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**ACTION**

# **RESEARCH OBJECTS CATALOGUE**

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<b>Abstract</b>	This deliverable describes the catalogue of research objects identified in the project. Also, a methodology to characterize these objects has been developed to facilitate this work, adapting it to the needs of citizen science projects.
<b>Keywords</b>	Research objects, citizen science

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## TABLE OF CONTENTS

<b>EXECUTIVE SUMMARY</b>	<b>4</b>
<b>1 INTRODUCTION</b>	<b>5</b>
<b>2 Description of Research Objects Tools and Specifications</b>	<b>6</b>
2.1 RO-Crate	6
2.2 ASSET-ACTION	7
2.3 RO-Hub platform	12
2.4 The Survey Ontology	13
<b>3 Research Objects Catalogue</b>	<b>15</b>
3.1 ACTION Pilots update	15
3.1.1 WOW Nature	15
3.1.2 Walk Up Aniene	16
3.1.3 Restart Data Workbench	16
3.1.4 Open Soil Atlas	17
3.1.5 Mapping Mobility	18
3.1.7 Water Sentinels	19
3.1.8 Azotea	20
3.1.9 Loss of the Night	20
3.1.10 CITIZEN SCIENTISTS, DRAGONFLIES AND PESTICIDES	21
3.1.11 TATORT STREETLIGHT	22
3.1.12 Summary	22
3.2 Research objects generated by survey studies about motivation	23
3.2.1 Research Objects	24
3.2.2 Publication	26
<b>4 CONCLUSIONS</b>	<b>28</b>
<b>5 REFERENCES</b>	<b>29</b>

## EXECUTIVE SUMMARY

This deliverable contains the second version of the research objects catalogue. A research object allows to represent the knowledge generated in different investigations carried out in the project, specially within the pilots. In this second version, the graphical notation has been updated to visualize this knowledge using more clear diagrams. This can be especially useful for both researchers and citizens.

These diagrams allow researchers to monitor the status of their research, it means, identifying resources they need or resources that are not linked with other elements of their research. Thus, they can have a *big picture* of the outputs generated by their research and the relation among them. It benefits the reproducibility of the research. Also, it allows external researchers to identify resources that can be relevant for their own investigations, promoting the reusability of resources.

In order to create these diagrams, a new tool named ACTION ASSET has been deployed. With this tool, citizens can create simplified diagrams and can export them following the specification Ro-Crate. These files can be integrated in our Open Data Portal and in RO-Hub.

As in the first version of the deliverable, research objects have been deployed in the new version of the platform ROHub<sup>1</sup> which allows us to manage the research object lifecycle, as well as provide us with interesting features such as versioning, semantic annotation and machine access through an API. In the next months, the new version of the platform will be redirected to the production address (<https://www.rohub.org>)

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<sup>1</sup> <https://www.rohub.org/>



# 1 INTRODUCTION

Open Science promotes a change of paradigm to make available the outputs of scientific activity to different stakeholders: education, research institutions, private sector and the society in general. In the past, the dissemination of these activities has been limited to scientific publications.

With the introduction of new technologies, the role of data, software and protocols has become more relevant in the description of scientific experiments. Hence, to support the Open Science principle of reproducibility and transparency), all the components needed for reproducing the experiment have to be identified, catalogued and provided with instructions.

A Research Object (RO) is an aggregation of digital objects that packages resources describing a research activity. ROs can improve reuse and reproducibility<sup>2</sup> in a scientific process by:

- Supporting different types of researching resources such as publications, data, code, slides, images, videos, etc...
- Publishing these collections of resources as a shareable and cite-able resource
- Enriching these resources with additional information (metadata and vocabularies).

This research object will evolve in time (when more outputs will be aggregated to the RO)

In chapter 2, we introduce the tools developed and adapted by ACTION to manage our research objects. The tool ASSET has been adapted to describe graphically a research object and to generate a JSON file to integrate the results in our Open Data Portal.

In chapter 3, we describe the updates of the methodology and the new research objects included in the catalogue.

Finally, in chapter 4, conclusions are presented.

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<sup>2</sup> <https://www.researchobject.org/>

## 2 Description of Research Objects Tools and Specifications

This section describes the specification, the vocabulary and the tools used to build our Research Objects Catalogue. The specification of a research object plays a crucial role because it is used to communicate the platforms Open Data Portal and RoHub. This schema can be seen in Figure 1, where boxes in red represent the components described in this section.

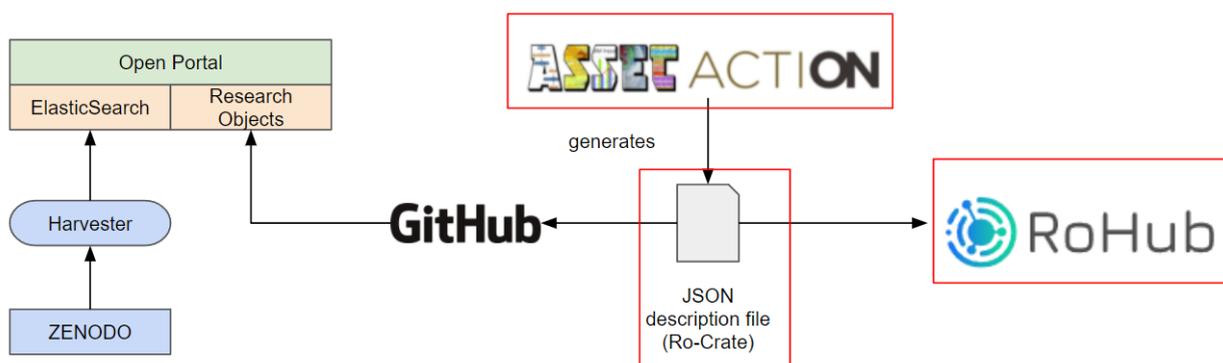


Fig 1. System architecture

The tool ASSET-ACTION is used to generate the Ro-Crate file from a graphical notation.

### 2.1 RO-Crate

RO-Crate<sup>3</sup> is a community created to define a lightweight specification for packaging research objects. This specification is based on schema.org<sup>4</sup> annotations in JSON-LD. Schema.org provides a vocabulary to describe structure data on the Internet. Concepts as Organizations, Persons, Digital Objects and Actions can be modeled in a standard vocabulary, as well as their associated metadata.

The use of this specification reports some advantages:

- All the research objects are homogeneous.
  - The research objects generated can be used by a wider community
  - The research objects can be manipulated for other tools generated by the community.
- Some examples can be found here: <https://www.researchobject.org/ro-crate/tools/>

The research objects used JSON-LD as format files. JSON-LD is designed to represent linked data on the Internet allowing in our case to express the relations between the different resources of a Research Object. Also, the use of this format facilitates the consumption of research objects for other services, it means, gives support to a M2M (Machine to Machine) model.

The specification selected to describe our research objects is 1.1, the latest version..

<sup>3</sup> <https://www.researchobject.org/ro-crate/>

<sup>4</sup> <https://schema.org/>

According to Ro-Crate, a Research Object has the following structure:

- RO-Crate Metadata file. This file must be written with the format JSON-LD 1.0 and has to be named like *ro-crate-metadata.json*. This metadata file is generated by the tool ACTION-ASSET (see next section). The resources that compound research objects, and relations between them must be described in this document.
- RO-Crate Website. In this case, a human readable version (based on HTML) of the research object can be attached. In our case, this version is supported by the platform ROhub, where our ROs are shared.
- Payload files and directories. In the context of ACTION, our ROs are not packed with the files inside them. The resources are external, and they are published on external platforms such as Zenodo, Youtube, Slideshare, etc ...

## 2.2 ASSET-ACTION

One of the problems found in ACTION (see D4.6 Research Objects Catalogue v1) was that the concept of research objects is difficult to manage by citizens. For that reason, a visual tool like draw.io was used to describe them.

Nevertheless, citizens were confused about the symbols to represent the different resources and the relations. Plus, transforming these draws to RO-Crates files was a difficult task for them because of the complexity of the JSON-LD format for non expert users. For that reason, we got up a feasible alternative

*Asset* is a tool to create sketches to represent workflows. It is a web based tool without a backend system, so there is no persistence and no log in system. Users can visually describe workflows and generate a JSON file with the description.

In the context of ACTION, this tool has been adapted to describe research objects with a visual interface, and with a special notation. The interface has been simplified for adding only the most used resources. Also, all the resources published in our data portal are pre-loaded in the tool. It means, to add a resource, a user only has to add the element, all the metadata associated is assigned automatically. This shortens the time to create ACTION research objects.

Figure 2 shows the different areas of the tool. There are four main areas in ASSET.

- Canvas where the users will add resources of a research object and their relations to build a workflow. Users will drag these tasks from the *Tasks and tools selector area* and drop it in the canvas
- Metadata where the metadata associated with each task will be displayed and modified. Some relevant metadata are periodicity of the workflow, user and password of external tools, etc ...
- Controls to display the available tasks and external platforms in the *Tasks and tools selector area*..
- Tasks and tools selector where the user will be able to select the available tasks and external platforms.

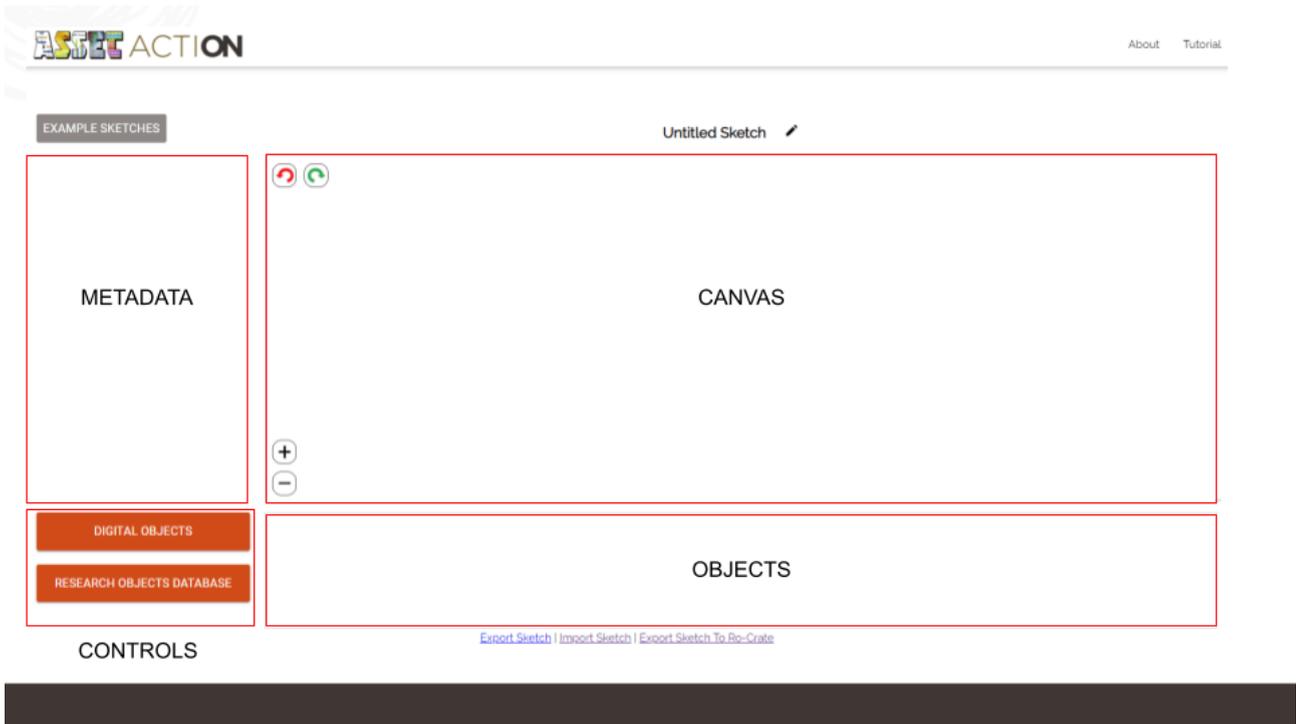


Fig 2. ASSET areas

Our adaptation of ASSET provides ten different categories that can be added to our research object (see Figure 3).



Fig 3. Categories in ASSET. From left to right: i) Database, ii) Software, iii) Dataset, iv) Website, v) Publication, vi) Presentation, vii) Visualization, viii) Video, ix) Image and x) Audio

In the research objects database, a collection of digital objects can be found (see Figure 4). This collection is composed of the digital objects deposited in our Open Data Portal (see D4.6 - Open Data Portal).



Fig 4. Digital Objects Database

## RESEARCH OBJECTS CATALOGUE

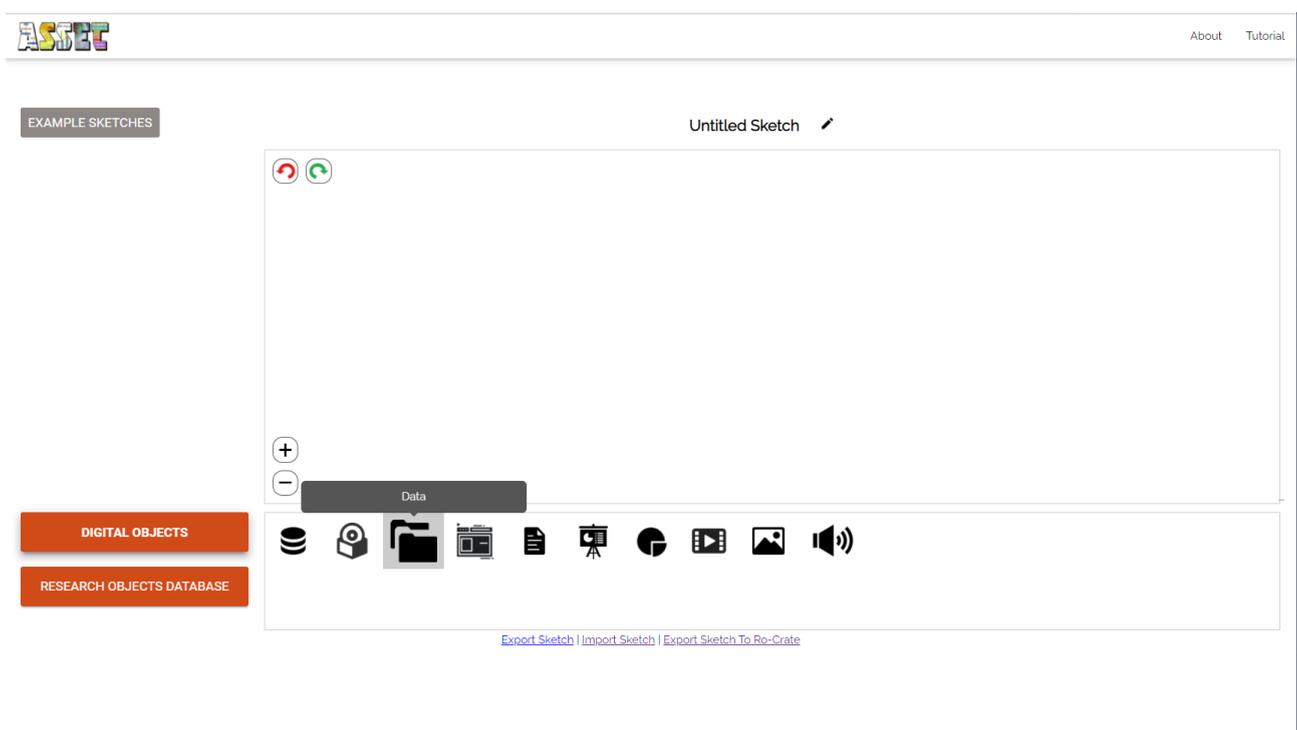
Users can add these objects to the canvas, taking into advantage that the metadata associated with each digital resource will be completed automatically. This facilitates the work to create research objects.

Next, the main activities covered by the tool ASSET will be described.

### Adding an element to your research object

On loading the ASSET sketching interface, at the bottom of the screen, a list of digital objects (corresponding to the "Digital Objects" button) will be loaded in the tools panel adjacent to the buttons. Clicking on the other buttons will load their respective tools in the tools panel.

Hovering over an item in the tools panel will show the item's name.



**Fig 5. Select a Digital Object**

Now just click the desired element and drag it to the canvas:

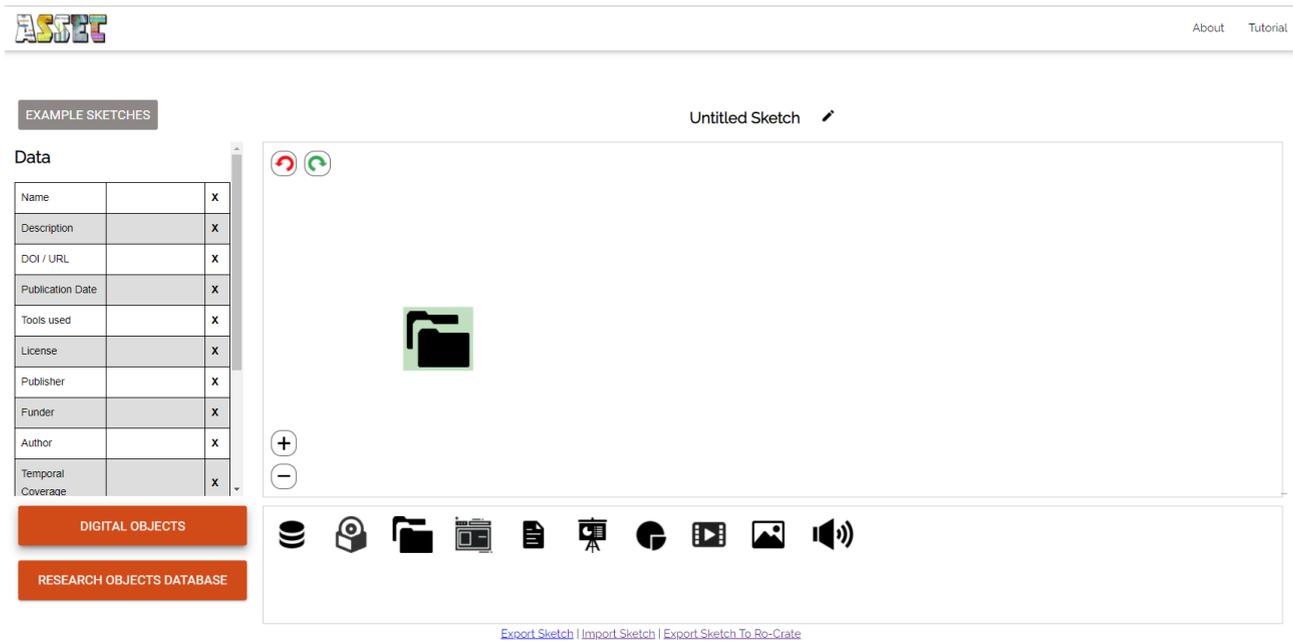


Fig 6. Add an element to the canvas

### Describing an element in your sketch

Click on the desired element and a table will appear on the left of the screen. Any of the properties of the table can be edited or deleted. By clicking on "Add property", a new row will be added in the table. The "Name" property will be displayed on the sketch.

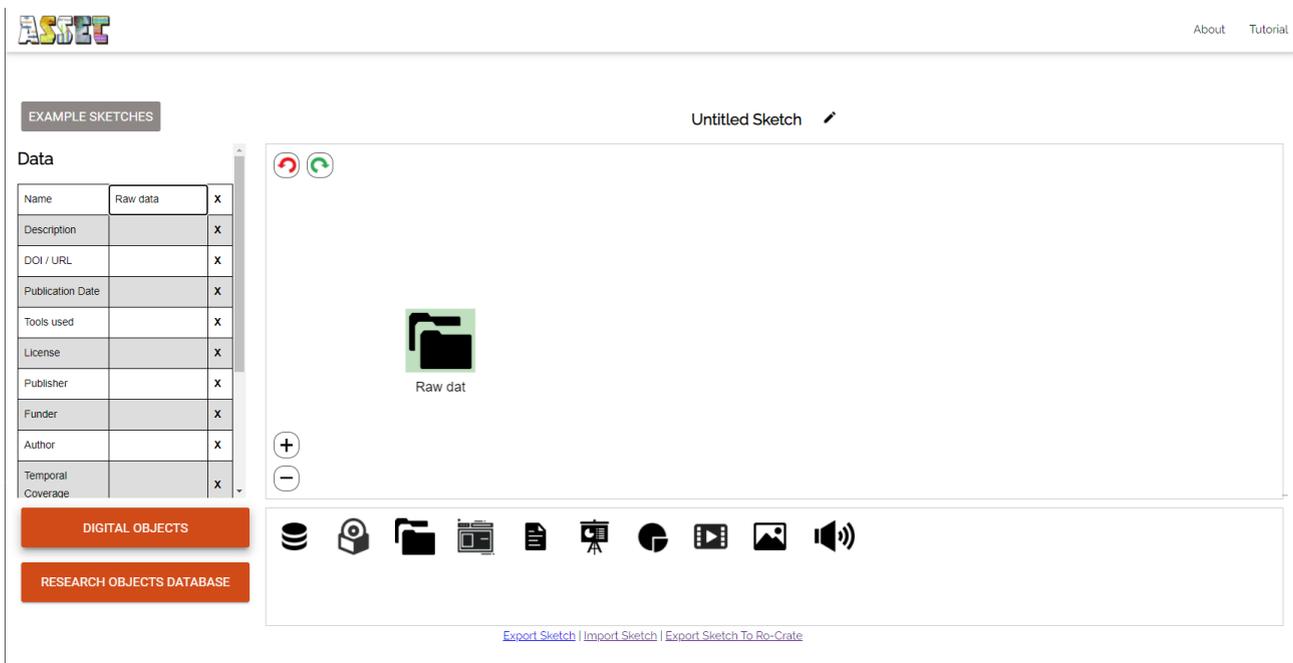


Fig 7. Describe an element

### Deleting an element in your sketch

Select an element (an arrow or a task in the canvas) and press the "delete" key on your keyboard.

### Connecting two elements in your sketch

First, add the two elements you wish to connect in your canvas. Double click on one of the elements to turn it red.

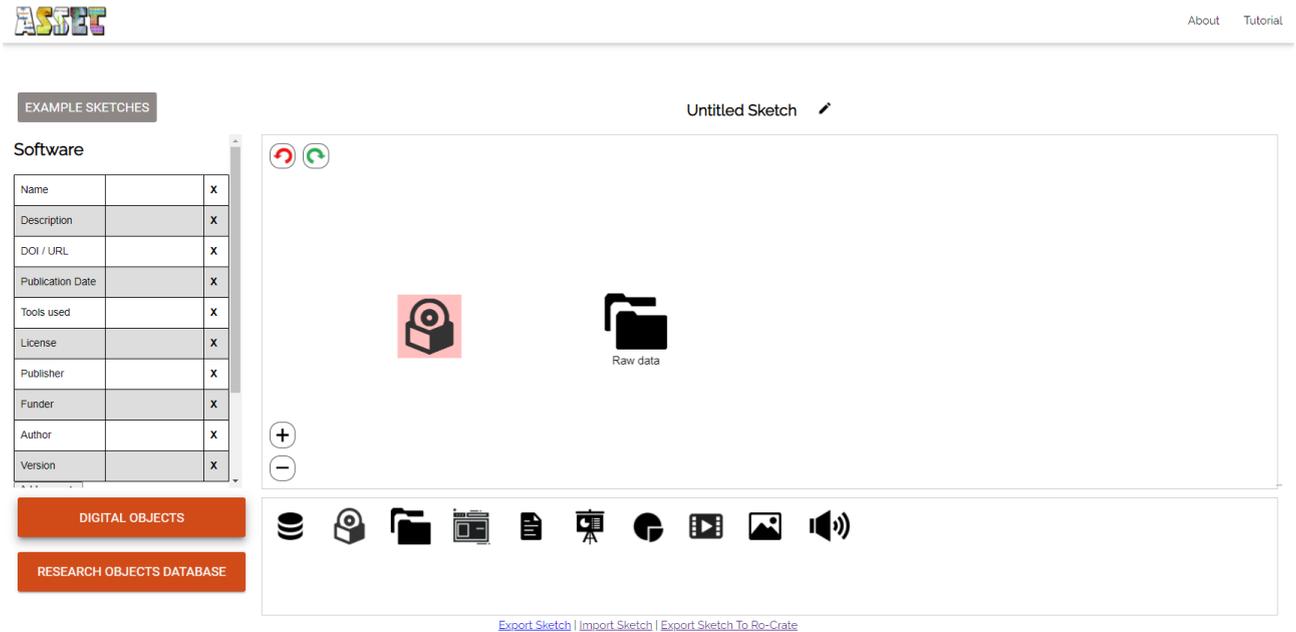


Fig 8. Define link between elements

Then click on the target element and an arrow will be drawn:

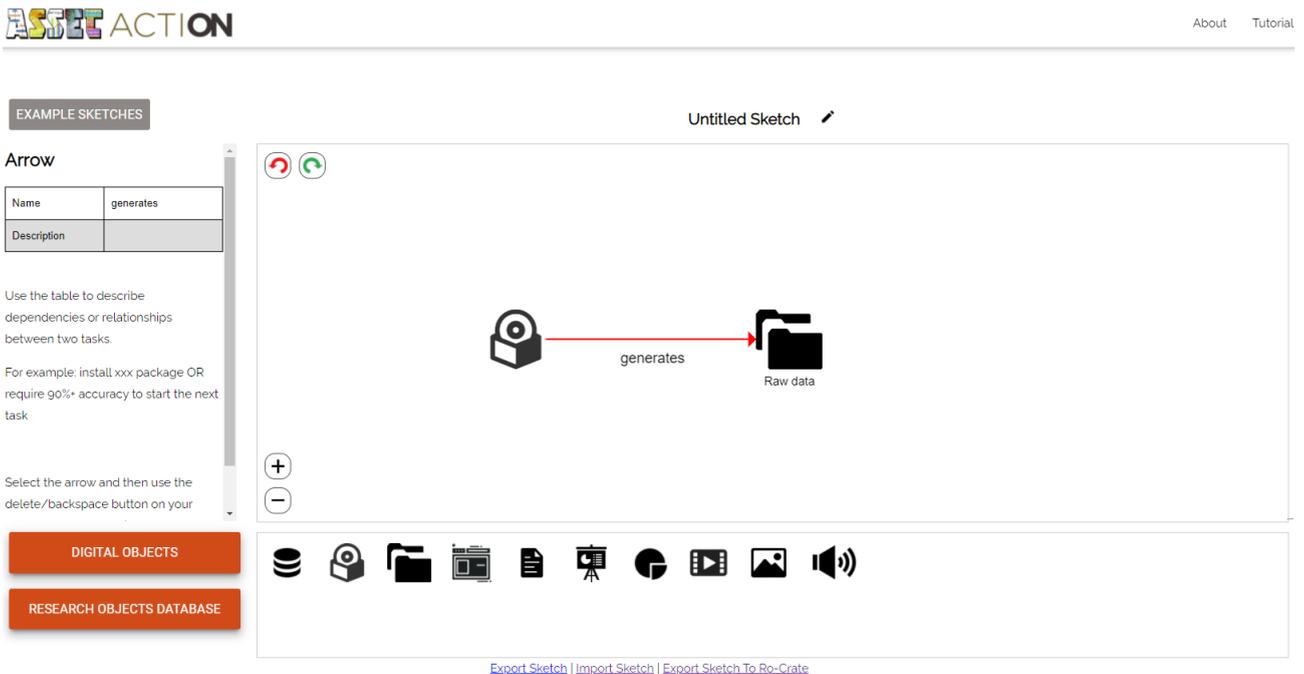


Fig 9. Link two elements

The relation can be named and described if you click on the arrow.

### **Deleting an element in your sketch**

Select an element (an arrow or a task in the canvas) and press the "delete" key on your keyboard.

### **Exporting your sketch**

Click on the "Export Sketch" link on the lower part of the screen. A JSON file will be downloaded with the information required to draw the Research Object.

### **Importing a sketch**

Click on the "Import Sketch" link on the lower part of the screen and choose a previously exported sketch from your file system.

### **Exporting your sketch to RO-Crate**

RO-Crate is the specification that ACTION uses to represent Research Objects. Clicking in this option, a JSON RO-Crate file will be downloaded. This file can be used both in the portal and the RO-Hub platform.

## **2.3 RO-Hub platform**

The platform RO-Hub was introduced in the previous version of this deliverable. Nevertheless, during this period of time, some changes have been introduced in the platform. At this moment, the new version is available in the following link: <https://reliance.rohub.org/>. During the present year, the new platform will be released in the regular link: <http://www.rohub.org>

The platform has changed its graphical user interface, but maintaining the features commented in the previous version of the deliverable. Figure 9 shows the new interface.

The final version of the platform will include some interesting features such as:

- Export research object as RO-Crate file.
- Package research object as a ZIP file. The platform can link it to a Zenodo account. It means, that a research object can be published in Zenodo
- Import research objects from a ZIP file or from a description file compatible with RO-Crate
- Integration with EOSC services such as EGI Notebooks, B2SHARE, B2DROP
- Integration with services to measure the FAIRness of a research object
- Generation of PID per research object and per resource with the service w3id
- Possibility of generation of DOI per research object and per resource

The screenshot displays the RoHub platform interface for a research object. At the top, there are navigation tabs: Overview (selected), Content, Quality, Activity, Life cycle, Relations, and Impact. Below the tabs, the project is identified as 'APPLIED SCIENCES' and 'IN MY BACKYARD', an ACTION project created on 13 January 2022. The description states the project's aim is to understand and map the use of pesticides and fertilizers in home farming and gardening. The 'CONTENT' section lists a tree structure with folders for Datasets, Presentations, and Publications, containing items like 'On-Site Survey Responses Raw Dataset', 'Key Insights', 'Project reflections and take aways', 'Project Final Report', and 'Data Analysis Report'. The 'ACTIVITY' section shows a log of 'Project Final Report' being added as a resource. On the right, a sidebar provides statistics (0.00/5 stars, 0 comments, 0 hearts, 0 downloads, 1 view), a list of agents (ACTION project Creator), a quality score of 0%, a toolbox with icons for download, RSS, settings, and other functions, share options for social media, and a 'CITE AS' section with a project URL.

Fig 9. RoHub platform

As a new feature, the team of ROHub has developed a python library<sup>5</sup> to invoke the services provided by the platform, using the API developed for this purpose. This facilitates the automation tasks.

## 2.4 The Survey Ontology

The Survey Ontology (<https://w3id.org/survey-ontology>) is an open vocabulary that allows representing, annotating and sharing a representation of the survey structure and the gathered responses as a research object (Scrocca et al., 2021).

<sup>5</sup> <https://pypi.org/project/rohub/>



The Survey Ontology leverages and extends the *Research Object Suite of Ontologies* (Belhajjame et al., 2015) to address the research object principles of identity, aggregation and provenance. The Survey Ontology models:

- a complete survey research study as a *research object*,
- the survey procedure as a scientific workflow (*wfdesc* module<sup>6</sup>), and
- the survey's collected answers as provenance traces of its execution (*wfprov* module<sup>7</sup>).

A *survey research object* aggregates two main resources identified in the ontology: (i) a *survey procedure*, describing the survey structure (questions, answers, etc.), and (ii) a *survey dataset*, containing the collected answers.

Moreover, a survey research object can aggregate *any other additional resource*, e.g., representing study hypotheses, investigated variables, models produced from the result analysis, related publications, etc.

Considering a *survey procedure*, all the questions can be annotated with the respective *latent variable* investigated, i.e., the variable measured indirectly using the collected answers to that question. Moreover, closed answers can be associated with both a qualitative value, a textual label to be displayed in the chat, and a quantitative value, the numerical coding for results analysis.

Coney<sup>8</sup>, the conversational survey tool listed in the ACTION toolkit<sup>9</sup>, allows to automatically export data of surveys designed and administered through it using the Survey Ontology.

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<sup>6</sup> <http://purl.org/wf4ever/wfdesc#>

<sup>7</sup> <http://purl.org/wf4ever/wfprov#>

<sup>8</sup> <https://coney.cefriel.com/>

<sup>9</sup> <https://actionproject.eu/toolkit>

### 3 Research Objects Catalogue

In the first version of the deliverable, a methodology was designed to make this catalogue. The steps included:

- Characterization. This step was designed to model the digital objects that composed research objects. A graphical notation was used, defining the relations between the objects.
- Creation and deployment. In this step, we created the research object in the platform RO-Hub, based on the results of step 1

In this new version, a novelty was introduced in the first step. Now, we use the tool ASSET to model the research objects instead of the tool diagram.io. This simplifies the design stage and generates the research objects description files based on RO-Crate

This new version of the methodology has been applied to the pilots’ research objects generation and to the research object for the survey study about motivation in citizen science projects.

#### 3.1 ACTION Pilots update

##### 3.1.1 WOW Nature

WOW Nature aims to measure air pollution with innovative sensors within and outside urban forests in order to assess their efficacy as a mitigation measure for air pollution, facilitate their funding and educate and engage with citizens. Citizens will be involved throughout the project, participating in data collection and in co-developing solutions and policies proposals. Project activities will include education and dissemination activities as well. The team from Etifor, a consultancy spin-off of the University of Padova specialising in ecosystems services, will gather data using Wiseair’s air quality sensors in forests run by citizens’ groups and organizations and financed through the WOWnature, a web-based platform for forest finance.

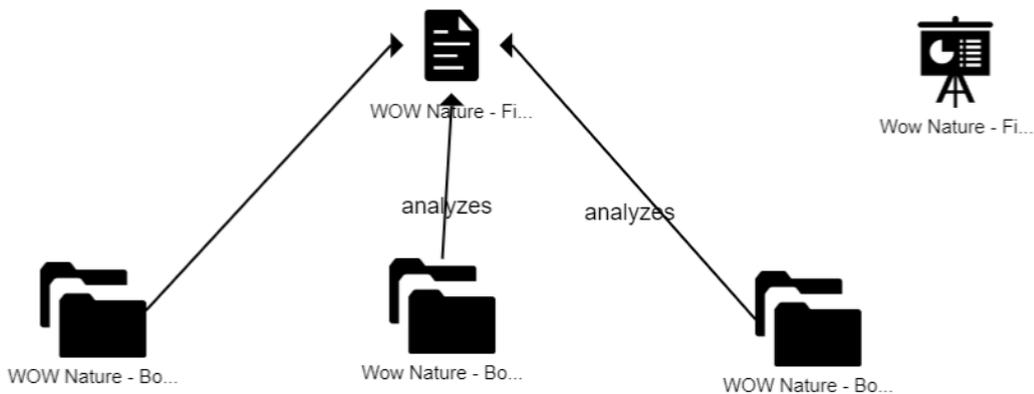


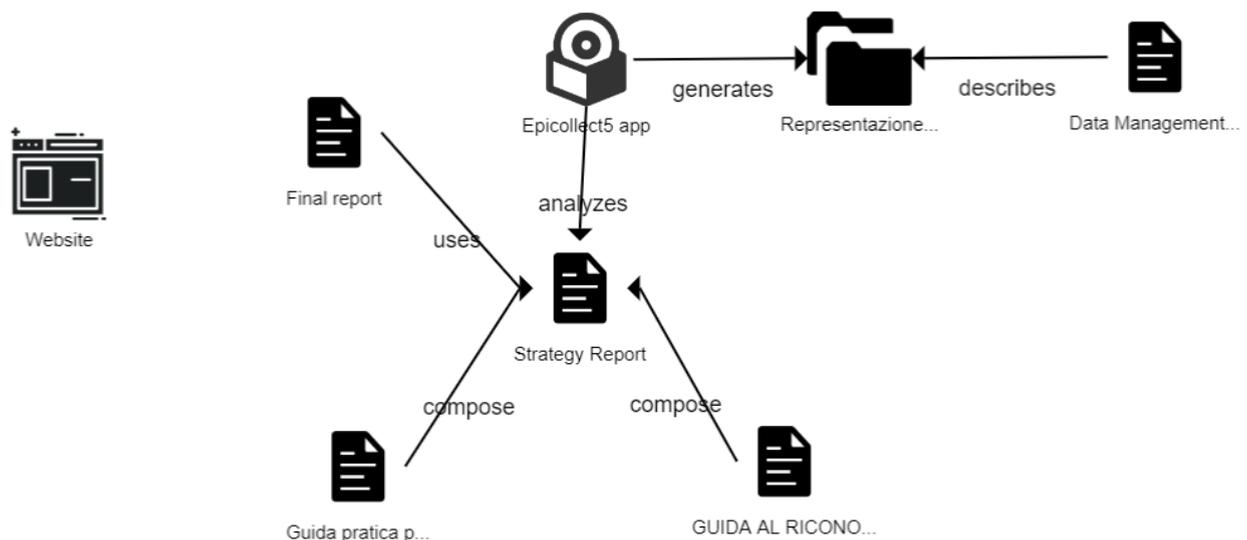
Fig 10. WOW Nature Research Object

These projects have generated three datasets, one per location that are analyzed in a report. A final presentation with results is available to the citizens.

### 3.1.2 Walk Up Aniene

Walk Up Aniene will implement its actions in the Aniene Valley Nature Reserve, which is located in the North East periphery of Rome (Italy). Between 60 to 80 people will engage in individual observation and data gathering through mobile technologies. This will provide key data on an essential natural area resisting urbanisation and anthropic pressure. With the help of citizens it will be possible to map environmental criticalities and support responsible institutions to plan environmental restoration measures.

The figure 11 generated by ASSET depicts the research object of Walk Up Aniene



**Fig 11. Walk Up Aniene Research Object**

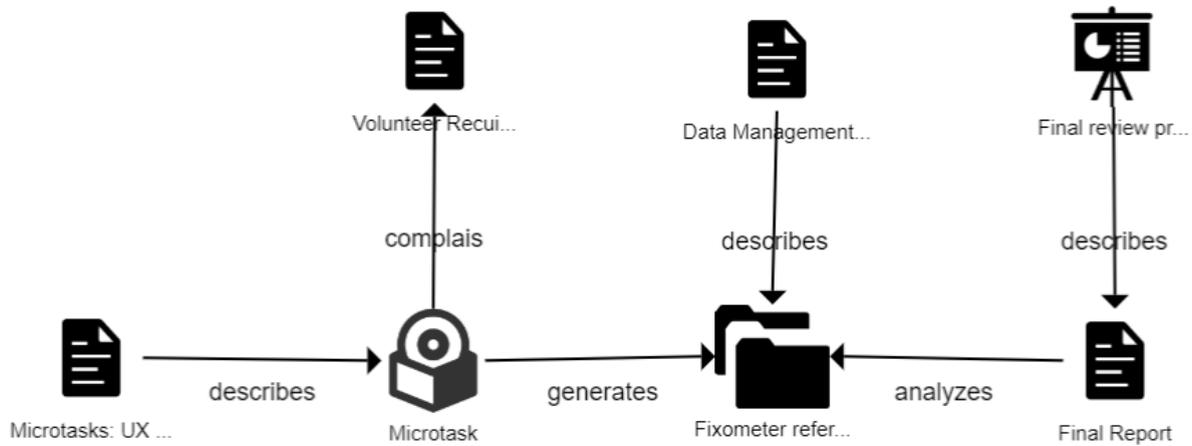
The research object is composed of a set of guidelines (written in Italian) to train citizens to recognize biological species. Walk Up Aniene has created a project in Epicollect5 (see D4.3 Templates) to collect data from the area. A tutorial of this app can be found in the Strategic Report. Data is described in a Data Management Plan as well as the process to publish it.

The project has a website where citizens can find more information about the project and its activities

### 3.1.3 Restart Data Workbench

Run by The Restart Project, Restart Data Workbench addresses the global dimensions of pollution and consumerism, the impacts of our take-make-throw economy. Many imported goods have really short lifespans, which we try to extend at our community repair events. Around 80% of a small electronic devices' carbon footprint is emitted before it even reaches European shores. What if we can use our stuff for longer by fixing it? What if these products are impossible to repair by design? What are the real impacts of this on the environment and on people across the planet?

The figure 10 generated by ASSET depicts the research object of Data Restart Project



**Fig 12. Data Restart Project Research Object**

In ACTION, the Data Restart project has developed a microtask service to generate the data used to estimate the environmental impact of repairs. This software implements the design defined in the document “Microtask: UX design” and it is aligned with the volunteers recruitment strategy

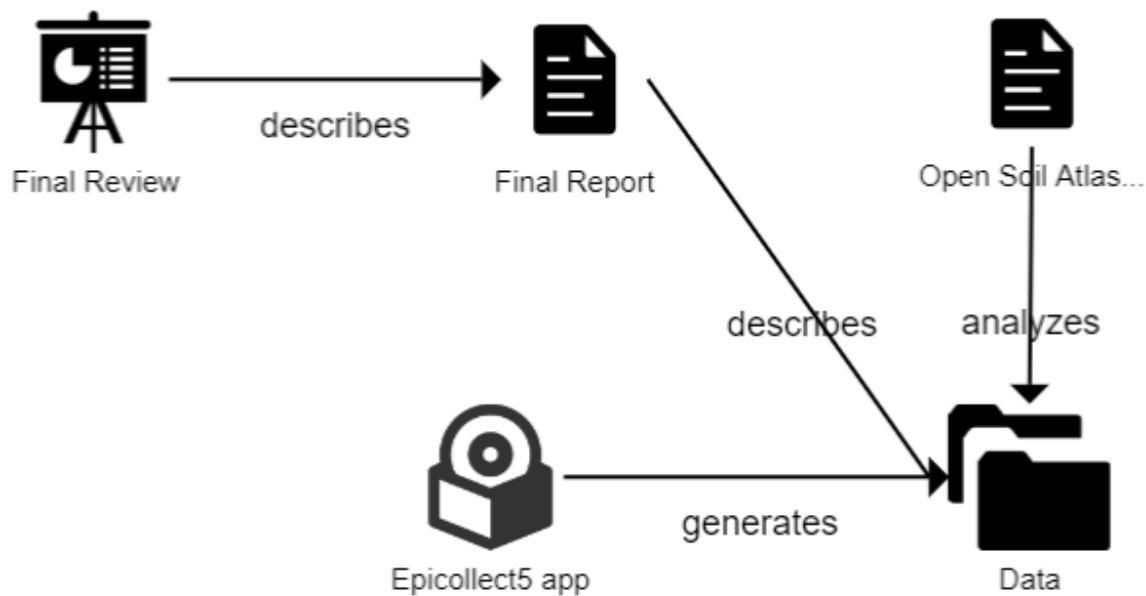
Dataset is published in Zenodo and a Data Management Plan has been created to describe them, as well as the process to archive them. This document is available in ARGOS.

Finally, a final report has been published to describe the process. A presentation is available to present the results of the project.

### **3.1.4 Open Soil Atlas**

This pilot will create an open-source co-learning center for the local community of Berlin. It will consist of a website presenting guidelines in a textual and infographic form to educate the public and raise awareness about soil quality and fertility and the correlation between healthy soil and healthy communities. The online material will be combined with a series of free workshops, where citizens will be taught how to make observations, test the soil, interpret results and draw conclusions. We will upload soil quality data and GPS locations to a digital entry form. Citizens’ observations will generate a high-resolution soil quality map.

The figure 13 generated by ASSET depicts the research object of Open Soil Atlas



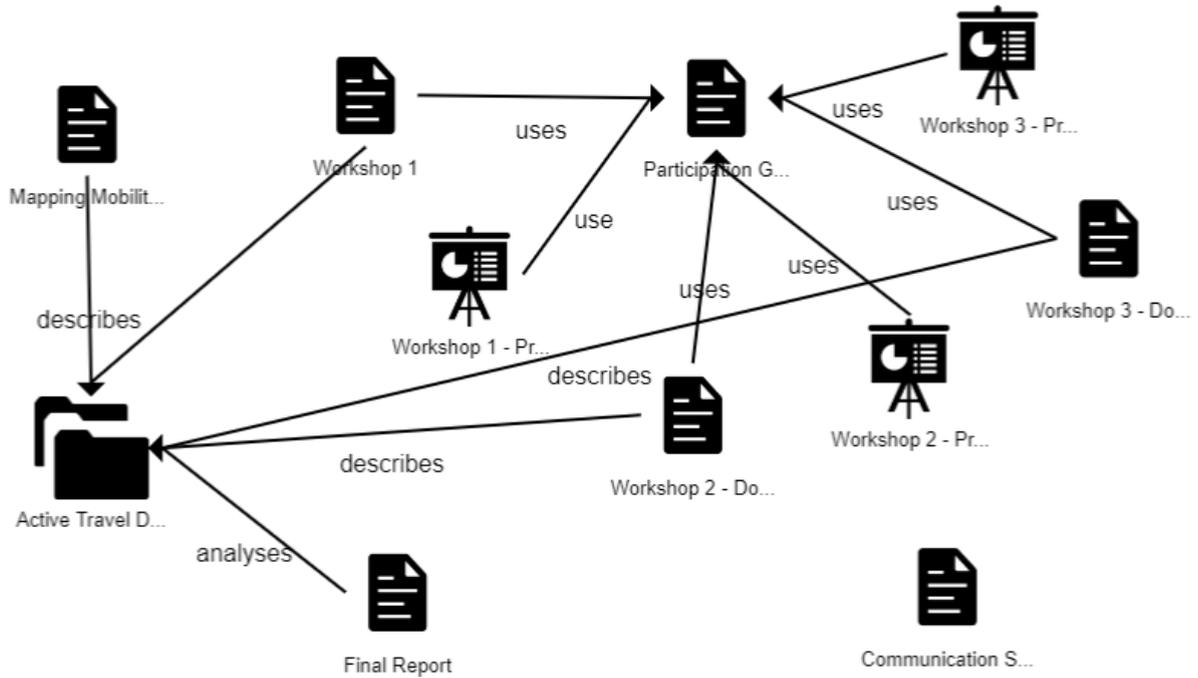
**Fig 13. Open Soil Atlas Research Object**

Open Soil Atlas, as well as Walk Up Aniene, has used an Epicollect5 application to collect the different parameters used to measure the quality of the soil. Data is available in the application Epicollect5 and they are analyzed in a paper. The final results are presented in a final report, and a presentation of the review is included too.

### **3.1.5 Mapping Mobility**

This project will engage citizens in collecting spatially referenced mobility data pertaining to their patterns of active travel within their community. They will use the outputs from this data to encourage and educate their community and local authorities about sustainable travel opportunities/barriers for the town, thus tackling issues of local transport-related pollution.

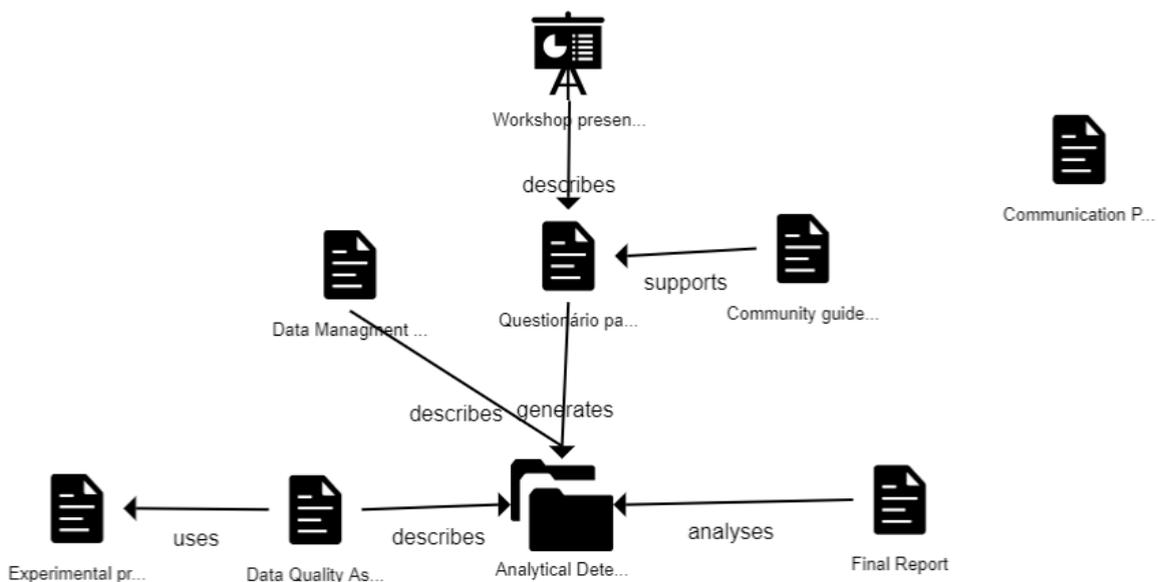
Figure 14 depicts the research object of this project. A workshop with three sessions has been organized inside this project in different weeks. For each session, a presentation and a practical guide have been developed to teach participants mapping tools. An example has been supplied and it is described in a Data Management Plan. All the activities are described in a Final Report. Also, a communication strategy document has been published.



**Fig 14. Mapping Mobility Research Object**

### 3.1.7 Water Sentinels

*Water sentinels* is a community project that empowers people from coastal communities to play a role as citizen scientists for water quality. This project is rooted in a wider aim: the conservation and restoration of seagrass meadows in the Sado Estuary area (Portugal).



**Fig 15. Water Sentinels Research Object**

Figure 15 depicts the research object of the pilot. The dataset generated is the central point of the object. This dataset has been generated with Google Forms, which questions are described in a

document. A presentation to teach citizens the procedure of collecting data and its motivation is available.

Results publication procedure is described in a Data Management Plan and in a Data Quality Assurance document. This last document uses the protocol defined by experts to take water samples.

As always, a final report with the results is published and available to citizens

### 3.1.8 Azotea

Azotea is a citizen science project to monitor night sky brightness and color with DSLR cameras, to assess the decrease in light pollution that isolation or reduction to human activities is expected to produce.

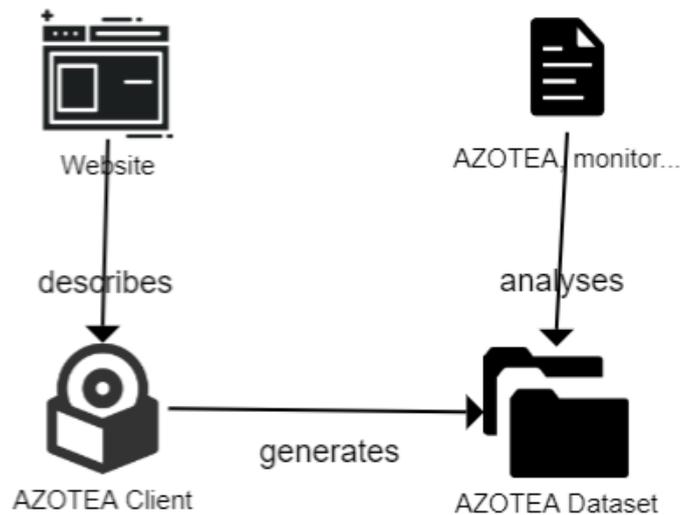
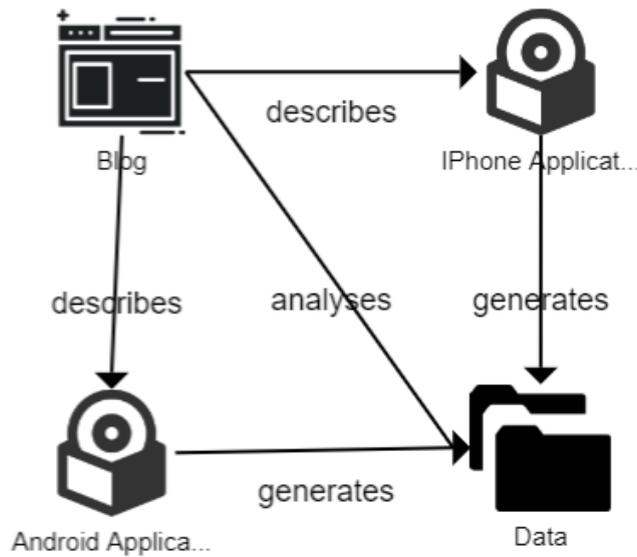


Fig 16. Azotea Research Object

This project has a website that describes the objectives of the project and the software created to generate the datasets. These datasets are generated from the images taken by citizens and that have previously been uploaded to a server. A booklet has been created to explain the process and to show the results.

### 3.1.9 Loss of the Night

The Loss of the Night App invites citizen scientists worldwide to take part in a research project that measures light pollution by using the human visual system as a light meter. Specifically, participants are asked to look for specific stars, and report if they can see them from their location.

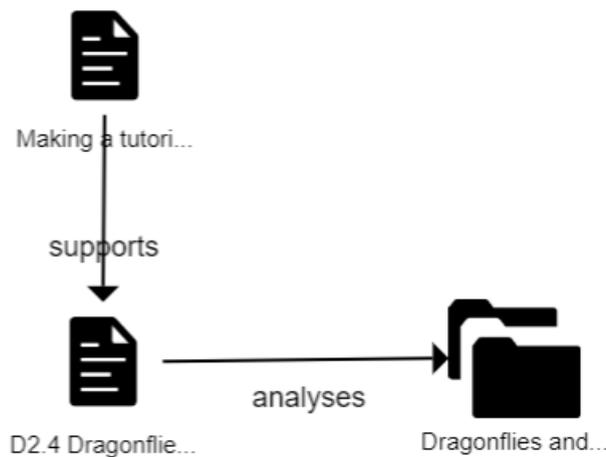


**Fig 17. Loss of the Night Research Object**

This project is composed of two mobile applications: one for Android and another for Iphone. These applications generate data that is published in a specific portal. The project has a blog where posts are published periodically..

**3.1.10 CITIZEN SCIENTISTS, DRAGONFLIES AND PESTICIDES**

Water quality has improved quite a lot in the second half of the last century and dragonflies, as aquatic insects, have recovered in this period. However recently we have seen that numbers have started declining again and this seems to be mostly the case with the common species outside of nature reserves. We know this because there are hundreds of volunteers counting dragonflies every two weeks on fixed transects.



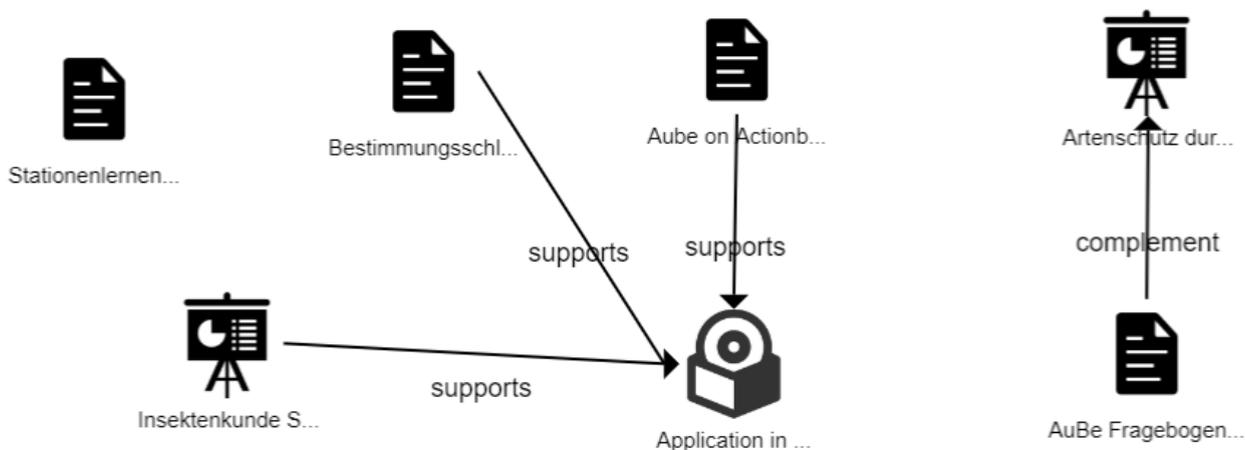
**Fig 18. Loss of the Night Research Object**

## RESEARCH OBJECTS CATALOGUE

This research object has a dataset with the samples collected by citizens and a document describing the process of sampling. Also, a second document is available to show the results obtained from the data collected.

### 3.1.11 TATORT STREETLIGHT

The pilot engages a network for citizen scientists and people interested in engaging in the research on how to protect the insect fauna from light pollution. The project invites amateur entomologists to participate in the research as well as discuss and analyze insect behavior to street lights and develop ideas for sustainable solutions for night time illumination.



**Fig 19. Tatort Streetlight Research Object**

The pilot has a project created inside the platform Actionbound (<https://en.actionbound.com/bound/Insects>). Citizens can find complementary information that support them in a presentation and two documents created to identify insects. For the other hand, the research object has a presentation to show it in schools and a form to get the opinion of the participants.

### 3.1.12 Summary

The following table summarizes the research objects created and published in the platform ROHub.

Name of the pilot	URL
STREET SPECTRA	<a href="https://w3id.org/ro-id/b5b86f8e-5c07-4b43-9b21-6df3bb6ebe72">https://w3id.org/ro-id/b5b86f8e-5c07-4b43-9b21-6df3bb6ebe72</a>
STUDENTS, AIR POLLUTION AND DIY SENSING	<a href="https://w3id.org/ro-id/959fa202-b251-4fcd-8d5f-8ed83740fe43">https://w3id.org/ro-id/959fa202-b251-4fcd-8d5f-8ed83740fe43</a>

NOISE MAPS	<a href="https://w3id.org/ro-id/370d93ab-df01-46de-982e-0ef74b3acf8a">https://w3id.org/ro-id/370d93ab-df01-46de-982e-0ef74b3acf8a</a>
SONIC KAYAKS	<a href="https://w3id.org/ro-id/4776fc21-01a3-4806-b248-70a577cbc6b0">https://w3id.org/ro-id/4776fc21-01a3-4806-b248-70a577cbc6b0</a>
IN MY BACKYARD	<a href="https://w3id.org/ro-id/b7601048-d964-4c6f-92ac-f6956817dd44">https://w3id.org/ro-id/b7601048-d964-4c6f-92ac-f6956817dd44</a>
WOW NATURE	<a href="https://w3id.org/ro-id/7f2a62c1-21cb-42b1-875f-e7d2d19873c8">https://w3id.org/ro-id/7f2a62c1-21cb-42b1-875f-e7d2d19873c8</a>
WALK UP ANIENE	<a href="https://w3id.org/ro-id/06e181e7-2b8a-4be3-84c2-23a478124a96">https://w3id.org/ro-id/06e181e7-2b8a-4be3-84c2-23a478124a96</a>
RESTART DATA WORKBENCH	<a href="https://w3id.org/ro-id/20d36a59-bef3-4e45-8593-09c8755c0b50">https://w3id.org/ro-id/20d36a59-bef3-4e45-8593-09c8755c0b50</a>
OPEN SOIL ATLAS	<a href="https://w3id.org/ro-id/779e414c-0f1c-449f-8a13-6bb226f3b5fb">https://w3id.org/ro-id/779e414c-0f1c-449f-8a13-6bb226f3b5fb</a>
MAPPING MOBILITY	<a href="https://w3id.org/ro-id/d8872d42-80b9-4159-ae23-a26d83d74798">https://w3id.org/ro-id/d8872d42-80b9-4159-ae23-a26d83d74798</a>
WATER SENTINELS	<a href="https://w3id.org/ro-id/d023eb59-88d7-4035-8045-d5c4bc5bb6a2">https://w3id.org/ro-id/d023eb59-88d7-4035-8045-d5c4bc5bb6a2</a>
AZOTEA	<a href="https://w3id.org/ro-id/c8d3b7b7-cc36-4257-a785-6991780fc142">https://w3id.org/ro-id/c8d3b7b7-cc36-4257-a785-6991780fc142</a>
LOSS OF THE NIGHT	<a href="https://w3id.org/ro-id/2fdec72d-e533-4490-9a09-91e9e2316944">https://w3id.org/ro-id/2fdec72d-e533-4490-9a09-91e9e2316944</a>
CITIZEN SCIENTISTS, DRAGONFLIES AND PESTICIDES	<a href="https://w3id.org/ro-id/59127a39-5efd-4da6-b3fb-ec30972fb0ff">https://w3id.org/ro-id/59127a39-5efd-4da6-b3fb-ec30972fb0ff</a>
TATORT STREETLIGHT	<a href="https://w3id.org/ro-id/3dc681e1-cfbf-4540-a033-9bb3df338a46">https://w3id.org/ro-id/3dc681e1-cfbf-4540-a033-9bb3df338a46</a>

### 3.2 Research objects generated by survey studies about motivation

Deliverables D5.6 “Initial analysis and guidelines of incentives and motivation within citizen science” and D5.7 “Final analysis and guidelines of incentives and motivation within citizen science” describe the study of motivation for citizen scientists performed within the ACTION project. The study, based on a survey designed to investigate the motivating factors of participants involved in citizen science projects, was performed considering the TESS Network<sup>10</sup> community and six citizen scientist pilots who took part in the second ACTION acceleration program (Mapping Mobility, Open Soil Atlas, Water Sentinels, Restart Data Workbench, Wow Nature, Walk Up Aniene).

<sup>10</sup> <https://tess.stars4all.eu/>



This section describes the research objects defined and published to share the performed study of motivation in citizen scientists. The research objects, designed using the ASSET tool, leverage the Survey Ontology (discussed in Section 2.4) and the RO-Crate specification to describe the relevant resources and their relations.

### 3.2.1 Research Objects

Survey data exported from Coney and modelled using the Survey Ontology, are packaged in comprehensive RO-Crate research objects including:

- the representation of the survey procedure,
- the collected answers with provenance information,
- the script and results of the analysis, and
- related publications.

For the survey study of motivation for citizen scientists, a *template survey*, designed to investigate different motivation factors, was customised and administered to the participants of different citizen science projects. We decided to define one research object for each survey administered, and a comprehensive research object for the overall study referencing all the others.

Figure 12 represents through the ASSET tool the template structure of the research objects defined for each of the surveys administered: TESS Network, Mapping Mobility, Open Soil Atlas, Water Sentinels, Restart Data Workbench, Wow Nature, Walk Up Aniene.

Resources made available within each research object are:

- *Survey Procedure* (\*-procedure.ttl): contains the RDF representation of the structure of the conversational survey (questions, answers, etc.) using the Survey Ontology
- *Survey Results* (\*-results.ttl): contains the RDF representation of the answers collected using the Survey Ontology
- *Survey* (\*-survey.ttl): contains a comprehensive RDF representation of the survey data using the Survey Ontology
- *CSV Survey Results* (\*-results.csv): contains the CSV of the collected answers
- *Analysis Script* (\*-script.R): is the R script developed to analyse the collected answers
- *Mean-Var-Questions* (\*-mean-var-motivating-questions.csv): contains the computed mean and average for each question considered (observable variables)
- *Mean-Var-Factor* (\*-mean-var-motivating-factor.csv): contains the computed mean and average for each motivation factor considered (latent variables)
- *Correlation-Global-Motivation* (\*-correlation-factors-global-motivation.csv): contains the correlation analysis between each motivation factor and the global motivation

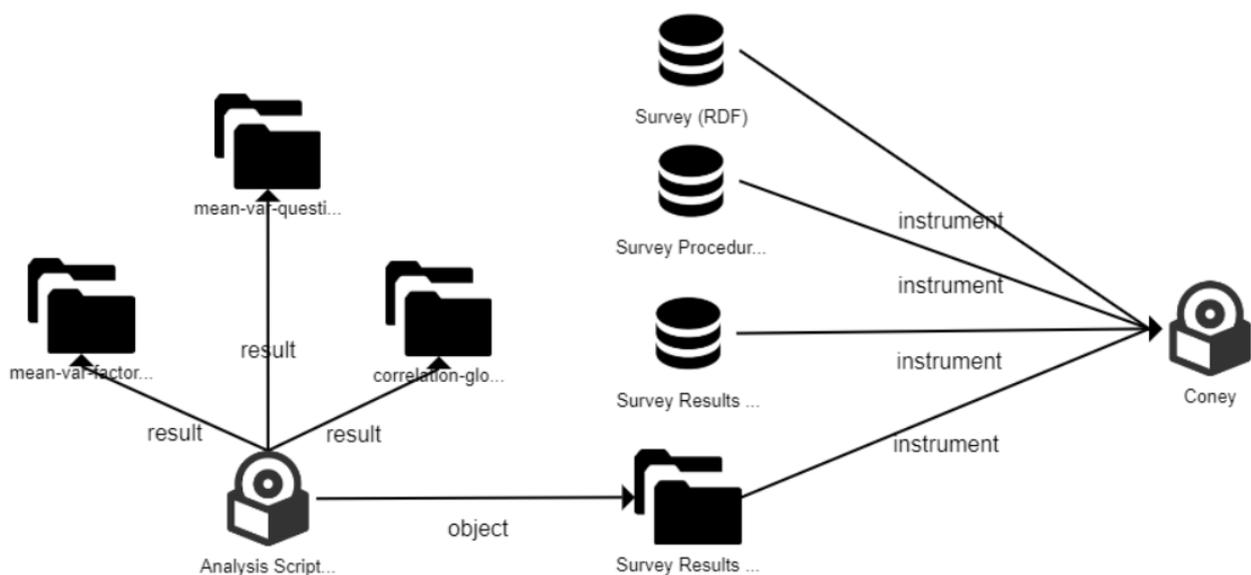
**Figure 12: Structure of Research Objects defined for each survey designed and administered in the study**

Each RO-Crate also defines two *CreateAction* to describe provenance information<sup>11</sup>:

- *Export Survey Data*: specifies which files, representing survey data, were extracted using Coney;
- *Run survey results analysis*: specifies (i) which file, representing the CSV results of the survey, was used to run the analysis, (ii) which file, representing the R script, was used to run the analysis, and (iii) specifies which files, representing the results of the analysis, were generated.

Minor remarks are related to the structure of the RO-Crates for the *Mapping Mobility* and *Water Sentinels* pilots. The RO-Crate for the *Mapping Mobility* pilot does not contain information about the analysis due to the low number of answers collected. The RO-Crate for the *Water Sentinels* pilot contains an additional export of the results in the CSV format of Google Forms<sup>12</sup> that was used to administer the survey. For the *Water Sentinels* pilot, the script defined to analyse the results considers as input the Google Forms export as defined in the associated *Run survey results analysis* action.

Figure 13 represents through the ASSET tool the structure of the research object defined to describe the overall study. The research object references all the RO-Crates, describing the



different surveys administered in detail, and the deliverable D5.7 discussing the results of the study.

**Figure 20: Structure of the Research Object describing the overall study**

<sup>11</sup> <https://www.researchobject.org/ro-crate/1.1/provenance.html>

<sup>12</sup> <https://www.google.com/forms/about/>

Resources made available within the research object are:

- *Survey Procedure* (\*-procedure.ttl): contains the RDF representation of the *template* structure of the conversational survey (questions, answers, etc.) to investigate the motivation for citizen scientists using the Survey Ontology
- *Mean-Var-Questions* (\*-mean-var-motivating-questions.csv): contains the computed mean and average for each question considered (observable variables) comparing all the surveys performed
- *Mean-Var-Factor* (\*-mean-var-motivating-factor.csv): contains the computed mean and average for each motivation factor considered (latent variables) comparing all the surveys performed
- *Correlation-Global-Motivation* (\*-correlation-factors-global-motivation.csv): contains the correlation analysis between each motivation factor and the global motivation comparing all the surveys performed

### 3.2.2 Publication

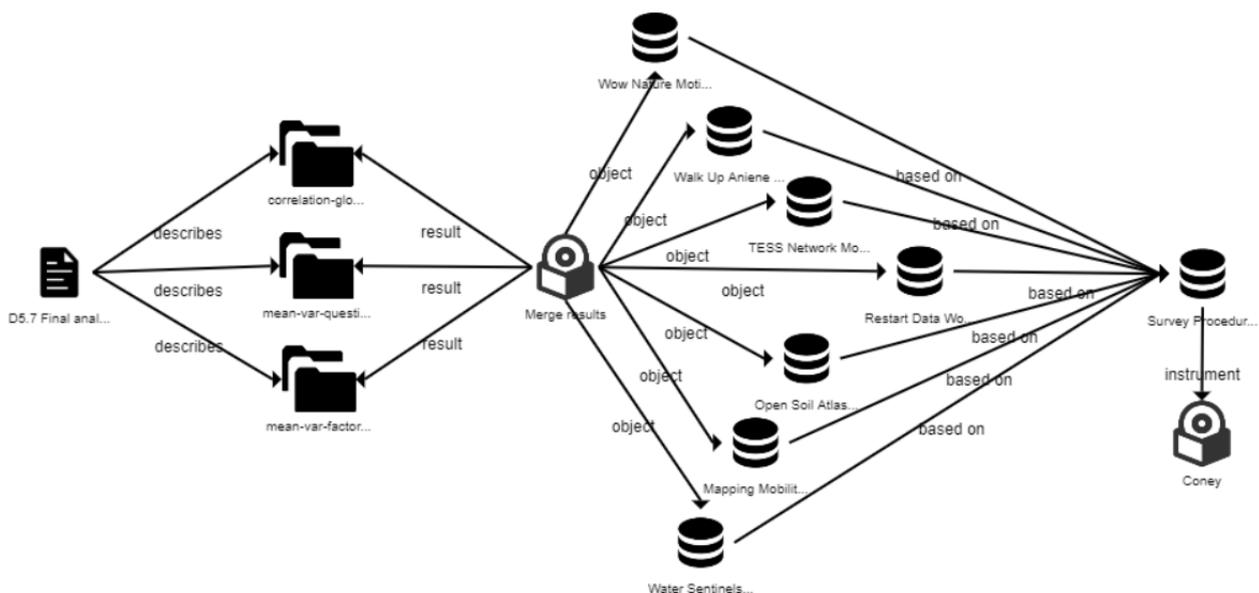


Figure 21: Structure of the Research Object describing the publication

The defined research objects are publicly available on Zenodo within the ACTION community. The resource packages are published as RO-Crates and have the following identifiers:

- Walk Up Aniene Motivation Survey <https://doi.org/10.5281/zenodo.5753229>
- TESS Network Motivation Survey <https://doi.org/10.5281/zenodo.575376>
- Restart Data Workbench Motivation Survey <https://doi.org/10.5281/zenodo.5753123>
- Open Soil Atlas Motivation Survey <https://doi.org/10.5281/zenodo.5752354>
- Mapping Mobility Motivation Survey <https://doi.org/10.5281/zenodo.5727476>
- Wow Nature Motivation Survey <https://doi.org/10.5281/zenodo.5770198>
- Water Sentinels Motivation Survey <https://doi.org/10.5281/zenodo.5770164>

## RESEARCH OBJECTS CATALOGUE

The research object for the overall study “Survey Study about Motivation for Participants in Citizen Science Projects” is identified with <https://doi.org/10.5281/zenodo.5753092>.

A single resource in a RO-Crate can be referenced using the template url <https://zenodo.org/record/<record-number>/files/<name-file>>. For example, <https://zenodo.org/record/5753092/files/survey-motivation-template-procedure.ttl> identifies the template survey procedure.

The survey research data made available in the RO-Crates using the Survey Ontology, have been also published as Linked Open Data<sup>13</sup>. Each RO-Crate on Zenodo lists as a *related identifier* the IRI assigned to the *survey research object* entity described in RDF. For example, [https://coney.cefrriel.com/lod/Survey\\_626734392-1569918565818](https://coney.cefrriel.com/lod/Survey_626734392-1569918565818) identifies the one for the TESS Network Motivation Study.

Exploiting a customisation of the LodView<sup>14</sup> framework, the data can be easily navigated through a user interface and downloaded in different formats. The interface is also enriched with the ontology documentation and offers information on the entities and properties used for the data. A SPARQL endpoint is available at <https://coney.cefrriel.com/sparql> to semantically query and discover the available data.

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<sup>13</sup> <https://www.w3.org/standards/semanticweb/data>

<sup>14</sup> <https://github.com/LodLive/LodView>



## 4 CONCLUSIONS

One of the objectives of the WP4 is to implement and integrate the software needed to support the lifecycle of Research Objects. Capturing the knowledge generated in a project is not only identifying resources, but also relationships. For this reason a mechanism to interconnect researchers and knowledge designers is needed.

There are specifications like RO-Crate that help in these tasks, but require a long curve of learning, and are difficult for non-expert users to understand . Since the first version of the document, we decided to use a graphical notation to model it, similar to the one used by computer scientists to model their applications (UML notation).

After our experience with the pilots, we decided to change the notation presented in the first version. Although the process to extract knowledge was not a problematic task, the notation was complicated for them. For this reason, we concluded to simplify it.

Another objective defined in the first version of the deliverable was to integrate the open data portal with the research objects. We needed a representation language to model our research objects. Our first option was to choose RO-Crate as *this language*, but as we have said, it is not easy to manage by non-expert users. We have solved the problem by adapting a tool to draw our research objects, following the new notation, and generating the research objects in an Ro-Crate format. Once the research object is created, it can be exported to the data portal and to the platform RO-Hub,

With these decisions, we have achieved the goals planned at the beginning of the project.

## 5 REFERENCES

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