From the field to the clouds: data collection and publication with QGIS

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Open source GIS, and in particular QGIS, is a leading free and open source solution for desktop mapping since many years already. Its versatility, ease of use, and analytical power have made it the software of choice for many professionals around the world (see https://analytics.qgis.org). Field data collection and checking, and web publication are attracting more attention in the recent years. A whole suite of integrated tools is now available to implement a complete workflow, all centered on QGIS. Central to all tools is the QGIS project, designed and created using QGIS Desktop. Its power in creating beautiful and rich styling is probably unsurpassed, with expression-based styling, fusion modes, and a huge set of other functions. The same project can be used on a mobile device, and exposed through a web service (WMS, WFS, WCS, WPS) and a complete web interface.

Mobile

Over the 20+ of life of QGIS, a number of mobile interfaces have been designed, from the first attempt to run the whole of QGIS on Android, or a simplified interface on Windows Mobile, to proper mobile apps. Currently the most important and used solutions to use QGIS on a mobile are Qfield (https://qfield.org/) and MerginMaps (https://merginmaps.com/). Both are generic tools, that can be effectively employed in a wide variety of contexts. Their flexibility stems from the ease with which they can be configured, simply through QGIS projects, that include sophisticated styling and simple to complex forms, with all expected functionalities such as custom menus (drop-down, checkbox, calendar etc.), relations, constraints, default values, user guiding tips, etc. While still relatively new entries in the market, they have been successfully employed in extensive surveys, from single users up to thousands of field surveyors simultaneously collecting data in the field.

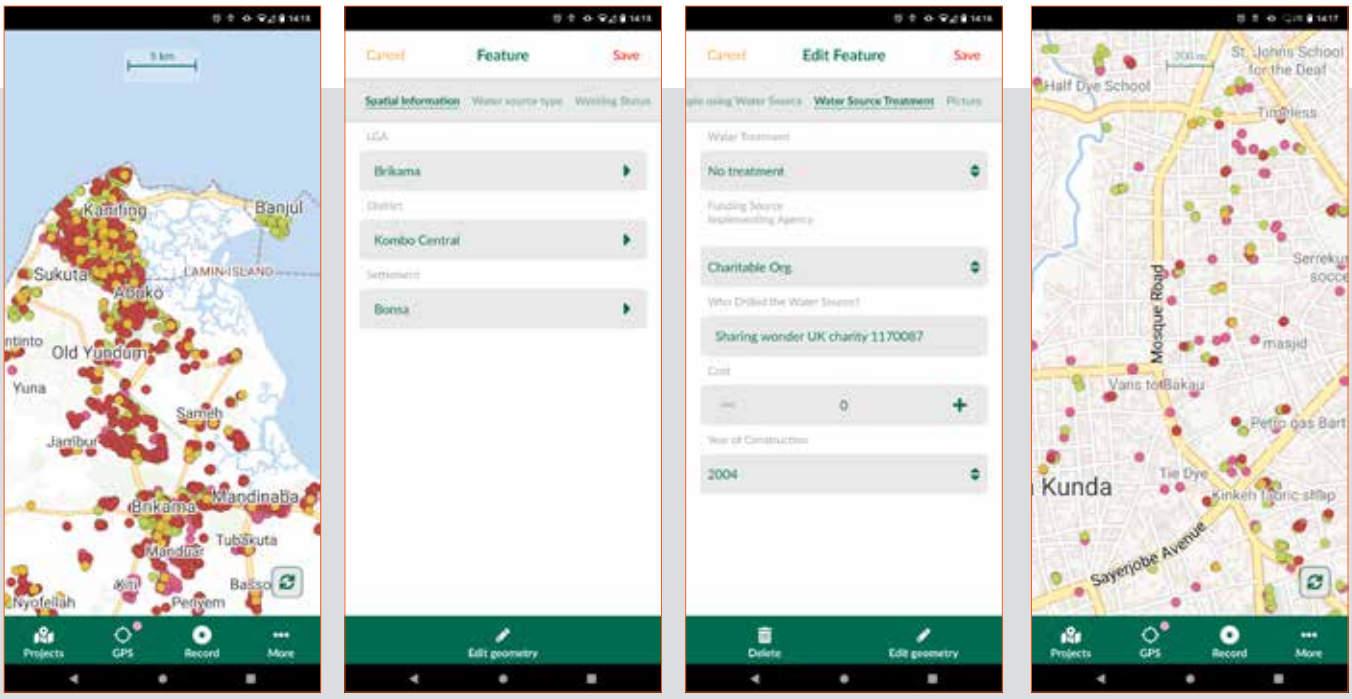
MerginMaps

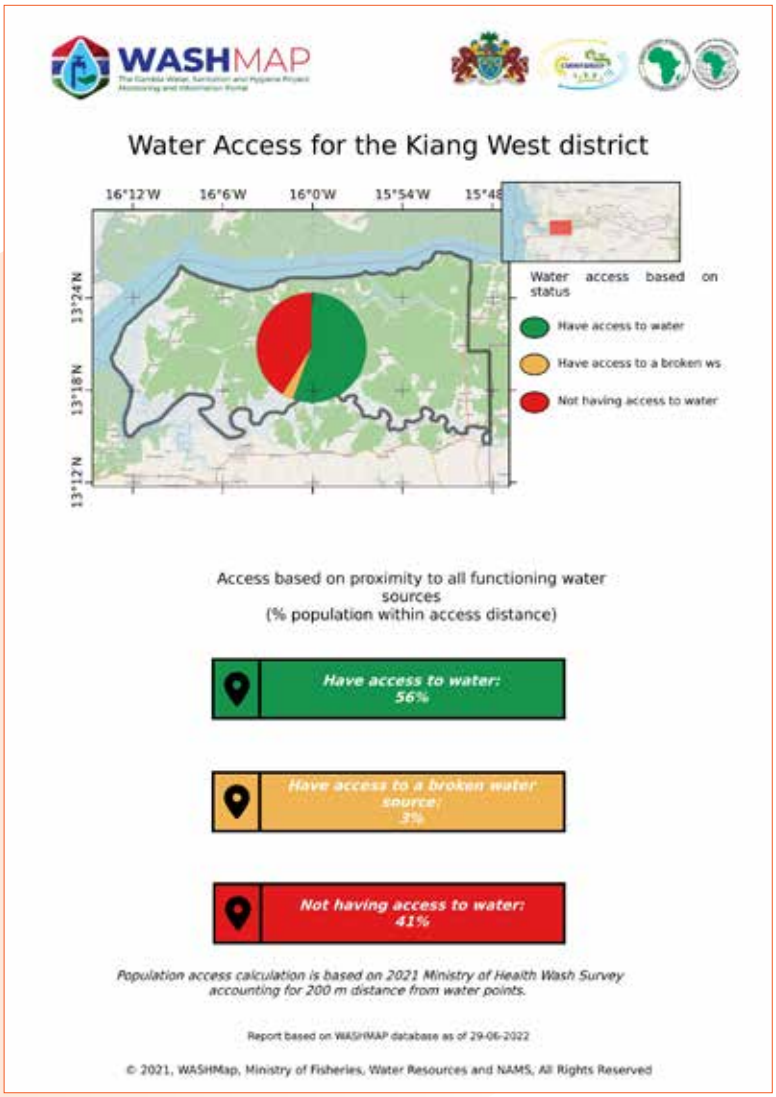
MerginMaps is a web service, written in Python with flask, that manages the synchronization process of a QGIS

project, and all the related files. For media files, it is not unlike other cloud file management service. Unlike other cloud file managers, though, MerginMaps is able to manage geospatial information, primarily in the form of geopackage files. When a new version of a geopackage is uploaded, for example because a surveyor added some features and is uploading them back on the centralized server, the geodiff library is used to check for changes, merge them and solve any conflicts. This enables some flexibility in the downloading and uploading of new data, since multiple surveyors can add features for their area of interest, upload different versions of the modified geopackage, and MerginMaps will take care of adding every new feature to the centralized repository.
Lutra Consulting, the firm developing MerginMaps, offers an official hosted instance, a reliable way to use MerginMaps without the need for configuration and installation on a local server. The official hosted instance offers a generous free trial for non-commercial usage. Pricing is clear and reasonable, with no per-user pricing, and the support is quick and responsive.
The surveying process is effectively split in two. The first phase involves the generation of the QGIS project, the related layers, and the form structure, and the subsequent upload to the MerginMaps web service. Far from being complicated, this phase still requires a good understanding of GIS software and data formats.
Once the project is uploaded and ready, the surveying phase can begin. Due to the ease-of-use of the mobile application, the surveying requires minimal technical skill, and operators can be trained in a matter of few few days. From their point of view, the intricacies of the project are invisible: they just need to add or modify the features according to the form, preconfigured through QGIS, and click on the synchronization button once they are online. A very recent addition, the option to automatically upload new changes whenever an internet connection is detected, further simplifies this.
The project folder itself is what is visible from the web interface. In order to manipulate the project, and the geospatial data, MerginMaps can be accessed from QGIS, through the official plugin, and through the MerginMaps mobile application, available for Android and iOS.
The MerginMaps application has a special focus on simple UI and UX design, in order to be accessible by everyone, regardless of their GIS experience and in demanding field conditions.

Qfield

Qfield has been the first natively Android mobile application connected to QGIS. Downloaded around half-million times it is available for Android and now iOS.
The idea of the usage is very simple: the user sets up a project in QGIS and thanks to the plugin QfieldSync it will be packaged in a folder. The folder created has to be copied to the device and with the App data can be collected on the field. Back to the office the data collected with the mobile device have to be copied back on the machine and re-synchronized to the original data source with the QfieldSync plugin.





The App has a very simple design and it comes with a lot of features: snapping facilities, advanced form layout, pictures and interaction with the legend to name a few.
The manual synchronization can be nowadays avoided thanks to QfieldCloud, a Django framework that is able to store and automatically synchronize the data from the computer to the mobile device and vice versa. Open Source, QfieldCloud is still in Beta version and let the user choose between installing the software on the server or register to the web with a free plan (limited space) or buy additional space. The main advantage of QfieldCloud is that the user can log in both on the machine and on the device with the same name and immediately synchronize the data between all the devices. The QfieldSync plugin in QGIS has all the options needed to log in, synchronize and also see the data changes difference.

As for Mergin, also Qfield has the possibility of using a server managed by OpenGIS.ch, the firm developing it without the need for configuration and installation on a local server.

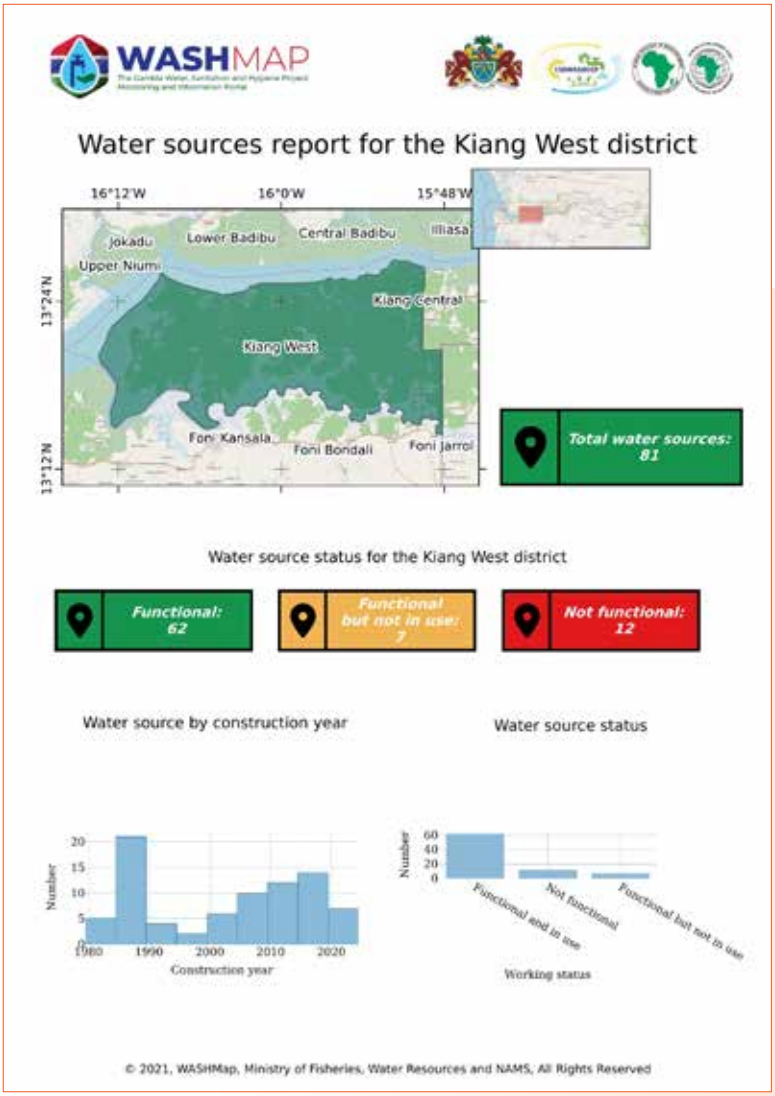
Web

A number of different web interfaces have been designed around QGIS. For all of them the basic mechanism is the same: all user requests are sent to the backend (QGIS Server) that creates the map and other objects (legend, print layouts etc.) and send them back to the web app.

The main advantages over other free and open source webGIS solutions are the ease to create both visually sophisticated maps, and complex print and reporting through QGIS Desktop layouts, without the need for specific web skills.

The most widely used is Lizmap, created and maintained by 3Liz, a South French company, who also substantially contributes from years to core QGIS development.

As for the other solutions described, also Lizmap can be used without the need for configuration and installation on a local server through a service managed and maintained by 3Liz, the firm developing it.



Case study

MerginMaps was recently used in a project geared towards the improvement of water resources infrastructure in The Gambia, financed by the African Development Bank; the project is headed by Hydronova, and its GIS section is technically managed by Faunalia.

Special acknowledgment for this project goes for the continuous support to the Climate Smart Rural WASH Development Project Office Team and to the Department of Water Resources Staff, under the Ministry of Fisheries and Water Resources of the Gambia.

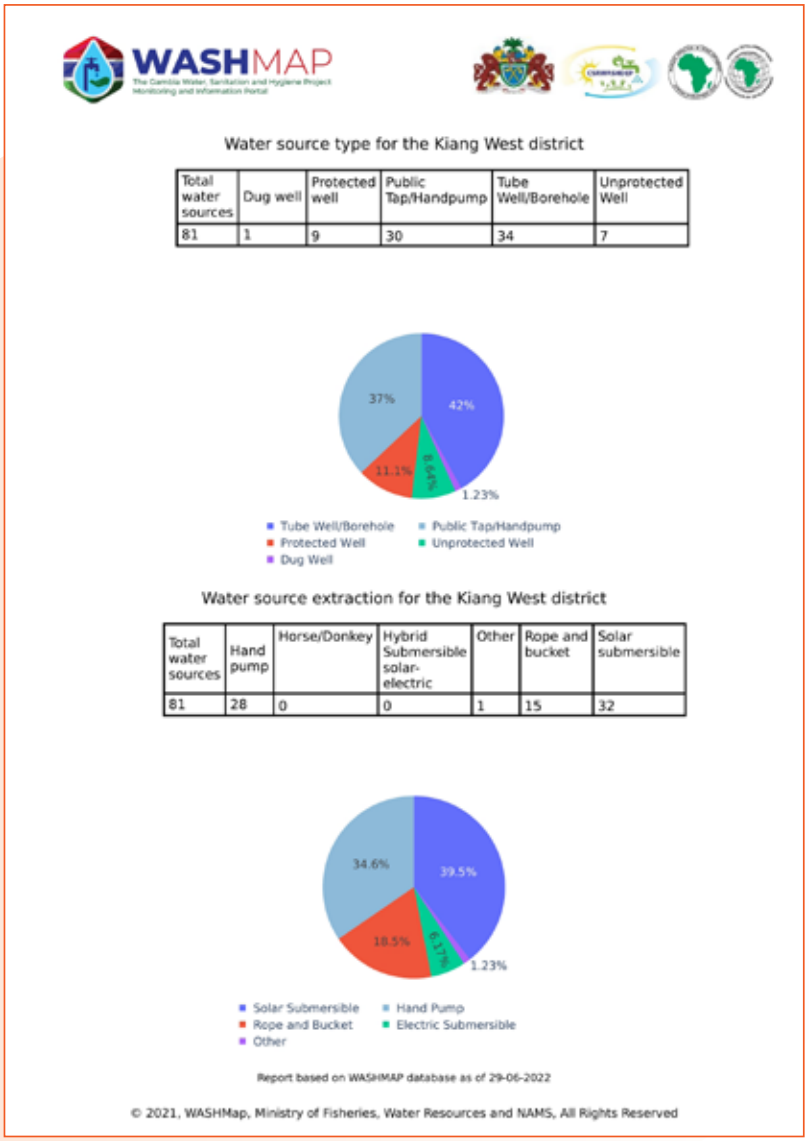
Data collection is the first task upon which the whole project is built, since in order to improve resource management, key stakeholders need to know the current situation and distribution of the resources at their disposal.

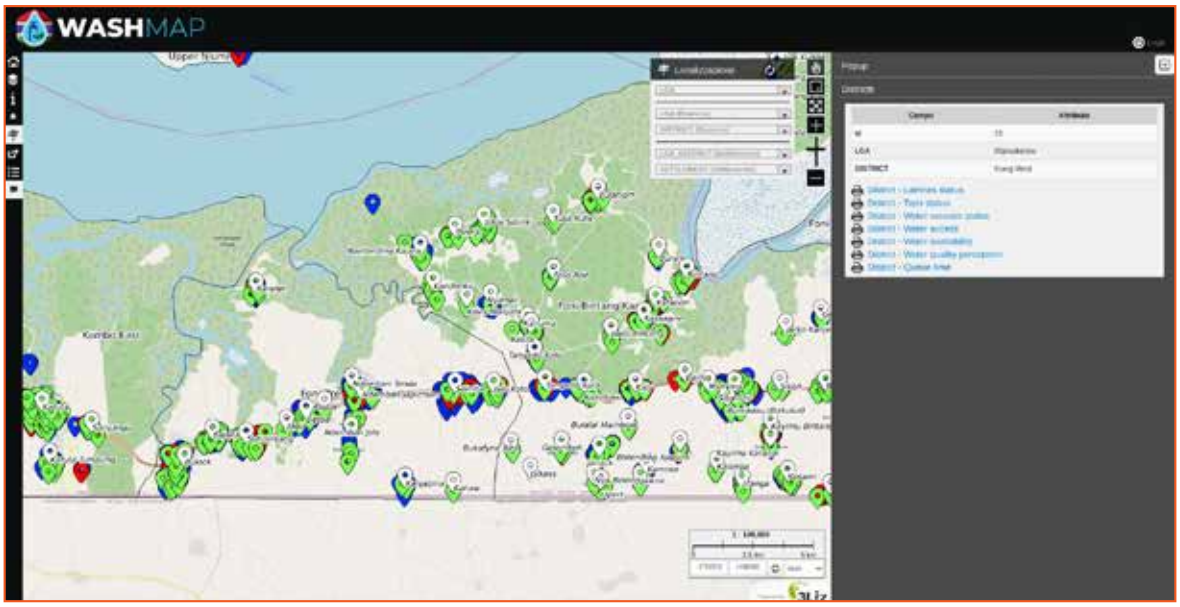
An open source solution is ideal in most contexts, even more so in a context where free access to data is paramount, and budget constraints are tight.

The MerginMaps mobile application, backed by the Mergin web service, was chosen due to its ease of use and synchronization. Due to the possibility and ease of setting up a Mergin instance, all the data was kept in-situ at the relevant ministry, retaining control on this crucial information.

A QGIS project with four layers, each with a custom form, was created. In order to have all the data fully offline, vector tiles were used. These were generated, for the whole country, by extracting OpenStreetMaps data, packaging it in an mbtiles file, and

by styling them with one of the OpenMapTiles styles. The resulting project was only 16 MB, a small fraction of the 160+ MB that would have been needed for rasterized tiles.
Using the QGIS drag-n-drop form, extensive logic was introduced in the data entry user interface. With this setup, users were guided in choosing the three different administrative levels from a drop down, with automatic filtering of the available options, and constraints with appropriate description were implemented. For water sources, which are of upmost importance, a photo was also required.
After the project was tested, teams of surveyors covered the whole country in the span of a few months, while the survey manager constantly analyzed data quality with spot crosschecks.
Periodically, the tablets were brought back online, and the data was synchronized. In this process, the selective sync option, introduced in MerginMaps (at the time called Input) 1.0.1, was crucial. This feature instructs all the tablets to upload the photos that were taken locally, without downloading all of the other media in the project, that was added by other surveyors. Without this, more than 15 GB of photos would have been downloaded into each tablet, severely impairing the synchronization process and requiring a stable and fast internet connection.
At the completion of the survey, the data was checked and cleaned, then it was synchronized with a PostgreSQL/PostGIS database, using the mergin-db-sync tool, as described in the "Extensions and integrations" section. This procedure initialized the new database, and ensures that any change in the data will be reflected in the database tables.
Using the newly initialized database, a second QGIS project based on the same data was created and published on a WebGIS based on QGIS server and Lizmap, thus reusing QGIS styling without the need for re-styling and conversion. In this phase, the advanced forms could be reused, thus showing on the website all the information as entered by the surveyor, including the water source photo.
Other layers, such as the administrative subdivisions, were added, as well as the localization tool, that enables any user to quickly find the current location, a village, or an area of interest.
By combining the efficiency of PostgreSQL materialized view, and the flexibility of the QGIS print layout, multiple layouts were created and personalized for each administrative level,





from country aggregates to the village level. Graphs created with DataPlotly, a recent addition to the QGIS print layout, were also used. These layouts were then exposed in Lizmap with the AtlasPrint QGIS Server plugin.

Extensions and integrations

MerginMaps, being written in Python, with good documentation, has quite a few extensions, that enable it to adapt to the specific needs of most survey projects.
Mergin-db-sync, first released in June 2020, is a crucial part of the MerginMaps offering. Also written in Python, it interfaces with the main Mergin web service and with a PostgreSQL/PostGIS database, keeping the two in constant sync. Whenever a change is detected in the specified geopackage, the changes are propagated to the PostgreSQL database, and vice versa. Strict versioning is still maintained, since the tool creates a new version of the MerginMaps project, just as a user uploading new data would. The tool uses two PostgreSQL schemas, one in which changes can be made directly, and a backup copy used to check for changes. It utilizes the geodiff library to check and merge changes, even if they happen in the two backends at the same time. Mergin-db-sync can also be used to expose the data on a WebGIS such as Lizmap.
Mergin-media-sync, first released in December 2021, allows for the offloading of the media files, often representing a good chunk of the project size, to a local drive, or to the MinIO object storage. When new media files are added, the tool downloads them, uploads them to the configured service, and updates the relevant rows in the geopackage, pointing the media path to the new url. In a wide-area survey, covering many features and containing photos, this tool can effectively be used to avoid cluttering the MerginMaps project with hundreds of gigabytes of images.
Both MerginMaps and QField can be used with an external GPS/GNSS device, that can be obtained at a low cost, enabling high precision location, up to a centimeter of accuracy. These devices, once highly priced, are now accessible and reliable.

METAKEYS

FIELD SURVEY; WATER RESOURCES; QGIS; QFIELD

ABSTRACT

QGIS is the leading free and open source desktop GIS. It is also a complete ecosystem, that allows to build complete workflows, from field data collection to publication on the web. Central to it are QGIS projects, that define data sources, projections, styling and integration, and are reused from mobile to the web without a need to reconfigure them. We describe the main solutions available for data collection and seamless publication over the web: MerginMaps, Qfield, Lizmap, with an example form a water resources project in Gambia.

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