REPAiR

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

D2.5 Adapted GDSE modules

Version 2.0

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Acronyms and Abbreviations

AMA	Amsterdam Metropolitan Area
AS-MFA	Activity-based Spatial Material Flow Analysis
CA	Consortium Agreement
CE	Circular Economy
CFS	Certificate on the Financial Statement
DMP	Data Management Plan
DoA	Description of Action
EB	Executive Board
EC	European Commission
ECA	European Court of Auditors
ECAS	European Commission Authentication Service
EIS	Eco-Innovative Solution
EU	European Union
FSIGN	Project Financial Signatory
GA	Grant Agreement
GAP	GDSE Application points
GDSE	Geodesign Decision Support Environment
GF	Guarantee Fund
GPL	General Public License
LCA	Life Cycle Assessment
LEAR	Legal Entity Appointed Representative
LSIGN	Project Legal Signatory
NACE	Statistical Classification of Economic Activities in the European Community
OLAF	European Anti-Fraud Office
PaCo	Participant Contact
PM	Person Month
PO	Project Officer
PULL	Peri-Urban Living Labs
SC	Steering Committee
SP	SharePoint
UB	User Board
UoR	Use of Resources
WP	Work Package

Table of Contents

Publishable Summary

The Geodesign Decision Support Environment (GDSE) is the core product of the REPAiR project. The GDSE constitutes the main digital support tool for both the research and the interactive workshop sessions that are part of the execution of the Peri-Urban Living Labs (PULLs) for all six case studies in the project. The GDSE is programmed as a web-based open source tool that adapts the geodesign methodology to the purpose of spatial diagnosis and creation of territorial and systemic eco-innovative strategies towards a Circular Economy. This deliverable builds on deliverable 'D2.3 Programmed GDSE Modules', which presented the first version of the GDSE two years into the project. The present deliverable presents the final module structure of the GDSE, together with an explanation of the various functionalities and capabilities of each module. Finally, this deliverable shows how the GDSE has been applied, tested, and evaluated within the case study site of the Amsterdam Metropolitan Area, that is the Peri-Urban Living Lab of the Amsterdam Metropolitan Area (the AMA PULL).

1. Introduction

The Geodesign Decision Support Environment (GDSE) is the core digital support tool of the REPAiR project's approach and methodology. It is a web-based open source tool that adapts the geodesign framework for the purpose of spatial diagnosis and creation of territorial and systemic eco-innovative strategies towards a Circular Economy (CE) (Arciniegas et al., 2019). The GDSE links and organises the collected thematic and spatial data, as well as the generated flow data, with regards to the ideas and preferences of the stakeholders that participate in the Peri-Urban Living Lab (PULL) workshop series of the project's six case studies. The main objective of the GDSE is to support both the decision-making process and the research process conducted by the study team that is required for all phases that guide the living lab process for a study area.

This deliverable is originally based on three previous deliverables, namely D2.1, D2.2, and D2.3. Deliverable D2.1 "Vision of the GDSE Applications" contains the common vision of the GDSE developed at the beginning of the project (REPAiR, 2016). Based on this vision, a more detailed draft of the GDSE was developed in consultation with the project partners, particularly the work package leaders of WP3, 4, 5 and 6 as well as the "data captains" of the six case studies, namely deliverable D2.2 "Data Requirement Description and Data Delivery Plan for the Case Study Areas" (REPAiR, 2017). Deliverable D2.3 "Programmed GDSE Modules" presented the progress of the software development process of the GDSE, two years after the start of the project (REPAiR, 2018). D2.3 contained descriptions and demonstrations of the GDSE's programmed modules at that time, including basic schemes of the GDSE's main structure and screenshots of all modules.

This present deliverable contains an updated and extended version of the deliverable D2.3 and outlines the updated structure, final architecture and screenshots of all modules of the final version of the GDSE. Chapter 2 introduces the reader to the GDSE's website. Chapter 3 outlines the final structure of the GDSE, particularly the menus and screens under each module. Chapter 4 presents the GDSE's environments for data entry and the administrator area. Chapters 5 and 6 describe the GDSE's PULL workshop preparation environment (the Setup mode) and the workshop execution environment (the Workshop mode). Finally, Chapter 7 describes briefly how the GDSE was used in workshops with stakeholders of the PULL for the Amsterdam Metropolitan Area (AMA).

2. The programmed GDSE

2.1. GDSE homepage

This document contains a description of the programmed GDSE, whose starting screen can be seen in Figure 1. It is a web-based application that runs on Google Chrome and Chromium and is programmed for usage on a touch screen computer in workshop settings (both preparation and execution), that are part of the PULLs of the REPAiR's six case studies.

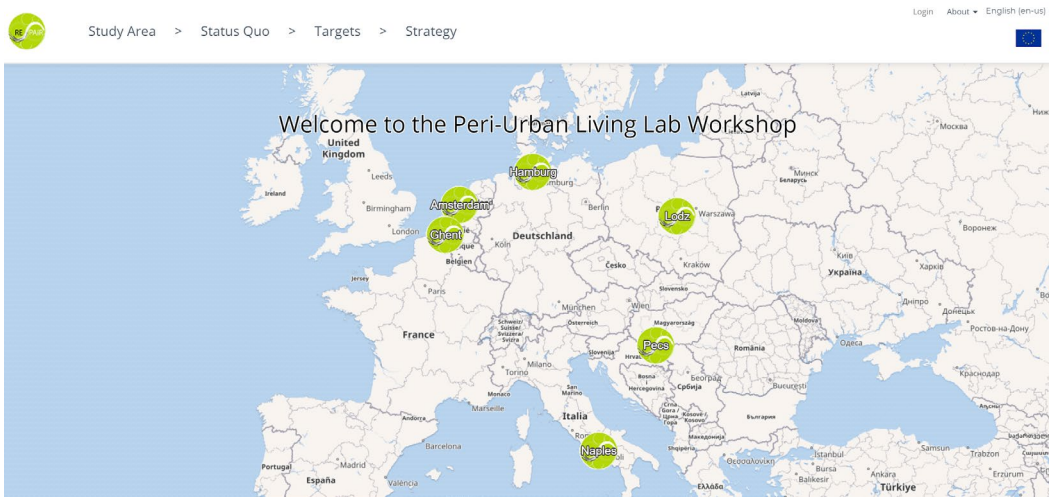


Figure 1. Homepage of the GDSE website.

The programmed GDSE application can be directly reached and used in a web browser via the following URL:

https://gdse.h2020repair.bk.tudelft.nl/

The GDSE application is protected by a log-in procedure (see Chapter 3). For demonstration purposes, the following test account can be used:

username: Testuser
password: Agarigupe537

The test user account has access to the case study "SandboxCity" which contains dummy data only. It has permissions, which are similar to those of a Data Captain, to enter, edit, upload and view data in the "Data Entry" form (see Chapter 3). This user is also allowed to switch between the "Setup Mode" and the "Workshop Mode" in order to view, respectively, either the configuration or workshop views for Study Area, Status Quo, and Strategy. For Chapters 4 and 5, screenshots are shown for the Amsterdam case study for the sake of illustrating some generic GDSE steps.

The test account has no access to the administrator area.

Detailed information about the GDSE's backend integration into an open source platform can be found in Arciniegas et al. (2019). The GDSE is meant to be easily reusable. Therefore, the GDSE is built with free and open source components and has GPLv2 open license (https://www.gnu.de/documents/gpl-2.0.en.html). Vagrant (https://www.vagrantup.com) and Docker (https://hub.docker.com/repository/docker/maxboh/docker-circleci-node-miniconda-gdal) are used for providing a reproducible operating system, which is independent of the software environment setup. All versions of the source code are available on a public GitHub repository, available at the following URL:

https://github.com/MaxBo/REPAiR-Web

Data storage and management tasks are arranged by means of the Open Science Framework (https://osf.io) as explained in D8.4 'Draft Data Management Plan' (REPAiR, 2017a). GeoServer (http://geoserver.org) is used to publish and host spatial data layers, as web feature services, incorporated and visualised in the GDSE, which are externally prepared using the open source geographic information software QGIS (https://qgis.org). The AS-MFA data used for the analysis and assessment are stored in a PostgreSQL object-relational database (https://www.postgresql.org). The LCA is conducted externally. All outputs are displayed in the GDSE. Next section presents the final stepwise structure of the GDSE.

2.2. Final structure of the GDSE

The final version of the GDSE is structured in five steps:

- Study Area
- Status Quo
- Targets
- Strategy
- Conclusions

These steps are represented in the GDSE's main menu (see Figure 2), which can be found at the top of the GDSE's screen. The five steps become functional once a user has logged in successfully. The step that is currently selected is highlighted. Each step addresses one or more of the design questions proposed in Steinitz's Geodesign framework (Steinitz, 2012).

Figure 2: Screenshot of the GDSE showing its main menu and five steps.

This stepwise structure supports the decision-making process and the research that is required for each of the five phases to guide the living lab process, and the corresponding workshops series, for a study area. Deliverable 2.4 "Handbook for Geodesign workshops" outlines the connection between GDSE steps, PULL phases,

Geodesign questions, and workshop types (REPAiR, 2019b). Each of the five steps features a number of sections. For example, the step "Study Area" contains the following four sections: Maps, Charts, Stakeholders, and Key flows.

The sections that belong to a particular GDSE step can always be accessed through a secondary menu, which can be found on the left hand side of the screen Figure 3 shows all GDSE *steps* together with all corresponding side menus containing step-specific *sections*. Upon selection of a specific step in the main menu (Figure 2), the entries of the side menu (i.e., sections) change correspondingly. When a particular section is selected, it gets highlighted in green.

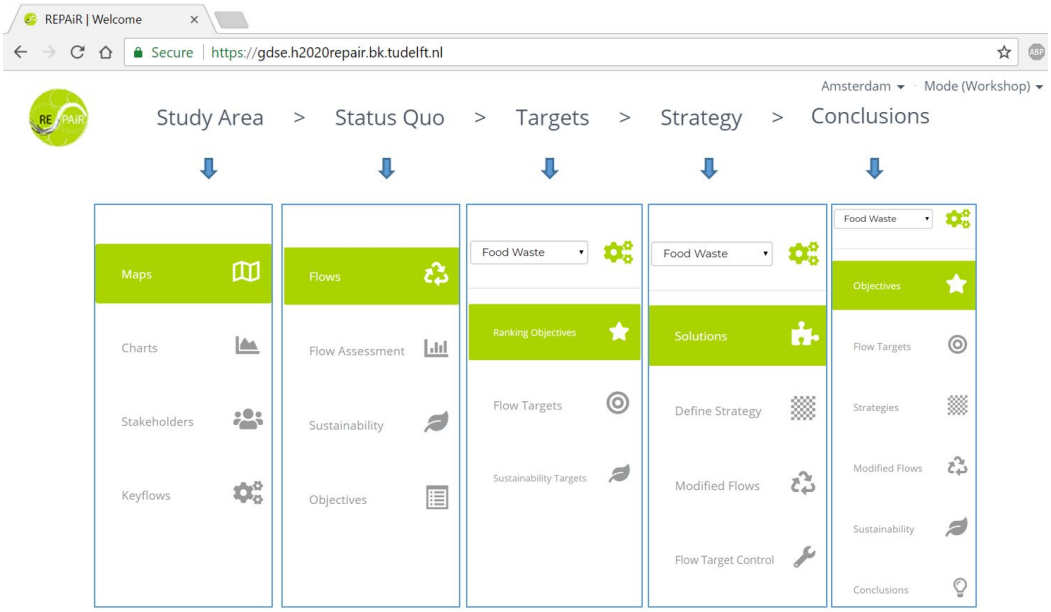


Figure 3. Screenshot of GDSE showing five Steps (top) and Sections (box under each step).

Before the GDSE can be used, users need to perform the following actions:

- Log into the GDSE
- Select a language (depending on the PULL case study)
- Select a case study (from the six case studies)
- Select a mode (setup or workshop)

These four actions are implemented through drop-down menus that can be found at any time at the top right corner of the GDSE screen (see Figure 4). Before logging in, only the selection options for the language and the login are visible, together with an "About" drop-down menu.

Figure 4. Login button and selection of language.

The GDSE is programmed to support English as well as the languages of the six case study regions. After clicking on the "Login" button (see Figure 4), the user is prompted to type in a password. All users must be logged in, no matter if they are Data Captains of the study areas or members of a PULL workshop team. The login procedure serves several purposes. Not only does it protect the GDSE from unwanted and destructive usage, it also manages different user groups and corresponding profiles with specific user rights and information access. The GDSE features a number of 'user profiles' that define the rights for accessing information of a specific case study, as well as the roles of user, such as researcher, expert, PULL workshop leader, workshop participant, administrator, and data captain (see Chapter 3). For example, the user account of a research team member or even an administrator account has access to more options in comparison with the user account of a small group participating in a PULL workshop.

After a successful login, the list of drop-down menus is expanded to four menus, now enabling the possibility to select a case study and a mode. By clicking on the "case study" drop-down menu, a case study can be selected (see Figure 5).

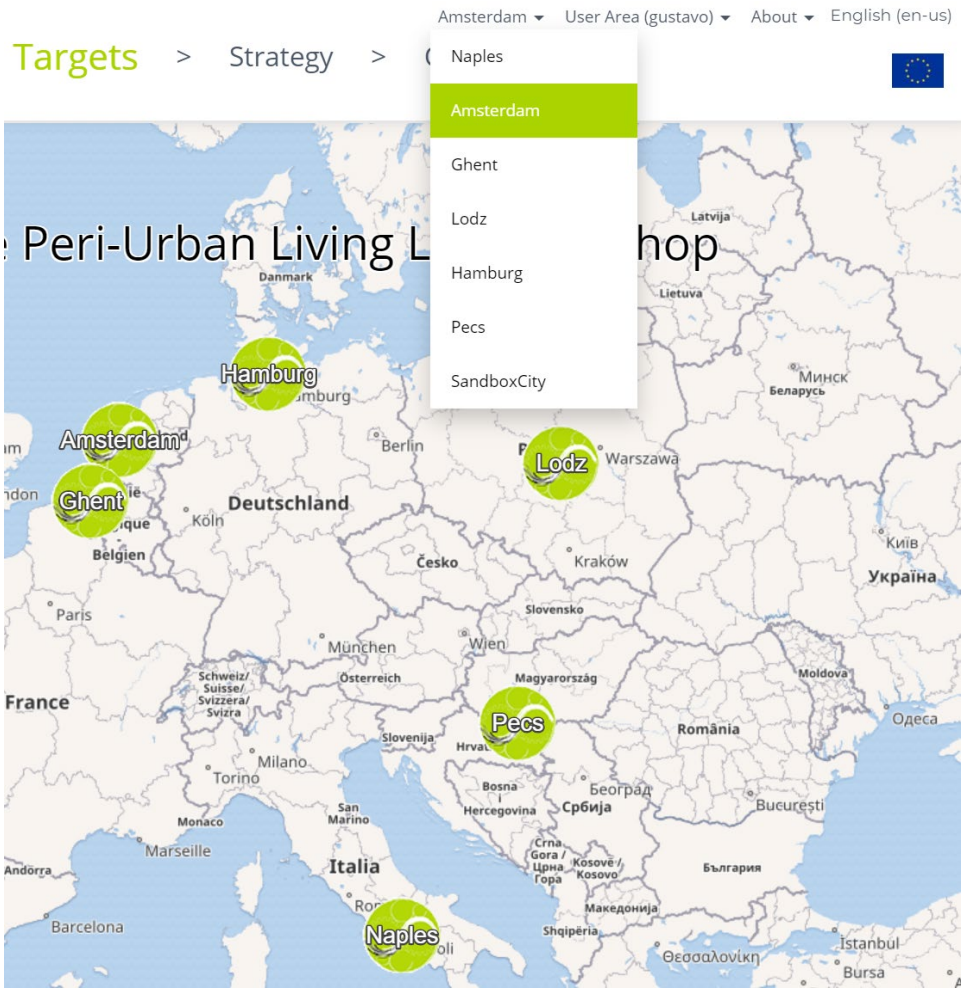


Figure 5. Selecting a PULL case study via top menu or by clicking on a map location.

In order to protect the data for the six case studies from being accidentally altered or deleted, as well as to have a test case with smaller and manageable amounts of dummy data, a "sandbox case study" named "SandboxCity" was added by WP2. A case study can also be selected by clicking on a REPAiR icon on a desired case study location on the map. Not all case studies are equally accessible to all users; only WP2 members have access to all case studies, other project members have access only to those case studies on which they are working.

With the exception of the Data Entry module (see Chapter 4), all steps of the GDSE can be displayed in two different modes:

- *"Workshop mode"*, which the workshop participants will see, and
- *"Setup mode"*, which is only accessible to the persons within the REPAiR teams which are responsible for setting up and preparing the workshops.

Once a case study is chosen, the dropdown menu "Mode" appears for user profiles with access to the Setup mode. This menu offers the possibility to switch between the Setup and the Workshop mode (see Figure 6). In this way, users in charge of preparing a workshop can directly see how the GDSE will visualise both the data and settings to the workshop participants (see Chapters 5 and 6).

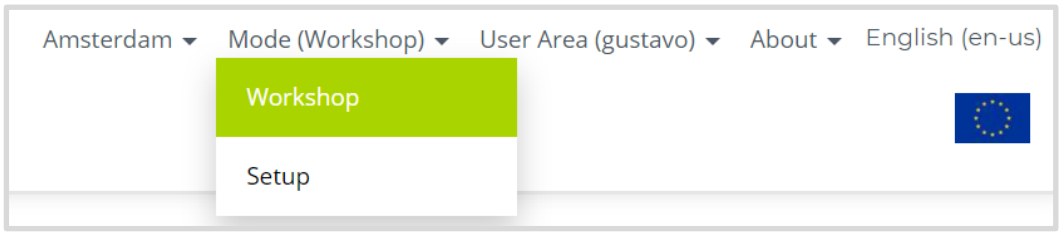


Figure 6: Drop-down menu 'Mode' for switching between Workshop and Setup mode.

The GDSE has also two additional modules (or modes) that can be reached via the "User Area" drop-down menu (see Figure 7):

- *"Data Entry"* module, where all data concerning flows and stocks of resources as well as the evaluation data is entered, and
- *"Admin area"*.

Both modules are restricted to users with special user rights. Table 1 shows an overview of these GDSE use modes.

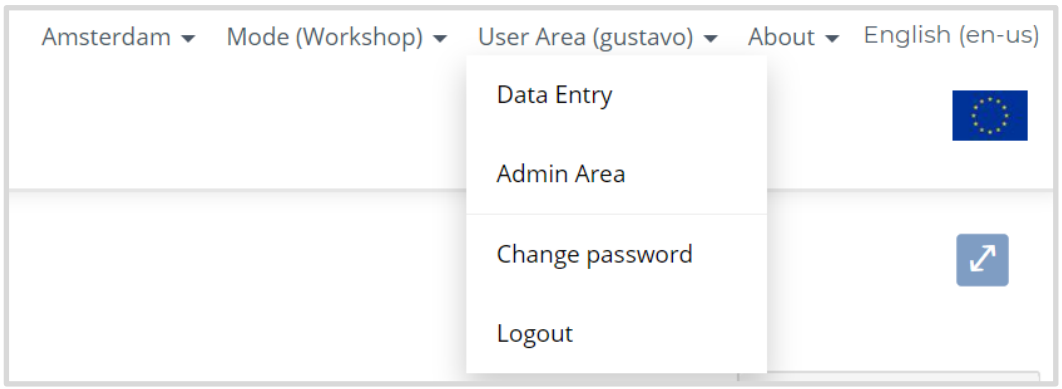


Figure 7. Drop-down menu "User Area", where "Data Entry" and "Admin Area" are accessible.

Table 1. GDSE user modes.

Mode	Main Purpose	Accessible for	Description in
Data Entry	Entering data on waste flows and stocks into the GDSE Mode is not visible to workshop participants	WP2 team and data captains of the case studies	Chapter 4
Admin Area	General administration of the GDSE Mode is not visible to workshop participants	WP2 head programmers	Chapter 4
Setup	Setting up a workshop Mode is not visible to workshop participants	WP2 team and PULL workshop responsibles	Chapter 5
Workshop	Interactive usage by the workshop participants	All (including PULL workshop small groups)	Chapter 6

Next chapter "Data Entry and Admin Area" describes the software implementation of the GDSE environments used, respectively for bulk data entry, and for administering GDSE users and rights, namely the Data entry and Admin areas environments.

3. Data Entry and Admin Area

In the weeks after the finalisation of deliverable D2.2, it became clear that the data captains of the six case studies needed additional software features/tools to enter their data on waste and material flows and stocks into the GDSE.

This need for tools was not only generated by the task "to get the data in", but also by the urgent need of WP3 (and partly WP4) to assure a consistency of the provided data across all six case studies. An intensive research by WP3 has revealed that none of the existing MFA tools were able to support entering spatial data with the granularity that was required by REPAiR. Therefore, a new web application able to support the developed methodology of Activity-Based Spatial Material Flow Analysis (D3.1) was created as an alternative to combining multiple existing tools (REPAiR, 2017a).

Seeing this, it was decided to include a data entry section into the GDSE whose access and usage is restricted to the data captains and the WP2 team (see Section 4.1.). Even though the content of the data to be handled was defined in detail in deliverable D2.2, the "Data Entry" module of the GDSE was not, and is addressed in the next section.

3.1. Data Entry mode

Data Entry mode is focused only on entering the data related to the AS-MFA. All other types of data that are necessary for the GDSE are entered using the 'Setup mode' of the respective steps.

There are two ways to enter AS-MFA data:

1) Manual data upload for specific data points or editing;
2) Bulk data upload for large datasets.

AS-MFA data is always case-study-specific and in most cases key flow-specific as well. This means that even if the same classification of economic activities (NACE) is used for all case studies and all key flows, they have to be uploaded separately. Also, if there are actors that appear in the AS-MFA of multiple case studies (e.g. waste from Amsterdam is treated in Flanders region by a waste treatment company that is also treating waste from Ghent case study), they are considered as separate entities, and therefore separate database entries.

The type of data that is case-study-specific but not key flow-specific is spatial data that can only be entered using Bulk Data upload. It will be explained later in this section (3.1.2).

The first step that needs to be taken is logging in into the system and choosing the "Data Entry" module in the top right drop-down menu called "User Area". The user will be asked to select a specific key flow, as shown in Figure 8.

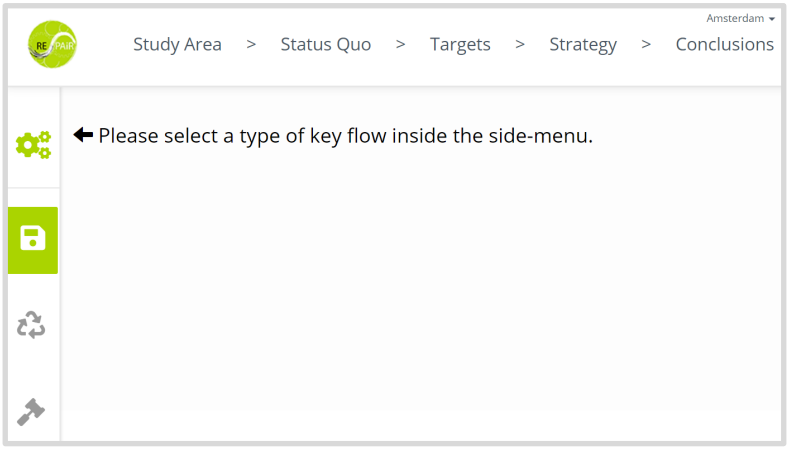


Figure 8. Prompt for the selection of a specific key flow before the other menu items are enabled.

3.1.1. Manual Data Entry

There are two sections that allow manual data entry:

1) Edit Actors / Flows
2) Edit Materials

For the manual editing of actors and flows, first, economic activities and their groups have to be uploaded using the 'bulk data upload' as those groups cannot be modified manually. The web app will ask to select a specific economic activity for which an actor or its related flow needs to be added or modified.

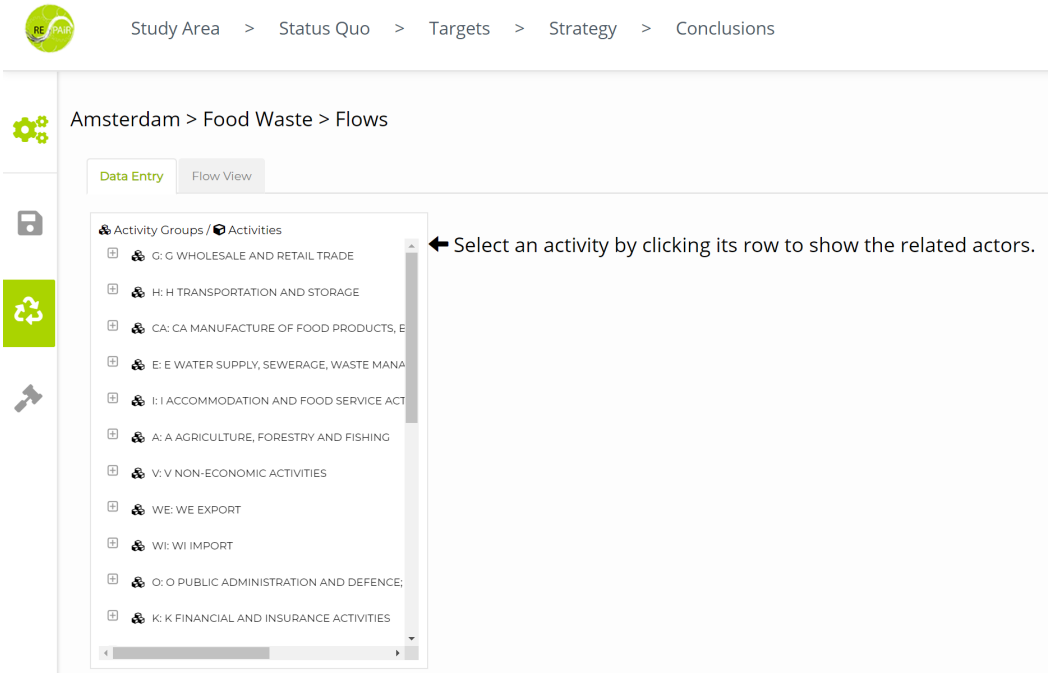


Figure 9. Prompt for the selection of a specific economic activity before the actors and their respective flow entry/editing menu is enabled.

After selecting an economic activity, a list of actors will appear if any of the actors have already been uploaded. In case no actors have been uploaded for the selected activity, the interface allows to add actors and their specific properties:

- Name
- Website
- Year of the last available information
- Turnover
- Number of employees
- BvDid number or a different unique identifier
- BvDii code
- Consolidation code
- Free text description
- Administrative location (location on the map as well as address details)
- Operational location (location on the map as well as address details)

Only a name and a 'BvDid' number are necessary fields, all other fields are optional. BvDid must be unique for an actor within a chosen key flow, while the name can be used for multiple actors. Currently only administrative location is used, but operational location can be entered as well, but will not be taken into account while performing any other operations within the GDSE. This means that in case a specific company has multiple operational locations where waste materials are produced, kept or treated, separate actors will have to be created for each of these locations. All the aforementioned fields of any chosen actor can be modified using the manual data entry process, also if those actors have been uploaded using the bulk data upload.

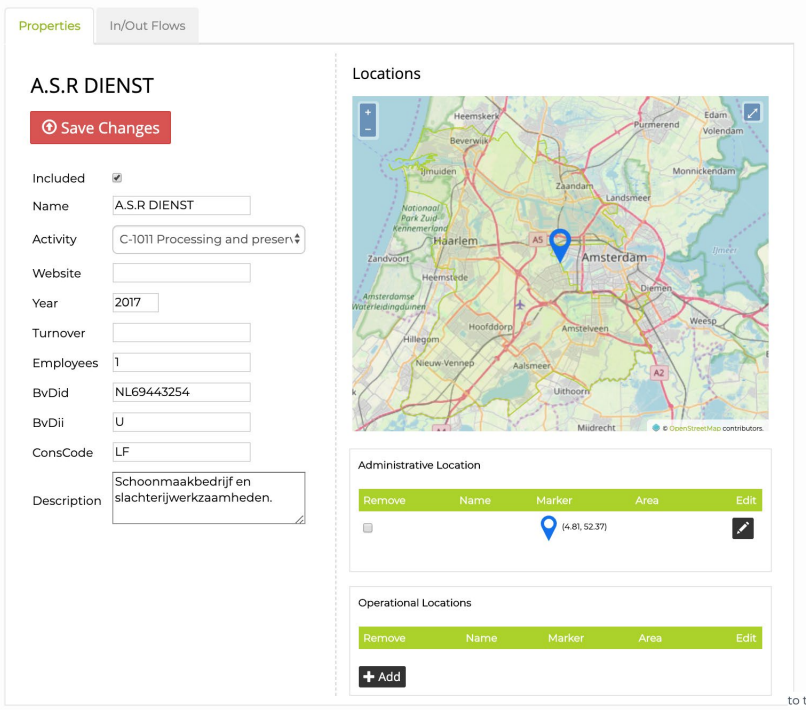


Figure 10. Editing window for the Actor properties.

Figure 10 shows the two tabs available in the actor editing window: “Properties” and “In/Out Flows”. The first tab was described above. The latter allows to add, edit or delete flows associated with the chosen actors, as shown in Figure 11.

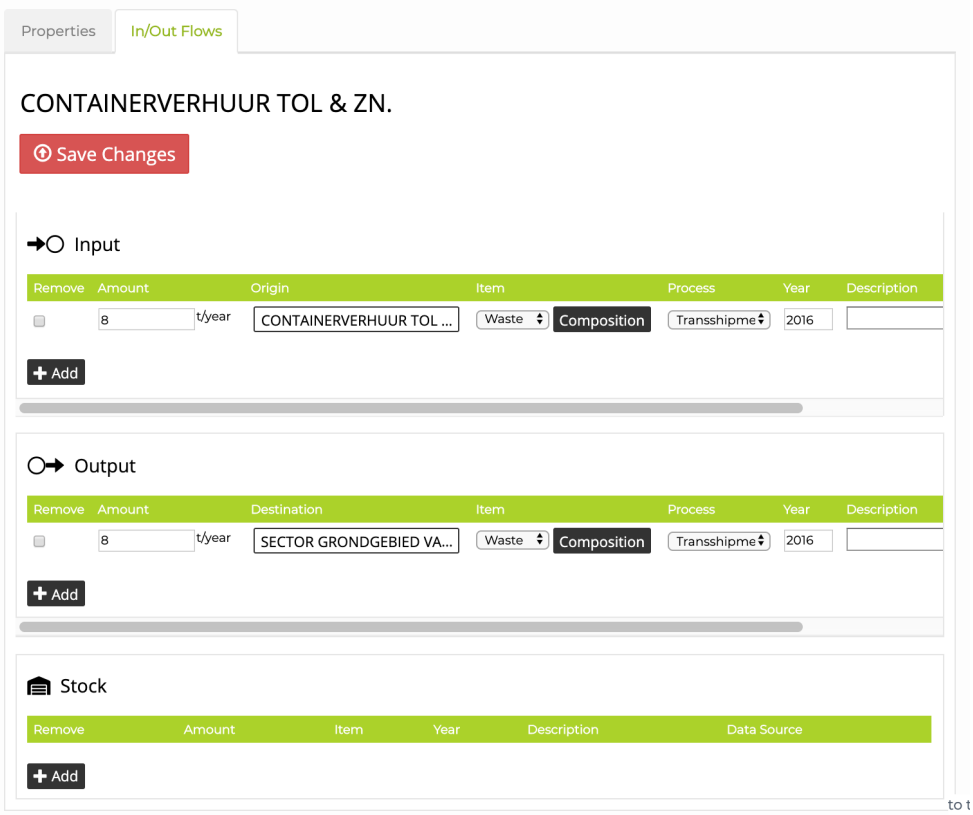


Figure 11. Editing window for the Actor in- and outflows.

‘Input flows’ mean the amount of materials that have been physically transferred to the chosen actor within the chosen year. ‘Output flows’ mean the amount of materials that have been physically transferred from the chosen actor within the chosen year. Stocks mean the amount of materials that have stayed at the chosen actor throughout the chosen year.

The following flow (stock) properties can be edited:

- Amount in tonnes/year
- Origin or destination actor (must be already present in the actor list)
- Choice between waste or product (the exact definition of waste is presented in D3.1)
- Composition: material and its specific fraction within the amount
- Final treatment process
- Year for which the data is being entered
- Extra free text description
- Source of data

The ‘Material’ section of the Data Entry module provides an interface for creating a material hierarchy. The interface visualises the hierarchy as an expandable tree where new members of the tree can be added or existing ones modified (renamed)

or removed (see Figure 12). The interface does not allow to remove those materials that already have associated flows in order to avoid data loss.

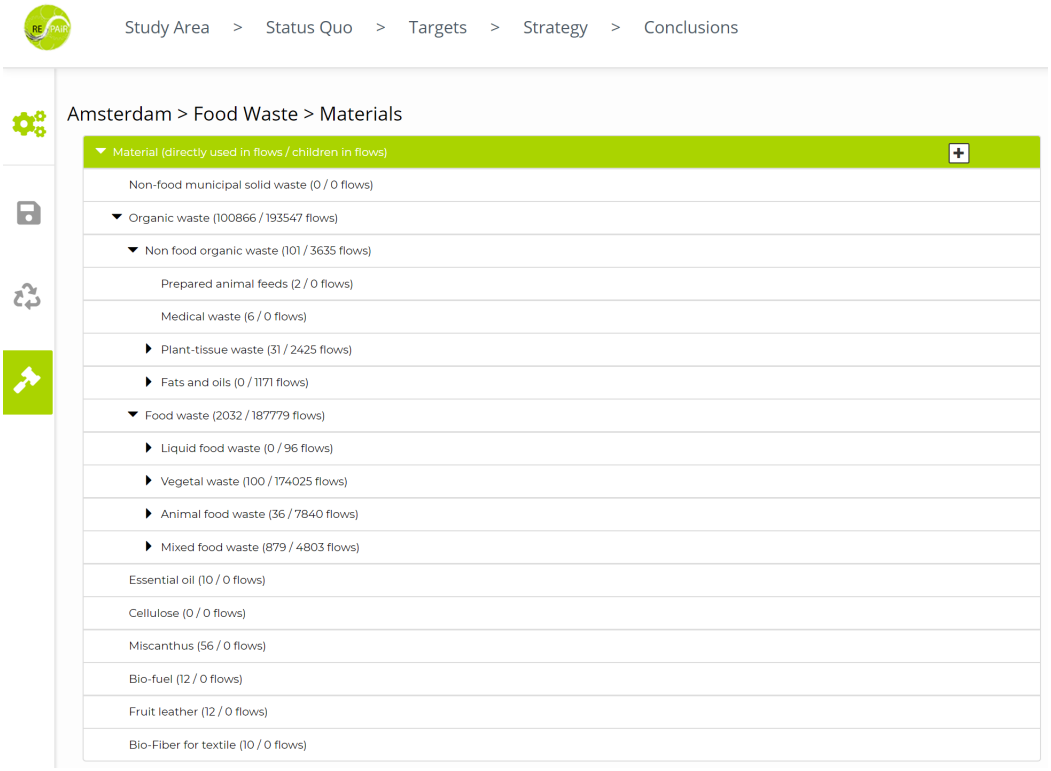


Figure 12. Interface to modify the material hierarchy. The first number in brackets indicates how many flows hold the specific material, the second number in brackets indicates how many flows hold the children of that specific material.

3.1.2. Bulk Data Upload

Although initially it was expected that the manual data entry will be sufficient to enter all the AS-MFA data, the amount of data that has been collected proved to be much bigger than anticipated and therefore too big to be entered manually. A bulk data upload section has been developed for the datasets that needed to be finished outside the web application using already available more powerful statistical data analysis tools (e.g., Microsoft Excel, SPSS or Python Pandas). The bulk data upload is designed to be as strict as possible to the probable errors, and provides feedback on which errors or inconsistencies occured in which dataset. However, great care needs to be taken by the data captains to correctly prepare the datasets for the upload. Figure 13 shows a screenshot of the bulk data upload section, together with tabs and drop-down menus.

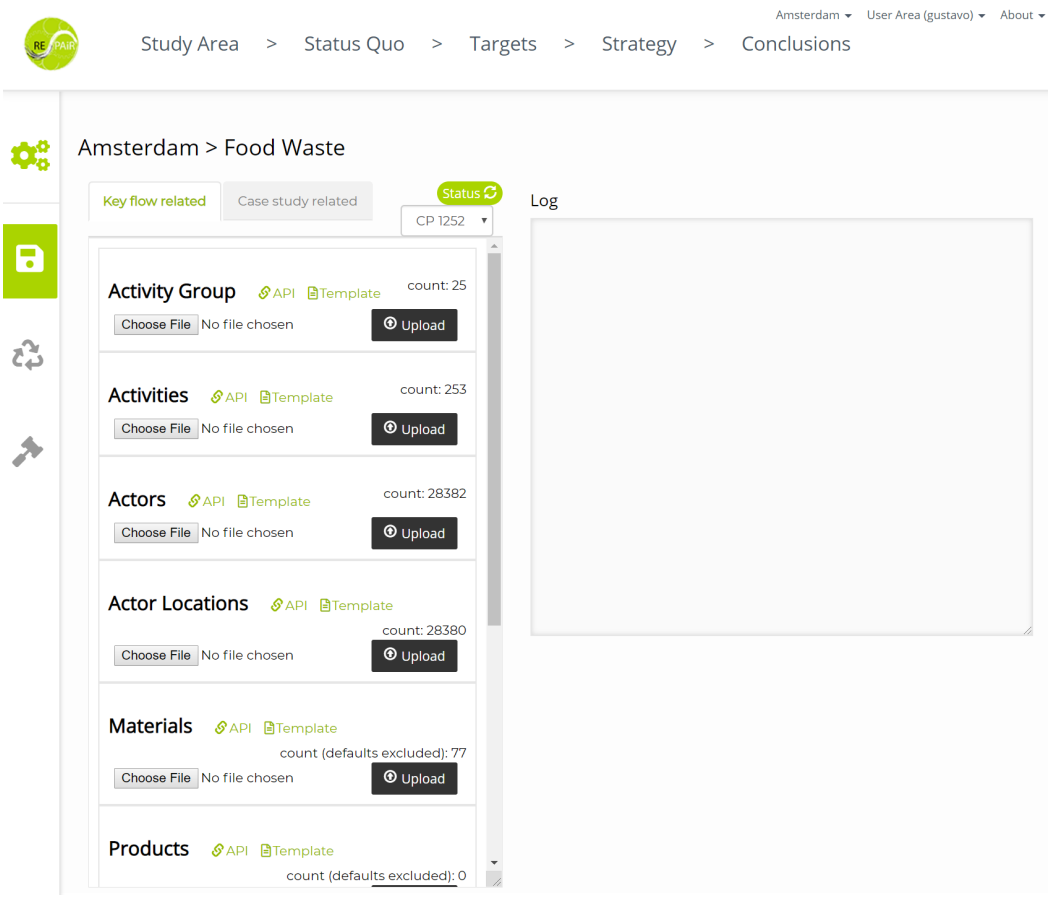


Figure 13. Bulk data upload section of the Data Entry module.

To be able to trace back the original datasets and possible errors in case the results in the GDSE do not correspond with the expectations of the PULL leaders and data captains, all datasets that are uploaded using bulk data upload need to be uploaded on OSF as well. Each dataset must be uploaded along with the metadata.txt file using the form available at the following URL: (https://docs.google.com/forms/d/e/1FAIpQLSdI-c9AzFYuox7yEOy-smJMb5bY_qINJ17pAScP5ROuFcXrlg/viewform)

All datasets should be uploaded following the order shown in Figure 14.

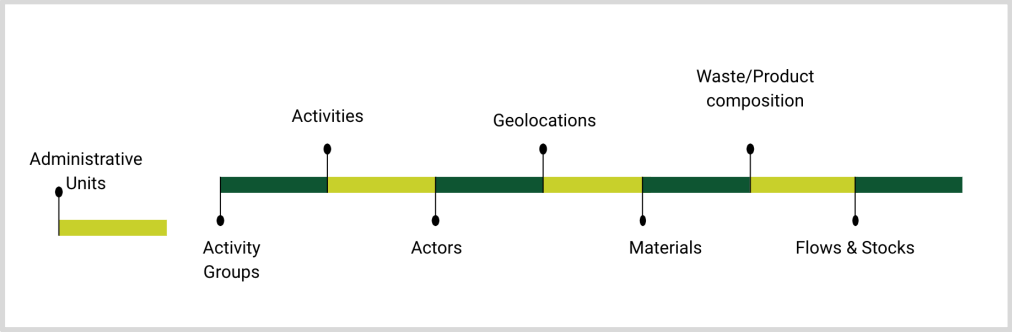


Figure 14. Timeline showing sequence for uploading datasets.

If needed, the datasets can always be updated later during the project. However, it is important that each dataset that appears later in the timeline is dependent on all of the previous datasets and therefore cannot be uploaded earlier than them.

The detailed explanation about bulk data upload is available in the following URL: https://mfr.osf.io/render?url=https://osf.io/3nejt/?direct%26mode=render%26action=download%26mode=render

3.1.3. Case-study-specific data

Spatial data is case-study- but not key flow-specific, which means that all key flows belonging to the same case study will reuse the same spatial information. Case study-related data can only be uploaded using the Bulk Data Upload section, tab "Case study related" (Figure 15).

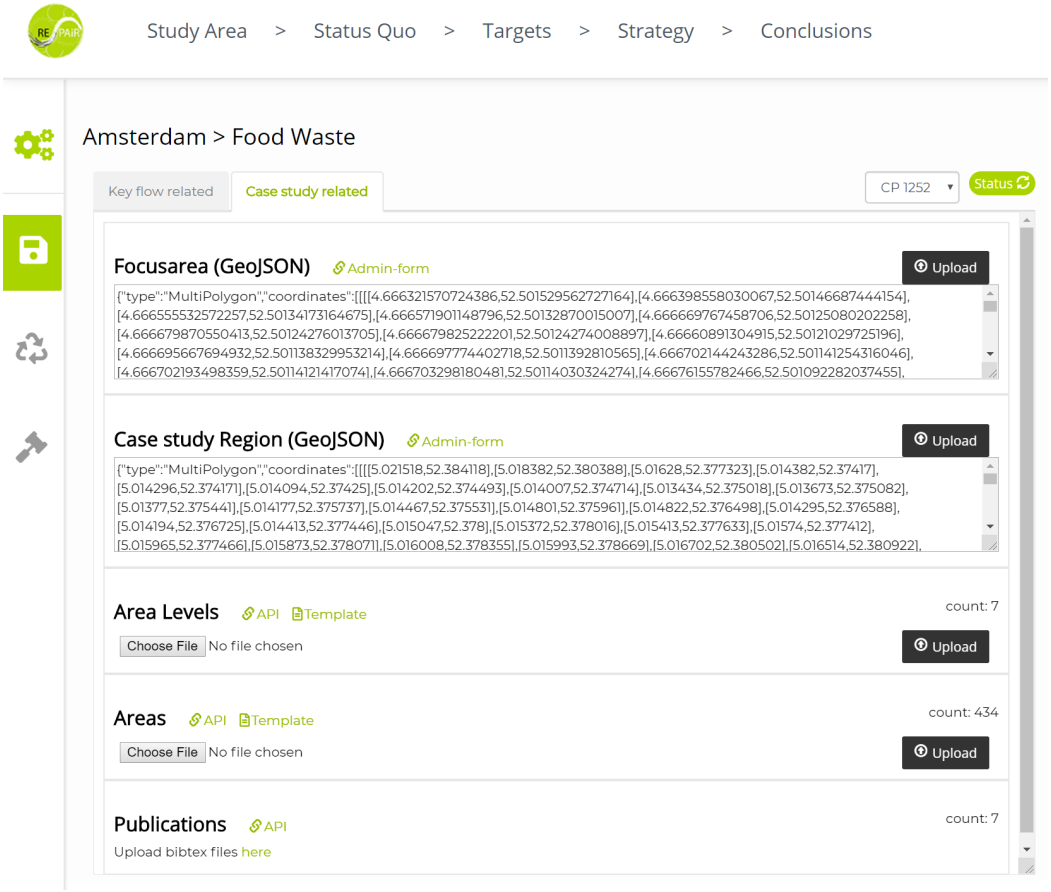


Figure 15. Case study-related data upload tab within the Bulk data upload section of the Data Entry module.

In particular, the datasets that need to be uploaded are:

- a GeoJSON linestring that defines the geographical boundaries of the **Focus Area** (see D3.1);
- a GeoJSON linestring that defines the geographical boundaries of the **Case Study region**;

- **Area levels** describe which administrative units are chosen as relevant for each case study. As Administrative units are not harmonised in different countries, all case studies are requested to use the same level structure and choose the most appropriate units that describe their administrative unit scales. Table 2 shows an overview of all the available units.
- **Areas** are a collection of polygons that represent the geographical boundaries of the chosen administrative units and their interrelation (which polygons consist of which smaller polygons). Areas also hold their population data that is later used for the indicators.
- **Publications** is a bibTEX file that references all the used data sources with a bibTEX key. The bibTEX is used to indicate what data source has been used for each specific data point.

Table 2. Overview of a general hierarchical structure of the administrative units to be used by each case study within REPAiR.

Scale	Administrative unit
1	World
2	Continent
3	Country
4	NUTS1
5	NUTS2
6	NUTS3
7	District
8	Municipality
9	CityDistrict
10	CityNeighbourhood
11	CityBlock
12	StreetSection
13	House

All geo-referenced datasets are to be uploaded in WGS84 (EPSG:4326) coordinate reference system.

3.1.4. Data View

Data Entry module serves not only the data entry but also control of data points through multiple views and visualisations.

The 'Edit Actors/Flows' section allows to see what economic activities are available, how they have been grouped and which actors carry out those activities. Clicking on each actor allows to see what properties are known, where the actor is located

and which flows and stock it participates in. All of these properties can be modified in place.

The "Flow View" tab duplicates the functionality of the Status Quo step in the Setup mode. It allows to filter the flow data and visualise it in interactive maps and Sankey diagrams (see Figure 16).

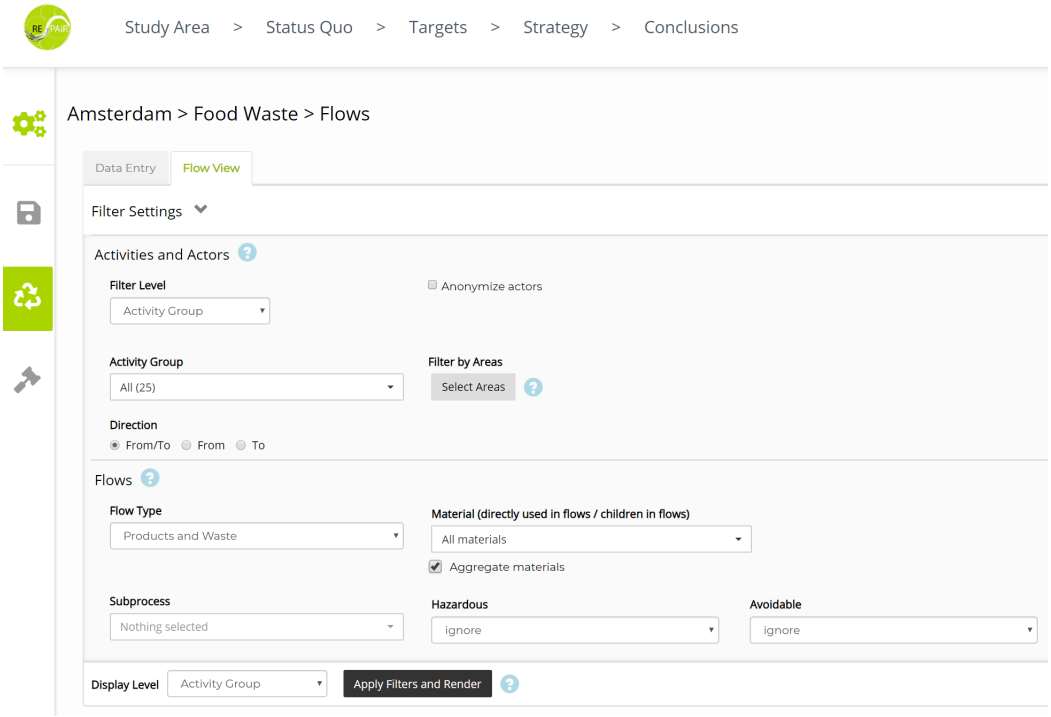


Figure 16. A set of filters available in the Flow View tab of the Edit Actors/Flows section of the Data Entry module.

3.2. Admin Area mode

The 'Admin Area' mode is only accessible to those users who are granted system administrator rights. The WP2 members are actively involved in tool development and database administration. The Admin Area mode is not a designed GDSE interface but an automatic admin interface provided by Django at this URL:

(https://docs.djangoproject.com/en/3.0/ref/contrib/admin/)

It reads metadata from the models to provide a quick, model-centric interface where trusted users can manage content of the site.

The Admin Area mode allows creating new users, managing their access rights and managing resources available for the different case studies. It is in fact used as a more human-readable direct interface to the database.

4. Setup Mode

The purpose of the 'Setup Mode' is to enable the REPAiR team members in charge of the PULL workshop series in a specific case study region to set up and prepare for an upcoming workshop. The setup mode allows team members to set up the GDSE for all steps: Study Area, Status Quo, Targets, Strategy, and Conclusions. Just as for workshop users (see Chapter 5), the PULL team member using the setup mode will always find a secondary menu on the left side of the screen which includes the individual sections of the GDSE step chosen in the main menu.

4.1. Study Area

For the "Study Area" step, the side menu displays four sections, namely "Maps", "Charts", "Stakeholders", and "Key Flows" (Figure 17). Information concerning all these four sections is to be entered by the member of the team in charge of preparing the workshop.

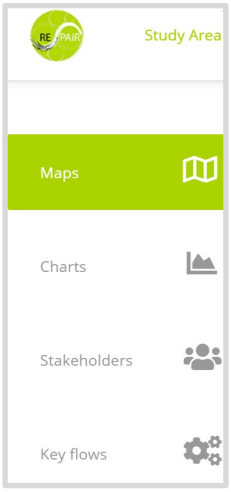


Figure 17. Side menu with the four sections of the "Study Area" phase.

After selecting a step, the side menu shrinks to an icon-only view (see Figure18). The main purpose of the "Study Area" step is to clearly define the study area and its main characteristics, which are expressed in maps, charts and text). A second, but also very important, purpose of the "Study Area" step is to get the workshop participants familiar with working with the maps included in the GDSE.

Thus, it is one of the first tasks of the person in charge of setting up the workshops to define map categories and put together layer-based maps, which at the same time 1) show the definition of the focus area and the study area, and 2) give the workshop participants a chance to try out all major map functionalities, such as

- zooming in and out
- panning
- switching layers on and off

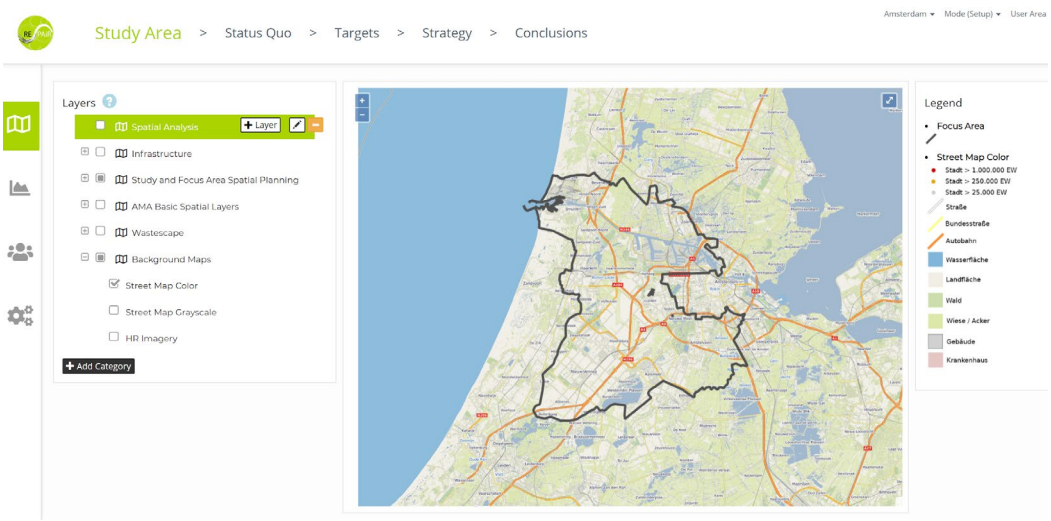


Figure 18. Section "Maps" of step "Study Area" for the AMA (in Setup Mode). The drawing order of both map categories and/or map layers is defined via drag-and-drop gestures.

In order to compose this map, the setup mode user can create map categories and add layers to a category by clicking on the "**+ Layer**" button. After that, a window appears prompting the user to select a map layer from a number of web map services and the GDSE's dedicated GeoServer (accessible via this URL: https://geoserver.h2020repair.bk.tudelft.nl/), which contains PULL-case-specific map layers (see Figure 19), and configure the import settings for this layer.

Data Captains are responsible for uploading all the spatial layers with their appropriate styles on the geoserver using the OSF workflow described in detail in the document available at this URL:

https://mfr.osf.io/render?url=https://osf.io/gr762/?direct%26mode=render%26action=download%26mode=render

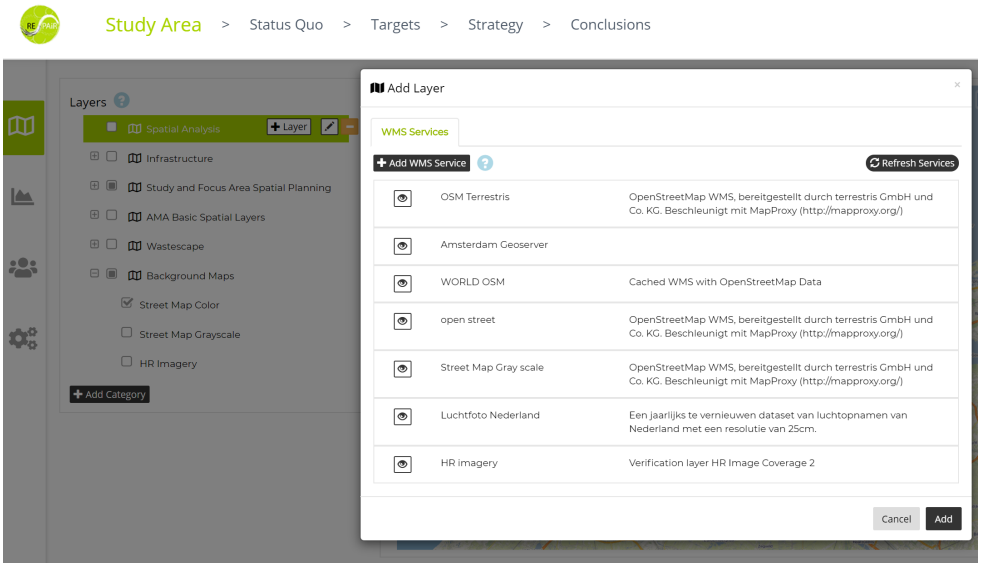


Figure 19. Adding a map layer to a category from the GDSE geo server.

As shown in Figure 20 below, it is also possible to add an external WMS of WFS map service from the URL of a website providing such services (e.g., OpenStreetMap, Leaflet, OpenLayers, Google Maps). If necessary, a username and password can be submitted to the respective web map service.

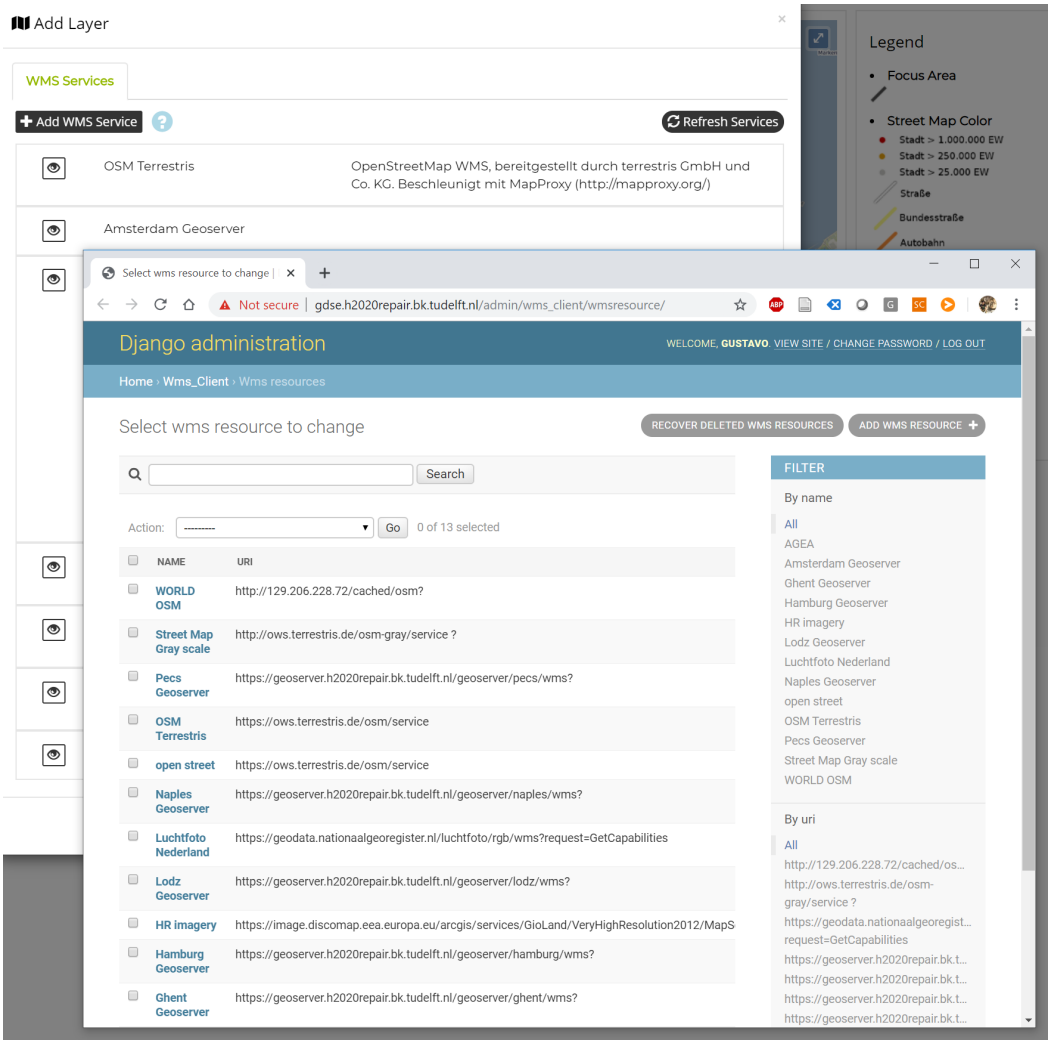
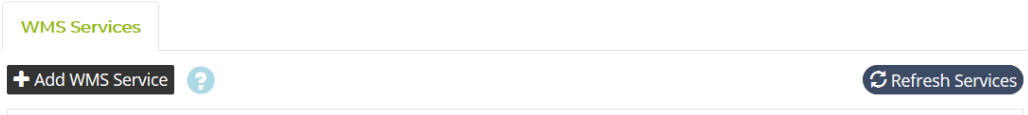


Figure 20. Adding an external WMS or WFS layer service.

After adding or changing WMS-Services, the “Refresh Services” button must be pressed in the setup mode to update the list of available layers. Due to a bug in an underlying library under Linux, which could not be resolved so far, this task has to be carried out by an administrator who has to start the GDSE-Django project under Windows on localhost and press the “Refresh Services”-Button there, as shown in the screenshot of Figure 19 below:



To display some background information concerning the study area and the case study as a whole, it can be of value to present charts, diagrams, tables or pictures

instead of maps, e.g. when showing the population development over the last 10 years. Diagrams and charts can be easily added to the second section of the "Study Area" step, which is called "Charts" (see Figure 21). In the same way as the layers in the "Maps" section, charts are grouped by categories. In order to add a chart to an existing category, a user needs to click on the "**+ Chart**" button (see Figure 21).

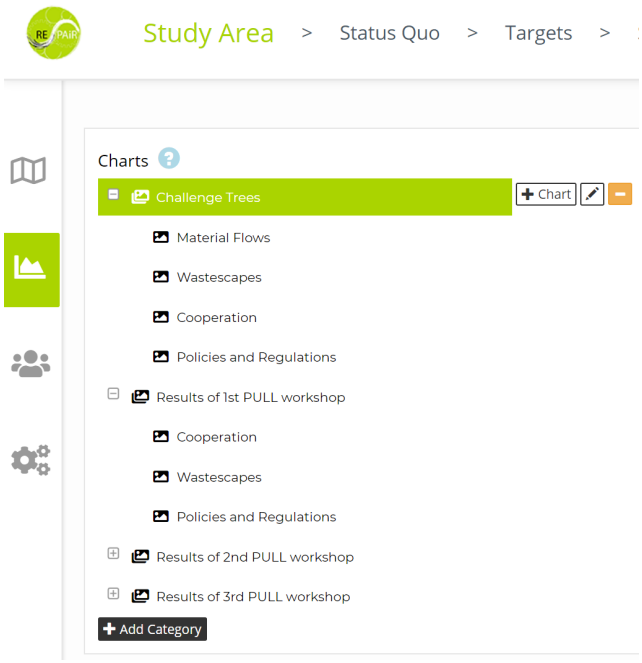


Figure 21. Adding a chart to the "Charts" section ("Study Area" step). Adding or removing charts is only possible in the setup mode.

Once a category is defined, a standard floating dialogue window for selecting and opening files appears (see Figure 22). All standard graphic files can be used. PNG formatting mostly achieves the best results in terms of resolution and readability (see Figure 23).

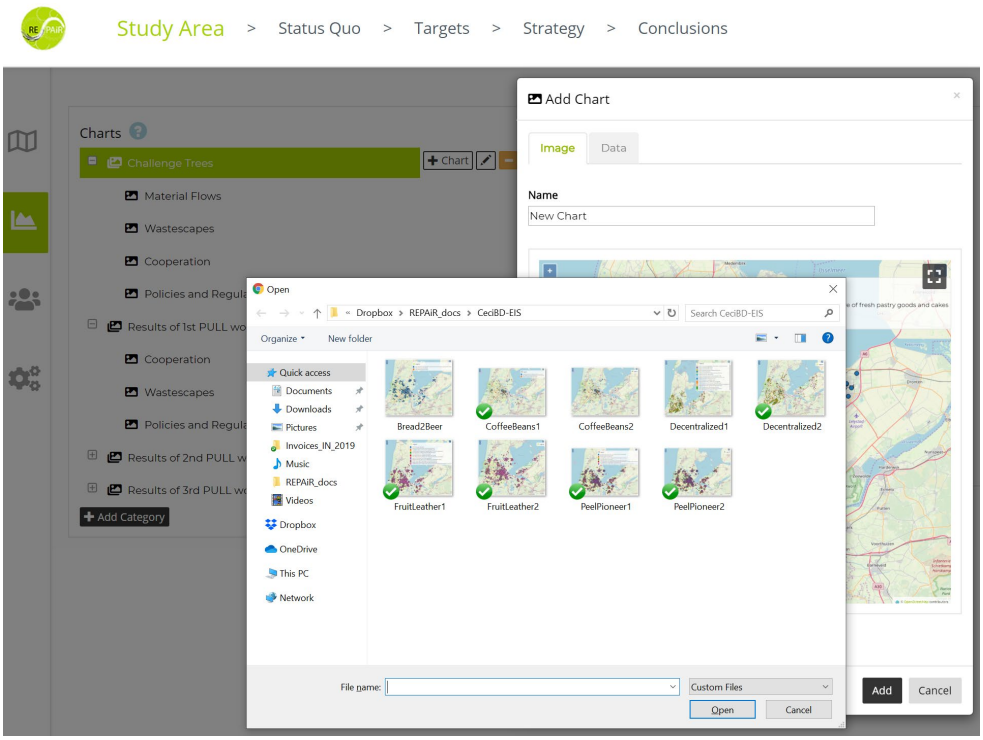


Figure 22. Selecting a graphic file as a chart to be added.

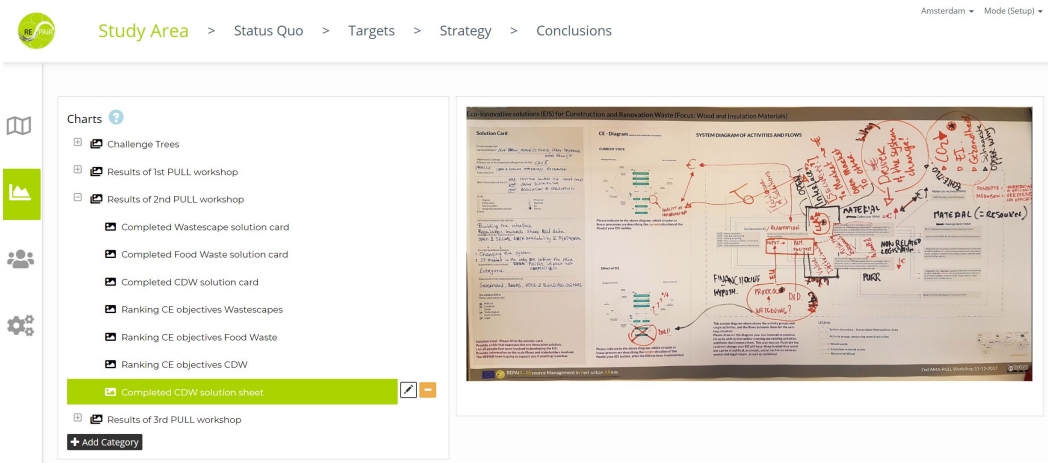


Figure 23. Added PNG picture file displayed in the "Charts" section.

The third section of the "Study Area" step is called "Stakeholders" (see Figure 24) and lists the stakeholders that are relevant to the challenges and eco-innovative solutions of the case study. Stakeholders can also be grouped by categories. When preparing a workshop, the user can add and modify stakeholders as well as categories, in the same way as when preparing maps and charts.

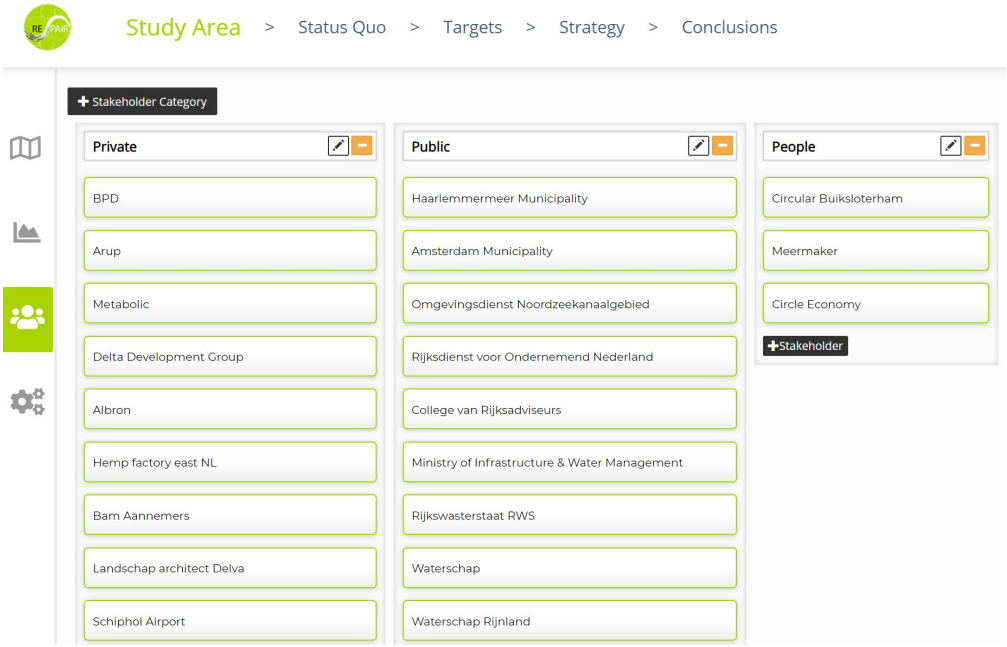


Figure 24. List of stakeholders in the "Stakeholder" section of the "Study Area" step. Adding, deleting and editing stakeholders is only possible in the setup mode.

The stakeholders addressed in this section will later become relevant in the "Strategy" step, in workshop mode, where the workshop participants can pick from the list of available stakeholders to be involved in the implementation of solutions or coordinating and promoting strategies. Step "Conclusions" will compare eco-innovative strategies on the basis of, amongst many other aspects, the stakeholders selected for each of the solutions involved in the strategies.

The fourth and final section of the "Study Area" step is called "Key Flows" and lists the most relevant flows of (secondary) resources for a PULL case study. These key flows have been defined based on previous stakeholder interviews and surveys and will be addressed by the eco-innovative strategies co-developed by the workshop participants as part of the PULL process. In the setup mode, information on key flows is uploaded via an HTML form (see Figure 25). The list of key flows that are defined and described in this section will constitute the basis for further flow visualisation, analysis and assessment in subsequent steps of the GDSE.

In the setup mode, all the information on the Study Area can be edited, organised and sorted. In the workshop mode, this information is read-only.

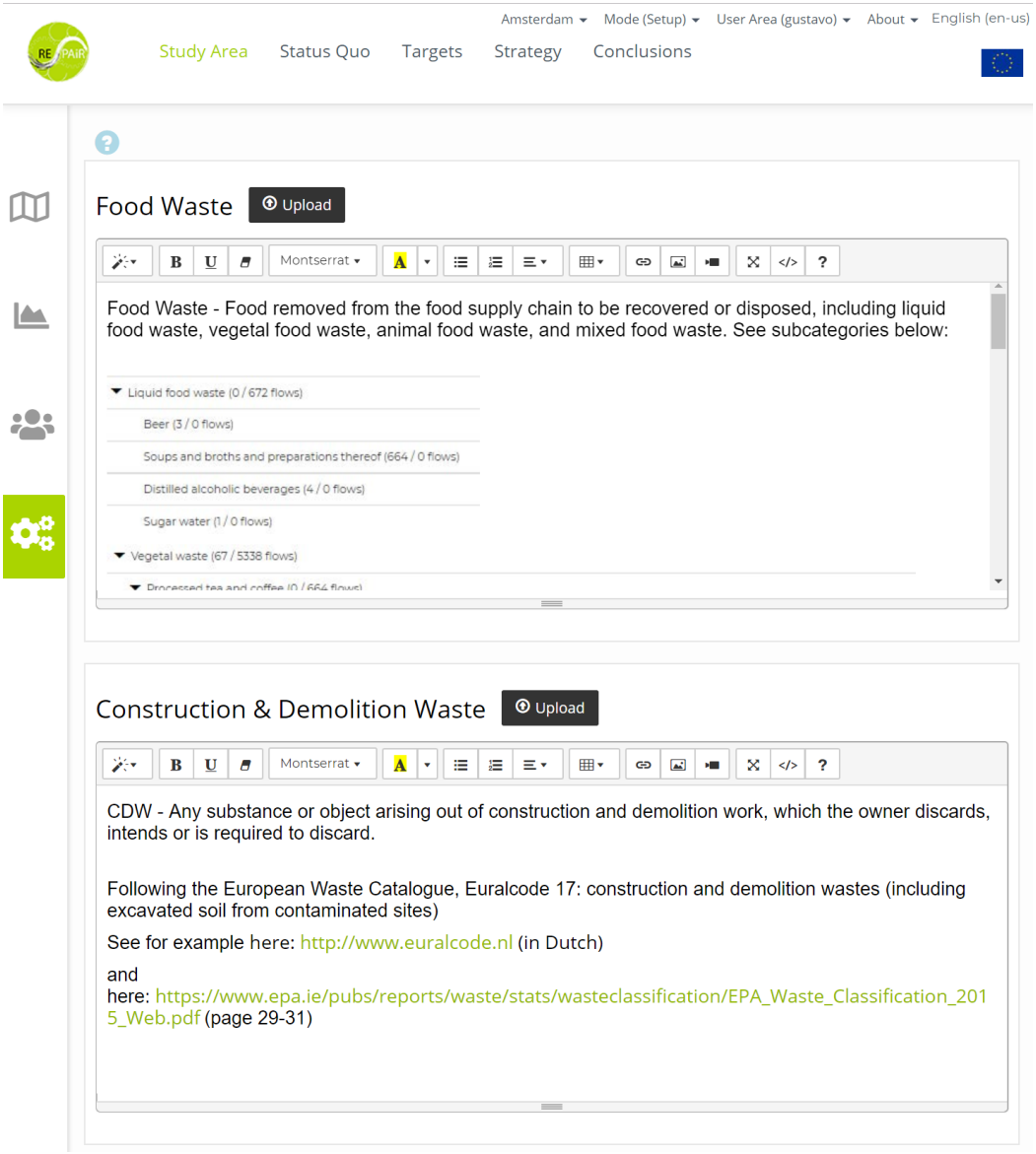


Figure 25. Uploading information about key flows of a PULL case study.

4.2. Status Quo

In the next step of the GDSE setup, the REPAiR team members can configure the "Status Quo" views of the PULL study area. The status quo describes the current situation, or baseline scenario, of a study area in terms of 1) relevant resource flows, 2) flow assessment indicators, 3) wastecapes in the area, 4) sustainability assessment, and CE objectives for the PULL case study (See Figure 26).

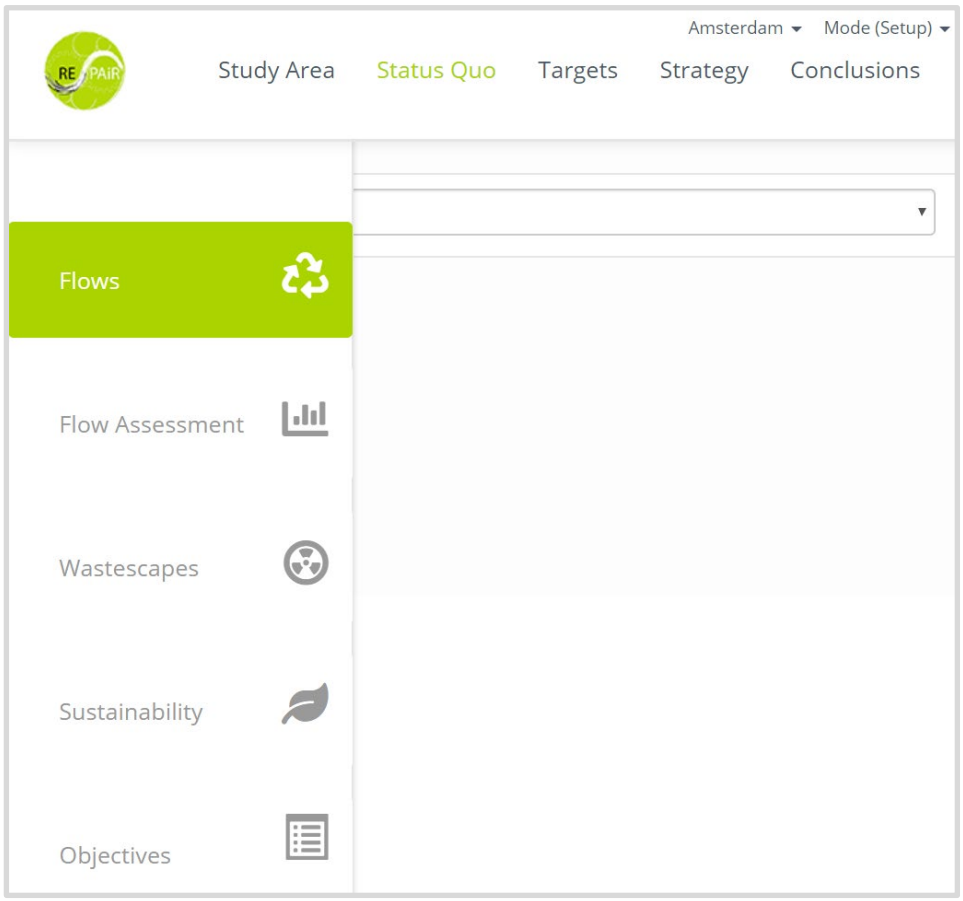


Figure 26. Sections of "Status Quo" step (Setup mode).

Flows

The screen 'flows' is used to prepare flow visualisations for use in the workshop. These flow visualisations are called 'Flow views' in the GDSE. A flow view can be defined in the step "Flows" by selecting one or several materials, from which actors/activities the flow originates and what actors/activities are the destination of the selected flows. The flow views defined in this step will be analysed in further steps. Data required for these flow views needs to be uploaded previously in the "Data Entry" mode as explained in Chapter 3 "Data Entry and Admin Area". It includes datasets on materials, their quantities, geo-locations of actors (e.g., companies and households), economic and non-economic activities, and activity groups involved in the waste flows and relations between them.

Creating flow views is necessary for two reasons:

1) the amount of data is too big to be portrayed all at once, which makes the maps and Sankey diagrams too cumbersome and therefore unreadable;
2) views allows PULL leaders to analyse and get familiar with the existing data and start forming insights that can guide the workshop participants.

In general terms, datasets on flows describe amounts of waste over a specific period of time for actors of a study area. In the specific pilot case study of the

Amsterdam Metropolitan Area (AMA), the datasets typically comprise annual waste data for companies and households, describing the generation, composition and management of company/industrial and household waste. The datasets describe waste flows for the year 2015. This data contains additional detailed information on the type of waste (Eural code), 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 (Arciniegas et al., 2019).

The Flow section in the GDSE is designed in such a way that all flow views must be created separately for each specific key flow and the key flow-specific information cannot be combined into a single view, Therefore, in order to create and save a flow view, i.e., the way a key flow is portrayed in the workshop', the PULL team member has to first choose one key flow from a drop-down list (see Figure 27).

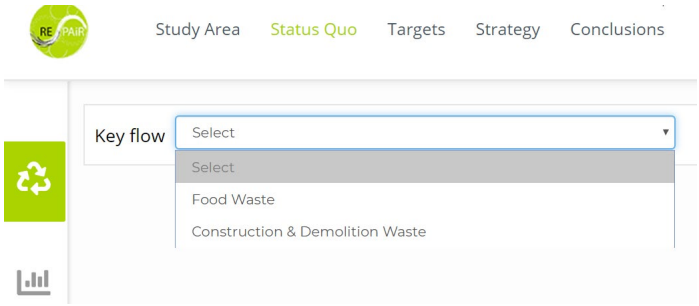


Figure 27. Selecting one (example) of the key flows previously defined.

Once a key flow is selected, the PULL team members can create multiple views. Selected prepared views (in the setup mode) will be available in the Workshop Mode, and will also be used to show differences between status quo and strategy implementation, that involve the flows in question. A flow view represents a filtered part of the AS-MFA dataset based on a number of available filters and their combinations, namely:

- A filter for a specific set of or a single activity group, activity or actor to which or from which the materials flow.
- A filter for a specific set of or a single geographical area of any chosen administrative level to which or from which the materials flow.
- A filter on a type of material: waste of product.
- A filter for a specific material or material group (based on the material hierarchy) that participates in flows.
- A filter for a processing method that has been used to treat the chosen (waste) flows.
- A filter for the hazardousness of materials that participate in flows.
- A filter for the avoidability of materials becoming waste.

Figure 28 shows the form used in the "Flows" section used to query the dataset and generate a new flow view called 'New Flow View' for example key flow 'Food Waste'. Button **'New'** is used to create a new blank flow view. The form contains drop-down menus for selecting (one or more) parameters involved in the flow.

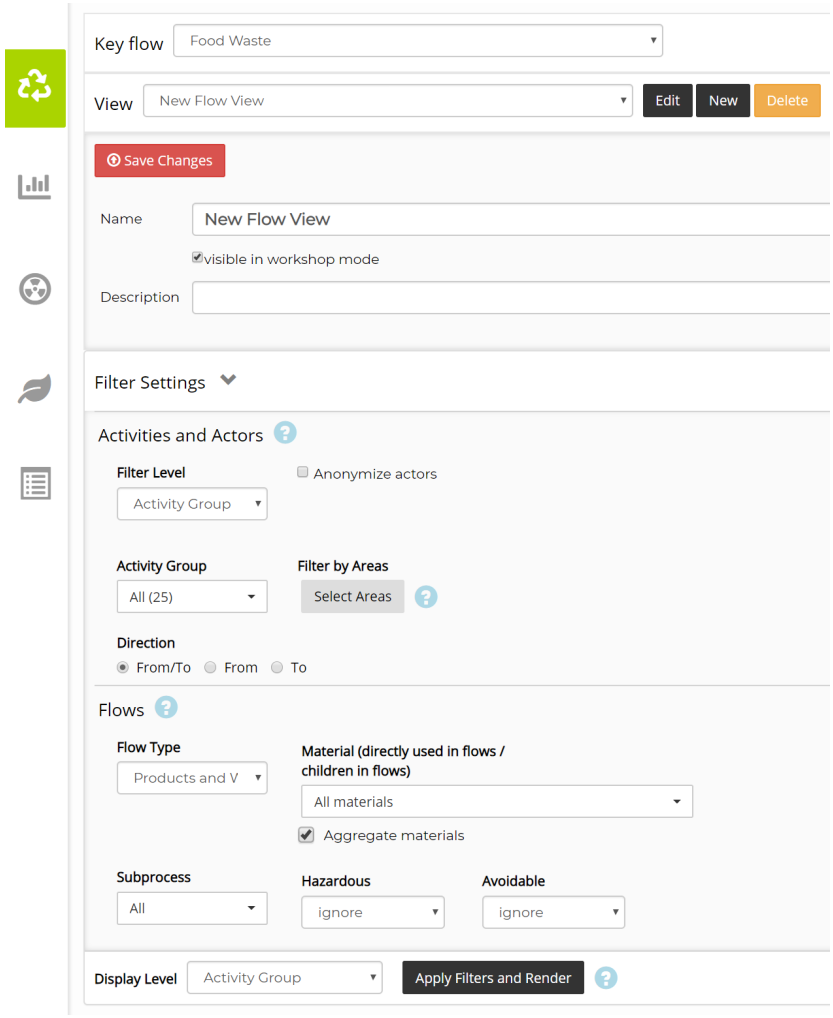


Figure 28. Form for creating a flow view for a chosen key flow (setup mode).

The main steps for filling out this form are:

- Click **New** to create a new flow view.
- Select a key flow to which the flow view is relevant
- Name the flow view
- Write a description about the view (optional)
- Select one filter level: *Activity group* (coarsest), *Activity*, *Actor* (most detailed) to set the detail level of the filtering to the database
- Choose one flow direction: *From/To*, *From*, *To*.
- Choose Flow type: *Products and Waste*, *Products*, *Waste*.
- Pick sub-processes involved: *exchange for waste*, *recycle*, *recycle or recover*, *recycle/compost*, *Store*. More than one is allowed.
- Choose materials to include in the flow (more than one is allowed))
- Click **Apply Filters and Render** to render the flow view below the form.
- Review the rendered flow view
- Click **⇧ Save Changes** to confirm the flow view.

Once all settings for the flow view are specified, the flow view can be generated by clicking on the button called 'Apply Filters and Render', which is located at the bottom of the form. The flow view now appears right below the form in the form of the two flow view panels, as follows: the left panel containing the **Sankey diagram**, and the **flow map** showing the background map with no flows or actors. Flows will show on top of the background map as soon as a flow is clicked on the Sankey diagram. Figure 29 shows an example of a flow view where selected (clicked) flows between different pairs of activity groups are color-coded respectively using data from the dummy case study "SandboxCity". A flow view comprises two parallel panels containing a color-coded Sankey diagram on the left hand side and a color-coded flow map on the right of the filtered part of the waste flows deemed relevant by the PULL team member.

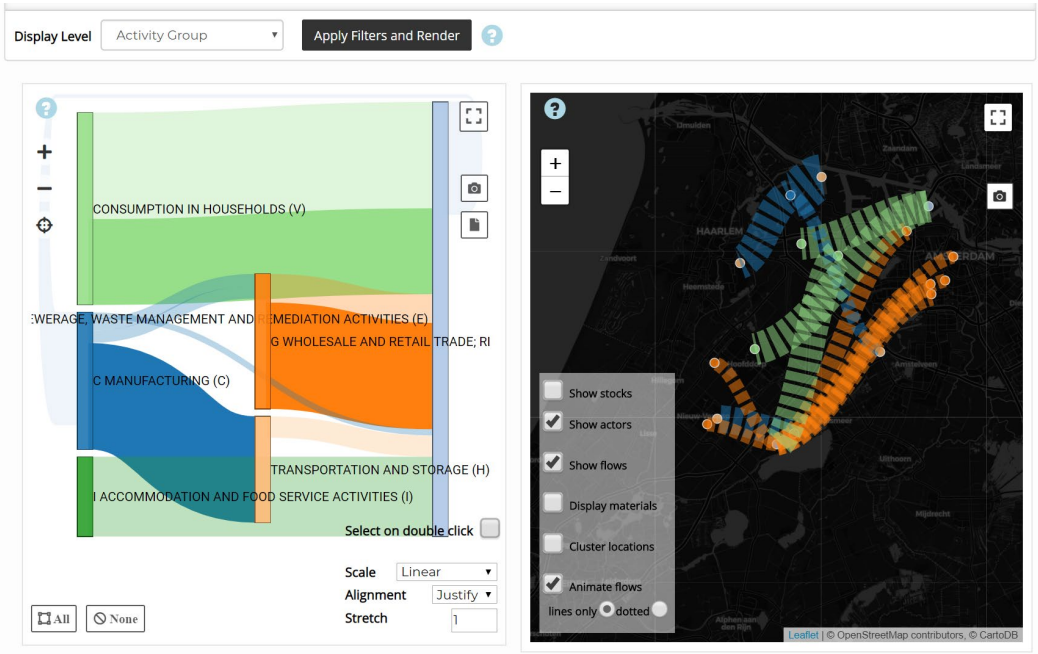


Figure 29. Flow view displayed on activity group aggregation level, example case "SandboxCity". Sankey diagram (left) shows one or more flows between actors belonging to particular activity groups. The geographic embedding of the flows selected in the Sankey diagram is shown on the flow map (right).

Both visualisations are linked with each other, i.e., each flow in a Sankey diagram corresponds to one or more flows on the map, and the color used to mark a relation between two activity groups, activities or actors in a flow in the Sankey diagram is the same color of the corresponding flow(s) that are geographically visualised in the flow map. While the map always displays flows on an *actor level*, the Sankey diagram can be displayed on an *activity group*, *activity* or *actor level*. The chosen level of display depends on the amount and diversity of the filtered data. Huge amounts of flows that involved a high diversity of economic activities are best displayed using the most aggregated activity group level of display, while specific flows that involve only a bunch of actors can still render a readable Sankey on an actor level.

Actors involved in the flows can be switched on and off by checking the '**Show actors**' checkbox in the interactive legend located on the bottom left corner of the flow map panel. By clicking on multiple flows on the Sankey, multiple flows will appear on the map. All flows can be selected at once by clicking on the button '**All**' at the bottom left side of the Sankey panel (see Figure 29, left panel, bottom right corner). Likewise, all flows can be turned off by clicking on the "**None**" button. Figure 30 shows an example of a flow view that contains flows that are color-coded based on the pairs of activities. Figure 31 shows an example of a flow view with flows that are color-coded based on pairs of individual actors.

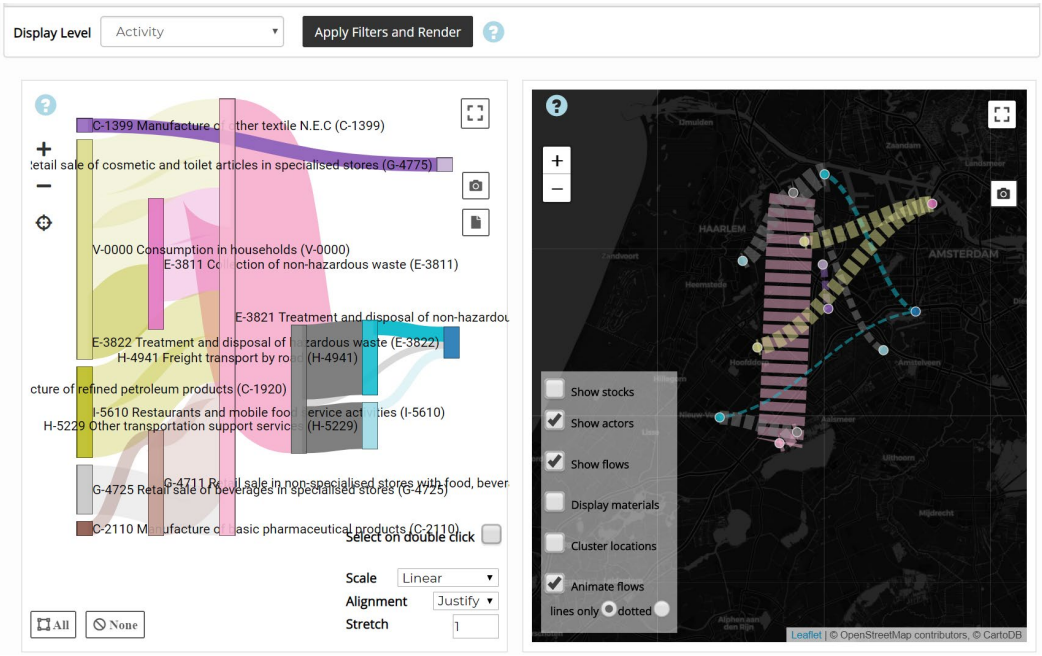


Figure 30. Flow view per Activity aggregation level. Sankey diagram (left) shows one or more flows between actors belonging to a particular activity, whose geographic embedding is shown on the flow map (right).

By *hovering the mouse pointer* on a particular flow, information on that particular flow, namely actor and economic activity of origin, actor and economic activity of destination, flow amount (tons/year), processing type, and material composition) is displayed in a **floating pop-up window** (see Figure 32). The thickness of the flows in the Sankey diagram indicate the **relative flow size** in t/year (i.e., amount of waste). Thus, a thicker flow indicates a relatively larger amount of waste, whereas a thinner flow denotes a relatively smaller amount of waste involved in the flow. The spatial extent of selected flows (i.e., locations for origin and destination) are automatically visualised in the flow map.

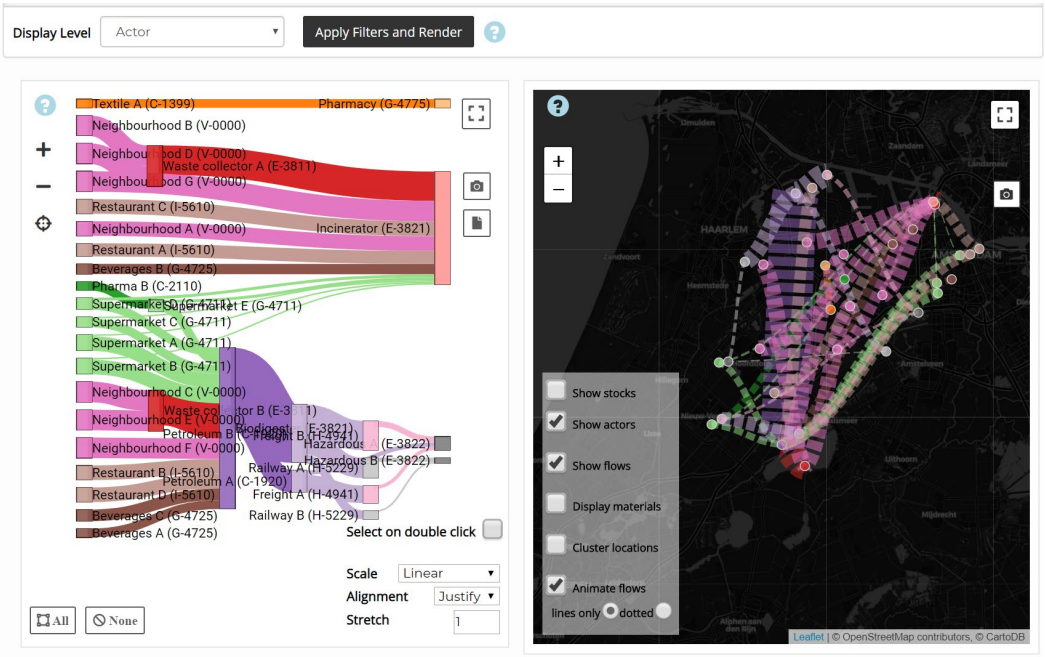


Figure 31. Flow view displayed on actor level (no aggregation). Sankey diagram (left) shows one or more waste flows between individual actors, with corresponding geographic embedding (right).

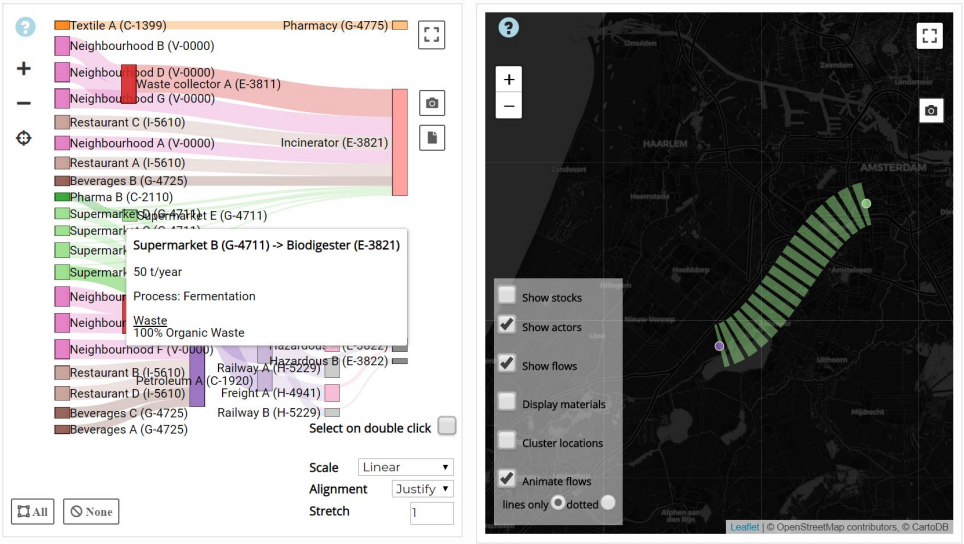


Figure 32. Flow view displayed on actor level. Pop-up window displaying information about a specific flow on the Sankey diagram (left), and corresponding spatial view of that flow (right).

The **flow direction** is portrayed using two types of animations, namely using moving *dashed lines* or *moving dots*., available at the bottom left corner of the flow map panel. The "*mouse hover*" function can also be used on individual flows on the map, and will reveal the same information shown in the flows on the Sankey diagram. The material **flow composition** of a particular flow on the Sankey diagram can be viewed using the mouse hover functionality (Figure 32, left). On the flow map's bottom left corner, by checking the '**Display materials**' checkbox, an interactive color-coded legend appears on the bottom right corner, which allows on-click render of a particular material involved in the flow (Figure 33). Colors on this

legend correspond to the various materials involved in the flow. If a flow has been composed of multiple materials, it will be split into multiple parallely displayed flows of the respective width. While creating a flow view, a user can select whether this legend displays materials on an aggregated level (only the top levels of the material hierarchy) or based on each individual available material regardless of the hierarchy. This choice is made based on the number of available materials after applying all the selected filters. Information on a particular flow (namely origin/destination, process type, material, and flow amount) on the flow map is also available via the mouse hover function.

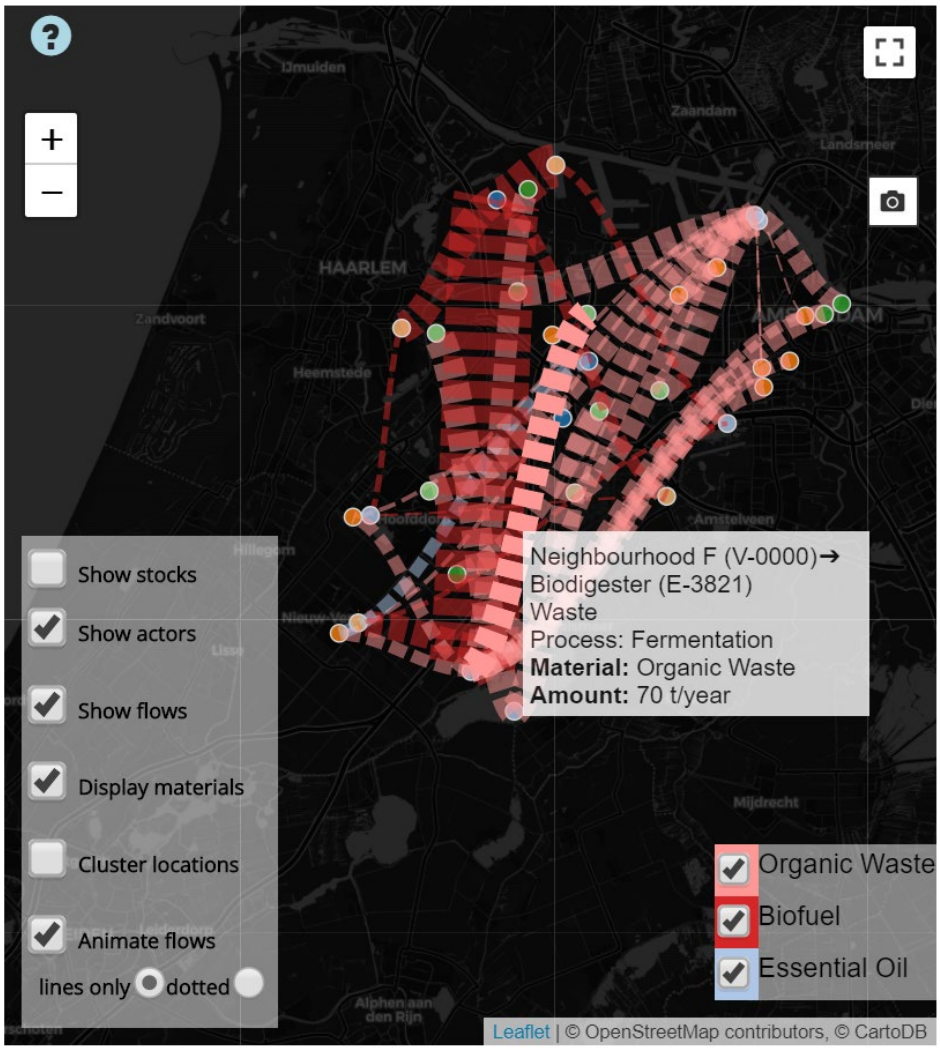


Figure 33. Flow view map with actors switched on and materials displayed. Displaying information about a specific flow on the flow map panel .

Flow Assessment

This section is used by the PULL team member to define the indicators that will be used 1) to quantitatively assess the key waste flows that are relevant to the PULL stakeholders in relation to their geographical context, and 2) to identify and quantify the changes made by the of the eco-innovative strategies on these key

flows. In the GDSE, flow assessment indicators are to be defined for specific key flows, so in order to define indicators a key flow must first be selected. Figure 34 shows the form for preparing flow indicators for a particular key flow. Flow indicators can be defined and expressed in four different ways (Zhang, et al., 2009), namely in terms of:

- the waste amount of a single flow;
- the ratio between two flows;
- waste amount per inhabitant; and
- waste amount per area.

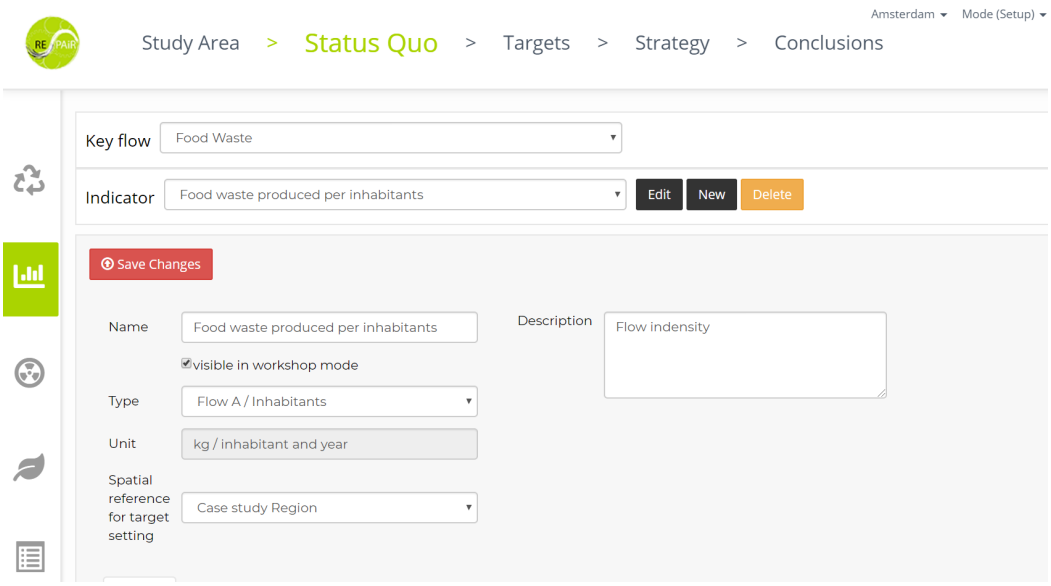


Figure 34. Form for configuring flow assessment indicators (setup mode).

Figure 35 shows the interface for selecting a type of flow assessment indicator. Flows are also used for setting quantifiable targets for measuring the performance of the strategies developed by the workshop participants. These targets are prepared in the next GDSE step 'Targets'.

Once an indicator type is selected, a flow indicator definition form appears right below the drop-down menu (see Figure 36). Using this form, PULL team members can set the parameters that define the indicator. At the bottom of this form, there is a Sankey diagram that visualises the flows involved in the calculation of the indicators, based on the parameters and filters set in the form, namely type of processing method, type of materials, specific activity group, activity, or actor. An example of a flow indicator can be the amount of animal food waste (in tons per year) generated by all restaurants in the study area.

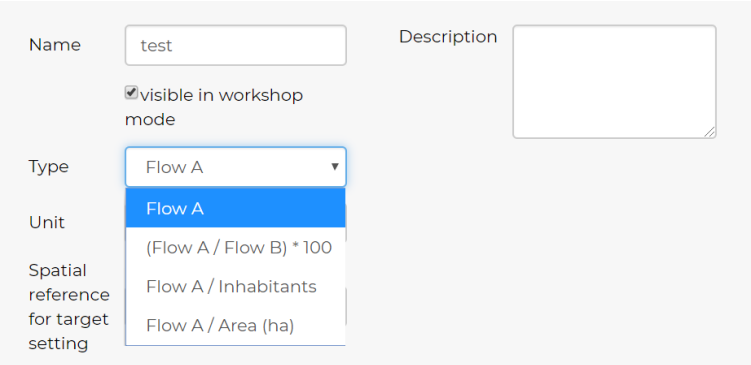


Figure 35. Choosing one of the four types of flow indicators (setup mode).

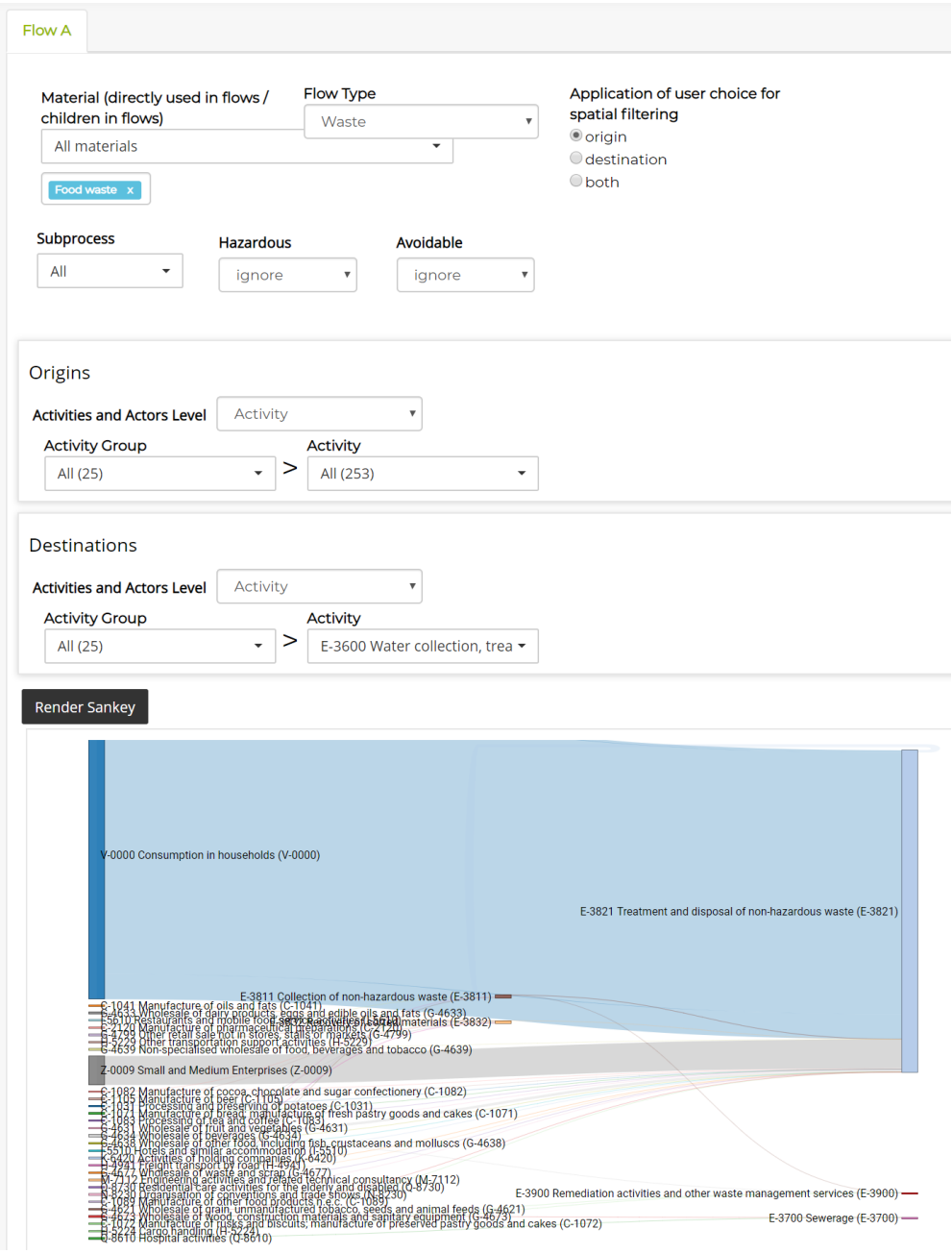


Figure 36. Input form for a flow assessment indicator (setup mode) .

Wastescapes

This Status Quo section is used to view and arrange map layers that describe the current situation of a PULL study area with regards to wastescapes. PULL team members use this section to select the wastescape maps that will be used during a workshop. This section is very similar to the 'Maps' section of the 'Study Area' GDSE step (see Section 4.1., Figure 20). Maps relevant to wastescapes can be composed by creating map categories and adding web mapping layers (e.g., WMS) to each category. Map layers can be selected from a number of existing web map services and/or the GDSE's dedicated GeoServer containing PULL-case-specific map layers. Figure 37 exemplifies this section using data for the AMA case study.

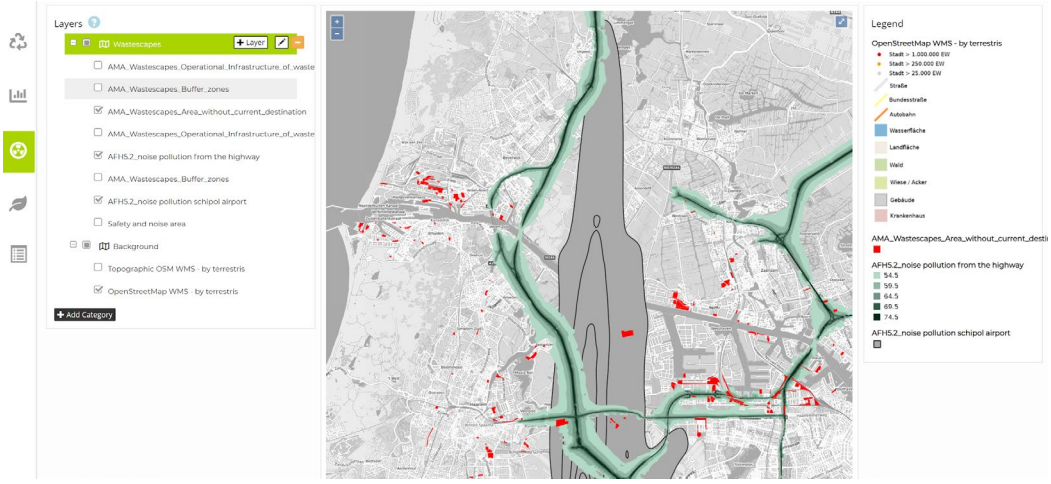


Figure 37. Section Wastescapes used to prepare wastescape maps (setup mode).

Sustainability

Setup mode users use this section to select and upload one or more PDF or similar documents containing the results of the life cycle-based sustainability assessment for the status quo and the EIS/strategies of particular case studies focusing on selected waste flows (e.g. food waste, vegetable, fruit and garden waste, construction and demolition waste, amongst others), as an outcome of WP4. A report file can be uploaded using the form shown in Figure 38.

A key flow must first be selected in order to upload the corresponding report. This report will be informative and available for exploration to participants of a PULL workshop anytime they want to discuss the sustainability assessment results of the scenarios. Figure 39 shows an example extract of such a report for the pilot PULL case studies, namely Amsterdam and Naples. This report is based on D4.8 Sustainability assessment for the pilot case studies – Eco-innovative solutions. (REPAiR, 2019d).

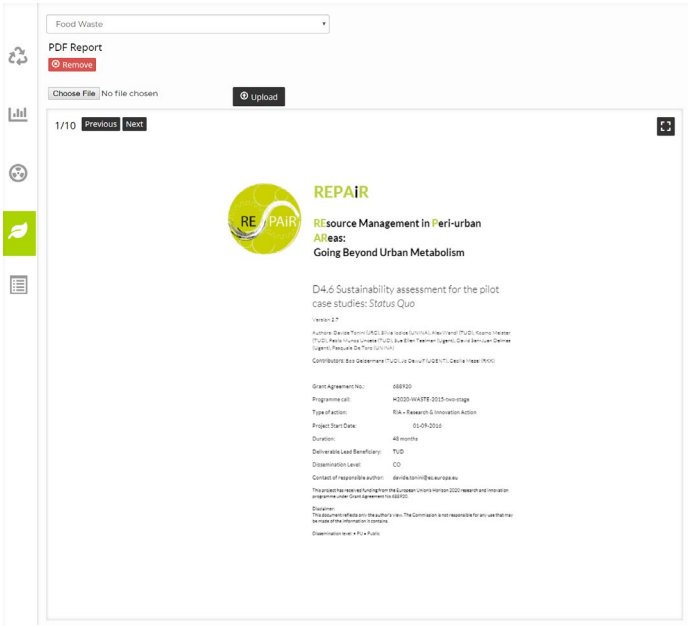


Figure 38. Using the section Sustainability to upload an example document for the sustainability assessment report of the status quo of the pilot PULL case studies: Amsterdam and Naples.

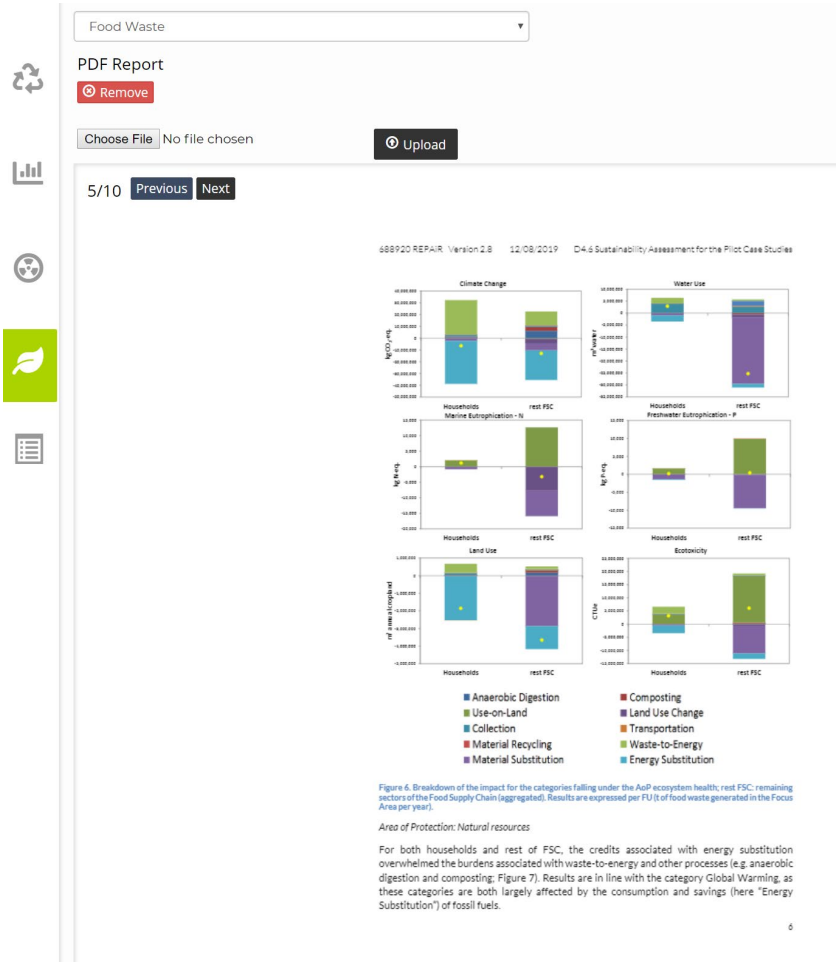


Figure 39. Extract of life cycle-based results for selected indicators taken from the sustainability assessment report of the status quo of the pilot PULL case studies: Amsterdam and Naples.

Objectives

This section is used by PULL team members to upload both the CE challenges and the CE objectives defined earlier by the PULL stakeholders. Uploaded challenges and objectives are displayed in the GDSE for each key flow defined earlier as shown in Figure 40. The CE objectives defined in this section will be ranked by workshop participants and further analysed in later stages of the PULL.

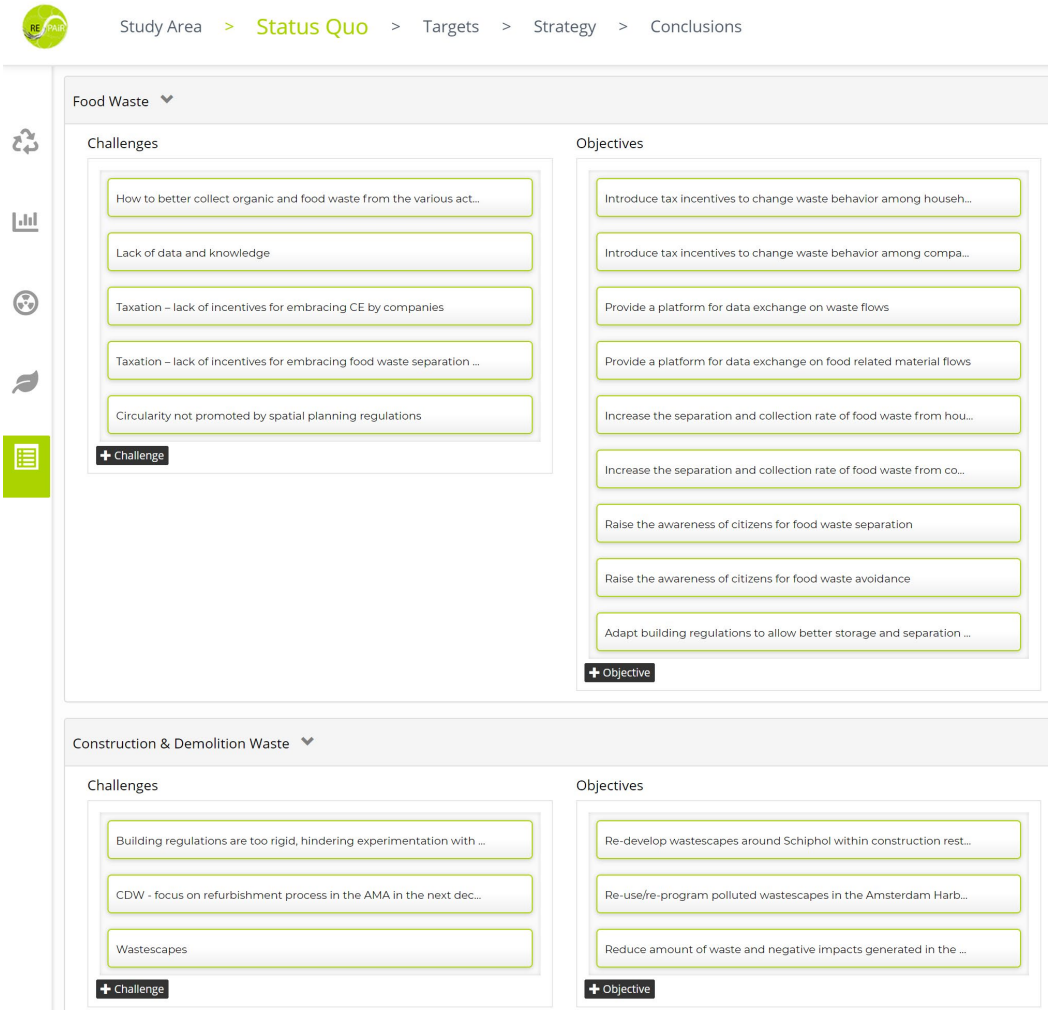


Figure 40. Adding CE challenges and CE objectives to key flows (setup mode).

4.3. Targets

This step contains only one section, which is used to define the target year for the CE objectives that the EIS will address, using a simple text upload box (Figure 41).

Figure 41. Defining a target year (setup mode).

4.4. Strategy

This section of the GDSE step is used by PULL workshop leaders and data captains supported by a team of researchers and research assistants to upload and configure the individual eco-innovative solutions that will be used by stakeholders when defining strategies in later stages and workshops. This GDSE step consists of three sections (Figure 42), which are used to configure solutions for each key flow.

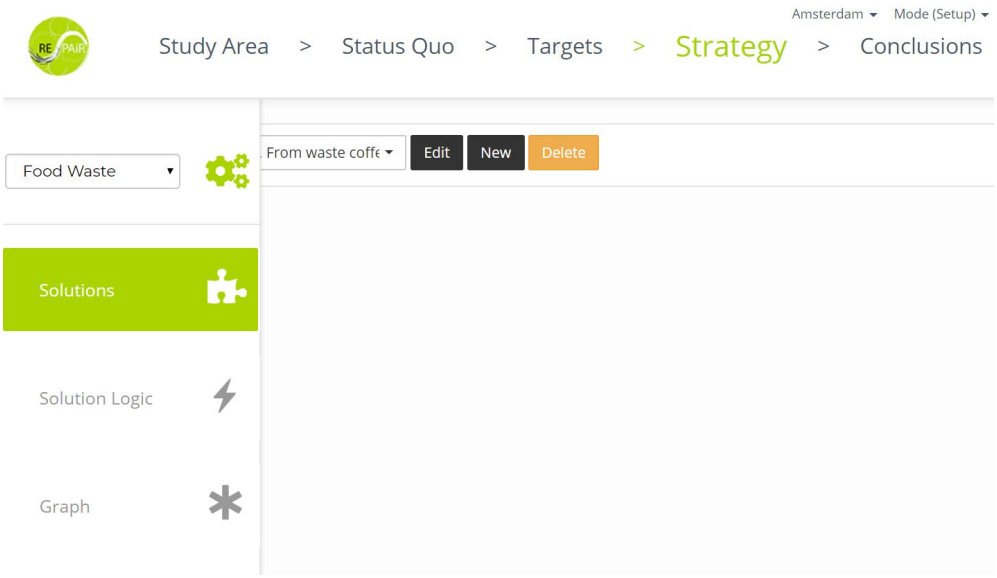


Figure 42. Sections of the Strategy step (setup mode).

Solutions

First, a key flow is selected via the top drop-down menu. Eco-innovative solutions can be created, and existing solutions can be edited or deleted. This is done using the form shown in Figure 43.

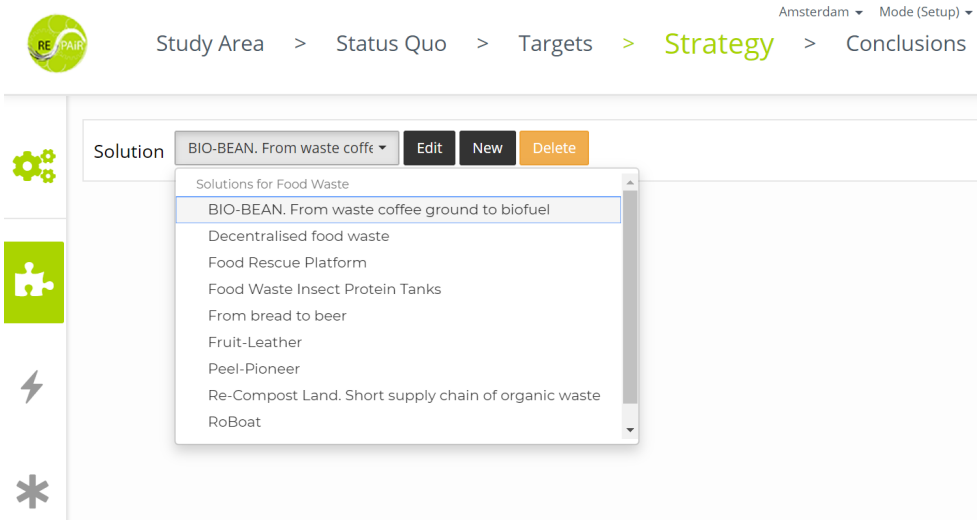


Figure 43. Solutions section (setup mode).

Creating a new solution

To add a new solution, a setup mode user clicks on New. A small form appears (Figure 44). A name can be typed for the new solution. Solution categories are used to organise solutions into groups according to the main flows they address, New categories can also be created via this form.

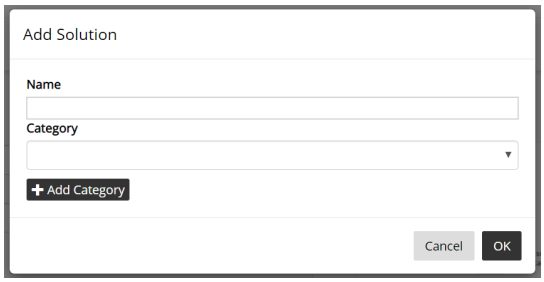


Figure 44. Add Solution form (setup mode).

Editing an existing solution

Next, solutions are further described by using the 'Edit solution' form (Figure 45). The form is used to upload a full description of the solution (in text form), and images files for both current and proposed process. Activities involved can also be uploaded as image files.

There is a free text field that allows users to enter textual description of the solution. The field allows formatting the text to ensure that the text appears as clear as possible and can be read and understood by the workshop participants in a short amount of time during the workshop.

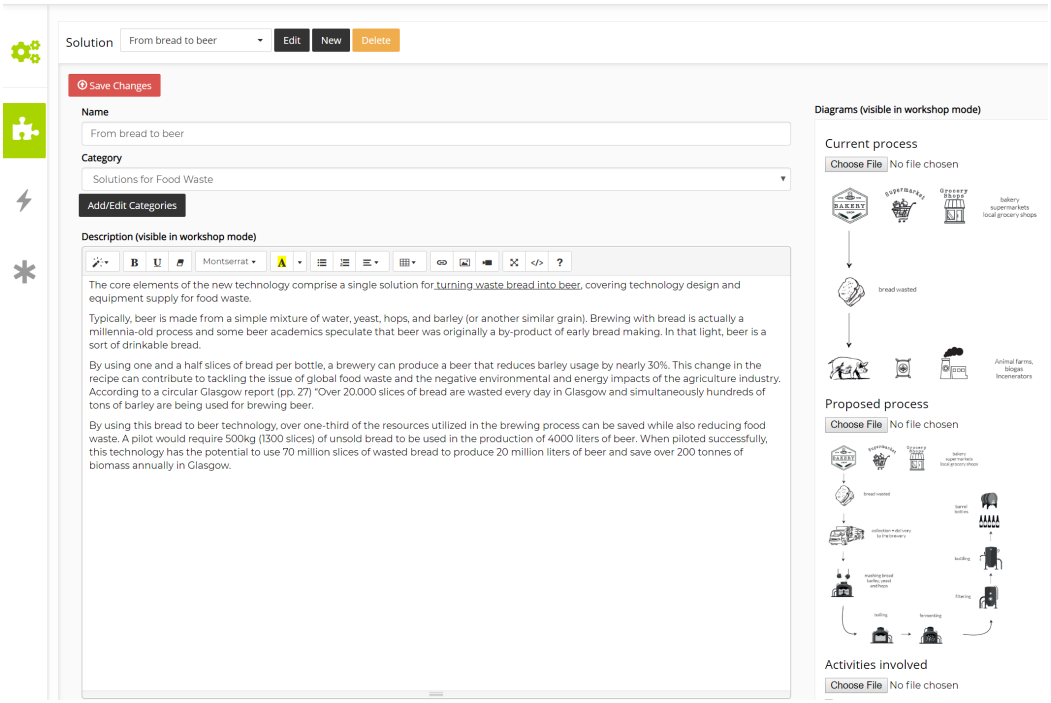


Figure 45. Edit Solution form (setup mode).

The “Current process diagram” field requires an upload of a scheme that visually describes the current state of flows that are changed by the proposed solution. “Proposed process diagram” requires upload of a scheme in the same visual style as the previous one that describes how the solution is intending to change the flows. “Activities involved” is an optional image file that can be a map of the economic activities involved into the proposed solution, a map of potential areas for those activities to take place or any other visual aids that provide extra information on the economic activities involved in the solution.

Solution Logic

The solution logic describes formally how the flows between economic activities are expected to change after the proposed solution is implemented. This is done in the second screen of the Strategy step. This screen contains three tabs, namely *Solution Parts*, *Implementation questions*, *Possible implementation areas*, each of which dealing with the specific aspects of the definition of a particular solution. In order to describe formally how the proposed solution is expected to change status quo flows, each solution needs to be broken down into multiple *parts*. Each solution must consist of at least one *solution part* and there is no maximum number of solution parts. In order to understand how to break a solution into its parts, a user is first of all asked to redraw the “*current process*” and “*proposed process*” diagrams following the defined symbology which directly relates to the possible modeling choices in the GDSE. Figure 46 shows an example of such diagrams.

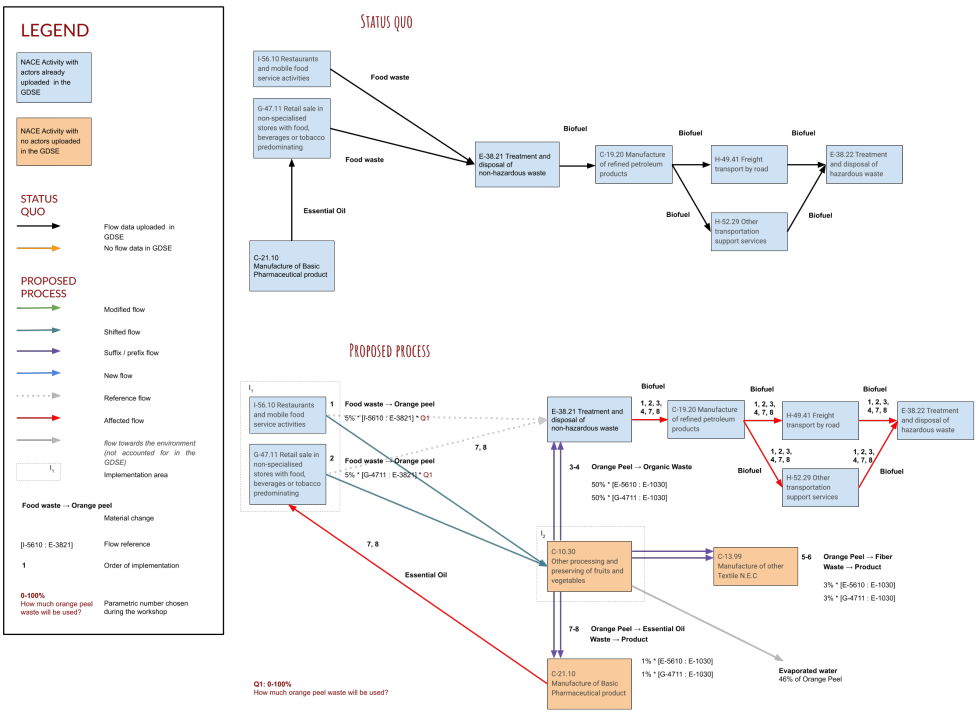


Figure 46. Example of the Current Process (Status Quo) and Proposed Process diagrams drawn according to the defined symbology. A high-quality version of this image can be found here: https://mfr.osf.io/render?url=https://osf.io/zkp27/?direct%26mode=render%26action=download%26mode=render

Drawing Process Diagrams

In order to draw the two process diagrams, a user must first start by drawing the Current Process. The diagrams are drawn on an Activity aggregation level, meaning that each box represents a (non-)economic activity.

First, the current process should be drawn based on the conceptual scheme that must have been provided together with each EIS in the EIS catalogue (see REPAiR XXX)5.. The conceptual schemes typically describe a type of activity without stating which exact NACE activity codes are relevant. E.g. “waste treatment” can point to “E-3821 - Treatment and disposal of non-hazardous waste” or “E-3822 - Treatment and disposal of hazardous waste” or “E-3832 - Recovery of sorted materials” or “E-3900 - Remediation activities and other waste management services”. Then, it must be checked which of the required status quo flows are already available in the GDSE.

If data is missing on some of the flows, then it must be further investigated whether 1) the flows do happen in the case study region, only the data on them has not been entered in the GDSE yet; or 2) these flows are not happening in the case study region.

In the first case, the data must be found / estimated and entered in the GDSE before the solution can be modelled further. In the second case, the solution cannot be applied in the area and needs to be adapted first (in consultation with WP5). Even after the relevant data has been added into the GDSE, the arrows and the activity boxes in the process scheme should stay orange (marking missing data) as this data is most likely to be an estimation and coming from a different data source than the rest of the data used to determine the status quo.

The Proposed Process diagram should also be drawn first based on the conceptual scheme. At the beginning it should depict the desired state of the system without assigning a specific colour to any of the arrows. Then it should be checked again if all necessary activities are already present in the GDSE and if all of them have at least one actor. If that is not the case, new activities with (dummy) actors need to be uploaded before continuing the modeling.

Next, the two diagrams need to be compared and necessary modifications need to be marked to change the system from the current to the proposed state.

The general rule is that: **each change performed on one flow (one arrow) is one solution part.** After performing the change, a single flow might change into *one or two* flows (arrows). It is not possible to remove a flow.

Figure 47 shows the ‘Solution parts’ tab, which contains three existing solution parts (left panel) and a Notes panel for adding remarks and further explanation of the solution. A new solution part is added by clicking **+ Add Part**.

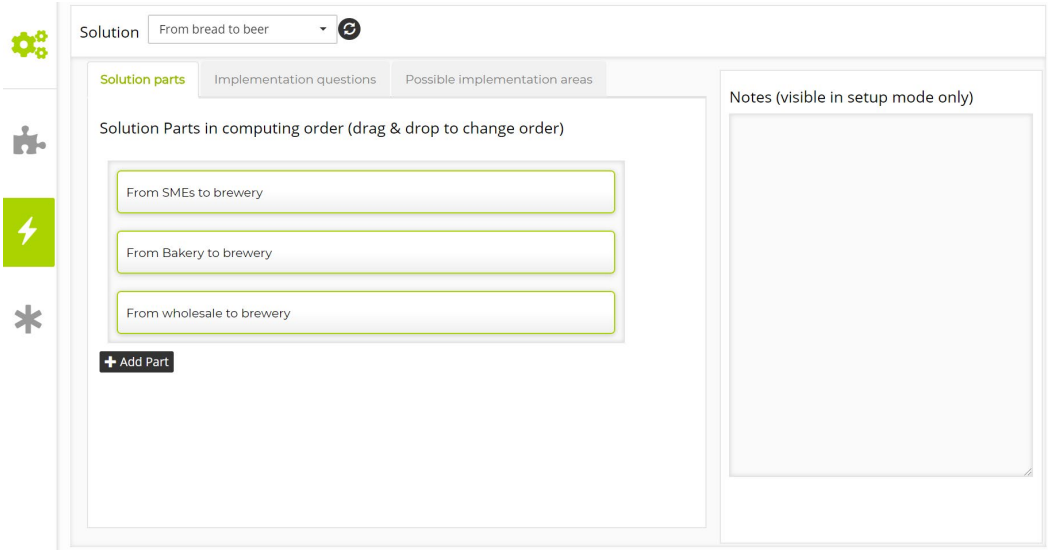


Figure 47. Solution logic section: containing three tabs for defining the solution (setup mode).

Solution parts

The WP2 team has identified six possible schemes for defining a solution part, namely a) modification, b) shift origin, c) shift destination, d) new flow, e) prepend flow, and f) append flow. Figure 48 shows how the six available schemes are presented in this section of the GDSE step 'Strategy'. When adding a new solution part, setup mode users can choose one of the six schemes that best fit the intended purpose. Upon clicking on one solution scheme thumbnail (left panel), a magnified image of the part appears on the right panel, together with an amplifiable legend that explains the symbols used in the solution part scheme.

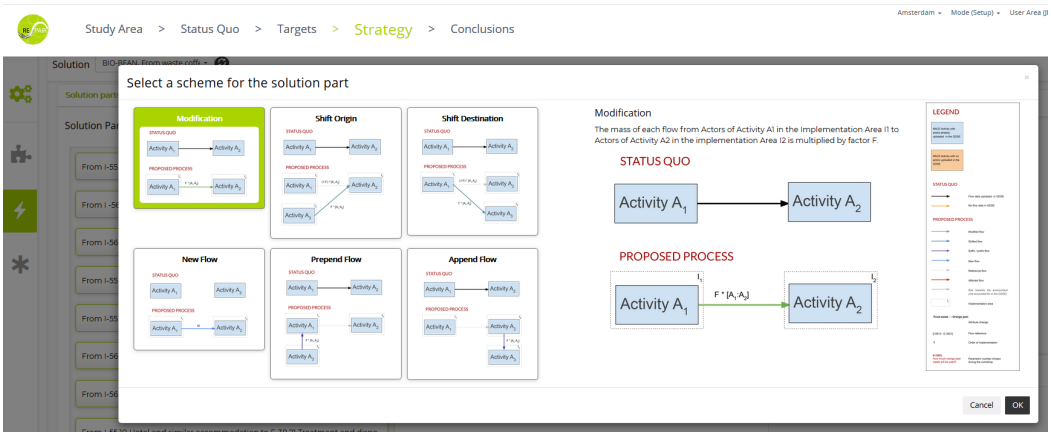


Figure 48. Schemes available for modelling solution parts (setup mode)

a) Modifying a flow

Definition. The mass of each flow from Actors of Activity A_1 in the Implementation Area I_1 to Actors of Activity A_2 in the implementation Area I_2 is either multiplied by the relative factor F or reduced/increased by an absolute amount "Delta". Figure 49 shows process scheme and illustration of change.

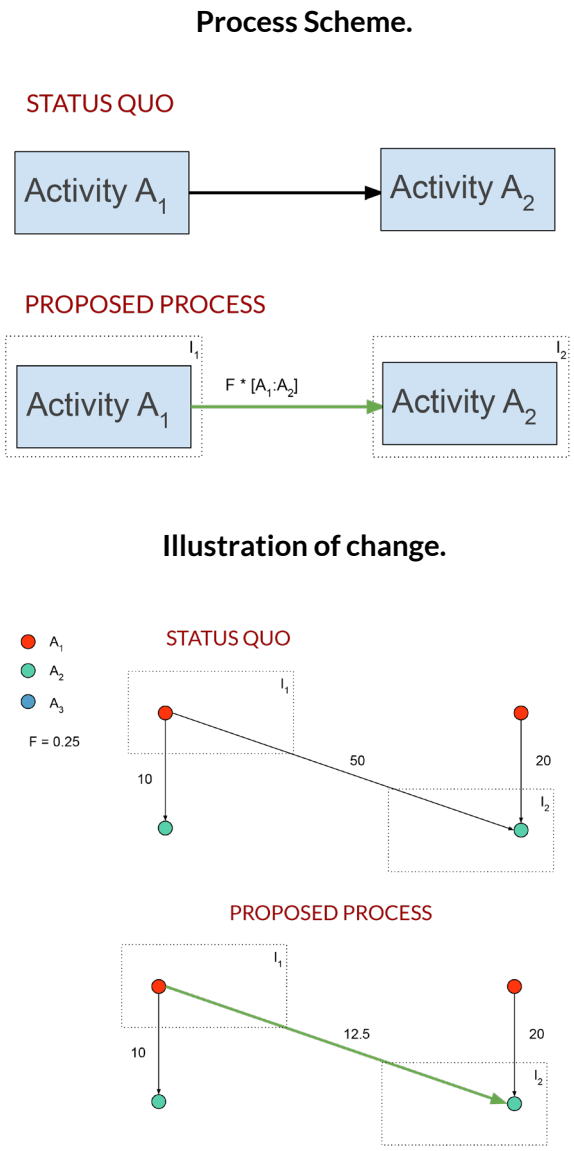


Figure 49. Solution part scheme 'Modifying a flow': process scheme (top) and illustration of change (bottom) for status quo and proposed process.

Example. Modifying a flow is suitable to model such changes that happen at the activity of the flow origin which reduces the material output of that activity without shifting the reduced part into a different activity. A good example of a modified flow would be producing packages of a certain product using two times less plastic. In that case the flow of plastic from production activity to retail activity would need to be multiplied by factor 0.5. A bad example of a modified flow would be people separating plastic from municipal waste, this waste reducing the amount of mixed municipal waste by 20%. Even if the flow from households to municipal waste treatment is modified by reducing it, the reduced part does not simply disappear but is going to a different treatment facility. This means that this is a Shifted Flow. Setting the factor to 100% (F = 1.00) would reduce the flow to 0 and that would be an equivalent of removing the flow.

b) Shifting Flow's Origin

Definition. The mass of each flow from Actors of the Activity A_1 in the Implementation Area I_1 to Actors of Activity A_2 in the Implementation Area I_2 will be multiplied by (1 - F). For each of these reduced flows, a new flow with the respective mass multiplied by the Factor F will be created from the closest Actor of Activity A_3 in the implementation area I_3 to the respective Actor of the Activity A_2 in the Implementation Area I_2 (see Figure 50).

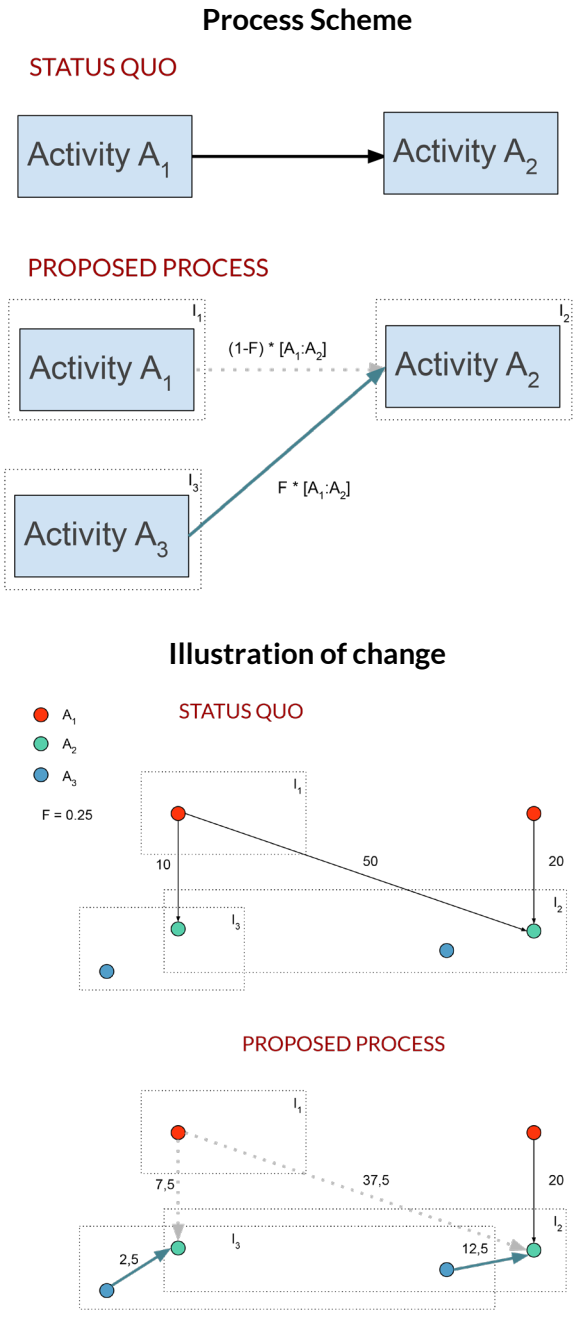


Figure 50. Solution part scheme 'Shift Flow's Origin': process scheme (top) and illustration of change (bottom).

In case an absolute change is defined instead of a relative factor, the absolute "delta"-amount is deducted from flow "$Activity_1$->$Activity_2$", and a new flow with this absolute amount is created between $Activity_3$ and $Activity_2$.

Example. Shifting an origin is suitable to model such flows where one activity receives (part of) its input from a different activity than it used to do before and the reduced part of the original flow is deemed irrelevant to the analysed process. A good example of shifting an origin would be part of the building insulation being produced from mycelium instead of polystyrene. It is irrelevant what happens with the polystyrene that is not used for the insulation anymore as it might simply be not produced anymore. A bad example would be an incinerator getting part of the waste from a different waste producer. The first waste producer does not stop producing less waste but instead shifts the reduced part to a different treatment.

c) Shifting Flow's Destination

Definition. The mass of each flow from Actors of the Activity A_1 in the Implementation Area I_1 to Actors of Activity A_2 in the Implementation Area I_2 will be either multiplied by (1 - F) or reduced by F. For each of these reduced flows a new flow with the respective mass multiplied by the Factor F will be created from each Actor of Activity A_1 in the implementation area I_1 to the closest Actor of the Activity A_3 in the Implementation Area I_3. Figure 51 shows the process scheme. Figure 52 shows the illustration of change.

Example. Shifting a destination is suitable to model such flows where an origin activity of a certain flow gives part of its flow to a different destination activity. A typical example of such flow would be waste sorting due to which part of the same flow gets shifted to a different treatment process.

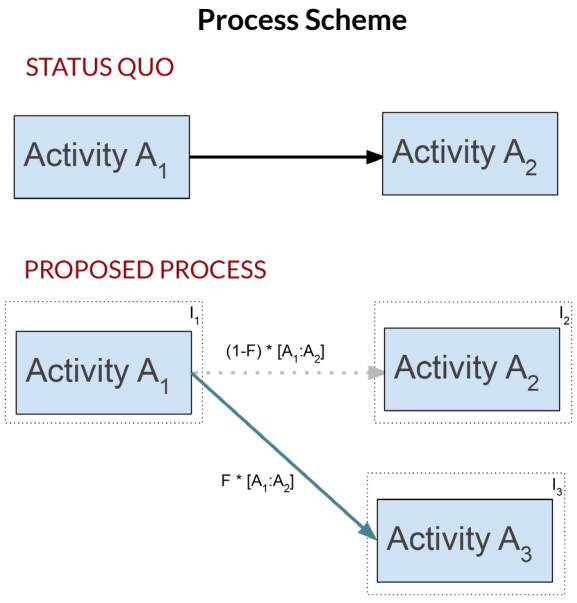


Figure 51. Solution part scheme 'Shift Flow's Destination': process scheme for status quo and proposed process.

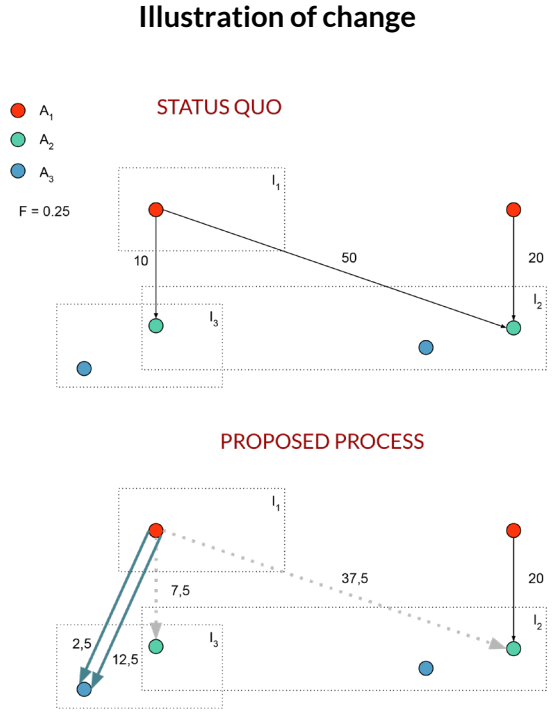


Figure 52. Solution part scheme 'Shift Flow's Destination': illustration of change for status quo and proposed process.

d) Creating a New Flow

Definition. For each Actor of Activity A_1 in the Implementation Area I_1 a new flow with the absolute mass M is created to the closest Actor of the Activity A_2 in the Implementation Area I_2. Figure 53 shows the process scheme. Figure 54 shows the illustration of change for this solution part scheme.

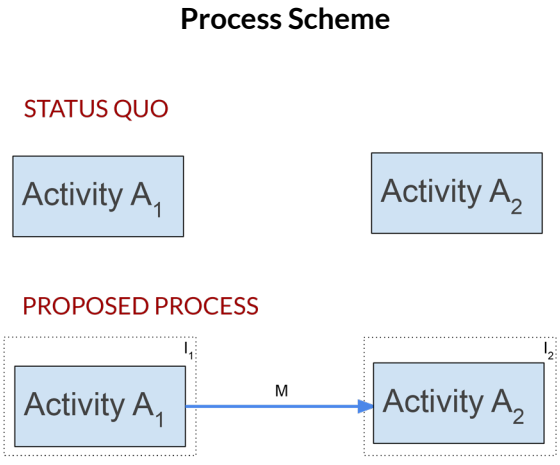


Figure 53. Solution part scheme 'Creating a New Flow': process scheme for status quo and proposed process.

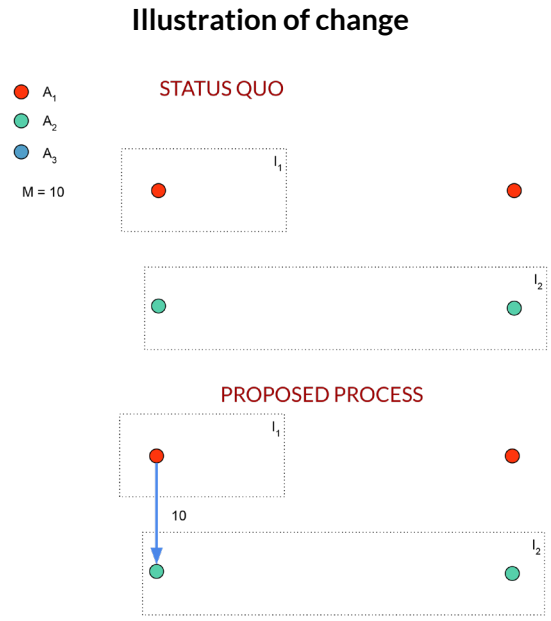


Figure 54. Solution part scheme 'Creating a New Flow': illustration of change for status quo and proposed process.

Example. A new flow is created in case no link between the two activities has previously existed and the amount of the newly created flow is not relative to any of the existing flows. A good example of such flow is creating a new activity such as growing of algae that afterwards is used as a construction material for road surfaces.

The amount of algae grown is only relevant to the amount of available land and other conditions but not relevant to any of the existing flows. A bad example would be a new flow from waste sorting facility to a recycling facility as this flow is relative to the flow that arrives to the sorting facility. In that case this is either a shifted flow or a suffix flow dependent on whether flows from the sorting facility are known (relevant) or not.

e) Creating a Flow Suffix

Definition. For each Actor of Activity A_2 in the Implementation Area I_2 that has inflows from Actors of Activity A_1 in the Implementation Area I_1, a new Flow is created to the closest Actor of Activity A_3 in the Implementation Area I_3.

The amount of this new Flow equals the sum of all the respective inflows to the Actor of Activity A_2 in the Implementation Area I_2 from an Actor of Activity A_1 in the Implementation Area A_1 multiplied by a factor F (see Figure 55).

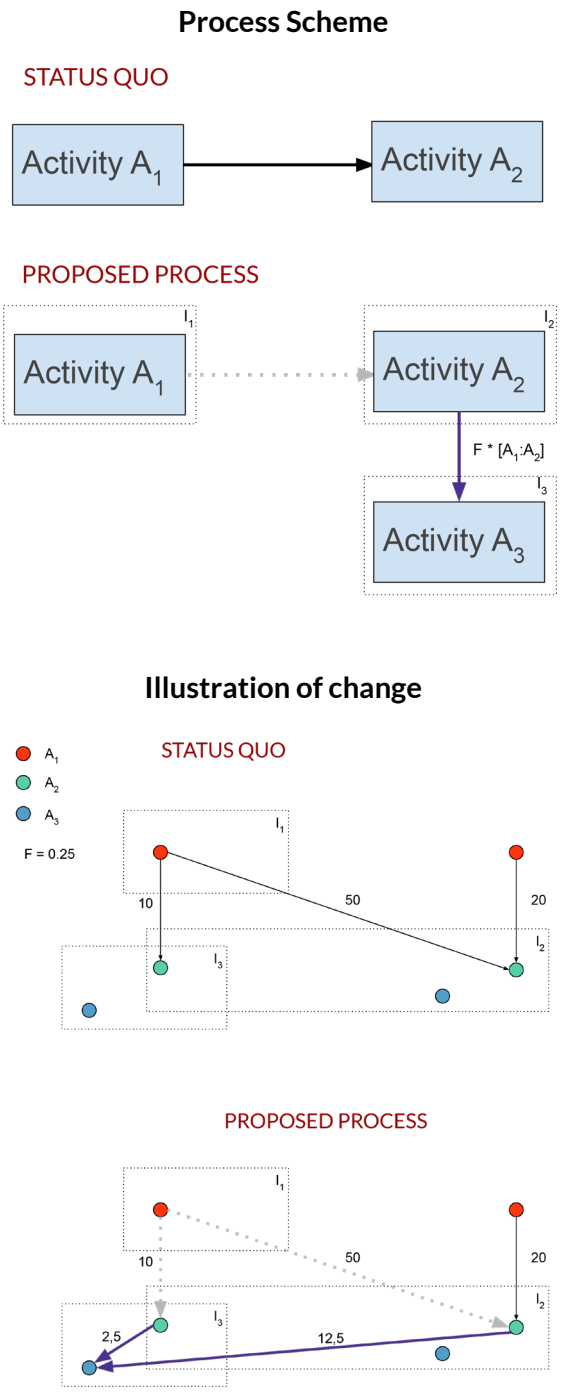


Figure 55. Solution part scheme 'Creating a flow suffix': process scheme (top) and illustration of change (bottom).

Example. A suffix flow is meant to model a flow starting from an activity the input to which is known and the output is not known or has not been relevant in the current process. A suffix flow is especially useful to model extensions of the shifted flows. It also allows modelling circular flows where an additional processing activity is needed before the material can be put back into the system.

f) Creating a Flow Prefix

Definition. For each Actor of Activity A_1 in the Implementation Area I_1 that has flows to Actors of Activity A_2 in the Implementation Area I_2, a new Flow is created to the closest Actor of Activity A_3 in the Implementation Area I_3. The amount of this new Flow equals the sum of all the respective flows from the Actor of Activity A_1 in the Implementation Area I_1 to an Actor of Activity A_2 in the Implementation Area A_2 multiplied by a factor F (see Figure 56).

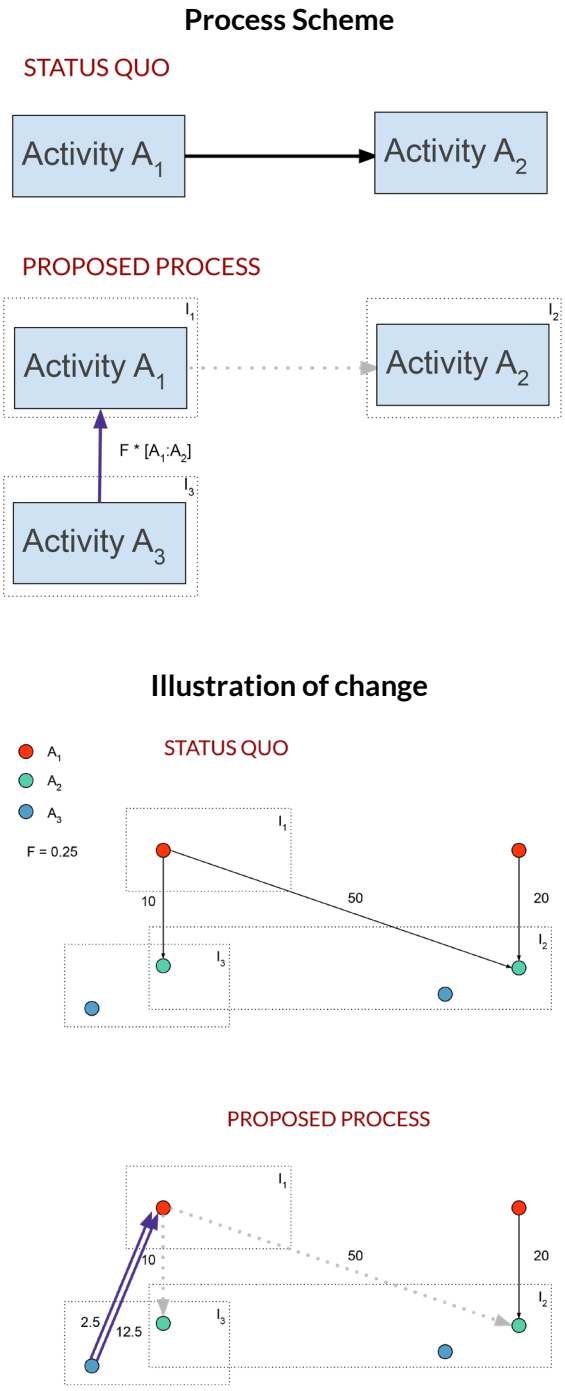


Figure 56. Solution part scheme 'Creating a flow prefix': process scheme (top) and illustration of change (bottom).

Example. A prefix flow is meant to model a flow ending at an activity the output from which is known and the input is not known or has not been relevant in the current process. It is also useful to model upstream flows from the known downstream flows.

Other Modelling Parameters

Once a solution part scheme is selected, a scheme-specific screen called 'Edit Solution Part' appears containing two tabs. The first tab contains a form for specifying parameters of the solution part; and the second tab contains a form for specifying flows that will be affected by the solution part. Figure 57 shows the first tab containing the form for solution part scheme "Shift Destination".)

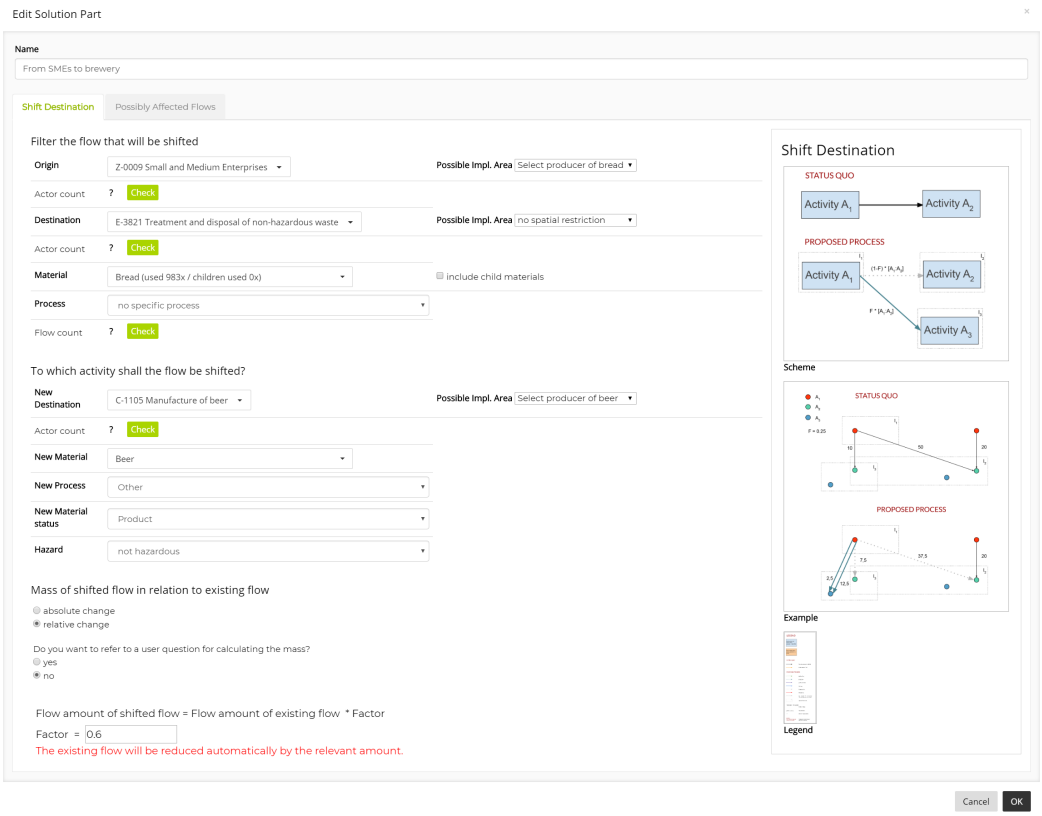


Figure 57. Edit Solution Part form for a 'Shift Destination' solution part scheme type.

Naming. The first field of the form asks to give a name for a solution part. The names do not necessarily have to be unique but it is advisable to give very explicit names that explain what change the solution part is meant for. A good example would be: *Shifting incinerated orange peels from "I-5510 Hotels…" to "C-2893 … food, beverage and tobacco processing" instead of "E-3810".*

Filtering Reference Flow. The first part of the form is different depending on which scheme has been selected for modeling. It allows to model the selected change by selecting the origin and the destination of the reference flow (except in the case of a New Flow), and accordingly the new origin or destination for the shifted or suffixed/prefixed flow. Each node of the participating flows can have a spatial restriction to include only those flows in the solution whose actors exist in a specific

selected area. This area is called the "**Implementation Area**" and is further explained in the section Implementation Area.

The green "Check" button for Actor Count under each activity selection bar allows users to check if any actors of the selected Activity exist in the selected Possible Implementation Area. If Actor Count returns 0, it means that no actors exist and the solution part will not be effective there (will not cause any changes). In that case, either new dummy actors need to be created or the implementation area needs to be expanded to include areas where the specific economic activity takes place.

In order to specify further which flows need to be affected by the solution part, those modeling options that include a reference flow, have an option to select a specific material that a reference flow is carrying and and a specific waste treatment process that is applied to that material. For example, if a solution part aims to shift only vegetal waste coming from the restaurants towards farming instead of waste treatment facilities, then not specifying a particular material would also include non-vegetal waste products such as meat scraps. Similarly, the solution might want to include only those flows that end up in treatment processes with the biggest value loss, e.g. landfilling or incineration, excluding composting or animal feed.

Only one process and one material can be selected per one solution part. If a solution is meant to affect flows with various materials and processing methods, then a new solution part must be created for each of those choices (or their combinations). The "**clone solution part**" button is meant to make the process of multiplying solution parts faster and easier.

The "**include child materials**" checkbox allows users to choose if the materials in the material hierarchy that fall under the selected material need to be included as well. E.g., "vegetal waste" may include more specific materials such as "potato peels" or "garden waste". In some cases it might be desirable not to include those more child materials. In that case the checkbox should not be ticked.

When all the flow properties are selected for filtering, a green "Check" button allows to see if there are any flows that fit all of them. If the Flow Count returns 0, the properties need to be adjusted.

Creating New Flow. A new, shifted, suffixed or prefixed flow may have the same characteristics as the reference flow or they might be different. The form allows to change those following characteristics: material, treatment process, material status (product or waste) and hazardousness.

The mass of the new flow is defined in relation to the reference flow by specifying a factor F. The factor might be a relative or an absolute value. For a new flow, an absolute value has to be provided. For a flow with shifted origin or destination, the relative factor F or an absolute value "**delta**" can be specified. A relative value would multiply the reference flow by the given value F to determine the amount of the

shifted flow and multiply the original flow by (1-F). If an absolute value for "delta" is provided, then the original flow is reduced by this delta and the new flow has the given amount "delta". In case of an appended or prepended flow, only a relative factor F can be specified, which relates this amount of the appended/prepended flow to the referenced flow. It is possible to relate the relative factor F or absolute change "delta" with an interactive question that may be asked during the workshop this way making the factor a parametric value. The Implementation Question is explained more in detail further in this chapter.

Affected flows

Definition. For each flow from Actor of Activity A_1 in the Implementation Area I_1 to Actors of Activity A_2 in the Implementation Area I_2 all subsequent flows towards Activity A_3 get the mass value that is calculated by multiplying the status quo value of the respective flow by the ratio between all inflows from the Actors of Activity A_1 towards Actors of Activity A_2 in the Implementation Area I_2 in their Status Quo state and the Proposed Process state.

The second tab of the Solution Part Form is used for specifying the flows that will be affected by the change that the solution part will cause (see Figure 60). This tab is called '**Possibly Affected Flows**' and allows users to add (via the button **+ Add affected flow**) and edit all flows that could possibly be changed due to the changes of the initial impact flow caused by the solution part. Figure 58 illustrates the concept of affected flows in a process diagram.

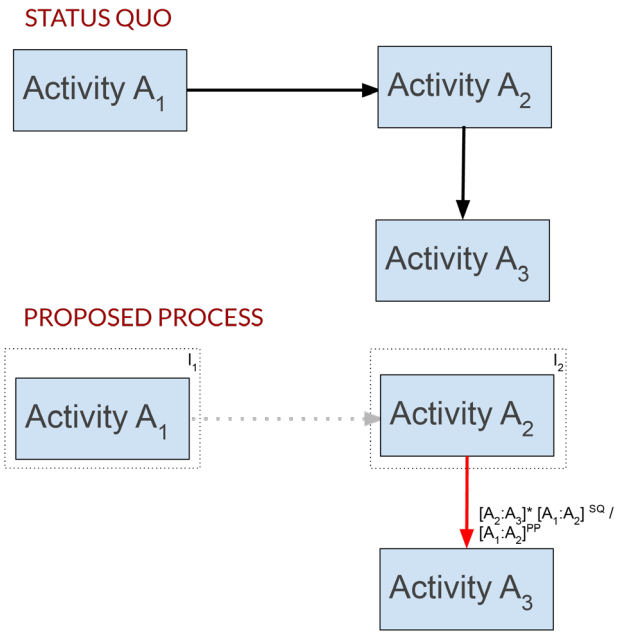


Figure 58. Process scheme diagram of the affected flows. The change of flow in between Activity A_1 and A_2 will accordingly affect the flow between Activity A_2 and A_3.

The system is able to propagate the change downstream through the process diagram and automatically calculate how the related flows that do not belong to

any of the solution parts will be affected. This propagation, however, needs to be controlled by the system user. The system interface provides means to choose which flows are affected by each of the solution parts.

To give an example, if Activity A_1 in Figure 59 represents restaurants, Activity A_2 represents waste collection and Activity A_3 - waste treatment, then the decrease in flow between restaurants and waste collection will accordingly decrease the flow between waste collection and waste treatment.

However, if the user assumes that the waste collector would try to fulfill the capacity of the waste treatment facility by collecting more waste from different activities or restaurants but located outside of the implementation area, then the flow between waste collection and waste treatment would not be affected by the former change. This decision is left upon the person responsible for formally modeling the EIS.

Figure 59 illustrates how the change propagates towards the affected flows on an actor level.

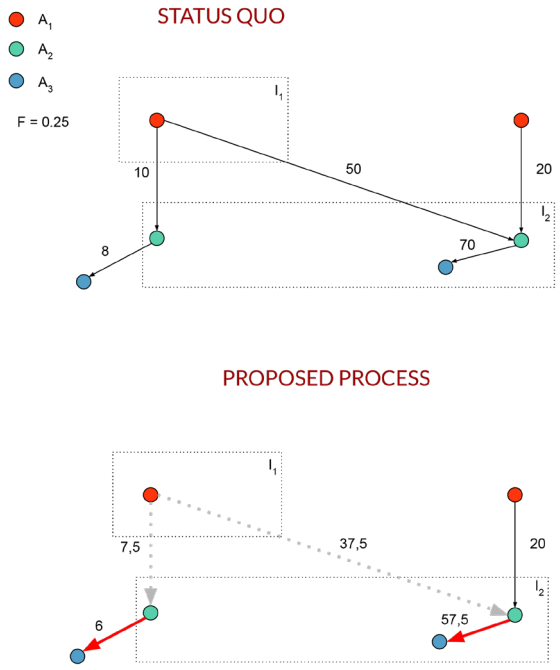


Figure 59. Illustration of the affected flows on actor level. The change of flow in between actors of Activity A_1 and A_2 will accordingly affect the flow between actors of Activity A_2 and A_3

In case a node has multiple input and flows, the extent to which affected flow is increased or reduced is calculated as shown below:

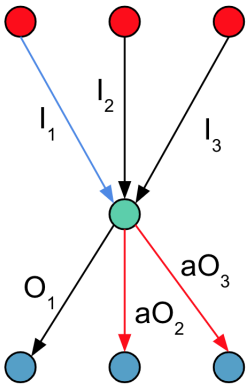
$$\Delta aO_i = \frac{aO_i}{\sum_n^i aO_i} * \Delta \sum_n^i I_i * \frac{\sum_n^i O_i}{\sum_n^i I_i},$$

where

aO_i is the mass of affected Output flow,

O_i is the mass of Output flow,

I_i is the mass of Input flow.



The formula ensures that the ratio between input and output stays the same per each actor and that the change on the input side is accordingly distributed to all the affected flows on the output side.

If in some cases this assumption doesn't hold true, then the affected flows can be modelled as modified flows with a custom ratio. In principle, the six possible modeling schemes along with the Affected flows should allow formally modeling any solution, however, this assumption will still be tested further once all follow-up case studies do the modeling of their EIS.

Figure 60 shows how the affected flows can be chosen in the user interface. In order to assist the user with choosing possible affected flows, a Sankey diagram is drawn for the combination of selected activity and material.

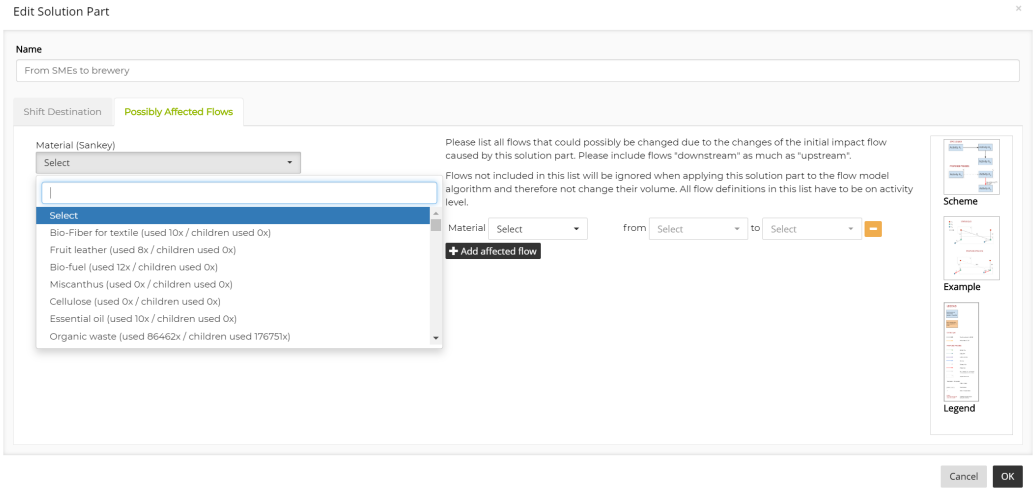


Figure 60. Solution part form showing tab for possibly affected flows.

Implementation Questions

In some cases the ratio up to which a solution can modify the existing flows is based rather on a personal opinion, or an educated guess, than an actual measure. An example of such a ratio would be a solution that involves participation, such as home separation of waste. In order to consult PULL participants as local experts about what ratio can be expected for a certain solution part, Implementation

Questions have been added to the Solution Logic module. An 'Implementation question' will be asked interactively at the PULL workshop meeting during the solution implementation phase. The answer to the question can be used as an extra factor in the solution model. Figure 61 shows a GDSE screenshot of the second tab 'Implementation questions'.

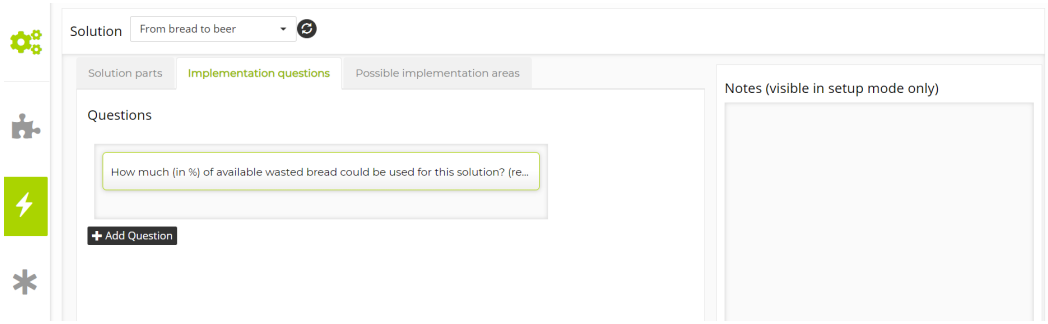


Figure 61. 'Implementation questions' tab.

An example of a question relevant to a solution in Amsterdam case study called "Bread to Beer", which aims to use wasted bread as raw input material for brewing beer, can be "How much (in %) of available wasted bread could be used for this solution?". This question can be used in the solution part which shifts part of the bread carrying flow from restaurants to breweries instead of waste collection. In that case the factor F is set as 1 and then multiplied by the answer given during the workshop. If 20% is given as an answer, the shifting factor will be 0.2.

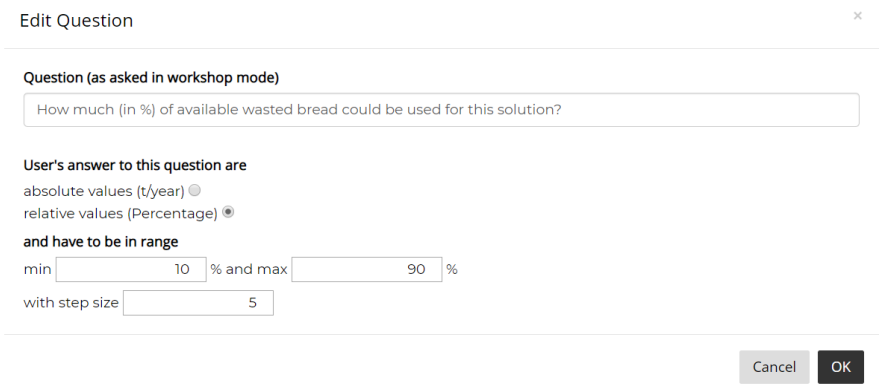


Figure 62. Form for editing implementation questions.

Figure 61 shows how setting the question appears in the GDSE. A question can be added by clicking **+ Add Question**. Answers can be provided in absolute or relative values and an appropriate range with relevant step size can be given to restrict the answers.

Possible implementation areas

Setting an implementation area is one of the tasks carried out by the workshop participants during the solution implementation phase. However, some solutions by definition can only be implemented by actors located in certain areas. An example would be a RoBoat waste collection using autonomous boats. Such a solution can only be implemented in the areas that have direct access to the water

canal system. In order to provide such geographical restrictions, Possible Implementation Areas can be associated with each activity participating in any of the solution parts (see Figure 63).

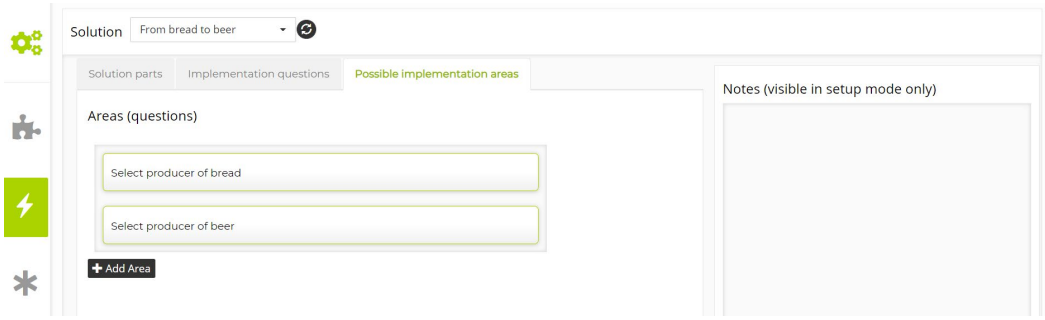


Figure 63. 'Possible implementation areas' tab.

To define possible implementation areas, PULL team members need to prepare a geoJSON file with a multipolygon and upload it using the "Possible Implementation Areas" tab. The areas optional and one area can be reused by multiple solution parts (see Figure 64).

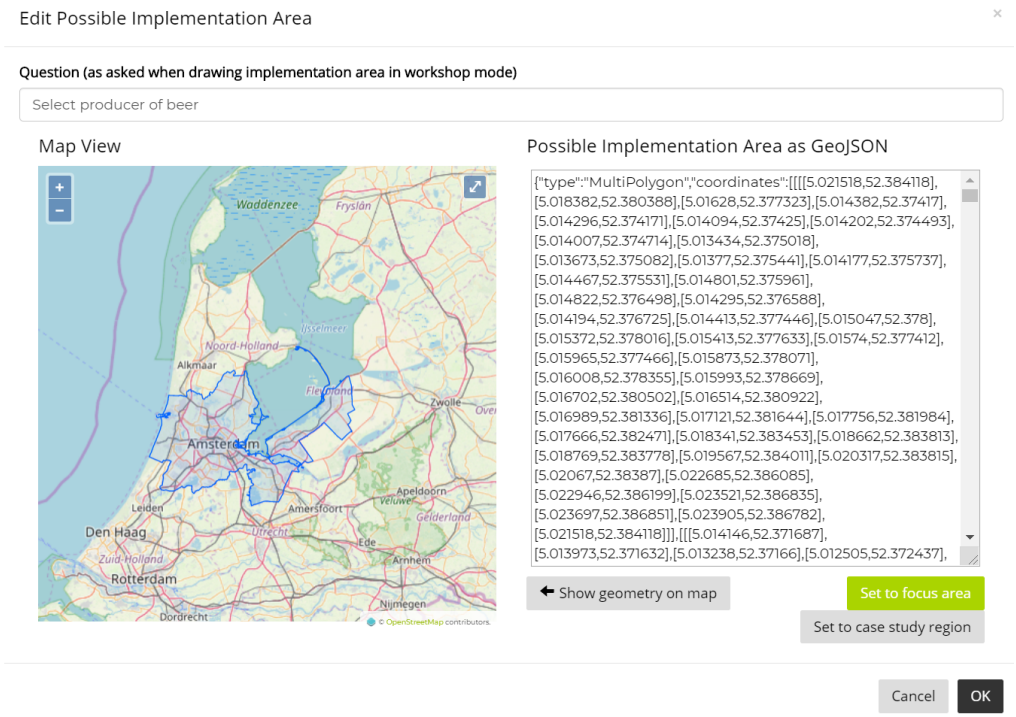


Figure 64. 'Edit Possible Implementation Area' tab showing the AMA focus area and its corresponding GeoJSON notation.

Graph

This section is used for building the graph using all the actors as graph nodes and flows between them as directed links (see Figure 65). The graph needs to be rebuilt after the underlying data for the case study and the key flow have been changed. This includes adding/removing/relocating actors, changing the materials or the amounts of flows in the status quo. In case of doubt if data has been changed since

the last building of the graph, it should be re-built to avoid inconsistencies between the graph and the solution logic. Once the graph has been built, solutions can be specified and then be implemented in strategies.

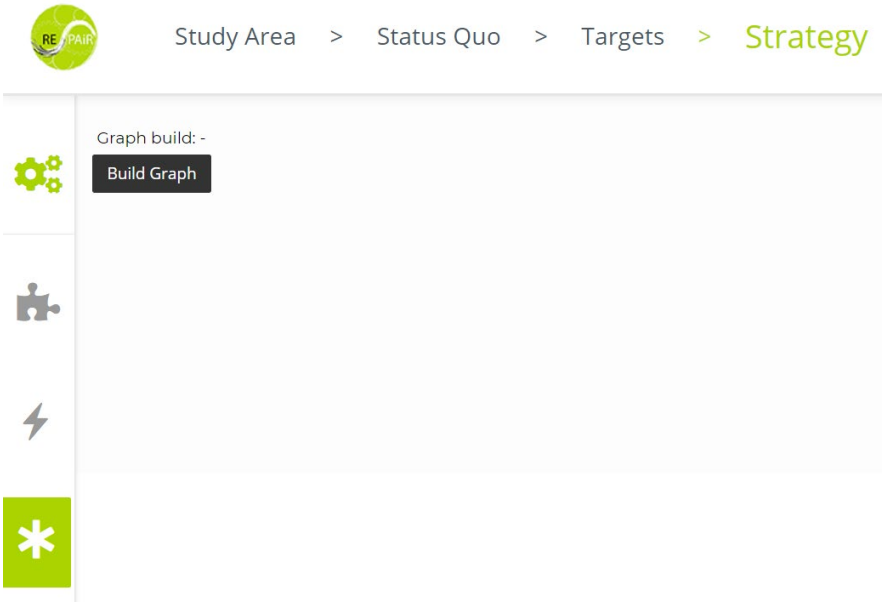


Figure 65. Screenshot of the Graph section, setup mode.

4.5. Conclusions

In setup mode, the final step of the GDSE, called "Conclusions", consists of three sections, namely Users, Notepad, and Sustainability (Figure 66).

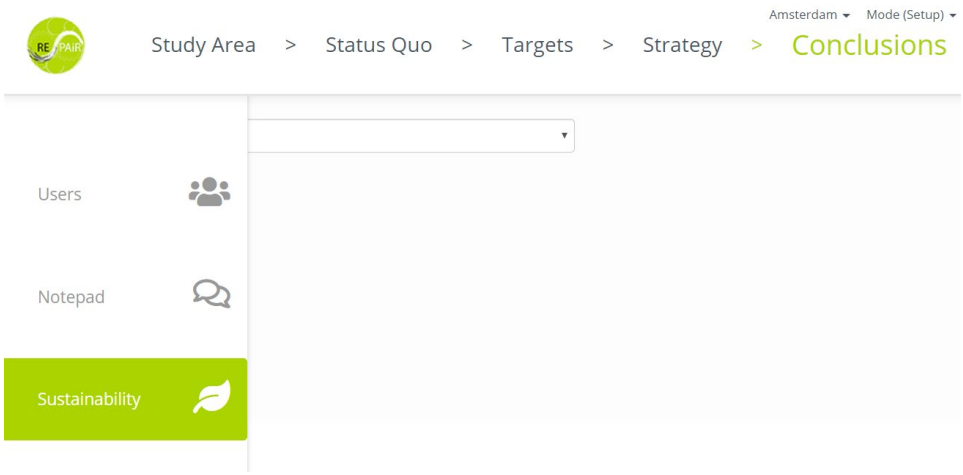


Figure 66. Sections of the "Conclusions" step.

Users

This section is used by PULL team members to choose the GDSE users that will be included in the evaluation that takes place in the "Conclusions" step in workshop mode (see Section 5.5). The GDSE users have been previously created in Admin Area mode. In preparation for a workshop, the PULL team member chooses these GDSE users that represent the small groups of a PULL case study that will interact with the GDSE modules later in the PULL workshop. "Users" section is used for this

purpose. Figure 67 shows a table listing usernames used in the system, aliases for the users and a tickbox to include or exclude users.

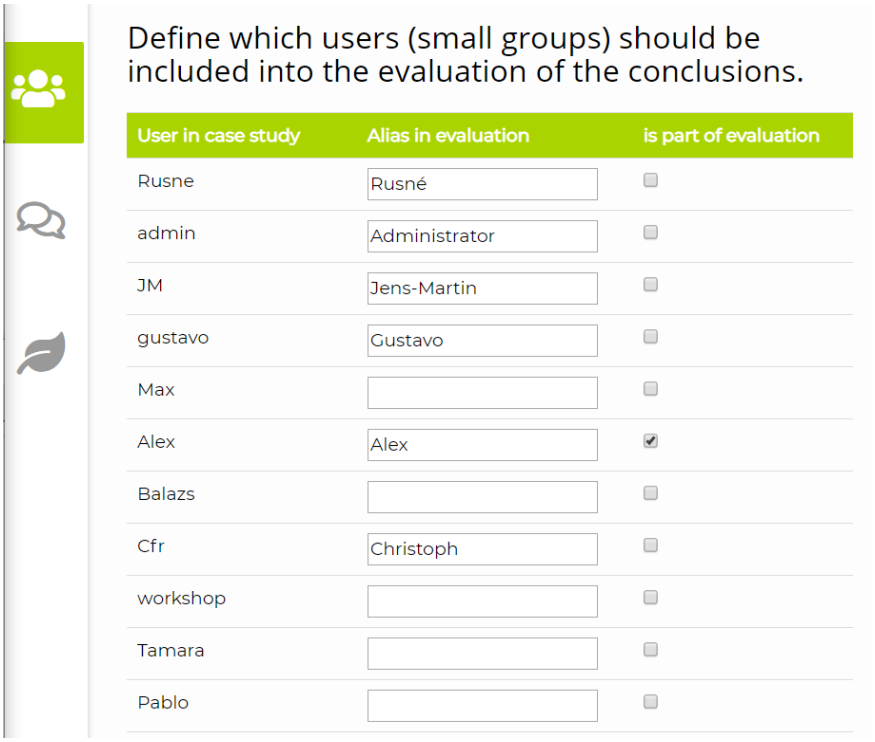


Figure 67. Section "Users" of the "Conclusions" step include user 'Alex' in the evaluation.

Notepad

The notepad section functions as a documentation tool that helps to facilitate and structure the final workshop discussion with the large stakeholder group. It will be only visible for the data-captain. It allows us to structure the discussion based on level of consensus as well as on different topics, both can be modified by the PULL-leader.

Figure 68 shows a screenshot of the Notepad interface in the GDSE.

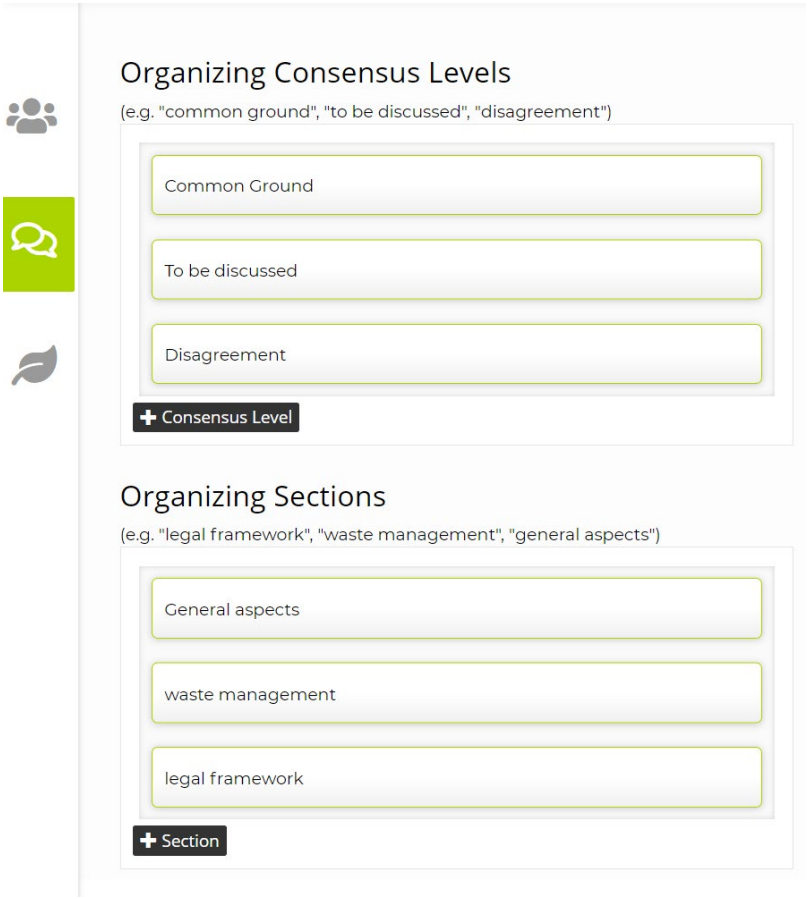


Figure 68. Section "Notepad".

Sustainability

Via this section, setup mode users can upload a PDF file containing the life cycle-based sustainability assessment of the PULL case study after the eco-innovative strategies have been developed by the small groups during a workshop (see Figure 69).

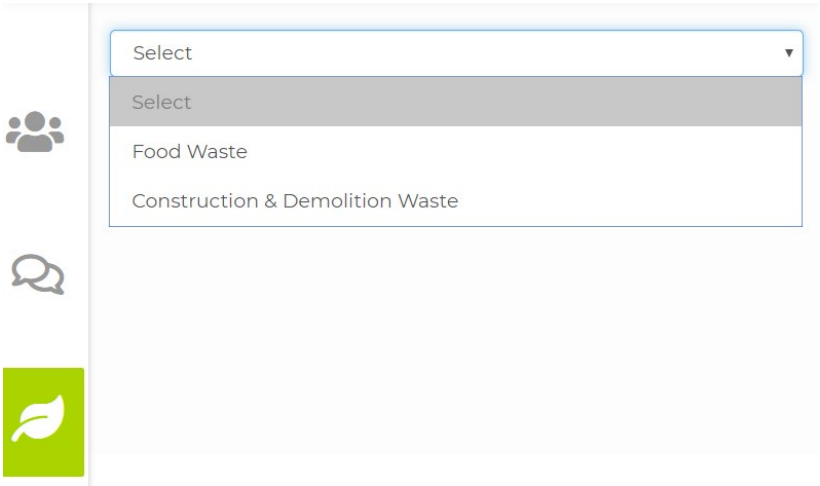


Figure 69. Section "Sustainability". Choosing a key flow.

This will allow them to see and discuss the impact assessment results of the status quo and the strategies related to a certain PULL study area and relevant waste flow. A report can be uploaded for each key waste flow, with the related results normally expressed according to the Functional Unit (describing qualitatively and quantitatively the service under assessment): "management of the (key) waste flow generated during a year in the chosen Study / Focus Area" (see Figure 70).

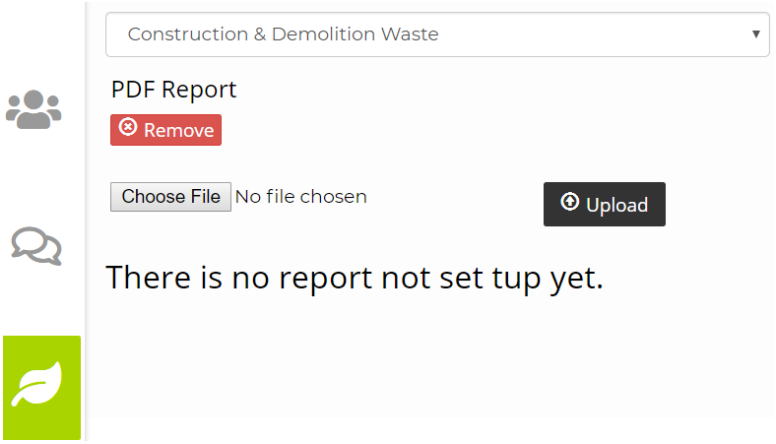


Figure 70. Section "Sustainability". Uploading a sustainability assessment report for a key flow.

The next chapter describes the software implementation of the second main role that is supported by the GDSE, namely the workshop mode.

5. Workshop Mode

This chapter describes the GDSE steps, and respective sections, as programmed in the workshop mode. The GDSE workshop mode is used to allow workshop participants to interact with the GDSE modules as a PULL workshop is held. To facilitate group work, the design of all steps and sections in workshop mode is optimised for use on touch-enabled computers and supports a variety of touch gestures. While the workshop mode shows the same five GDSE steps as the setup mode (Study Area, Status Quo, Targets, Strategy, Conclusions), the sections under each step of the workshop mode are in some cases different. The rationale is that a small group participating in a workshop logs in with its unique username to the GDSE and has access only to the workshop mode and in this mode, to steps Study Area, Status Quo, TArgets, and Strategy. PULL team members, after logging in to the GDSE, have access to all GDSE steps in the setup mode to prepare the workshop, and to the workshop mode to test and preview the preparations, as well as to be able to run the last GDSE step 'Conclusions'.

5.1. Study Area

This step features the same four sections as in the setup mode (Maps, Charts, Stakeholders, Key flows). All maps, charts, a list of stakeholders, and a list of key flows, which have been prepared using the GDSE setup mode, are now available in the workshop mode to participants for viewing and discussion. Workshop participants are not allowed to add any new features within all these sections. Just as in the setup mode, the side menu displays the sections of a GDSE step, and after selecting a section, the side menu shrinks to an icon-only view.

Figure 71 shows an example screenshot of the Maps section as it appears in the workshop mode. This section is essentially an interactive web map viewer with layer groups (map categories) and web layers. Workshop participants can toggle maps and corresponding layers on and off. Legend items will appear accordingly. Participants can also change the transparency level of a map layer (see Figure 71, under map layer "AFH17.7_Inmigrant_pop_NWO" in order to combine layers into a map. Map layers inside a map category can be reordered via drag-and-drop gestures. On the top right corner of the map space there is a button  that users can press to display a maximised version of the map viewer.

The second section, Charts, allows workshop participants to display and review information pertinent to the PULL case study; for example, results generated previously in workshops in the PULL process. The charts can be grouped in categories and can contain pictures, diagrams, schemes used in the PULL up to the workshop. Figure 72 shows an example of how charts, which were prepared in the setup mode, are available to workshop participants. Charts can also be maximised by clicking on a chart image on the right panel.

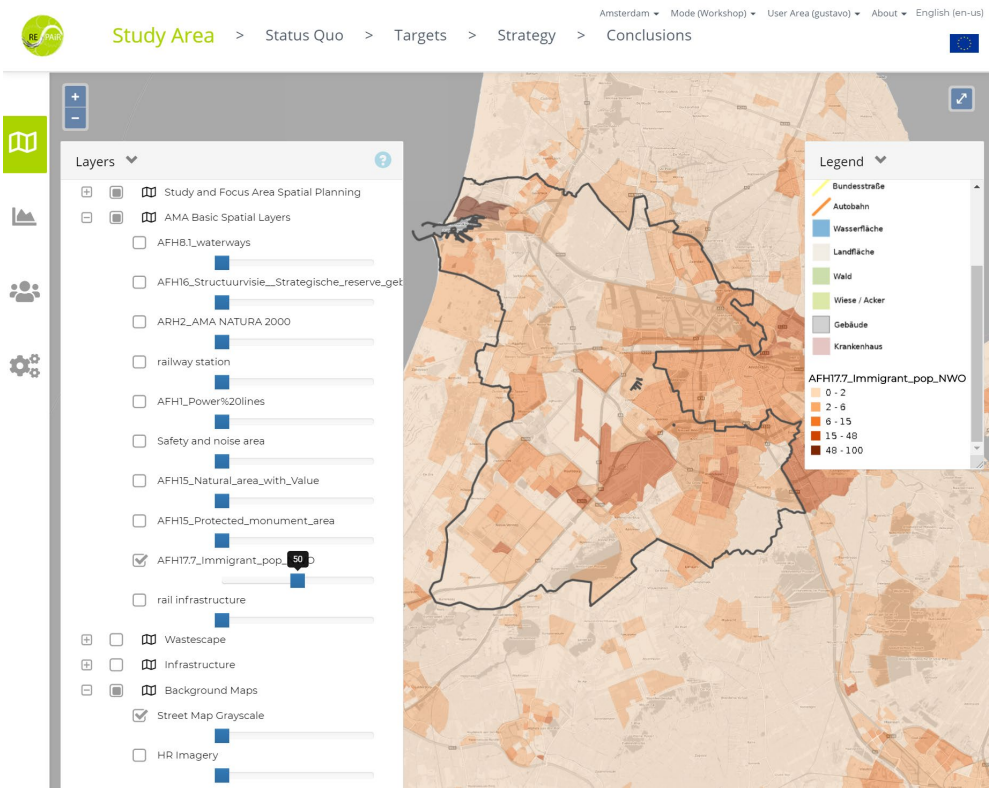


Figure 71. Study Area step. Maps section. Layers panel (left) contains map categories and underlying map layers. Legend panel (right) updates symbology of layers that are switched on only. Below each layer there is a transparency control (workshop mode).

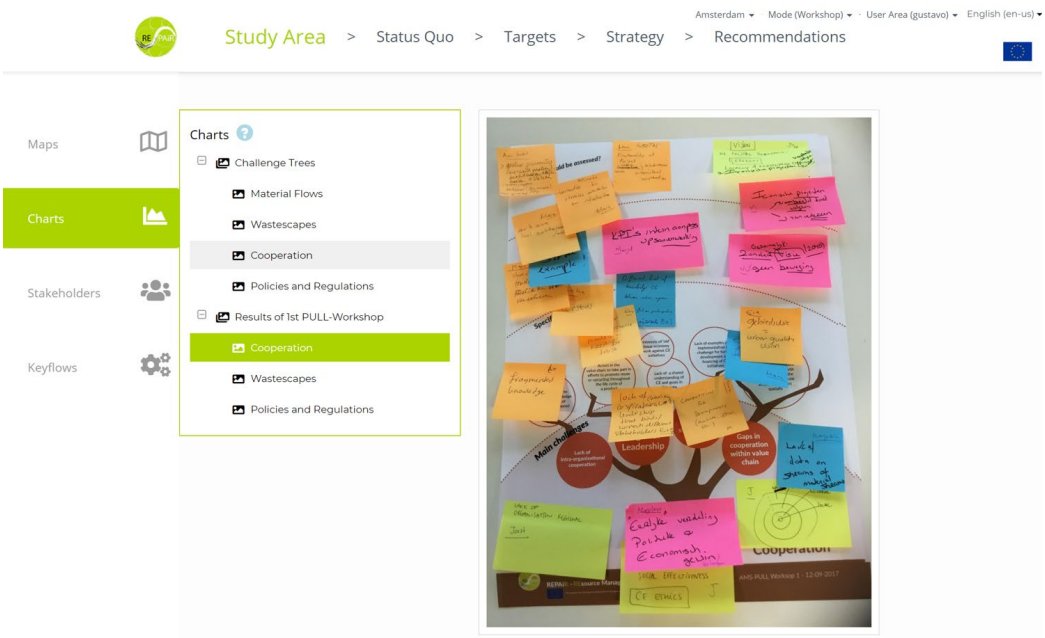


Figure 72: Charts in workshop mode. Example chart names are displayed per category (left panel) and upon click visible on the right panel. In this example, an image of a challenge tree as one example of workshop outcome being available in the GDSE for subsequent workshops.

The third section, Stakeholders, shows the stakeholders that were entered previously in the setup mode. Stakeholders are grouped by categories (see Figure

73). New stakeholders cannot be added in workshop mode. The fourth section, Key Flows, shows the key flows as both text and images (see Figure 74).

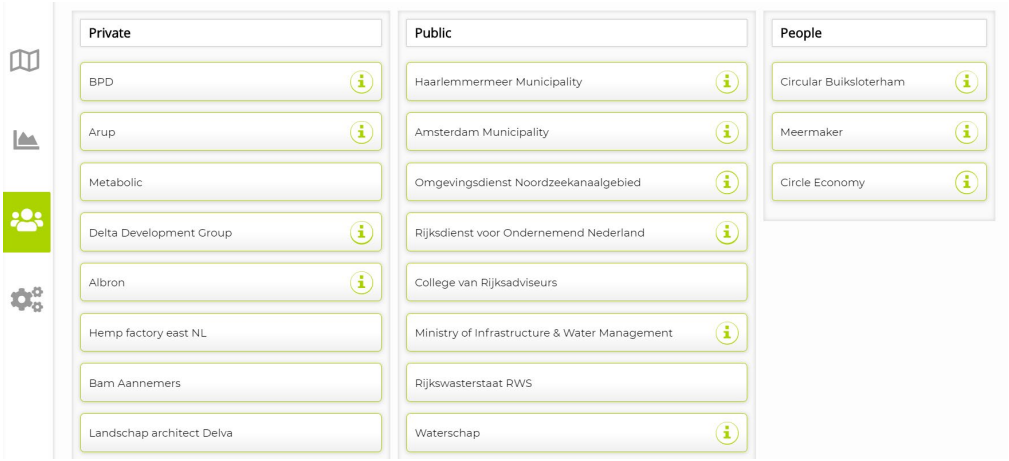


Figure 73. Stakeholder section in workshop mode.

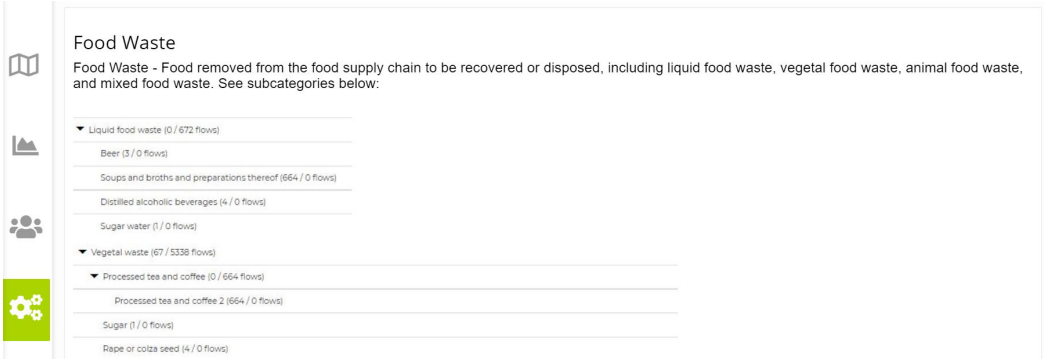


Figure 74. Key Flows section in workshop mode.

5.2. Status Quo

This step contains the same four sections as displayed in the setup mode, namely Flows, Flow Assessment, Wastescapes, Sustainability, Objectives.

Flows

Workshop participants use this section to explore the "flow views" created in the setup mode by the PULL team. For each flow, one or more flow views are available to workshop participants. First, a key flow is selected via the "Key Flow" drop-down menu, then the views available for this key flow become available via the "View" drop-down menu. Once a flow view is selected, the display level of this view can be selected via the "Level" drop-down menu. A flow view shows flows in two interconnected panels, as an interactive Sankey diagram, and in a flow map. Specific flows can be selected in the Sankey diagram on the left panel and visualised in their spatial context on the map on the right panel (see Figure 75). Workshop participants are not allowed to create new flow views in this mode.

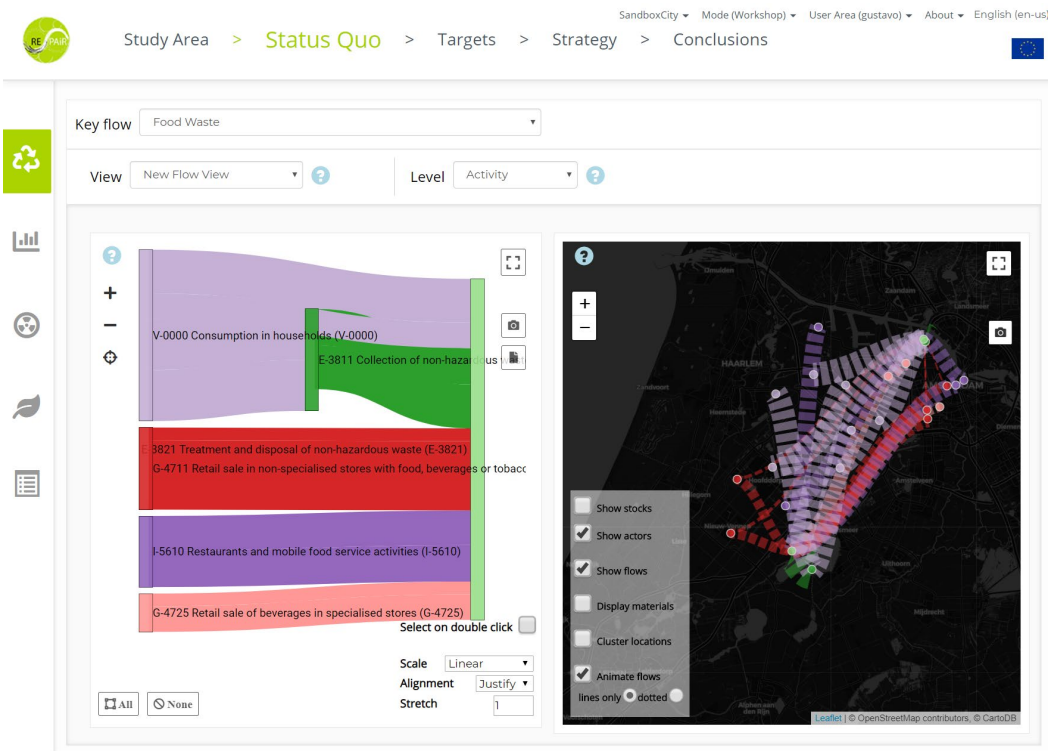


Figure 75. Status Quo step, Flows section. Flow visualisation in the workshop. Example of an interactive flow view showing flows, color-coded by activities involved, in a Sankey diagram (left panel), and between actors in a flow map (right panel).

Just as in the setup mode, the workshop mode allows workshop participants to select and display flow views, filtered and color-coded on the basis of:

- Activity group level aggregation
- Activity level aggregation
- Actors level (no aggregation)

Likewise, the workshop mode allows participants to hover the mouse over a flow, either on the Sankey diagram or on the flow map, in order to enable a floating window showing flow information, namely origin and destination, flow amount, process type, and material composition. Selected flows in the Sankey diagram will appear in the flow map. It is possible to display all flows included in the flow view, or to clear the selection of flows. This is done, respectively, by means of the buttons All and None, which are located in the Sankey diagram, on the bottom left corner.

Flow Assessment

This section allows workshop participants to view the flow indicator maps that were prepared in the setup mode. Flows are assessed using absolute or ratio type of indicators allowing participants to better compare flows originating or ending in different administrative units in relation to their area, the number of inhabitants or other flows with the same origin or destination(see Figure 76).

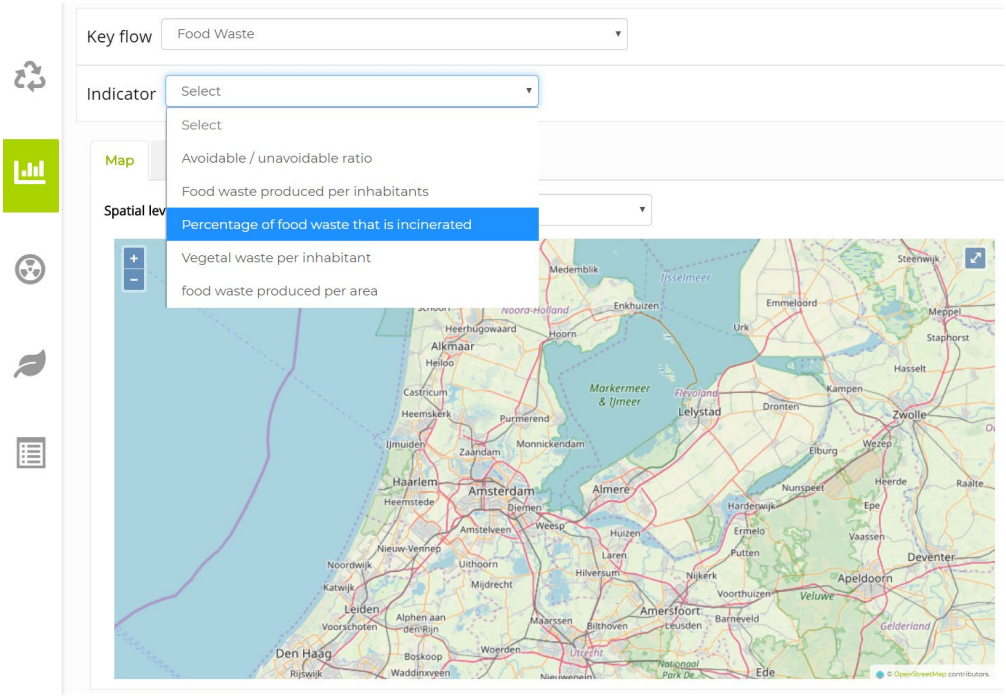


Figure 76. Flow assessment. Selecting from available flow indicators in workshop mode.

After selecting a flow indicator, it is possible to view this indicator on the basis of a particular spatial level by choosing from the available list of the administrative units that are different for each case study. For example, a workshop participant might be interested in viewing the percentage of food waste that is incinerated in all municipalities in the PULL study area (see Figure 77).

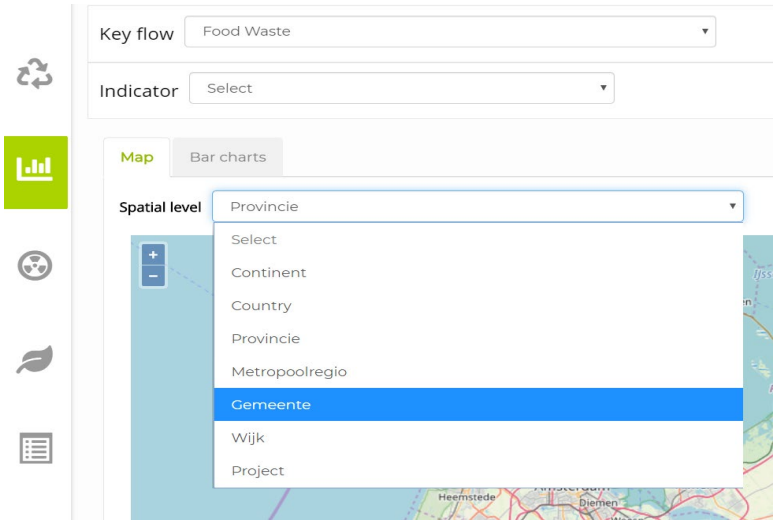


Figure 77. Flow assessment. Selecting 'Gemeente' (English: municipality) as the spatial level for displaying a flow indicator on a map.

The result is an interactive choropleth map portraying the aforementioned percentage for all municipalities, which can be retrieved via a 'mouse hover' functionality, as indicated in Figure 78.

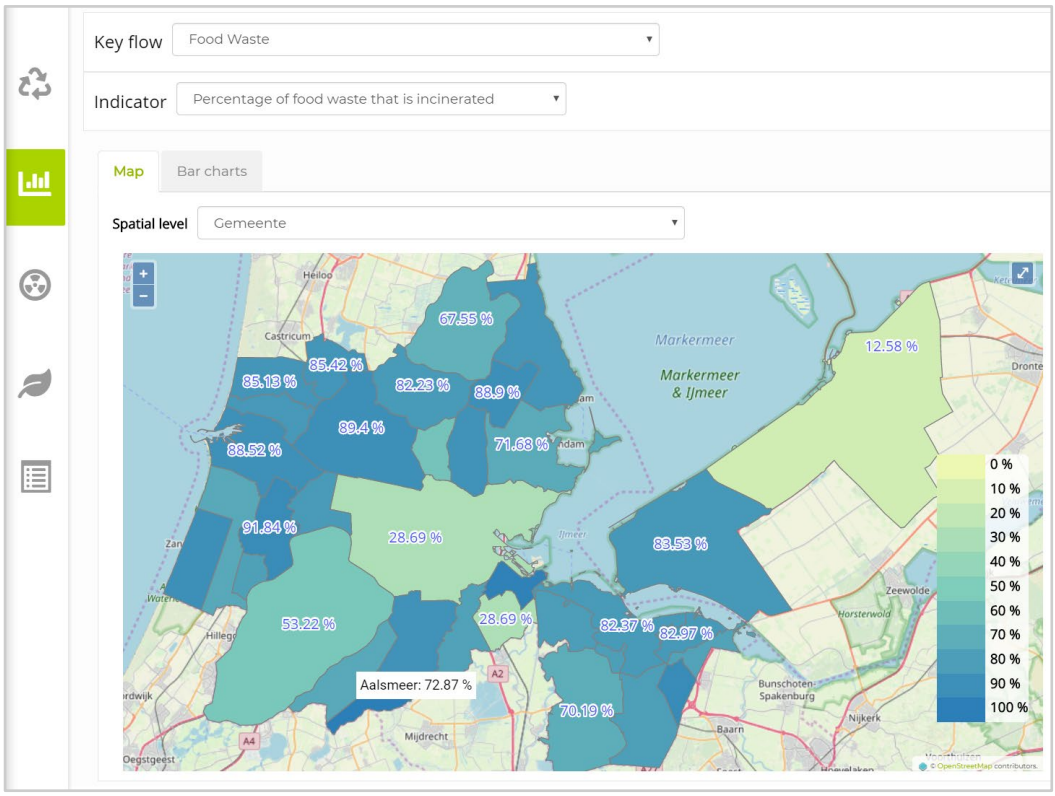


Figure 78. Flow assessment section (workshop mode). Indicator 'Percentage of food waste that is incinerated' is mapped for all municipalities in the AMA PULL study area.

Indicators can also be aggregated to a total figure for a particular spatial level (see Figure 79) and this way compared with each other. This is done via the tab "Bar charts" of this section. 'For example, workshop participants can create a bar chart that shows indicators for a selection of municipalities.

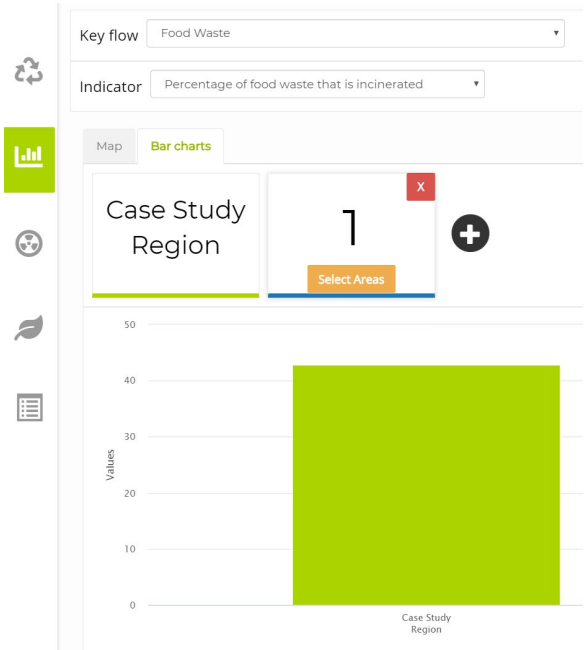


Figure 79. Flow assessment indicators shown in bar charts.

Wastescapes

This section contains the maps depicting wastescapes, which were prepared and configured in the setup mode as map categories containing map layers. Workshop participants can view these maps on request (see Figure 80).

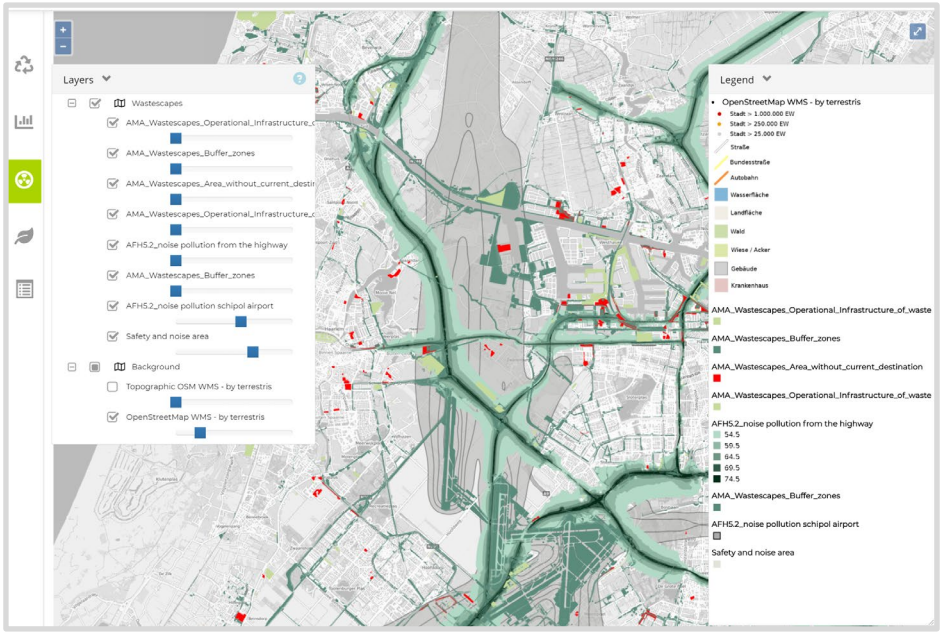


Figure 80. Section Wastecapes (workshop mode).

Sustainability

In this section, workshop participants can retrieve and view the sustainability assessment report for the status quo of a PULL study area, which has been prepared in consultation with WP4 (see Figure 81).

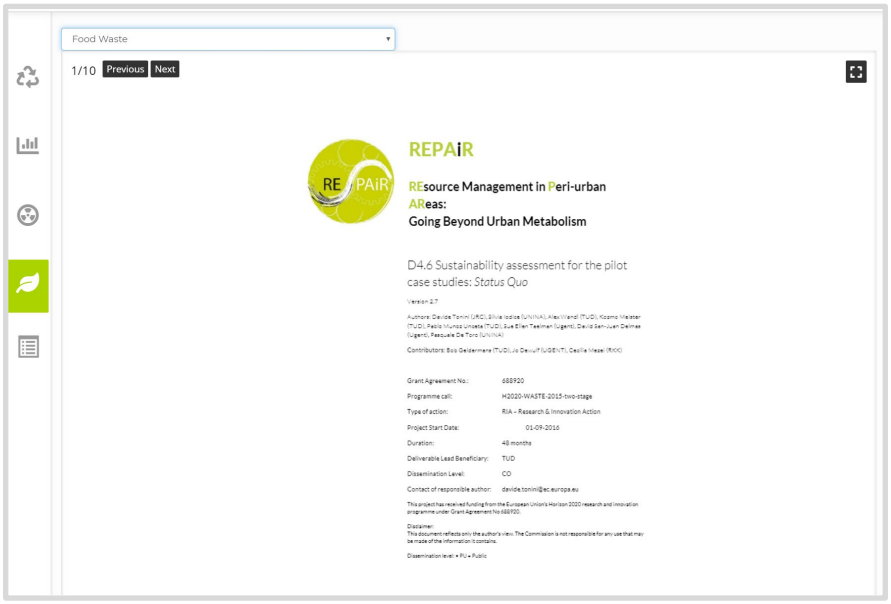


Figure 81. Retrieving a sustainability assessment report for the status quo of a PULL study area.

In this section workshop participants retrieve and discuss both the CE challenges and the CE objectives formulated by PULL stakeholders for each key flow that is relevant to the PULL area. Figure 82 shows a GDSE screenshot of how the section shows the objectives, which were uploaded in the setup mode by PULL workshop organisers, as boxes categorised by key flow.

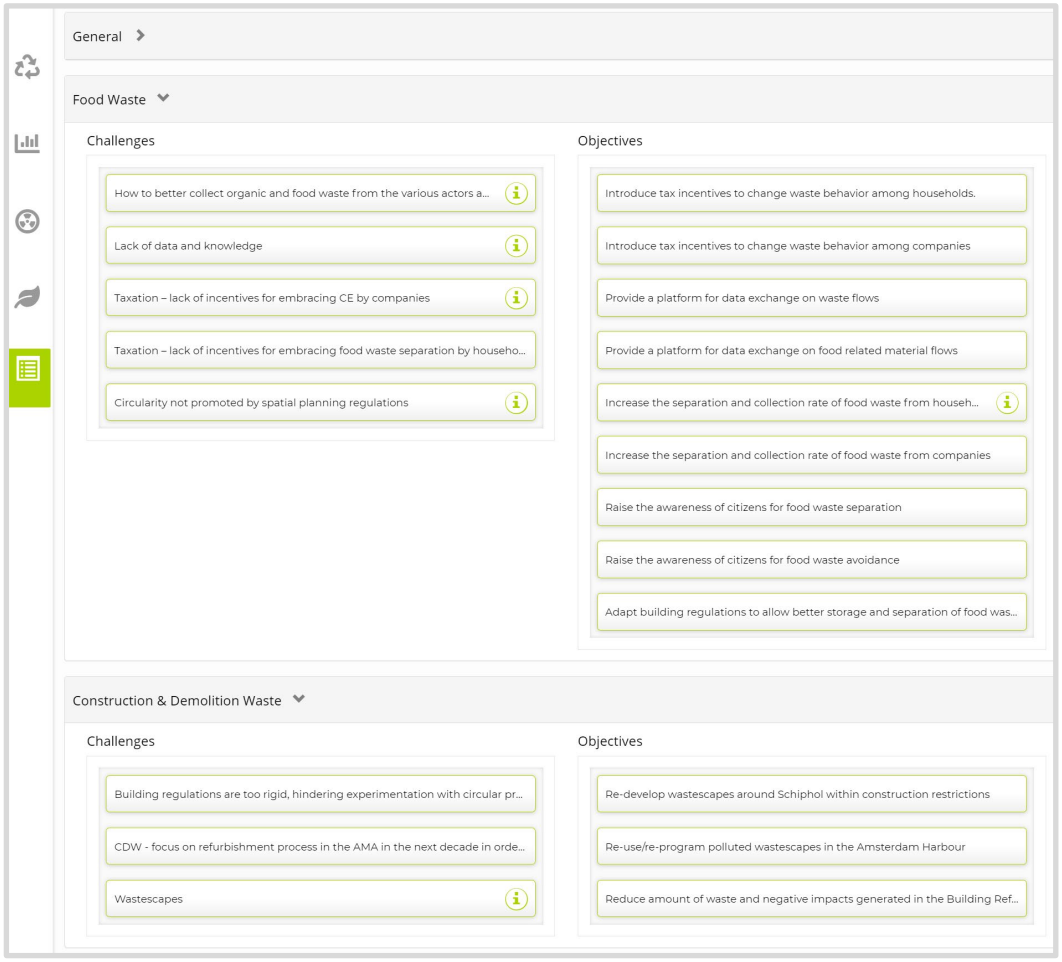


Figure 82. Section "Objectives" showing CE challenges and objectives per key flow.

Workshop participants can explore details of particular objectives by clicking on one box containing the objective. Figure 83 shows one example of a particular general objective as its details are retrieved.

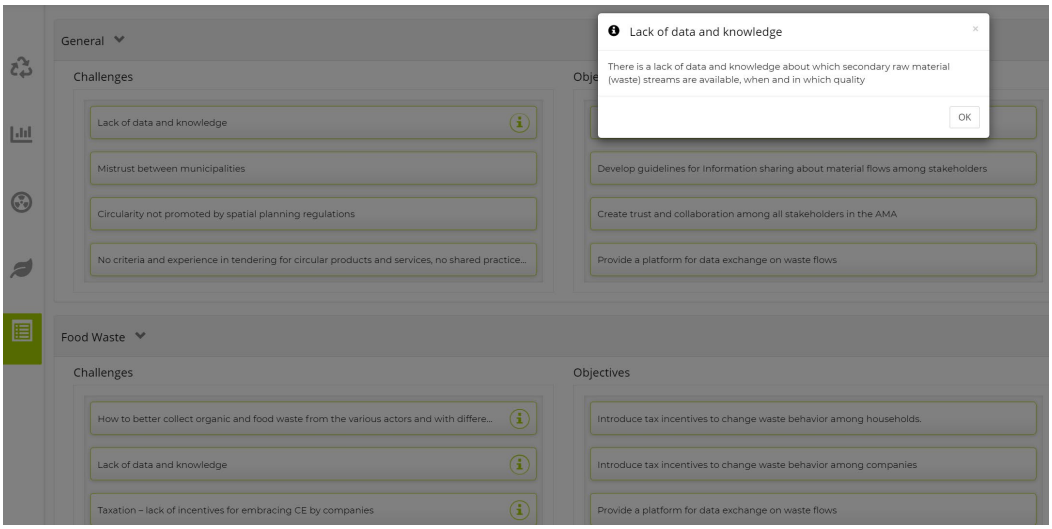


Figure 83. Retrieving details on a particular key flow objective (workshop mode).

5.3. Targets

This GDSE step is used by workshop participants of **particular small groups** to rank CE objectives and link them to targets. Prior to the workshop, the PULL team has created the credentials (username, password) for each small group participating in the workshop. The ranking is done for each individual key flow. Therefore, a key flow must first be selected, as shown in Figure 84.

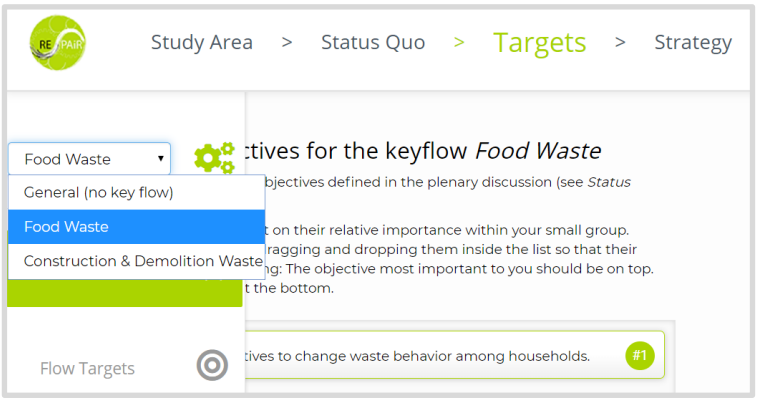


Figure 84. GDSE step Targets: Selecting a key flow.

Ranking Objectives

Once a key flow is selected, **small group members** use the next screen 'Ranking Objectives' for discussing and ranking the CE objectives defined earlier. Participants first decide collectively how to rank the list of CE objectives. To rank one objective, participants touch, hold and drag the objective box, the box becomes green, and then drop it where desired. This is done for all the listed objectives. The ranking is completed when the circles in front all objectives are colored green (see Figure 85). The Reset button clears all rankings.

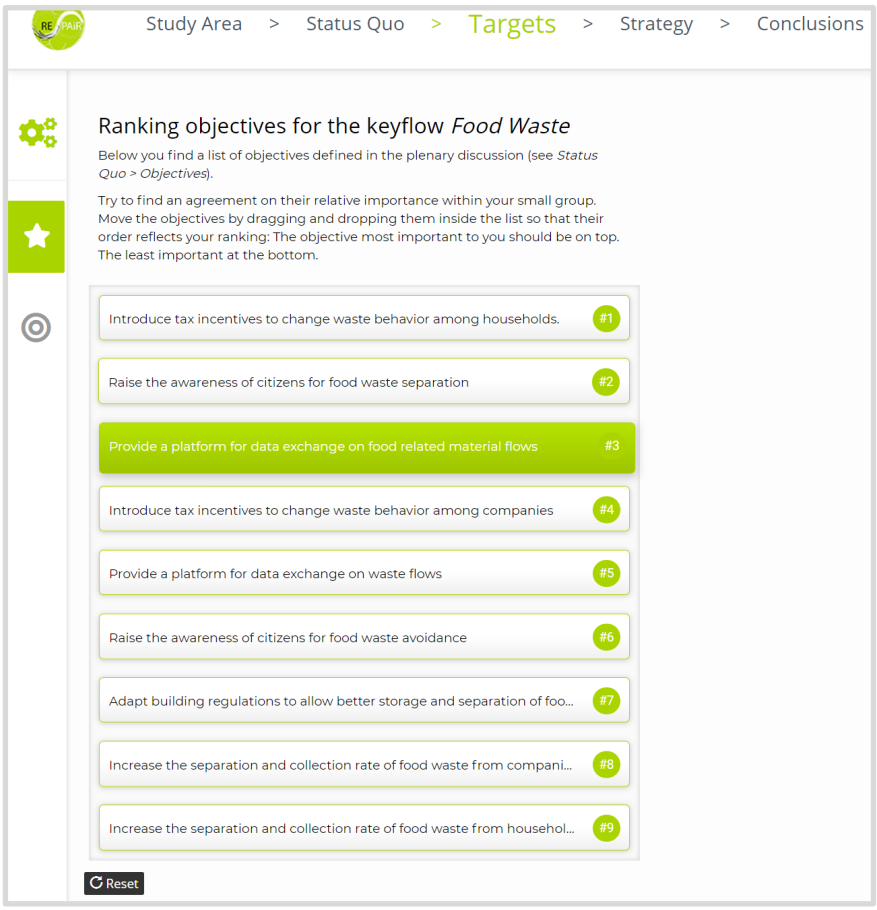


Figure 85. Ranking CE objectives. Example showing GDSE screnthostof

Flow Targets

Via this screen a small group can link indicator targets with the CE objectives they have just ranked. By clicking on a particular objective, it expands into a form with drop-down menus to select an indicator, spatial reference, and the actual target, which is expressed as a percentage for increase or decrease of the indicator value. Figure 86 shows an example screenshots of this form.

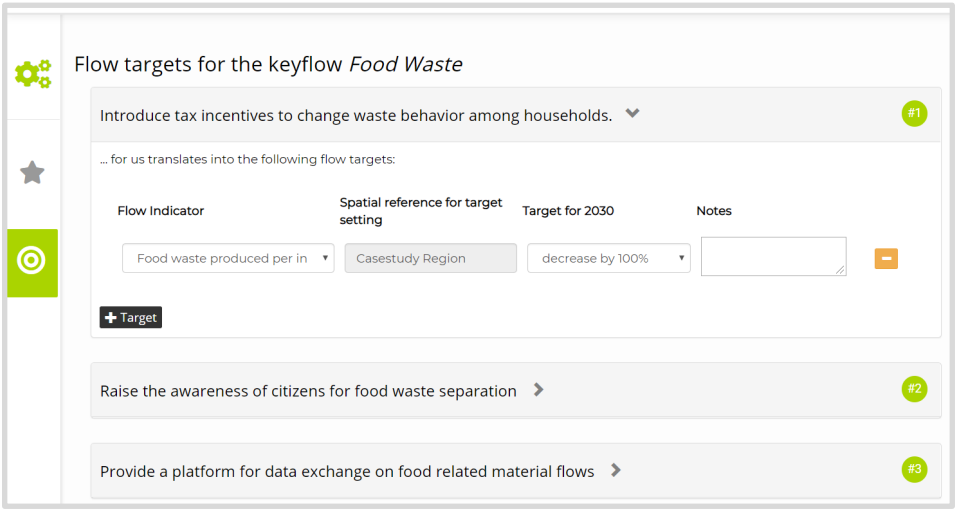


Figure 86. Setting one flow indicator value as a target for a CE objective.

5.4. Strategy

This GDSE step of the workshop mode is used to facilitate the co-development of deals with eco-innovative strategies by individual small groups. The strategies correspond to one particular key flow. Therefore, participants must first select a key flow. Four screens comprise this step: Solutions, Define Strategy, Modified Flows, and Flow Target Control (see Figure 87).

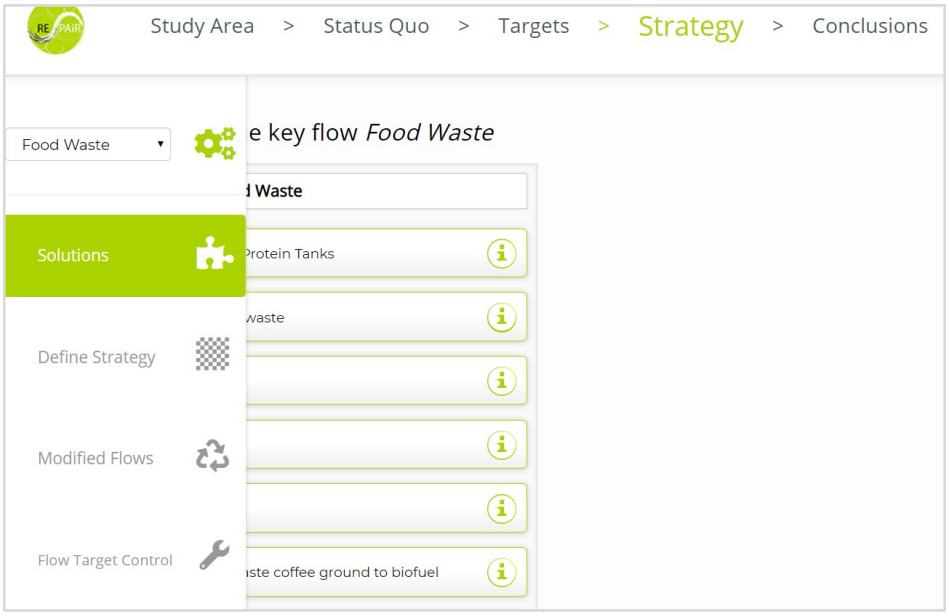


Figure 87. screens of the GDSE step 'Strategy' in workshop mode.

Solutions

The first screen is used by the workshop leaders to present all solutions available for each key flro the workshop. Figure 88 shows a GDSE screenshot of this list.

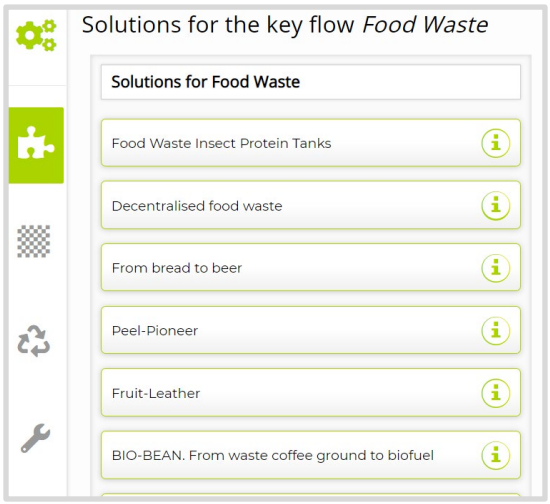


Figure 88. Example screenshot of screen Solutions, workshop mode.

Workshop participants get acquainted with all solutions available. Clicking one solution box on this list will open a pop-up window with information on the specific

solutions presented in two tabs: *Description*, which shows text about the selected solution (Figure 89) and *CE diagrams*, which shows a scheme for the current process (status quo) and the proposed process, after implementing the solutions (Figure 90).

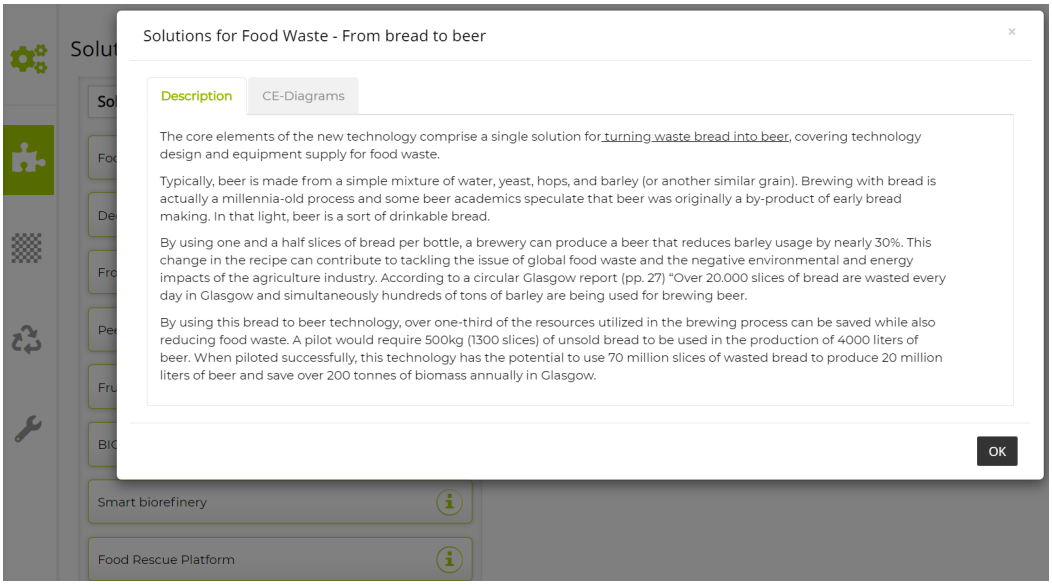


Figure 89. Example screenshot showing Description tab of a solution.

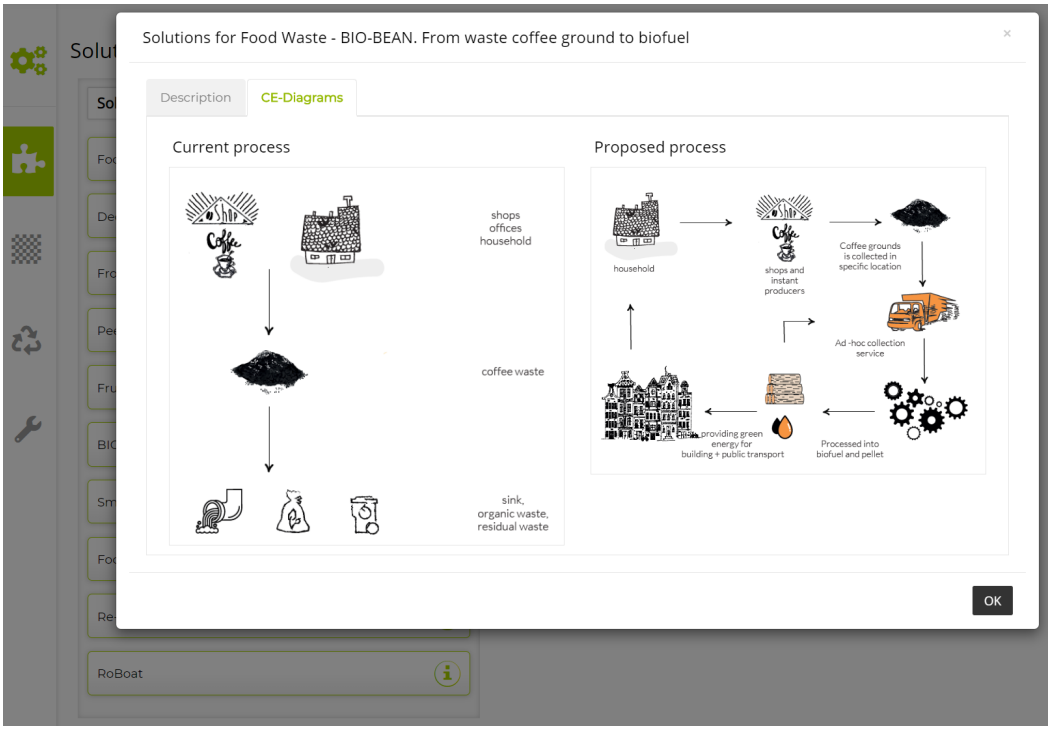


Figure 90. Example screenshot showing CE Diagrams tab for one solution, as follows: Current process (left), Proposed process (right).

Define Strategy

This section is used by each small group individually, under supervision of workshop leaders. Prior to the workshop, the PULL team has created the credentials (username, password) in the GDSE for each small group participating in the workshop. Via this section, workshop small groups can define their eco-innovative strategies. An GDSE-compatible eco-innovative strategy consists of locations of implementations for one or more selected eco-innovative solutions.

Members of a small group must first select a solution, then specify stakeholders to be involved in the solution, and finally specify the implementation location(s) for this solution. This procedure is repeated for additional solutions until the participants are finished co-developing their full strategy. A strategy is meant to be developed to address one key flow (see Figure 91).

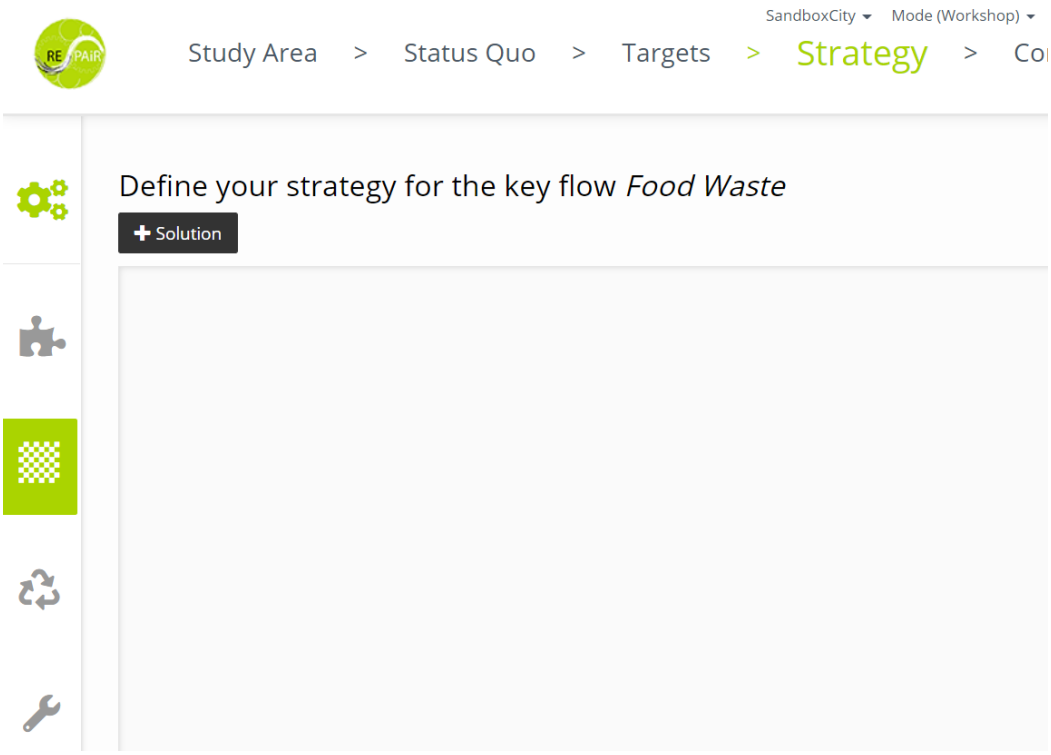


Figure 91. Screen 'Define Strategy', workshop mode.

To select a solution, click on + Solution. A drop-down list with available solutions will appear (see Figure 92). A solution is picked. It appears now within one container, ready to be configured. Figure 93 shows a screenshot with two containers holding solutions for one strategy for *Food Waste* key flow. Clicking **OK** will add the solution but without implementation locations and descriptions. This needs to be specified for the solution to be correctly incorporated in the strategy and the further calculations of its impacts. At the top right corner is the button **'Calculate'**, which is used to start the flow assessment calculation for the small gorup's trategy, once all implementations are drawn and confirmed.

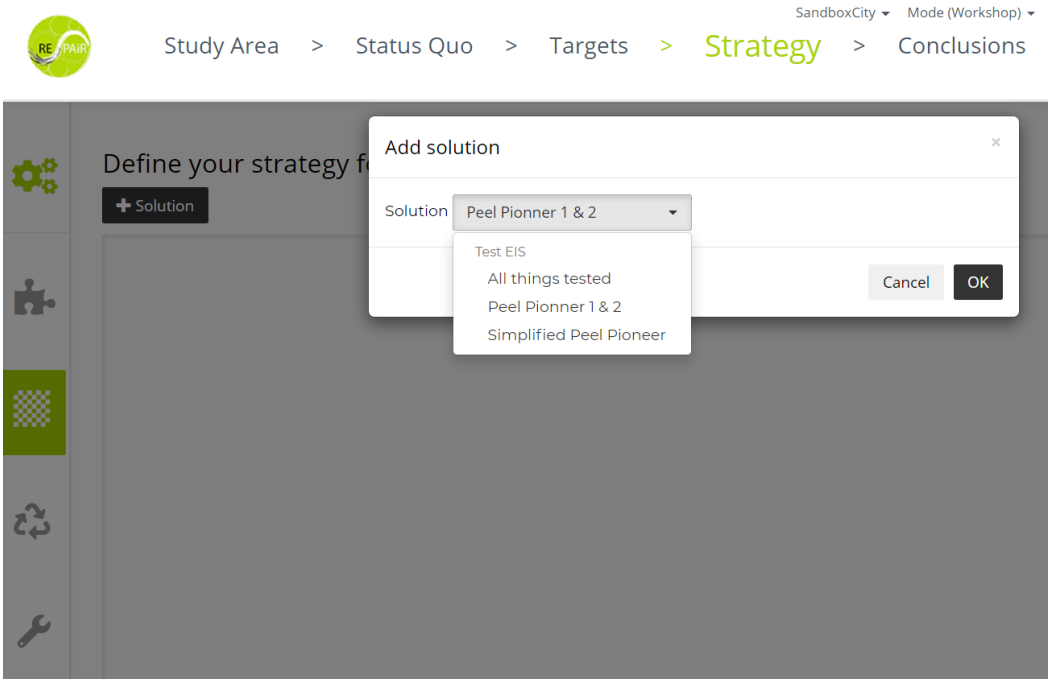


Figure 92. Choosing from available solutions, workshop mode.

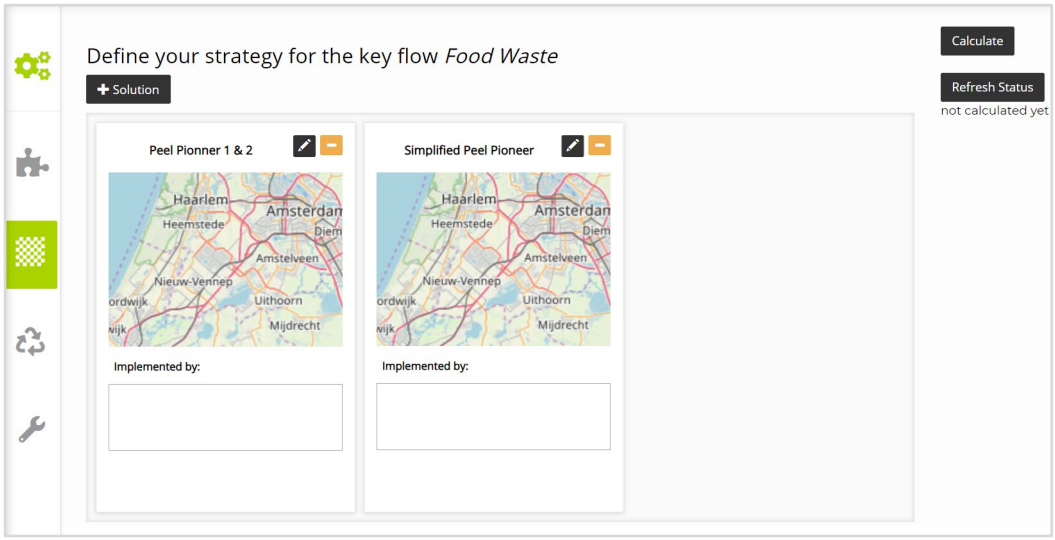


Figure 93. Example of two containers, each holding the implementation of one solution.

To edit the implementation of the solution, click  . The 'Edit implementation' will open (see Figure 94). This window contains three tabs, namely *Implementation*, *Implementation Areas*, *Description*. Participants use each tab to configure the solution implementation. Figure 94 shows the first tab, through which participants can pick stakeholders to involve in the solution implementation. Participants can also add notes and remarks about the solution by typing on the textbox 'Personal Notes' on the right hand side of this tab.

Click **OK** will save changes, but the solution can be edited further via  .

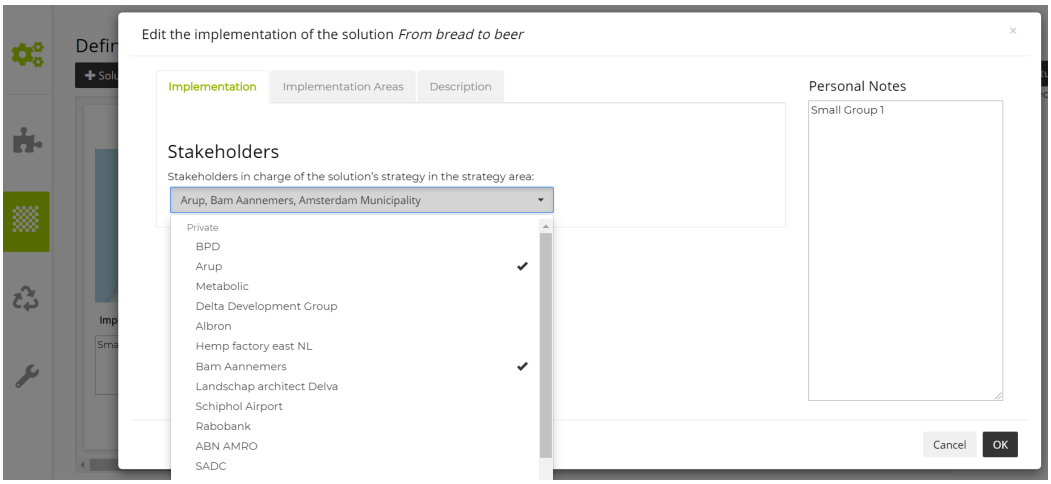


Figure 94. Edit Implementation of solution: for choosing stakeholders, workshop mode.

The second tab 'Implementation Areas' is used by the small group to draw areas of implementation of a selected solution in locations in the focus area. Figure 94 shows an example screenshot of this tab, which features an implementation question menu, a background layer-based web map, and a drawing toolbar.

The third tab 'Description' contains a text description of the solution and a textbox for the small group to type notes and remarks regarding that particular implementation of that solution.

Implementation question menu. Via a drop-down menu at the top right corner participants can select an *implementation question*, which was defined previously (Figure 61, Setup mode, Strategy). Figure 95 shows one example of one implementation question being selected to draw solution implementations.

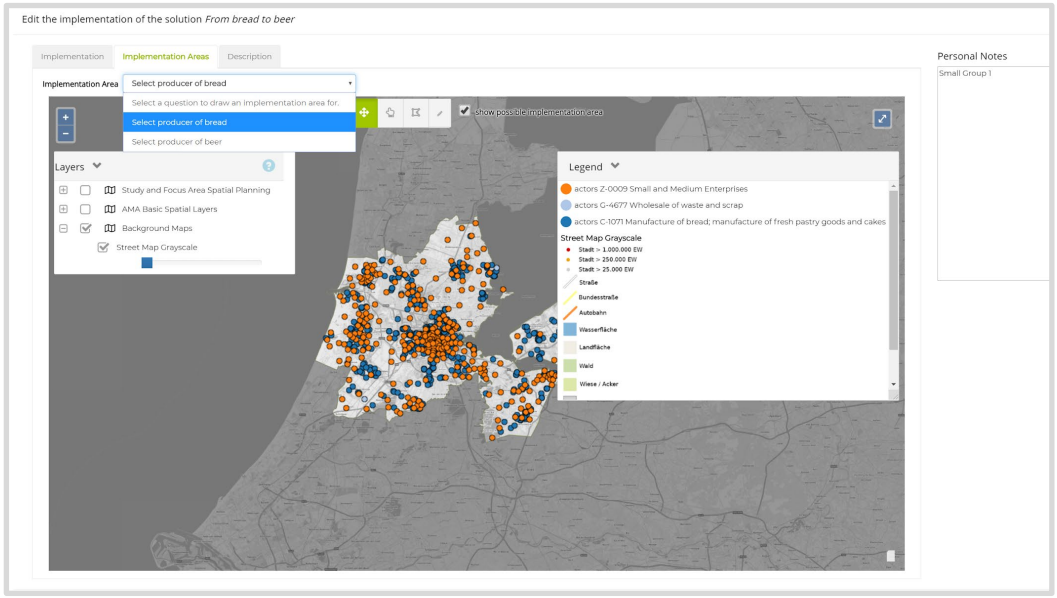
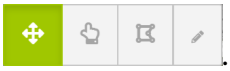


Figure 95. Edit Implementation of solution: drawing solution implementations.

Background web map. This web map contains the same layers that were prepared and loaded in setup mode, step 'Study Area', screen 'Maps'. All layers and legends

are available for small group members to support drawing their solution implementations. In addition to these layers, a map of actors that are relevant to the specific implementation question are also available in this map. For example, Figure 94 shows the web map for implementing the solution 'Bread to beer', which aims at producing beer using wasted bread as raw input, question 'Where are the producers of bread?'. A number of layers can be seen in the expandable legend on the left of the map, together with their respective legend items. In addition to these items, the legend box also features actors in the study area involved in the production of beer. These additional map layers were added in the 'implementation questions', setup mode of step Strategy.

Drawing toolbar. At the middle top of Figure 96 below, inside the map area, a toolbar containing four buttons can be seen:  . These buttons are used by small group members to draw their particular implementations. From left to right, the buttons are used for 1) Move map (panning), select drawn features, draw polygons (point by point), and draw polygons freehand. It is possible to draw multiple polygons for each implementation question.

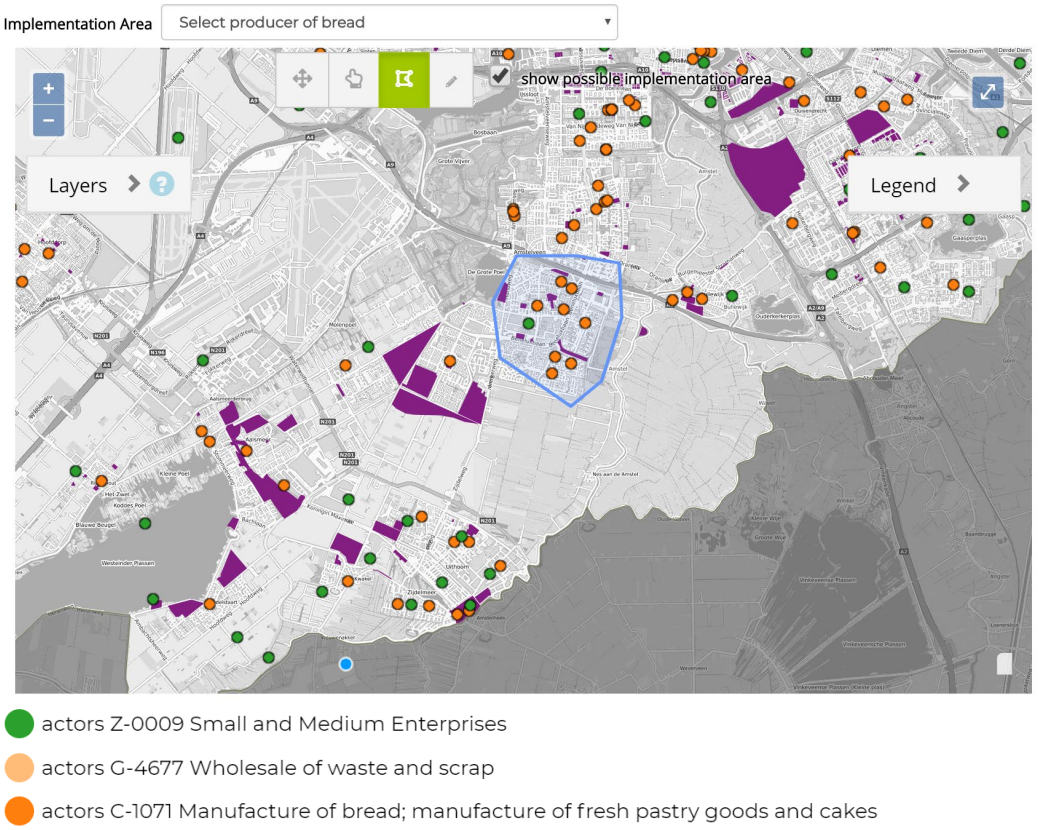


Figure 96. GDSE drawing toolbar. Example of drawn polygon (blue outline) to indicate an implementation area for solution 'Bread to Beer'. Three types of bread producers appear on the map, according to the implementation question (top).

Once the small group is finished drawing all implementations of all the solutions they chose, their eco-innovative strategy is ready to be assessed. The next step is

to click the Calculate button and start the flow impact assessment that determines the impact of this strategy on existing flows. This calculation features an algorithm that redistributes the flows in between the economic activities, keeping the overall mass balance of the affected flows consistent, and distributing the total surplus or shortfalls within an economic activity in between all the actors present in the drawn geographical area of implementation. In this way, the flow changes are reflected in the chosen indicators and their values can be compared with the targets that were set up earlier (Arciniegas et al., 2019). This calculation takes a few minutes, depending on the amount of actors that are captured within the implementation polygons.

Modified Flows

This screen is used to present a visual comparison between the waste flows of the status quo, and the strategy. Figure 97 shows a screenshot of this screen. There is a drop-down menu that allows users to view the flows of status quo, strategy, and their differential flow. This screen has similar functionalities to the screen Flows, GDSE step Status Quo, as flows are visualised on a Sankey diagram and on the flow map. What is different for this screen: via drop-down menus, a flow view and display level can be selected for rendering. Workshop participants can toggle between status quo and strategy to view the flow impacts of their strategy.

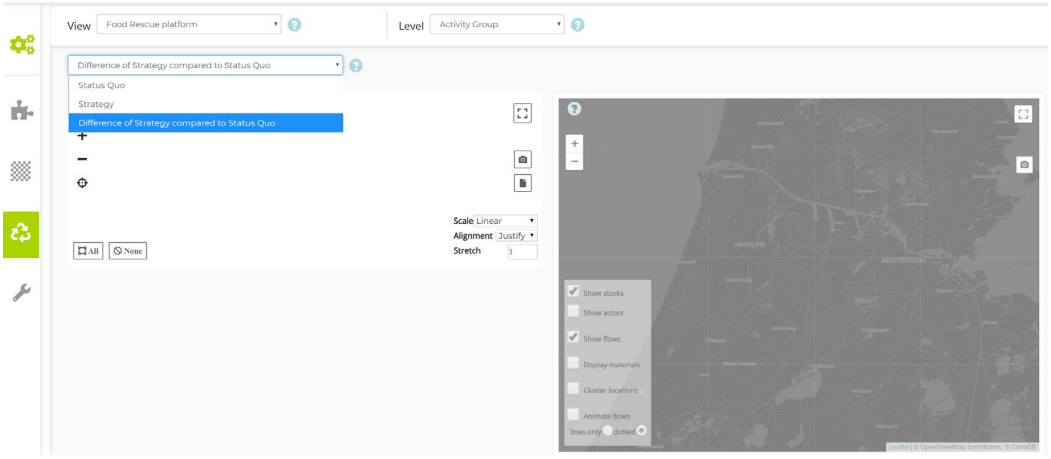


Figure 97. Screen 'Flow assessment'

Flow Target Control

This screen is to check whether the flow targets were met by the strategy developed by the small group, and if so, to what extent. There are two tabs: Target Control, and Indicator map. In the first tab, the ranked CE objectives are listed in boxes, and by clicking on one box, the results of this check are displayed. Figure 98 shows an example of this screen.

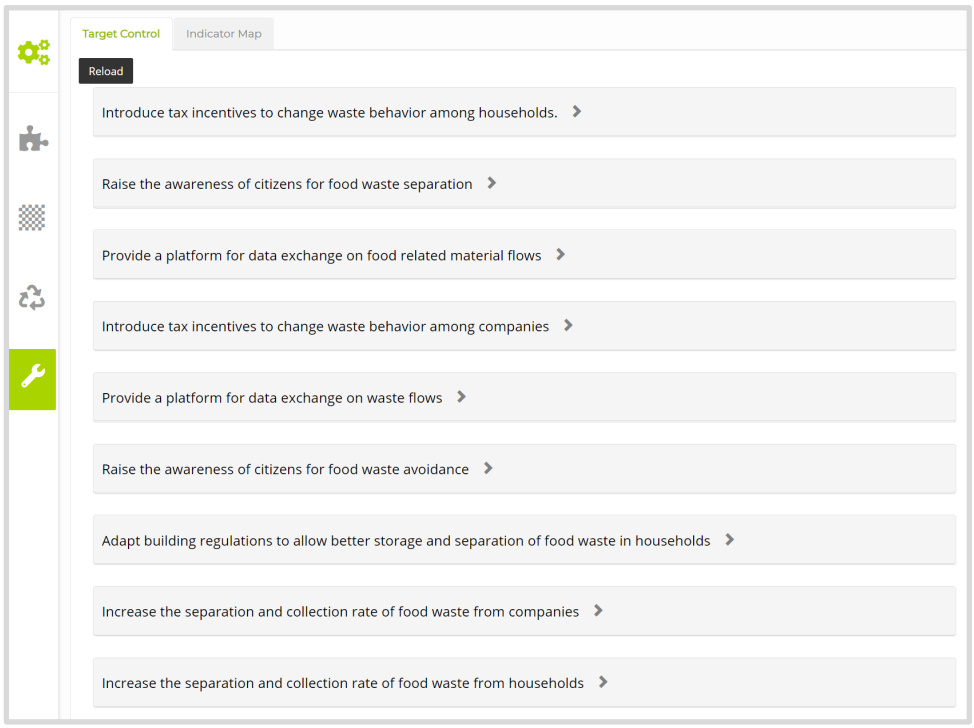


Figure 98. Flow Target Control. Tab 'Target Control'.

The tab 'Indicator map' has two sub-tabs. The first sub- tab 'Map' shows the flow assessment per spatial units in a map (see Figure 99). A drop-down menu allows users to select a flow indicator and display status quo, strategy, and difference maps. Spatial levels can also be selected, such as province, town, study area.

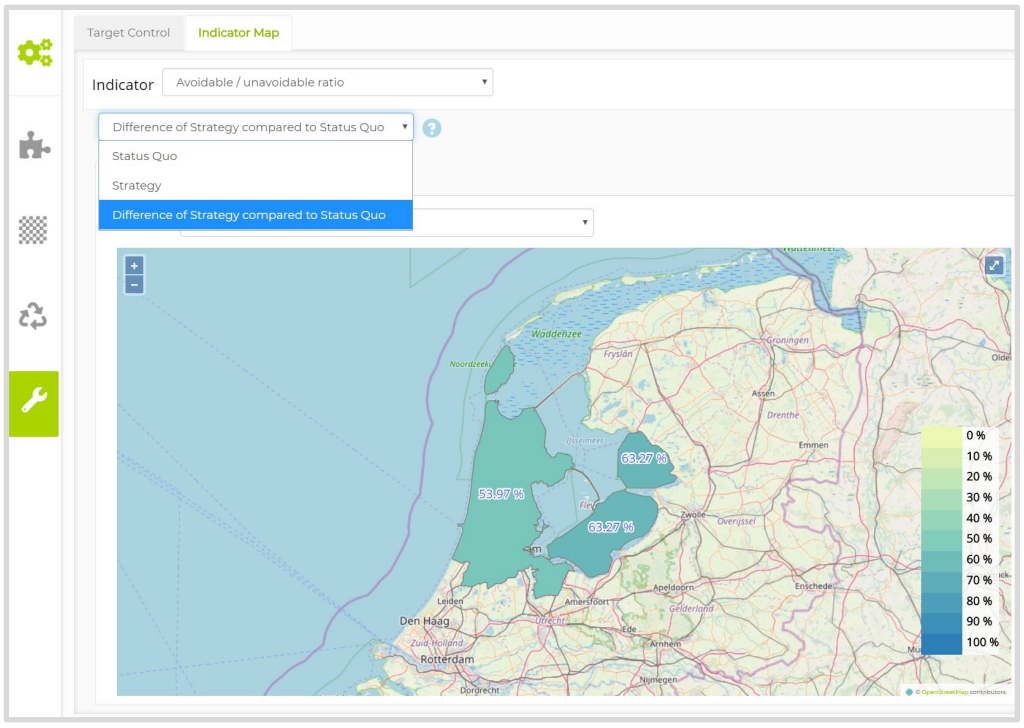


Figure 99. Flow Target Control. Tab Indicator Map'.

The second sub-tab shows the mapped values as aggregated values in a bar chart. Figure 100 shows a screenshot of this sub-tab.

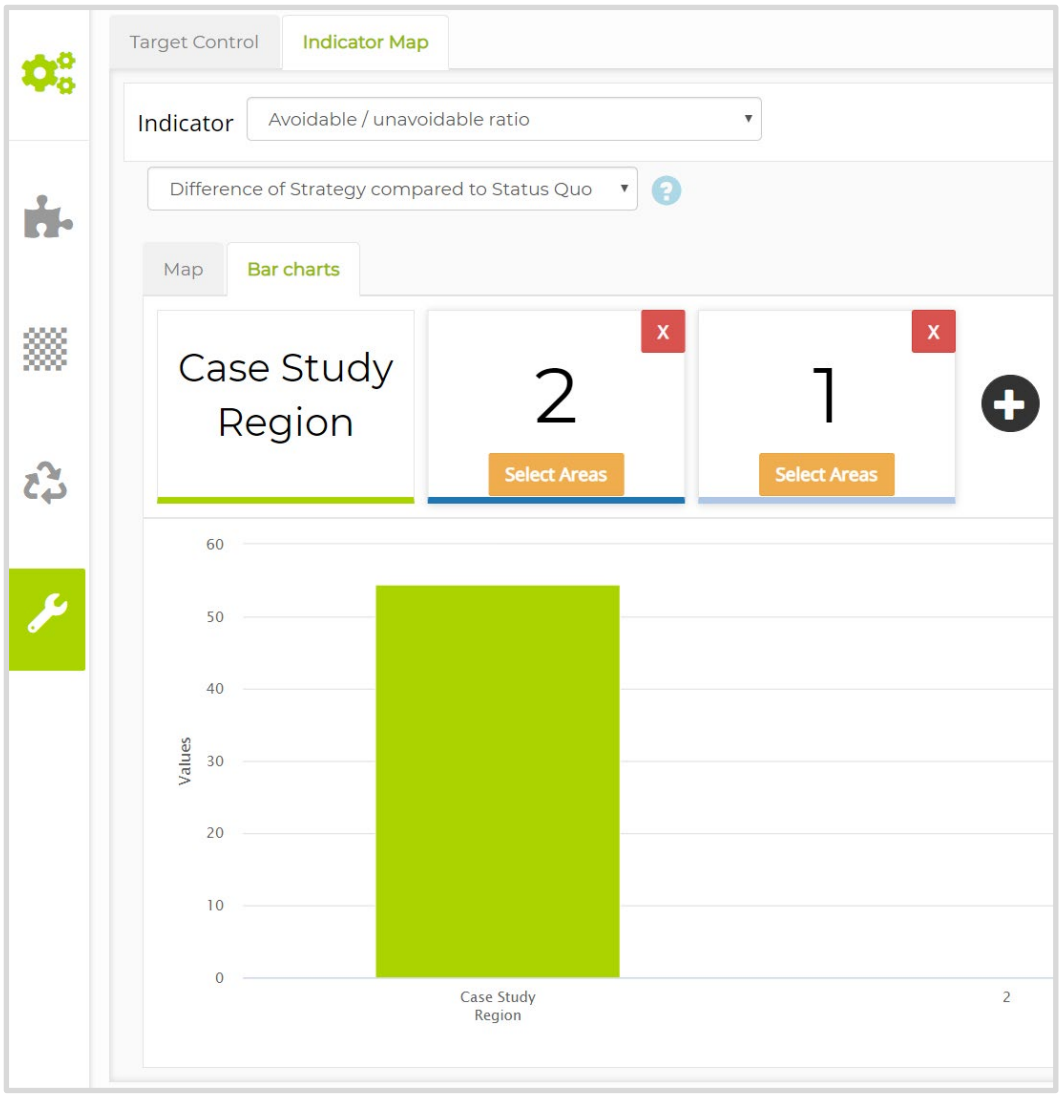


Figure 100. Flow Target Control. Sub-tab 'Bar Charts.'

5.5. Conclusions

In workshop mode, this GDSE step is meant to be run centrally by a PULL leader, with administrator rights and with access to the strategy-related work of all small groups, who must be logged in to the GDSE as administrator. This workshop part is done for each key flow. Figure 101 shows the start screen of the GDSE step Conclusions. It shows two side menus in icon-only view, namely the left hand side menu and the right hand side menu. Both these menus are available throughout the entire GDSE step Conclusion in workshop mode. Firstly, a key flow must be selected by clicking on the drop-down menu at the top of the left hand side menu.

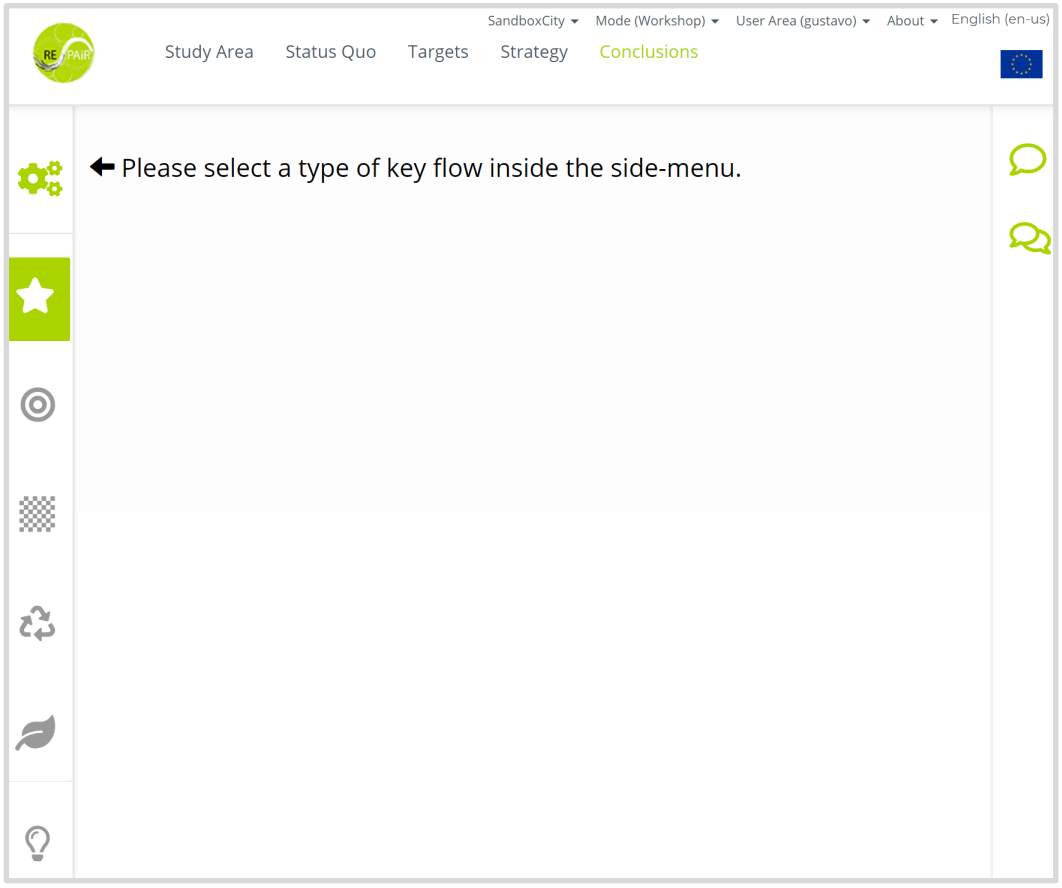


Figure 101. Screenshot of starting screen of GDSE step conclusions, workshop mode, showing both side menus at either side.

The icon-only menu on the right has two buttons: Add Conclusion and Manage Conclusion. This menu is used by PULL workshop leaders to add a new conclusion or manage/edit added/existing conclusions at any point of the Conclusions step. These conclusions are meant to summarise the work of the small groups, and are to be presented centrally at the final screen of this GDSE step. Upon clicking or mouse hovering on this icon-only side menu, it expands to reveal text in front of the two icons.

To add a conclusion, click on 'Add Conclusion' on the side medu. A form will be opened. Figure 102 shows an example of this form. Drop-down menus are used to select a section and a consensus level when entering the conclusions. Choices for both sections and consensus level have been previously defined in the setup mode, step Conclusions using the Notepad. The screenshots of the current point in the GDSE conclusions step can also be added to the conclusion by ticking the checkbox.

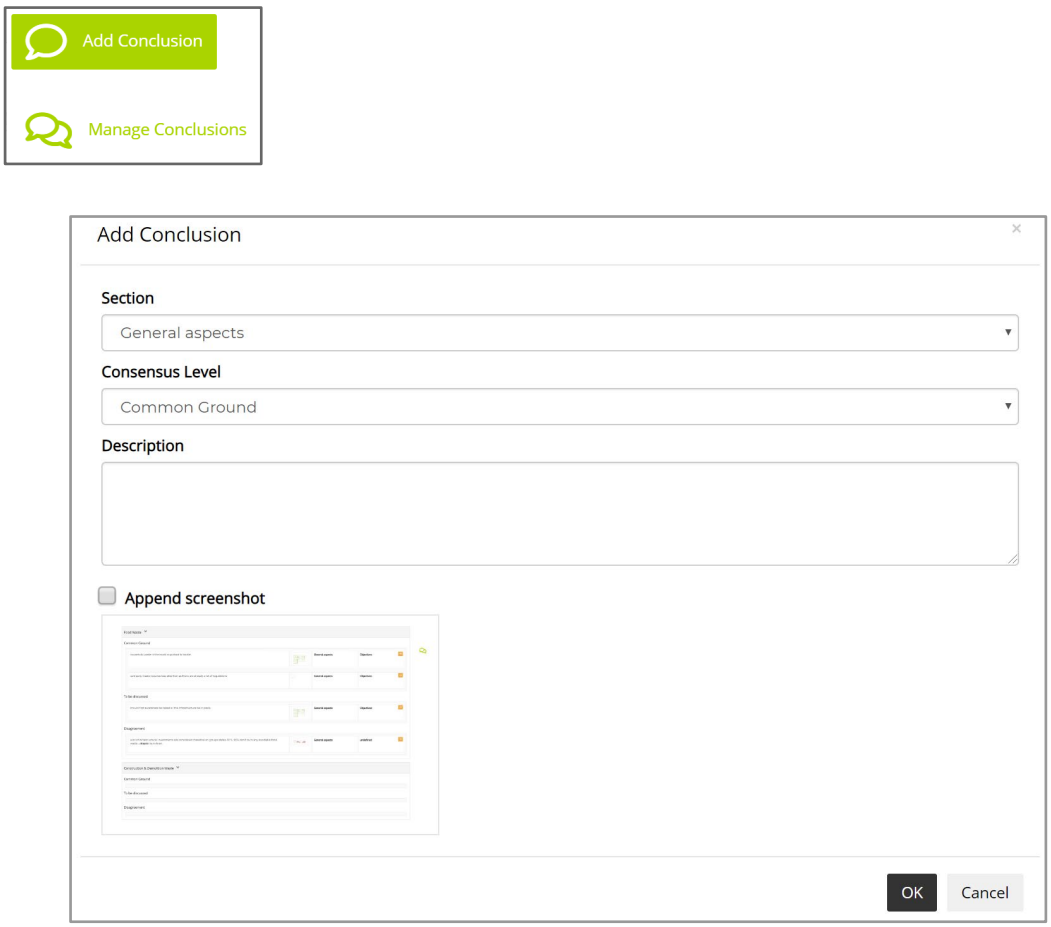


Figure 102. Adding a conclusion at any point of the GDSE step Conclusion. Screenshots of the chart in the current point can also be included.

Secondly, once a key flow is selected, the PULL workshop leader goes through each side section to present, compare and lead a discussion on the work of the small groups, in terms of Objectives, Flow Targets, Strategies, Modified Flows, Sustainability, and Conclusions. Figure 103 shows all the screens that are to be covered in this step of the workshop.

Each section contains one or more sub-steps that are to be followed in order to present and compare the strategies co-developed by the groups. The Conclusions step contains a total of nine sub-steps, which are provided as tabs. The right hand side menu will be always available at any point of these steps for the purpose of collecting conclusions whenever the PULL workshop leader sees fit, and in consultation with the workshop participants (i.e., the small groups).

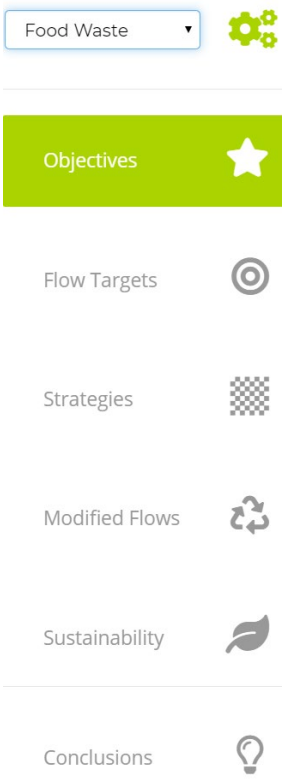


Figure 103. Screens of the GDSE step 'Conclusions' in workshop mode.

Objectives

By clicking this section, the work of the small groups is compared on the basis of the CE objectives relevant to one particular waste. This section includes one sub-step displayed in a tab. Figure 103 shows an example of this screen using data from the Amsterdam PULL case study. The ranking of the objectives appears on the right hand side. For each objective it is shown how each small group ranked this objective using a green color ramp that indicates the fraction of targets met, where dark green indicates a high ranking and light green a low ranking. For example, Figure 104 shows that the highest ranked CE objective was also ranked the most important by small group 'Governance 1'.

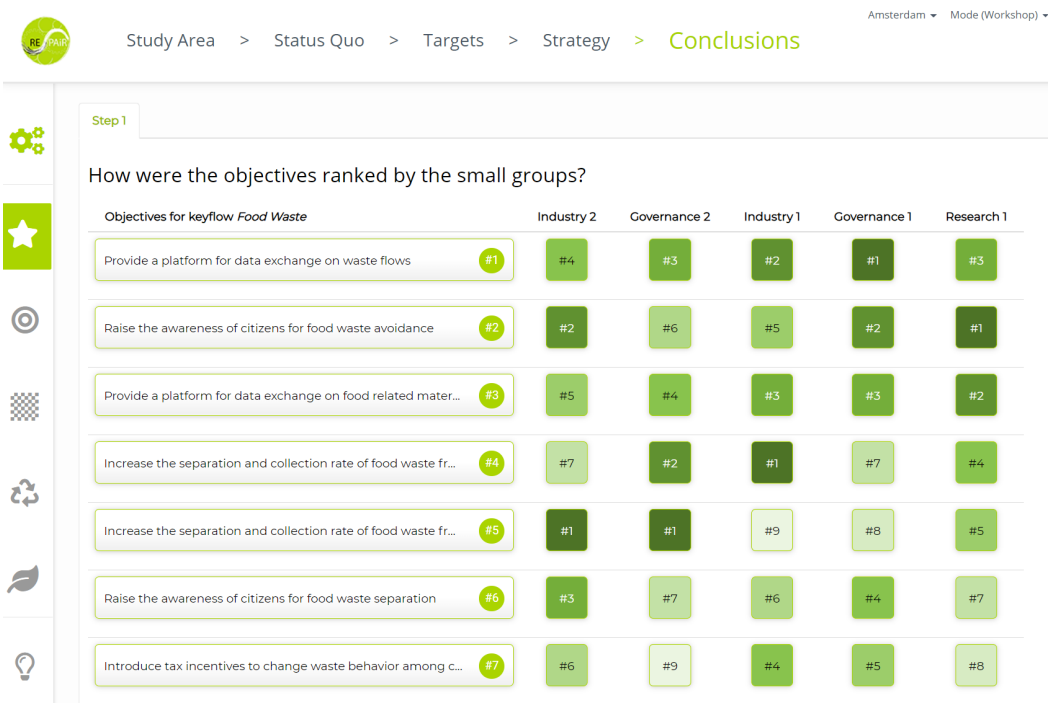


Figure 104. Example of GDSE step Conclusion, screen Objectives.

Flow Targets

In the next section 'Flow Targets', the PULL leader compares the work of small groups in terms of flow indicators. This section includes two sub-steps 2 and 3, displayed respectively as two tabs. The first sub-step shows which flow indicators were picked as targets by the small groups, for particular CE objectives. A green color ramp is used to denote how often an indicator was picked by the groups. Dark green indicates a high number of times, light green a low number. Figure 105 illustrates this step for four example CE objectives and five indicators.

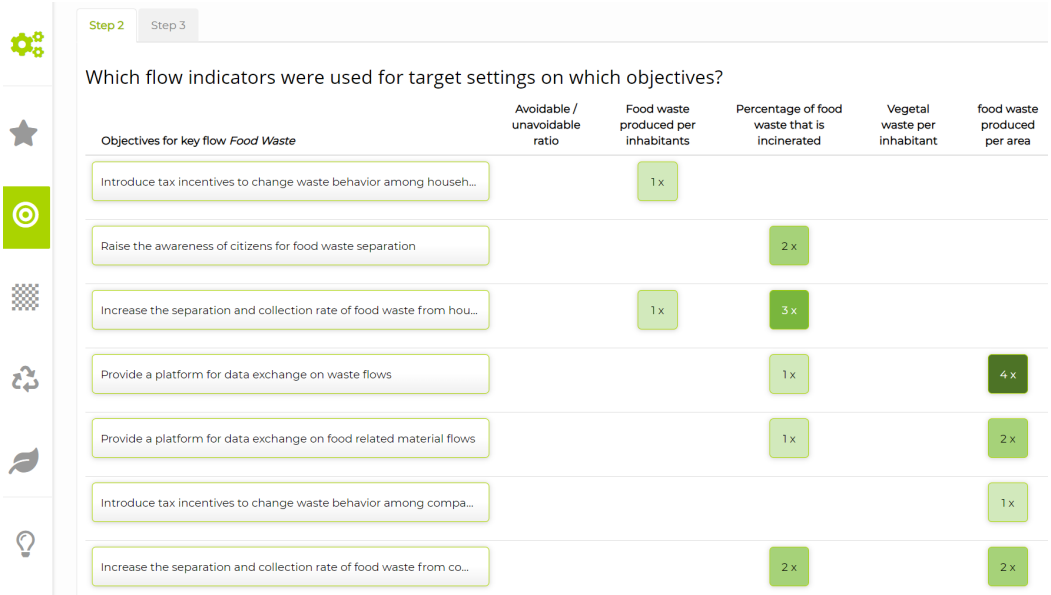


Figure 105. Example of section Flow Targets, sub-step 2.

The second tab is used by PULL workshop leaders to show how the target values were set by the small groups. For each small group, using a red color ramp it is shown whether an indicator target value is decreased (dark red) or increased (light red). Figure 106 shows an example of how this is visualised.

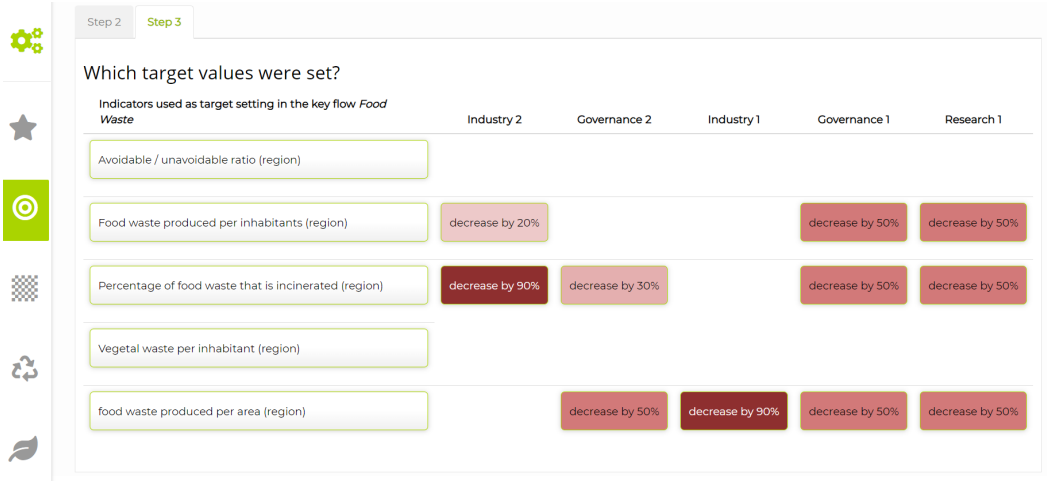


Figure 106. Example of section Flow Targets, sub-step 3.

The third screen 'Strategies' is used to present and compare the strategies developed by the small groups in four tabs. The first tab shows which specific solutions were selected by the small groups when co-developing their strategies. Figure 107 shows an example of this tab. The solutions are listed on the left hand side and ranked by usage, with specific solution parameter questions below each solution. Solutions at the top were picked the most, solutions near the bottom were selected the least. On the right hand side the small groups are displayed and those who specified solution parameters are highlighted.

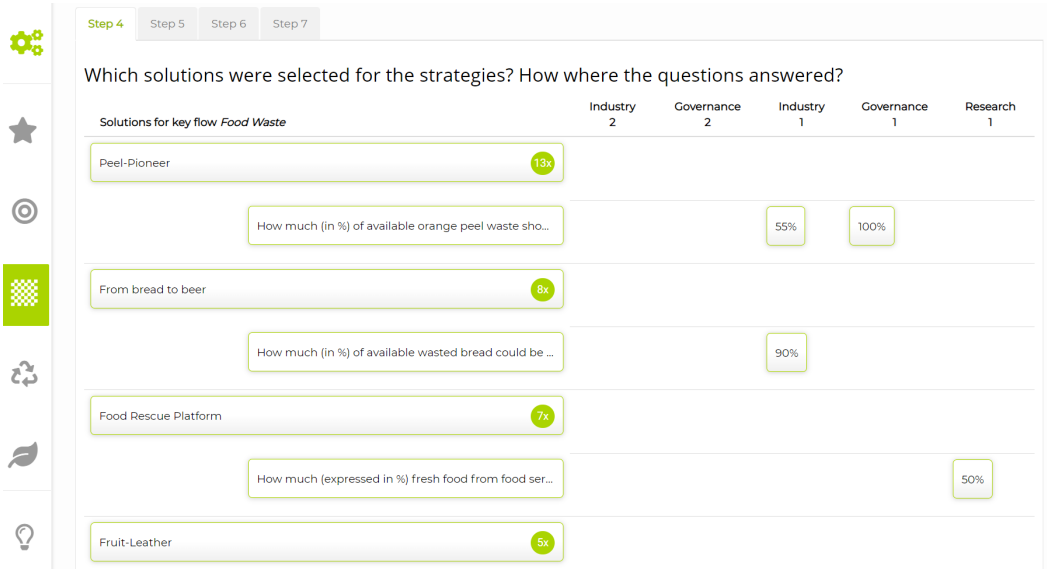


Figure 107. GDSE step Conclusions, screen Strategies. Example of how solutions were picked by the small groups and which solution parameter questions were posted.

The second tab is used to present the locations of solution implementations drawn by the small groups. This tab is interactive and features a drop-down menu located at the top right under the question 'Where were the solutions applied?'. Using this drop-down menu, a specific solution (or an implementation question) can be selected to display an overlay of all implementations of this solution that were drawn by the small groups, rendered on top a topographic background map. Figure 108 shows an example screenshot of this tab for a solution called 'Smart biorefinery' and two implementations of this solution, which were drawn respectively by two small groups.

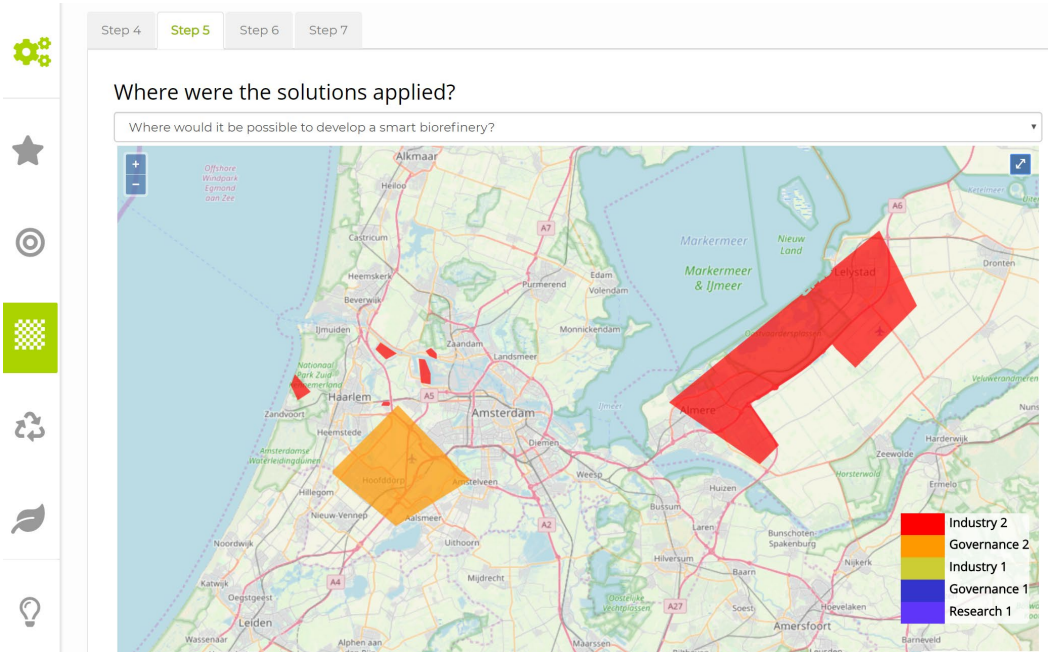


Figure 108. Drawn implementation locations for 1 eco-innovative solution. Example of the work of two small groups, who drew locations for a smart biorefinery in the Amsterdam Focus Area.

The third tab deals with the actor groups involved in the strategies developed by the small groups. This is determined automatically using the geographic locations of all actors and the drawn solution implementations. Using a drop-down menu, the workshop leader can choose Activity or Activity group for presenting the actors involved in the strategies (i.e, the small groups' work) for each key flow. Figure 109 shows an example screenshot of this tab. Actor groups are displayed per Activity on the left hand side. In front of each actor group it is shown how many and which small groups are involving the actor group in their strategy.

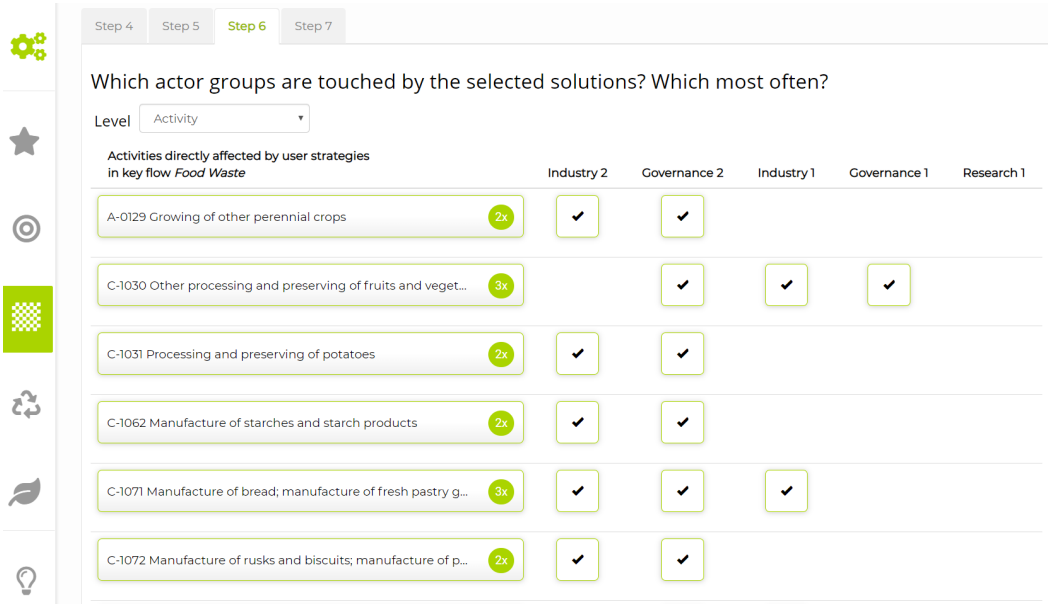


Figure 109. Example screenshot of tab showing Actor groups per Activity involved in the strategies developed by small groups .

The fourth tab is used to present the specific stakeholders that were selected to be involved in the strategies developed by the small groups. Stakeholders are grouped per category and ranked by selection rate, as follows: the stakeholders that were picked the most often will appear at the top. In front of each stakeholder name it is shown the total of times it was picked by a small group, and the specific small groups. Figure 110 shows an example screenshot of this step for Private stakeholders. A green color ramp is used to denote how often a stakeholder was involved in a strategy developed by a small group.

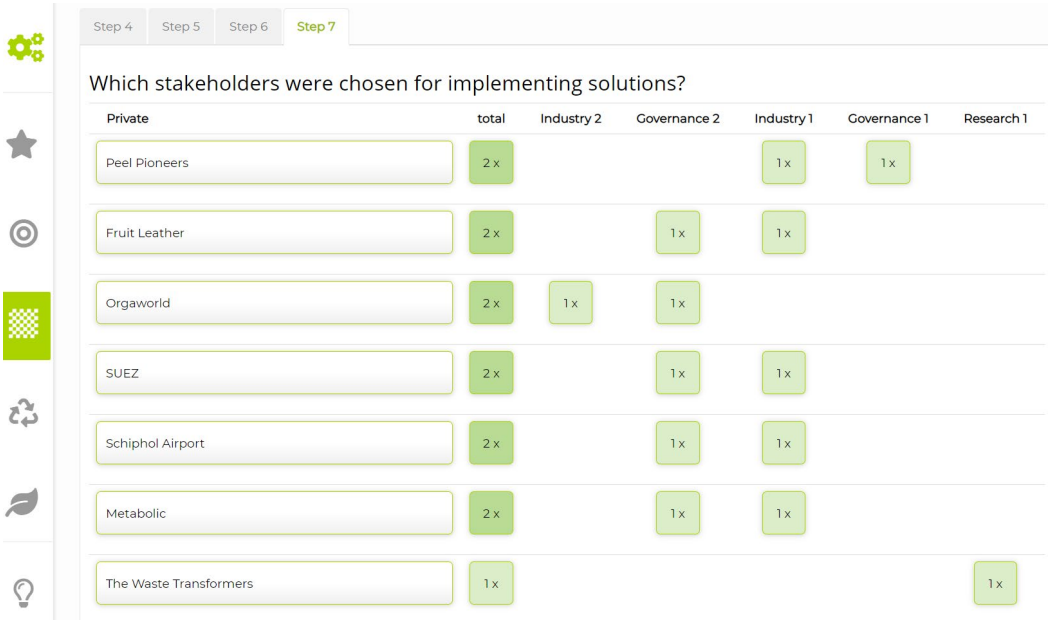


Figure 110. Screenshot of tab showing how often the stakeholders were chosen to be involved in the work of the small groups.

Modified flows

This screen is used to present the strategies in terms of the extent to which flows of waste were modified by the strategies developed by the small groups. Two tabs are involved in this screen. The first tab lists the flow indicators, grouped by key flow, and displayed on the left hand side. On the right panel, in front of each flow indicator there is a percentage under each small group, indicating how much each flow indicator was either increased or decreased as a result of the strategy developed by the particular small group. Figure 111 shows an example screenshot of this tab for one key flow (Food Waste). Under Each small group is a percentage value color coded using a green-to-red color ramp. Green denotes increased flow indicator values, red denotes decreased.

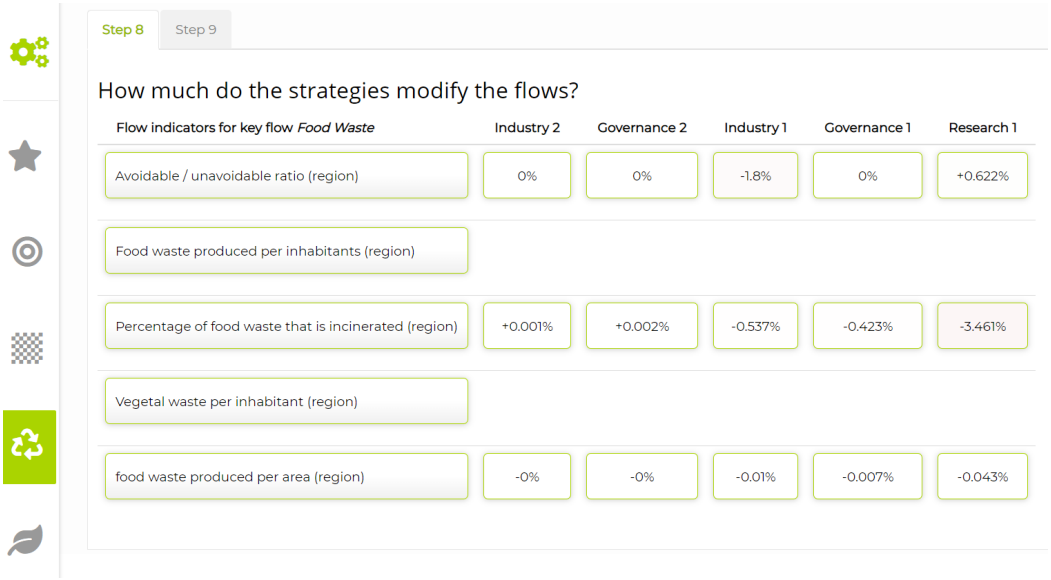


Figure 111. Comparing strategies based on flow indicators. Example screenshot showing flow indicators and the impact of the strategies developed by the small groups.

The second tab is used to present and compare the flow indicator targets set by the small groups to see to what extent the strategies are able to meet their own targets. Figure 112 illustrates this step.

Figure 112. Comparing strategies based on flow indicator targets.

Sustainability

This screen is used to present, and compare, the life-cycle based sustainability assessment report for the strategies developed by the small groups. These results can be presented using a PDF document that can be uploaded prior to the workshop using the setup mode. Figure 113 illustrates how this can be presented.

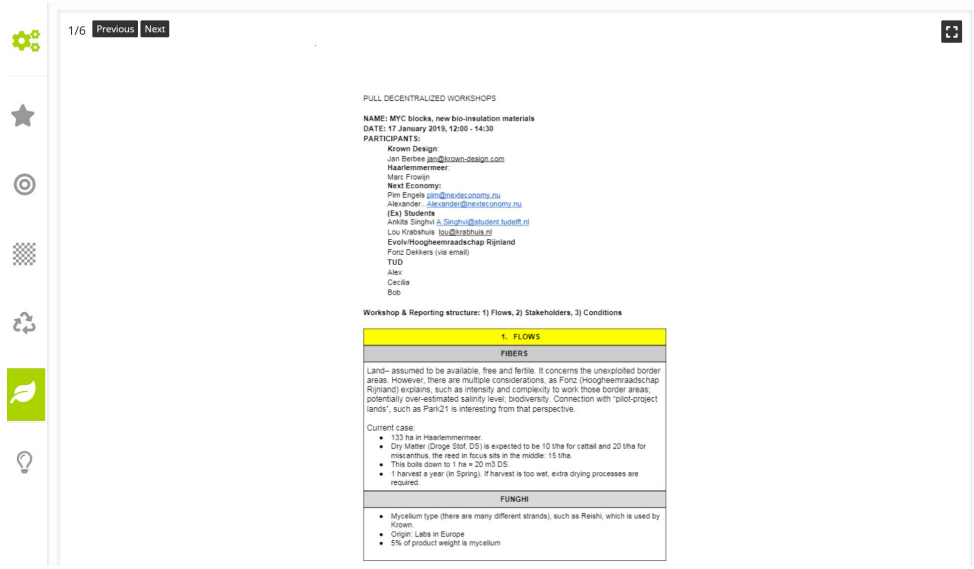


Figure 113. Presenting the sustainability report of the strategies developed by the small groups.

Conclusions

This is the final screen of the GDSE step Conclusions and is used to present the summarised conclusions of the work of the small groups, for each key flow, which were collected and entered by the PULL leading team using the 'Notepad' at previous points of the GDSE step Conclusions. Conclusions are expressed in terms of three aspects, namely Common Ground, (issues) To be discussed, and Disagreement. For each aspect, conclusions are shown alongside respective screenshots, where were collected and appended to each conclusions, and are available as clickable thumbnails. Figure 114 illustrates this screen.

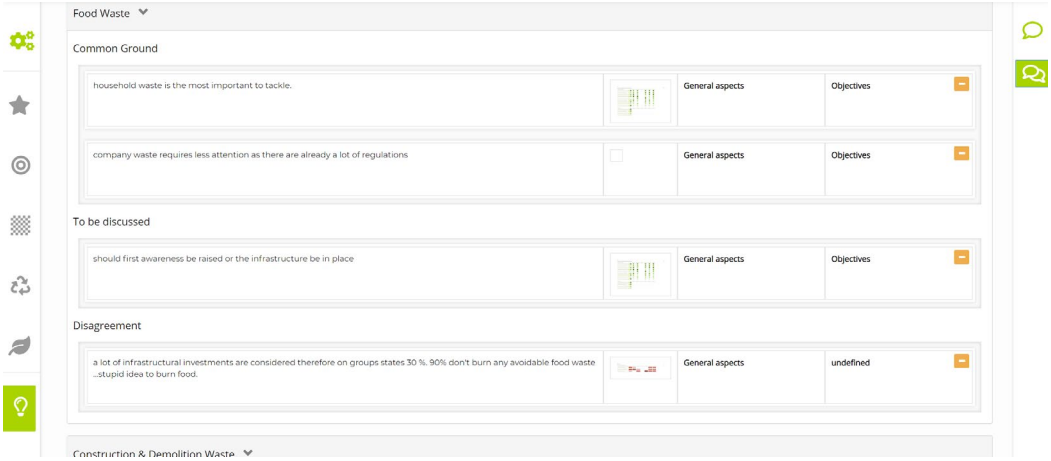


Figure 114. Screenshot of GDSE screen Conclusions, workshop mode.

6. Use of the GDSE

Now that all GDSE modules are fully programmed, the GDSE can be applied to the PULL processes of all REPAiR case studies. The final version of the GDSE is ready to support the entire workshop series of a PULL. For the case of Amsterdam, the GDSE was already used in the series of four PULL workshops held with AMA stakeholders. Each of these workshops was designed to feature the GDSE as the main support tool. However, both the workshop series and the GDSE software development began simultaneously. While the GDSE was not physically available for the first workshop, the workshop was held around GDSE tasks with GDSE-friendly outcomes. A GDSE prototype was demonstrated in workshop 2 and a more advanced version of the GDSE was utilised in workshop 3. Details on this process can be found in the REPAiR 2nd Periodic Report (REPAiR et al., 2019c). All outcomes of the first three workshops were uploaded to the GDSE.

6.1. The AMA PULL

The final version of the GDSE was utilised and evaluated at the fourth AMA PULL workshop, which was organised jointly by WP5, WP2, WP3, WP7 (see Figure 115). The GDSE was used to support stakeholder group work throughout the following process:

- Ranking the CE objectives previously defined for the AMA
- Setting resource flow targets to address the CE objectives
- Co-developing strategies using the catalogue of solutions developed for the AMA (see D5.2 REPAiR, 2018a)
- Assessing changes in terms of flows the strategies achieve in relation to the targets set

Figure 115. 4th AMA PULL workshop in full session. Four touch-enabled computers (each for one small group, running the GDSE in workshop mode) were used to support group work.

A full report of this 4th AMA PULL workshop report can be found in REPAiR (2019a). Five eco-innovative strategies were co-developed by the workshop participants. The GDSE was used to quantitatively compare not only these strategies, but also the work done by the participants on the basis of aspects, such as CE objectives, flow indicators, targets, individual solutions, actor groups, stakeholders (see Figure 116).

Figure 116. 4th AMA PULL workshop. Members of one small group work together on the GDSE.

6.2. GDSE effectiveness

Both the effectiveness and usability of the GDSE was evaluated using pre- and post-workshop surveys. Workshop participants answered questions regarding the GDSE. Participants found the GDSE to be a complex tool that requires familiarity but appreciated the capacity to disclose the immense datasets available and create queries on spatial data, visualisation of flows and actors involved, which can both potentially and clearly assist the process of generating solutions in space and amidst data transparency.

In general terms, the participants thought the GDSE-workshop combination to be effective for helping achieve consensus regarding locations of strategies, as indicated by 25% of all participants (to a great extent effective) and 63% (to some extent). Likewise, participants thought the GDSE workshop increases transparency in decision making to a great extent (as indicated by 63% of all participants), and to some extent (25% of participants). Table 3 shows how participants ranked specific GDSE tasks.

The participants were also asked to rate the various modules of the GDSE using a 1-10 scale for two aspects, namely understandability of the support information provided in the specific module, and helpfulness of the module in the participants' daily work. Table 4 shows that ‘Study Area’ has the highest perceived understandability of information, followed by ‘Status Quo’. All modules were rated

an average score of 7.8. Participants thought the GDSE module 'Status Quo' was the most helpful in their daily work, followed by 'Strategy'.

Table 3. Effectiveness of GDSE to support tasks (Average = 7.53).

GDSE task	score	rank
Ranking objectives	8.33	1
Setting flow targets	7.47	2
Defining strategy	7.47	3
Assessing flow changes	6.90	4

Table 4. Ranking of GDSE steps.

GDSE capability	Study area	Status quo	Targets	Strategy	Average
Understandability of support information in GDSE	**8.1**	7.9	7.8	7.5	7.83
Helpfulness of GDSE in daily work	7.6	**7.7**	7.6	7.6	7.63

7. Next Steps

This deliverable presented the final version of all GDSE modules. The full version of the GDSE is meant to support the entire living lab process, particularly the entire workshop series of a PULL. This includes supporting both the research, data entry, input-output tasks, and interaction (among stakeholders, and with the tool) during the PULL workshop series.

Next steps will feature the application of GDSE to the PULLs of the follow-up cases: Ghent, Łódź, Pécs, Hamburg. The GDSE will be the main support tool for the work that aims at generating the full REPAiR set of eco-innovative strategies covering all six PULL case studies.

The GDSE is already available as an open source code on GitHub and it will stay like this after the project is finished. Once the project is finished, a DOI will be given for its final version and the code will be preserved in a 4TU archive.

The GPLv3 license means that:

- Anyone can copy, modify and distribute this software.
- The license and copyright notice must be included with each and every distribution.
- This software can be used privately.
- This software can be used for commercial purposes.
- If business is built solely from this code, it might need to open-source the whole code base.
- In case of modifications, it must be indicated which changes have been made to the code.
- Any modifications of this code base MUST be distributed with the same license, GPLv3.
- This software is provided without warranty.
- The software author or license can not be held liable for any damages inflicted by the software.

8. Links to external documents related to GDSE modules

All external documents (e.g.handbooks, instructions and procedures) related with the GDSE modules are available on the public OSF folder under the following DOI: 10.17605/OSF.IO/UC75Y

Bulk Data Upload Procedures:

https://mfr.osf.io/render?url=https://osf.io/3nejt/?direct%26mode=render%26action=download%26mode=render

Instructions for Georeferencing Actors:

https://mfr.osf.io/render?url=https://osf.io/5k8f2/?direct%26mode=render%26action=download%26mode=render

Peel Pioneer Example of the EIS scheme:

https://mfr.osf.io/render?url=https://osf.io/zkp27/?direct%26mode=render%26action=download%26mode=render

Instructions to Upload Data on Geoserver:

https://mfr.osf.io/render?url=https://osf.io/gr762/?direct%26mode=render%26action=download%26mode=render

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