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RiskPACC

INTEGRATING RISK PERCEPTION AND ACTION TO ENHANCE CIVIL PROTECTION-CITIZEN INTERACTION

COMPLETION OF ADAPTATION OF VGI MAPPING TOOL TO CLOSE THE RPAG

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ABOUT RISKPACC

Increasingly complex and interconnected risks globally highlight the need to enhance individual and collective disaster resilience. While there are initiatives to encourage citizen participation in creating a resilient society, these are typically fragmented, do not reach the most vulnerable members of the communities, and can result in unclear responsibilities for building disaster resilience.

New technologies can also support preparedness and response to disasters, however, there is limited understanding on how to implement them effectively. Awareness of risks and levels of preparedness across Europe remain low, with gaps between the risk perceptions and actions of citizens and between the risk perceptions of citizens and Civil Protection Authorities (CPAs). The RiskPACC project seeks to further understand and close this Risk Perception Action Gap (RPAG). Through its dedicated co-creation approach, RiskPACC will facilitate interaction between citizens and CPAs to jointly identify their needs and develop potential procedural and technical solutions to build enhanced disaster resilience. RiskPACC will provide an understanding of disaster resilience from the perspective of citizens and CPAs, identifying resilience building initiatives and good practices led by both citizens (bottom-up) and CPAs (top-down).
Based on this understanding, RiskPACC will facilitate collaboration between citizens, CPAs, Civil Society Organisations, researchers and developers through its seven (7) case studies, to jointly design and prototype novel solutions.

The "RiskPack" toolbox/package of solutions will include a framework and methodology to understand and close the RPAG; a repository of international best practice; and tooled solutions based on new forms of digital and community-centred data and associated training guidance. RiskPACC consortium comprised of CPAs, NGOs, associated organisations, researchers and technical experts will facilitate knowledge sharing and peer-learning to close the RPAG and build disaster resilience.

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Executive Summary

This report outlines the work carried out in creating Volunteered Geographic Information (VGI) tools for the Municipality of Rafina-Pikermi (MRP) and the Comune di Padova (CDP) case studies using an iterative co-creation approach. It provides a detailed account of the process followed, beginning with the conceptualisation of the tool, which explains the approach taken to understand the disaster situations in the case studies. The tool conceptualisation was informed through the co-creation process and workshops in WP3, drawing from the knowledge gained from the SWOT analysis of VGI in WP1 and WP2, as well as the repository of existing best practices from WP4. It addresses questions regarding the specific disasters focused on and their respective stages.

The pre-development stage included determining the data requirements, conducting a literature review, and analysing the data. For the MRP case study, the focus was on wildfires and floods. Earth Observation (EO) data and open data from OpenStreetMap (OSM) were analysed and categorised using various geospatial analysis techniques. For CDP, a thermal comfort tracker tool was created to supplement the objective thermal data provided by strategically placed indoor and outdoor sensors within the city of Padova. Both tools were developed on the GeoCitizen platform, with additional functionalities added to better suit the requirements of the case studies.

Glossary and Acronyms

TABLE 1: GLOSSARY AND ACRONYMS

Acronym	Definition
ASV	Assumed Sensation Vote
CAFO	Czech Association of Fire Officers
CDP	Comune di Padova
CPA	Civil Protection Authorities
dNBR	Differential Normalised Burn Ratio
EO	Earth Observation
HOTOSM	Humanitarian OpenStreetMap Team
HVAC	Heating, Ventilation and Air Conditioning
KEMEA	Greek: Κέντρο Επιστημών Ασφαλείας
LC	Lancashire Constabulary
MRP	Municipality of Rafina-Pikermi
NBR	Normalised Burn Ratio
NIR	Near Infrared
OSM	OpenStreetMap
PDD	Predicted Percentage of Dissatisfied
PET	Physiologically Equivalent Temperature
PMV	Predicted Mean Vote
RPAG	Risk Perception-Action Gap
SWIR	Shortwave Infrared
SWOT	Strength, Weakness, Opportunity and Threat
UoW	University of Warwick
USGS	United States Geological Survey
UTCI	Universal Thermal Climate Index
VGI	Volunteered Geographic Information
WP	Work Package

1 INTRODUCTION

1.1 Overview

This report fits into the RiskPACC workplan as follows:

Work Package (WP):	WP5 Tool Development
Task:	Task 5.3. – VGI Tool Development
Deliverable:	Deliverable 5.3: Completion of adaptation of VGI mapping tool to close the RPAG

VGI within the context of this task and report is defined as "the harnessing of tools to create, assemble, and disseminate geographic data provided voluntarily by individuals" (Goodchild, 2007). Hence, the term “volunteered” here refers to explicit consent to participating and are actively involved in the data collection process, with a full understanding of the intended uses of the data they collect (Klonner et. al., 2016).

RiskPACC Task 5.3 focuses on the development and adaptation of the VGI tools. The intended objectives of this task include (i) the creation of a VGI experimental tool, based on existing tools, to implement a range of human and cognitive experiments to create protocols and insights, (ii) to develop improved data validation processes, and (iii) to translate the experimental ICT framework into a quasi-operational tool that can be adapted to fit different CPA needs for disaster management scenarios. In short, the aim of this task is not to build a new VGI tool, but to adapt and optimise already existing tools to generate understanding of the processes, methods, and data needs of Civil Protection Authorities (CPAs) in a disaster management context. The process includes engagement with the stakeholder needs assessment process to determine the specific information needs that VGI could address, and those requiring EO information. These information and data needs were translated into specific VGI tasks and a data collection workflow.

Task 5.3 began with the initial case study pairing that resulted from earlier implementation of Tasks 3.1 and 3.2. The user stories we created were paired with four case studies, namely MRP, CDP, Lancashire Constabulary, and Czech Association of Fire Officers (CAFO). Further bilateral talks with the case studies led to the realization that UT does not have adequate subject matter know-how to effectively tackle CBRN disasters – which was the focus disaster for CAFO – and that other technical solutions within the consortium best fit their needs. LC subsequently left the project, thus MRP and CDP are the only case studies featured in the report.
The solutions presented from this Task will be further integrated in WP7 and will be featured in observer cities in WP6. The observer cities will be used to validate the impacts and usefulness of the tools in a wider geographic context. The feedback will be used to identify possible improvements.

1.2 Intended Readership

The readership of this document is open to the public. It is addressed to everyone who is interested, both within the consortium and the general public - and provides a detailed insighted into the workflow and processes that occurred during the development of the tools.

1.3 Structure of the Deliverable

After this initial orientation, this document includes the following chapters:

- **Chapter 2:** This chapter introduces the MappingDamage and Thermal Comfort Tracker tools by providing an overview of each technical solution created during Task 5.3.
- **Chapter 3:** This chapter consists of the tool conceptualisation, explaining the concept formation process of the tool. The chapter is subdivided into four parts explaining the co-creation communication approach between the UT and the case studies we were paired with. The subsequent subdivisions explain the situational analysis of the current disaster landscape, formulation of technology concepts and the delineation of tool functionalities for MRP and CDP respectively. The last subchapter describes an inventory process of existing VGI tools that offer the functionalities that were listed.
- **Chapter 4:** The chapter describes the processes and workflows of the relevant pre-development analysis for both MRP and CDP, respectively.
- **Chapter 5:** This chapter provides an overview of the development process, information exchange with relevant stakeholders, and technical and conceptual implementation of feedback received.
- **Chapter 6:** This chapter provides a conclusion reflecting on the successes and limitations of the deliverable in reaching the intended objectives of Task 5.3 and within the wider framework of operational disaster risk management.
- **Reference:** A list of all literature referenced during the creation this document.

2 VGI TOOL SOLUTION

2.1 The MappingDamage Tool

This tool (**Figure 1**) was formulated based on the needs of the MRP case study and is used to assess post-disaster damage to basic infrastructure. Originally, it was focused solely on post-wildfire usage. However, to make the tool more dynamic, it was updated to include tasked data collection for pre-disaster purposes, specifically for floods and wildfires. We restrict the usage of the tool to these two stages, because the MRP only has jurisdictional rights before an event, and again later in the response and recovery process (after immediate event response by national emergency agencies). The infrastructure of interest includes buildings, roads, and water and fire infrastructure, such as fire hydrants and rainwater manholes. Reporting of burned vehicles is also included. Tasked routine checks on the water and fire infrastructure comprise the pre-disaster section of the tool in the case of both impending floods and wildfires. Post-disaster damage mapping includes reporting the conditions of burned buildings, roads, vehicles, fire hydrants, and manholes. The tool can be accessed here.

2.1.1 Purpose of the Tool

In the context of disaster risk management and the Risk Perception-Action Gap (RPAG), the tool aims to achieve several objectives. Firstly, it provides need-specific information to the case study. Secondly, it leverages the resources of volunteers to report disaster impacts. The volunteers refer to individuals with local knowledge, tasked to collect relevant information that meets the CPAs' needs. Thirdly, this approach raises awareness among citizens regarding the scale of disasters and their impact on the community as it allows citizens to act as data collection agents. Fourthly, the tool records the differing perceptions of damage among citizens.

2.1.2 EXPECTED IMPACTS AND BENEFITS

This tool has been designed to support the municipality in prioritising areas that require utmost attention for post-disaster recovery and reconstruction efforts following a calamity. The collection of damage information plays a vital role in facilitating efficient reconstruction and recovery endeavours. It contributes in various ways, including the assessment of needs, resource allocation, planning and decision-making, damage documentation, and targeted interventions. Moreover, the tool incorporates feedback from citizens during the damage reporting process, fostering a more inclusive bottom-up approach to disaster management. Ultimately, this tool equips the municipality with valuable information that can guide effective decision-making and resource allocation in the aftermath of a disaster.

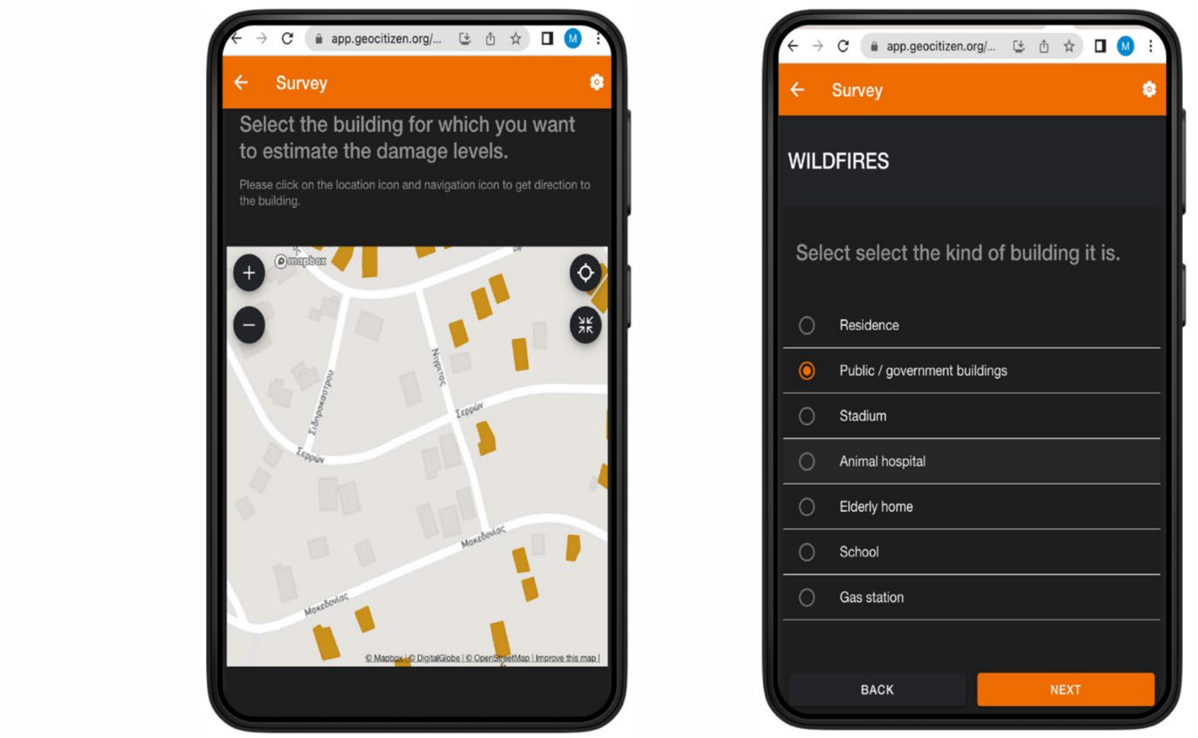

FIGURE 1: ILLUSTRATIONS OF THE MAPPINGDAMAGE APP BUILT ON THE GEOCITIZEN PLATFORM.

2.2 The Thermal Comfort Tracker Tool

Italy is prone to experiencing heatwaves, which are extended periods of excessively hot weather. Heatwaves can have significant impacts on both human health and the environment, characterized by high temperatures and health risks, particularly for vulnerable populations such as the elderly, young children, and individuals with pre-existing health conditions. In addition, climate change is expected to lead to a substantial increase in heat waves, including in Europe. CDP has identified heatwaves as a primary concern, as there is insufficient information available regarding their impact, adaptive behaviours, and the perspectives of citizens in Padua. Other than expanding the presence of green infrastructure in the city, not much has been done to capture data about the thermal and perception variations within the city. The tool can be accessed here.

In a bid to do so, the municipality announced plans to install outdoor and indoor meteorological sensors throughout the city of Padua, allowing better insight into actual variability of temperatures within the urban fabric. Thirty indoor sensors will be strategically placed in municipal buildings with varying building materials and urban fabrics. These sensors will measure air temperature, air speed, and humidity - three of the four key meteorological parameters required to calculate the objective aspects of thermal comfort. The data collected from these sensors will be used in conjunction with our tool to provide a comprehensive assessment of personalised thermal comfort. The combined data will be correlated to identify the relationship between the measured environmental parameters (such as temperature, air speed, humidity) and the perceived level of comfort. This will help understand the specific environmental conditions that affect people's comfort perceptions. The tool (**Figure 2**) is utilised for monitoring the subjective perceptions of thermal comfort.

2.2.1 Purpose of the tool

In the context of disaster management and the Risk Perception-Action Gap (RPAG), this tool, combined with the sensors, facilitates an understanding of perceptions regarding thermal comfort. A target group consisting of individuals of different ages within municipal buildings will be requested to provide information about their age, gender, country of origin/place of residence within the past 5 years, clothing types as a measure of thermal insulation, previous metabolic activity, current thermal state, which ranges from cold (-3) to hot (+3) on a 6-point scale, and an indication of the desired change in thermal state.

2.2.2 Expected impacts and benefits

Understanding people's perceptions of thermal comfort is crucial for appropriate heatwave management. This is because thermal comfort is subjective, and varies based on factors such as age, gender, and health status. Heatwaves can have severe health impacts on vulnerable populations, and inappropriate management can result in significant economic consequences. Understanding people's perceptions can help policymakers design more effective and targeted interventions, as well as promote sustainable practices to mitigate the impact of heatwaves on the environment.

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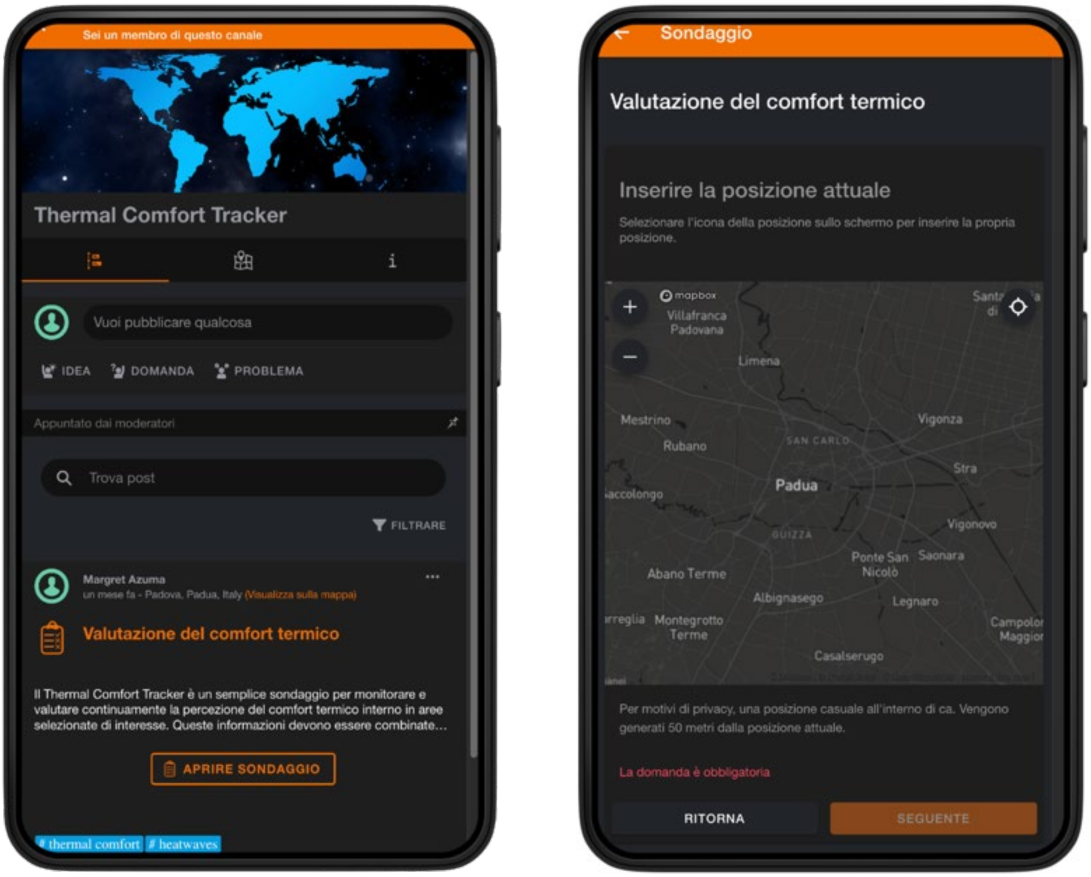

FIGURE 2: ILLUSTRATIONS OF THE THERMAL COMFORT TRACKER APP BUILT ON THE GEO-CITIZEN PLATFORM

3 TOOL CONCEPTUALISATION

3.1 Iterative Co-creation approach with Case-studies

Based on the initial findings and case study-technology partner pairing in WP3, the tool was conceptualised through a co-creation approach involving MRP and CDP, as well as their respective scientific partners, namely KEMEA and STAM. The process entailed several cycles of designing, testing and refining, as well as managing stake-holder expectations. The needs of each case study were identified by conducting a situation analysis of the disasters, the disaster stage of focus, and the required data. Furthermore, enquiries were made about the jurisdictional capabilities and responsi-bilities of each case study to enhance conceptualisation and usability within the disas-ter risk management framework. This information led to the development of the de-sired technological concepts and tool functionalities. Finally, an inventory of existing tools was created, and the tool with the highest functional match was chosen.

3.2 Conceptualisation of MappingDamages

3.2.1 Situational analysis of MRP's disaster landscape

To conduct a situational analysis of MRP disaster management, a process was followed to first understand their disaster history and the hazard type(s) they were mostly interested or had issues with addressing. Next, a discussion took place on what disaster risk stage(s) were within their jurisdictional rights to manage. This was followed by an effort to understand their current data needs, as well as their current interaction with citizens during disasters. It was found that MRP faces several hazards throughout the year, with floods and wildfire hazard being particularly difficult to manage due to their magnitude and intensity induced by a changing climate and recurring fire and flood seasons.

We established that municipal responsibilities to intervene in disaster events were limited to pre-disaster and post-disaster management. The time period of the post-disaster intervention is specifically when response intervention has been completed by national emergency authorities. Hence, their data needs include the use of citizens to collect data that will aid pre-disaster and post-disaster efforts.

We further attempted to understand the municipality's current use of citizens as volunteers and data collection agents. MRP has a group of volunteers that assist the municipality with requested tasks. The volunteers are officially registered with the municipality with the responsibility of carrying out regular caretaking tasks in line with municipal needs. It was established that a tool was needed that primary contributors will go beyond registered volunteers but involve citizens in its data collection efforts.

3.2.2 Formulation of technology concepts and data needs

We agreed on creating a primarily tasked post-disaster data collection app that builds on open data from OpenStreetMap (OSM) and Earth Observation (EO) data. A burn scar analysis was performed and used to argument and provide burn categorisation to the feature data collected from OSM. Volunteers (anyone with internet access and intention) are tasked with providing useful information that meets functional data needs. Table 2 lists in details the information to be retrieved by volunteers.

Table 2: Data needs to be collected via the MappingDamage platform

Assert	Type	Wildfire categorisation	Flood categorisation
Buildings	1. Main residence 2. Secondary residence 3. Public building 4. Stadium 5. Animal hospital 6. Elderly home 7. Schools 8. Nurseries 9. Gas stations	1. No damage 2. Can be restored. 3. Destroyed to be demolished	1. No damage 2. Flooded basement. 3. Partial damage (inside the house-doors, windows or other structural elements) 4. Garden-surrounding area

			5. Building Collapsed (partial or whole) 6. Landslide (landslide that had provoked or might provoke static problems to the building) 7. Unknown/ other
Roads	1. Highway 2. Track 3. Pedestrian 4. Path 5. Dead-End Street	1. Clear 2. Blocked a. Inert materials b. Garbage bins c. Vehicles d. Fallen trees. 3. Damaged road	1. Unaffected 2. Flooded 3. Subsidence 4. Partial damage (potholes) 5. Blocked or impassable
Fire hydrant		1. Broken 2. Leak 3. Blocked with debris or mud.	1. Broken 2. Leak 3. Blocked with debris or mud.
Rainwater manhole		1. Visible melt burns on mental 2. Blocked by debris, mud or trees.	1. Blocked by debris or mud. 2. Blocked by trees.
Area of greenery		1. Severely burned: total collapse of the trees 2. Broken branches, standing tree. 3. Minor damage – leaves/ small branches 4. Verify if the original greenery still exists.	1. Destruction of cultivation areas 2. Uprooting of trees 3. Falling trees
Destroyed vehicles	1. Truck 2. Van 3. Bus 4. SUV 5. Car 6. Motorcycles	1. Burned 2. Partially damaged 3. Abandoned - no knowledge of the owner.	

Private water supply infrastructure		1. Geolocation mapping using GPS	

3.3 Conceptualisation of Thermal Comfort Tracker

3.3.1 Situational analysis of CDP's disaster landscape

During our discussions with CDP, it was revealed that heatwaves were identified as the primary hazard of concern. While CDP also deals with flood-related hazards, heatwaves are often overlooked and under-managed due to inadequate comprehension of how it impacts individuals, especially vulnerable groups such as those over 65 and those with cardiovascular health issues. Understanding heatwave vulnerability is complex due to the interplay of various social, environmental, and individual factors that influence how different people experience and respond to heat stress. Social factors, such as age, income, housing quality, and access to healthcare, can significantly affect a person's vulnerability to heatwaves. For example, older adults and low-income households may be more vulnerable due to their increased risk of chronic health conditions and limited access to resources like air conditioning. On the other hand, older individuals of relatively high socio-economic status with access to air conditioning may not be as vulnerable as individuals living in densely populated urban areas. Such individuals may be at higher risk due to the urban heat island effect, which can increase ambient temperatures in urban areas compared to surrounding rural areas.

When considering heatwaves, it is important to note that our focus is often on the external temperatures, such as a forecast predicting temperatures in excess of 35 degrees. However, what truly matters for individuals is their specific exposure (e.g., working outdoors or having access to indoor spaces) and how the temperature varies, particularly indoors. During a 35-degree scenario, indoor temperatures can vary significantly, ranging from approx. 25 to 45 degrees, depending on factors such as the number of floors, insulation, and other variables. Due to this variation in indoor environments, it was determined that the focus of our project would be on examining people's perceptions of thermal comfort during heatwave events, in order to identify coping mechanisms and inform optimal HVAC system design in buildings.

To narrow down a feasible approach, it was agreed that installing indoor and outdoor thermal sensors throughout the city of Padua is necessary to account for and acquire data environmental variables that influence variations in perception. It was decided that the indoor sensors should be placed in government buildings (office and social housing) across the city to always enable full access and control during heatwave season. Social houses with older, more vulnerable residents will be selected. Outdoor sensors are placed in strategic locations with blue/green and red infrastructure within the city of Padua. Our task was to determine the most effective approach for gathering data on thermal comfort and how to integrate subjective data with objective data from the thermal sensors to gain a comprehensive understanding of thermal comfort.

3.3.2 Formulation of Technology Concepts and Data Needs

The Thermal Comfort tracker collects data from individuals within areas of interest. Individuals will be tasked with providing preceptive information that indicate their thermal comfort. The tool will allow for administrative users to access and download the information. The relevant data needs include information about:

- Age.
- Gender.
- Country/place of past residence.
- Clothing – to calculate thermal insulation.
- Metabolic activity prior.
- Exposure prior.
- Current thermal state.
- Desired change in thermal state.

3.4 Delineation of Tool Functionality

The approach taken involved creating an inventory of the requirements for the matched case study and identifying existing VGI solutions that could meet these needs based on technical specifications and usability ease. The following core functionalities were highlighted based on the technological concepts and data needs discussed above.

1. Register a user's location.
2. Based on location, retrieve closest infrastructure to the person.
3. Displays map and give direction through network navigation.
4. Allow the user input information based on a predefined categorisation.
5. Allow users take photo of feature they mapped.
6. Allow administrative rights to either accept or reject user input.
7. Allow information of a feature to be collected multiple times.
8. Inform the users on what features are to be prioritised.
9. Access to information collected through APIs.
10. Third party data retrieval to embed in third part website and for further analysis - API capabilities is necessary.
11. Available as a mobile app.
12. Supports offline data collection.
13. Relative ease of use for non-GIS expert.

The first step was to make an inventory of already existing VGI tools that have functionalities that matched the technological concepts and data needs. After conducting crosschecks to compare technical requirements against the available tools, it was discovered that a few solutions could effectively address the case study's needs. Table 3 illustrates these crosschecks. Popular humanitarian data collection apps such as OpenDataKit and Kobo ToolBox, QGIS integration apps (QField and Merge in Maps) and GeoCitizen were included in comparison analysis. It was concluded that GeoCitizen was the best option due to its ability to meet relevant needs and offers a range of technical flexibility for customisation. Therefore, customising and enhancing the Geo-Citizen platform to suit the specific requirements of the project was deemed the most suitable approach.

TABLE 3: COMPARATIVE ANALYSIS OF EXISTING VGI TOOLS BASED ON REQUIRED FUNCTIONALITIES

Core App Functionality	ODK	Kobo Toolbox	QField	Merge in Maps	GeoCitizen
Register a user's location	Yes	Yes	Yes	Yes	Yes
Based on location, retrieve closest infrastructure to the person	No	No	Yes	Yes	No
Displays map and give direction through network navigation	No	No	No	No	No – customisation possible)
Allow the user input information based on a predefined categorisation	Yes	Yes	Yes	Yes	Yes
Allow users take photo of feature they mapped	Yes	Yes	Yes	Yes	Yes
Allow administrative access and change base information	Yes	Yes	Yes	Yes	Yes
Allow administrative rights to either accept or reject user input	Yes	Yes	Yes	Yes	Yes
Allow information of a feature to be collected multiple times.	Yes	Yes	Yes	Yes	No - (customisation possible)
Inform the users on what features are to be prioritised	No	No	No	No	Yes - customisation necessary
Access to information collected through APIs	No	No	No	No	Yes
Third party data retrieval to embed in third part website and for further analysis - API capabilities is necessary	Yes	Yes	No	No	Yes
Available as a mobile app	Yes	Yes	Yes	Yes	No (customisable as a progressive mobile app)
Supports offline data collection	Yes	Yes	Yes	Yes	Yes
Relative ease of use for non-GIS expert	Easy	Easy	Training is	Training is rec-	Easy

			recom-mende d	om-mended	

4 PRE-DEVELOPMENT DATA ANALYSIS AND ACQUISITION

4.1 MappingDamages Tool Pre-Development

A nested approach was followed during the pre-development for the MappingDamage platform. The nested approach involved the use the integration of EO data with vector dataset from OSM and administrative database to create preliminary information for volunteered mapping to be carried out.

4.1.1 Burn Severity Mapping

Sentinel-2 imagery available in Google Earth Engine (GEE) was used for the burn severity mapping. The Sentinel-2 satellites are part of the European Space Agency's Copernicus program and are equipped with multispectral optical imaging sensors. Sentinel-2 Level-1C was used. Sentinel-2 Level-1C refers to a specific processing level of data acquired by the Sentinel-2 satellite mission. The Level-1C data have been orthorectified and radiometrically calibrated. It undergoes geometric correction to remove distortions caused by the satellite's position and the Earth's surface, resulting in accurate spatial information (Gaudel et. al., 2017).

The methodology used for conducting burn severity analysis using Sentinel-2 Level-1C (**Figure 3**) (Howe et. al., 2022):

1. **Acquire Sentinel-2 imagery:** Obtain Sentinel-2 Level-1C imagery for the pre- and post-fire periods. The imagery was selected based on cloud cover and the timing of the fire event.
2. **Atmospheric correction:** Perform atmospheric correction on the Sentinel-2 imagery was used to remove the atmospheric effects and improve the quality of the images. The script features a cloud-and-snow-masking algorithm based on quality assurance (QA) band. This process removes clouds and snow and their shadows from all images of a collection (Tarrio et. al., 2020).
3. **Vegetation indices:** Calculate the Normalised Burn Ratio (NBR) for the pre- and post-fire images. The NBR is a commonly used index to measure the severity of burn.
   The NBR formula is – NBR = (NIR - SWIR) / (NIR + SWIR): where NIR refers to the Near-Infrared band and SWIR refers to the Shortwave Infrared band of the satellite imagery (Gaveau et al., 2021).
4. **Image differencing:** Subtract the pre-fire image from the post-fire NBR image to obtain the difference image, also known as the Differential Normalised Burn Ratio (dNBR) image. This image shows the changes in reflectance caused by the fire (Lasaponara et al., 2020).

5. **Burn severity classification:** Classify the burn severity using the dNBR index. The dNBR values range from -1 to 1, with lower values indicating higher severity of burn. Table 4 displays the threshold value used to classify the burn severity three classes was based on threshold defined by the United States Geological Survey (USGS).

TABLE 4: BURN SEVERITY CLASSES AND THRESHOLDS PROPOSED BY USGS

Severity level	dBNR Range
Enhanced Regrowth, high	-0.500 to -0.251
Enhanced Regrowth, low	-0.250 to -0.101
Unburned	-0.100 to +0.99
Low Severity	+0.100 to +0.269
Moderate-low Severity	+0.270 to +0.439
Moderate-high Severity	+0.440 to +0.659
High Severity	+0.660 to +1.000

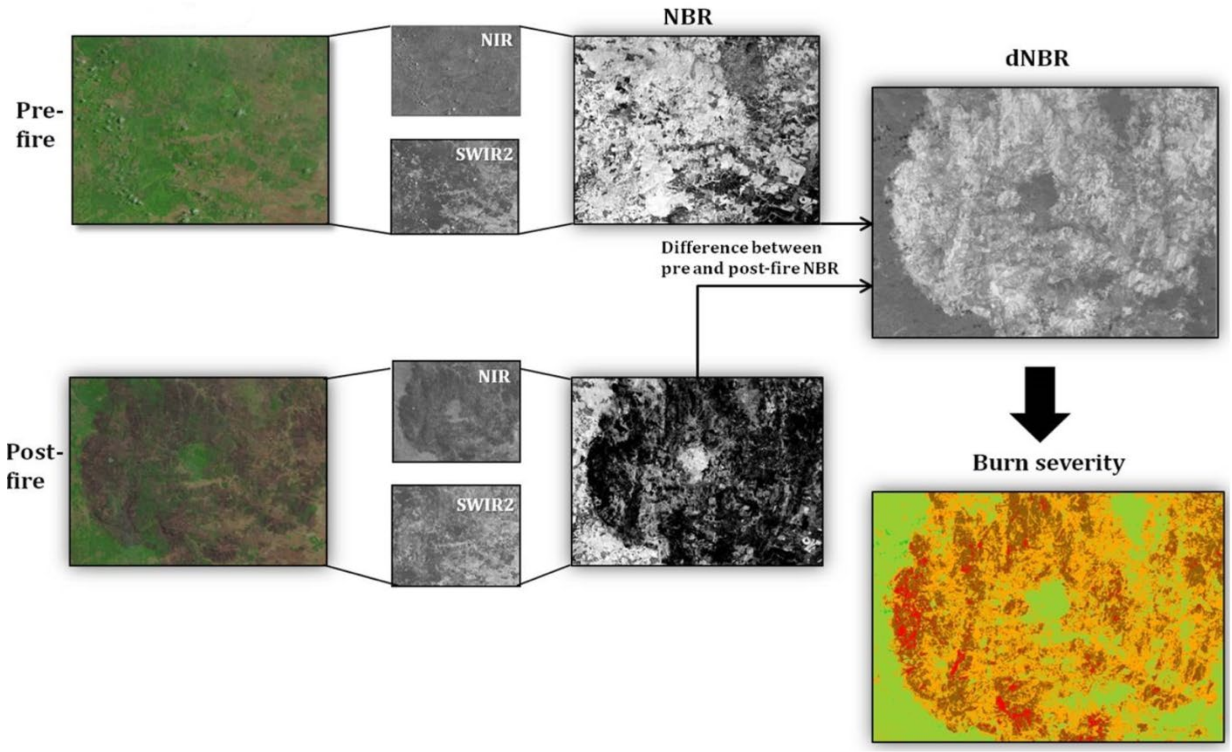

FIGURE 3: WORKFLOW ILLUSTRATING THE STEPS FOR THE BURN SEVERITY ASSESSMENT.

The initial analysis was performed on GEE platform using data from the 2018 fire to serve as an analytical basis. This event was selected because it is the most recent devastating fire disaster that occurred in MRP. The fires broke out on July 23, 2018, and quickly spread due to strong winds and extremely dry conditions. The wildfires resulted in the loss of many lives and widespread destruction of homes and properties. The plan is for this analysis to be repeated by changing the pre and post image dates to future dates. The result (**Figure 4**) was exported and used to analyse the OSM data.

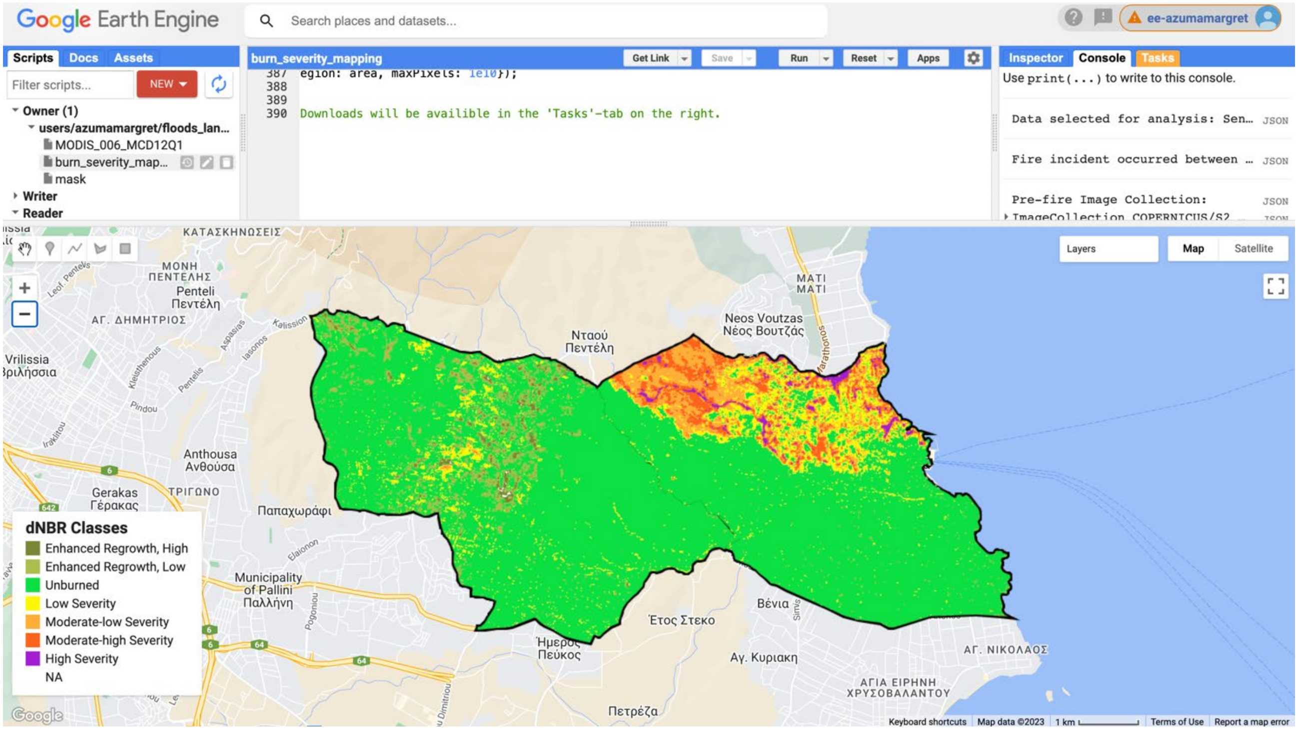

FIGURE 4: BURN SEVERITY ANALYSIS FOR THE 2018 FIRES IN MRP.

4.1.2 HOTOSM CAMPAIGN ACTIVATION

Upon discovering that the OSM data for MRP were largely incomplete, in partnership with UoW, MRP and KEMEA, a Humanitarian OpenStreetMap Team (HOTOSM) campaign was organised to improve the currency of the OSM data. The workshop was held on the 12th of January 2023 and volunteers (from local schools, employees at the municipality, hospital and elder home) were invited to participate in the map making event. While roads were complete on OSM, features such as buildings and green areas had to be updated. Hence, the main goal was to complete building and green area features in OSM.

Other features such as fire hydrants and rainwater manholes were mapped into OSM using administrative data points.

4.1.3 GEOSPATIAL DATA ANALYSIS

The features retrieved from OSM were overlayed on the burn scar map to categorise and add an extra layer of information on the OSM data. The following geospatial vector analysis were performed.

1. **Polygonise the raster data:** The burn severity map was converted to a vector format to allow for further analysis.
2. **Union overlay:** Overlay geospatial analysis involves overlaying different layers of data on top of each other and analysing the overlapping areas to identify patterns. Each feature was overlayed on the burn scar and assigned a Digital Number (DN) that matches the burn severity.
3. **Burn severity classification of features:** Based on the DNs, each feature in the vector layer was assigned to a corresponding burn severity class.

4. **Dissolve**: Results of the union overlay leaves fragmented features because a single feature can have multiple DNs. The dissolve function removes this fragmentation by combining adjacent features into a single feature based on a shared attribute (in the case, the unique OSM ID).

4.2 Thermal Comfort Tracker Tool Pre-Development

4.2.1 HUMAN THERMAL COMFORT DYNAMICS

A literature review of existing thermal comfort analysis methods was conducted. Several methods such as Universal Thermal Climate Index (UTCI) (Jendritzky et al., 2012), Predicted Mean Vote and Predicted Percentage of Dissatisfied (PMV & PDD) (Fanger, 1970), Physiological Equivalent Temperature (PET) (Höppe, 1999) and Assumed Sensation Vote (ASV) (Nikolopoulou et. al., 2004) were compared. Such comparative analysis is necessary to determine what preceptive information is required. The consensus is that there are six basic environmental (psychical and physiological) parameters: air temperature, mean radiant temperature, air velocity, humidity, clothing insulation, age and gender and metabolic rate (**Figure 5**). On the subjective aspect, several psychological factors influence human thermal comfort, including but not limited to thermal expectations, prior experiences, thermal history, environmental stimulation, duration of exposure, and alliesthesia (Lai et. al., 2020).

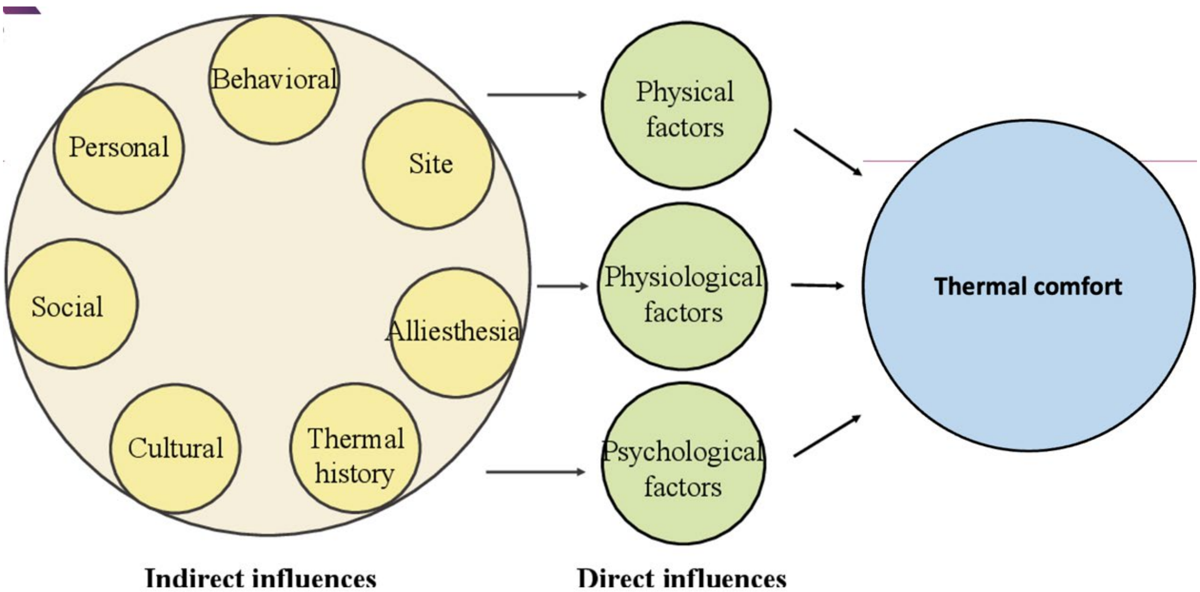

FIGURE 5: DIRECT AND INDIRECT INFLUENCES ON THERMAL COMFORT (LAI ET. AL., 2020)

5 TOOLS DEVELOPMENT

5.1 Development of First Prototype

The development of the tool consisted of two stages. The first stage involved the initial translation of the pre-development analysis to the GeoCitizen platform and the design of the data collection process. Data are collected with a survey, which volunteers can select and fill out by following clear instructions about the tasks they are expected to complete in each stage. While registration is not required to collect data, it is advisable for offline data collection. CPAs undergo the same registration process but are granted administrative rights as moderators by the administrator. Moderators have access to survey results, and can delete, edit, or create surveys as well as change user statuses from regular users to moderators (**Figure 6**).

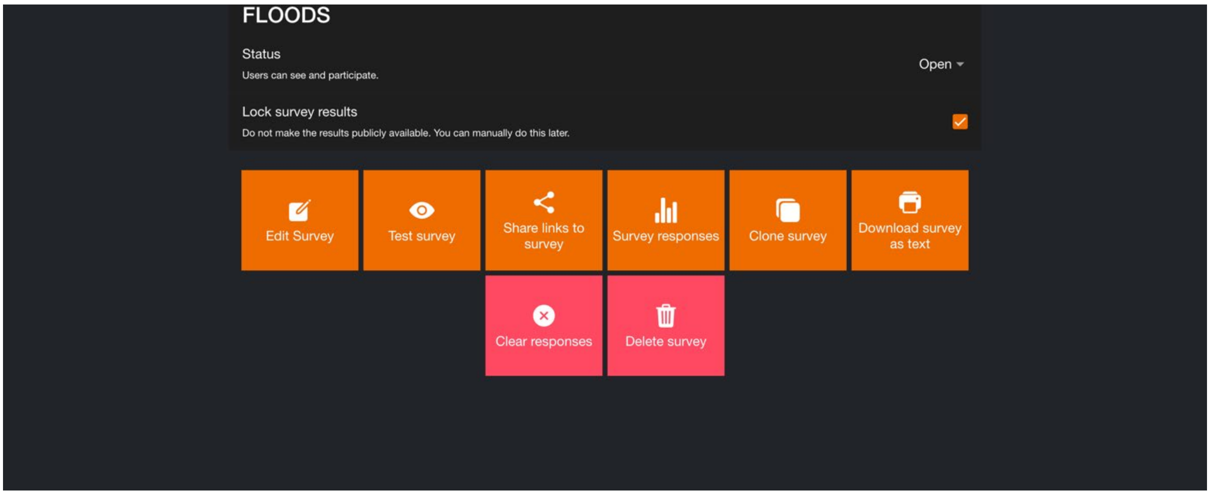

FIGURE 6: ADMINISTRATIVE OPTIONS FOR MODERATIONS TO CHANGE SURVEY STATUS, TEST SURVEY, SEE SURVEY RESPONSES, CLEAR SURVEY AND DELETE SURVEY

5.1.1 *EMBEDDING MAPPINGDAMAGE AND THERMAL COMFORT TRACKER TOOL ON THE GEOCITIZEN PLATFORM*

To integrate both tools into the GeoCitizen platform, individual channels were established for each tool (**Figures 7 and 8**). In GeoCitizen, a "channel" refers to a designated platform or category that serves a specific purpose or theme. The geographic boundaries for each tool were defined, i.e., Italy for the Thermal Comfort Tracker tool and Rafina-Pikermi for the Mapping-Damage Tool. Links were generated to serve as the landing page that visitors are directed to upon arrival.

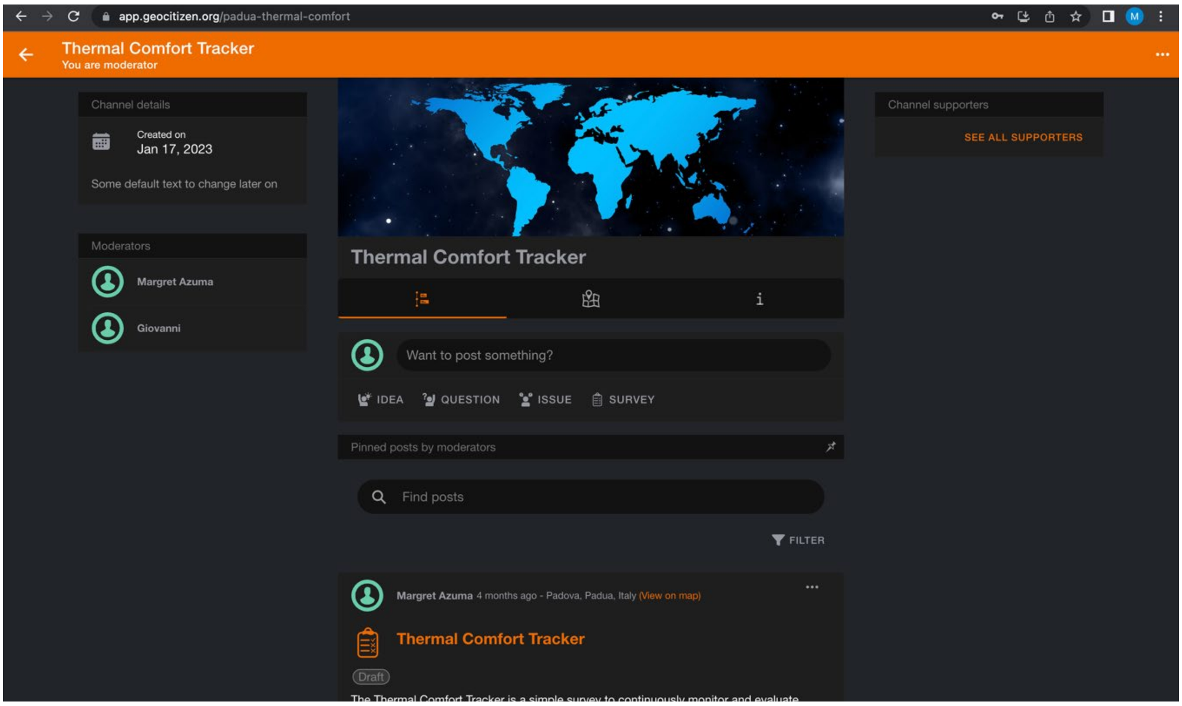

FIGURE 7:THERMAL COMFORT TRACKER CHANNEL PAGE

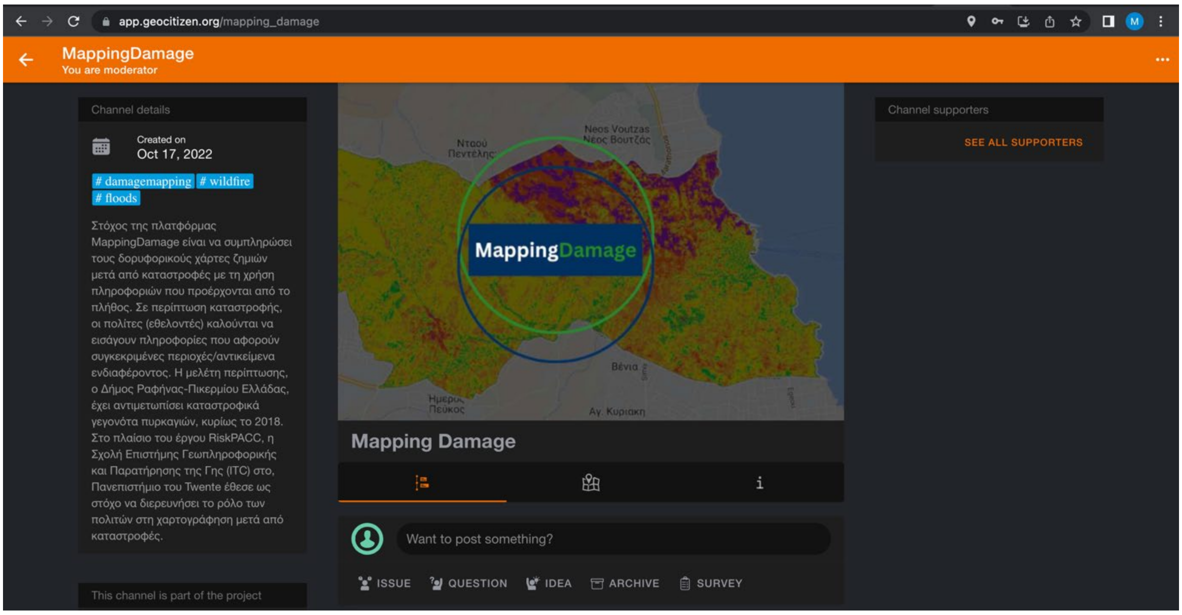

FIGURE 8: MAPPINGDAMAGE CHANNEL PAGE

5.1.2 MAPPINGDAMAGE TOOL

The following functionalities and customisation were done during the first release of the MappingDamage tool:

1. **Integration of categorised data:** Results derived from the pre-development phrase were uploaded in a Geoserver and used to create Web Map Services (WMS) and Web Feature Services (WFS). The WMS allowed for background visualisation categorised features, and the WFS to allow users interact with and select individual features. WMS of buildings, roads, green areas and WFS of

fire hydrants and manholes were included. Users see their current location on display and select the feature closest to them and provide information for the selected feature.

2. **Customisation of data collection workflow**: The first data collection workflow includes separate surveys for individual features of interest. Separate surveys means that a user had to answer separate surveys depending on the feature they wanted to collect data on. **Figure 9** illustrates the data collection flow present during the first release.

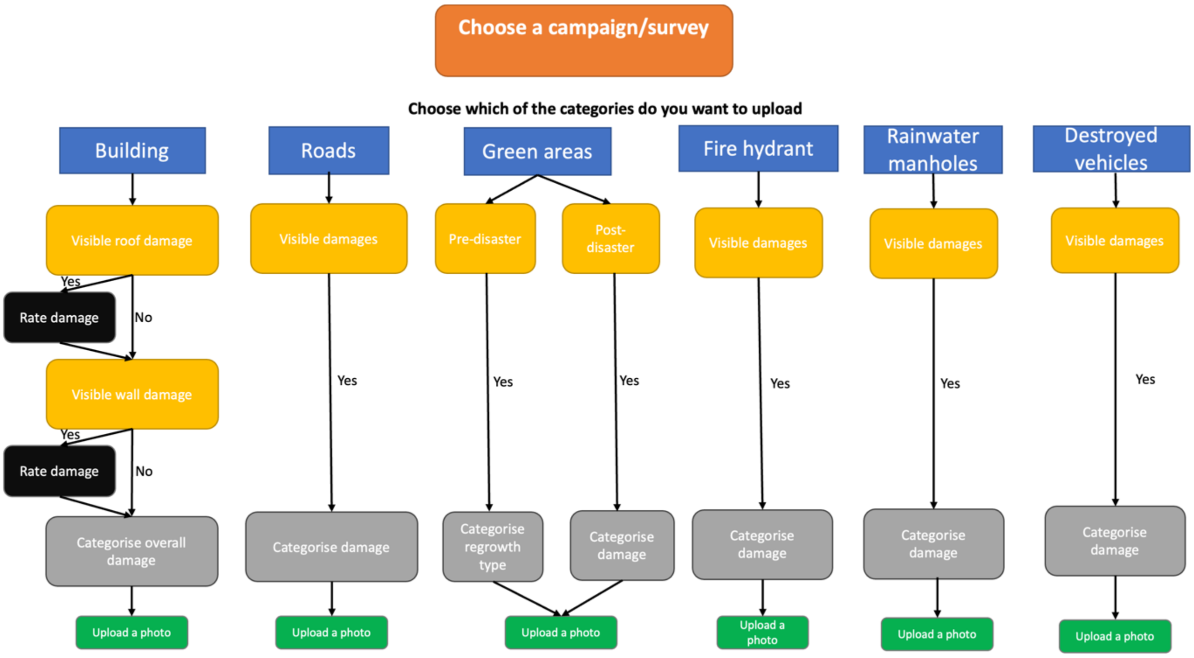

FIGURE 9: DATA COLLECTION FLOW FOR THE FIRST RELEASE OF MAPPINGDAMAGE TOOL.

5.1.3 THERMAL COMFORT TRACKER TOOL

The following functionalities and customisation were done during the first release of the Thermal Comfort Tracker tool:

1. **Customisation of data collection workflow:** A user is asked to provide their locational information and answer questions regarding their age range, gender, current thermal state, prior thermal exposure, prior activity, and a multichoice option to select the clothes they have on (**Figure 10**).

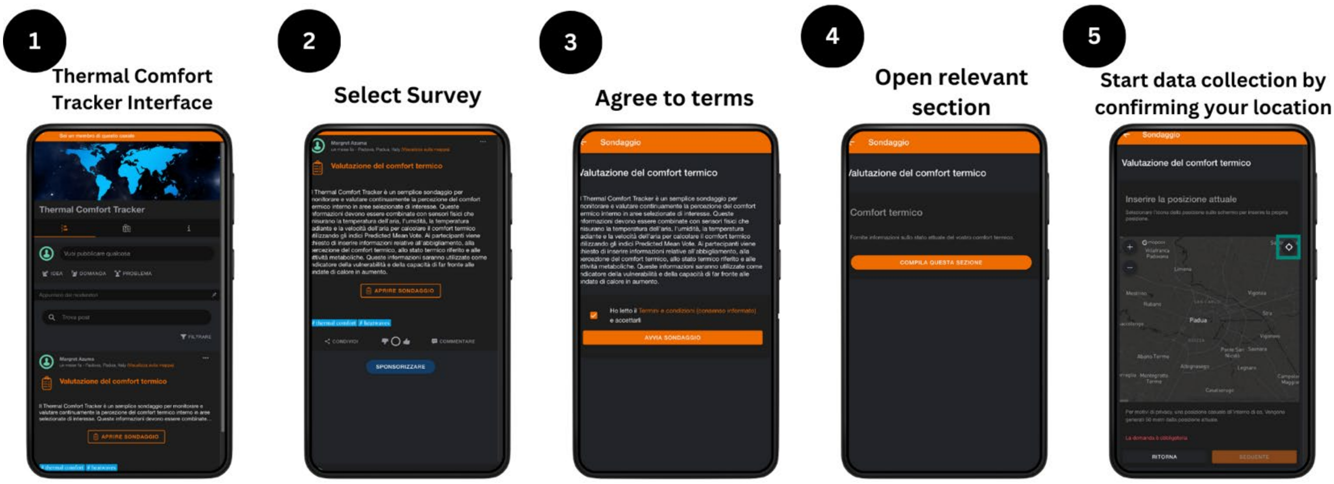

FIGURE 10: CUSTOMISATION OF THE THERMAL COMFORT TRACKER TOOL.

5.2 Stakeholder Feedback

After consultation with the relevant stakeholders, request for improvements were made. Table 5 shows the improvements that were requested by case study partners.

TABLE 5: REQUESTED IMPROVEMENTS TO BE MADE AFTER DEVELOPMENT OF FIRST PROTOTYPE

Case study partner	Requested improvement	Explanation
MRP (Mapping-Damage Tool)	Improved damage classification of features.	Damage classification of buildings have been reduced from a 4-level categorisation to a 3-level categorisation. In addition, the categorisation of the area of greenery was revised to cater towards monitoring the forest areas that were burned during the 2018 Greek fires.
	Inclusion of pre- and post-disaster data collection	Categorisation representing the state of water and fire infrastructure pre-disaster were included.
	Network navigation	Google maps network navigation was included to help data collector locate places.
	Complete Greek language translation and adaptation of the tool	All icons and buttons have been translated to Greek. However, there are many incoherent translations that needed to be manually improved.

	Better seamless flow of app navigation	The initial version of the app allowed data collectors view all the results of the data collected. This function has been removed.
	Allowing for data collection more than once	This refers to an inherent limitation of GeoCitizen that prohibits users from filling surveys more than once. This issue has been fixed.
	Improved sign-up and login experience	There were issues with not receiving authentication codes after entering phone numbers. We have not been able to completely solve it, so we will eliminate the option to authenticate with phone number.
CDP (Thermal Comfort Tracker Tool)	Improved thermal comfort delineation.	Improved phrasing of metabolic and clothing insulation questions and delineation of options.
	Transformation from web app to progressive web app.	Progressive web apps (PWAs) are a type of web application that utilises modern web technologies to provide a native app-like experience to users, without requiring **them** to download and install an app from an app store. We decided to convert the web app into a PWA.
	Italian translation improvements	Iterative process with CDP partners to ensure correct translation.
	Allowing for data collection more than once	This refers to an inherent limitation of GeoCitizen that prohibits users from filling surveys more than once. This issue has been fixed.

5.3 Development of Final Prototype

In the second and final stage of the release, our aim is to enhance the functionalities that were not initially incorporated in the GeoCitizen platform but are crucial to the effectiveness of the tool. The following functionalities were integrated for the second demonstration of the tool.

5.3.1 MappingDamage tool

1. Conversion from a webapp to a progressive web app. PWAs offer cross-platform compatibility which allows them to run on multiple platforms and devices, including desktops, tablets, and smartphones, offline functionality, app-like experiences, fast performance, discoverability, cost-efficiency, seamless updates, an enhanced security. These advantages make PWA a better alternative to plain web apps, creating a user-friendly and accessible software.
2. Allowing users, except moderators with administrative access (i.e., CPAs), participant in data collection without authentication and login. These unregistered users can also collect data offline. This functionality was made possible to fulfil WP7 requirements of a common authentication system.
3. Implementation of the Google Earth Engine network navigation. This functionality allowed data collectors to easily locate data points.
4. Improved data collection workflow to cater to floods and wildfires and included additional data points to be collected (**Figure 11 and 12**).
5. OSM mapping of green areas and buildings to improve the currency of the features.
6. First version of Greek translation.
7. Created a social media-like post functionality to allow for participants to interact with survey.

5.3.2 Thermal Comfort Tracker tool

1. Conversion from a webapp to a progressive web app.
2. Allowing users, except moderators with administrative access (i.e., CPAs), participant in data collection without authentication and login. These unregistered users can also collect data offline. This functionality was made possible to fulfil WP7 requirements of a common authentication system.
3. Italian translation was implemented.
4. Improved delineation of personal thermal comfort.
5. Created a social media-like post functionality to allow for participants to interact with survey.

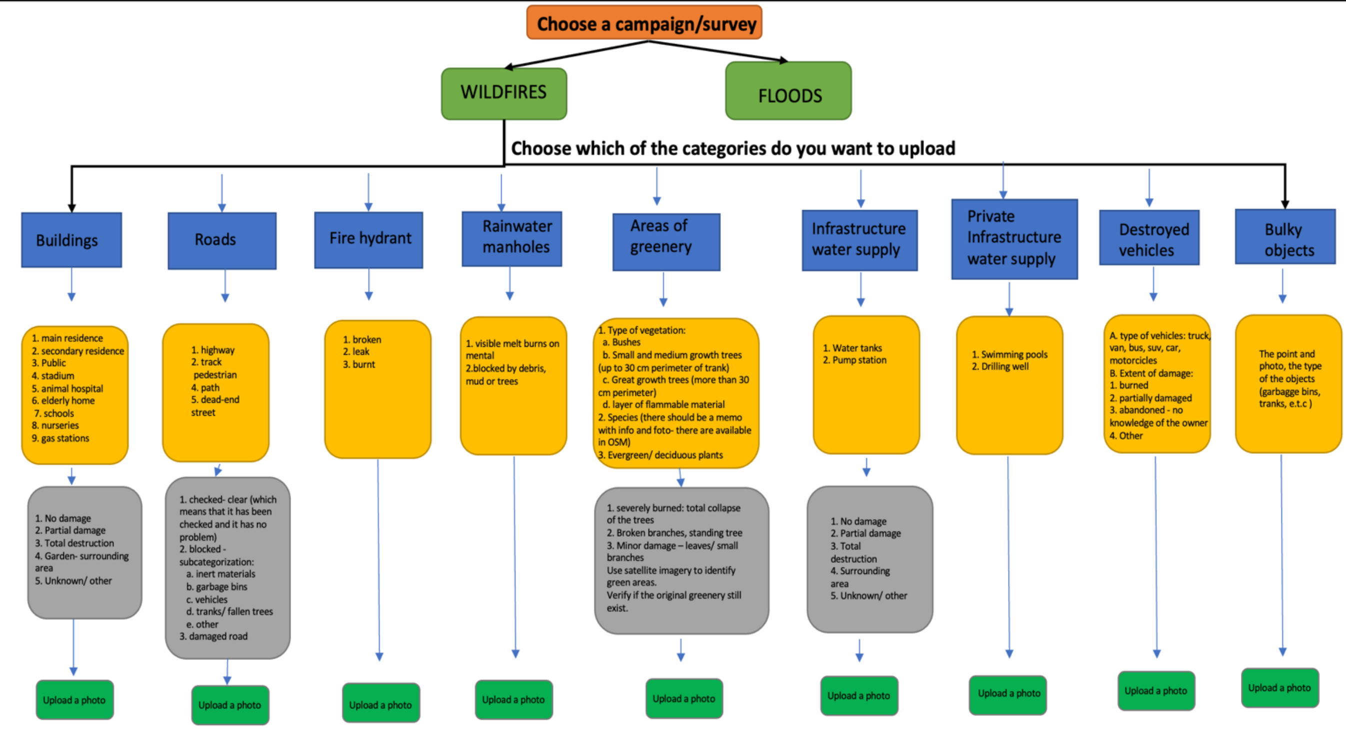

FIGURE 11: REVISED DATA FLOW FOR WILDFIRES IN MAPPINGDAMAGE IN FINAL TOOL RELEASE.

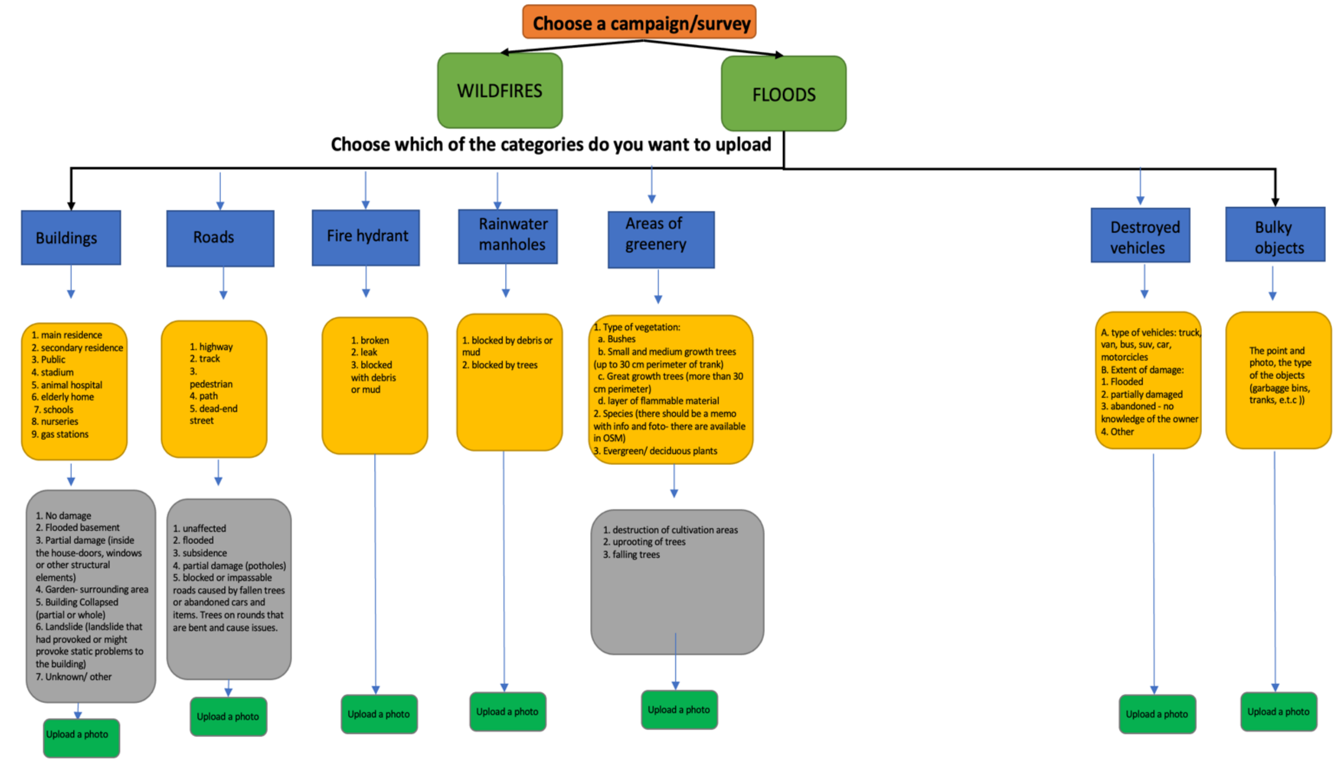

FIGURE 12: REVISED DATA FLOW FOR FLOODS IN MAPPINGDAMAGE FINAL TOOL RELEASE.

6 CONCLUSION

The objective of Deliverable 5.3 is to enhance and modify existing VGI tools to gain valuable insights into the processes, methodologies, and data requirements of Civil Protection Authorities (CPAs) for effective disaster management and for closing the RPAG. The focus of this deliverable was primarily on the Municipality of Rafina-Pikermi (MRP) and Comune di Padova (CDP) case studies, where their specific functional needs were identified through co-creation activities. Through a thorough analysis of data needs and roles in disaster management, conceptual frameworks for Mapping-Damage and Thermal Comfort Tracking tools were developed, supported by extensive literature review and pre-development analysis. The feedback received during the iterative process of prototyping and testing was predominantly centred on enhancing data collection processes and improving the user experience of the tool.

A notable strength of the process employed in this task lies in comprehending the underlying and practical requirements of the community. The derived information was subsequently utilised to inform the co-creation process, aiming to enhance the effectiveness of VGI tools in addressing these needs. Nevertheless, it is essential to acknowledge that this task does not encompass the comprehensive evaluation of these tools in real-life disaster scenarios, given that the tools were originally designed and developed for non-disaster contexts.

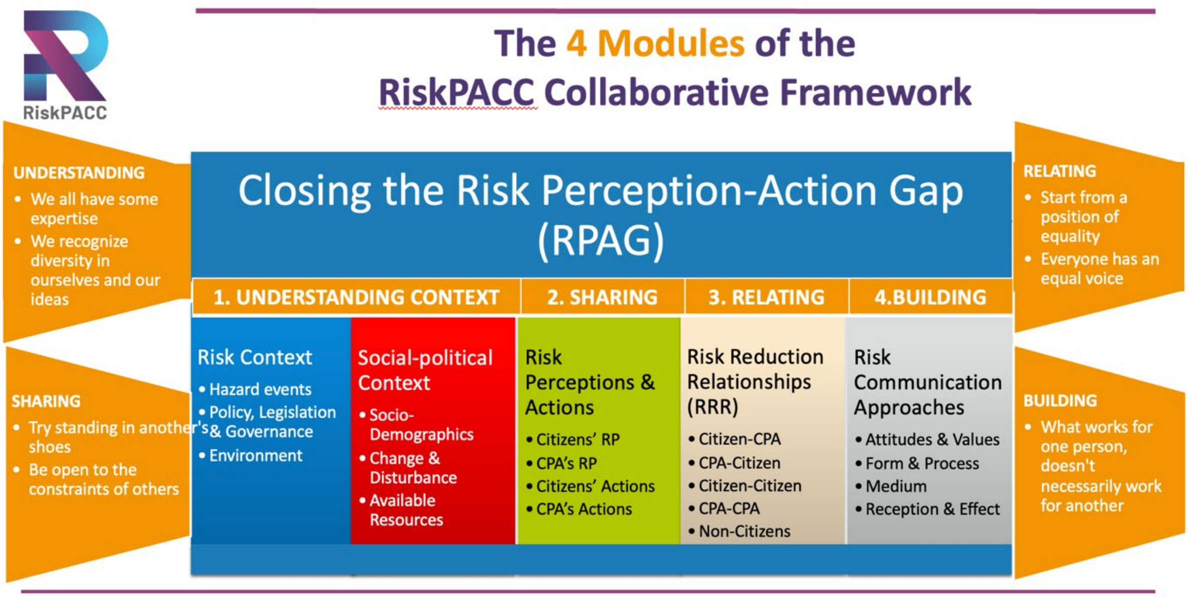

FIGURE 13: THE RISKPACC FRAMEWORK

Within the RiskPACC framework (**Figure 13**) to reduce the RPAG developed in WP4, the MappingDamage tool aligns with the understanding context, facilitating the categorization and correlation of framework elements. The tool enables citizen participation in post-disaster damage mapping, providing valuable insights for both citizens and CPAs to comprehensively assess the extent of physical impacts and identify community recovery needs. Similarly, the Thermal Comfort Tracker tool, situated within the understanding context dimension of the RiskPACC framework, enables CPAs to conduct controlled experiments to understand citizen perceptions of heatwave situations, their experiences on heatwave and non-heatwave days, and the relationship between subjective perceptions and objective thermal indicators. This reciprocal flow of information between citizens and CPAs fosters a collaborative approach, combining bottom-up and top-down perspectives, and supports the identification of operational information needs by CPAs while citizens contribute to the necessary data requirements. This information flow also highlights the interconnections and advancement aspects of the framework.

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FIGURE 14: THE RISKPACC CONSORTIUM