Citizen science tools for lake monitoring in the framework of the United Nations Sustainable Development Goals: the project SIMILE

Alberto Vavassori, Carlo Andrea Biraghi, Gorica Bratic, Daniela Carrion, Giorgio Zamboni, Maria Antonia Brovelli

Politecnico di Milano – Lecco Campus, Department of Civil and Environmental Engineering, Via Gaetano Previati, 1/c, 23900 Lecco, Italy
(alberto.vavassori, carloandrea.biraghi, gorica.bratic, daniela.carrion, giorgio.zamboni, maria.brovelli)@polimi.it

Abstract

SIMILE (Informative System for the Integrated Monitoring of Insubric Lakes and their Ecosystems) is a cross-border Italian-Swiss project aiming to improve the management of the Insubric lakes and their ecosystems with different technologies as well as the participation of citizens and stakeholders in water resources monitoring. In this project, water monitoring and management was carried out through different technologies: in situ sensors, satellite imagery, and data coming from citizen science. This paper focuses in particular on this last source of information, describing how data sourced from citizen science can contribute to the Sustainable Development Goals (SDGs) of the United Nations (UN). The report illustrates the tools that have been developed for the collection and management of information provided through citizen science; a mobile cross-platform application for smartphones that can be used by any citizen and a Web application for administrators, useful for data management and editing.

Keywords:

Lake monitoring, water quality, citizen science, Sustainable Development Goals

1 Introduction

Lakes are a fundamental resource for the environment, not only in terms of water consumption for agricultural and domestic usage, but also for the touristic and leisure activities that benefit from them (Carrion et al., 2020). Recently, scientific and technological development has provided useful tools for improving the management and monitoring of water resources.

SIMILE (Informative System for the Integrated Monitoring of Insubric Lakes and their Ecosystems) is a cross-border Italian-Swiss project. It aims to improve the collaboration and coordination between public administrations and stakeholders; for the management of the Insubric lakes (Lugano, Como and Maggiore) and their ecosystems, as well as monitoring water resources quality. The project involves both technical/scientific partners (Politecnico di Milano, Fondazione Politecnico, Water Research Institute – National Research Council and University of Applied Sciences and Arts of Southern Switzerland) and institutional partners

(Lombardy Region and Ticino Canton), yet also benefits from the involvement of schools, general public, and associations (Carrion et al., 2020).

The project's aim is the development of a business intelligence platform supporting decision and policy making for the public administrations regarding the Insubric lakes' management (Brovelli et al., 2019). This platform will integrate all the data retrieved in the context of the project. In particular, the technologies used for data collection including low-cost in-situ sensors (installed on dedicated buoys) that make high-frequency measurements, free and open satellite images (for example, those provided by the European Space Agency Sentinels), and information derived through a citizen science approach.

This paper primarily focuses on a citizen science approach, particularly tools developed for the collection and management of data coming from citizen science. Albeit, it is worth underlining that the business intelligence platform will integrate all the data collected and elaborated in the framework of the project. Therefore, data retrieved from satellite images and in-situ sensors represent relevant components as well.

The project strongly links to the purpose of the 6th Sustainable Development Goal (SDG) of the United Nations ("Ensure availability and sustainable management of water and sanitation for all"). There is a particular focus on targets 6.3 (stressing the importance of improving water quality and encouraging the recycling and safe reuse of water on a global level) and 6.5 (highlighting the importance of a coordinated management of water resources, including a transboundary cooperation). As SIMILE aims to strengthen the coordinated management of the water resources and the participation of citizens in water quality monitoring, we can view it as a form of "geospatial enabler" monitoring the SDG 6 (Brovelli et al., 2019).

2 Existing tools for the collection and management of citizen science data

The development of the above-mentioned applications started from an in-depth research of existing tools.

As for the mobile application, a detailed analysis of similar tools is described in a paper from Jovanovic et al. (2019). The authors presented six different applications used for water quality monitoring with a citizen science approach. These tools allow the user to provide information about different water quality related parameters (such as water colour, reflectance, transparency, and turbidity). Even though most applications are free, none of them is open source. For this reason, a new mobile application has been designed according to the following criteria: it should provide user support, it has to be user-friendly, able to work offline, free, and open source (Jovanovic et al., 2019).

In terms of the integrated system mobile/Web application, there are existing tools developed for the collection and visualization of crowdsourced data. For example, EpiCollect+ allows users to collect spatially referred data with a smartphone by completing a single questionnaire. Users have the possibility of attaching photos, short videos, sound clips, and measurements. The mobile app is integrated with a Web page dedicated to data visualization, downloading, and management (Aanensen et al., 2014). Another example is the Ultra Mobile Field GIS system, which consists of a mobile component dedicated to real-time data collection and a Web-GIS application for data visualization, downloading, and analysis (Lwin et al., 2011). Two other examples based on free and open source technologies are the projects: PoliCrowd 2.0 and The Paths of Via Regina. In both cases, data is collected with a smartphone, and a Web platform enables their visualization. With crowdsourced data displayed on a Virtual Globe, users can edit the data visualization, create customized maps, and use a time bar to investigate temporal distribution (Brovelli et al., 2016).

Although the above-mentioned systems have not been developed specifically for lake monitoring, there were some similarities with the tool created for SIMILE. The latter consists of a client-side with both the mobile and Web applications; and a server side with servers used to host, install, and execute the applications, the database, and a workstation processing collected images (Jovanovic et al., 2019). In the following section the system's functionalities will be introduced.

3 Description of the mobile application and administration interface

The first tool is a cross-platform, open-source mobile application called "SIMILE – Lakes Monitoring" (Biraghi et al., 2020). The application interface opens with a map centred on the user's current position and showing the contents uploaded by all users. In the application, a user can: share observations relative to the lake status (presence of algae, foams, oil stains, litters, odours, drains, and fauna), measure the water quality (transparency, temperature, pH, oxygen, and bacteria concentration), participate in education and sensibilisation events (such as clean-ups andworkshops), and learn more about the lake ecosystem (through a glossary available in the app).

The user can report strange phenomena or measure one of the water-quality parameters by adding a new observation to the map. A single observation consists of a georeferenced image and a series of attributes, selected through a guided interface (a list of entries is available for every indicator). A dedicated interface offers more precise information for every item, and a help button provides explanations about concepts that the user might not be familiar with. These contributions can be provided by any user, as they do not require particular competencies nor additional tools with respect to the smartphone. Additional instruments are necessary for actual measurements; for example, the Secchi disk to evaluate the water transparency and a thermometer to measure the water temperature. This functionality, which is available for everyone, allows sharing the results of lake monitoring through a simple tool.

Once the fields are completed, the observation can be submitted, and it will become visible to all the users.

Figure 1 shows some functionalities of the mobile app.

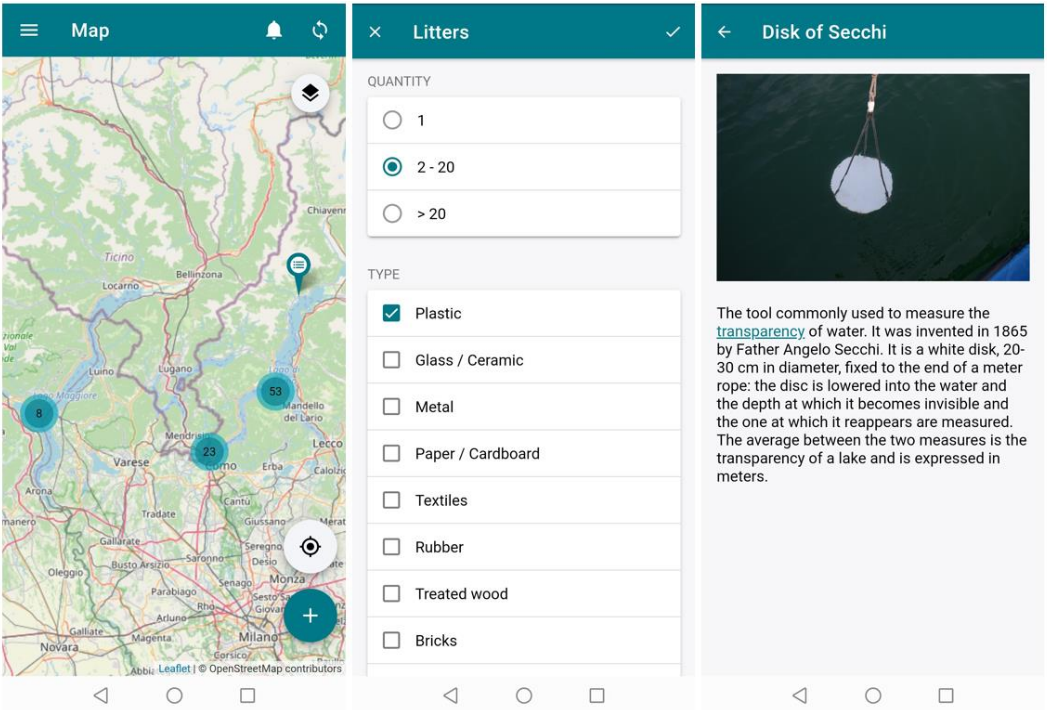

Figure 1: screenshots representing the functionalities of the mobile app. From left to right: cartographic representation displaying the position of events and observations; guided interface for adding a new observation; glossary.

In case of particularly dangerous or severe conditions, it is possible to contact the competent authorities through their official channels. The observations and the photographs uploaded through the app can be advantageous for a preliminary evaluation of the phenomenon.

Thanks to the mobile application, public and private authorities can promote public events with subjects relating to the project, directly addressing all application users. Uploaded events are visible in the dedicated section, accessible from the main menu, through an icon symbolizing a bell and the map itself. In the same section, the user can also find important communications published by the project partners or the competent authorities about environmental issues. This functionality can be quite helpful in case of weather warnings (or other types of alerts).

The information provided by citizens through the app is collected and managed with a dedicated Web application. The administration interface allows the user to visualize, delete, and edit the data provided with the app . The two applications are synchronized, thus, the edits performed on the database through the Web app are visible on the mobile app and vice versa. The information provided through the app is visible and editable with the Web app.

On the home page of the Web interface, it is possible to easily access all the functionalities through a series of buttons, each one dedicated to a specific theme (Figure 2). Data is provided either in a table format and through cartographic representation; therefore, it is possible to visualize their spatial distribution (either singularly or grouped in spatial clusters).

The themes accessible through the app are also available in the Web app. With proper credentials, it is possible to edit the database. For instance, a user can delete or edit existing observations, or improve their geographic position. Deleted data can be consulted applying an adequate filter to the table, and they can be recovered at any time.

Provided here is a short description of the available functionalities. Firstly, it is possible to consult, delete, and edit observations submitted by the users and create new observations (theme "observations"). The system can visualise graphs of some numerical variables (temperature, oxygen, and pH) as functions of depth. The Web interface is intuitive and well guided. The user can choose pre-set attributes for each field and manually add the value of the numerical variables.

Similarly, the user can consult or edit events and add new events (theme "events"). The possibility to modify or create a new event is available only on the Web application (through the mobile app, the user can only consult existing events). Similar functionalities are available for alerts (theme "alerts"); however, alarms have an "expiry date" after which they are no longer visible.

The Web app displays photographs uploaded by the users (theme "photos"), with all corresponding observation information in chronological order. Moreover, it is possible to visualize the boundaries of the different sub-areas within the region of interest (theme "ROIs", Region Of Interests). All the uploaded news, events and observations in either application are visualized on a dedicated calendar (theme "scheduler") or time bar (theme "timeline").

Finally, the Web application allows performing some analyses on the data (theme "analysis"): in particular, a user can filter the observations based on their attributes and visualize some useful statistics and trends.

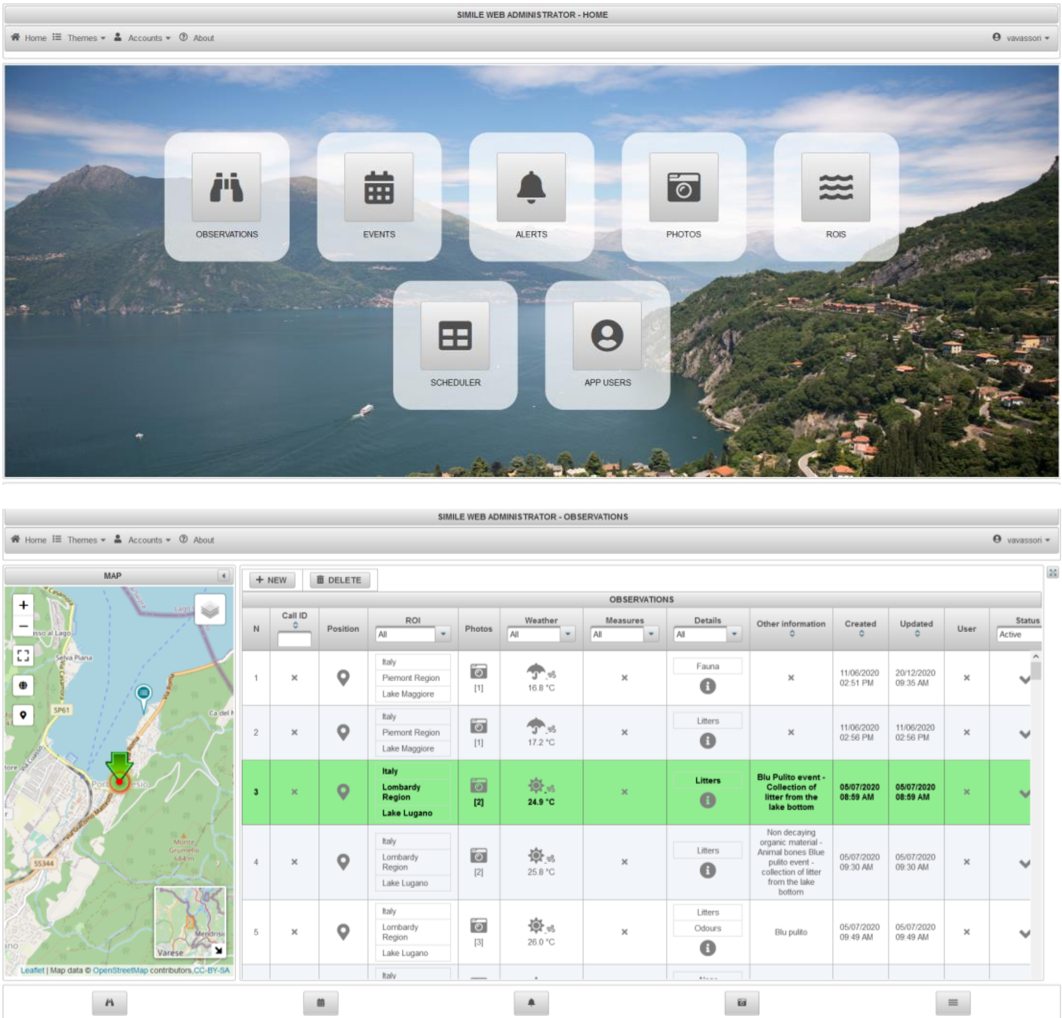

Figure 2: above, home page of the administration interface; below, interface for the management of observations.

4 Conclusions

This paper describes the tools that have been developed in the framework of SIMILE Interreg Italy-Switzerland project: allowing citizens to get involved in monitoring the Insubric lakes and the public administrations to manage the data provided with a citizen-science approach.

The project provides an example of how citizen science activities can contribute to the monitoring and management of water resources. The project involves citizens and public administrations along with schools, local leisure associations, and regular lake visitors. The goal is for more conscious management of the water resources and increasing awareness of citizens about the problems regarding water quality and preservation. For this reason, the project is consistent with the sixth SDG (in particular, targets 6.3 and 6.5) of the UN, encouraging the reduction of pollution for the water quality improvement and the coordinated management of this resource.

The proposed tools are a cross-platform mobile application and a Web-based application that can be used by any citizen or specific users with administrator credentials. The mobile app is currently promoted through online or public events among public administrations, schools, leisure associations (such as rowers and fishermen), and environmental associations (e.g. Legambiente) demonstrating app functionalities. Public events include clean-ups, mapathons and workshops, where participants can collect observations and measurements on lake conditions, or suggest improvements for app functionalities, aiming at attracting their interest for water preservation. A push notification service is enabled on significant "international days" (i.e. Earth Day, Environment Day, Water Day). The Web application is presumed to be used by a limited number of people (i.e. project partners and regional institutions) that can edit and manage the data provided by citizens. Therefore, dedicated courses are organized to teach the application functions.

This data alone is not sufficient for monitoring purposes. It will be integrated with satellite images and data from in-situ sensors, through the business intelligence platform, for a broader, more comprehensive view of the lake conditions. Citizen science contributions are currently being used by the project partners for monitoring purposes, as they contribute to validate the other data and improve their spatial and temporal coverage. They will be used by politicians and public administrations as a decision support system. In any case, data can be accessed and used by anyone.

Approximately 100 contributions have been uploaded so far; hopefully they will keep increasing, thanks to newly scheduled events and the involvement of more people. These contributions have already revealed to be effective in detecting potentially dangerous phenomena occurring in the lakes. For instance, a user observed an active outlet draining into the lake for five consecutive days, leading the competent regional authority to intervene for further inspections.

These tools are currently being tested and will be released as open-source software. The mobile application is already available for Android devices and will soon be available for IoS. In the next months, the measurement campaigns will be activated, and new algorithms will be introduced in the software dedicated to data management. The project will be concluded by January 2022.

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