly the result of two activities: the airport noise and the port/industrial noise; this overlap makes the selected area within the focus area very problematic in this respect. Of course, also active railways and roads produce noise impacts. Odour pollution can be the result of agriculture and farming, as well as productive activities. People react in different ways to odours and so, in addition to data, a perceptive dimension is necessary to investigate in the Peri-urban living-labs about this last category.

+

6 OPERATIONAL INFRASTRUCTURE OF WASTE (W6)
Operational infrastructures of waste are related to the facilities dedicated to the waste storage and management. Therefore, they are quite easy to be located and mapped, as dots spread in the peri-urban areas. REPAiR includes in this category the waste collection and storage points, incinerators and landfills, the site for waste dismantling, and processing. Together with the roads and the infrastructures that connect these dots operational networks emerge.[3]

[3] These networks can be linked to several subsystems. In the case of Amsterdam, for instance, the heat network has been mapped as well.

Data for mapping Wastescapes can be provided by, for example:

- (Regional) environmental authorities - about pollution of soils, water and air (i.e. for Naples pilot: http://www.arpacampania.it);
- Basin (and/or hazards) authorities - about risks (i.e. for Naples pilot: http://www.adbcampaniacentrale2.it)
- Real estate registry – about land and building use and property (https://www.catastoinrete.it/acquisto_immediato_visure.asp?IdC=34875654&gclid=CNiS37OD0tYCFRPjGwodH7IISA)
- Plans and studies related to public policies and surveys (from Regional and Metropolitan authorities but also from municipalities and private developers or enterprisers)
- Processing of aero-photogrammetry and aerial images

Last but not least, the diagram of Figure 17 visualises interactions between spatial analysis, - activity-based spatial - material flow analysis (Chapter 2.2), and social analysis (Chapter 2.3), from the perspective of Wastescapes.

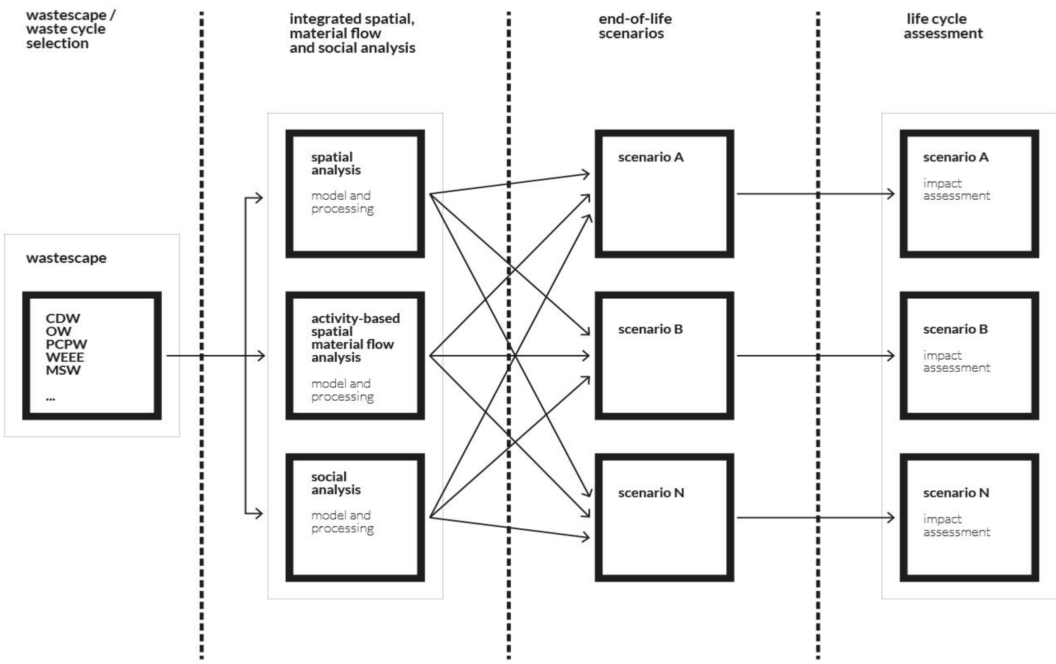


Figure 17: Wastescapes: interaction of spatial analysis, activity-based spatial material flow analysis, social analysis

2.1.5 Outcomes & Validation

The expected outcomes of the spatial analysis process, as described in the preceding sections, are listed below:

1. Clear definition and delineation of the system boundaries: identifying the key areas that need to be investigated;
2. Description and spatial representation of geographies (GG, PG, HG) of the different study cases;
3. Mapping of Wastescapes within the focus areas, in accordance with the categories listed above;
4. Spatial representations of the eco-innovative solutions and their effects on the territory.

The WP3 team will produce drafts of the graphics related to the spatial analysis. In following iterations these can then be adjusted/fine-tuned. Validations of the outputs will happen during the Living Labs and, more specifically, during the PULL workshops, tapping into the technical competences and knowledge of the stakeholders involved. The Figure below visualises the draft map as used in the first three PULL workshops concerning the Naples case study.

Figure 18. Draft map used in the first three PULL workshops in Naples pilot

2.2 Task 3.2 | Material Flow Analysis

2.2.1 Introduction to Task 3.2

"Material Flow Analysis (MFA) is a systematic assessment of the flows and stocks of materials within a system defined in space and time. It connects the sources, the pathways, and the intermediate and final sinks of a material. Because of the law of the conservation of matter, the results of an MFA can be controlled by a simple material balance comparing all inputs, stocks, and outputs of a process. It is this distinct characteristic of MFA that makes the method attractive as a decision-support tool in resource management, waste management, and environmental management" (Brunner and Rechberger, 2004).

In Task 3.2 of WP3 in REPAiR, MFA is used to study the material flows and stocks of the subsystems of the six case studies, based on consumption patterns and waste production. By introducing a new method for MFA, "Activity-based Spatial Material Flow Analysis" (AS-MFA), specific activities relating to material flows and stocks from waste production in subsystems, the involved actors and their interrelations can be identified. The AS-MFA aims to connect the spatial, material and social analyses in REPAiR.
Before introducing the AS-MFA further, this chapter begins with describing the goals and scope of Task 3.2 and the concepts and tools that will be used. That part includes the various system boundaries and scopes that have been set. Thereafter, the goals and scopes of AS-MFA, its employed databases, data requirements, terminology and the methodological steps will be presented. Finally, anticipated and first outcomes will be shown.

2.2.2 Goals & Scope of Task 3.2

The overall goal of Task 3.2 is to generate MFAs for two to three key flows for each of the six European metropolitan regions. More specifically it aims to:

- Determine the qualitative and quantitative waste flow specifications in content, space and time
- Identify the specific activities relating material flows & stocks from waste generation in subsystems
- Identify the area's major physical and human geographical processes in relation to waste management
- Find out how and where the associated processes are interlinked
- Illustrate the magnitude of stocks and flows on a map (quantification)
- Perform a plausibility check of the available data with regard to these processes

As for the scope of the task, it deals with the concepts of Urban Metabolism and Material Flow Analysis, both of which are further explained in the following chapters and the latter having scopes of time, space, material, and system modelling on its own.

2.2.3 Urban Metabolism and Material Flow Analysis

Urban Metabolism

Kennedy et al. (2007) define Urban Metabolism (UM) as "the sum total of the technical and socio-economic processes that occur in cities, resulting in growth, production of energy, and elimination of waste." Broto et al. (2012) explain that UM links material flows with ecological processes and social change by the understanding of flows and circularity. Ultimately, UM describes the continuous flows of resources (e.g. water, energy, food, materials, waste, information, people) into, out of, and within any given metropolitan area. It considers the area as interacting subsystems, permanently adapting to political, economic and natural environments. The UM concept has *inter alia* been used as an analytical tool to examine the energy and material exchanges 'between cities and the rest of the world'

(Fischer-Kowalski, 2002). In other words, UM is a framework for modelling complex urban systems' resource flows as if the city were an ecosystem. Using this framework enables studying the dynamics of cities in relation to scarcity, carrying capacity, and conservation of mass and energy (Newman et al., 2009).

REPAiR's objective is to better interpret the link between metabolic flows and urban processes. To achieve this, REPAiR builds on the extended UM approaches (e.g. Minx et al., 2011; Schremmer et al., 2011; Pincetl et al., 2012), in which urban subsystems with their environmental and spatial impacts are addressed more explicitly. REPAiR also builds upon the notion of *synergism* in UM studies, focusing on the benefits of the intrinsic relationships existing within the urban metabolic system (Zhang et al., 2014).

There are several ways of analysing the UM, yet Beloin-Saint-Pierre et al. (2017) point out that Material Flow Analysis and emergy were the most common methods in their literature study. While a MFA can have different material scopes, based on the intention of the study an UM analysis usually records all flows (Minx et al., 2011). However, REPAiR only looks at selected flows in the MFA due to restraints in data and time. There is a certain danger in considering only specific flows, because the systems approach might be lost and environmental problem shifting could remain undetected (Minx et al., 2011). As a result, the same area or system is not comparable on a year-to-year basis since it cannot be guaranteed that the system still fulfils the same functions (Beloin-Saint-Pierre et al., 2017).

Material Flow Analysis

As pointed out in the previous section, MFA is one of the most common methods in UM studies. MFA is a systemic assessment of flows and stocks of materials within a spatially and temporally defined system connecting sources, pathways, and sinks of materials in order to analyse the transformation, transportation or storage of materials (Brunner and Rechberger, 2004; Broto et al., 2012).

Since the system has defined boundaries, the principle of mass conservation aids in the accounting exercise that follows. Allesch and Brunner (2015): "The fundamental principle of MFA is the conservation of matter: Inflows into an MFA system equal the outflows plus changes in stocks to consider accumulation and depletion. Every MFA system as well as each process within the system has to be balanced according to the mass balance principle." The results of the MFA can be a material balance comparing all inputs, stocks and outputs of a process (Brunner and Rechberger, 2004).

To define the scope and system boundaries of the MFA, four methodological choices have to be made with regards to:

1. Temporal scope
2. Spatial scope
3. Material scope
4. System modelling approach

1. Temporal Scope

The temporal scope in MFA is the time span over which the system is analysed and balanced and depends on the investigated system and the related challenge or problem (Brunner and Rechberger, 2004). For cities or countries often a specific year or (average of) yearly variations or a time series (up to multiple centuries) can be chosen, depending on the interest and availability of input data (Brunner and Rechberger, 2004; Beloin-Saint-Pierre et al., 2017).

In REPAiR, the temporal scope used is one year. While "a specific year might not offer much insight on the UM's development" (Beloin-Saint-Pierre et al., 2017, p. 7), data availability, the need to produce appropriate values for the functional unit of the LCA and to have one reference year (status quo) to compare the eco-innovative solutions to are leading in this choice. When data is not available for a specific year an average of yearly variations can be taken. In case that there is enough significant data available to carry out a

time series, then it is possible to do so. However, it should be borne in mind that the LCAs will be carried out using the management of selected key flows during one year-time as proposed functional unit (i.e. service assessed; deviations from this are also possible if relevant to the project). This will be applied to a number of selected case study areas. This means that annual data used in the MFA of the selected case study areas should be representative of the current metabolism (e.g. up-to-date) and, preferably of a year that all case study areas have in common or that is close to others.
When a material is in the system for less than a year, then it is considered as a flow. In case that it stays in the system for more than a year, then it is a stock. If a material was in the system in form of a stock but it is flowing out in the reference year, then it is an (out)flow. With this knowledge, it becomes obvious that considering the lifetime of materials is important.

2. Spatial Scope

The spatial scope in MFA is often determined by the geographical area in which the processes are located and can be the boundaries of a company, town or city, region, country or the whole planet (Brunner and Rechberger, 2004). Beloin-Saint-Pierre et al. (2017) classify these scopes into three levels of geographical boundaries, namely (1) political limit of a city, (2) relative concept of regions (e.g. metropolitan region, state, country) and (3) global, which are used in less than 20%, less than 20% and more than 60% of their reviewed studies respectively.
Simply stating a certain geographical area does not necessarily provide a very precise boundary in terms of actual geographical limits, which in turn diminishes the representativeness of the study (Beloin-Saint-Pierre et al., 2017). Therefore, the researchers in REPAiR make a point of drawing precise geographical boundaries. In fact, in REPAiR there are several spatial boundaries drawn for each case study area (see Figure 3 above), with a method that is presented in chapter 2.1.4 of this handbook.
The region is the spatial scale on which accounting of (waste) material flows and analysis of MFA results take place for the REPAiR case studies. The regional, case-specific boundary is treated as a fuzzy boundary in order to avoid edge effects. Edge effects originate from the ignorance of interdependencies that occur outside the defined boundary (Stewart Fotheringham and Rogerson, 1993). An example of the edge effect is the location of a large generator of waste or a high-volume waste company right outside of the regional boundary. By cutting off these stakeholders, important nodes and interdependencies would be disregarded. Therefore, for MFA, it is ensured that if needed, a distance of 10 km from the regional border is the hard boundary for cut-offs. (These 10 km coincide with the micro impact range of LCA and are therefore deemed appropriate.)
The focus area (FA), as boundary, is not relevant for MFA, as the FA is not an administrative boundary and data gathering (top-down) would be difficult. However, the FA will be considered when specifying the location of activities to state whether an activity in a region is also in the focus area or not, and to provide additional data to the LCA. (For more information on LCA, see REPAiR Deliverables D4.1 and D4.2.)

3. Material Scope

The selection of materials that are to be investigated depends on the purpose of the MFA, the scope, the degree of precision, data availability, the kind of system on which the MFA is based and the financial and human resources that are available (Brunner and Rechberger, 2004). Brunner and Rechberger (2004) distinguish two approaches to define the substances relevant for the MFA:

- Information from listings of relevant substances in legislation or safety codes. This approach is based on existing knowledge.
- Evaluation of the relevance of substances in the important flows of goods. This is based on a study to determine the ratio of substance concentrations in the selected flows of goods.

These two approaches could be used when the task of the project is related to a specific technology or process in order to find potential for optimization. However, they point out that another approach that is often used is related to the determination of a system's metabolism of one or several substances for resource and/or environmental aspects. Then the selection of materials is based on the project definition (Brunner and Rechberger, 2004). REPAiR focuses on the latter. This does leave the selection of materials fairly open, but at the same time enables to tailor it to the project's goals and focus, which is on "waste as a resource."

Before further diving into the various kinds of waste materials, it needs to be stated that REPAiR focuses on waste materials on a material level, as opposed to an elementary or substance level. In doing so, it also looks at the components and goods level, as these can be higher in the hierarchy, as becomes evident from Figure 18, displaying the relationship of substances, materials, components, and goods. The figure shows that substances are lowest in the hierarchy, due to their purest form. They contribute to making up materials, components and/or goods. Materials are the basis for components and goods and so on.

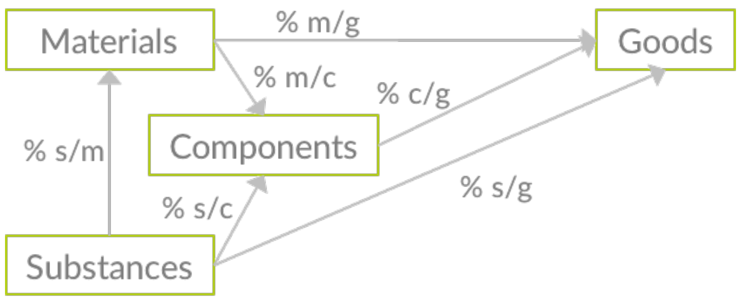


Figure 18: Triangle relationship of substances, materials, components and goods (adopted from ProSUM 2016)

Due to the many variables and different approaches of establishing a scope, as described above, there is generally not one scope to look at in MFA. There is the attempt to establish the economy-wide MFA (EW-MFA), also referred to as the Eurostat method, which is a specific method that dictates the scope. Researchers of UM of cities and regions have tried to adopt this method/scope to their cases and in doing so, they have proposed changes to it to make it more suitable (Voskamp et al., 2016). However, as the name suggests, it encompasses materials of an entire economy and therefore ranges from biomass, to metals ores, non-metallic minerals and fossil energy materials/carriers. As REPAiR focuses on waste, the scope of the EW-MFA is not suitable.

Instead, the material scope for the MFA in REPAiR deals with solid waste material flows starting at the activities and the spatial locations where they become waste, tracing them further on to the collection, waste treatment, and production of new materials/secondary resources that stay in the technosphere. In determining what constitutes waste, REPAiR follows the EC (European Commission Directive 2008/98/EC), which defines waste as: "any substance or object that the holder discards or intends or is required to discard."

Simultaneously, the REPAiR researchers are aware of the European Commission's End-of-Waste (EoW) criteria and acknowledge that waste ceases to be waste when it has undergone a recovery process and complies with specific criteria (Villanueva et al., 2010). Yet, as of now, EoW criteria have only been laid for iron, steel and aluminium scrap, glass cullet and copper scrap (European Commission, 2016). Hence there won't be too many secondary raw materials to be quantified from that stream, unless dealing with CDW. REPAiR still takes these materials into account as they were at one point declared waste. It helps in keeping track of the total wastes and examining their paths. That means that even if waste ceases to be waste, REPAiR continuous to account for this secondary raw material, as it is required for the system-based circular thinking.

Having established that REPAiR operates on the material level and will examine waste, it can now be presented that REPAiR has already made a pre-selection of 5 waste categories in its project proposal since there is an abundance of waste types and subfractions. The selection includes Construction and Demolition Waste (CDW), Organic Waste (OW), Post Consumer Plastic Waste (PCPW), Waste Electrical and Electronic Equipment (WEEE) and Municipal Solid Waste (MSW), as defined by the European Commission (EC), see Table 1.

These categories still constitute a vast range of different materials and application spectra. Moreover, even though the EC's definition is meant as guiding definitions for EU countries, these can adopt their own definitions and classifications; accordingly, municipalities are able to do so as well. In some cases the municipality does not define the classification based on e.g. recycling goals, but the waste collection and treatment companies operating in the area instead do so by proposing a certain range of materials that they accept based on the collection schemes, treatment setups and technologies used. As a result, the definitions regarding sorting and generally waste categories typically vary or are differently adjusted across EU geographic areas.

This is an issue to bear in mind in REPAiR, when comparing waste management systems and flows across different geographic areas. Primarily because the range of definitions and waste management technologies in-use (e.g. pre-treatments such as mechanical-biological plants, pre- or post-sorting plants, waste refineries, etc.) hampers the comparability of datasets on waste generation, recycling efficiency, recycling rates, residual flows, etc. across geographic areas in Europe (EEA, 2013). Beside such comparability issues, it should also be borne in mind that some datasets reported by local authorities on waste flows sorted/separately collected may not reflect the actual quality of the material flow owing to impurities (following e.g. missorting), ultimately affecting the actual recycling rate and circularity.

Table 1: EC waste definitions, compared with other definitions

	Definition from proposal REPAiR:	Updated definition REPAiR:	Relation EC list of waste:
CDW	CDW accounts for 25%-30% of all waste generated in the EU. The level of recycling and reuse of CDW waste varies greatly (between <10% and >90%) across the EU.	Any substance or object, arising out of construction and demolition work, which the owner of the substance discards, intends or required to discard.	- 17: Construction and demolition wastes (including excavated soil from contaminated sites)
OW	This waste flow can include different types of organic streams, depending on the case study area, and may differ slightly from the biodegradable waste classification deployed by the EC, which excludes e.g. forestry and agricultural residues. Two current primary areas of concern in Europe are: the production of methane from biowaste decomposing in landfills, and the growth in food waste.	Defined by the European Commission as biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants. It does not include forestry or agricultural residues, manure, sewage sludge, or other biodegradable waste such as natural textiles, paper or processed wood. It also excludes those by-products of food production that never become waste (EC, 1998, 2016).	- 02: Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing - 20: Municipal wastes (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions

PCPW	In Europe, only 24% of plastic waste is recycled, close to 50% is landfilled, and the rest is incinerated. Large differences exist between the waste-management measures of the EU member states	Any substance or object made out of mouldable polymers that the holder discards	- 20: Municipal wastes (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions + many others, however often not post-consumer
WEEE	WEEE is one the fastest growing waste streams in the EU. Due to its hazardous content, WEEE may cause major environmental and health problems. Moreover, the production of modern electronics requires the use of scarce and expensive resources. In 2013, from the list of fifty-four candidate materials, twenty one raw materials were assessed as critical at EU level (Oakdene Hollins /Fraunhofer, 2013).	Electrical and electronic equipment related waste – within the meaning of Article 1(a) of Directive 75/442/ EEC – including all components, subassemblies and consumables that are part of the product at the time of discarding.	- 16: Wastes not otherwise specified in the list - 20: Municipal wastes (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions
MSW	Depending on consumption patterns, lifestyle, and waste management policies, the composition of MSW varies by country and even by municipality. Recycling performance of MSW has increased over the years in most European countries, but dumping untreated MSW in landfills is still common practice in some countries (European Environment Agency, 2013).	Mainly solid waste produced by households, but similar wastes from sources such as commerce, offices and public institutions are included as well. The amount of municipal waste generated consists of waste collected by or on behalf of municipal authorities and disposed of through the waste management system (Eurostat 210).	- 20: Municipal wastes (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions

Some (parts of) waste categories are by definition part of other waste sorting categories, e.g. some organic waste, some PCPW and some WEEE are actually a subcategory of MSW, as households produce these wastes as well (see Table 2). This underlines the necessity and importance of properly delineating the waste flows to be studied, as a selection of one sorting category may include other waste categories as well, which would lead to a scope that is too large to be handled in this project. Bearing this in mind and seeing the definitions and scopes above, it should become evident that these categories still constitute a vast range of different materials and application spectra. Therefore, it is necessary to determine and delimit the waste flows to be studied for each of the six case study areas, for which a method is provided in Step 1 of the AS-MFA.

Lastly, for sake of completeness, it needs to be added that neither energy nor monetary data are provided through this task. Energy flows are not included because performing an energy balance is not the first concern of WP3 T3.2. The most important issue here is the difference in approach between traditional analytical methods and the innovation that is aimed for in REPAiR. Key is the novel activity-based spatial approach, which will enable to move from subsystem linear thinking to system-based circular thinking when analysing waste flows, to address the networked activities that are at stake here. This necessitates a focus on both upstream and downstream processes, which is difficult enough concerning materials. Including an energy balance in the equation is unmanageable with the limited resources.

Table 2: Discrepancy between proper sorting category and where certain waste fractions may actually be found. Green fields are the EC designated categories, while yellow fields represent the nested-ness in other categories and typical examples of missorting.

		Waste that can be found in sorting category				
		CDW	OW	PCPW	WEEE	MSW
Proper sorting category	CDW					
	OW			non-bioplastic bags		cat litter
	PCPW		bioplastic bags			
	WEEE					
	MSW					

MFA unit

A common unit is required to describe the mass flow of the material to be studied and to allow for comparison of different flows. For (urban) Eurostat MFAs, the most commonly used unit is kiloton (Voskamp et al., 2016). However, this method usually looks at the entire urban/metropolitan system and deals with large mass flows, without breaking the system down into smaller components on lower geographical levels than a region (see point 4: System Modelling Approach). Since REPAiR aims to go to lower spatial scales, it seems inappropriate to use kiloton and favours the metric ton (1 tonne = 1,000 kg) as a unit instead. Combined with the temporal scale, the unit of a mass flow is consequently expressed in tonne/year.

Additional layers of information

From a CE perspective, it is desirable to not only determine the weight or volume of a resource but also provide additional information on quality and market conditions, especially since the definition of waste does not address the value or state of the substance or object. That means, information should be made available on the quality/value/state (e.g. level of purity) and/or composition (which links to the purity aspects) of said resource, but also on possible and intended pathways (reuse, further treatment for recycling etc.). Quality information allows getting an overview of the actual recyclability and to further estimate the potential for increased recyclability and circularity of the material flows. The information on intended and possible (alternative) pathways following the market conditions are useful to inform authorities and operators on status-quo and alternative management practices highlighting hotspots for eco-innovative solutions.

The information on quality further illustrates the level of quality in the lifecycle of a material. During e.g. recycling which can be defined as the "process of recovering materials for the original purpose or for other purposes, excluding energy recovery. The materials recovered feed back into the process as crude feedstock. If this results in a reduction in quality it is often described as downcycling. Processing to improve material or product quality is described as upcycling." (EMF, 2013). As a result, that means that keeping track of a material's quality can be reveal whether and which activities are detrimental (degrading/downcycling), neutral or positive (upcycling) from a resource value perspective.

Table 3 shows how quality, next to other attributes should be attached instead of merely describing a material flow in mass per area and time. PVC class 3 could stand for polluted PVC, for example, similar to how wood quality is expressed with letters (A, B, C). Depending on the material, this would ideally be a standardised categorisation in the industry so that stakeholders on the market know what they buy or in which class(es) they sell.

Table 3: Unit carrying attributes or remarks on material, area and time, illustrated with examples

Standard	Unit	Additional	Example
Mass of Material	t of PVC	State of material	kg of PVC class 3
		Quality of flow / Intended path	kg of PVC for direct reuse
		Source of origin	kg of PVC locally sourced
		Impurities (expected / known, etc.)	kg non-PVC material in PVC flow (and further breakdown of this)
Area	m^2	Land-use	m^2 of industrial area
		Location of space	m^2 of peri-urban area
Time	year	Remarks	1 year during recession Earthquake hit in that year 10 years during redevelopment

4. System Modelling Approach

In MFA, a system is defined as a set of material flows, stocks and processes within a well-defined boundary. For the processes within the system, usually a black box approach is used, see top of Figure 19 (Brunner and Rechberger, 2004). In this approach, only the inputs and outputs of the main process are studied and it lacks reference to specific activities, actors and precise (spatial) information (Moffatt and Kohler, 2008).

In REPAiR, the region is not considered as a black box, but it is investigated by a manageable balance between grey-box and network approach. In a grey-box system, the components of the system and their material inputs and outputs are accounted for (see Figure 19). A network system identifies the links between the components and thereby highlights key players and processes. However, a network system approach is very data intensive and since REPAiR aims for several spatial scales, perhaps different time scales and various material flows, it will have to be defined on a per case study basis where the scope can be significantly limited to make it manageable.

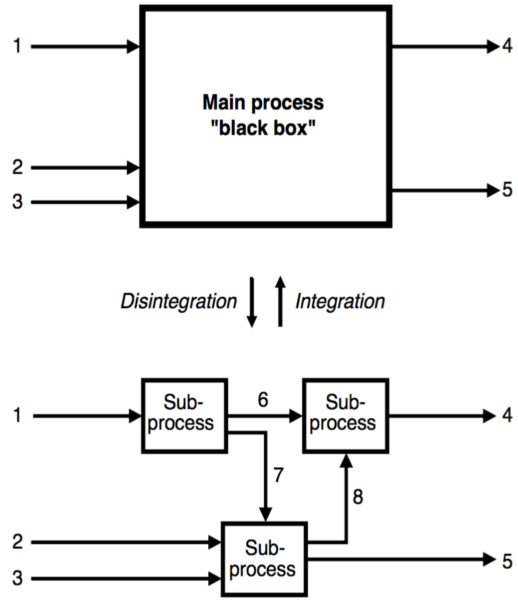


Figure 19: Opening up a black box by subdividing a single process into several subprocesses provides additional information about the black box (Brunner and Rechberger, 2004).

Having presented scopes and system boundaries that need to be drawn for a MFA in general and elaborated on the specific REPAiR boundaries, the following chapter will describe the newly developed AS-MFA methodology.

2.2.4 Activity-based Spatial Material Flow Analysis

For REPAiR, a novel and refined MFA method was created by the involved researchers from TU Delft, the Activity-based Spatial Material Flow Analysis (AS-MFA). The starting point for the development of the AS-MFA was taken from REPAiR's proposal:

"REPAiR integrates life cycle thinking and geodesign to operationalise Urban Metabolism. REPAiR's understanding of Urban Metabolism facilitates the shift to seeing waste as a resource, while determining the implications of this shift and exploring ways to tackle it. Therefore, REPAiR does not focus on 'end-of-pipe' potential alone, but traces waste flows back to resource consumption patterns. This is essential for two reasons: (1) the role of consumption behaviour in sustainable urban development is still insufficiently studied; and (2) this approach enables estimating the best possible change routes towards a circular economy." (REPAiR, 2016, p. 139)

Introduction to AS-MFA

The Activity-based Spatial Material Flow Analysis (AS-MFA) methodology provides a systematic way of analysing material flows within regions using the three main system components (1) (economic) activities, (2) activity-associated materials, (3) the actors involved, and their interrelations.

This methodology enables the identification of key activities and actors, which reveals where responsibilities lie and therefore lays open distinct points for policy or business (case) interventions. Knowledge of the actors discloses their spatial location, thereby providing spatial understanding of the regional actor network and its geographical position related to material flows. Analysing the links and patterns between spatial characteristics and material flows allows designers, policy makers, investors and urban planners to seek for optimum solutions (Moffatt and Kohler, 2008) and reveal possibilities for eco-innovation and circularity.

The AS-MFA consists of six steps that are conducted in close collaboration between scientists and stakeholders of the local case study:

1. Determination of material scope
2. Defining the material supply chain
3. Selection of geographical area and spatial scales
4. Defining case specific supply chain
5. Mass balancing
6. Visualising the results (in geographical context)

These six steps are further explained in the AS-MFA methodological guidelines in this chapter.

Goals & Scopes of AS-MFA

Carrying out an AS-MFA has the goal to:

- Determine material categories and flows that are crucial for the six case studies
- Quantify material flows; in some cases e.g. food waste, distinction between avoidable and unavoidable waste to determine actual opportunities for interventions through e.g. eco-innovative solutions
- Reveal activities and actors that are involved in the material flow system
- Analyse magnitudes of contributions to the quantities through activities and/or actors
- Connect the spatial analysis (T3.1), material flow analysis (T3.2) and social analysis (T3.3) of REPAiR's WP3.

The scope of the method is aligned with the scope and system boundaries that have been presented above (see sections 2.2.2 and 2.2.3).

AS-MFA databases and data requirements

Databases

In order to support and feed the AS-MFA with real data and to make it tangible for REPAiR's case studies, it was decided to link it to existing (Eurostat) data structures and databases. The three main components of the AS-MFA methodology (1) activity, (2) products and (3) waste are matched with the (Eurostat) references as shown in Table 4. Additional information such as location and actor of activity can also be obtained. Figure 20 visualises the (inter-)connections in a scheme. For more information on the databases, see Annex 1.

Table 4: Activity-based Spatial MFA components linked to (Eurostat) database

Activity-based Spatial MFA	(Eurostat) database
Activity	NACE Rev. 2
Location and *actor* of activity	Orbis
Products used or consumed in activity	Prodcom
"Waste" produced by activity	EWC-STAT 3

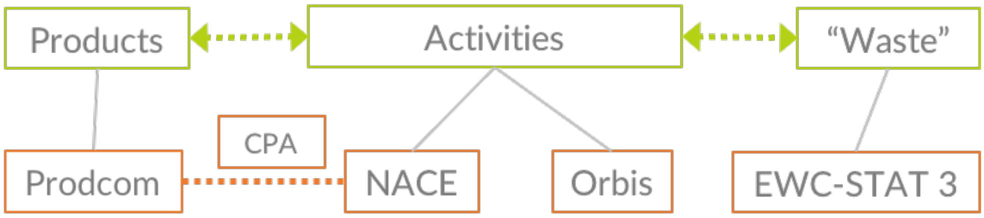


Figure 20: Interconnections of AS-MFA and various databases

Data requirements

Overall in REPAiR, data on mass, energy, land area, social aspects, economic aspects, emissions, etc. have to be collected. Per case, the level of data collection has to be defined, related to the key flows that were selected. In general, in order to obtain data, the following means should be followed, ranked by order of preference for REPAiR:

1. Obtain primary/company or actor specific (bottom-up) data that is required
2. Work with proxy data by e.g. disaggregating secondary data
3. Use assumptions based on expert interviews

Aggregation (of bottom-up data) and disaggregation (of top-down data) for/on different spatial scales and a verification between these two levels (bottom-up, top-down) will have to take place in order to ensure a more comprehensive data collection. How disaggregation should be done depends heavily on the level of aggregation and data specifications in general, which is not known yet at this stage. There are several ways to carry out this process, such as using ratio-based normalization, linear regression, linear regression with spatial autocorrelation, multilevel linear regression, and a basic Bayesian analysis (Horta and Keirstead, 2016). According to the needs and situation of the case study, this can be decided after the data has been obtained.

Nevertheless, it should be stated that there are drawbacks of the top-down (aggregated) method, which for example in one case where downscaling of energy consumption data was attempted, lead to a typical prediction error of 20% for six classes of downscaling (Horta and Keirstead, 2016).

The data that need to be obtained per case study can be summarised as follows:

- Local waste definition and classification
- Waste system
    - Source segregation into number and kind of categories for residents
    - Source segregation into number and kind of categories for businesses
    - Payment schemes and amounts for residents, for businesses and for industry
    - Waste treatment technologies used (for selected key flows) in region
    - Collection scheme: underground containers, drop-off, waste transport (which type of trucks, size, fuel use)
- Waste amounts per company and activity (in tonnes/year)
- Waste composition, including impurities (if applicable), waste sampling method and time
- Population distribution
- Participation rate (=if an actor participates in recycling or not).
- Sorting efficiency (=how well the participation in recycling is carried out) Both parameters, participation rate and sorting efficiency are needed. Even though sorting efficiencies are hard to find in the literature, they could potentially be obtained from waste samplings and surveys, similar to participation rates.

AS-MFA terminology

The following list provides an overview of the AS-MFA specific terms and their meaning:

- Activity - an action or a process that inherently has:
    - A location (that is based on actor's location)
    - Production and consumption of resource(s) (materials, goods, water, energy)
    - Logic relationship to other activities
    - A duration of use
    - Frequency and intensity
    - Economic impact / cost
    - Environmental impact / cost
    - Social impact / cost

  The activities and their range are based on NACE codes.
- Actor - a person, a public and/or private party with a socio-cultural background that carries out one or several activities
- Input - Physical resources such as materials, goods, water or energy that are fed into an activity, where they are used, consumed or undergo throughput without modification.
- Stock - Physical resources such as materials, goods, water or energy that are spatially bound for at least a year.
- Output - Physical resources such as materials, goods, water or energy that are produced or undergo throughput without modification by an activity.
- Key flow - A material flow that is deemed important for a case study to be studied in order to overcome a circular economy challenge in the region. The key flow is defined by: the material scope and the actors that are involved.
- Waste - "Any substance or object that the holder discards or intends or is required to discard."

AS-MFA methodological guidelines

On the following pages, each of the six methodological steps is presented by describing the (aim of the) step, listing the required tools, explaining the procedure of carrying out the step and giving an example of a result.

Step 1: Determination of material scope

In order to determine the material scope, i.e. the range of materials that will be subjected to the study, (waste) material(s) and their relevant application(s) have to be selected and defined. This selection is based on the interests of stakeholders, which in turn originate from local challenges and "personal" values. Furthermore, the selection should be done within REPAiR's pre-selected waste categories: Construction and Demolition Waste (CDW), Organic Waste (OW), Post Consumer Plastic Waste (PCPW), Waste Electrical and Electronic Equipment (WEEE) and Municipal Solid Waste (MSW).
The exact *definition* of the waste materials is a combination of several definitions, namely the EC's definition of wastes, end-of-waste criteria; national definitions and "classifications" of waste; and municipal definitions and regulations. Even though the EC's definitions are supposed to guide the waste definitions of the EU countries, the actual classifications might deviate (as was discussed in Chapter 2.2.3 - material scope).
Overall, this step is not only important to make the MFA feasible, it is also required to ensure that there were traceable and justifiable reasons for the selection of the waste materials. It can then be certain that the materials are of relevance to the region and its challenges, and that they play a part in the local circular economy efforts.

Tools: Waste scope overviews; PULLs with stakeholders;

Procedure of carrying out this step:

1. **Determine challenges:** Researchers should meet with their local stakeholders (partners, user board members etc.) and find out which challenges they are facing in the region. It needs to be determined which materials are associated with these challenges and are therefore of importance to the region. These could be materials that are already there (e.g. illegally dumped waste on land) or materials that will be used and partly wasted in the future (e.g. insulation material to refurbish houses, because energy inefficient building stock is a challenge).
   To make stakeholders aware of the vast amount of possible waste materials to be studied, the researchers and/or PULL leaders should present them with the material scope overviews and the waste definitions (see Annex 2). It should be made clear that generally, the respective waste definitions of the EU/EC are followed, but per case study the exact scope should be detailed as well.
2. **Value ranking:** While selections of material categories have been (see chapter 2.1.5) and can be made for most case studies rather easily, the material scope and number of subfractions that these encompass are still too large to carry out meaningful material flow analyses in the limited time that is available in REPAiR. Therefore, it is necessary to further limit the material scope. By determining the consortium's participants' and user board's values or criteria for waste material selection that are deemed most important to them, it can be better decided which materials are relevant for further analyses (MFA, LCA). In order to properly narrow down the material scope with regards to the REPAiR objectives, PULL leaders will be briefed by WP3 T3.2 members on questioning local stakeholders in the PULLs.
3. **Define selection:** After the researchers obtained a good understanding of the regional challenges, important criteria and the associated (waste) materials, a selection of materials should be agreed upon with the stakeholders. PULL leaders should facilitate a meeting to arrive at a definite decision. The flows that are then chosen and specified in collaboration with user board members and local stakeholders according to aspects in Table 5, are so-called key flows (see terminology). In order to make the work manageable, not more than 2-3 key flows should be chosen. A written statement should be provided by the PULL leaders, explaining the reasoning behind the selection: e.g. key flow A was chosen based on local challenge X, size (weight/volume) of flow, estimated (negative) environmental/social/economic impacts, importance for CE, and data availability. It is crucial to keep in mind that even though the focus is on a specific key flow, the waste composition of the flow that contains the key flow must still be assessed and information on it provided.

Table 5: Key flows are specified and limited through selection aspects

Aspects for key flow selection	Example 1	Example 2
Waste category	*OW* from MSW	*PCPW* from CDW
Waste material	Food waste	PVC
Application of materials	-	piping, window frames
Involved actors/generators of waste	Households	Demolition companies; refurbishment companies
Involved steps in the supply chain	Production, wholesale, retail, consumption, waste treatment	Application (installation, removal), collection, waste treatment

<u>Example result 1:</u> Plastic bottles for non-alcoholic beverages waste produced by households
<u>Example result 2:</u> Food waste from catering companies.

Hint: Consider which level of detail is sensible for your case. E.g. in the case study of plastic bottles for non-alcoholic beverages, does it suffice to determine the amount of plastic bottle waste in total or is it needed to break down the group of plastic into the various types of plastic (PET, HDPE, PP)?

Step 2: Defining the waste material supply chain

To get a good understanding of the origin, destination and flowpath of flows and stocks of the in Step 1 defined materials, a for the region/country typical supply chain should be defined conceptually per waste material / key flow. It is important to understand the whole chain, including all activities where the waste material under study is generated, collected or processed, in order to know where the waste material occurs and where data should be collected. In doing so, a systems perspective is taken, acknowledging that the waste material is not only produced post-consumer (see Figure 21), but may also occur more upstream in the, chain.
Building the so-called foreground supply chain does not imply that the entire process chain of products before they become waste needs to be built. For example, if the key flow is PVC waste, then it is not necessary to trace the supply chain all the way from oil extraction to refinery, to plastic pellet production etc. This is because even though that would be the supply chain of PVC, the focus is on PVC waste and PVC does not exist in the previous stages, so it cannot become waste. At this point the importance of defining the waste scope well (in Step 1) becomes evident. In case the supply chain becomes too vast, the material scope can still be limited.

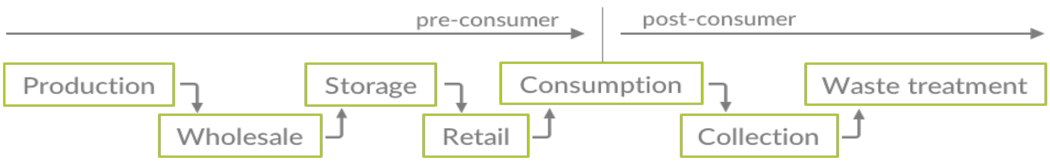


Figure 21: Typical groups to collect activities under for easier processing of the foreground supply chain

Tool: If the (pre-consumer) supply chain is compiled in collaboration with stakeholders, then the in Annex 3 provided activity and waste cards should be used. Alternatively, sketching a supply chain diagram by hand with pen and paper is recommended.

Procedure of carrying out this step:

1. **Select involved activities**: In case the supply chain is compiled with the activity and waste cards (Annex 3) (and with local stakeholders), the group should familiarise itself with the bigger cards that have activities printed on them and select the ones that are relevant for the (waste) material chain of the in Step 1 chosen material(s). (There is no transport card to simplify things, instead, this is an activity that is illustrated through drawn arrows later.)
Alternatively, if the cards are not used and the supply chain is hand drawn instead, researchers should think about which activities are needed to produce, handle, and consume the material that eventually becomes waste. (They can of course still use the activity cards as suggestions for possible activities.)
2. **Bring activities in order:** Activities will have to be brought into order on a big blank sheet of paper (see Figure 22). The first activity to start with in the chain, is the first activity where the material that was chosen in Step 1 becomes waste. (It

is crucial to really question where the chain starts: e.g. food waste is not only generated at the households, but already at farms.)

   a. If participants in the group are familiar with specific stakeholders involved in the actual chain, it is recommended to write down names of these actors on the activity cards.
   b. While it is not required to do so already, knowledge on boundaries and locations can also be included on the sheet, meaning that people can draw the system boundaries (Focus Area, Region, Country, EU, Outside EU) and arrange the activities therein accordingly.
   c. Finally, the activities should be grouped into logical activity groups, with group names as suggested in Figure 21, to allow for an easier handling for the rest of the AS-MFA method, as some activities will be similar in terms of the actions carried out and actors involved. For example, there are several activities that provide food and beverages for consumption in the public (restaurants, catering companies, schools). These could simply be grouped under the activity group "public consumption."

3. **Mark (waste) material flows:** After arranging the activities, researchers and stakeholders should indicate with lines (using markers) where waste is transported from one activity to another and where products or by-products are produced (see Figure 22). Aside from the big activity cards, there are little waste cards that can be used to write down which (waste) material, and in which quality, it is flowing between activities. Using differently coloured markers, it should be indicated where materials that are not waste yet, such as materials' inputs, outputs, stock, throughput, continue to be located in the chain. To later remember the meaning of the colours, a legend should be written on the same paper sheet.

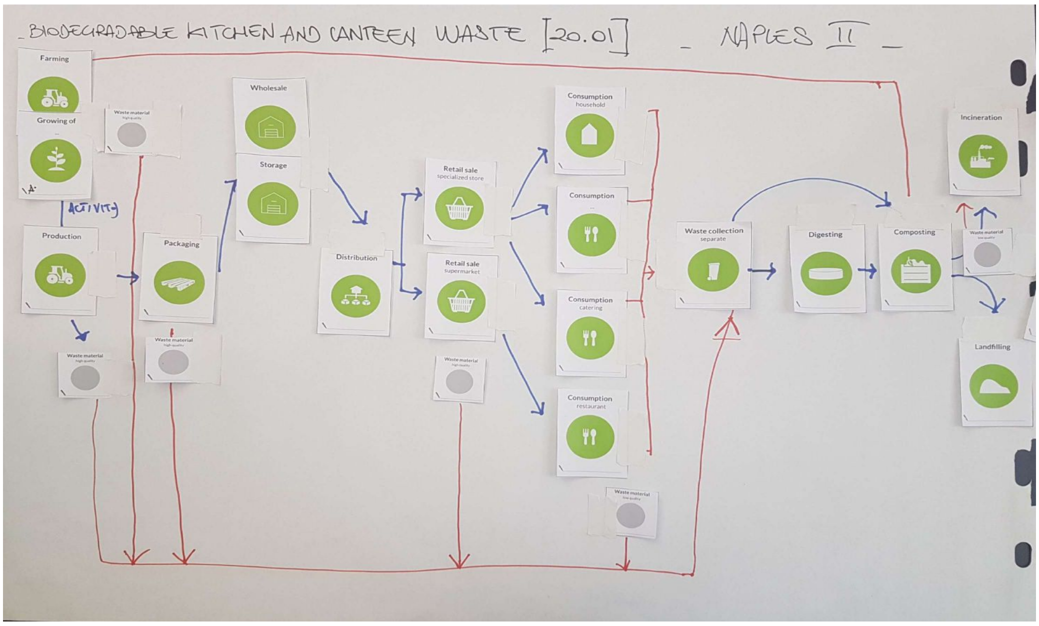


Figure 22: Example of conceptual Flow Chart for Step 2

Step 3: Selection of geographical area and spatial scales

A spatial area and boundary in which the waste material supply chain will be analysed has to be defined, e.g. an entire country, a metropolitan area or a neighbourhood. For REPAiR, this will be the administrative region of each case study, as described in Chapter 1.3. Since a region can be divided into smaller spatial areas, such as municipalities and neighbourhoods for example, various spatial scales within that region can be chosen for which the data shall later be aggregated or disaggregated to.

It is important to note that even though the product or material that will eventually end of as waste, can have significant waste amounts upstream in the supply chain. Yet, if this waste (from the waste scope) is in the (pre-consumer) chain but not in the defined region, then it won't be covered by the AS-MFA. (This is because a MFA of the region is performed as opposed to a material system analysis.)

Tool: For the tools used for the delineation, refer to chapter 2.1.4 of Task 3.1.

Procedure of carrying out this step:

1. **Defining geographical area:** Researchers should refer to chapter 2.1.4 of Task 3.1 and follow the descriptions on how to define the geographical area of a region.
2. **Selection of spatial scales:** Researchers and stakeholders should carefully consider which spatial scales provide added value and data, and are worth examining. The purpose is to show that aside from defining the geographical area (T3.1), the spatial scales for which the aggregation should be performed also have to be selected. For example, does a case study only look at actors and the region or is an aggregation on a municipality level valuable as well? For this, it is recommended to select from the following scales: actor < neighbourhood < city quarters < district < municipality < focus area < region.

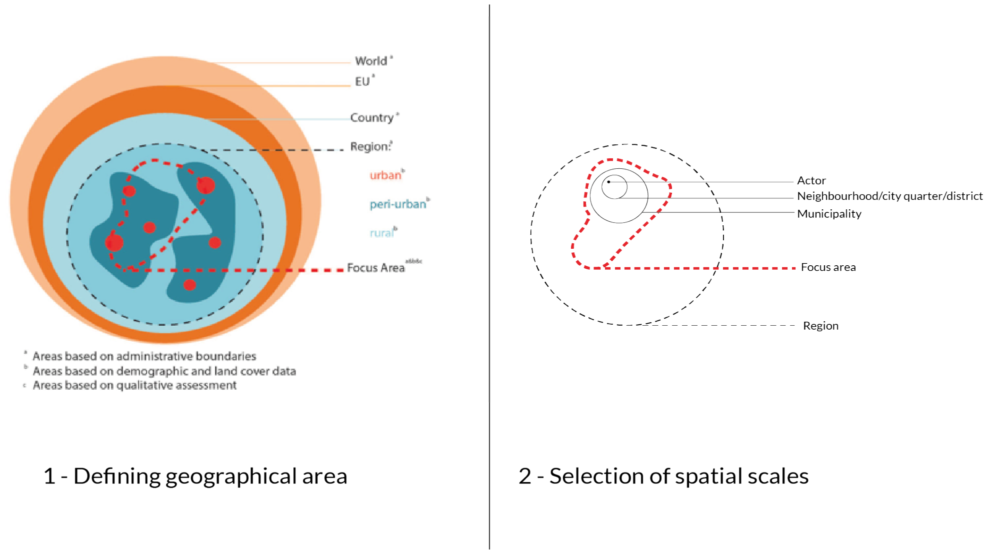


Figure 23: Selection and delineation of geographical area and spatial scales

Example result 1: Key flow A is accounted for on an actor and regional level.
Example result 2: Key flow B is accounted for on an actor, neighbourhood, municipality and regional level.

Step 4: Defining case specific supply chain

After defining the typical SC in Step 2 and choosing the geographical area in Step 3, the case specific SC can be defined for the region. That means it is specified which activities are carried out in the region (or focus area) and by whom (actor).

Tool: It is recommended to collect this information, which is mostly gained from searching the NACE database and carrying out desktop research, in a simple Excel sheet, as can be seen in Figure 26. The decision tree, shown in Figure 25, can also assist in this step.

Procedure of carrying out this step:

1. **Collect SC NACE codes:** Researchers should consult the NACE code database, which can be [downloaded as an excel file] and use the search function, looking up keywords for the various parts of their SC to find the appropriate codes, which then need to collected in a list, preferably an Excel sheet. Figure 24 illustrates a NACE code, code 47.11, showing the different hierarchies that it is nested in and the description that it includes.

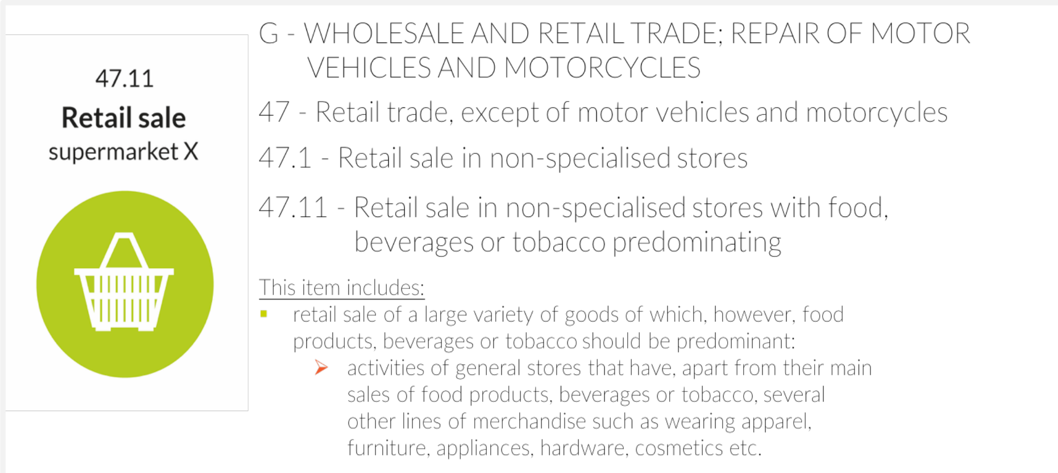


Figure 24: Example of a NACE code, including code and description

1. **Check regional activity occurrence:** Per activity it has to be asked: Does this activity take place in the region? This can be found out by determining if an actor carrying out the activity is (a) present in the region <u>and</u> (b) if the actor actually operates there. These two conditions can be examined as follows:
    a. Present in the region: researchers need to send their NACE code list to WP3 researchers at TU Delft, who will then look up the respective NACE codes in the Orbis database. They will then determine how many actors are registered with this code and located in the region. This is done automatically by the search query used, which filters out the actors that have an address in the region. The list of NACE codes and found actors will then be exported and sent to the MFA researchers of the case study.
    b. If actor actually operates there: a desktop research of the actor/company needs to be carried out to find out if the operations or activities are actually taking place at the registered location.

    If no actor is present or actors are present but do not operate in the region, then the activity does not take place and the materials occurring in the product chain have to come from outside of the region or be imported to the country. (Should the activity-associated materials come from outside of the region, then the origin needs to be specified i.e. if they are from the country, from EU or from outside of EU.)
2. **Determine regional activity intensity:** If at least one actor is present and the activity takes place in the region, then the following has to be asked, answered and finally noted down:
    a. How many actors are present and operate in the region in total?
    b. Are the materials from the defined material scope involved by the single actor's activities? If not, then these actors can be disregarded.
    c. For the after sub-step 3b involved actors: It needs to be determined if the activity takes place in the focus area. (This can be done with assistance of TU Delft researchers as well.)

    The researchers have to note the findings of Step 4 sub-step 2b-3c in the Orbis excel file that they received and then inform the WP3 T3.2 researchers so that this information can be incorporated into the GDSE.

3. Validate sense of findings: If the findings are not satisfactory because they do not provide a sufficient understanding of the system or are too comprehensive, step 3 and 4 should be refined and repeated by the researchers.

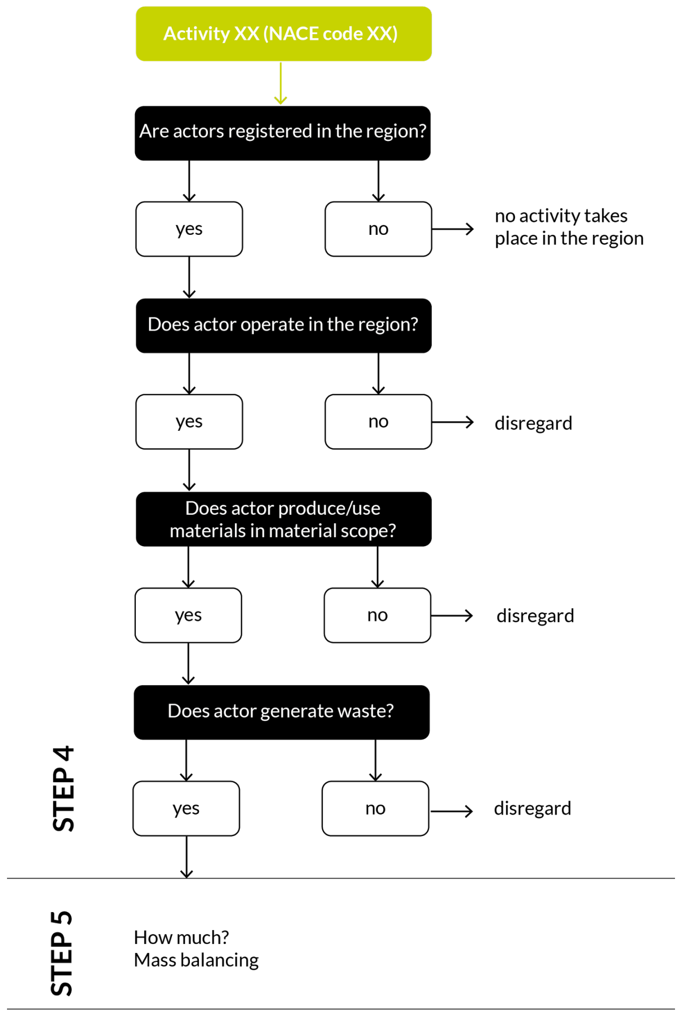


Figure 25: Decision tree for Step 4

Step 5: Mass balancing

After determining how many and which actors are registered in the region, operate with the studied (waste) material in the region and create waste, data on quantities and waste/material quality has to be collected by the researchers and entered into the GDSE. Afterwards, a mass balance has to be carried out per actor, for each activity, each spatial scale and the entire region to determine if the inputs, stocks and outputs check out, if it represents the actual situation and/or if losses occur, and to see where data gaps lie. In general, the input should equal the sum of the stock and the output, measured in a mass unit (kg or tonnes) and over the course of a year, see Figure 26 and 27.

Tool: The GDSE will facilitate the collection of data and calculations.

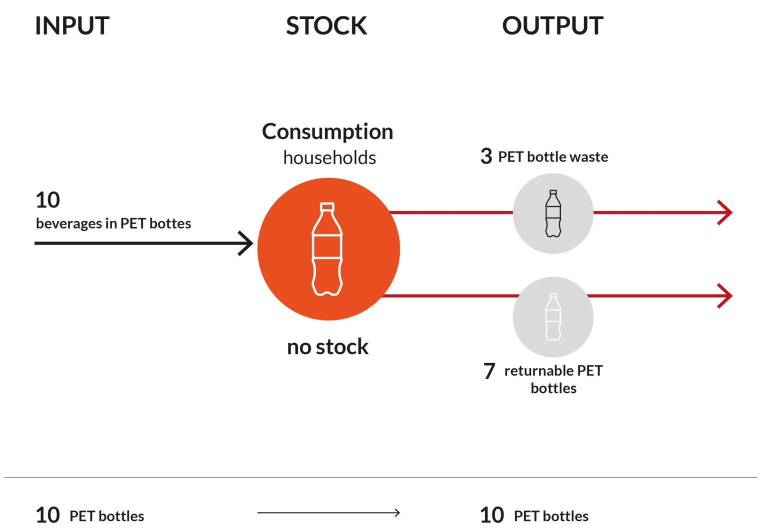


Figure 26: Mass balancing one actor: PET bottle example

Procedure of carrying out this step:

1. **Balance each actor:** For each actor, the following has to be asked:
   Per company:
   a. How much material and waste does it consume and produce (what goes in and out of the company)?
   b. Does it provide (a share of its) products to the region?
   c. If it does, then how much?
   d. Which quality do the materials have?
   For persons/households:
   e. Do they consume/use these materials?
   f. If they do, then how much?
   g. How much by whom (according to different types of households)? And in total?

   The data that is collected for the single actors needs to be entered by the researchers into the GDSE directly. Since the software is not actually programmed for that yet, it will be described what it will look like with the help of Figure 27 and Figure 29. As Figure 29 shows, there will be a graphical representation of the material flowchart in the form of a Sankey diagram. The diagram and the software behind it will contain the activities (=NACE codes) and the actors that have been identified from the Orbis database and found to be operating with the material in the region (Step 4). Researchers need to click on the activity for which they want to fill in the actor data, prompting a new window to open. In this window, the following can be selected and entered, as shown in Figure 27:

   - **Actor:** Actor for which to enter the data
   - **Material_Name:** The kind of material that arrives, remains or leaves
   - **Material_In [tonnes/year]:** Material quantity that arrives
   - **Material_Origin:** Activity and actor where the material comes from
   - **Material_In_Quality:** Material quality that arrives
   - **Material_Stock [tonnes/year]:** Material quantity that remains
   - **Remains with:** Location that the material stays at
   - **Material_Stock_Quality:** Material quality that remains
   - **Material_Out [tonnes/year]:** Material quantity that leaves
   - **Material_Destination:** Activity and actor to which the material goes
   - **Material_Out_Quality:** Material quality that leaves

- **Data source:** The source of the data above

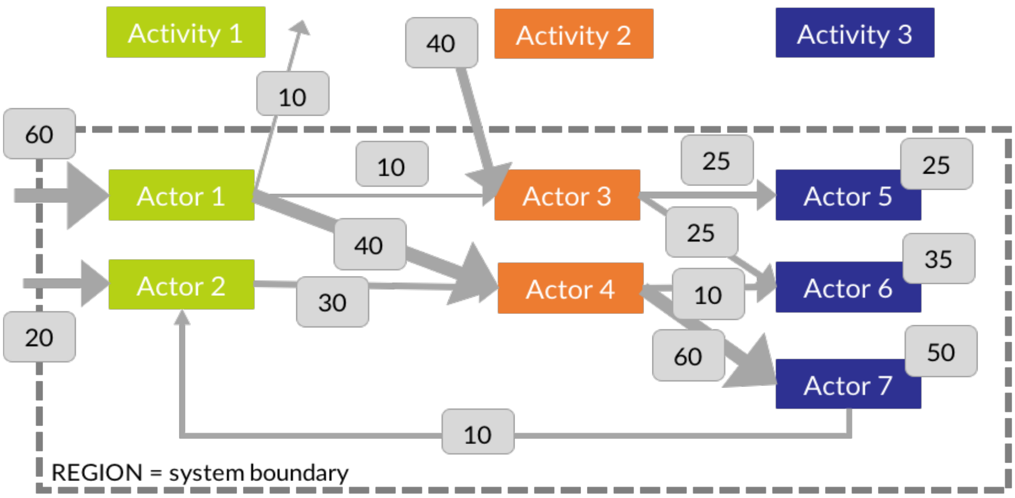
The inputs to an actor should equal the stock plus outputs. In order to determine if that is the case, the GDSE will make calculations for that. The data needs to be put into three columns, totalled within those columns and finally the stock and output have to be subtracted from the input.

- If the obtained value is 0, then the actor is balanced out.
- If the obtained value is >0, then the actor has more input than stock + output and there is no balance in mass.
- If the obtained value is <0, then the actor has less input than stock + output and there is no balance in mass.

2. **Balance each activity:** If there is only one actor carrying out the activity, then the mass balance of sub-step 1 is carried out and nothing else has to be done. If there is more than one actor, then the inputs, stocks and outputs of the various actors have to be added up respectively, as is shown in Figure 28. In case an actor carries out more than one activity, then only the flows and stocks pertaining to the one currently calculated activity are added up.
3. **Balance spatial scales:** Starting with the lowest spatial scale (after actor) as defined in Step 3, every spatial scale needs to be balanced. The GDSE will perform this task by adding the actors with the respective addresses to the desired scale.
4. **Plausibility check:** After the calculations, experts from JRC and TU Delft will carry out a plausibility check to determine whether the results make sense and whether more follow-up work has to be done.

Activity	Activity_Number	Actor	NaceCode	Material_ID	Material_Name	Material_In [tonnes/year]	Material_Origin	Material_In_Quality [Q]	Material_Stock [tonnes]	Remains with	Material_Stock_Quality [Q]	Material_Out [tonnes/year]	Material_Destination	Material_Out_Quality [Q]	data source
Consumption of juices, mineral waters, and soft drinks	Activity 2	Actor 3	**98.2**		Plastic bottles	40	outside of region	1							
		Actor 3	**98.2**		Plastic bottles	10	Activity1_Actor1	1							
		Actor 3	**98.2**		Plastic bottle waste							25	Activity3_Actor5	2	
		Actor 3	**98.2**		Plastic bottle waste							25	Activity3_Actor6	2	
		Actor 4	**98.2**		Plastic bottles	40	Activity1_Actor1	1							
		Actor 4	**98.2**		Plastic bottles	30	Activity1_Actor2	1							
		Actor 4	**98.2**		Plastic bottle waste							10	Activity3_Actor6	3	
		Actor 4	**98.2**		Plastic bottle waste							60	Activity3_Actor7	3	
					TOTAL	**120**						**120**			
					locally sourced ->	*80*						*120*	*<- locally used*		
					Import ->	*40*						*0*	*<- Export*		
Treatment and disposal of PET	Activity 3	Actor 5	**38.21**		Plastic bottle waste	25	Activity2_Actor3	2							
		Actor 5	**38.21**		Recycled plastic				25	same actor	2a				
		Actor 6	**38.21**		Plastic bottle waste	25	Activity2_Actor3	2							
		Actor 6	**38.21**		Plastic bottle waste	10	Activity2_Actor4	3							
		Actor 6	**38.21**		Recycled plastic				35	same actor	3				
		Actor 7	**38.21**		Plastic bottle waste	60	Activity2_Actor4	3							
		Actor 7	**38.21**		Recycled plastic				50	same actor	1b				
		Actor 7	**38.21**		Recycled plastic							10	Activity1_Actor2	1b	
					TOTAL	**120**			**110**			**10**			
					locally sourced ->	*80*						*10*	*<- locally used*		
					Import ->	*40*						*0*	*<- Export*		

Figure 27: Simplified example of an Excel sheet with actors and materials in region for Step 4. The material quality is exemplified in terms of numbers (1-3) with a lower number representing higher plastic material value.



Total in to activity 1 = **90** (60+20+10)	Total out from activity 1 = **90** (10+10+40+30)	Total in to activity 2 = **120** (40+10+40+30)	Total out from activity 2 = **120** (25+25+10+60)	Total in to activity 3 = **120** (25+25+10+60)	Total out from activity 2 = **10** → In (120)-Out (10) = Stock (110)

Figure 28: Example of adding up actors, inputs, stocks and outputs to determine the totals for the activity

Step 6: Visualising the results (in geographical context)

Visualisations will be made to illustrate the results and highlight the distribution of material production, consumption and losses and the activity and actor network. Two types of visualisations will automatically be made in the GDSE: **52**

- (1) Sankey diagram for case study area/region (for one year) (see *Figure 29*)
- (2) Spatial AS-MFA for region in which it is possible to zoom in and out. (see *Figure 30*)

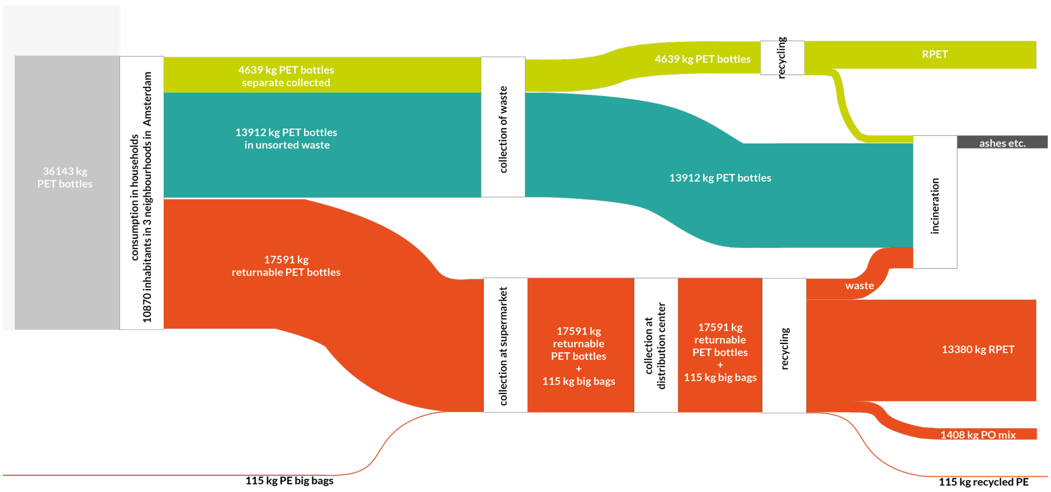


Figure 29: Exemplary part of Sankey diagram for Step 6

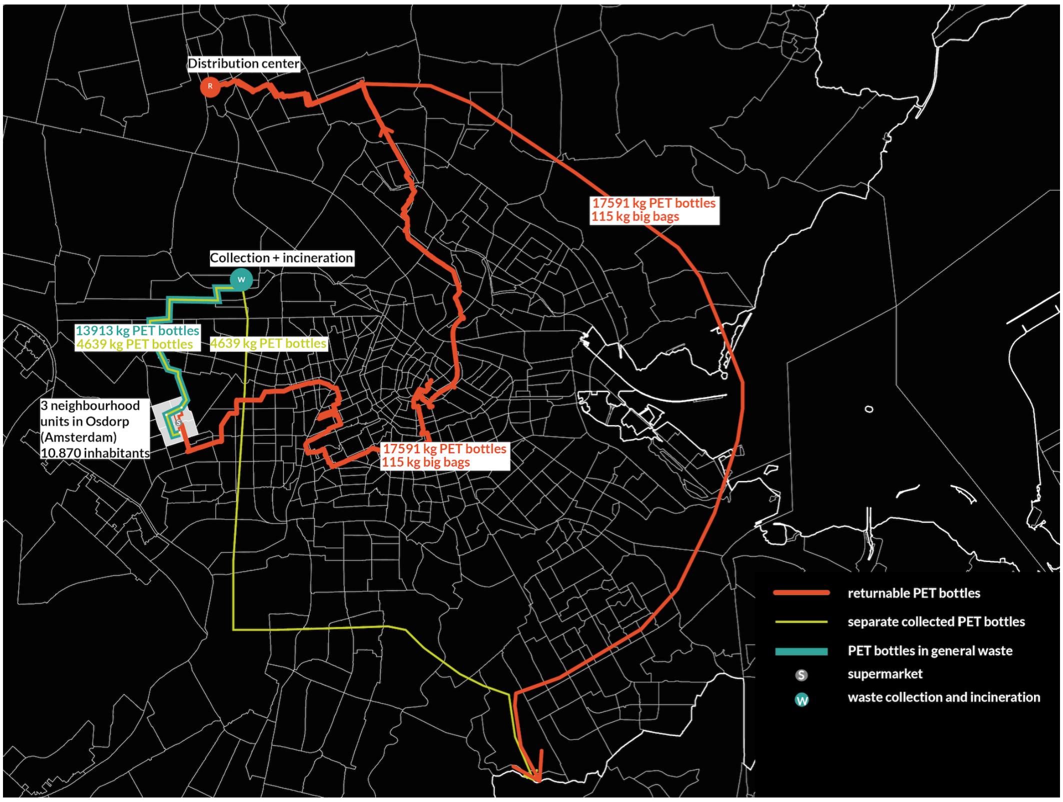


Figure 30: Exemplary spatial representation for Step 6

2.2.5 Outcomes & Validation

The outcomes that can be expected from AS-MFA are as follows:

- Material scope(s) per key flow(s) per case study
- Quantifications of key flows
- Illustration of flows in Sankey diagrams and spatial flow representation
- Actor network

Preliminary results of Step 1

Preliminary results on the waste category selection, shown in Table 6, reveal that all case studies selected organic waste as a category to be studied. Depending on the producer of the waste, OW can be considered MSW or it can come from e.g. restaurants or parks. Thus, the category can be further limited.

Table 6: Waste categories selected by six case study areas as of June 2017

		REPAiR case study areas					
		MAN	AMA	Ghent	Pecs	Lodz	HHP
REPAiR waste categories	CDW						
	OW		Food waste			organic fraction from HHW	
	PCPW		Plastic bottle waste				
	WEEE						
	MSW						

2.3 Task 3.3 | Social Analysis

2.3.1 Goal & Scope

Task 3.3 is dealing with the linkages between sociocultural features and social sensitiveness about general environmental issues, and particularly about waste and resource management. In brief, the research is focusing on four different tasks. Firstly, there is a theoretical phase that aims to provide a conceptual framework for the abovementioned relation. For this task a multi-theoretical approach is suggested which can point out interplays between concepts on sociocultural features (mostly different value theories) and frameworks about sustainability and environmental awareness. Secondly, Task 3.3 is dealing with a multi-phased comprehensive secondary sociocultural analysis to investigate empirically the assumed theoretical linkages. Thirdly, the research provides a primer empirical analysis about the perceptions of different stakeholders on the relevancy of various factors and social, cultural features for waste and resource management. Finally, a socioeconomic analysis aims to map out relevant factors about each case study area.

Task 3.3 has a multilevel scope: the secondary sociocultural inquiries are focusing on national level specificities, while the primer sociocultural stage of the research and the socioeconomic investigation is done on local (focus area) level.

2.3.2 Concepts & Methods

Multi-phased Secondary Sociocultural Analysis (SSCA)

As the theoretical arguments are strongly related to the secondary analyses, it is better to give a short introduction to them jointly. As a first investigation of the multi-phased secondary sociocultural analysis (SSCA-1), Task 3.3 provides a comprehensive literature review on the topic and a descriptive empirical inquiry. The planned working paper of SSCA-1 aims to give an overview about writings dealing with linkages between social and cultural features, on the one hand, and sustainability, environmental awareness and environmentally friendly attitudes on the other. This stage of the research gathers theoretical and methodological inputs from previously published studies, tries to identify similarities in their arguments, builds up a synthesized framework, and summarises the findings of these papers. Based on the developed framework, SSCA-1 also provides a descriptive empirical investigation. It uses the European Social Survey (ESS) as a source of data for the social and cultural features.

ESS is an academically driven cross-national survey that has been conducted across Europe since 2001. Every two years, face-to-face interviews are taken with newly selected, cross-sectional samples. The survey measures the attitudes, beliefs and behavior patterns of diverse populations (generally more than 40.000 respondents), in more than 30 nations, among them the case study countries of REPAiR. As ESS is using standard and varying blocks of variables, it provides the opportunity to do multi-year, longitudinal cross-analyses on the data base. The main aims of the ESS are to chart stability and change in social structure, conditions and attitudes in Europe and to interpret how Europe's social, political and moral fabric is changing. Further, it introduces sound indicators of national progress, based on citizens' perceptions and judgments of key aspects of their societies. The survey contains thousands of value-, attitude-, and behaviour-related variables, while it provides a massive socio-demographic pool of data about the respondents too.

For the variables of sustainability, environmental awareness and environmentally friendly attitudes SSCA-1 uses Eurobarometer as a database. It contains several surveys, some of which are not ongoing projects anymore, but because of the longitudinal aspect that does not exclude them from the inquiry. The Eurobarometer surveys comprise the following series: Standard & Special Eurobarometer; Flash Eurobarometer; Central & Eastern Eurobarometer (1990-1997); Candidate Countries Eurobarometer (2000-2004). All of them contain different and often changing variables about the abovementioned

environmental dimensions.
SSCA-1 applies mostly descriptive statistical methods on the partly nominal/ordinal and partly metric data. These methodological options are adequate to describe basic features of the data. They provide simple summaries about the sample. The investigation aims to involve univariate analysis as well, which allows comparative inquiries across cases about one variable at a time. By this, SSCA-1 could reflect to three major characteristics of the selected variables, such as distribution, central tendency, and dispersion. For the comparison of the two data sources' variables, the working paper applies crosstabs, correlation and regression analysis from inferential statistics in a multi-layered approach.

The second stage of the multi-phased secondary sociocultural analysis (SSCA-2) builds on a more complex theoretical argument and it uses more comprehensive statistical methods as well. It invokes the concept of Ronald Inglehart (1997, 2000, 2005) about post-material values to elaborate an argument on the linkages between sociocultural features and attitudes and environmental awareness. Inglehart stresses that there are two major dimensions of cross-cultural variation in the world: traditional values versus secular-rational values, and survival values versus self-expression values. Traditional values emphasize the importance of religion, parent-child ties, deference to authority and traditional family norms. People who embrace these values also reject divorce, abortion, euthanasia and suicide. These societies have high levels of national pride and a nationalistic outlook. Compared to traditional values, secular-rational ones have exactly the opposite preferences. Societies that embrace these norms place less emphasis on religious beliefs, conventional behavior patterns and authority. Based on these understandings, members of these societies apply much different attitudes in their social interactions. About survival values, Inglehart states that these norms trace back to simple economic and physical security. They are linked with a relatively ethnocentric outlook and low levels of trust and tolerance. In comparison, and this is where the REPAiR project mostly has interests in this framework, self-expression values – as Inglehart underlines – give high priority to environmental protection, to tolerance of foreigners, gays and lesbians and gender equality, and to demands for participation in decision-making of public issues.
Based on the framework of Inglehart, SSCA-2 assumes that there is a strong linkage between post-materialist values and environmental awareness. SSCA-2 aims to support this claim of Inglehart by invoking other middle-range theories into the conceptual interpretation, both to expand the explanatory frame and to enrich the main argument by a more extended multi-theoretical understanding. This makes SSCA-2 able to propose a more comprehensive secondary empirical inquiry. To be more adapted to Inglehart's approach, this phase of the research uses World Value Survey (WVS) as a source of data. WVS is elaborated and conducted by the project team of Inglehart, therefore it is a proper pool to test both his claims and SSCA-2's extended conceptual framework. WVS, which started in 1981, seeks to use rigorous, high-quality research designs in each country that makes the survey one of the best global level series on social values, norms, attitudes and other cultural patterns. It builds on nationally representative, partly standardised, partly varying surveys from almost a hundred countries, which contain almost 90 percent of the world's population, using a common questionnaire. Just as the ESS, WVS is collecting complex socio-demographic datasets about the respondents that make the survey applicable for comprehensive statistical investigations.
SSCA-2 aims to use more sophisticated statistical methods than SSCA-1, particularly by applying tools of inferential statistics like principal component analysis (PCA), factor analysis, Analysis of Variance and regression analysis. While SSCA-1 builds on correlations and cross-tabs of composite indexes, SSCA-2 does statistical comparisons on individual level that means more accurate, more sensitive and fine-tuned methods.

The last stage of the multi-phased secondary sociocultural analysis (SSCA-3) is more similar to SSCA-2 than to SSCA-1, insofar as it builds on another, closely related value theory, and it applies a just as comprehensive and well-elaborated methodology to test the basic assumptions as SSCA-2. SSCA-3 invokes the concept of Shalom H. Schwartz

(1992, 1994, and 2012) on Basic Human Values (BHV). Schwartz's approach is considered as a refined and essential extension of previous value theories, such as social psychologist Milton Rokeach's much-appreciated framework from the 70s and Erik Hofstede's less elaborated, but on more fields applied, concept from the 90s.

BHV measures universal values that are recognized throughout all major cultures (or civilizations). The concept identifies ten such composite values and further describes the dynamic relations amongst them by arranging them into a circular structure. The ten values are grouped into four higher-ordered categories. 'Openness to change' encompasses on the one hand 'self-direction independency' which refers to a form of self-concept and attitudes like being able to make choices and decisions for oneself, creating and exploring; while on the other it embraces 'stimulation excitement' that should be translated as motivated by the novelty, risks, and challenges in life. The second higher group in Schwartz's theory is 'self-enhancement' that refers to (1) 'hedonism', i.e. searching and enjoying of pleasures in life, and being inspired by sensuous gratification for oneself; (2) 'achievement' which should be understood simply as personal success through demonstrating competence according to social standards; and (3) 'power' which means social status and prestige, as well as control or dominance over people and resources. 'Conservation' is the third composite group embraces (1) 'security' i.e. the need of the feeling of safety, harmony and stability about social relationships, structural circumstances and individual life situations; (2) 'conformity' which refers to restraint of actions, inclinations, and impulses likely to upset or harm others and violate social expectations or norms; and it also comprises (3) 'tradition' that should be interpreted as respect, commitment, and acceptance of the customs and ideas that one's culture or religion provides. The last higher group is 'self-transcendence' which is built up on 'benevolence', i.e. preserving and enhancing the welfare of those with whom one is in frequent personal contact; and 'universalism' which embraces values and attitudes like showing understanding, appreciation, tolerance, solidarity and protection for the welfare of all people and for nature.

As it seems, Schwartz's concept is a complex enough and well-elaborated value typology that refers to environmental-awareness and environmentally friendly attitudes in its last higher group. As it was mentioned above, the theory also explains how these ten values are interconnected and influence each other, since the pursuit of any of the values results in either an accordance with one another (e.g. conformity and security) or a conflict with at least one other value (see for instance: benevolence and power). Therefore, the values are arranged into a dynamic circular structure, as an explanatory framework, along two bipolar dimensions. The first dimension is openness to change versus conservation, which contrasts independence and obedience. The second bipolar dimension is self-enhancement versus self-transcendence and is concerned on the one side with the interests of oneself and on the other side of the welfare of others. Consequently, by mapping out one's accepted and followed value structure, it is possible to make an ethical self-profile, and through accumulating these individual traits, the approach proposes theoretical and methodological tools to identify on collective level respected moral standards.

Beside the conceptual complexity of Schwartz's model, it is frequently applied because 1) it is well tested and reliable; and 2) there are open databases about the necessary variables. SSCA-3 uses ESS as a source of data that was already introduced above. The survey not just contains the whole questionnaire of BHV (in multi-year sense), but because of the gathered other data about the respondents, it proposes a wide variety of statistical inquiries. SSCA-3, just as SSCA-2, applies sophisticated methods of inferential statistics like principal component analysis (PCA), factor analysis, Analysis of Variance (ANOVA) and regression analysis.

The multi-phased secondary sociocultural analysis (SSCA-1, SSCA-2 and SSCA-3) of T3.3 is providing a comprehensive, multi-theoretical and on various databases tested empirical investigation about the main question of the research, namely: what can be said about the linkages between sociocultural features and sustainability, environmental awareness, and environmentally friendly attitudes? As it was mentioned, T3.3 presupposes that there is a strong, positive correlation between the analyzed factors, i.e. societies which have a more favorable socio cultural context, like higher moral standards and deeper social integration, their members are more sensitive about environmental issues. Therefore, the sociocultural context matters to the efficiency of waste and resource management policies.

Primer Sociocultural Analysis (PSCA)

T3.3 is testing the same assumption by a primer sociocultural analysis (PSCA) too. While SSCA's target groups are mass populations of the case study countries, PSCA has a more concentrated scope; it investigates relevant stakeholders from the six focus areas. The stakeholders are identified by WP6; their numbers should reach at least 15 people per case, all together around 90-100 agents. They are surveyed through an online questionnaire. The surveys are using standardised questions but they are translated to the first language of the stakeholders. The filled in responses will be directly channeled to an online database; anonymity is strictly secured.

The questionnaire of PSCA has three thematic blocks and one profile-identifier part. The latter is collecting data about the respondents' backgrounds, such as how they are connected to waste and resource management; on which level do they are active; and whether their organisations have a primary waste or resource management orientation. PSCA does not gather socio-demographic data about the stakeholders.

PSCA surveys stakeholders about their perceptions on certain factors' relevancy for waste and resource management. The first block comprises questions about 'hard' institutional variables such as financial aspects, regulations, using sanctions, developing strategies and policies, applying new innovations and technologies, involving actors, preparation for decision-makings, studying good practices and learning know-hows. The second block embraces aspects of the sociocultural context, i.e. these are soft, value-, norm-, and attitude-related dimensional factors like social integrity, tolerance, solidarity, voluntary deeds, trust, risk-taking behavior, reflectivity, participation, collective responsibility. The third block then turns back to the hard variables to gather stakeholders' perceptions from a more in-depth perspective.

The analysis of the data produced by the PSCA's survey is based on mainly descriptive statistics with cross-tabs and simple correlations. Because of the low number of respondents, to apply more sophisticated methods would be inadequate. PSCA is, on the one hand, informative in itself, while on the other, it is comparable with the main findings of SSCA. Regarding this possibility, T3.3 assumes that stakeholders in focus areas which are parts of countries with more favorable socio cultural contexts will perceive the relevance of 'soft' cultural variables more important for waste and resource management than stakeholders in focus areas which are parts of countries with rather unfavorable socio cultural milieu. This is likely because those stakeholders who are living in more favorable sociocultural context and in more integrated social collectivity accept and respect higher moral standards. Therefore, PSCA does not investigate directly the sociocultural features of the relevant stakeholders, yet it presupposes macro, i.e. social level impacts on agents' values, norms and behavior patterns.

Socio Economic Analysis (SEA)

The third pillar of T3.3 is a brief socio economic analysis (SEA) of the case study areas. SEA is based on a template that aims to gather geography-, demography-, and economy-related basic quantitative inputs about the focus areas and the wider regions. SEA is important for the basic introduction of the cases. The representation of the data is descriptive without statistical or other kind of inquiries.

2.3.3 Tasks & Timeline

The table below displays the various subtasks within T3.3, related to the methods described above (SSCA-1, SSCA-2, PSCA, and SEA). Each subtask is followed by an indication of the responsible partner (in most cases RKI, in some cases with contributions of all partners), and delivery period (REPAiR months).

CHART OF WORK PLAN IN TASK 3.3								
Task / Responsible Partner / Month		1-6	7-12	13-18	19-24	25-30	31-36	37-40
SSCA-1 – Literature review	RKI	X	X					
SSCA-1 – Empirical inquiry	RKI		X					
SSCA-1 – Working paper	RKI			X				
SSCA-1 – Presenting paper	RKI			X				
SSCA-2 – Theoretical phase	RKI				X			
SSCA-2 – Empirical inquiry	RKI				X			
SSCA-2 – Working paper	RKI				X			
SSCA-2 – Paper for journal	RKI					X		
SSCA-3 – Theoretical phase	RKI						X	
SSCA-3 – Empirical inquiry	RKI						X	
SSCA-3 – Working paper	RKI						X	
SSCA-3 – Paper for journal	RKI							X
PSCA – Questionnaire	All partners	X						
PSCA – Translations	All partners		X	X				
PSCA – Editing online survey	RKI		X	X				
PSCA – Surveying	All partners			X				
PSCA – Procession of raw data	RKI			X				
PSCA – Analysis of cleared data	RKI			X	X			

PSCA – Working paper	RKI				X			
PSCA – Paper for journal	RKI					X		
SEA – Template	RKI	X						
SEA – Data collection	All partners		X	X				
SEA – Description of data	RKI		X	X				

3 Conclusions and next steps

The objective of this deliverable is to provide an introduction to the methodology for integrated spatial (Task 3.1, Chapter 2.1), material flows (Task 3.2, Chapter 2.2) and social (Task 3.3, Chapter 2.3) analyses. It explains methodological considerations and choices, whilst laying out the approaches, developed in close conjunction with the two main pilot case studies Amsterdam and Naples. As such, this deliverable functions as a handbook, providing guidelines for application in the four other case study areas. The main concerns are related to transmitting a stepwise approach for performing spatial, material flow, and social analyses. Given the complexity of the analytical tasks, not least linked to the level of innovation required for the overall REPAiR goal i.e. providing tools to facilitate Circular Economy models in shifting from waste to resource perspectives, the guidelines provided are not simply 'plug and play'. It can be concluded that in particular with regard to data sourcing the methodology's validity depends on further testing – and maturing – in practice, in a shared effort between experts and other consortium members involved in the living labs and occupied with executing the analytical steps. This is true for the spatial analysis, particularly regarding Wastescapes mapping, the material flow analysis, not least concerning the comprehensive *activity-base* of the AS-MFA, and the social analysis, specifically the Primer Sociocultural Analysis. The latter is currently under development in a cross-workpackage endeauvour, to be fine-tuned in the coming period. The former two are in the final development stage of the Naples and Amsterdam case, in the process towards Milestone 3.3 (Preliminary representation and process models including: overview of geography plus flow diagrams for the two pilot case studies ready to be integrated into GDSE. Month #14) and Deliverable 3.3 (Definitive process model for the two pilot cases, including digital maps, database and reports of – the interplay between – spatial, material flow and social analyses. Month #16). In the same period, testing and validation in the four other case studies takes off, heading for Milestone 3.4 (Validation of the methodology and calibration of models from two pilot studies in order to review system boundaries, core flows, spatial qualities and social aspects for the four follow-up studies finished. Month #19). The coming months are thus aimed at reaching a higher level of know-how with regard to the process steps and data specifications. This is done in discussions between workpackage researchers, as well as in dedicated workshop sessions. Important interrelations exist with WP2, integrating the models into the GDSE, WP4, aligning sustainability impact assessment, WP5, concerning eco-innovative solutions and strategies, and WP6, with regard to decision-making specifications. Moreover, thorough interaction with the Peri-Urban Living Labs, relating data sourcing and processing, is key. In that respect, the following breakdown of (sub-)milestones and timeline is proposed:

- Month 13/14 – List of data to collect from follow-ups (based on the pilots' preliminary representation)
- Month 14 – Task 3.1 and Task 3.2 workshops (Consortium meeting #3)
- Month 15 – System boundaries: focus areas & geographies (general and waste-specific), first draft
- Month 16 – Feedback, remarks and questions from PULLs
- Month 17 – System boundaries: focus areas & geographies (general and waste-specific), second draft
- Month 18 – Feedbacks - remarks and questions - from PULLs

Via these steps, optimisation and transmission of methodological steps can proceed in an effective learning process. Simultaneously, the ins and outs of context-dependent opportunities and challenges will reveal themselves. This is most important, as at the end of the day the methodological quality-level correlates with the extent to which it is robust and resilient enough to be applied to different European case study areas. The two pilot cases have brought, and continue to bring, a wealth of information on bottlenecks and leverage points for acquiring data. The lessons learned can now be applied to the follow-up cases, whilst acknowledging their unique – social, cultural, political, economical, environmental – contexts.

References

Allen, A. (2003). Environmental planning and management of the peri-urban interface: perspectives on an emerging field. *Environment and Urbanization*, 15(1), pp.135-147.

Allesch, A. and Brunner, P. (2015). Material Flow Analysis as a Decision Support Tool for Waste Management: A Literature Review. *Journal of Industrial Ecology*, 19(5), pp.753-764.

Arnkil, R., Järvensivu, A., Koski, P. Piirainen, T. (2010). Exploring Quadruple Helix Outlining user-oriented innovation models. Final Report on Quadruple Helix Research for the CLIQ project, Working Papers, 85/2010, pp.1-120, University of Tampere, Tampere, Finland.

Beloin-Saint-Pierre, D., Rugani, B., Lasvaux, S., Mailhac, A., Popovici, E., Sibiude, G., Benetto, E. and Schiopu, N. (2017). A review of urban metabolism studies to identify key methodological choices for future harmonization and implementation. *Journal of Cleaner Production*, 163, pp.S223-S240.

Berger, A. (2006). Drosscapes, Wasting Lands in urban America, New York: Princeton Architectural Press.

Brenner, N. (2014). Implosions/Explosions: Towards a Study of Planetary Urbanization, Berlin: Jovis.

Broto, V., Allen, A. and Rapoport, E. (2012). Interdisciplinary Perspectives on Urban Metabolism. *Journal of Industrial Ecology*, 16(6), pp.851-861.

Brunner, P. and Rechberger, H. (2004). *Handbook of material flow analysis*. Boca Raton, FL: CRC Press, Taylor & Francis Group.

EEA (2013). *Managing municipal solid waste - a review of achievements in 32 European countries*. [online] European Environment Agency. Available at: https://www.eea.europa.eu/publications/managing-municipal-solid-waste [Accessed 25 Sep. 2017].

EMF (2013). *Interactive system diagram - Circular Economy*. [online] Available at: http://www.ellenmacarthurfoundation.org/circular-economy/circulareconomy/Interactive-system-diagram [Accessed 25 Sep. 2017].

European Commission (2016). *End-of-waste criteria - Environment - European Commission*. [online] Ec.europa.eu. Available at: http://ec.europa.eu/environment/waste/framework/end_of_waste.htm [Accessed 25 Sep. 2017].

Fischer-Kowalski, M. (2002). Exploring the History of Industrial Metabolism. A Handbook of Industrial Ecology; Ayres, R.U., Ayres, L.W., Eds.; Edgar Elgar: Chaltenham, UK.

Geldermans, B., Taelman, S.E. (eds.) (2017). REPAiR Terms & Definitions v1.1 April 28 2017

Ghisellini, P., Cialani, C., and Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, (*114*), pp.11–32.

Gonc¸alves, J., Castilho Gomes, M., Ezequiela, S., Moreira, F., Loupa-Ramos, I. (2017).

Differentiating peri-urban areas: A transdisciplinary approach towards a typology. *Land Use Policy*, (63), pp.331-341.

Haining, R.P. (2003). Spatial data analysis: theory and practice. Cambridge University Press, Cambridge.

Haining, R.P. (2009). The special nature of spatial data. In Fotheringham AS, Rogerson PA (eds), The SAGE handbook of spatial analysis, SAGE, Los Angeles, pp. 5–24.

Haining, R.P., Kerry, R., Oliver, M. (2010). Geography, spatial data analysis and geostatistics: an overview. *Geographical Analysis,* (42), pp.7-31.

Hornis, W., van Eck, J.R. (2008). A typology of peri-urban areas in the Netherlands. *Tijdschrift Voor Economische en Sociale Geografie,* (99), pp.619-628.

Horta, I. and Keirstead, J. (2016). Downscaling Aggregate Urban Metabolism Accounts to Local Districts. *Journal of Industrial Ecology*, 21(2), pp.294-306.

Iaquinta, D.L., Drescher, A.W. (2000). Defining the peri-urban: rural-urban linkages and institutional connections. *Land Reform*, 2000(2), pp.8–27.

Ingegnoli, V., Forman R.F. (2002). Landscape Ecology: A widening Foundation, New York: Springer-Verlag.

Inglehart, R. (1997). Modernization and Post-modernization. Cultural, Economic, and Political Change in 43 Societies. Princeton, Princeton University Press

Inglehart, R. and Baker, W. E. (2000). Modernization, cultural change and the persistence of cultural values. *American Sociological Review,* (65), pp. 19–51.

Inglehart, R. and Welzel, C. (2005). Modernization, Cultural Change and Democracy. New York, Cambridge University Press

Kennedy, C., Cuddihy, J. and Engel-Yan, J. (2007). The Changing Metabolism of Cities. *Journal of Industrial Ecology*, 11(2), pp.43-59.

Korcelli, P., Korcelli-Olejniczak, E., Kozubek, E. (2008). Typologies of european urban-rural regions: a review and assessment. *Geographia Polonica,* 81(2), pp.25-42.

Liu, J., Dietz, T., Carpenter, S., Alberti, M., Folke, C., Moran, E., Pell, A., Deadman, P., Kratz, T., Lubchenco, J., Ostrom, E., Ouyang, Z., Provencher, W., Redman, C., Schneider, S. and Taylor, W. (2007). Complexity of Coupled Human and Natural Systems. *Science*, 317(5844), pp.1513-1516.

Marcotullio, P. and Solecki, W. (2012). What Is a City? An Essential Definition for Sustainability. *Urbanization and Sustainability*, pp.11-25.

Martín-López, B., Palomo, I., García-Llorente, M., Iniesta-Arandia, I., Castro, A., García Del Amo, D., Gómez-Baggethun, E. and Montes, C. (2017). Delineating boundaries of social-ecological systems for landscape planning: A comprehensive spatial approach. *Land Use Policy*, 66, pp.90-104.

Mcintyre, N., Knowles-Yánez, K. and Hope, D. (2000). Urban ecology as an interdisciplinary field: differences in the use of "urban" between the social and natural sciences. *Urban Ecosystems*, 4(1), pp.5-24.

Minx, J., Creutzig, F., Medinger, V., Ziegler, T., Owen, A. and Baiocchi, G. (2011). Developing a pragmatic approach to assessing urban metabolism in Europe: A Report to the Environment Agency, Berlin: Technische Universität Berlin and Stockholm Environment Institute.

Moffatt, S. and Kohler, N. (2008). Conceptualizing the built environment as a social–ecological system. *Building Research & Information*, 36(3), pp.248-268.

Moreira, F., Fontes, I., Dias, S., Silva, J. and Loupa-Ramos, I. (2016). Contrasting static versus dynamic-based typologies of land cover patterns in the Lisbon metropolitan area: Towards a better understanding of peri-urban areas. *Applied Geography*, 75, pp.49-59.

Moss, B. (2008). Water pollution by agriculture. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 363(1491), pp.659-666.

Newman, P., Beatley, T., Boyer, H. (2009). Resilient Cities: Responding to Peak Oil and Climate Change. Island Press, Washington DC.

OECD (2008). Handbook on Constructing Composite Indicators. Methodology and User Guide. https://www.oecd.org/std/42495745.pdf

Panagos, P., Van Liedekerke, M., Yigini, Y. and Montanarella, L. (2013). Contaminated Sites in Europe: Review of the Current Situation Based on Data Collected through a European Network. *Journal of Environmental and Public Health*, 2013, pp.1-11.

Pincetl, S., Bunje, P. and Holmes, T. (2012). An expanded urban metabolism method: Toward a systems approach for assessing urban energy processes and causes. *Landscape and Urban Planning*, 107(3), pp.193-202.

Potere, D., Schneider, A., Angel, S. and Civco, D. (2009). Mapping urban areas on a global scale: which of the eight maps now available is more accurate?. *International Journal of Remote Sensing*, 30(24), pp.6531-6558.

ProSUM. (2016). Harmonising Data Production and Storage for WEEE in the Urban Mine. The EU-UMKDP (Urban Mining Knowledge Data Platform). Presentation at WEEE Waste Cluster Meeting, Diamant Conference and Business Centre, Brussels.

Pumain, D. (2005). Theories of spatial analysis. Hypergéo, Spatial Themes, 1-3, http://www.hypergeo.eu/IMG/_article_PDF/article_190.pdf

Russo, M. et al., 2017. REPAiR PULLs Handbook D5.1.

Shannon, K. (2006). Drosscape: the darkside of men's cultural landscape. Topos: European Landscape Magazine 56, 63-71.

Schremmer, C., Bory, B., Collon, H., Mollay, U., Neugebauer, W., Novak, S., Tordy, J., Schmitt, P., Dubois, A., Galera-Lindblom, P., Reardon, M. et al. (2011). Urban Development Scenarios. (Parts A, B & C) SUME. Wien: Working Papers.

Schwartz, S. H. (1992). Universals in the content and structure of values: Theory and empirical tests in 20 countries. In M. Zanna (Ed.), Advances in experimental social psychology (Vol. 25) (pp. 1–65). New York: Academic Press.

Schwartz, S. H. (1994). Are there universal aspects in the content and structure of values?

Journal of Social Issues, 50, 19-45.

Schwartz, S. H. (2012). An Overview of the Schwartz Theory of Basic Values. Online Readings in Psychology and Culture, 2(1)

Stewart Fotheringham, A. and Rogerson, P. (1993). GIS and spatial analytical problems. *International journal of geographical information systems*, 7(1), pp.3-19.

Steinitz, C. (2012). A Framework for Geodesign. Changing Geography by Design. (E. Press, Ed.). New York, pag. 19 and 27.

Uchiyama, Y., Mori, K. (2017). Methods for specifying spatial boundaries of cities in the world: The impacts of delineation methods on city sustainability indices. Science of the Total Environment, 592, 345–356.

UNFPA (United Nations Population Fund) (2011). State of World Population 2011 People and Possibilities in a World of 7 billion. UNFPA, New York.

Villanueva, A., Delgado, L., Luo, Z., Eder, P., Catarino, A.S., and Litten, D. (2010). Study on the selection of waste streams for end-of-waste assessment. http://ftp.jrc.es/EURdoc/JRC58206.pdf

Voskamp, I., Stremke, S., Spiller, M., Perrotti, D., van der Hoek, J. and Rijnaarts, H. (2016). Enhanced Performance of the Eurostat Method for Comprehensive Assessment of Urban Metabolism: A Material Flow Analysis of Amsterdam. *Journal of Industrial Ecology*, 21(4), pp.887-902.

Wandl, A., Nadin, V., Zonneveld, W. & Rooij, R. (2014). Beyond urban–rural classifications: Characterising and mapping territories-in-between across Europe. Landscape and Urban Planning, Vol. 130, pp. 50–63, DOI: 7 10.1016/j.landurbplan.2014.06.010.

Wirth, L. (1938). Urbanism as a way of life. Am. J. Sociol. 44 (1), 1–24.

Zhang, Y., Yang, Z. and Yu, X. (2015). Urban Metabolism: A Review of Current Knowledge and Directions for Future Study. *Environmental Science & Technology*, 49(19), pp.11247-11263.

Annexes

Annex I - Database descriptions

NACE, Rev 2: Nomenclature statistique des activités économiques dans la Communauté européenne (Statistical Classification of Economic Activities in the European Community, Revision 2)

"NACE is a four-digit classification providing the framework for collecting and presenting a large range of statistical data according to economic activity in the fields of economic statistics (e.g. production, employment and national accounts) and in other statistical domains developed within the European statistical system (ESS).
NACE Rev. 2, a revised classification, was adopted at the end of 2006 and, in 2007, its implementation began. The first reference year for NACE Rev. 2 compatible statistics is 2008, after which NACE Rev. 2 will be consistently applied to all relevant statistical domains." (source)
Metadata
Manual and guideline

Orbis: European Company Data

Orbis is a database that has information on nearly 250 million companies across the globe and is managed by Bureau van Dijk. Orbis Europe, a sub-database includes around 86 million companies in Europe, providing comparable information on business activities, industry (NACE Rev2. core code), financial ratios, company information (ownership, location, number of employees, etc.) (source)

CPA: Statistical classification of products by activity

Statistical Classification of Products by Activity in the European Economic Community. CPA links NACE and Prodcom. "Each CPA product - whether a transportable or non-transportable good or a service - is assigned to one single NACE activity. This linkage to NACE activities gives the CPA a structure parallel to that of NACE at all levels. CPA has a hierarchical structure with six levels, each identified with a specific code:

- first level: 21 sections (alphabetical code);
- second level: 88 divisions (two-digit numerical code);
- third level: 261 groups (three-digit numerical code);
- fourth level: 575 classes (four-digit numerical code);
- fifth level: 1 342 categories (five-digit numerical code);
- sixth level: 3 142 subcategories (six-digit numerical code)." (source)

CPA Version 2.1 (newer) vs. CPA 2008: "The detail has increased, from 3,142 to 3,218 subcategories. The increase in detail primarily affected the lower level of the classification. Since CPA version 2.1 is more detailed than CPA 2008, but the coding system remains the same, identical codes can be used in both versions of CPA but with different content, i.e. corresponding to different sections, divisions, groups, classes, categories and subcategories." (source)
Metadata

PRODCOM: PRODuction COMmunautaire" (Community production)

PRODCOM List 2015;
"PRODCOM is the title of the EU production statistics for Mining, Quarrying and Manufacturing, i.e. Sections B and C of the Statistical Classification of Economic Activities in the European Community (NACE Rev. 2). The title comes from the French "PRODuction COMmunautaire" (Community production). The headings of the PRODCOM list are derived from the Harmonized System (HS) or the Combined Nomenclature (CN), which thus enables comparisons to be made between production statistics and foreign trade statistics. PRODCOM headings are coded using an eight-digit numerical code, the first six digits of which are, in general, identical to those of the CPA

code. The PRODCOM list is therefore linked to, and consistent with, the central product classification." (source)
Metadata PRODCOM List 2016
Excel files with annual data from 1995-2016
Database, detailed data by PRODCOM list

EWC-Stat 3: European Waste Classification for Statistics, version 3

EWC-Stat is a waste classification code, also referred to as LoW (List of Waste) or EWC (European Waste Catalogue) code; LoW replaced EWC and is now EWC-STAT 3.
More information

Other

- Eurostat's Metadata Server: http://ec.europa.eu/eurostat/ramon/index.cfm?TargetUrl=DSP_PUB_WELC
- Eurostat's Concepts and Definitions Database: http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL_GLOSSARY&StrNom=CODED2&StrLanguageCode=EN
- Combined Nomenclature, 2017; sections that list various products (for trading): http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=CN_2017&StrLanguageCode=EN&IntPcKey=&StrLayoutCode=

Annex 2 - Waste definitions and material scopes

The waste definitions and material scopes can be found in this google folder.

Annex 3 - Activity and waste cards

The activity and waste cards can be found in this google folder.

Annex 4 - Tools of Social Analysis

Questionnaire of the Primer Sociocultural Analysis (PSCA)

I/ On a 0 to 10 scale, where 0 is 'absolutely not important' and 10 is 'absolutely important', how would you perceive the relevance of the following factors for a sustainable waste/resource management?

Financial issues

1) Stable financial background of the responsible provider to secure EU standard quality waste services for every customer

0	1	2	3	4	5	6	7	8	9	10	Don't know

2) To continuously aim for additional financial resources (e.g. private investments, government subsidies, etc.) for waste sector

0	1	2	3	4	5	6	7	8	9	10	Don't know

3) To reduce the loss-making waste services and improve the profitable ones even if this intervention has social costs/potentially negative impacts

0	1	2	3	4	5	6	7	8	9	10	Don't know

4) To reduce the loss-making waste services and improve the profitable ones even if this intervention has environmental costs/ potentially negative impacts

0	1	2	3	4	5	6	7	8	9	10	Don't know

5) To provide the same quality services for every customer even if securing accessibility is reducing profitability

0	1	2	3	4	5	6	7	8	9	10	Don't know

Regulations and laws

6) Comprehensive and executable regulations on waste/resource management

0	1	2	3	4	5	6	7	8	9	10	Don't know

7) To explicitly formalize in different (national, regional, local, organizational, etc.) level regulations all the waste/resource management-related issues and practices

0	1	2	3	4	5	6	7	8	9	10	Don't know

8) To leave room for implementation based on the local context

0	1	2	3	4	5	6	7	8	9	10	Don't know

Implementation

9) To benchmark by a multi-level monitoring system waste/resource management service providers according to outputs/costs indicators

0	1	2	3	4	5	6	7	8	9	10	Don't know

10) Strict fines on violating customers

0	1	2	3	4	5	6	7	8	9	10	Don't know

11) To leave grace period before fines on violating customers become due

0	1	2	3	4	5	6	7	8	9	10	Don't know

12) Promotion campaigns to encourage participation in and acceptance of waste/resource management

0	1	2	3	4	5	6	7	8	9	10	Don't know

Infrastructure and technologies

13) Using eco-innovative and smart technologies to improve waste/resource management even if these developments are increasing the costs of services

0	1	2	3	4	5	6	7	8	9	10	Don't know

14) Using eco-innovative and smart technologies to improve waste/resource management even if these developments are challenging the acceptability of services

0	1	2	3	4	5	6	7	8	9	10	Don't know

15) Using eco-innovative and smart technologies to improve waste/resource

management even if these developments are challenging the equal accessibility of services

0	1	2	3	4	5	6	7	8	9	10	Don't know

Learning/knowledge-transfer

16) Waste/resource management service providers should continuously study best practices

0	1	2	3	4	5	6	7	8	9	10	Don't know

17) Waste/resource management service providers should continuously learn from webinars (online transmitted presentations about best practices and innovative solutions)

0	1	2	3	4	5	6	7	8	9	10	Don't know

18) Instead of developing local innovations, waste/resource management service providers should adapt an existing model of best practices if it seems a cheaper solution

0	1	2	3	4	5	6	7	8	9	10	Don't know

19) Waste/resource management service providers should cooperate in developing and sharing eco-innovative solutions

0	1	2	3	4	5	6	7	8	9	10	Don't know

II/ As some research highlights, the social and cultural milieu of a collective entity (society or smaller community, social group) – through the generally accepted and respected social values, norms and attitudes – could influence the effectiveness of public policies. Based on this argument, we are now interested in how you perceive the relevance of the following social and cultural features and attitudes for a sustainable waste/resource management? The scale refers to the same values: 0 to 10, where 0 is 'absolutely not important' and 10 is 'absolutely important'

1) A collective feeling of unity arising from common responsibilities, interests and objectives

0	1	2	3	4	5	6	7	8	9	10	Don't know

2) A bond of social togetherness based on an informal agreement that everybody should have the same opportunities

0	1	2	3	4	5	6	7	8	9	10	Don't know

3) Social cohesion based on commonly respected principles that everybody is entitled to basic individual rights and needs

0	1	2	3	4	5	6	7	8	9	10	Don't know

4) Social unitedness founded on the idea of advancing public interests

0	1	2	3	4	5	6	7	8	9	10	Don't know

5) Willingness for doing, making, undertaking something by one's own accord in the name of collective goals

0	1	2	3	4	5	6	7	8	9	10	Don't know

6) Acting on behalf of the community without force or coercion to promote public interests

0	1	2	3	4	5	6	7	8	9	10	Don't know

7) Supporting others by free choice

0	1	2	3	4	5	6	7	8	9	10	Don't know

8) Willingness to make changes in one's own life and lifestyle

0	1	2	3	4	5	6	7	8	9	10	Don't know

9) Openness for new challenges

0	1	2	3	4	5	6	7	8	9	10	Don't know

10) Searching for new opportunities

0	1	2	3	4	5	6	7	8	9	10	Don't know

11) Ability to cope with individual failures

0	1	2	3	4	5	6	7	8	9	10	Don't know

12) Being critical on one's own customs and habits

0	1	2	3	4	5	6	7	8	9	10	Don't know

13) Confidence in the possibility that things could be better

0	1	2	3	4	5	6	7	8	9	10	Don't know

14) Faith in the achievability of progressive reforms

0	1	2	3	4	5	6	7	8	9	10	Don't know

15) Optimistic beliefs that wrongs are repairable

0	1	2	3	4	5	6	7	8	9	10	Don't know

16) To believe that generally people are honest in dealing with others

0	1	2	3	4	5	6	7	8	9	10	Don't know

17) To believe that generally people are helpful

0	1	2	3	4	5	6	7	8	9	10	Don't know

18) To believe that generally people are taking into consideration common norms before they doing actions or making decisions

0	1	2	3	4	5	6	7	8	9	10	Don't know

19) Willingness to participate in activities promoting public interests

0	1	2	3	4	5	6	7	8	9	10	Don't know

20) Joining civil organizations and/or social movements

0	1	2	3	4	5	6	7	8	9	10	Don't know

21) Protesting against things (decisions, actions, outcomes) that are contradicting or preventing the facilitation of public interests

0	1	2	3	4	5	6	7	8	9	10	Don't know

22) To respect the individual opinion and approach of others

0	1	2	3	4	5	6	7	8	9	10	Don't know

23) Being open for discussion with everybody

0	1	2	3	4	5	6	7	8	9	10	Don't know

III/ Finally, we are interested in how you perceive the relevance of the following factors compare to each other for a sustainable waste/resource management? 1 means you completely agree with the statement on the left; and 10 means you completely agree with the statement on the right. If your answer would fall between 1 and 10, pick up the number that rightly reflects on your perception.

1)

Waste/resource management should be funded by private financial resources

Waste/resource management should be funded by public financial resources

1	2	3	4	5	6	7	8	9	10	Don't know

2)

Waste/resource management
should be regulated
by local level regulations

Waste/resource management
should be regulated
by national level regulations

1	2	3	4	5	6	7	8	9	10	Don't know

3)

Waste/resource management
should be regulated
by local level regulations

Waste/resource management
should be regulated by
EU level regulations

1	2	3	4	5	6	7	8	9	10	Don't know

4)

Waste/resource management
should be regulated
by national level regulations

Waste/resource management
should be regulated by
EU level regulations

1	2	3	4	5	6	7	8	9	10	Don't know

5)

Multi-level strategies on waste/resource
management should be formulated
in bottom-up sense

Multi-level strategies on waste/resource
management should be formulated
in top-down sense

1	2	3	4	5	6	7	8	9	10	Don't know

6)

In waste/resource management related decision makings, political actors should take the lead

In waste/resource management related decision makings, non-political actors should take the lead

1	2	3	4	5	6	7	8	9	10	Don't know

7)

Waste/resource management related strategies and policies should be discussed by a narrow coalition of actors

Waste/resource management related strategies and policies should be discussed by a wide coalition of actors

1	2	3	4	5	6	7	8	9	10	Don't know

8)

Waste/resource management related strategies and policies should be developed by a narrow coalition of decision makers

Waste/resource management related strategies and policies should be developed by a wide coalition of decision makers

1	2	3	4	5	6	7	8	9	10	Don't know

9)

Waste/resource management policies should offer solutions to imminent challenges

Waste/resource management policies should aim for long term solutions

1	2	3	4	5	6	7	8	9	10	Don't know

10)

Waste/resource management should be based on practitioner's knowledge

Waste/resource management shoul be based on academic knowledg

1	2	3	4	5	6	7	8	9	10	Don't know

IV/ Please, specify your background as a stakeholder!

1) Representative of a public institution
2) Representative of a semi-public/semi-private not-for-profit organization
3) Representative of a private, non-business-oriented organization
4) Representative of a private, business-oriented organization
5) Individual not representing any institution or organization

V/ Please, define the main territorial scope of your institution/organization! (If you are not member of any institution/organization as a stakeholder, please, do not answer this question!)

1) Local
2) Regional
3) National
4) Supranational/international

VI/ Does your institution's/organization's main field of interest/business is waste/resource management? (If you are not member of any institution/organization as a stakeholder, please, do not answer this question!)

1) Yes
2) No

Indicators of the Socio Economic Analysis (SEA)

Population size, in millions
Number of live births
Number of death
Inbound migration
Outbound migration
Population ages 0-14, percent of total
Population ages 15-64, percent of total
Population ages 65 and above, percent of total
Female population, percent of total
Urbanisation level (%)
Land area in sq. km
Life expectancy, in years
Fertility rate, births per woman
Residents with elementary school
Residents with high school/secondary education
Residents with university/tertiary education
Average net salary (per capita)
Number of income tax payers
Labor force, million people

Unemployment rate
Unemployment rate for females
Unemployment rate for males
Long term unemployment (more than 180 day are unemployed)
Employment rate
Employment rate for females
Employment rate for females
Labor force participation rate
Labor force, percent female
Female labor force participation rate
Male labor force participation rate
Forest area, percent of total land area
Total employment number in different sectors
Employment number (or rate) in Agriculture (of total employment)
Employment number (or rate) in Industry (of total employment)
Employment number (or rate) in Service sector (of total employment)
Total number of business
Number of business in industry
Number of business in agriculture
Number of business in service sector
Value added in the agricultural sector as percent of GDP
Forest area, sq. km
Agricultural land in use in all agricultural farms (ha)
Number of organic farmers
The share of organic area in relation to the total Utilised agricultural land (%)
Area under organic farming (ha)
GDP per capita (at purchasing power parity)
GNI (gross national income)
Consumer Price Index (CPI)
R&D in GDP rate
Export rate (%) of registered business
Import rate (%) of registered business
Balance of trade (in million EUR) - (EU vs. Non.EU)
Balance of trade (in million EUR) - (country vs. EU/Non.EU if available)
Gini index/coefficient
HDI (Human Development Index)
Railway density (km/100 km2)
number of cars per 1000 inhabitant
Road transportation (in ton=1000kg)
Transportation on railway (in ton)
Road network (in km)
Road network density (m/km2)