DESIGN AND IMPLEMENTATION OF AN OPEN-SOURCE WEB-GIS TO MANAGE THE PUBLIC WORKS OF ABRUZZO REGION: AN EXAMPLE TOWARDS THE DIGITALIZATION OF THE MANAGEMENT PROCESS OF PUBLIC ADMINISTRATIONS

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ABSTRACT:

The Abruzzo Region, in compliance with the performance goals to be achieved in 2021 - 2023 (Performance Plan 2021-2023), commissioned the development of a Web-GIS to map the assets related to public works, that must be judged by the Regional Technical Administrative Committee (C.R.T.A). The Web-GIS aim to support the "Civil Engineering" authority of the Abruzzo Region and other professionals and technicians involved in the assessment steps of the public works during their whole administrative process and to share the data with citizens. For this purpose, and in compliance with the strategic objectives of the European Commission (Open Source Software Strategy 2020 -2023) to use free and open-source software (FOSS) inside public administrations, an open-source Web-GIS was proposed and developed. The proposed solution is realised using a user-friendly application, from QGIS software, the most popular and well-known free and open-source GIS, for the design of the GIS project, to the use of Lizmap for developing the Web platform. The combination of QGIS and Lizmap guarantees an easy way to implement a free and open-source Web-GIS and it represents an opportunity to move Public Administration toward the use of FOSS as required by the European Commission. In addition, this tool has the purpose of ensuring maximum transparency to citizens who, although not insiders, can access the geoportal to see how the funds allocated by the region, the Italian governamental authorities and the European community are distributed and spent.

1. INTRODUCTION

The paper presents the developed approach for the realization of an open-source Web-GIS to transfer and map the information assets, related to the public works with amounts greater than one million euros, that must be judged by the Regional Technical Administrative Committee (C.R.T.A), on a web platform to support the "Civil Engineering" authority of the Abruzzo Region for the management and the evaluation of public works during their whole administrative process. In particular, the Web-GIS platform has to satisfy three main requirements:

1. to manage in a unique shared geospatial database the public works, that must be judged by the C.R.T.A. of the Abruzzo Region;
2. to monitor the activities and the life-cycle of the public works;
3. to share information relating to public works both with other regional authority offices and citizens.

Since the 2000s, Italian regions and the local administrations have provided geoportals for consulting, querying and in some cases downloading geographical data. However, these portals do not allow data managers, technicians and professionals to work directly on the geoportal itself, thus resulting in only consultation systems and not always up-to-date. The possibility of having interactive tools, which allow insiders to work directly on Web-GIS platforms, has the great advantage of having databases that are constantly updated and shared in real-time.
Furthermore, because of the future European strategies ("Open-Source Software Strategy 2020 – 2023") for the transition to the usage of open-source technologies inside the public sector, this work relies on the potentialities of the actual and open-source technologies. In geospatial fields, the usage of free and open-source solutions is increasing and many countries and governments of the world support and promote the development and the usage of open-source technology (Coetzee et al., 2020, Mobasheri et al., 2020). The free and open-source solutions have matured over time, they are considered equivalent to that of proprietary Web-GIS products, and today different technologies are available to create customized Web-GIS applications for several purposes (Singh and Gambhir, 2014).
Web-GIS platforms are used in a wide range of sectors and fields like urban planning (Ostadabbas et al., 2021, Bendib et al., 2016, Ostadabbas et al., 2019), meteorology (Stefanov, 2021), water and coastal management (Arias Muñoz et al., 2017, Randazzo et al., 2021) , tourism aims and cultural heritage management (Oxoli et al., 2019, Vacca et al., 2017) and health application (Mushonga et al., 2017, Tiwari and Jain, 2013).
In this paper, all the performed steps to realise the open-source Web-GIS, starting from QGIS to implement the database and Lizmap to share the project on the web, are presented. The

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following sections explain the performed activities to implement the Web-GIS. Section 2 includes the main steps to create the geodatabase, taking into account the analysis of the user-requirement provided by the Abruzzo Region and the Web-GIS architecture. Section 3 shows the final configuration of the Web-GIS and Section 4 presents the conclusions.

2. MATERIALS AND METHODS

The needs of the Abruzzo Region were to transfer and map the data assets related to public works (from 2015 to 2020), that should be subjected to the opinion of the C.R.T.A., to a Web-GIS. It allows the management of the evaluation process of the projects between insiders, monitoring the life-cycle of the public works and finally to share these projects with citizens.
To properly design the requested Web-GIS application, as a first step the structure of the geodatabase has been designed and developed locally into the QGIS software (QGIS Development Team, 2020b), one of the most popular open-source GIS. Among the main geodatabase formats, the GeoPackage has been selected. The GeoPackage, an Open Geospatial Consortium (OGC, https://www.ogc.org/standards) standards-based, platform-independent, portable, self-describing, compact format for transferring geospatial information, describes a set of conventions for storing it within an SQLite database (Yutzler, 2017).
The usage of QGIS for the geodatabase implementation was made considering the idea of using Lizmap software to publish directly the contents of the geodatabase locally designed. Other important aspects of this choice consist in the fact that QGIS is well-known among the public authorities employees and this simplified, on one hand, the interaction during the design phase of the database to verify if the structure of the database itself satisfies all the requirements of the "Civil Engineering" authority of the Abruzzo Region, and on the other, in the future, the employers will be able to modify or update autonomously the public works directly in QGIS.
Lizmap is an open-source software designed by *3Liz (https://www.3liz.com/)*, a service company revolving around QGIS software, which facilitates the publishing of web mapping applications from QGIS using QGIS Server (QGIS Development Team, 2020a). Qgis Server is an application server for the creation of web services following the OGCs standards (Open Geospatial Consortium, 2021). It relies on a Web Server (in this case Apache (Fielding and Kaiser, 1997)) and uses the same libraries of QGIS software; this feature enables the publication of maps with the same graphical representations of the QGIS project.
Online publication via Lizmap mainly takes place in three steps:

1. configuration of publishing options and tools performed on Lizmap plugin in QGIS;
2. transfer the QGIS project on the map server, by the Lizmap Web Client installed on QGIS Server;
3. Web map access through a web browser.

Figure 1 shows the system architecture of the Web-GIS (QGIS Development Team, 2020b) from the database realisation in QGIS to the client-server side Web-GIS architecture. The next sections describe the realization of the database and the settings of the Web-GIS following the requirement established by the users.

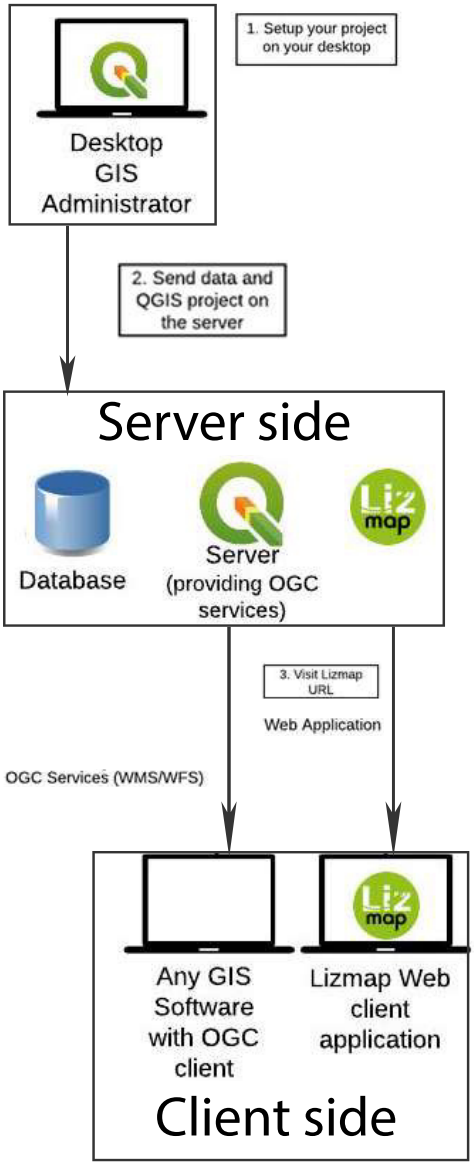

Figure 1. Architecture of the Web-GIS, Modified from (Lizmap Documentation, 2021).

2.1 Geodatabase realisation

The geodatabase was extracted by the digital archive on the online Abruzzo Region Portal in which the projects are stored as *digital sheet documentation*, which are accessible by insiders only. The public projects to implement into the database are very heterogeneous: works of seismic improvement of buildings, extraordinary maintenance interventions of roads, consolidation works, etc.). To setup the design, a classification to better choose the spatial model to represent the type of intervention was established in agreement with the region requests. Several types of interventions are identified:

1. Scholar buildings;
2. Healthcare buildings;
3. Soil defence;
4. Hydraulic works;
5. Strategic works;

6. Road works;
7. Others.

Regarding the spatial model, the primitives were defined case by case, considering the type of work and its spatial extension. For this reason, the GeoPackage format, similar to the classical well-known shapefile format, was selected for storing the three types of primitive in a single database for sharing and simplifying the management of the information by technicians and operators of the public administration in the future.
The reference system adopted, following the Italian decree of 10/2011, was the ETRF2000. The attribute table was defined, keeping into account that it must contain information for the C.R.T.A. evaluation (to share with the professionals only) and information to share with citizens.

Table 1 shows the definition of the attribute table, the entities and if they are shared or not with citizens.

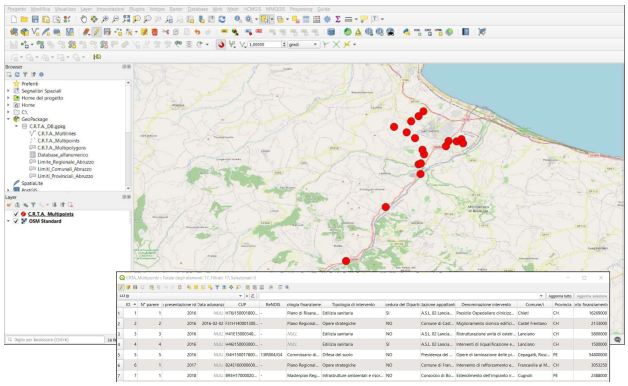

Figure 2. Overview of the QGIS project and the attribute table.

Once the geodatabase is complete, also the symbology and the legends of the data that will be adopted on the Web-GIS were set into the GeoPackage database using QGIS. Four legends are stored: the year of the project submission, the type of intervention, the type of funds (European, Italian or local) and the amount of financing. The first three were subdivided into classes with unique values, while the amount of financing was grouped in three ranges of amount (up to 3.000.000€; 3.000.000€ to 6.000.000€ and more than 6.000.000€). In Figure 2 an overview of the final project.

2.2 Web-GIS implementation

After the realization of the project in QGIS, the Lizmap solution (https://docs.lizmap.com/3.4/it/introduction.html) was used to realize and share the QGIS project. Lizmap is an open-source web application that allows sharing the maps or projects realised directly in QGIS, without the knowledge of programming language. It is composed of two interfaces, a plugin inside QGIS and a Web Client application, installed on the map server with QGIS Server. To publish the map online, the publishing options, i.e. scales, base layers, metadata, etc., were configured into the Lizmap plugin. For each section of the Lizmap plugin, decisions were made as to whether or not to use the various tools offered to obtain the best structure of the Web-GIS to guarantee the map's potential, intuitiveness and streamlining, while at the same time not neglecting the information that it should provide to users.
Once the file configuration is established, it is possible to synchronize the working folder of the QGIS project with the QGIS Server. When synchronisation is complete, the QGIS project can also be accessed on the web, through the Lizmap Web Client application using a web browser (i.e.:Mozilla Firefox). Lizmap Web Client is installed on QGIS Server and it converts the projects realised in QGIS into geo-services and to configure the application front-end. As mentioned above, the Web-GIS will be a tool that allows sharing and consulting with the citizens the works of the "Civil Engineering" authority of the Abruzzo Region but also a tool for the C.R.T.A to analyse and evaluate the projects. Thus, different users classes were set to guarantee the proper right access for every type of user. A further request of the Abruzzo Region was to allow the automatic visualization of the layer legend when the map is opened, simplifying the understanding of the map content by the inexperienced users. The basic configuration of Lizmap doesn't allow to show the extended legend of the layers when the map is opened. To set the automatic opening of the legend, a script code, written by "Nicolas Boisteault" and stored in 3liz/lizmap-javascript-scripts, was used and adapted for the purpose (Figure 3).

```
lizMap.event.on({
    uicreated: function(e) {
        $('#layer-CRTA_Multipoints td a.expander').click();
        $('#layer-CRTA_Multilines td a.expander').click();
        $('#layer-CRTA_Multipolygons td a.expander').click();
    }
});
```

Figure 3. Customised Javascript code to obtain the extended legend.

3. RESULTS

The final configuration of the Web-GIS is presented in Figure 4. On the left, the layers panel is shown and the type of intervention is set as the first legend. The different legends are shown in Figure 5. In the same panel, the province boundaries are inserted to better understand the spatial localisation of the interventions. Two versions of OpenStreetMap have been chosen and a Web Map Service (WMS) link of the 2013 orthophoto of the region was added as basemap. On the right, some tools to navigate, zoom and the graphical scale have been set. About the latter, eight levels of visualization scales have been set, ranging from the minor scale (1:1.000000), for visualising the entire region, to the major scale (1:5.000): it has not been considered necessary to proceed beyond this last scale ratio because was not required a higher level of detail. The header, menu bar, layer legend, display scale and navigation options were made visible on the map to provide the user with all the necessary tools for an optimal browsing experience. In addition, the 'map' view was chosen to visualise the attribute table, showing the exit popup from the queried element directly in the centre of the map. For the localisation of the public works, Lizmap allows setting a default search tool by street and municipality (settable from "Address search" in the "Map options" section) offered by OpenStreetMap, Google or other providers. Since public works could affect several municipalities and not necessarily a single street, it was deemed appropriate to replace this tool with a filter to provide the location by the municipality. To do this, a municipal boundary layer was added to the project in QGIS, which was hidden to end-users, but which allowed selecting a municipality, either from a drop-down menu

Intervention	Attribute type	Citizens sharing
Opinion number	Integer	yes
Year of submission	date	yes
CUP	text	yes
Date of meeting of approval	date	no
Rendis code	text	no
Type of financing	text	yes
Detailed description of intervention	text	yes
Intervention subject to the procedure of the Civil Protection Department	bolean	no
Contracting Station	text	yes
Intervention Name	text	yes
Municipality/ies	text	yes
Province	text	yes
Amount of financing	€	yes
Link to the documentation of the project	attachment	no

Table 1. Table of attributes and features.

Figure 4. Web-GIS Interface.

or keyboard input, to zoom on the public works in the specific municipality (Figure 6).

4. CONCLUSIONS

In this paper, an example of an open-source Web-GIS platform was realised to support the activities of the Abruzzo Region to manage the public works that must be judged by the C.R.T.A. The implemented solution consists of the usage of QGIS to realize the database. To share the data on the Web, the Lizmap software was selected considering the possibility to share, directly, the QGIS project and, in the future, to update and manage the database inside QGIS. The new free and open-source available solutions for the realisation of Web-GIS allow for the creation of customisable applications adapted for different aims. It is possible also thanks to the spirit of cooperation between developers of the free and open-source technologies. In conclusion, the possibility of using user-friendly FOSS represents an opportunity to move public administration towards the usage of open-source solutions as required by the European community. In addition, this tool has the purpose of ensuring maximum transparency to users who, although not insiders, can access the geoportal to see how the funds allocated by the region, the Italian governamental authorities and the European community are distributed and spent.

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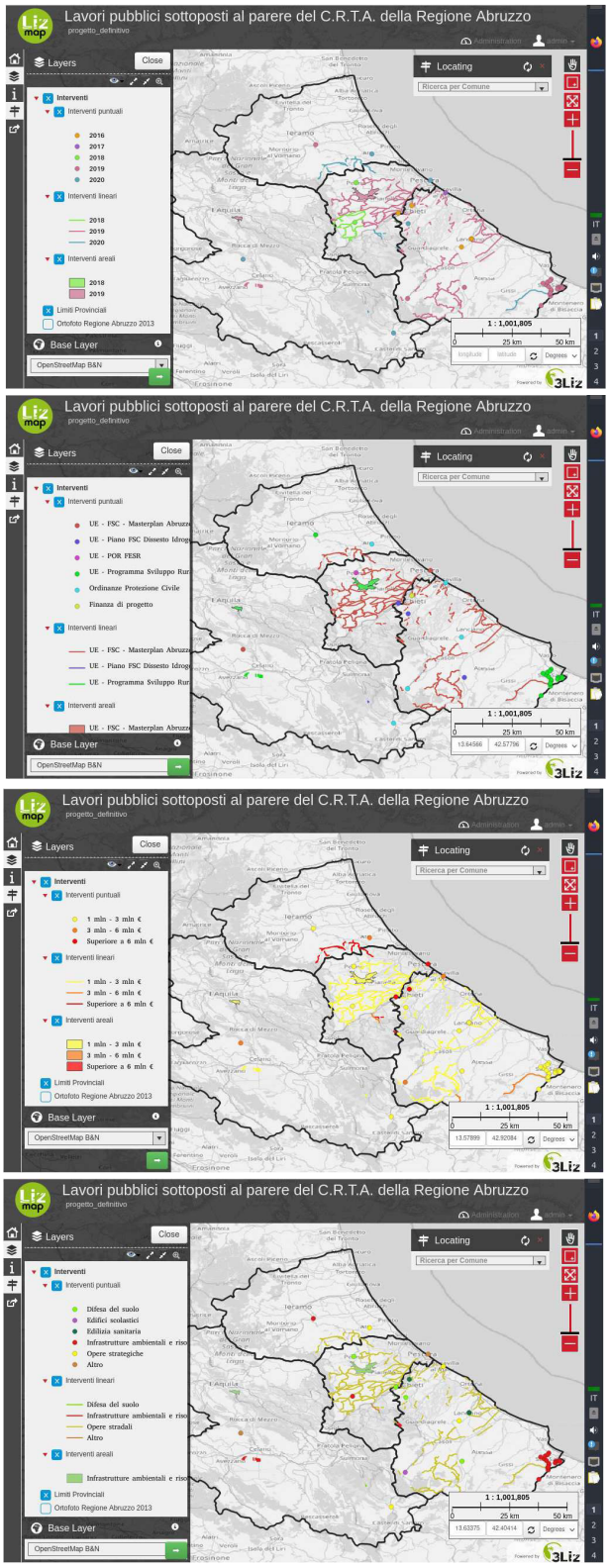

Figure 5. Different configuration for citizens visualisation.

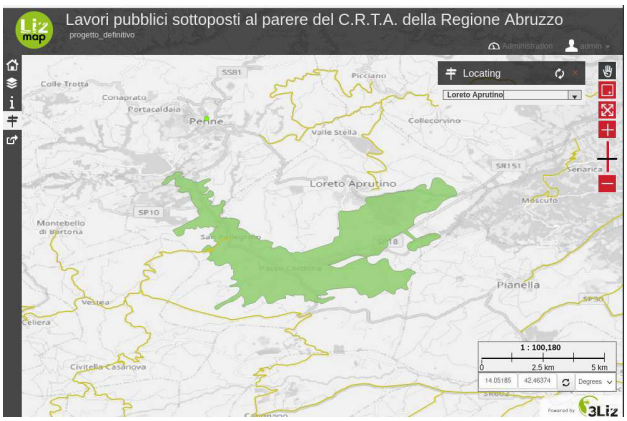

Figure 6. Zoom on a municipality.

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