This project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement n° 101037648 – SOCIO-BEE

Grant Agreement No: 101037648
[H2020-LC-GD-2020-3]

Wearables and droneS fOr CIty Socio-Environmental Observations and Behavioral ChangE

Deliverable

D5.12 - Evaluation of pilots & behaviour change assessment.R1

Workpackage No.	**WP5**	Workpackage Title	**Pilots, Integration Testing & Evaluation**
Task No.	**T5.6**	Task(s) Title(s)	**Evaluation & interpretation of the pilot results**
Lead beneficiary		**HKU**	
Dissemination level		***PU***	
Nature of Deliverable		***R***	
Delivery date		**30 09 2023**	
Status		**F**	
File Name:		[SOCIO-BEE] D5.12 - Evaluation of pilots & behaviour change assessment.R1_final.pdf	
Project start date, duration		**01 October 2021, 36 Months**	

Authors List

Leading Author (Editor)				
Surname		***Initials***	***Beneficiary Name***	***Contact email***
Renger		WJR	HKU	willem-jan.renger@hku.nl
Co-authors (in alphabetic order)				
#	***Surname***	***Initials***	***Beneficiary Name***	***Contact email***
1	Hoogendoorn	EJMH	HKU	evert.hoogendoorn@hku.nl

Contributors (in alphabetic order)				
#	***Surname***	***Initials***	***Beneficiary Name***	***Contact email***
1	Barco	AB	UDEUSTO	a.barco@deusto.es
2	Crombie	DC	HKU	david.crombie@hku.nl
3	Casado-Mansilla	DCM	UDEUSTO	dcasado@deusto.es
4	Kotzagianni	MK	MK	mkotzagianni@maroussi.gr
5	Lisbona	DL	IBER	dlisbona@ibercivis.es
6	López-de-Ipiña	DLDI	DEUSTO	dipina@deusto.es
7	Morresi	NM	UNIVPM	n.morresi@pm.univpm.it
8	Udina	SU	BETTAIR	sudina@bettaircities.com

Reviewers List

List of Reviewers (in alphabetic order)				
#	***Surname***	***Initials***	***Beneficiary Name***	***Contact email***
1	Kopsacheilis	EVK	CERTH	ekops@iti.gr
2	*Morresi*	*NM*	*UNIVPM*	*n.morresi@pm.univpm.it*
3	*Recanatini*	*PR*	*ANCONA*	*paolo.recanatini@comune.ancona.it*

Document History			
Date	***Version***	***Author***	***Description***
14-09-2023	v001	**Renger**	first document framework
18-09-2023	v002	**Renger**	
21-09-2023	v003	**Hoogendoorn**	chapter 5: questionnaires
22-09-2023	v004	**Hoogendoorn**	Socio-Demographic analysis
25-9-2023	v005	**Renger**	Recommendations
26–9-2023	v006	**Renger**	KPI analysis
26-9-2023	V007	**Hoogendoorn**	Layout, lists of figures, -tables etc.
26-08-2023	V008	**Renger**	Final draft

List of definitions & abbreviations

Abbreviation	Description
AVT	Ancona Visualization Tool
AQ	Air Quality
BK	Beekeeper
CS	Citizen Science
CO	Confidential
D	Deliverable
KPI	Key Performance Indicator
M	Milestone
MVE	Micro-volunteering Engine
MVP	Minimum Viable Prototype
O	Objective
PU	Public Use
QB	Queen Bee
QC	Quality Control
SO	Sub Objective
TRL	Technology Readiness Level
WB	(Worker) Bee
WP	Work Package
WSN	Wearable Sensor Node

Executive Summary

The purpose of this deliverable is to scrutinize and assess the initial phase of citizen science trials facilitated under the aegis of the SOCIO-BEE initiative, with a focus on understanding the transformation in participants' perspectives and behaviors concerning air pollution.

Executed in Ancona, Zaragoza, and Marousi, these trials served as a rigorous evaluation platform for all facets of the Socio-Bee citizen science strategy in genuine, real-world settings. Our goal is to not only gather substantial data from the pilot's enactment but also to engage in a profound reflection on its outcomes in order to come up with recommendations for MVP2 in preparation of the second iteration of pilots.

Most of our KPIs progress satisfactorily. In some instances, KPIs have not yet achieved their intended values. Especially impact related KPIs and behavior change KPIs need adaptations of the technological components and their support materials to fully materialize.

The available SOCIO-BEE components were operational to the extent that pilot cities could perform test campaigns under field conditions. But the maturity of components fell slightly short in closing the citizen science loop to its full extend, prohibiting extensive evaluation of campaign outcomes informing actionable steps after campaign completion.

Main areas of improvement can be summarized in four categories:

1. Closing the Citizen Science Loop enabling citizens to analyze data, reflect on hypotheses, drawing conclusions and disseminating results.\
2. Improving the usability and self-efficacy for Queen Bees and Bees
3. Improving support and communication materials as scaffolding materials for stand-alone Hive operations.
4. Attempts to alleviate some of the questionnaire related workload for the pilot cities and Beekeepers.

The first round of pilots can be deemed successful in presenting the consortium with clear areas of improvement and lessons learned to support successful achievement of the SOCIO-BEE objectives set out for the project.

Table of Contents

List of Figures

List of Tables

1 Introduction

1.1 Purpose of the document

The objective of this report is to scrutinize and assess the initial phase of citizen science trials facilitated under the aegis of the Socio-Bee initiative, with a focus on understanding the transformation in participants' perspectives and behaviors concerning air pollution.
Executed in Ancona, Zaragoza, and Maroussi, these trials served as a rigorous evaluation platform for all facets of the Socio-Bee citizen science strategy in genuine, real-world settings. Our goal is to not only gather substantial data from the pilot's enactment but also to engage in a profound reflection on its outcomes in order to come up with recommendations for MVP2 in preparation of the second iteration of pilots.

1.2 Reflection on T5.6 Evaluation and interpretation of the pilot results

This deliverable stems from the efforts in Task 5.6, which emphasizes the holistic evaluation of the work leading to the first set of pilots. Prior to the pilot launches, we teamed up with DEUSTO, who oversaw pilot planning, and BETTAIR, who monitored the pilot execution, to lay the groundwork for this report.

Upon the conclusion of the pilots, we embarked on an in-depth assessment of key deliverables leading up to D5.12. This included reviewing D2.6 (SOCIO-BEE Methodology for Ecosystem & Hive Creation), D5.6 (Definition and Planning of Pilots), D5.8 (Pilot Site Preparation & End User Training), and D5.10 (Execution and Monitoring of SOCIOBEE Pilots).

All findings from the pilots and the SOCIO-BEE system validation underwent thorough analysis and interpretation. Our primary goal was to chart out guidelines to enhance the system concerning model performance, data collection, and usability. This entailed evaluating user interface responsiveness and usability, gauging user engagement, and appraising the significance of the collated data. From this, we've distilled ten essential recommendations to enhance the second iteration. Some of these insights will be integrated into T5.4 and T5.5 activities, prepping for the final pilot phase.

This report is the inaugural step in a two-phase process. Moving forward, we'll collaborate with all project stakeholders to translate these recommendations into actionable tasks. It's crucial that we prioritize these recommendations, keeping in mind the resources at our disposal.

Post the second pilot, we will revisit this deliverable in M35, employing a similar approach.

1.3 Structured Analysis

To ensure a robust analysis leading to actionable recommendations for enhancing the upcoming iteration of Socio-Bee citizen science trials slated for M19 (March 2023) to M22 (July 2023), we will undertake a meticulous analysis guided by the following steps:
1. **Critical Evaluation of KPIs**: An analysis of the progression of the Key Performance Indicators (KPIs) related to the performance in the initial trials.

2. **Data Analysis from Questionnaires**: Detailed scrutiny of data accrued from the extensive questionnaires administered pre, mid, and post-pilot campaigns.
3. **Qualitative Analysis with Key Partners**: Engaging with primary stakeholders for a qualitative analysis of the pilot's conduct.
4. **Issue Analysis**: A comprehensive review of the issues logged in the Redmine environment concerning the utilization of the mobile and desktop apps, alongside the wearable sensor node during the pilot's duration.
5. **Triangulation of analytical data and conclusions**: an analysis of all findings, forming provisional conclusions based on the evidence garnered.
6. **Recommendations for pilot 2**: Outlining recommendations to refine the Socio-Bee components, thereby ensuring a more successful second pilot phase.

1.4 Relationship with other deliverables

Table 1: relationship with other deliverables

#	Title	Dissemination Level	Due Date	Relationship to D5.12
D2.6	SOCIO-BEE Methodology for ecosystem & hive creation.R1	PU	M22	D2.6 is an analysis of the barriers in relation to the bears and how to make the data from Socio-Bee actionable
D5.6	D5.6 - Definition and planning of pilots – 1st release	PU	M17	Defines the evaluated pilots, onboarding materials and questionnaires
D5.8	Pilot Site Preparation & End User Training	CO	M19	
D5.10	Execution and monitoring of SOCIO-BEE Pilots	CO	M21	Describes and analysis thee outcomes of the alpha and beta tests of Pilot 1.

2 Socio-Bee objectives

Following the completion of Pilot 1, this deliverable aims to evaluate the impact of the SOCIO-BEE approach across all pilot sites, specifically its effectiveness in prompting citizens to adopt greener habits. We analyze and interpret the data garnered from the pilots and from the validation of the SOCIO-BEE system to assess the overall efficacy of the system, as well as the tools and methods employed. This analysis will yield:

- An assessment of model accuracy, evaluating how well they capture user profiles and the outcomes of behavior change analyses.
- Recommendations for enhancing the system, encompassing improvements in model performance, data collection, and usability.

- An evaluation of the user interface's responsiveness and user-friendliness.
- An assessment of user engagement levels.
- An appraisal of the data's value in refining or adapting the services offered.

When aligning with the overarching objectives of the Socio-Bee project (refer to Annex 1), this deliverable zeroes in on a select subset of objectives. These specifically pertain to the components of Socio-Bee that hold potential for refinement and further development.

O2: Development of low-cost modular wearable hardware solution suitable for large crowdsourcing environmental measurements ensuring mass adoption and replicability.

O3: The development of a citizen science-based web platform to allow CS Hives in the active collection of environmental and socio-economic data through wearable technologies and research-based instruments.

O4: Establish an open and sustainable decision-making process with a data analysis platform for the overall CS process: cross-linking of environmental data in collaboration with citizens, scientists, citizen observatories and local decision makers.

This does not mean that we do not look at the other objectives. At the end of this deliverable we will make recommendations and relate them to the specific objectives, sub objectives and KPI's.

3 Contextual description regarding pilot 1

3.1 Introduction

Before delving into the data, KPIs, and further analysis, it's pivotal to understand the conditions and state of development of the Socio-Bee components in MVP1 as the cities launched their pilots. The maturity of technological components and support materials impacted the outcomes of pilot 1 and should be identified to properly assess pilot 1 results.

3.2 Maturity of the technological components

Socio-Bee represents a pioneering endeavor in the realm of citizen-driven initiatives. Ahead of the first pilot, there was a significant push to advance and unify both hardware and software components. Impressively, by the time the pilot commenced, the consortium had unveiled a near-complete technological prototype, including a working Wearable Sensor Node, an introductory app, and an operational online platform. Another integral piece of the SOCIO-BEE infrastructure is the BEE-MATE API, designed to analyze multimedia data to extract insights about air quality and pinpoint specific pollution sources. During the initial pilot phase, the BEE-MATE services operated separately, rather than being integrated into the AcadeMe app. Participants from Amaroussion and Zaragoza captured videos, which BEE-MATE subsequently analyzed to determine the sources of air pollution.

However, the stringent timeline meant certain features, or integration of components with the AcadeMe app, of the prototype were incomplete. This was the reason for the project's design into two developmental stages. While prioritizing component integration and operability, exhaustive user testing and comprehensive bug fixes were unfortunately compromised. This led to a series of challenges, also due

to project interdependencies.

3.3 Maturity of the support materials

The majority of the supportive materials could be conceived irrespective of the advancement of the technological components. Some support materials depended on the delivery of the final incarnation of the first MVP, like training materials and some campaign materials. There was limited time to perfect these materials given the time pressure on the pilot cities to start executing their test campaigns.
With the development moving close to the pilot start date, the pilot cities had to work with a great number of constraints, having ample time to recruit, instruct and supervise the Hive pioneers to execute test campaigns. The successful execution of pilot campaigns is a testimony to their dedication and flexibility.

3.4 Pilot execution specifics relevant to data interpretation

Despite these complexities, the core technological components were operational and pilot cities managed to conduct test campaigns. But as is the case with a first iteration of a MVP, some issues emerged throughout the test itself. These issues were collected in a Redmine environment. A quick response support structure between pilot cities and technological partners meant that many issues prohibiting campaign execution could be solved in the process. Other issues still remain and from the basis of recommendations in this deliverable.
The scope of the pilots in terms of number of participants and the nature of participants varies between pilot cities. A number of factors are important to note being of influence in interpreting the data results.

- The scope of the test Hives. The scope of the first pilot was limited for various reasons, like the number of available calibrated WSN's. These novelty pieces of complicated hardware had to be engineered and developed, produced and calibrated on a very ambitious timeline. It is commendable that the majority of the sensors met expectations and performed well in field conditions with non-expert users. The scope of the first pilot also means relatively small groups of respondents on the questionnaires, which sometimes result in larger standard deviations.
- The nature of the target audiences. To a greater or lesser extent, citizens should be involved in the first pilot rounds, combined with professional users to test the MVP. Marousi and Ancona involved their primary target audience, with satisfactory results. Zaragoza did not involve their primary target group (children) for a variety of valid reasons. The test window of opportunity with the children could not be met; support materials were not yet tailored to a very young audience and could not be adapted in time; and the maturity of the first MVP was deemed too complex to use with this group yet. In general, this means that as part of the user groups involved in the first pilot, a relatively large proportion of the test users are not fully representative of the eventual intended primary user groups. Users were in general more informed on the subject matter, well versed in the use of immature technology, and capable and persistent in trouble shooting whenever the MVP contained a bug or unpolished feature. This should be taken into account when interpreting the dataset from the first pilot.
- The nature of the support structures. In the pilot cities, some dedicated Queen Bees close to the project provided intensive support to the target users. Through their ingenuity and

dedication a number of pending issues could be overcome. This contributed substantially to the successes in pilot one, but this factor can not be extended in the future of the Socio-Bee environment once Queen Bees step in with different levels of involvement and different skill sets. This means the Socio-Bee components will have to mature in usability, accessibility and clarity to neutralize this temporary additional effort.

- A critical constraint during the pilot was the MVP's unfinished state, notably the feature for comprehensive campaign results visualization across all user levels. While a makeshift solution (Ancona Visualization Tool) served the pilot's purpose, it necessitated significant manual intervention. The entire "citizen science loop," from hypothesis formulation to final conclusions, wasn't universally actionable in all pilot campaigns. This limitation impacts several KPIs. However, the anticipated MVP2 is expected to resolve many of these early-stage development issues. Although this had a negative impact on a number of KPI's, we expect this last part of the functionality to be incorporated in MVP2 solving many issues reported at this stage of development.
- All pilot cities reported the additional burden in dealing with the large number of questionnaires and number of items, related to the KPI's set for this project. They share the impression that this additional layer of data collection, which is project specific but not part of the future Socio-Bee scalable solution, might have had a negative impact on campaign participation and adherence results. Still, it has been necessary in order to learn from iteration 1 and be able to adapt the SOCIO-BEE approach and toolset.

3.5 Closing the citizen science loop

Considering the focus of this deliverable on "evaluation of pilots and behavior change," it's essential to examine the entirety of the citizen science loop and how the current MVP stands within this framework. Socio-Bee's foundational belief is that by actively involving citizens in measuring air quality in their communities, awareness is cultivated — both about the scientific process and their local air quality assessment. When measurements yield concerning results, this awareness should ideally spark behavioral adjustments. These changes can manifest individually, influencing daily routines and lifestyle choices, but preferably propel a more collective effort, spurring dialogues with policymakers to instigate actions improving air quality. To truly gauge the impact on behavior change, it's therefore imperative that the citizen science loop is fully closed.

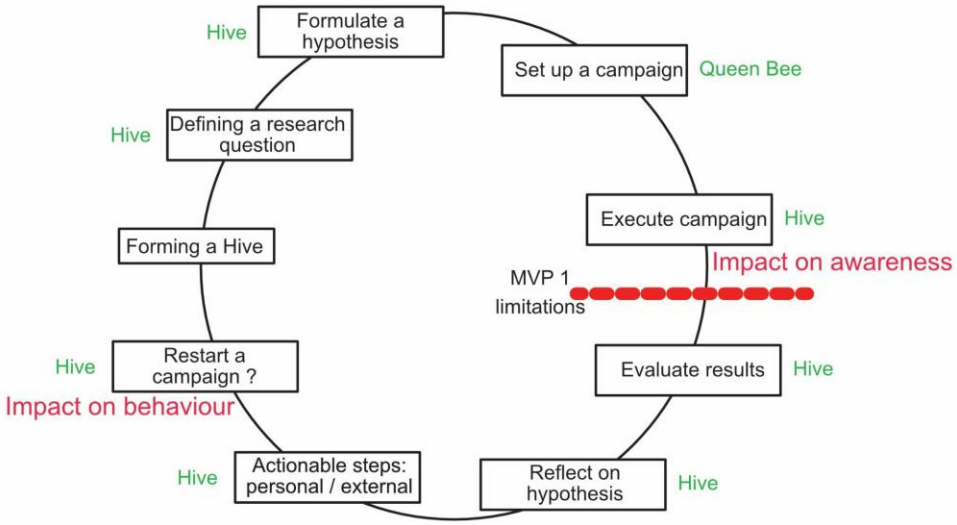


Figure 1. Simplified representation of the Socio-Bee citizen science loop

In Figure 1, we observe the envisioned complete citizen science loop. While the MVP available at the outset of Pilot 1 showed promise, it hadn't matured enough to fully close this loop. A significant barrier was the absence of an integrated method for visually presenting campaign results, supplemented with materials that would allow reflection on the campaign's outcomes, its initial hypotheses, and the final observations regarding air quality in each campaign. Although a last-minute solution provided pilot cities with a separate tool (Ancona Visualization Tool) to manually compile campaign data, this approach was provisional and demanded significant manual effort. As a result, while the loop could be completed at the Queen Bee/Beekeeper level, it wasn't consistently extended to all Bees. Consequently, making informed conclusions about behavioral changes at a Bee level is currently premature. This makes closing the citizen science loop in both the technological components and the supportive materials one of the key priorities for pilot 2.

4 Critical Analysis of KPI's

The initial pilot phase was designed to evaluate every facet of the Socio-Bee MVP1. The goal was to engage volunteers, introduce them to the Socio-Bee framework, and integrate them into groups called Hives. These volunteers were then familiarized with fundamental air pollution concepts and their respective roles within the Hives. Each Hive was then tasked with crafting a research question, formulating a hypothesis, and organizing a measurement campaign. To facilitate this, a designated Queen Bee established a campaign in their vicinity, aiming to investigate the hypothesis through air pollution data collection. This process was supported by the Socio-Bee mobile app, which interfaced with the Wearable Sensor Node developed by Bettair. The app provided suggested measurement locations within their specified research domain. Upon concluding their campaigns, the Hives would analyze the data, evaluate its alignment with their initial hypotheses, and deliberate on subsequent actions based on their findings.

4.1 KPI's in progress

The performance and progress in the Socio-Bee project is covered by 80 KPI's in 13 sections. Reaching those KPI's is a work in progress. Since this document marks an important milestone in completing Pilot

1, we will look at the KPI's and identify which KPI's will require special attention for the second pilot, specifically those relevant to the iterative improvement of the SOCIO-BEE technical components, supportive tools and materials and other aspects related to the performance of the pilot cities in pilot 2 .

4.1.1 KPI 12 results: addendum

The results of KPI 12 were not available at the time of writing D5.10. These data are therefore included in this deliverable. As can be seen from table 2, after pilot 1 this KPI meets its intended targets already.

Table 2: KPI 12 Scientific Literacy

KPI 12	Scientific Literacy						
KPI12.1	Increased interest or engagement in science	>= 80%		85	88	81	86
KPI12.2	Intention to be involved in new citizen science projects	>= 75%		86	88	84	85
KPI12.3	Improved participant understanding of science	>= 50%		78	80	79	76
KPI12.4	Better participant attitudes toward science	>= 75%		81	80	76	87
KPI12.5	Increased participant interest in science as a career	>= 35%		65	58	73	65

4.1.2 Reflections on KPIs

KPI 1 is slightly below 50% at this stage of the project but the overall target set is still ambitious.
KPI 2 related to the WSN deployment in the SOCIO-BEE project, progresses as expected
KPI 3 shows positive results for Ancona and Marousi, with less positive results for Zaragoza. The differences in these results will be analyzed in this document (see **Section 6**)
KPI 4 is influenced by the state of maturity of the MVP related to the ability to fully close the citizen science loop in pilot 1. More on this is elaborated in **Sections 3, 6 and 7.**
KPI 5 is progressing satisfactorily and on track.
KPI 6 seems mostly on track, with some special attention KPI 6.1.a in pilot 2.
KPI 7 becomes more relevant towards the end of the project and is on track.
KPI 8 is progressing satisfactorily and on track. Some numbers might still be ambitious; the Bee/Sensor ration for Pilot 2 is challenging in its aim involve 150 participants.
KPI 9 is influenced by the same as KPI 4 and needs attention, especially from a communication point of view
KPI 10 is progressing satisfactorily and on track.
KPI 11 Data results for this KPI are not in line with impressions from other data sources, those being more positive. Our overall impression is that the MVE works as advertised but might have suffered from usability issues based on the maturity of the prototype app and backend.
KPI 12 Based on the state of maturity of the current MVP these are above expectation at this stage of the project.
KPI 13. This KPI will benefit from the results harvested in Pilot 1 which will help disseminate concrete project results, but more work needs to be done in this area.

Table 3: Full list of KPIs and current values at D5.12 submission date

KPI	Description	Objective Value	Adjusted Objective Value	Current Value			
				Total	ANC	MRSI	ZRZ
KPI 1	**Air pollution reduction support initiatives KPIs**						
KPI 1.1	Total number of EU citizens involved in the design process (surveyed or interviewed)	3000		1243	42	39	35
Comment on KPI 1.1 **BETTAIR:** Value includes 1127 interviews corresponding to a cross-sectional survey to EU citizens in Spain, Greece and Italy distributed by UDEUSTO and VUB that shaped the project design process. A preliminary analysis is reported in D2.4.							
KPI 1.2	% of EU citizens who feel more aware of air pollutions issues after being involved in SOCIO-BEE	>= 70%	>= 70%		76%	80%	68%
KPI 1.3	Availability of integrated, ready-to-use CS co-creation platform and the engagement toolkit	1	1	1			
KPI 1.3a	SOCIO-BEE platform open-source releases at https://eu-citizen.science/	>=3		1			
KPI 1.3b	Publication in GitHub repository of SOCIO-BEE platform and toolkits	>= 2		1			
KPI 2	**Low-cost modular wearable sensor solution KPIs**						
KPI 2.1	Integrated, ready-to-use SOCIO-BEE compatible low-cost sensing devices integrated into personal wearables and drones	March 2023	WSNs March 2023 (Drones Jan 2024)	60 (0)	18 (0)	18 (0)	18 (0)
KPI 2.2	Availability of interchangeable and attachable sensor modules to SOCIO-BEE wearable device demonstrating versatility of the solution	3		2	2	2	2
KPI2.3	Number of wearable devices produced	226	160	64	18	18	18
Comments on KPI2.3 **BETTAIR:** 6 of the produced devices were kept for development partners: 1 CERTH, 1 HYP, 4 BETTAIR, 1 ID2M, 1 DEUSTO							
KPI 3	**Citizen Science platform KPIs**						
KPI 3.1	% of Micro volunteering issued recommendations	>= 95%					
KPI 3.2	Technology acceptance rate	>= 80%		76%	82%	89%	56%
KPI 3.2a	User's appreciation (satisfaction) of the SOCIO-BEE (AcadeMe) platform	>= 90%		65%	80%	85%	30%
KPI 3.3	Perceived usability score (e.g. using the System Usability Scale - SUS) related to how the solution fits in their everyday life	>= 70%		72%	80%	85%	52%

Warning from MRSI about calculation for KPI 3.2, 3.2a, 3.3:
MRSI: MK believes that the way questions 12.2, 12.4, 12.8 and 12.10 are phrased leads to confusion and the more satisfied a person is the lower the score he/she gives

KPI 3.3a	Level of usability and accessibility of pilot artefacts	>= 70%		46%	37%	77%	25%
KPI 4	**Open and sustainable decision-making KPIs**						
KPI 4.1	Availability of open science repository in Zenodo connected with SOCIO-BEE platform	1		0			
KPI 4.2	Number of relevant datasets from pollutants types analysed, at least 5 datasets per pilot case	>=6		3			
KPI 4.2a	Publication of open datasets generated in two iterations of pilots	>=6		0			
KPI 4.2b	Access to the open science datasets created by the project	>= 5000		0			
KPI 4.2c	Higher accuracy finer grained pollution datasets (compared with open datasets from public stations)	>= 50%		0			
KPI 4.3	Accessibility and adoption rate of the intelligence supporting tools	>= 70%		65%	65%	81%	48%
KPI 4.4	Number of experts/researchers participating and mentoring in the SOCIO-BEE platform	4		0			
KPI 5	**Citizen Science application KPIs**						
KPI 5.1	Pilot deployments in different pilot sites	6	6	3	1	1	1

Comments on KPI 5.1
None

KPI 5.2	Number of hypothesis or what-if scenarios addressed	15	15	7	2	3	2

Comments on KPI 5.2
Zaragoza: Corresponding to the 2 scientific campaigns defined in WP5.6 Expected at least 2 more hypotheses in the 2nd iteration (two school involved, 1 what-if scenario each)

KPI 5.3	Number of blueprints and templates available for reducing air pollution in cities	3	4	2	2	2	2
KPI 5.3a	CS Experiment blueprints made available	>= 6		5	1	2	2

Comments on KPI 5.3a:
Ancona: analysis of the difference between the AQ in the city center and the reference stations UNIVPM
Zaragoza: Corresponding to the 2 scientific campaigns defined in WP5.6 Expected at least 2 more in the 2nd iteration (two school involved, 1 what-if scenario each)

KPI 5.3b	Demonstration of spreading of use case by exchanging CS blueprints in	>=3	4	2			2

	pilots						
Comments on KPI 5.3b: **Zaragoza:** Corresponding to the 2 scientific campaigns defined in WP5.6 Expected at least 2 more demonstrations in the 2nd iteration (two school involved, 1 what-if scenario each)							
KPI 5.4	% of new participating citizens engaged because of SOCIO-BEE outreaching capabilities after initial campaigns	16%	10%	16%	0%	50%	0%
KPI 5.4a	Demonstration of scaling use case in pilots from iteration 1 to iteration 2	>= 20%	40%	-		50%	
KPI 6	**Legal, ethical, inclusion KPIs**						
KPI 6.1	Number of studies in relation to legal and ethical requirements	>= 3	3	3			
KPI 6.1a	Audit of legal compliance of pilots per iteration	>= 6	6	0	0	0	0
KPI 6.1b	Audit of social values compliance per pilot per iteration	>=3		3			
KPI 6.2	Number of privacy-preserving organizational and technological measures implemented during the project lifecycle	>=5	5	6			
KPI 7	**Business development KPIs**						
KPI 7.1	Business model canvas for 2 types of business and financing models	2	2	1			
KPI 7.2	Deliver a focused business plan at the end of the project to demonstrate the sustainability and reproducibility of the project in at least 2 different cities	2	2	0			
KPI 7.3	Preparation for post-project exploitations: IPR agreements between project partners, agreement on individual/ joint exploitation plans and business plan preparation activities	1	1	0			
KPI 8	**Engagement rates per societal group and type of stakeholder**						
KPI 8.1	Queen Bees recruited by pilot and iteration	>= 3		2.7	2	3	3
KPI 8.2	Bears involved by pilot and iteration	>= 3		3	3	2	4
KPI 8.3	Working Bees involved by pilot and iteration	>= 20		16.7	9	25	16
KPI 8.4	Societal groups involved	>= 3		12	2	3	7
Comments to KPI 8.4: **Ancona:** senior and member of the pilot staff **Zaragoza:** First iteration ran "at home". The pilot activities have not started yet for Zaragoza							

KPI 8.5	Women participation	50%		57%	60%	60%	50%
KPI 8.6	Inclusivity rate target	>= 85%					85%
KPI 8.7	Citizens actively collecting air quality data via wearables	> 600	200 (50 1st iteration + 150 2nd iteration)	50	13	25	20
	Citizens actively collecting multimedia data to identify air quality pollution sources		same as 8.7 for integrated BEEMATE			16	14
Comments to KPI 8.7 **BETTAIR:** metrics for multimedia data collection were provided by pilots for data acquisition performed independently of the SOCIO-BEE App, which does not include capability of media capture at the moment of first pilots iteration.							
KPI 8.8	Citizens collecting qualitative & socio-economic data with micro-volunteering app.	> 2000	450	58	13	25	20
Comments to KPI8.8 **UDEUSTO:** Interpreted as citizens using the micro volunteering app who have gathered at least one measurement Number of times the MVE is invoked to get pollination recommendations from SOCIO-BEE app							
KPI 8.9	National institutions reached by the project	>= 10		5			5
KPI 8.10	Positive feedback from relevant institutions	50%					
KPI 9	**Impact KPIs**						
KPI9.1	Whitebook with recommendations on how CS can impulse citizen engagement and their pro-environmental behavioral change	1		-			
KPI9.2	Mass communication campaigns per pilot	>=2		2	1	1	
KPI9.3	"Word of mouth" communication campaigns per pilot	>=2		10	2	6	>=2
KPI9.4	Meeting with European Institutions regarding the management of citizen initiatives	2	4	2			
KPI9.5	Proof of Value Outside the consortium uses of SOCIO-BEE artefacts	>=2	2	1			
KPI9.6	Cities using SOCIO-BEE	3		3	1	1	1
KPI9.7	Institutional toolkit sent to local authorities	>= 3000	90	0			
KPI9.8	CO2 emission reduction related to citizens involved in the project			-			
KPI9.9	Interest in the project by local		100	150			150

	populations						
KPI 9.10	Improving social and open innovation capacity			-			
KPI9.11	Impact on employment	100	-	105			
KPI9.12	Relevant financing institutions involved in the seminars	>= 3	>= 2	-			
Comment on KPI9.12 **HYP:** This KPI is not applicable for the pilots of SOCIO-BEE. It focuses on the number of financial institutions that the project aims to attract and form public-private partnerships with. The first piloting phase did not focus on engaging financial institutions. Evaluation of this KPI belongs to deliverable D8.5							
KPI 10	**AcadeMe related KPIs**						
KPI10.1	Visualizations of AcadeMe tutorial video	>= 1000	200 at most	16			
KPI10.2	Accesses to SOCIO-BEE AcadeMe portal	>= 3000	1000	543			
KPI 11	**Micro-volunteering engine related KPIs**						
KPI11.1	User willing to follow recommendations	>= 70%		38%			
Comments to KPI 12 In the Spanish translation of the questionnaire "POST SOCIO-BEE Citizen Science Activists Evaluation Questionnaire" a translation error occurred in Q7.1 which might have influenced the measurement.							
KPI 12	**Scientific Literacy**						
KPI12.1	Increased interest or engagement in science	>= 80%		85	88	81	86
KPI12.2	Intention to be involved in new citizen science projects	>= 75%		86	88	84	85
KPI12.3	Improved participant understanding of science	>= 50%		78	80	79	76
KPI12.4	Better participant attitudes toward science	>= 75%		81	80	76	87
KPI12.5	Increased participant interest in science as a career	>= 35%		65	58	73	65
KPI 13	**Communication KPIs**						
KPI13.1	Total # of workshops/webinars by end of project	>=5		4			1
KPI13.2	Number of attendees per workshop	>= 30		40			15
KPI13.3	# of events by end of project	1		1			1
KPI13.4	# of attendees for the final event	>= 50					30
KPI13.5	Total # of project presence in events (national & international)	>= 15		17	2	1	1
KPI13.6	total # of publications (conferences & journals)	>= 8		6	1	2	
KPI13.7	Articles in local newspapers	>= 6		1	1	4	

KPI13.8	Access to the project website	>= 100		3700			
KPI13.9	Numbers of participant visits to the project Web sites	>= 5000		570			
Comment on KPI 13.9 **BETTAIR:** Value provided corresponds only to AcadeMe participant logins into AcadeMe WebApp. It was not possible yet to track which of the visitors to www.Socio-Bee.eu were participants.							
KPI13.10	Total # of visits (sessions) by the end of the project	>= 10000		2200			
KPI13.11	AVG Duration (time spent) per session	>= 3		1.06			
KPI13.12	Total # of followers (Facebook, Twitter, LinkedIn, YT) by the end of the project	>= 1800	>=500	340			
KPI13.13	Total # of mentions in Newsletters by the end of the project	>= 6	>=20	17			
KPI13.14	# of readers per newsletter	>= 80		>2000			
KPI13.15	Total # of brochures by the end of the project	>= 2		2		2	1
KPI13.16	Total # of videos produced for project purposes	>=2		6		2	1

5 Data Analysis from Questionnaires

5.1 Socio Demographic data

In this section, we will present the socio-demographic variables identified for each pilot. The data reveals some discrepancies between the actual demographics and the intended target groups, which in turn affects the key performance indicators (KPIs).

Table 4: Socio-Demographic Analysis: Gender

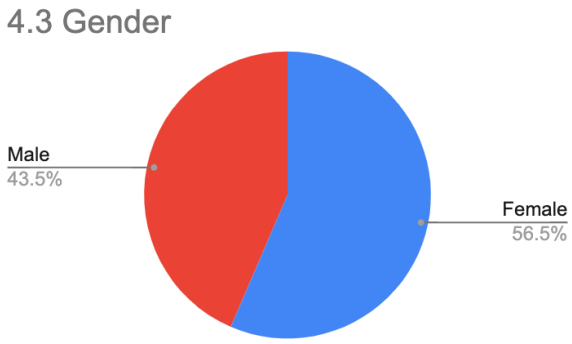
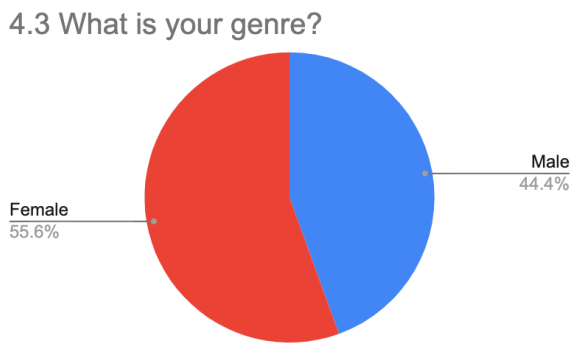
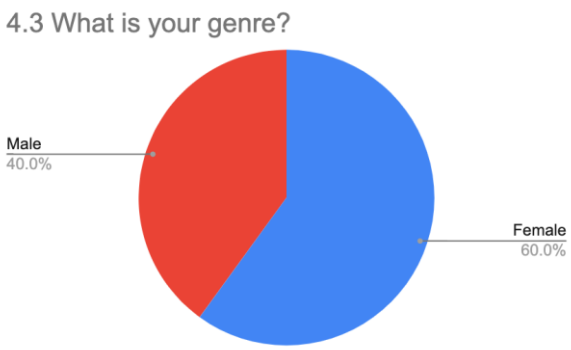
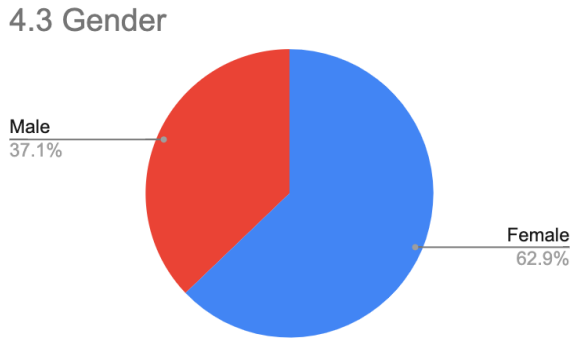
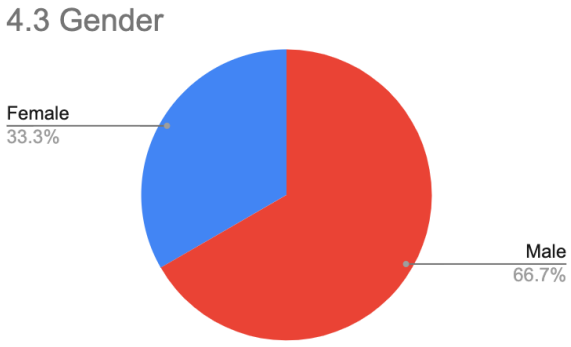
General


Figure 2 average gender balance Socio-Bee Pilot 1

Zaragoza alpha	Zaragoza beta
 Figure 3 Figure 001. Gender balance Socio-Bee Pilot 1 Zaragoza Alpha	 Figure 4 Gender balance Socio-Bee Pilot 1 Zaragoza Beta
Marousi	**Ancona**
 Figure 5 Gender balance Socio-Bee Pilot 1 Marousi	 Figure 6 Gander Balance Socio-Bee Pilot 1 Ancona

Pilot 1 was conducted in three cities: Zaragoza, Ancona, and Marousi. Across all three pilots, we achieved a balanced distribution between male and female participants. None of the participants selected the 'other' option for gender.

Table 5: Socio-Demographic Analysis: Age

General

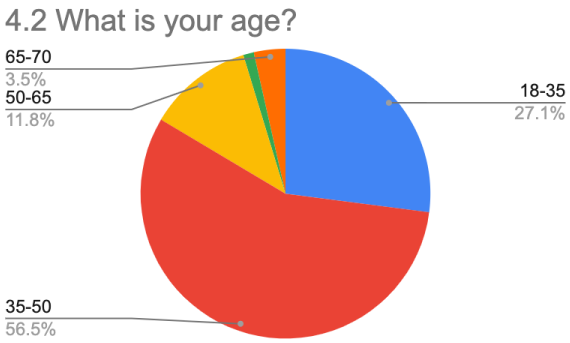


Figure 7 Age distribution Socio-Bee Pilot 1

Zaragoza alpha

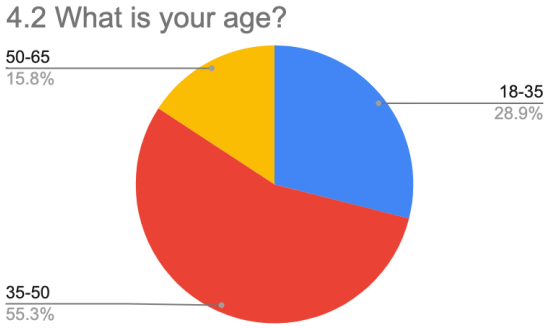


Figure 8 Age distribution Socio-Bee Pilot 1 Zaragoza Alpha

Zaragoza beta

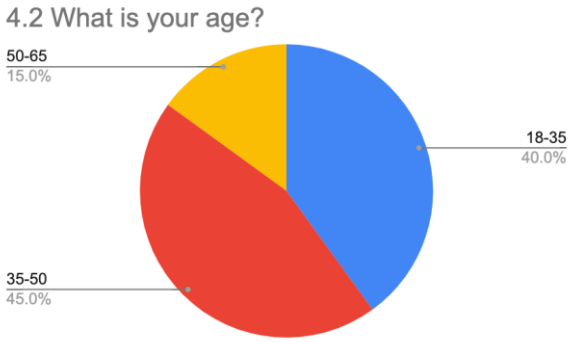


Figure 9 Age distribution Socio-Bee Pilot 1 Zaragoza Beta

Table 6: Socio-Demographic Analysis: Education

General

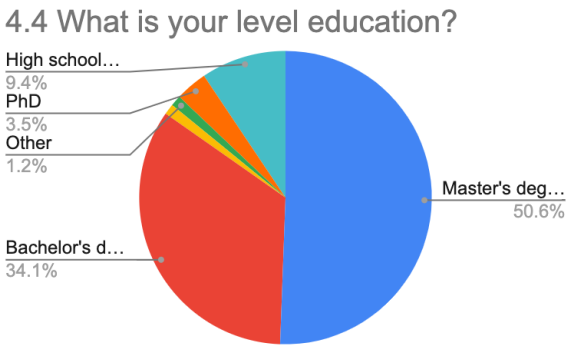


Figure 10 Education distribution Socio-Bee Pilot 1

Zaragoza alpha

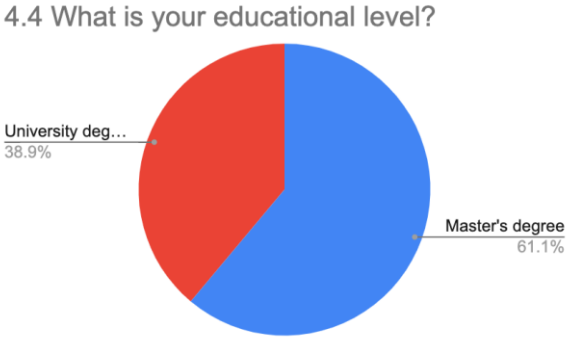


Figure 11 Education distribution Socio-Bee Pilot 1 Zaragoza Alpha

Zaragoza beta

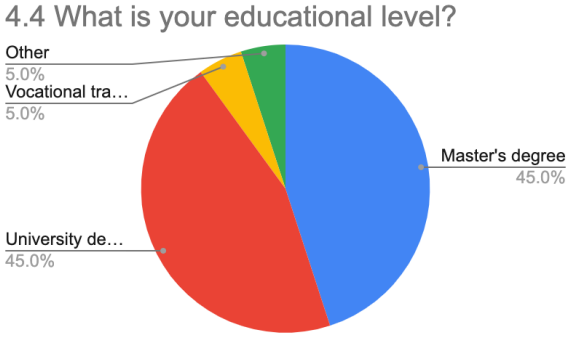


Figure 12 Education distribution Socio-Bee Pilot 1 Zaragoza Beta

Marousi

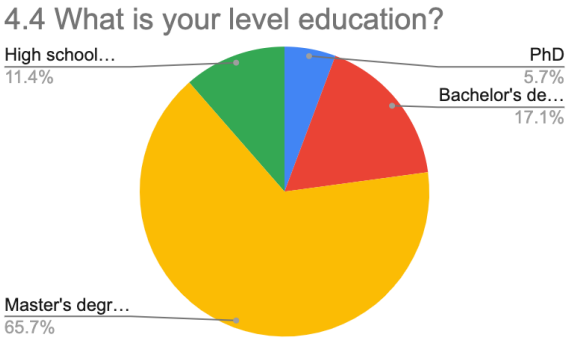


Figure 13 Education distribution Socio-Bee Pilot 1 Marousi

Ancona

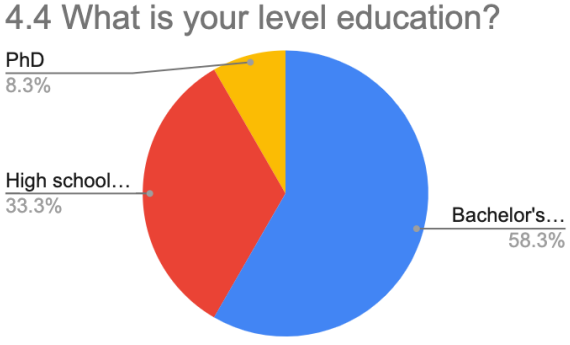


Figure 14 Education distribution Socio-Bee Pilot 1 Ancona

The average participant in the pilots was in the medium age range 35-50 (56%) having some notable representations in age range 18-35, i.e. young people (27%) and mature adults in age range 50-65 (12%) Generally, Pilot 1 participants were employed in either the public or private sector. Marousi's test group displayed the most diversity, with a notable representation of self-employed individuals.

Table 7: Socio-Demographic Analysis: Employment

General

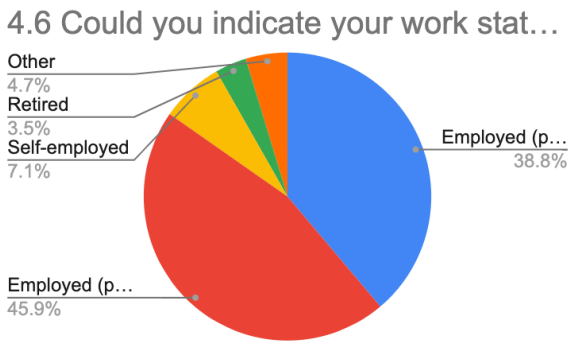


Figure 15 Employment distribution Socio-Bee Pilot 1

Zaragoza alpha

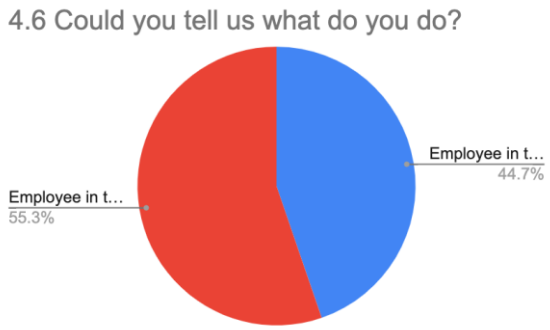


Figure 16 Employment distribution Socio-Bee Pilot 1 Zaragoza Alpha

Zaragoza beta

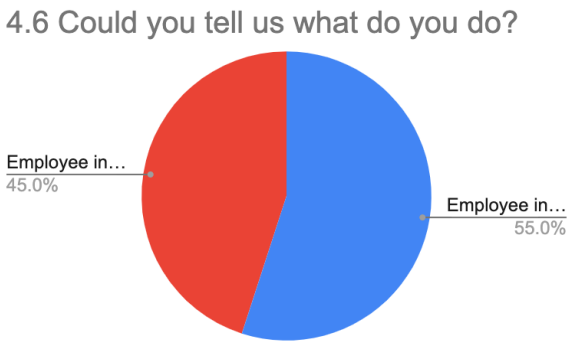


Figure 17 Employment distribution Socio-Bee Pilot 1 Zaragoza Beta

Marousi	Ancona

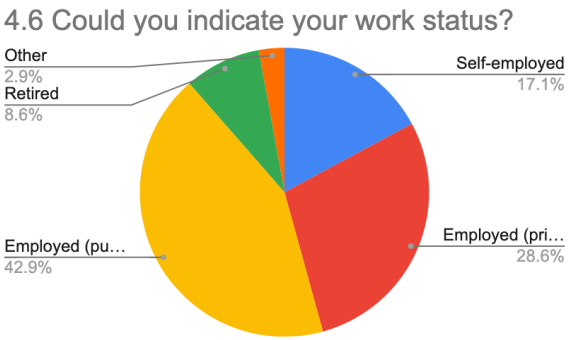
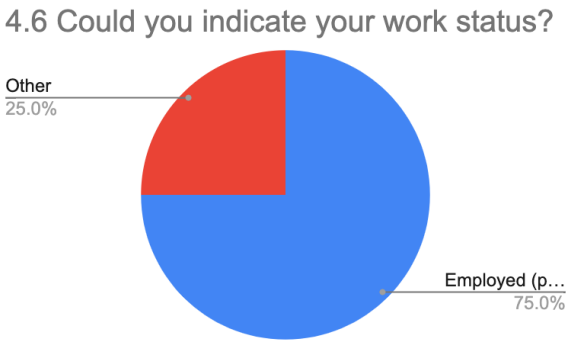

	

Figure 18 Employment distribution Socio-Bee Pilot 1 Marousi	Figure 19 Employment distribution Socio-Bee Pilot 1 Ancona

Most participants identified as technologically advanced, suggesting a strong familiarity and comfort with technology. This inclination may stem from Socio-Bee's approach of integrating a Citizen Science (CS) project with an app, an online platform, and a specialized sensor, which naturally attracts early adopters and tech enthusiasts.

Table 8: Socio-Demographic Analysis: Digital ability

General	

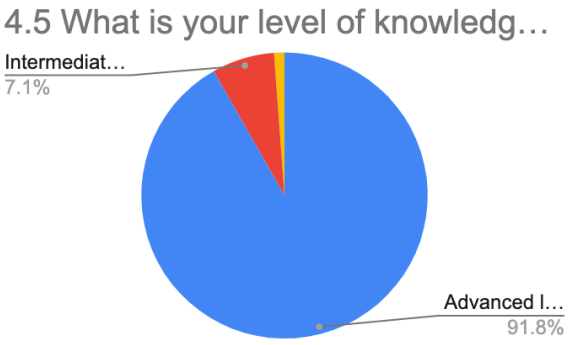



Figure 20 Handling level Digital tools Socio-Bee Pilot 1	

Zaragoza alpha	Zaragoza beta

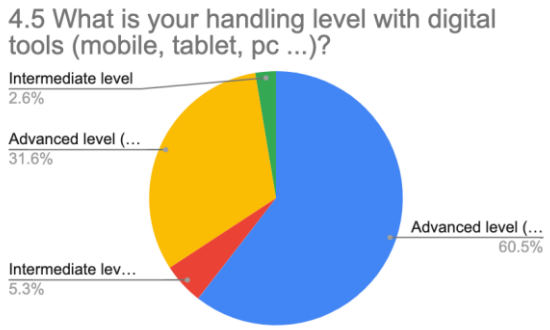
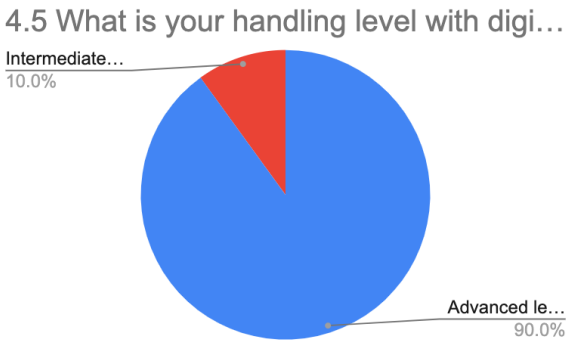

	

Figure 21 Handling level Digital tools Socio-Bee Pilot 1 Zaragoza Alpha	Figure 22 Handling level Digital tools Socio-Bee Pilot 1 Zaragoza Beta

Marousi	Ancona

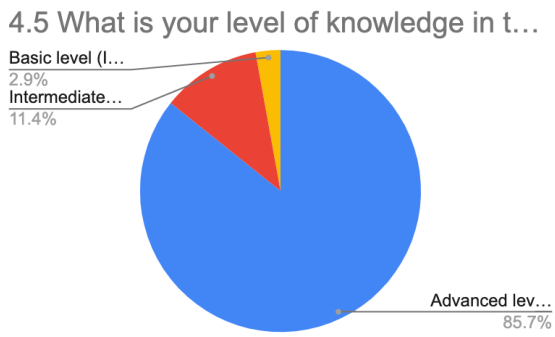



Figure 23 Handling level Digital tools Socio-Bee Pilot 1 Marousi	Figure 24 Handling level Digital tools Socio-Bee Pilot 1 Ancona

In Pilot 1, the majority of participants assumed the role of WB. Due to the hierarchical structure of the hive, there were fewer BKs and QBs. Often, these roles were held by the same individuals, making it challenging to distinguish between them in the data.

Table 9: Socio-Demographic Analysis: Role distribution

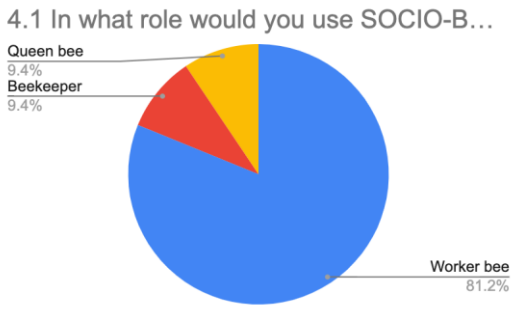
General


Figure 25 Role distribution Socio-Bee Pilot 1

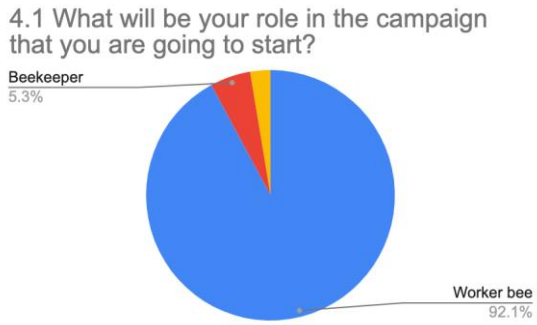
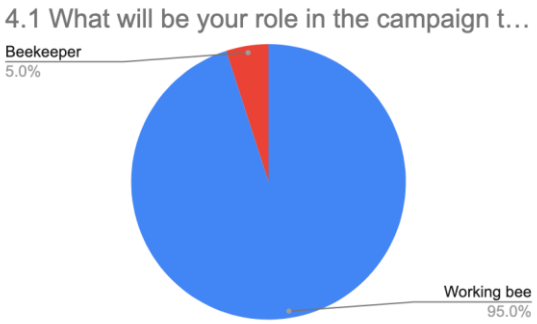
Zaragoza alpha	Zaragoza beta
	

Figure 26 Role distribution Socio-Bee Pilot 1 Zaragoza Alpha

Figure 27 Role distribution Socio-Bee Pilot 1 Zaragoza Beta

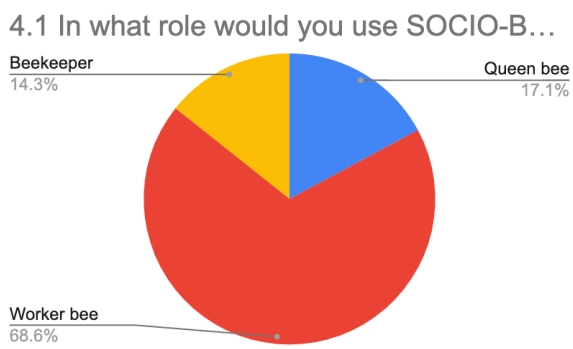
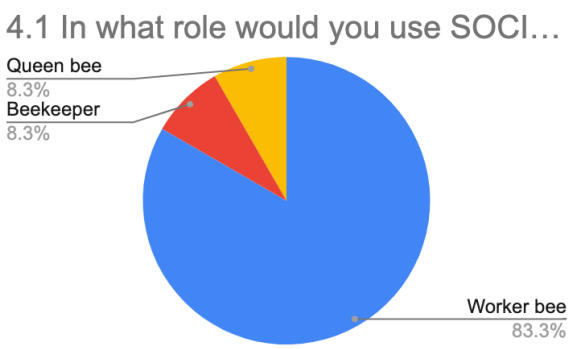
Marousi	Ancona
	

Figure 28 Role distribution Socio-Bee Pilot 1 Marousi

Figure 29 Role distribution Socio-Bee Pilot 1 Ancona

5.2 Pilot participant evaluations

5.2.1 Zaragoza

Table 10: Data analysis Questionnaires, Zaragoza

Values of PRE	
Acceptance	77,2%
Interests and attitudes	84,8%
Awareness regarding Air Quality	78,6%
Previous experience on CS	Very good Very dynamic and entertaining Funny, slow and deep. Very good Positive to know the development of the scientific process and to influence decision making through evidence Comforting Like Alfa Tester de Socio-Bee Good I have not previously participated in citizen science activities I have not participated Enriching No never. Positive experience Contribute dust samples from my domestic environment. Very interesting. I planted strawberries on my balcony to measure air pollution. I have not participated in any other project It is my first participation Air quality data collection with strawberry plant. I did not collect data, the plant died
Values of POST	
Acceptance	68,8%
Interests and attitudes	78,0%

Experience with SOCIO-BEE	Learn Yeah Be aware of what each one can contribute for the common good Data collection The relationship with other people and belong to a team. Yes, what I liked most is to have a device that captures the data, although the possibility of comparing the data and the debate between the participants. If I liked participating Yeah. What I liked most is to be able to participate in a project in relation to the environment that over time can influence the behavior of the population and raise awareness of citizens to obtain a less contaminated air. I would like the app to show the measured values Yes, I liked getting out of the routine and experiencing science on street. Participating in Socio-Bee has given me greater awareness about the quality of air, pollution and the environment of our city. It seems to me a very interesting and pedagogical initiative, the only problem is the app, which could be much more intuitive and with a more attractive design for the user to which the campaign will be directed. I liked it Yeah I liked it. To travel my own city raising me environmental issues. Teamwork The experiment helps raise the population about the environment
Satisfaction	68,8%
Accesibility	59,4%
Inclusiveness	67,6%
Awareness regarding air quality	70,6%
Usability (SUS calculation method)	51,62

Table 11: Data Analysis Questionnaires Pre / Post comparison, Zaragoza

Pre-pilot questionnaire		Post-pilot questionnaire		Difference
Acceptance	77,2%	Acceptance	68,8%	-8,4%
Interests and attitudes	84,8	Interests and attitudes	78,0%	-6,8%
		Satisfaction	68,8%	
		Accesibility	59,4%	
		Inclusiveness	67,6%	

Awareness regarding Air Quality	78,6%	Awareness regarding air quality	70,6%	-8,0%
		Usability (SUS calculation method)	51,62	

Etopia, responsible for the Zaragoza pilot, faced challenges with the technology's delivery timeline, preventing them from preparing adequately for a workshop aimed at their primary target group: children visiting Etopia. Consequently, Pilot 1 was carried out with adults and professionals from their established network.
The data indicates that a significant number of these participants already had experience in both citizen science (CS) and technology-driven projects. The MVP's technological readiness during the pilot did not meet their anticipated standards.
Several key metrics reflected a decline in the post-pilot feedback compared to the initial expectations: Acceptance dipped by 0.42, interest and attitudes saw a decrease of 0.34, and awareness concerning air quality reduced by 0.40. Additionally, the System Usability Scale (SUS) yielded a grade equivalent to "D".

5.2.2 Marousi

Table 12: Data Analysis Questionnaires, Marousi

Values of PRE beta testers	
Acceptance	75,4%
Interests and attitudes	77,0%
Awareness regarding Air Quality	76,0%
Previous experience on CS	I have not participated in something similar in the past Participation in climate change information activities etc. It was a nice opportunity for low -intensity exercise like walking. I have no experience so far I have not I have not I have not I do not have any experience I have not I am at the beginning of the voluntary contribution. I don't have any experience of experience I don't have any experience I have not I have not I have not I haven't been a citizen of scientist I have no experience as this is the first time I am a volunteer. I'm in a beginner stage. I have not

	I have not I don't have any experience I have not I have not I did not happen to be a citizen scientist I have no experience as this is the first time I will become a volunteer. I have not I have no experience so far I have not My main studies are on business administration and I have chosen a transgressor studies in agricultural food businesses. I happen to be well aware of 3 foreign languages. In the context of my studies and not only I have offered a rich volunteer project such as participating in environmental school information campaigns at Oasi Smeraldino-Area Parki Archivio Regionale Educazione Ambientale Nei Parki Lombardi in Milan, population information campaigns for the work of the Ornithology Company, Tritsi Park Trees AMNESTY INTERNATIONAL Face to Face Campaign - Greek Department, Participation in the "Holidays and Volunteering" program 2 years in ELTA Akriti-Issia to inform / assist services provided to foreign tourism and much more. Volunteering is a way of life, scientist or not. Tree planting

Values of POST beta testers	
Acceptance	87,6%
Interests and attitudes	81,4%
Experience with SOCIO-BEE	I found her very interesting Participation in Information Actions for Climate Change Pleasant experience that makes me feel that I am contributing to my area and a good opportunity for walking. I have no experiences Socio-Bee campaign I have not It is a beautiful feeling of participating and offering to improve daily life and science I liked that I helped I found her very interesting I liked it very much I have not yet seen the results of the measurements but I find it interesting the experience I do not have any experience Enlightenment, group, fun and interesting I gained a particularly positive experience I liked and would like to join the next I found her very informative and I really liked the wholeprocess Excellent Good I have not I was glad I participated and learned new things about air pollution I was never a volunteer I don't have relevant experiences

	I have not I have not I don't have any I don't have any experience I have not I have not I have no experience so far I have not I like science that is focused on its social dimension to improve mainly the whole.
Satisfaction	88,2%
Accesibility	82,8%
Inclusiveness	68,2%
Awareness regarding air quality	87,8%
Usability (SUS calculation method)	84,69

Table 13: Data Analysis Questionnaires Pre / Post comparison, Marousi

Values of PRE beta testers		Values of POST beta testers	Diff.	
Acceptance	75,4%	Acceptance	87,6%	12,2%
Interests and attitudes	77,0%	Interests and attitudes	81,4%	4,4%
		Satisfaction	88,2%	
		Accesibility	82,8%	
		Inclusiveness	68,2%	
Awareness regarding Air Quality	76,0%	Awareness regarding air quality	87,8%	11,8%
		Usability (SUS calculation method)	84,69	

In the Marousi pilot, the profile of testers closely matched the intended target group in terms of age, education, and life phase. The data revealed an initial positive anticipation towards the Socio-Bee tools and project, which intensified post-pilot.

There was a noticeable growth in interest and a favourable attitude towards citizen science (CS) after participating in a Socio-Bee campaign. This suggests that the technology offered met the participants' expectations, bolstering their confidence in the potential of the app, platform, and sensor as effective tools for CS centered around air pollution after further refinement. Moreover, participants noted a heightened personal awareness about air pollution.

Distinctly, the usability in this pilot was awarded an "A+" grade, contrasting sharply with the "D" grade observed in the Zaragoza pilot.

5.2.3 Ancona

Table 14: Data Analysis Questionnaires, Ancona

Values of PRE beta testers	
Acceptance	83,6%
Interests and attitudes	82,6%
Awareness regarding Air Quality	4,29
Previous experience on CS	Participated Felli in the Alpha and Beta Test of the SocialBee Project Very Interesting and Active Experience, Thanks to Social-Beei Participated in the Campaign of the SocialBee Projecto Pe Worker Member Been | AinTeresting to Use The Collection Data and Undersand the Actual Trend of the situation there are many aphre actions to detect the air quality with the sensor available Social Data Collection Campaignn i Participated in The Beta Test of the SocialBee ProjectVe Intestaing it was a Useful and Interesting Experience Ve interesting
Values of POST	
Acceptance	85,5%
Interests and attitudes	76,0%
Experience with SOCIO-BEE	Participated Felli in the Alpha and Beta Test of the SocialBee Project Very Interesting and Active Experience, Thanks to Social-Beei Participated in the Campaign of the SocialBee Projecto Pe Worker Member Been | AinTeresting to Use The Collection Data and Undersand the Actual Trend of the situation there are many aphre actions to detect the air quality with the sensor available Social Data Collection Campaignn i Participated in The Beta Test of the SocialBee ProjectVe Intestaing it was a Useful and Interesting Experience Ve interesting
Satisfaction	79,2%

Accesibility	77,0%
Inclusiveness	70,0%
Awareness regarding air quality	77,0%
Usability (SUS calculation method)	79,81

Table 15: Data Analysis Questionnaires Pre / Post comparison, Ancona

Values of PRE questionnaire		Values of POST questionnaire		Diff.
Acceptance	83,6%	Acceptance	83,6%	0,0%
Interests and attitudes	82,6%	Interests and attitudes	76,0%	-6,6%*
		Satisfaction	79,2%	
		Accesibility	77,0%	
		Inclusiveness	70,0%	
Awareness regarding Air Quality	85,8%	Awareness regarding air quality	77,0%	-8,8%*
		Usability (SUS calculation method)	79,81	

*the downward trend in these numbers does not correlate with the qualitative data gathered in the same questionnaires and other data sources.

For the Ancona pilot, the majority of participants fell within the 50-65 age range, aligning with their objective of targeting elderly citizens. The questionnaire results from Ancona mirror those from Marousi. However, it's crucial to note that in both pilots, the beekeeper maintained direct communication and support lines with the technology developers throughout the pilot phase. This could potentially have mitigated certain usability challenges arising from the nascent stages of the app and web platform.

6 Qualitative Analysis with Key Partners

6.1 Introduction

To bolster the triangulation of various data sources, we interviewed key representatives from Ancona, Marousi, and Zaragoza who oversaw the pilot campaigns. Additionally, we held a parallel discussion with Bettair concerning D5.10, as well as addressing any specific insights about the performance of the WSNs.

6.2 Ancona interview

In general, Ancona's representatives were impressed with the enthusiasm displayed by the Bees in Pilot 1, especially given their focus on elderly citizens. Engaging individuals in citizen science projects is notoriously difficult, but the Bees' level of commitment and zeal in Pilot 1 defied initial expectations—

even when faced with technological challenges.

While initial setup posed some tech-related challenges, the citizens remained proactive in the measurement campaigns once past these hurdles. However, several significant issues surfaced. The app and platform in their present form were described as not particularly user-friendly. Many of the concerns reported were tied to usability, understanding the tasks, and navigating the platform. Notably, during campaign execution users faced wayfinding challenges, specifically when trying to navigate to locations suggested by the micro-volunteering engine. The relative positions of the citizens compared to the intended destinations were frequently highlighted in hampering executing measurements.

On a positive note, Ancona observed that users treated the sensors with utmost care, acknowledging their fragility and sophistication. They also noted anomalies in the acquired data. For instance, Ancona's seaside location meant that occasional gusts of wind might have skewed pollution measurements at specific spots—a hypothesis supported by static sensors stationed on rooftops.

Feedback also touched upon system flexibility, or rather, its lack. There were recurring issues regarding the inability to adjust campaigns both in their initiation and execution stages. Mistakes made during setup were irreversible, leading to (Queen)Bee confusion.

In terms of supporting materials and tools, Ancona found value in the ability to selectively use tools, materials, and slide decks provided, adapting them for local recruitment and onboarding purposes. However, they also flagged a need for material improvement, especially concerning the campaign's conclusion and subsequent interactions with Bears.

Lastly, concerns were raised about the extensive use of questionnaires:

- The task of collecting and processing these questionnaires exacerbated an already-demanding workload, partly because of the technology's current maturity stage.
- There's apprehension that the added cognitive burden on campaign participants could deter their continued involvement and overall commitment.
- The extensive number of questionnaires and their repetitive nature might skew the integrity of the responses provided.

6.3 Marousi interview

Marousi's representatives shared observations that resonated with those from Ancona, especially regarding participants' enthusiasm. In their specific neighborhood, they engaged a diverse group of citizens. Given the well-known challenges of involving citizens in such projects, the dedication and enthusiasm of the Bees in Pilot 1 exceeded anticipations, even amid technical challenges. However, variations in commitment were observed among the Bees.

It's essential to highlight that the high dedication and troubleshooting efforts from two Queen Bees close the project might have masked some of MVP one's shortcomings.

A significant concern Marousi representatives raised pertained to Bees living outside the designated measurement area. These Bees found it problematic as they couldn't access recommendations while outside this zone, hindering their ability to tweak daily activities to encompass suggested locations en route to other destinations.

Marousi's feedback emphasizes the need for more flexibility, allowing Bees to contribute measurements as they traverse different areas, be it within their campaign or aiding other local campaign initiatives.

Marousi also touched upon issues discussed in section 3.5—specifically, the challenge faced in Pilot 1 to

successfully close the citizen science loop. The current state of reporting and analysis doesn't yet facilitate actionable insights for citizens or meaningful interactions with Bears.

In terms of supporting materials and tools, Marousi's insights aligned with Ancona's. The ability to selectively use tools, materials, and slide decks for local adaptation was seen as beneficial. However, they too flagged a need for improvements, particularly concerning the campaign's closure and subsequent Bear interactions.

Lastly, Marousi provided feedback on the wearable sensor node. They advocated for a clear visual indicator on the device's casing that denotes its on-off status. Currently, the absence of a consistent visual cue and the sensor's intermittent blinking every 20 seconds has led to confusion among users regarding the device's operational status.

Lastly, concerns were raised about the extensive use of questionnaires:

- The task of collecting and processing these questionnaires exacerbated an already-demanding workload, partly because of the technology's current maturity stage.
- There's apprehension that the added cognitive burden on campaign participants could deter their continued involvement and overall commitment.
- The extensive number of questionnaires and their repetitive nature might skew the integrity of the responses provided.

6.4 Zaragoza interview

The representatives from Zaragoza struck a more critical tone regarding the outcomes of Pilot 1 compared to other cities. Describing their overall experience as "bitter-sweet," Zaragoza had designed their Pilot 1 around children participating in various projects at Etopia.

Due to delays in the delivery of technological components and materials, Zaragoza missed their main time frame at Etopia to engage children in test campaigns. They also felt that the MVP one and its accompanying materials were too immature for their intended audience. Concerns arose about potential disengagement among the children and potential adverse impacts on other Etopia program activities.

In discussing the technology, Zaragoza's feedback on tech acceptance was noticeably more critical than that of Ancona and Marousi. Notably, those executing the test campaigns in Zaragoza were seen as expert tech users, skilled in troubleshooting and accustomed to navigating incomplete software.

While they did manage to run test campaigns, Zaragoza highlighted that the substantial support and troubleshooting required would not be feasible for the second pilot. They stressed that with a projected teacher-to-student ratio of 1:20, offering intensive support would become impractical.

They also reported app-related concerns, such as multiple measurements being taken at a single location without any movement. This likely stems from Zaragoza's intention to use confined measurement areas, which cater to their audience and Etopia's safety standards. Preliminary insights suggest that the suggestions from the micro-volunteering engine might not scale well to these compact measurement zones, though this warrants further examination.

While Ancona and Marousi found the provided materials adequate, Zaragoza had reservations. They anticipated more visually compelling and well-explained resources tailored for a younger audience. They recommended segmenting support materials based on the Socio-Bee role categories like Beekeepers, Queen Bees, Bees, and Bears.

Echoing sentiments from both Ancona and Marousi, Zaragoza reiterated concerns (as noted in section

3.5) about the unfinished citizen science loop during Pilot 1. The present system doesn't facilitate actionable outcomes or foster meaningful interactions with Bears.
Looking ahead to Pilot 2, Zaragoza pinpointed specific issues, such as the app's current user interface not being child friendly. The inability to view submitted results and analyze campaign data is seen as a significant concern, with the current system likened to a “black box.”
Lastly, concerns were raised about the extensive use of questionnaires:

- The task of collecting and processing these questionnaires exacerbated an already-demanding workload, partly because of the technology’s current maturity stage.
- There’s apprehension that the added cognitive burden on campaign participants could deter their continued involvement and overall commitment.
- The extensive number of questionnaires and their repetitive nature might skew the integrity of the responses provided.

6.5 Bettair interview

In our discussion with Bettair, we assessed the current developmental state of the WSN and identified areas for enhancement. From the data gathered during Pilot 1, we determined that the WSN hardware has performed admirably. There are no plans to modify the hardware components, given that the sensor components have proven reliable and thoroughly vetted. However, Bettair expressed reservations regarding the device’s usage, particularly the challenge of ensuring citizens produce scientifically valid datasets.
The wearable functionality of the sensor kit (WSN) is a relatively novel concept and is susceptible to user-related errors. Contrary to its smartphone-like appearance, the WSN doesn’t match the robustness of typical mobile devices. The accuracy of the data it captures can vary depending on factors like the sensor’s handling, positioning, and exposure to brief instances of localized pollutants.
Bettair noted planned internal enhancements concerning the calibration process for a large batch of WSNs during production, an issue their engineering team is already addressing.
To elevate the data quality, Bettair proposed several modifications:
- At present, the app instructs Bees to remain stationary for 60 seconds at a measurement site to enhance data reliability. Bettair recommends integrating a concise checklist within the app at each measurement point. This would guide users to verify the appropriate positioning and status of the WSN. Sample checklist items might include: “I am safely positioned,” “Sensor is charged”, “Sensor is disconnected from power bank,” “Sensor is positioned freely,” “Sensor is dry,” and “No nearby sources of localized pollutant deviations.”
- Lastly, Bettair suggests enhancing the backend system’s capability to adjust for anomalous readings. One proposed method involves actively logging data for 10 minutes both prior to and following the actual measurement point. This would enable the data analysis engine to filter out any anomalies, thereby bolstering the overall reliability of the campaign dataset.

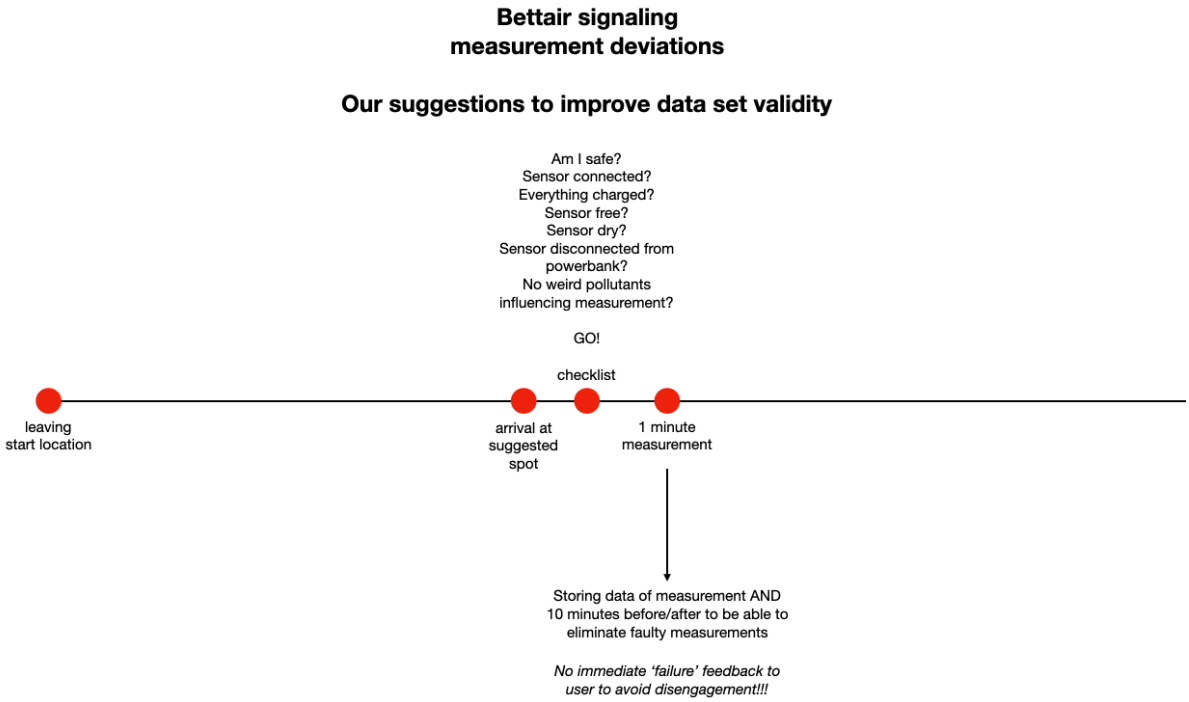


Figure 30 Bettair suggestions to potentially improve scientific validity of data sets

7 Issue Analysis reported during the pilots

7.1 Introduction

In this section we will analyze technological issues reported in D5.10 regarding the MVP usage during pilot 1. We also look at contributions from other deliverables, related to non-technological issues relevant for recommendations towards pilot 2.

7.2 MVP1 issue reporting

To efficiently monitor and address the technical issues associated with the Socio-Bee hardware and software components during the pilot phases, a dedicated Redmine[1] environment was established. This digital infrastructure enabled a systematic logging of pertinent issues emerging in the mobile app, the desktop app, and the wearable sensor node (WSN) by the pilot cities and partners involved in the trials. We recorded a total of 103 entries, with a notable number highlighting overlapping concerns.

7.3 Analysis model for technical issues

To facilitate a deep understanding and prioritization of the core issues, an analysis framework was designed to categorize and map the concerns, thereby steering the focus towards substantial improvements in the Socio-Bee technical domains. Based on a cluster analysis of all reported issues, we conceived a visual mapping of issues in specific categories. These categories are nested in three

[1] *"https://redmine.sociobee.apps.deustotech.eu/"*

hierarchies. (1) overarching project issues; (2) localized pilot issues at city level; (3) campaign specific issues at city level. In each hierarchy a number of topics has been identified to be able to map all issues on descriptive labels to identify key issues and collide them into core areas of improvement.

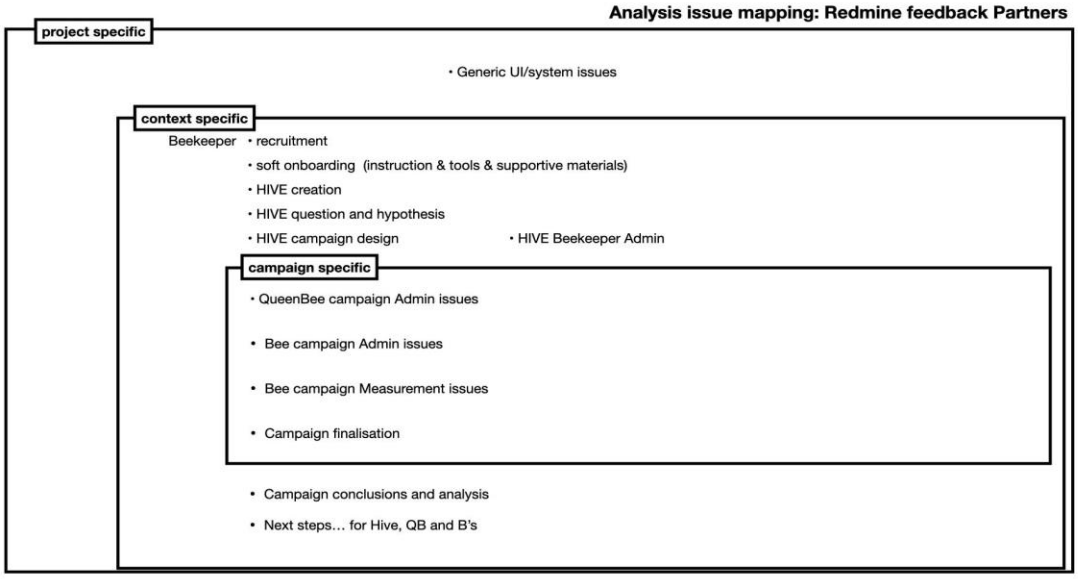


Figure 31 Analysis model for issue mapping based on Redmine registrations.

The three primary dimensions of the issues are detailed as follows:

7.3.1 Project specific issues (Level 1)

Scope: Encompassing overarching issues and generic user interface (UI) glitches.
Objective: To foster a user-friendly and cohesive experience across all Socio-Bee platforms.

7.3.2 Context specific issues (Level 2)

Scope: Pertaining to the distinctive challenges encountered during activities preparing and concluding the execution phase in individual cities of actual measurement campaigns.
Objective: identifying issues related to campaign preparation and evaluation and activities revolving around strategizing and assessing campaigns, exclusive of the technological engagements with Socio-Bee components.

7.3.3 Campaign specific issues (Level 3)

Scope: Issues emerging from the application of the apps and the sensor throughout the distinct phases of establishing, operating, and concluding measurement campaigns.
Objective: To streamline the campaign process, ensuring a seamless integration and functionality of the technological components from inception to completion.

7.4 Clustering of consortium expert issues reported for pilot 1.

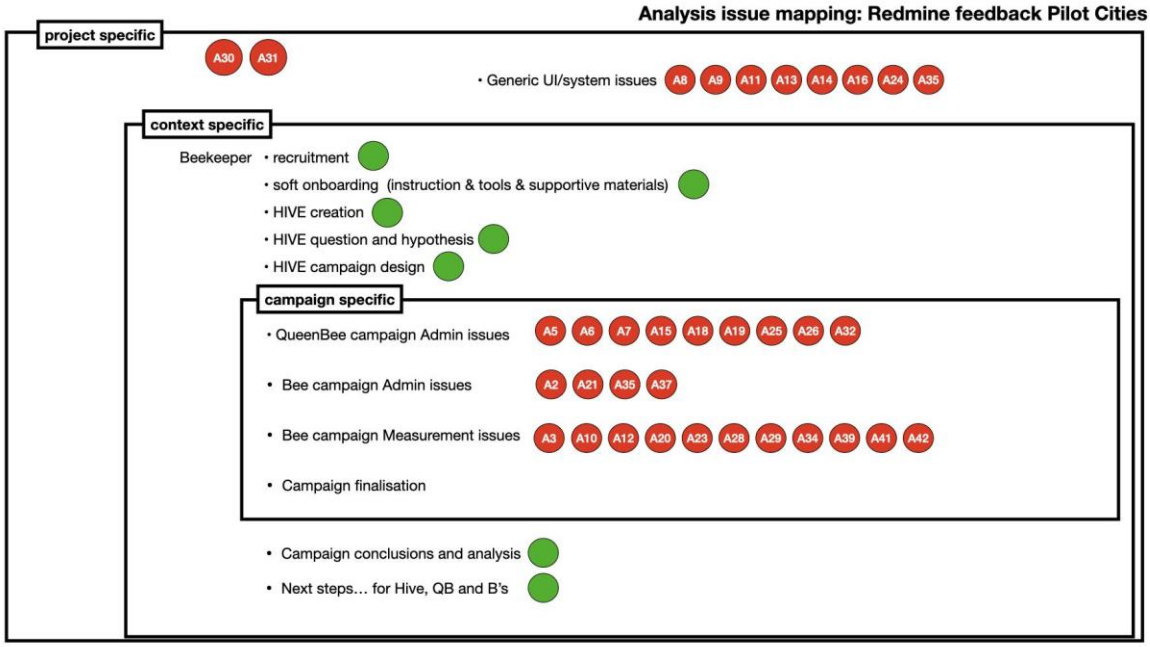


Figure 32 Issue mapping based on Redmine expert registrations

Figure 34 shows the mapping of all issues reported in Redmine by experts on the analysis model. This provides a clustering insight into the main areas of attention for further development of the MVP. Below, the detailed comments are presented clustered by theme.

Table 16: Expert report: Generic/UI system Issues

			Generic/UI system issues	
A	**8**	**ZGZ**	Back button does not work	Back button does not work
A	**9**	**ZGZ**	same name on two mobile screens	In the mobile app there are two screens with the same name: - Home (screen 1) -> notifications - notifications (screen 3)-> notifications
A	**11**	**ZGZ**	bettair device is linked,	once the bettair device is linked, if it is unlinked, only a message appears for a few seconds. It would be better if it stays fixed, to make sure you have noticed it.
A	**13**	**ZGZ**	map update	When taking data with the mobile app, there are times when the map does not update. We managed to get it to update by logging out of the app and restarting it.
A	**14**	**ZGZ**	search bee	Gros
A	**16**	**ZGZ**	screen of the app values fixed	The main screen of the app always keeps the values fixed. Issue similar to the one reported by Maria on 9/06/2023

A	**24**	**MRSI**	App frozen	The app was frozen. The volunteer reported that none of the buttons was responding and that after several trials she had to restart her phone. This solved the issue.
A	**35**	**MRSI**	Search button in the working bees email list	The search button in the email list of working bees is not working.

Table 17: expert report: Queen Bee campaign Admin Issues

		Queen Bee campaign admin issues		
A	**4**	**ZGZ**	delete the address campaign	When you create the campaign, you fill in all the data. And after determining the campaign area, you delete the address.
A	**5**	**ZGZ**	dates of the campaign	When you create the dates of the campaign, it is not very intuitive that you have to mark the start and end date. You can set the start date, and continue filling in the rest of the fields. It is possible to put a box for start date and another box for end date.
A	**6**	**ZGZ**	format hour campaing	In the creation of the campaigns, when you set the date and hour, the hour is displayed in 24h format. But in the campaigns view, it appears in 12 h format.
A	**15**	**ZGZ**	create campaigns	When creating a new campaign, show the map of Thessaloniki first. It is possible that it shows the actual location (internet connection). This issue is similar to the one reported by Maria on 9/06/2023.
A	**18**	**ZGZ**	delete hive and campaign	You can delete 1 hive and 2 campaigns we created by mistake. - Hive: #7 eTOPIA - Campaign: 2230529 (completed) - Campaign: 20230613_campaña_2_fuera_ZBW (Saved)
A	**19**	**ZGZ**	remove campaigns	It would be advisable for the queen bee or another role in the hive to be able to eliminate campaigns or hives that are created by mistake. Always put a confirmation message to confirm that we want to delete it. This is a similar issue to the one reported by Maria on 9/06/20
A	**25**	**MRSI**	Athens instead of MRSI in Location during hive creation	A volunteer spotted that when we created their hive in the tab location it says Athens instead of Maroussi.
A	**26**	**MRSI**	When creating a campaign the map shows Thessaloniki	When you create a new campaign the default location is Thessaloniki and not the users location.

A	**32**	**MRSI**	I cannot deactivate and/or delete a campaign	I cannot deactivate and/or delete a campaign. This function is important because the volunteers potentially could be confused and participate in a campaign which is either a trial or should be redesign for some reason, eg. an update in the platform.

Table 18: Expert report: Bee campaign Admin Issues

		Bee campaign admin issues		
A	**2**	**ZGZ**	Password to access App	Once registered, the password cannot be changed or, if forgotten, cannot be retrieved.
A	**21**	**MRSI**	User denied to download the app because it was not coming from a safe source	User denied to download the app because it was not coming from a safe source.
A	**35**	**MRSI**	Search button in the working bees email list	The search button in the email list of working bees is not working.
A	**37**	**ANCONA**	Campaigns created cannot be found by working bee	I had created a campaigns from the Hive's profile, and then I have addedd two new working bee to one hive. They cannot see the published campaign from the mobile app and therefore they cannot join the campain.

Table 19: Expert report: Bee Campaign Measurement Issues

	Bee campaign measurement issues		
3	**ZGZ**	Password to access App	Once registered, the password cannot be changed or, if forgotten, cannot be retrieved.
10	**ZGZ**	vibrates or beeps when you are on the spot.	Several bees commented that it would be nice if it would vibrate or beep when you are at the measurement point.
12	**ZGZ**	display the number of measures in the application	A bee proposed the possibility of showing in the app the number of measures that each point has, in order to be able to go to the points that have fewer measures.
20	**ZGZ**	tolerance of measurement	When we took the measurements, we realised that the tolerance from where we could measure with respect to the point was too large. We believe that the tolerance that allows us to measure with respect to a target point, is the distance between each point. So from each point it "plots a radius" of the distance between the points from where it allows us to measure (see picture 1), so from the same place we can take several target points. If it is as we told you, we think it would be better to put half the distance between points, so that from the same point, we cannot take more than one measurement.(see picture 2). Attached is a video of the test of the day 20230613, where the points are 50 m apart and as soon as we leave one, it allows us to measure the one in the centre of the roundabout(https://drive.google.com/file/d/1CNpmJAJdAghMzx7CfcFJS0eUaYyXL6jn/view?usp=drive_link).
23	**MRSI**	The volunteer couldn't find the "location of the measurement"	Day 1: volunteer goes to a specific place and makes a measurement

			Day 2: same volunteer selects the same measuring point, goes to the location and the measuring green circle to perform the measurement is not showing up! Volunteer keeps trying finding the correct spot but with no lack. \ The comment I received was that I was disappointed and I didn't go to another measurement because the app may not work and my effort will go wasted.
28	**MRSI**	?he volunteer should be able to see all potential points to go measure	This feature is important because somebody could go and measure to a point that is not close to him but it is close to a location of interest. Also this could explain, why a specific point (in campaigns Sunflower 2 and 3) was left without measurements (up to now - 9th of June). My reaction was to share a pic of the map of the measuring points (attached file).
29	**MRSI**	It is not feasible to perform a measurement at a location where the volunteer is already there.	Please consider this scenario (It happened during the first round of measurements for beta testers) A volunteer is outside the campaign area (=he/she cannot receive recommendations for measuring points) but he/she already knows the location of the closest point to go to measure. So he/she goes there by car without selecting the point in advance. Once he/she reaches the location, he/she cannot perform a measurement as the recommendation engine suggests 3 new points not including the one that he/she are already at.
34	**MRSI**	Symbol of recommended measuring point	The symbol of the recommended measuring point is very small and black. 2 volunteers complained that they cannot see it easily. (Their age is above 70 years old).
39	**Global**	No recommended measuring points for a volunteer who is outside the campaign area	If a volunteer is outside the campaign area, he/she cannot get recommendations on where to go and start measuring. I think it is important to be solved for the second iteration.
41	**Global**	Lack of indications to where to go when a measurement needs to be taken	The app should guide the worker bee to the point where a measurement wants to take place, walking directiongs shoudl be given and the user alerted when arrived to that point
42	**Global**	Essential features in mobile app for Worker Bees	General advice of feedback needed for worker bees: 1. When a user selects a point to pollinize, I believe that we should guide the user to walk to that point, walking intructions should be given. There is a period of time between selecting a point and traveling to that point to actually take the measurement. 2. When a user gets a measurement, s/he should be able to check what measurements were taken, a quick of log with all her contributions. For the campaigns to be useful we should be able to show the progress of the campaign in a map. Otherwise, neither the queen bee nor the worker bees can see their evalution and understand what is going on regarding air quality in the campaign's region 3. Whilst a user is gathering a measurement, in the very screen were progress is shown users could be suggested to gather

			multimedia contents and post them by email or whatsapp so that BEEMATE component could use it 4. It is very important that the dataset that is continously and incrementably beeing generated by worker bees can be loaded into a map with some analytics behind to be able to make sense of the data gathered. At the very least we should offer that insights driving capability. EXPLORE DATA views do not yet do anything

7.5 Preliminary conclusions

As can be seen from the issue clustering, some key areas of improvement can be identified.

- Overall UI issues and inconsistencies in the MVP; one important area of comments relate to the home screen and complexities encountered by users to find the right hive or campaign, hindering easy campaign onboarding in the app.
- Admin issues for Queen Bees and Bees. These issues are related to the lack of flexibility for Queen Bees and Bees to repair mistakes, add or modify campaigns, password etc. This leads to end-user confusion and forms a disengagement risk.
- Bee campaign measurement issues. These issues are related to taking measurements and include issues reported on wayfinding. Users report difficulties in orientation between their current location and how to navigate to a suggested measurement point by the micro-volunteering engine. Some issues relate to the diameter around measurement points in relationship to the size of the campaign area (Zaragoza).

7.6 Analysis of pilot city participants reporting during testing of pilot 1.

Pilot cities reported 42 issues throughout the execution of the pilots. These issues were mapped in the Analysis model in the appropriate segment.

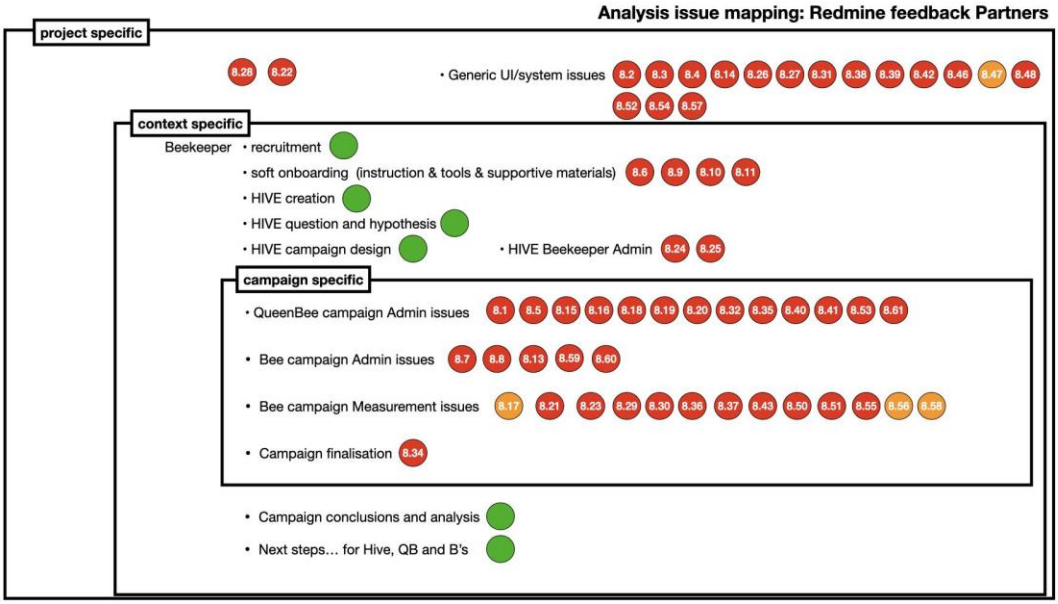


Figure 33 Analysis of Redmine issues

Table 20: Participants report: Generic / UI System Issues

		Generic UI/System Issues
8	2	Once I am connected to the device, I do not know anymore to which device I am connected, can create a mess if several devices are nearby
8	3	Once I am connected to a device, it is unclear for me how do I need to disconnect from it
8	4	Once I log out of the App, BLE is still connected to the device.
8	14	When creating a campaign if you do not select the Hive, a good warning message alerts you to do it, but it wipes out the other fields filled in
8	26	Log out icon in profile screen might not be sufficiently intuitive
8	27	Alerts view not available
8	31	When i want to create the campaign, the default location is so far. (not important problem but maybe disorient)
8	38	I had the impression that the measurements point are not always the same even when the measurement is at the same point from the perspective of the MVE. What I mean is that although the measurement was in the same cell I had the impression (very strong and repeatedly) that the center point of the cell was moving. Maybe it is because of a GPS or representation failure.
8	39	The number of measurements and campaigns in the mobile app information doesn't change. And i have to think that in the mobile we have to see the hive name... (more data in general)
8	42	In the mobile app, i didn't give feedback but the platform says that I did it
8	46	I could not register to the platform. I received the following error "authpage.Idenfined"
8	47	Once we login with MRSI's credentials as BK we cannot see any campaigns from other pilots. Just the one created by us.
8	52	Figure 2 -> the number in the visualization and in the table is not the same.
8	54	The main screen of the app always keeps the values fixed. Issue similar to the one reported by Maria on 9/06/2023
8	57	In the mobile app there are two screens with the same name: - Home (screen 1) > notifications notifications (screen 3)-> notifications

Table 21: Participant Report Soft Onboarding

		Soft onboarding (instruction & tools & supportive materials)
8	6	I do not know what to do as a user.
8	9	I can not choose the hive when logged in as worker bee, I can only choose campaign
8	10	I can not participate in any campaign until the Queen Bee adds me but then I cannot participate since I do not have a WSN
8	11	I have 3000 points just to start. Why?

Table 22: Participant report: Queen Bee Campaign Admin Issues

		Queen Bee campaign admin issues
8	1	I am trying to create a new campaign and I get the following message: "..."
8	5	It does not allow to register a new user from the mobile app, but it is feasible to do it from the web app
8	15	You are not able to delete campaigns and to change their status once they have been published
8	16	You can not delete Hives once created
8	18	Settings for QueenBee not available
8	19	Explore data in QueenBee view does not show the data gathered
8	20	A Queen Bee should be able to edit the details of the campaigns of its Hives

8	32	When i want to create a campaign i have to select the distance between the points but i can not see them so its hard to do the appropiete choose without see the consecuences.
8	35	When the campaign is created, even if the state is PUBLISHED, i can not modify anything of it (As the descripction of the date).
8	40	Define the duration of the Campaign is soo hard. So dificult... horrible.... i have too much problem with it.
8	41	When i want to define the campaign the adress is removes itself
8	53	It would be advisable for the queen bee or another role in the hive to be able to eliminate campaigns or hives that are created by mistake. Always put a confirmation message to confirm that we want to delete it. This is a similar issue to the one reported by Maria on 9/06/20
8	61	When creating a new campaign, show the map of Thessaloniki first. It is possible that it shows the actual location (internet connection). This issue is similar to the one reported by Maria on 9/06/2023.

Table 23: Participant Report: Bee Campaign Admin Issues

		Bee campaign admin issues
8	7	I can not change the name or personal information
8	8	If the passwords are not equal, there is no message that alerts you about this issue.
8	13	If a Beekeper creates adds a member to a Hive after the campaign has been created, the new added user does not see the campaign
8	15	You are not able to delete campaigns and to change their status once they have been published
8	16	You can not delete Hives once created

Table 24: Participant Report: Bee Campaign Measurement Issues

		Bee campaign measurement issues
8	17	It should be possible from the web front end for a worker bee to be able to type in a measurement by taking measurements from a non-connected WSN or by a nearby fixed station
8	21	Setting of BeeKeeper view does not exist
8	23	Explore data in Beekeper view not yet available
8	29	The app should guide the worker bee to the point where a measurement wants to take place, walking directiongs shoudl be given and the user alerted when arrived to that point
8	30	General advice of feedback needed for worker bees: 1. When a user selects a point to pollinize, I believe that we should guide the user to walk to that point, walking instructions should be given. There is a period of time between selecting a point and traveling to that point to actually take the measurement. 2. When a user gets a measurement, s/he should be able to check what measurements were taken, a quick of log with all her contributions. For the campaigns to be useful we should be able to show the progress of the campaign in a map. Otherwise, neither the queen bee nor the worker bees can see their evalution and understand what is going on regarding air quality in the campaign's region 3. Whilst a user is gathering a measurement, in the very screen were progress is shown users could be suggested to gather multimedia contents and post them by email or whatsapp so that BEEMATE component could use it 4. It is very important that the dataset that is continuously and incrementally being generated by worker bees can be loaded into a map with some analytics behind to be able to make sense of the data gathered. At the very least we should offer that insights driving capability. EXPLORE DATA views do not yet do anything
8	36	And i can not see the PUBLISHED campaigns in the mobile app. To see if any campaign can be available in the future.
8	37	I have problems with the GPS and the maps in the database. I left a picture on another sheet (caption Fig 1). if only I have this problem, but I don't think so. This issue is not for a moment. In some cases, i have to go to a point without a map (specifically with a grey map in which only my position and the destination are shown).

8	43	I can not see the result of my measurements in the mobile app. I can not see a message say thanks for do it consulting the app to see the result of somethig like this.
8	50	When we made the measurements, we realised that the tolerance from which we could measure with respect to the point was too large. We believe that the tolerance that allows us to measure with respect to a point is the distance between each point. So from each point it "plots a radius" of the distance between points from where it allows us to measure, so from one place we can take several target points. If it is as we say, we think it would be better to put half the distance between points, so that from the same point we cannot take more than one measurement.
8	51	Proposal for improvement: on the mobile screen, instead of showing the position point, it would be advisable for an arrow or triangle to show the route. This would make it easier for children to find their way around.
8	56	A bee proposed the possibility of showing in the app the number of measures that each point has, in order to be able to go to the points that have fewer measures.
8	58	Several bees commented that it would be nice if it would vibrate or beep when you are at the measurement point.

7.7 Preliminary conclusions from pilot cities issue reporting

As can be seen from the issue clustering at pilot city level, some key areas of improvement can be identified. It is apparent that these issues closely resemble the issues reported by experts (section 7.5).

- Overall UI issues and inconsistencies in the MVP; one important area of comments relate to the home screen and complexities encountered by users to find the right hive or campaign, hindering easy campaign onboarding in the app.
- Admin issues for Queen Bees and Bees. These issues are related to the lack of flexibility for Queen Bees and Bees to repair mistakes, add or modify campaigns, password etc. This leads to end-user confusion and forms a disengagement risk.
- Bee campaign measurement issues. These issues are related to taking measurements and include issues reported on wayfinding. Users report difficulties in orientation between their current location and how to navigate to a suggested measurement point by the micro-volunteering engine.

7.8 Analysis of non-technical issues

Coinciding with the delivery D5.10, D2.6 Analysis of consortium expert issues reported for pilot 1 contains additional findings and identifies some common barriers across pilots.
Related to the role of Queen Bees, Bees, and Bears:

- **Inadequate Data Accessibility and Visualization**: Both in Zaragoza and Ancona, the unavailability of a simple and effective data visualization and extraction tool from the AcadeMe platform emerged as a significant issue, hindering bears from understanding and working collaboratively on air quality issues.
- **Poor Communication and Dissemination Materials**: All cities reported a lack of quality materials to aid in planning awareness and behavioral change activities and showcasing campaign results to the public.

These findings corroborate with the observations of the state of the citizen science loop in MVP 1 and supportive materials.
In D2.6 these suggestions are made for Corrective Measures:

- **Enhanced Communication Materials**: Develop tailored communication materials that allow bears to learn about the results and progress firsthand, facilitating planning of policies to counter air pollution.
- **Data Access**: Ensure unrestricted access to campaign data in the next iteration to enable informed decision-making and public engagement.

Specific Findings and Recommendations per City:

Zaragoza:

Communicative Collaboration: Encourages developing materials that empower bears to actively participate in the mitigation of air pollution effects based on scientific evidence derived from the campaigns.

Ancona:

Focus on Informative Phases: Suggests the creation of communication materials explaining campaign details to stakeholders, a (portable) user manual for platform interaction, and considering expert boards for co-creating future citizen science campaigns.

Maroussi:

Positive Engagement: Noted a better-than-expected engagement level, with foreseen barriers like "lack of time," "limited volunteer-organizer engagement," and "financial constraints" not materializing.

Addressing Existing Barriers: While some barriers were effectively managed, issues such as "limited impact visibility of contributions" and "specific technological requisites" arose, needing attention in the next iteration.

Further Recommendations:

- INFORM phase: Enhance communication materials and channels, and assign team members for continuous updates to bears.
- GUIDE phase: Encourage a collaborative team spirit, stressing the adaptability of citizen science (CS) campaigns.
- WORK WITH phase: Clearly define CS result exploitation strategies and ensure easy data access with suitable visualization tools.

Overall:

The primary goal is to eliminate the existing barriers and enhance the functionality of the next iteration by offering straightforward data visualization tools, robust communication strategies, and unrestricted data access, thereby encouraging more active and informed participation from all involved parties. The feedback from each city provides a roadmap for improving engagement and making the project more successful in its next phase.

8 Preliminary conclusions of Pilot 1 evaluation

8.1 Positive results of pilot 1.

The Pilot 1 execution, predictably, presented a blend of achievements and hurdles.

Highlighting the successes, the technological foundation was up and running, proving its mettle in the initial pilot tests. The synergy between the mobile app, online platform, and the Wearable Sensor Node (WSN) was demonstrated. The WSN performed as expected. Moreover, the micro-volunteering engine

adeptly offered measurement points, enabling users to carry out their campaigns seamlessly.
To aid pilot cities, tailored supportive materials were made available. This allowed them to select relevant resources that best facilitated the recruitment, onboarding, and training processes for Hives, ensuring effective campaign setups and measurement activities.
Significantly, both Ancona and Marousi cities observed an unexpectedly high degree of enthusiasm, commitment, and participation from volunteers, including after campaign completion. These are promising signs.

8.2 Areas of improvement for pilot 2.

8.2.1 Citizen Science Loop

Despite these early successes, there are some critical areas that need further development of course.
Pilots were unable to satisfactorily "close the citizen science loop". The maturity of the technological components prohibited participants from having easy access to their campaign results and lacked support in analyzing these results to bring them to next actionable steps. A provisionary tool, the Ancona Visualization Tool, shows promise in how this part of the MVP might look like, but it was not mature enough to enable all Bees to close the citizen science loop. It was used to reflect on campaign results at Beekeeper and Queen Bee level in Ancona and Marousi (see **Annex 2**).

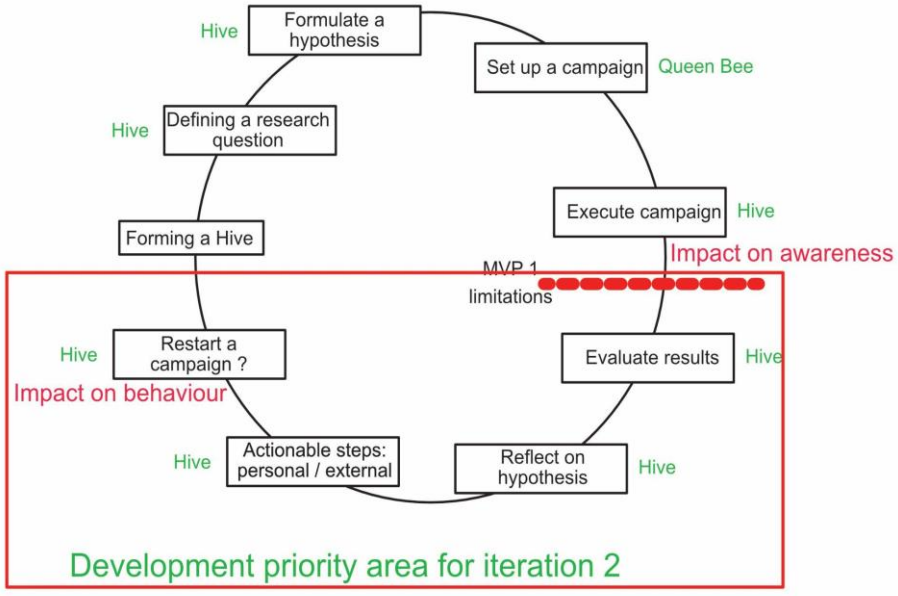


Figure 34 Socio-Bee citizen science loop deployment area

After data analysis revealed that participants in the pilot campaigns couldn't complete the citizen science loop, each city was asked to have their QB address a concise series of questions on this topic. These questions traced the Citizen Science Loop's steps, from formulating a hypothesis, validating it after measurements, drawing conclusions, to disseminating the findings.
In Zaragoza's case, this seemed a moot point, as they hadn't progressed to this stage in their campaigns. However, for Marousi and Ancona, it's clear that fully closing the loop poses a challenge for Citizen

Scientists, because most citizens lack the expertise to conduct a rigorous scientific analysis and derive sound conclusions. Nonetheless, the Socio-Bee experience has left participants motivated and eager to complete this step post-campaign, but they are currently without the requisite tools and resources.
In the Ancona pilot, the data collected contrasted with the readings from stationary sensors in the vicinity. Currently, Ancona specialists are exploring potential reasons for this discrepancy.
Marousi conducted three campaigns. For one, the participants are still analyzing and validating the data, well past the pilot's conclusion: "*We have not yet disseminated the results in terms of reports, but citizens have taken the initiative to begin processing the collected data. Creating a comprehensive report for independent dissemination to the general public and the public authorities has proven challenging for them. While local authorities (i.e. representatives from MRSI municipality) are aware of the campaigns, QBs and/or BKs intend to share the results with both citizens and public administrators in the future, potentially the 2nd pilot iteration.*"
Another Marousi pilot saw its results assessed by another consortium partner, with the initial findings presented at the SpliTech conference in Bol, Croatia. The participants of the third pilot utilized the AVT, noting: "This hands-on experience allowed them to extract valuable insights and conclusions related to the hypothesis"
These initial efforts to wrap up the campaign by fully engaging with the scientific process are promising signs. They indicate a move towards making scientific exploration accessible for citizens, empowering them to derive valid, actionable insights that can potentially drive policy shifts and behavioral changes.

8.2.2 Usability, self-efficacy for Queen Bees and Bees

While initial results on KPI 3 regarding technology acceptance are generally positive for two of the three pilot cities, it's essential to understand the context. The preliminary test campaigns witnessed a limited engagement of end-users and took place under controlled conditions. High levels of support, provided by committed Queen Bees and technology partners, were essential in overcoming initial technology deployment challenges. While this approach is appropriate for an inaugural run, conditions are set to evolve in pilot 2.
As we move forward, there's a pressing need to enhance the user-friendliness of both technological components and support materials. This will enable Hives to independently establish campaigns, oversee their progress, and evaluate outcomes, broadening their reach—either through wider dissemination or by engaging with Bears/policy makers. This ease of operation becomes even more crucial when considering specific user groups like Zaragoza's children or Ancona's elderly citizens. Thankfully, the comprehensive feedback from the initial pilots offers clear direction on potential enhancements.
Key areas for improvement in the MVP encompass enhancing flexibility, especially in admin-related tasks. This would enable users to correct or adjust mistakes during campaign creation or measurement submission. Another specific area to enhance is addressing the wayfinding challenges users face when following the micro-volunteering engine's suggestions.

8.2.3 Support and communication materials

The first round of supportive materials and tools was provided as a repository for cities to “pick and In the initial round, cities were offered a repository of supportive materials and tools, designed to be selectively adapted for local use in recruiting and onboarding Hives. While this approach resonated well with Ancona

and Marousi, it fell short of Zaragoza's expectations. They had anticipated more child-centric, visually appealing, and refined materials. With the vast diversity of potential user groups for Socio-Bee initiatives, this presents challenges. It's impractical to craft bespoke materials for every distinct target group. Present and future Beekeeper organizations will likely need to tweak these materials to suit local contexts and unique needs. Highly refined visual materials can complicate multilingual support and adjustments to local formatting nuances.
To successfully close the citizen science loop in the upcoming iteration, supportive materials, combined with data visualization and extraction, should form a structured foundation to guide citizens toward actionable measures.

8.2.4 Questionnaire related workload

All pilot cities have expressed concerns about the overwhelming workload associated with processing the questionnaires. They caution that this could lead to disengagement among end-users and potentially compromise the validity of the data collected. It should be noted that the questionnaires are a quintessential component of the Socio-Bee project in order to be able to monitor KPIs. Any future scale-up of Socio-Bee would not have to deal with this particular aspect. Still this is a point of concern and it might be advisable to see if measures can be taken to reduce this workload within the limitations on resources in the project.

9 Recommendations in preparation for Pilot 2

9.1 introduction

With the conclusion of pilot 1 we now have the possibility to improve on the Socio-Bee MVP to enhance the impact on behavior change as a result of successful deployment of campaigns in the second iteration of the project.
The recommendations are based on the triangulation of all data generated from pilot 1 evaluation.

9.2 Recommendations for improvement

Our recommendations are grouped into four primary categories:

- Software: This encompasses suggestions for the technical aspects of the Socio-Bee framework, which includes the mobile app, web platform, and other software components.
- Materials: This pertains to the auxiliary resources, such as instructional aids, communication materials, and tools, tailored to assist all Socio-Bee stakeholders.
- Questionnaires: This category focuses on tools and materials designed to measure and monitor the project's KPIs.
- Hardware: Recommendations in this category zero in on our Wearable Sensor Node.

9.2.1 {Software} Closure of the Citizen Science Loop

For the success of Pilot 2, it's vital that the citizen science loop is comprehensively closed. We suggest an integrated data analysis view and results export from the Academe environment.
This entails ensuring that Beekeepers, Queen Bees, Bees, and Bears can access the measurement results

seamlessly through the Socio-Bee Academe, both during and post-campaign.

The closure is pivotal for several reasons:
- Without immediate feedback on measurement results, there's a potential dampening of motivation and adherence among Queen Bees and Bees throughout the campaign and their drive to participate in future campaigns or pursuing new hypotheses.
- The absence of consolidated campaign results in an easily interpretable format hinders Hives from reflecting on their initial hypothesis.
- Not having these results in a clear format and the ability to bring the results outside the platform also obstructs Hives from considering subsequent actions, be it in their daily routines or, ideally, in engaging with Bears to instigate policy dialogues. The objective is to push for local environmental modifications that mitigate air pollution. Moreover, disseminating campaign outcomes is crucial for evaluating any behavior change stemming from Hive participation.

Expected impact:
Moving from awareness to behavior change among participating citizens. Involving Bears after campaigns in follow up actions.

Related objectives:
SO 1.3 Develop a crowdsourcing and collaboration instruments for assembling environmental action groups (i.e., CS Hives) targeting air quality improvement in cities (Relevant KPIs: KPI 1.3).
SO 3.1 Develop a citizen science visual platform for the creation of evidence-based and crowdsourcing initiatives (Relevant KPIs: KPI 3.1).
SO 4.1 Combine seamlessly data processing algorithms and data fusion techniques ready to be used by non- tech savvy users (Relevant KPIs: KPI 4.1, KPI 4.2). (Annex 1)
SO 4.2 Develop easy-to-use intelligence and data analytics tools for understanding, curating or validation of data quality and data freshness by action groups (Relevant KPIs: KPI 4.2, KPI 4.3).
SO 5.2 Deliver a platform to test different hypotheses elucidated by action groups through causality (i.e. what- if questions) that allows to observe the different intervention results and consequences (Relevant KPIs: KPI 5.1, KPI 5.2).
SO 5.3 Create a portfolio of intervention actions suitable for reducing air pollution in cities ensuring the sustainability and replication factor among other cities/groups (i.e., campaigning blueprints) (Relevant KPIs: KPI 5.2, KPI 5.3).
SO 5.4 Deliver effective means to outreach the results and figure out how to issue messages, communicate in an effective manner the actions that should be adopted by end users ensuring awareness and behavior change (Relevant KPIs: KPI 5.3, KPI 5.4).

9.2.2 {Software} Enhancing the User Experience of Mobile and Web Apps

It's imperative to elevate the usability of both the mobile and web apps, making them more intuitive and straightforward. This is even more important given the spread in end-users from children (Zaragoza) to elderly citizens (Ancona).
Many usability-related challenges faced in Pilot 1 were sidestepped due to the dedicated support provided to Queen Bees and Bees by local representatives. While this was instrumental in the pilot's success, such intensive support isn't feasible for Pilot 2. The second phase has ambitions to engage a broader user base

and scale the number of Hives and campaigns. End-users will be less tech-savvy, probably have less endurance and problem-solving skills and should be maximally supported in terms of ease-of-use, readability, accessibility and contain a high level of self-explanatory use.

A critical facet of usability revolves around amplifying the administrative flexibility for Beekeepers, Queen Bees, and Bees. There's a clear need for capabilities that allow for the rectification of errors, modification of parameters, user additions, etc., during the creation or execution of campaigns. The constraints in MVP 1 made it challenging to rectify mistakes or adapt to mid-campaign changes, resulting in a plethora of reported issues.
Another issue mentioned often by users is the user journey upon entering the mobile app (home screen). The path to find the appropriate Hive or relevant campaign in an intuitive way is missed, leading to confusion by especially the Bees to execute campaigns without a lot of support.

Expected impact:
Reducing confusion and improving adherence of Queen Bees and Bees to current and future campaigns. Reduction of intensity Beekeeper support in troubleshooting

Related objectives:
SO 1.2 Provide a toolkit for active participants that empowers them to involve more citizens (i.e., Worker Bees) and interested stakeholders (i.e., Honey Bears) in pursuing air pollution reduction actions through experimentation and evidence-based research (Relevant KPIs: KPI 1.3).
SO 4.1 Combine seamless data processing algorithms and data fusion techniques ready to be used by non- tech savvy users (Relevant KPIs: KPI 4.1, KPI 4.2).
SO 4.2 Develop easy-to-use intelligence and data analytics tools for understanding, curating or validation of data quality and data freshness by action groups (Relevant KPIs: KPI 4.2, KPI 4.3).

9.2.3 {Software} Solve wayfinding issues for Bees

Improve the wayfinding cues for Bees in the campaign area, navigating from current location to suggested measurement points.
Although related to usability this category of issues is rather specific. All pilots report issues with users unable to identify where they are in relationship to where they have to go to to perform measurements. There are also issues with zooming in on the map or losing map data in the app. Reduction of user cognitive load also contributes positively to situational awareness and increased safety of users in the public environment.

Expected impact:
Reducing confusion and improving adherence of Bees to current and future campaigns. Reducing cognitive load and increasing public safety of participating Queen Bees and Bees.

Related objectives:
SO 4.1 Combine seamlessly data processing algorithms and data fusion techniques ready to be used by non- tech savvy users (Relevant KPIs: KPI 4.1, KPI 4.2).

9.2.4 {Software} Improve measurement point spacing in the campaign area.

Analyze and improve the relationship between campaign area size and density of measurement suggestions.

There are several reports on the measurement distance between data points. Initial analysis seems to indicate that this might be caused by the size of the campaign area relative to the number of suggestions by the micro-volunteering engine. This issue needs more research and discussion with the technology partners to find the root of the problem.

Expected impact:

Reducing confusion and improving adherence of Bees to current and future campaigns.

Related objectives:

SO 4.1 Combine seamlessly data processing algorithms and data fusion techniques ready to be used by non- tech savvy users (Relevant KPIs: KPI 4.1, KPI 4.2).

9.2.5 {Software} Improve the validity of the data sets.

Campaign outcomes as data sets are not easy to extract and share with other stakeholders (i.e. Bears) and are not refined enough yet as a basis for policy discussions or dissemination purposes. One specific suggestion from Bettair entails a change in the measurement protocol for Bees, involving a) checklist of proper sensor use and b) including some history data before and after a measurement to improve on data quality of the data sets (see XXX)

Expected impact:

Improving the scientific value of the data sets

Related objectives:

SO 5.2 Deliver a platform to test different hypotheses elucidated by action groups through causality (i.e. what- if questions) that allows to observe the different intervention results and consequences (Relevant KPIs: KPI 5.1, KPI 5.2).

SO 5.4 Deliver effective means to outreach the results and figure out how to issue messages, communicate in an effective manner the actions that should be adopted by end users ensuring awareness and behavior change (Relevant KPIs: KPI 5.3, KPI 5.4).

9.2.6 {Materials} Reduction of the workload on Beekeepers, Queen Bees and Bees regarding questionnaires

Our recommendation is to see if we can find a better balance in the workload for BeeKeepers by exploring alternative ways of processing the questionnaires or integrating them in the Academe environment. This is a point of exploration for the consortium as a whole.

Expected impact:

Reducing confusion and improving adherence of Bees to current and future campaigns. Reducing cognitive load of BeeKeepers in supporting Queen Bees and Bees.

Related objectives:
SO 1.2 Provide a toolkit for active participants that empowers them to involve more citizens (i.e., Worker Bees) and interested stakeholders (i.e., Bears) in pursuing air pollution reduction actions through experimentation and evidence-based research (Relevant KPIs: KPI 1.3). (Annex 1)

9.2.7 {Materials} Improve support materials per stakeholder including Bears for follow up steps

Support materials and tools must be improved to support stand-alone operation of Hives. Closure of the citizen science loop demands materials for follow up actions with Bears towards policy influence.

Expected impact:
Moving from awareness to behavior change in participating citizens. Involving Bears after campaigns in follow up actions.

Related objectives:
SO 1.1 Recruitment and onboarding of new citizens who wish to become active participants (i.e., Queen Bees) in the SOCIO-BEE concept (Relevant KPIs: KPI 1.1, KPI 1.2).
SO 1.2 Provide a toolkit for active participants that empowers them to involve more citizens (i.e., Worker Bees) and interested stakeholders (i.e., Honey Bears) in pursuing air pollution reduction actions through experimentation and evidence-based research (Relevant KPIs: KPI 1.3).
SO 1.3 Develop crowdsourcing and collaboration instruments for assembling environmental action groups (i.e., CS Hives) targeting air quality improvement in cities (Relevant KPIs: KPI 1.3).
SO 5.1 Provide to CS Hives easy to understand air quality monitoring models (Relevant KPIs: KPI 5.1).
SO 5.3 Create a portfolio of intervention actions suitable for reducing air pollution in cities ensuring the sustainability and replication factor among other cities/groups (i.e., campaigning blueprints) (Relevant KPIs: KPI 5.2, KPI 5.3).
SO 5.4 Deliver effective means to outreach the results and figure out how to issue messages, communicate in an effective manner the actions that should be adopted by end users ensuring awareness and behavior change (Relevant KPIs: KPI 5.3, KPI 5.4).

9.2.8 {Questionnaires} Streamlining of the questionnaire process

Pilot cities reported a high level of cognitive load regarding the management of questionnaires. The task of collecting and processing these questionnaires exacerbated an already-demanding workload, partly because of the technology's current maturity stage. There's apprehension that the added cognitive burden on campaign participants could deter their continued involvement and overall commitment. The extensive number of questionnaires and their repetitive nature might skew the integrity of the responses provided.
If possible, we should look at ways to streamline the processing of questionnaires for the pilot cities, if possible simplifying the questionnaires in terms of number of items, mode of delivery and other measures possible. It should be noted that the questionnaires have a pivotal role in establishing KPI performance which should not be compromised.

Expected impact:
Reducing workload for Beekeepers and improving questionnaire response validity.

9.2.9 {Hardware} Improve WSN calibration in production process

There is a minor issue regarding the in-house calibration of the WSN's by Bettair. This issue is already tackled by Bettair engineers. A minor comment regarding the WSN is the suggestion to add a marking on the sensor housing to indicate the right on/off switch position. (see also **section 7.5**)

Expected impact:
Maximize effectiveness of WSN

Related objectives:
SO 2.2 *Improve the capability of delivered low-cost sensing devices to measure O3,NO2,NO, CO, SO2, and PM (Relevant KPIs: KPI 2.1, KPI 2.2)*

9.2.10 {Software} Integration of BEEMATE tool

The BEEMATE component is currently a standalone tool to capture audiovisual data on possible pollution sources. The BEEMATE can contribute to the analysis of campaign outcomes and provide for additional information for dissemination and taking actionable steps. It would be commendable to make the BEEMATE an integrated part of the user experience, to be discussed with technical partners for MVP2.

Expected impact:
Enrichment of campaign outcomes with audiovisual data to support dissemination and actionable next steps.

Related objectives:
SO 5.2 Deliver a platform to test different hypotheses elucidated by action groups through causality (i.e. what- if questions) that allows to observe the different intervention results and consequences (Relevant KPIs: KPI 5.1, KPI 5.2).
SO 5.3 Create a portfolio of intervention actions suitable for reducing air pollution in cities ensuring the sustainability and replication factor among other cities/groups (i.e., campaigning blueprints) (Relevant KPIs: KPI 5.2, KPI 5.3).
SO 5.4 Deliver effective means to outreach the results and figure out how to issue messages, communicate in an effective manner the actions that should be adopted by end users ensuring awareness and behavior change (Relevant KPIs: KPI 5.3, KPI 5.4).

ANNEX 1. SOCIO-BEE Project Objectives and specifications

O1: To support air pollution reduction initiatives in cities through widely adopted air pollution reduction actions and citizen involvement that will create long lasting effects and behavioral change.
KPI 1.1 KPI 1.2 KPI 1.3

- SO 1.1 Recruitment and onboarding of new citizens who wish to become active participants (i.e., Queen Bees) in the SOCIO-BEE concept (Relevant KPIs: KPI 1.1, KPI 1.2).
- SO 1.2 Provide a toolkit for active participants that empowers them to involve more citizens (i.e., Worker Bees) and interested stakeholders (i.e., Honey Bears) in pursuing air pollution reduction actions through experimentation and evidence-based research (Relevant KPIs: KPI 1.3).
- SO 1.3 Develop crowdsourcing and collaboration instruments for assembling environmental action groups (i.e., CS Hives) targeting air quality improvement in cities (Relevant KPIs: KPI 1.3).

O2: Development of low-cost modular wearable hardware solution suitable for large crowdsourcing environmental measurements ensuring mass adoption and replicability.
KPI 2.1 KPI 2.2
Air pollution can demonstrate ultra-localized pockets of harmful emissions in the cities. A significant amount of evidence shows that monitoring stations underestimate the exposure of population subgroups with a lack of democratized tools with poor flexibility in the sensors utilized to precisely monitor the citizen's exposure to air pollution at a very granular, massive scale and personalized level for different pollutants. SOCIO-BEE proposes several specific objectives to ensure the mass adoption and upscaling:

- SO 2.1 Miniaturization of current wearable devices for improving the portability of the air monitoring solution (Relevant KPIs: KPI 2.1).
- SO 2.2 Improve the capability of delivered low-cost sensing devices to measure O3,NO2,NO, CO, SO2, and PM (Relevant KPIs: KPI 2.1, KPI 2.2)
- SO 2.3 Cost reduction of the wearable device and reduced energy consumption for mass adoption of the devices (Relevant KPIs: KPI 2.1, KPI 2.2).
- SO 2.4 Improve the modularity of the wearable devices and the software embedded through open source demonstrating its easy deployment in person-worn devices and/or lightweight recreational drones (Relevant KPIs: KPI 2.2).

O3: The development of a citizen science-based web platform to allow CS Hives in the active collection of environmental and socio-economic data through wearable technologies and research-based instruments.
KPI 3.1 KPI 3.2 KPI 3.3
CS has a significant potential for enhancing not only public engagement and empowerment in policy making and for raising awareness of environmental issues and policies, but also creates more transparent and effective governance of cities. Furthermore, CS approaches can cultivate leadership capabilities in existing action groups in cities to tackle environmental issues. In this respect, it is important to provide a toolkit that can be easily adopted by citizens and action groups (i.e., CS Hives) to enhance the results of initiatives for air pollution reductions in cities.

- SO 3.1 Develop a citizen science visual platform for the creation of evidence-based and crowdsourcing initiatives (Relevant KPIs: KPI 3.1).
- SO 3.2 Develop micro volunteering features in the SOCIO-BEE frontend (e.g., web app, mobile app) for the citizens to gather environmental information (Relevant KPIs: KPI 3.2, KPI 3.3).
- SO 3.3 Develop pre-processing software embedded in mobile phones for curating and ensuring privacy of data collected from wearables and low-cost air monitoring technologies (e.g. drones) (Relevant KPIs: KPI 3.2, KPI 3.3).

O4: Establish an open and sustainable decision-making process with a data analysis platform for the overall CS process: cross-linking of environmental data in collaboration with citizens, scientists, citizen observatories and local decision makers.
KPI 4.1 KPI 4.2 KPI 4.3 KPI 4.4
To interpret vast amounts of data, it is necessary to provide action groups with easy to use and intuitive tools which will allow them to make better actions for improving air quality in the cities. These tools must be able to curate, process and visualize information from various sources, and convert it into value-added information to democratize environmental citizens' action while improving new or existing interventions. To this end:

- SO 4.1 Combine seamlessly data processing algorithms and data fusion techniques ready to be used by non- tech savvy users (Relevant KPIs: KPI 4.1, KPI 4.2).
- SO 4.2 Develop easy-to-use intelligence and data analytics tools for understanding, curating or validation of data quality and data freshness by action groups (Relevant KPIs: KPI 4.2, KPI 4.3).
- SO 4.3 Create a collaborative platform in which experts (e.g. scientists, air quality managers) assist group leaders in the understanding of gathered data (Relevant KPIs: KPI 4.3, KPI 4.4).

O5: Bridging gaps in pollution understanding in urban environmental monitoring and remediation actions through the scientific process.
KPI 5.1 KPI 5.2 KPI 5.3 KPI 5.4
Members of the CS Hives wishing to improve the air quality in urban environments require skills and expertise on air pollution. However, such knowledge cannot be a prerequisite for participation. It is important to provide a social inclusive approach for citizen science in cities and include complementary views on problems that burdens the wider community. SOCIO-BEE aims on employing features to automate the process of analyzing and test options for solutions thus allowing non-experts to make use of environmental models and discover better solutions to city problems through hypothesis testing and what-if analysis.

- SO 5.1 Provide to CS Hives easy to understand air quality monitoring models (Relevant KPIs: KPI 5.1).
  SO 5.2 Deliver a platform to test different hypotheses elucidated by action groups through causality (i.e. what- if questions) that allows to observe the different intervention results and consequences (Relevant KPIs: KPI 5.1, KPI 5.2).
- SO 5.3 Create a portfolio of intervention actions suitable for reducing air pollution in cities ensuring the sustainability and replication factor among other cities/groups (i.e., campaigning blueprints) (Relevant KPIs: KPI 5.2, KPI 5.3).
- SO 5.4 Deliver effective means to outreach the results and figure out how to issue messages,

communicate in an effective manner the actions that should be adopted by end users ensuring awareness and behavior change (Relevant KPIs: KPI 5.3, KPI 5.4).

O6: To address the data protection and privacy as well as other legal, ethical and societal concerns related to wearable-based air quality monitoring approach and the relationship of involved citizens in the CS hives.

KPI 6.1 KPI 6.2

The SOCIO-BEE project will assure that the proposed solutions will consider data protection and privacy as well as other legal, ethical and societal issues properly (e.g., digital divide or gender divide). The SOCIO-BEE platform supporters are municipalities and relevant stakeholders, which will facilitate the collection of data through the engagement of citizen scientists, starting with the Queen Bees, via municipal infrastructure and engagement and participatory activities. The key issues are to ensure respect for fundamental rights and freedoms, compliance with the principles of privacy and personal data protection, the principles of citizen science research integrity, the protection of equality, inclusion, and non-discrimination overall in cases where children under 18 years old may participate. The specific objectives are:

- SO 6.1 Establish a legal and ethical baseline framework in relation to the SOCIO-BEE citizen science activities (including engagement strategies), with respect to research and platform development (Relevant KPIs: KPI 6.1).
- SO 6.2 Implement a data management approach that will ensure continuous monitoring of the legal and ethical requirements through co-design methods, active dialogue, and intense cooperation among the partners in the CS hives (Relevant KPIs: KPI 6.2).
- SO 6.3 Develop and perform a tailor-made impact assessment and determine review mechanisms (Relevant KPIs: KPI 6.1).
- SO 6.4 Provide guidelines and codes of fair use to accompany usage (Relevant KPIs: KPI 6.1, KPI 6.2).

O7: Development of sustainable exploitation models around the SOCIO-BEE platform to ensure economic and environmental feasibility and sustainability of the overall CS platform.

KPI 7.1 KPI 7.2 KPI 7.3

SOCIO-BEE plans to bring citizen science to large scale; thus, it is compulsory to guarantee the economic feasibility and viability of the platform after the end of the project. SOCIO-BEE goes beyond the enthusiast audiences and targets on creating a financial and business model that will enable the long-term exploitation of the project in cities and communities worldwide while ensuring the environmental sustainability of the solution. To this end:

- SO 7.1 Development of public-private financing model for the SOCIO-BEE platform (Relevant KPIs: KPI 7.1, KPI 7.2, KPI 7.3).
- SO 7.2 Develop a business model for air pollution (static, wearable, flying) devices manufacturers (Relevant KPIs: KPI 7.1, KPI 7.3).
- SO 7.3 Ensure the environmental assessment of the overall platform created with the circularity principles in mind (i.e., waste avoidance, new business models, repair, durability, and versatility) (Relevant KPIs: KPI 7.1, KPI 7.2).

ANNEX 2: Questionnaire on Citizen Science Loop Pilot Cities

Upon analyzing the data, we noticed that participants in the pilot campaigns couldn't complete the citizen science loop. Consequently, each city was prompted to have their Queen Bee respond to a specific short questionnaire on this topic. For the Zaragoza pilots, this request seemed inconsequential as they hadn't reached this stage in their campaigns.

Table 25: Annex 2: CS-Loop Ancona Campaign 1 & 2

Ancona
Campaign Name
Campaign ANCONA 1: Compare air quality measurement in the city center, with the reference stations. Campaign ANCONA 2: Analyze the impact of green areas and of the sea on the air quality of the city.
What was your hypothesis?
Urban areas in the city center intended for pedestrians are affected by high pollution due to city traffic, especially during daylight hours. Due to the topology of the city, areas closer to the sea or protected by public parks could be the most suitable for carrying out activities or as meeting points.
Did you manage to validate the hypothesis or not and why?
During the Alpha and the Beta campaign, citizens conducted some measurement close to the reference station. At this stage of the project, there are some discrepancies between the measurements, that should be quantified and also the source of error should be defined. This aspect would be further investigated with Iteration 2 of the pilot.
What are the concrete outcomes of your campaign?
The outcomes of the campaign are related to the usability of the platform and the overall SOCIO-BEE system: - The ANCONA pilot is focused on seniors, therefore the. platfom should be easy to use for this specific population - There should be a manual that facilitate an easy set-up of the the platform. - The platform should be able to display the results of the measurement campaign in near real-time mode.
Have you disseminated the results to citizenry and public admins?
At the moment, it is too early to present the results to citizens and public administration or public structures that could take actions. This is because data collected still need to be validated and aggregated and need to be compared between the most polluted area and the least polluted one, in terms of timing of the day and also with more spatial resolution.

Table 26: Annex 2: CS-Loop Marousi Campaign 1

Marousi

Campaign Name
Campaign MRSI 1
What was your hypothesis?
The hypothesis for Experimental Campaign 1 was grounded in the assumption that increased traffic flow on Kifissias Avenue during rush hours on weekdays would significantly impact the concentration of air pollutants in proximity to this avenue. This hypothesis was formulated with the understanding that traffic emissions, particularly during peak hours, are a major contributor to urban air pollution. Therefore, it was anticipated that as traffic levels rose and fell throughout the day, there would be noticeable fluctuations in air pollutant concentrations in areas adjacent to Kifissias Avenue. In more detail, the hypothesis presumed that during peak traffic hours, emissions would be at their highest, leading to a surge in pollutant concentrations, while, during off-peak hours, when traffic volume decreased, pollutant concentrations would diminish.
Did you manage to validate the hypothesis or not and why?
This hypothesis is still under examination and its validation is on progress. This is primarily due to the inherent complexity and challenges associated with the hypothesis itself. Furthermore, factors such as volunteers unavailability during summer holidays and absence of a structured results analysis methodology have contributed to the current status of the validation process.
What are the concrete outcomes of your campaign?
The concrete outcomes of our campaign include the collection of 30 air quality measurements at various locations near the town hall and Kifissias Avenue. These measurements were part of effort of the Hive named “Socio-Bee Friends”.
Have you disseminated the results to citizenry and public admins?
We have not yet disseminated the results in terms of reports, but citizens have taken the initiative to begin processing the collected data. Creating a comprehensive report for independent dissemination to the general public and the public authorities has proven challenging for them. While local authorities (i.e. representatives from MRSI municipality) are aware of the campaigns, QBs and/or BKs intend to share the results with both citizens and public administrators in the future, potentially the 2nd pilot iteration.

Table 27: Annex 2: CS-Loop Marousi Campaign 2

Campaign Name
Campaign MRSI 2
What was your hypothesis?
The second experimental campaign incorporated two specific hypotheses. The first hypothesis postulated that if citizen scientists employ portable, low-cost Air Quality sensors for data collection, then the data gathered can be considered reliable and accurate. The second hypothesis revolved around the presence of a park or green area in proximity to Kifissias Avenue. It suggested that even during peak traffic hours, the air quality in this area is expected to be comparatively better. This hypothesis was grounded in the assumption that green spaces might act as natural filters, mitigating

the impact of traffic-related air pollutants.

Did you manage to validate the hypothesis or not and why?
Currently, we have been able to validate the first of the two hypotheses posed by the 2nd experimental campaign. This hypothesis, which assumes that if citizen scientists use portable low-cost Air Quality sensors for data collection, then the acquired information from the collected data can be reliable, has been partially validated. MRSI collaborated with Bettair, and they conducted an analysis of the data collected. The results of this analysis have been documented in D5.10. Concerning the 2 hypothesis, which suggests that if there is a park (green area) in the vicinity of Kifissias Avenue, then the air quality is expected to be better despite heavy traffic, the validation process is still ongoing. Work related to this hypothesis is in progress, as there are challenges related to the availability and participation of the volunteers as well as the level of expertise and degree of knowledge in analyzing data to reach a solid conclusion.
What are the concrete outcomes of your campaign?
The members of the two hives collected considerable number of measurements, (421 in total). For the first hypothesis, the hive named “Townhall” collected 84 measurements in short period of time (Blueprint 1: Pollinate a specific area in a short period of time) and in close proximity to the Reference Air Quality Station located at the southwest side of MRSI, while for the 2nd hypothesis, the members of the hive named “Friends of Forest Syggrou” collected 337 measurements in a longer time interval.
Have you disseminated the results to citizenry and public admins?
The results of our second experimental campaign have been processed by other partners within the consortium, and they have been documented in detail in D5.10, as previously mentioned. Furthermore, MRSI has also disseminated these findings to a broader audience, i.e. at the international conference SpliTech 2023, which took place in Bol, Croatia, 20th to 23rd of June 2023. However, it's important to note that the results related to the second hypothesis are still a work in progress. This is primarily because our volunteers lack the experience, knowledge, or established methods/guidance to conduct the necessary analysis.

Table 28: Annex 2: CS-Loop Marousi Campaign 3

Campaign Name
Campaign MRSI 3
What was your hypothesis?
The hypothesis for the 3rd experimental campaign was that the air pollution caused by a fire at a factory would be detectable in the MRSI region. This hypothesis was formulated with the aim of assessing the ability of the SOCIO-BEE project to detect and monitor air pollution events, specifically those resulting from industrial incidents such as factory fires or other extreme events. This campaign was initiated by the volunteers.
Did you manage to validate the hypothesis or not and why?
Yes the results collected were sufficient to draw some general conclusions.

What are the concrete outcomes of your campaign?

The volunteers organized and executed a campaign spanning 3 consecutive days, from July 4th to July 7th, during which, they conducted a total of 32 measurements.

Have you disseminated the results to citizenry and public admins?

The volunteers who actively participated in this campaign had access to the visualization tool created by UNIPD. Using this tool, they had the opportunity to see the results they acquired during these 3 days. This hands-on experience allowed them to extract valuable insights and conclusions related to the hypothesis. However, a broader dissemination of these results to the wider citizenry and/or public administrators was not performed and the results are not sufficient to draw safe conclusions.