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Chapter 11
Eliciting Information for Developing a Circular Economy in the Amsterdam Metropolitan Area

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11.1 Introduction

Accomplishing circularity in metropolitan areas involves planning, co-designing, and implementing spatially explicit interventions with a multitude of stakeholders who are required to work with waste and resource management information (Arciniegas et al., 2019; Remøy et al., 2019). Waste management data is often communicated using Sankey diagrams (e.g., Clift et al., 2015; Mairie de Paris, 2017), which depict cities as black boxes where flows enter, are transformed or stored, and then either directly consumed or exported. However, what occurs in the black box remains unknown to the decision-maker. An interactive cartographic and therefore spatially precise representation of (waste) streams constitutes a way to enable stakeholders to formulate waste management strategies based on this enhanced spatial understanding of waste streams in a city or region. Furthermore, a cartographic representation of waste streams allows overlay with other data, for example, zoning and development plans of cities and regions. This overlay enriches the possibility to rethink waste management strategies, focusing more on reusing as well as establishing local synergies than seeing the waste of one activity as the resource of another activity. Therefore, this chapter addresses the following research question:

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Can spatial planning and waste management digital information be used to portray and communicate information on streams of resources, materials and waste?

This chapter focuses on the digital representation and specific use of different types of information in a digital spatial decision support tool that aims to help decision-makers through stages of the collaborative process that begins at problem identification and status quo understanding, and finishes at the proposed circular economy (CE) strategies for a peri-urban area. The tool is called the Geodesign Decision Support Environment (GDSE) and is implemented as an interactive web application aimed to support the process of co-developing spatial strategies for quantitatively reducing waste flows, thereby promoting and advancing circularity in the Amsterdam Metropolitan Area (Arciniegas et al., 2019). The way in which information is modeled and presented in the tool is largely based on the geodesign methodology (Steinitz, 2012), and is specific to individual stages of the planning process. The GDSE presents information relevant to a study area through different mediums, namely web maps and charts to describe the study area, Sankey diagrams linked with dynamic vector flow maps to portray its resource flow streams, and the integration of the above to portray and assess the scenarios developed jointly by the stakeholders.

11.2 Circular Economy, Spatial Planning and Cartography

11.2.1 Circular Economy and Spatial Planning

In the last decade, more and more cities have recognized their crucial role in addressing the climate crisis, aiming for a "green recovery," achieving a "green deal," respecting the planetary boundaries or one of the many more "headlines" used to trigger and steer a more sustainable urban development. Cities are accounting for up to 80% of greenhouse gas emissions, two-thirds of the total energy demand, and 50% of waste generation globally; therefore, it is not surprising that circular economy strategies are recurrently part of urban and regional sustainable development policies. As cities become key players in the circular economy discourse, spatial planning is increasingly viewed as an instrument to integrate circular economy with other policy fields. Spatial planning aims to redevelop and adapt physical, socio-cultural infrastructure, the economy, and the environment into its built form as well as the planning and development process (van der Leer et al., 2018). As Williams (2020) puts it, "spatial planning needs to intervene in markets to provide space for low-value, circular activities and enable the localized looping of resources within city-regions. … support infrastructure needed for circular actions and ensure urban form continues to support circular systems adopted." The often unanswered question is "where does this all need to happen?" All the plans need to land in physical locations. Both cartography and geographically informed co-creation play a crucial role in this decision process, as we will demonstrate in the remainder of this chapter.

11.2.2 Interactive Cartography for Spatial Planning

The tool presented in this chapter, the GDSE, is used for involving stakeholders in the process of active co-creation of waste management strategies, which exemplifies practical implementations of the Geodesign concept. This approach derives directly from theoretical spatial planning considerations in the era of a widespread use of Information and Communication Technologies (ICT) and Geographical Information Systems (GIS) (Geddes, 1947; McHarg, 1969). This section follows the evolution of views on the role of cartography in the creation and communication of spatial information. The onset of establishing a framework for analyzing how maps work and perceiving cartography as a science is commonly linked to Arthur Robinson's publication *The Look of Maps* (1952). The so-called "theoretical revolution" in cartography consisted of reorienting the goals from recognizing historically changing conventions to identifying mechanisms determining the functioning of a map and working out methods for increasing its effectiveness. This could be achieved through an in-depth analysis of important elements of the system, in line with the prevailing notion of scientific positivism.

Initially, the aim was to establish principles for a precise presentation of information by means of a spatial, universal manner, detached from the specific content of a map (Arnberger, 1970). Robinson (1952) introduced the concept that the function of maps is to communicate their concrete content to the people (Board, 2017). The classical transmission of information theory (Hartley, 1928) assumed that cartography should be perceived as the transmission of information concerning specific fragments of reality encoded in the form of data and then not only transcoded in relation to requirements of a specific medium such as the map (visualization stage) but also decoded by the map user (perception stage). The role of cartography is to refine the methods of encoding such information to reach the user least distorted by the information noise occurring at the stages of visualization and perception (Robinson & Petchenik, 1976). Early in these stages, the information noise can be caused not only by the map editor's inappropriate conduct but also by a deliberate generalization and symbolization of data. Consequences of these actions include generalization, simplification, and partial distortion of transmitted information. Nevertheless, benefits emerge as reducing the uncontrolled and individually determined distortion of information while perceiving the map content. At this stage, the users' thought processes as synthesizing or abstracting are rather irrelevant. Thus, informativeness and legibility of a map are closely related to each other, establishing a form of negative feedback, and should be considered cumulatively.

Following the communication paradigm, the cartographic transmission of information was considered more broadly compared to the formal approach. However, while significant impacts of receiving information from the map on the final efficiency of transmission were acknowledged, the map user was still regarded as a passive recipient of encoded information; thus, being more a map reader rather than a user. Additionally, it was assumed that the map's author possesses objective knowledge on the presented fragment of reality, and map editing consists merely of an appropriate application of specific visual graphics' principles (Bertin, 1967; Dent, 1972).

In the following years, there were significant changes concerning this view, being an aftermath of geography's abandoning the neo-positivist pursuit for one universal truth through reductionism—understanding a complex phenomenon by developing knowledge on its isolated essential elements—in favor of the postmodern paradigm. Considering the possibility of employing cartography in spatial planning, these shifts in viewpoints proved crucial. Particular models regard cartographic communication as a unidirectional linear transfer of information. Reducing the possibility of feedback was an obvious consequence of the fact that models were devised at a time when the dominant medium for maps was paper and the scope for receiving feedback from map users was considerably confined. This remark became a crucial step toward further developing cartographic theory. In the next decades, the communication paradigm was depriving such assumption, ultimately being undermined and numerous attempts for its substitution occurred. In consequence, in cartography, a slightly different, broader view on the process of cartographic transmission of information gradually developed and became prevailing over time. This notion is formed by a whole group of theoretical concepts that share a common feature of shifting attention from cartographic editing toward map users. This reorientation of approach is closely related to the increase in popularity of the term "cartographic method of research" (Salishchev, 1955). As opposed to cartographic methods of presentation, it allows the active participation of map users in cartographic information transfer (Montello, 2002). During this process, not only information noise may arise, but also some "informative added value" (MacEachren, 1995). Information obtained as a result of using the map depends on the questions posed by its user, who provides the map with desired content (Olson, 1984). It is thus individualized, embedded in the context of the map user's conceptual model. Consequently, there are no universal map editing principles that would be optimal for every user. Furthermore, the map user can acquire answers to questions that go beyond the author's initial purpose. Therefore, the map provides the possibility of obtaining information on a specific matter rather than a particular message (Keates, 1996).

The role of the map's author in the process of cartographic information transfer has been perceived more broadly than in the assumption of cartographic method of presentation. Evidently, the cartographer's knowledge on the map's subject cannot be complete nor presented objectively (Perkins, 2017). Therefore, it has become reasonable that the map's author may also act as its user—who, by means of implementing cartographic methods of research—may obtain new information or adjust prior perception of the surrounding reality. The trend of increasing appreciation associated with the role of map users was rooted in the cognitive approach (Aslanikashvili, 1974; Salishchev, 1975). This research was characterized by a holistic view upon potentials of obtaining information based on a map, regarded as a coherent system of signs. The stage of map perception was in this case treated much more broadly than in the communication paradigm. It not only included psychophysical determinants attributed to reception of visual stimuli, but also a number of thought processes enabling interpretation of received information in the context of individual experience, conceptual models and map user's imagination. The consequence of accepting the individualized character of using a map was the rejection of reductionism in research, which was aimed at optimizing individual signs to produce one universal map. The map began to be compared to other sources of learning about the surrounding reality. It has thus been treated as a model depicting reality in a formalized, logical, simplified, and purposeful manner, considering only the attributes relevant to a particular objective. By means of the above-mentioned characteristics, one becomes acquainted with a certain aspect of reality's structure, which in the case of maps is mostly the spatial aspect (Czerny, 1993). The cognitive approach also embraces the semiotic concept (Freitag, 1971), in which cartography is compared to a language (Pravda, 1994). Semantic principles in this case define the meaning of individual cartographic signs (words), which can be expressed by means of a legend (dictionary). Rules of syntactics describe how these signs are constructed using elementary graphic variables (alphabet) (Bertin, 1967), and relations between them (grammar). The principles of pragmatics define the purpose and function of a map, i.e., the conceptualization and expression of reality by the map's author, features of a potential group of its end users along with anticipated circumstances and purposes of use (non-verbal context of a language communicate).

During the 1990s, the process of convergence of communication and cognitive approach was triggered, which is natural as each cognition requires flow of information (Berlant, 1992). The crucial difference relies on emphasis as principle. These basic, apparently contradictory, viewpoints are simply stressing syntactic (in communication approach) or semantic and pragmatic (in cognitive approach) relationships. While the Internet with a widespread use of the World Wide Web became a major medium for cartography since the mid-1990s (Peterson, 2007), another wave of attempts to develop cartographic theory occurred and convergence of communication and cognitive approach even accelerated, which is also strictly linked to ICT and GIS tools development. A smooth transition between transmission of spatial information and its visualization takes place in three dimensions of map using: the purpose of use (from reading a known to discovering unknown spatial information), the target group of users (from general public to the individual needs of the author) and the flexibility of use (from traditional maps to *interactive dynamic maps*).

Being in use since the 1990s, mapping means made it more feasible for anyone than ever to be a cartographer for his own purpose (Muehlenhaus, 2014). Simultaneously, maps are ideal for dissemination and consumption of spatial aspects of information because their graphical format of complex spatial patterns provides an immediate visual summary that can inform (or misinform) (Kent, 2017). Also, a map-maker receives from a map user immediate feedback concerning information disseminated via a map, even if it is not the same person. Thus, a constant evolution of maps triggers cartographic creativity and diversity as cartographic communication can nowadays simply become a "cartographic dialogue." This is reflected in the theory of cartography as well, where map using became to be perceived as another, equivalent ending of the same continuous axis.

Some cartographers go even further. Attracted by the epistemological break introduced by Harley (1989) as critical cartography, they claim that currently the entire purpose of designing maps is to provide quick visual delight and nothing more (Field, 2014). While the medium of web mapping is designed to be ephemeral, there is a diminishing return on the time spent on their aesthetics and a good design of maps is disappearing in a current age (Muehlenhaus, 2014). Nevertheless, even if the map user is the same person as the map-maker, successful map using requires providing a meaningful product.

Perceiving cartography as a science has evolved gradually. The last decades have seen the development of a broad view of its subject. As an aftermath, today's maps, which are not preserved on any solid medium (hard copy) by the author and its impact on undertaking concrete actions for spatial planning, perfectly fit into the existing concepts. In turn, the development of a cartographic methodology allows the map user to obtain increasingly accurate and precise answers to the questions raised. However, it was only the dynamic development of ICT and GIS that facilitated, accelerated, and disseminated this process in practice, granting the aforementioned theoretical concepts and progress in the methodological field a strictly applicative dimension. The following sections describe map use within the GDSE for the inclusion and activation of stakeholders in the spatial planning process, which is one of the numerous examples of possibilities to widely benefit from achievements in the field of "interactive" cartography for practical purposes.

11.2.3 Representing Waste Management Information

This chapter deals with the representation of waste management information, particularly flows of materials and waste between actors, and spatially explicit strategies that aim to reduce quantities of waste generated in these flows. Information on flows of resources is typically represented by Sankey diagrams. A Sankey diagram is a well-known type of flow diagram in which the width of the arrows is proportional to the flow rate, and emphasizes the major transfers or flows within a system. Sankey diagrams are often used to represent inputs, useful output, and wasted output, but do not give an indication of the spatial component, or detailed spatial patterns, of these flows. Figure 11.1 exemplifies how Sankey diagrams are currently used to visualize waste streams for three European cities: Paris, London, and Amsterdam.

The Paris Circular Economy Plan 2017–2020 describes the city's commitment to implement a circular economy, and the targets set targets to advance toward developing it (Mairie de Paris, 2017). To describe the current flows of materials entering and leaving Paris in 2015, the report utilizes aggregated Sankey diagrams that show the major flows of materials and waste (see Fig. 11.1a). This study also provided a "first portrait of emerging forms of economy," which were mapped using an interactive map of services provided by these "new forms of economy" and available online on the website of the Paris Urban Planning Agency (APUR, 2020). This map shows a point cloud portraying the potential services these economies produce and

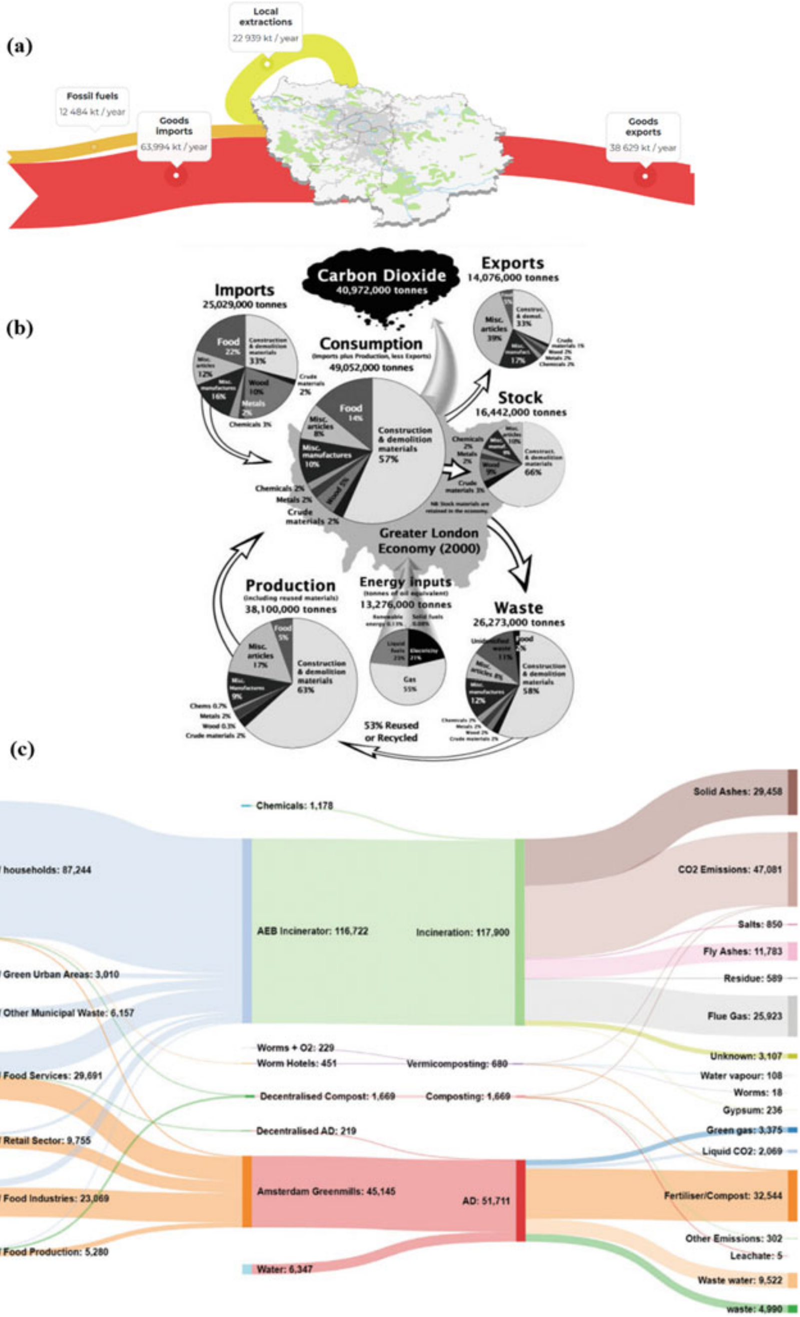

Fig. 11.1 Examples of resource flow visualizations using Sankey diagrams: (a) total amounts of waste flowing in and out of the Metropolis of Greater Paris (Urban Metabolism of Paris, 2019). (b) Urban metabolism of London in 2000. (c) MFA for organic waste (t/year) in Amsterdam visualized through a Sankey diagram

classifies them into categories, such as food, mobility, coworking, fablabs, resource centers, recycling centers, and accorderies.

As a second example, the city of London has set the circular economy goal to generate by 2036 net benefits of at least £7 billion every year. To address this goal, the London Waste and Recycling board (LWARB) published in 2017 the Circular Economy Route Map as the main plan of action to accelerate the circular economy across London. This plan reports total aggregated amounts of waste generated for waste themes, such as built environment, food, textiles, electricals, and plastics; and provides guidance for the acceleration of London's transition to become a circular city and it recommends actions for stakeholders (LWARB, 2017). In 2018, the Greater London Authority (GLA) published its London Environment Strategy, covering, among several environmental themes, energy, waste, and the transition to a low carbon circular economy (GLA, 2018). The total amount of municipal waste produced in London is reported and its major waste stream contributors identified as green garden waste and common dry recyclables (paper, card, plastics, glass and metal), food waste, and plastic packing. In a broader context, a working paper prepared by the Government Office for Science discusses urban metabolism and its implication for environmental sustainability for, among other UK cities, London. In this working paper, urban metabolism is understood as the inflows of material and energy resources, the outflows of wastes and emissions, and the retention of materials as stock in the built environment and infrastructure (Clift et al., 2015). This study uses results from an earlier analysis of urban metabolism in London by Best Foot Forward (2002), which delivered aggregated non-spatial results for material flows (construction and demolition, miscellaneous articles, food, and miscellaneous manufacturers, wood, gas, liquid fuels, unidentified waste, crude materials, metals, chemicals, electricity) in the Greater London Area in terms of imports, exports, consumption, production, energy inputs, waste, and stock (see Fig. 11.1b).

The city of Amsterdam implemented a "City Circle Scan" to identify areas in which the city can make progress toward realizing a circular economy. This scan helped identify construction and organic waste value chains as key streams to target and accelerate this transition (Circle Economy, 2015). The scan also shows how these resources move through the city, and highlights what is not circular in the current economy to target areas that can be further addressed. These aggregated flows are visualized in a 2.5D Sankey diagram overlaid on a landscape sheet. A study by Viva et al. (2020) performed a Material Flow Analysis (MFA) for organic waste in the city of Amsterdam and delivered classic Sankey diagrams for these flows (see Fig. 11.1c).

These examples show aggregated values for flows of energy, materials and waste, but disregard actual locations of all the individual actors involved in the flows. The next section describes a method to represent and visualize information on flows of waste and materials between involved actors, and the solutions to reduce waste quantities in these flows.

11.3 Presentation of Information for Co-Developing CE Economy Strategies

11.3.1 Geodesign Decision Support Environment

There are numerous ways to present and generate information to support spatial decision-making. Maps and charts are obvious and preferred means (Janssen & Uran, 2003). Maps and interactive charts are common means, and more recently implemented ICT tools, such as IoT and dashboards (e.g., Jagtap et al., 2019), virtual environments, multi-touch tables, and planning support theaters (e.g., Punt et al., 2020). This section shows how waste management information can be presented in a digital tool, which is used at living lab workshop settings by stakeholders of the Amsterdam Metropolitan Area to co-develop spatial waste management strategies that contribute to developing a circular economy. The tool is called the GDSE, and was developed as part of an EU-funded research project called REPAiR (http://h2020repair.eu/).

The GDSE features an open-source prototype web application that has been implemented in living labs in six European peri-urban areas with the purpose to support the process of developing place-based eco-innovative spatial development strategies that aims to have a quantitative reduction of waste flows (Arciniegas et al., 2019). Within REPAiR, a GDSE-related eco-innovative strategy is understood as: "*An alternative course of actions aimed at addressing the objectives identified within a Peri-Urban Living Lab (PULL) for developing a more CE in peri-urban areas, which can be composed of a systemic integration of two or more elementary actions, namely eco innovative solutions (EIS)* (Amenta et al., 2019)." The GDSE is meant to be used collaboratively by multiple stakeholders and is structured in five main steps, namely Study Area, Status Quo, Targets, Strategy, and Conclusions. Each step addresses one or more of the design questions proposed in Steinitz's Geodesign framework (Steinitz, 2012), and presents specific information to stakeholders. Table 11.1 describes the purpose of each step, and the information that is presented, generated, and used.

This chapter focuses on the steps Study, Area, Status Quo, and Strategy, and utilizes the example of the Amsterdam Metropolitan Area Peri-Urban Living Lab (AMA PULL) to demonstrate how information is presented and used, to support spatial decision making for developing a circular economy. A pilot case study of REPAiR, the Amsterdam peri-urban area includes the city of Amsterdam, the provinces North Holland and Flevoland, which amount to a total of 32 municipalities containing over 2.4 million inhabitants. The CBS, the Statistics Netherland's database, provided waste datasets for companies, which included supply, composition, and processing of company/industrial waste in the Netherlands, for the year 2016. More specifically, this data contains information on the type of waste (Eural code), waste generator (i.e., name and geo-location of the company), and waste collector (name and location of waste treatment), and the type of waste treatment.

Table 11.1 Purpose and information presented for all five GDSE Steps (adapted from Arciniegas et al., 2019)

GDSE step	Purpose of step	Information presented, processed, and used
Study area	Describe and explore the peri-urban area	Maps: spatial planning and MFA Charts: CE objectives as charts Stakeholders: as text Key resource flows: text and images
Status quo	Describe the current status of circularity of the peri-urban area Present results of MFA Present and rank CE objectives relevant in the peri-urban area	Flows: as Sankey diagrams and maps Flow Assessment: as charts and maps Wastescapes: as maps Sustainability indicators: as numbers, tables and charts Objectives: text and images
Targets	Match flow indicators targets with CE objectives Rank CE objectives	Flow indicators as interactive text boxes that can be linked with CE objectives CE objectives as interactive text boxes that can be ranked
Strategy	Present available solutions Present actors involved in solutions Choose solutions and their locations as combined strategies Explore how strategies affect flows Control if targets have been achieved and to what extent	Solutions as Images and charts Actors as Maps Strategies as maps Flows as Sankey diagrams and maps Charts
Conclusions	Present generated a comparative summary of the entire geodesign process	Text, tables, charts, and maps

The five steps of the GDSE are used in the phases of a peri-urban living lab, as defined in the REPAiR project by Amenta et al. (2019).

11.3.2 Presenting Information on Waste Flows in Spatial Planning

The first GDSE step "Study Area" presents the study area (i.e., the peri-urban Amsterdam Metropolitan area) to stakeholders using maps, charts, stakeholders, and key flows. Particularly, maps include external web mapping services (e.g., topographic or satellite photo from OpenLayers, Google maps, Leaflet, OpenStreetMaps), as well as individual thematic maps that were generated for the living lab's study area (e.g., environmental and socio-economic maps, waste management maps, and maps resulting from material flow analyses). These maps are available at all times at later stages of the collaborative process, and can be utilized, for example, as background maps, on which waste flows can be overlaid. The GDSE organizes and presents map information for the AMA PULL, and also stores and presents information about stakeholders of the decision process and their specific objectives as tables and charts.

The second step "Status Quo" presents stakeholders with the key flows of materials and waste relevant to the study area, and allows stakeholders to define flow assessment indicators relevant to the key flows and specific administrative locations. Flows or resources are modeled as follows: yearly household and industrial waste data is gathered, geocoded, and coupled with European activity data. The result is a georeferenced point cloud of actors in vector format with attributes for type of waste, waste generator, (e.g., name and location of the company), and waste collector (name and location of waste treatment), and the type of waste treatment. Activity-based Material Flow Analysis is used to analyze and visualize this point data up to the level of individual materials (Geldermans et al., 2019). Figure 11.2a shows flows visualized into two interlinked views: (1) as a Sankey diagram showing activities, materials involved, and flow rates. Flow direction is visualized mostly from left to right; and (2) as an animated flow line between actors in vector format on the map. The thickness of flow lines indicates relative flow ratios. The views are interactive and also interlinked, which means if a flow is selected on the Sankey diagram, it will be displayed on top of a background map, and color-coded accordingly on the flow map. The flow map shows the actual directions of the flows, which are determined based on whether the actor is categorized as the start (origin) or end (destination) of a flow. By hovering the mouse on a flow on the left, flow characteristics (such as start actor, end actor, material composition, treatment type) are displayed. Mouse hovering can also be done on Sankey flows on the flow map.

Figure 11.2b shows an example of a flow map used in an Amsterdam PULL workshop that focused on food waste. The participants wanted to visualize food waste flows for oils and fats at the material level in order to achieve an understanding of the individual material flows for this type of waste, and see which flows needed to be addressed in later steps to contribute to a CE. The GDSE evaluates the status quo in terms of flow indicators based on the MFA data. Flow indicators are first identified using existing literature and then are selected through a collaborative process by the stakeholders during a co-design workshop. REPAiR defines an initial list of flow indicators, which includes flow amounts (for each material or their combination, e.g., vegetal waste vs. separate vegetables and fruits), flow structure (e.g., percentage of renewable material in each flow), flow intensity (e.g., amount of flow consumed/conducted per person), flow efficiency (relationship between economic factors and each material flow), and flow density (material consumption/conduction to sustain urban development) (Arciniegas et al., 2019). For the case of the flow in Fig. 11.2b, stakeholders were interested in assessing the oils and fats flows per inhabitant for the entire city of Amsterdam.

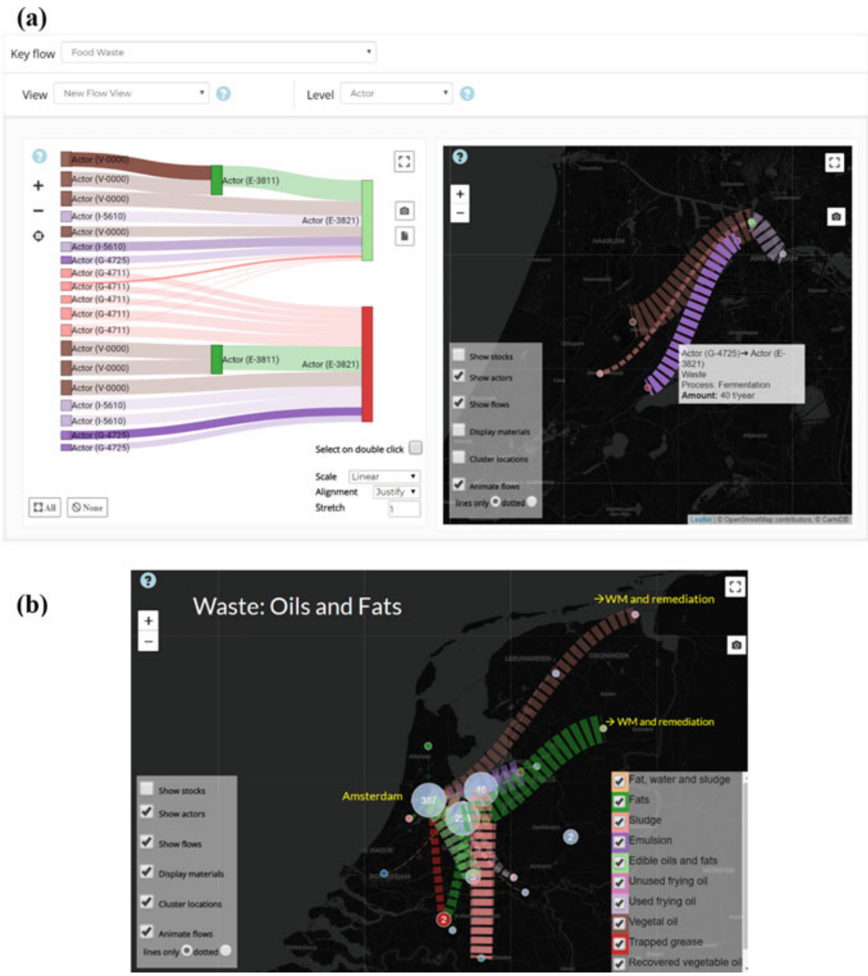

Fig. 11.2 Visualizing flows of food waste between actors in Amsterdam. (a) The Sankey diagram (left) shows individual flows color-coded for activity. A selection of flows is visualized on the flow map, while an animation shows the actual flow direction and flow attributes are retrieved via mouse hovering (right). (b) Aggregated flows visualized and color-coded at the material level

11.3.3 Presenting Circular Economy Strategies

The fourth step Strategy helps stakeholders co-develop eco-innovative strategies for their city. A Strategy is a proposed combination of solutions implemented in specific areas by specific stakeholders. The GDSE stores all the solutions available for the case study, which were developed by researchers of the living lab, based on the circular economy goals of the city. Stakeholders use the GDSE to select from these existing solutions and draw implementations (i.e., polygons in vector format) of these solutions at desired spots or locations in the study area. After choosing one solution, members of the small group indicate which stakeholders should be involved in the development of the solutions for their metropolitan area. Within the REPAiR project, an *eco-innovative strategy* consists of:

- One or more *eco-innovative solutions*
- Implementation Locations (areas) of these specific solutions
- One or more Stakeholders to be involved in these implementations
- A number of Actors (companies, households) affected by the value chains of the solutions in the strategies

A REPAiR solution can be viewed as creative and smart ideas aimed to improve a specific and fixed process in relation to the management of waste as a resource. For example, a REPAiR local solution called BIO-BEAN can transform coffee grounds into renewable energy, and was implemented for the city of Amsterdam. The solution is intended to alter the current linear process of generating coffee grounds (which normally would finish at a landfill or incineration plant), through a process, more circular, proposed in the solution, in which the coffee grounds are collected, transported, processed, and turned into renewable energy. At the PULL workshops, stakeholders used the GDSE to propose implementations of Eco-innovative solutions. These implementations are locations where the solutions are relevant and can be operationalized. Within the GDSE system, an implementation of a solution is a polygon drawn by a stakeholder using a touch-enabled screen. One or more polygons for the same solution can be drawn by the stakeholders. Figure 11.3a illustrates a GDSE-implementation of the BIO-BEAN solution in peri-urban Amsterdam.

The map of Fig. 11.3a shows all actors that generate coffee grounds in the city center of Amsterdam, and outside: restaurants, hotels, catering. This is the basis for drawing implementations. Next, participants set a desired percentage that could be used for the solution. This will have an effect on the impact of the strategies. Using the GDSE and the information on the key flows presented earlier together with the map of relevant actors, participants can draw multiple implementations of the same solution, and also of other solutions that are part of their integrated strategy to develop the circular economy of their city. Multiple solutions can be selected and locations of implementation can be drawn using the GDSE (see Fig. 11.3b).

Once the small group finishes drawing implementations of solutions (i.e., their strategy), the next step is to press the *Calculate* button (Fig. 11.3b), which will start assessing the impact of their strategy on the waste and material flows of the status quo. The GDSE selects those actors and activities that produce the specific waste flow and assesses all the strategies that were drawn by all the groups, both in terms of sustainability and circularity. Flows and actors inside a drawn polygon are incorporated in the calculations to modify the flow situation and thereby reduce quantities of waste (Fig. 11.3c).

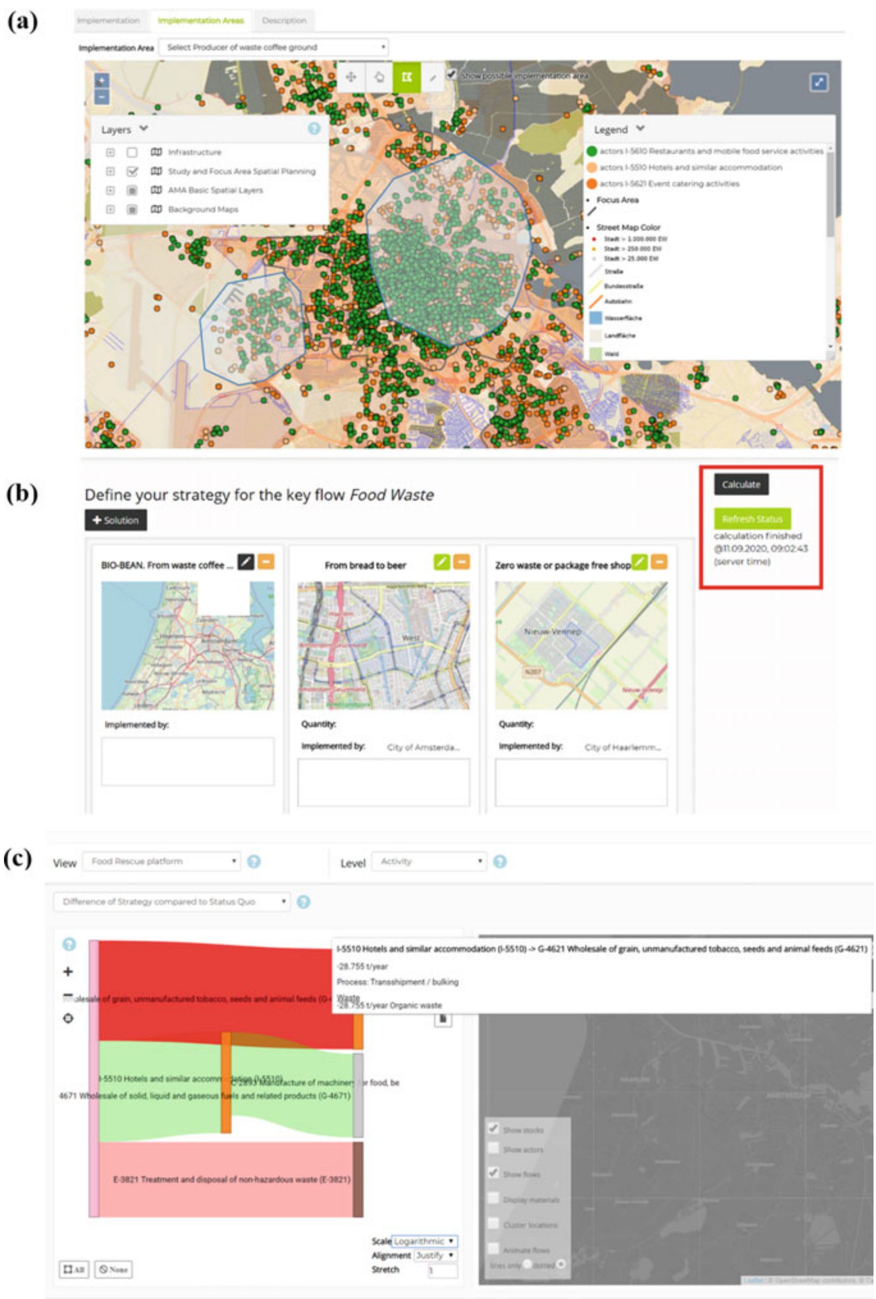

Fig. 11.3 Visualizing solutions and strategies, and their impact. (a) Drawn polygons represent spatial implementations of BIO-BEAN solution at workshop, overlaid with a map of actors that generate coffee grounds. (b) Combining implementations of BIO-BEAN with other two solutions into one strategy. (c) Sankey diagram showing color-coded impacts, and new attributes of the flow on mouse hovering

11.3.4 Presenting Flow Assessment of Circular Economy Strategies

To assess the impacts of one strategy (i.e., a bundle of solution implementations) on the flows, all solutions must be modeled and operationalized involving a consistent flow modeling. Thus, REPAiR solutions are modeled as a collection of *solution parts*, where one solution part describes a proposed process looking to affect a current process (this is, status quo flows between economic activities). A solution part is defined as six schemes for six processes, namely flow modification, shift of flow origin, shift of flow destination, new flow creation, flow prepending, and flow appending.

Assessing flow changes is done by comparing the status quo flow indicators set earlier with the anticipated changes introduced by the strategies. Once a combination of solutions and their implementation areas were chosen by the workshop participants, the GDSE calculated the impact in three steps; (1) actors within the drawn implementation areas are captured and selected. (2) A flow calculation algorithm redistributes the flows in between the economic activities, keeping overall mass balance of the affected flows consistent and also distributing total surplus or shortfalls within an economic activity in between all actors inside the drawn implementation area. (3) Flow changes are reflected in the chosen flow indicators and their values can be compared with the targets that were defined earlier. Figure 11.3c shows this visualized in the GDSE. The flow in red denotes a reduction of food waste at the level of activity “Wholesale of grain, unmanufactured tobacco, seed and animal feeds” by 28.8 tons/year, while green flows show increased quantities of materials or waste demonstrating a positive impact of the drawn strategy on the circular economy of Amsterdam.

11.4 Conclusions

This chapter demonstrated how information on flows of resources can be portrayed and used to improve the circularity of waste flows in a peri-urban area. The REPAiR project’s main support tool, the GDSE, is a tool that attests to the reported shift of cartography, in line with the development of ICT and GIS, from static maps and charts to *interactive dynamic maps* that prompt the inclusion and activation of stakeholders in the spatial planning process, and includes a cartographic representation of flows of resources and materials to create enhanced spatial strategic scenarios. The GDSE was used in workshops as part of the Amsterdam PULL, playing the role of the main tool for the creation and communication of both spatial information and strategic scenarios that decrease waste quantities. Flows of resources were successfully presented to stakeholders at the level of commercial activity, individual actors, and specific materials in order to provide more insight into the waste flows coming in and out of Amsterdam. Beyond applying sound cartographic principles when preparing informative interactive dynamic flow maps, it is important to note that the success of the GDSE-implementation also, and quite strongly, depends on the availability, quality, and detail level of the data necessary for mapping and processing flows of resources. Data on yearly household and industrial waste is not always easy to find, and very often is confidential, and in some countries not detailed enough (to allow analysis at the level of specific materials) or just absent. The GDSE is meant to be used in workshops and by teams of stakeholders, following a stepwise structure that allows them to (1) attain a common understanding of their study area both in geographical and waste management terms, (2) explore and understand the spatial dimensions, actors involved, and material-specific compositions of the various flows of resources flowing into and out of their city, and (3) use this information identify actors, neighborhoods, city areas where solutions can be optimally implemented in order to reduce waste quantities in their peri-urban area, thereby making progress toward developing a circular economy.

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