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The Use of Satellite Imagery and GIS for Humanitarian Assistance: Developing and Managing Water Supply in Urban Territories under Conflict

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Abstract

This paper describes the use of satellite imagery and GIS within projects of the International Committee of the Red Cross (ICRC) and describes how this type of information can be used as a support in the humanitarian field, specifically for the support of water supply in urban settings. The paper presents a brief overview of a project in the Kidal urban settlement in Mali, Africa, where the ICRC was exploring the development and management of water supply services and investigating how remote sensing can support and improve future groundwater planning, as current resource availability within aquifers underlying Kidal is poorly understood. The project is a strong collaboration between the ICRC, Groundwater Relief and the University of Salzburg (Z_GIS).

Keywords:

satellite imagery, ICRC, water network, Kidal, urban analysis

1 Introduction

Since 2005, the ICRC has been progressively expanding its use of satellite imagery to support its operations (Rebois & Alschner, 2015). Satellite imagery and Geographic Information Systems (GIS) are regularly used in emergency response and humanitarian relief, adding value to a wide range of activities. If specific areas had limited humanitarian access, in terms of difficulty or duration, satellite images have been, and still are, the only source of information. Within the ICRC, satellite imagery has proved to be useful for:

- planning response,
- protection activities,
- estimating extent of damage,
- estimating population figures,
- crosschecking information,
- land-cover analyses.

The first ICRC projects that used satellite images were related to water infrastructure. Satellite imagery still proves very useful for hydrogeological analysis in arid and semi-arid areas, as well as for land-cover analysis, such as vegetation follow-up in agricultural projects (irrigation, seed distributions, etc.).

Prior to planning and drilling new water points in settlements, hydrogeological research is required. It is necessary to find suitable rock formations, faults and lineaments, and to determine locations of water sources, distances between these sources and communities in need, in order to finally define the optimal path for a water pipeline (ICRCblog, 2015). All these supporting studies, as well as the monitoring of a project and its impact, can be carried out using satellite images.

2 Challenges of a well-maintained GIS database

GIS can help to manage water networks, but when authorities are weak or non-existent, the data maintenance is left to the ICRC alone. The management of the GIS data related to water infrastructure can vary from a simple global geospatial layer of water pumps, to the much more complex water infrastructure of a specific settlement or a whole city. Unfortunately, updating the database for GIS is not always the priority, as effort and resources concentrate on fixing the problem immediately; for example, when water is lacking or insufficient, immediate delivery to the populations concerned is the priority.

Another challenge that the ICRC often faces is that water networks provided by the authorities are modelled in CAD, which, most of the time, has no geographical reference; information about housing and building types is non-existent, so it is a challenge to put all of this data into a GIS in order to analyse and plan the improvement or extension of the water network.

3 Study area

Kidal is a settlement in Northern Mali and has an estimated population of almost 15,000 (Burrows, 2016). As it is in a desert region, Kidal has very low annual rainfall. According to WMO Climate data for Kidal, the average rainfall is 128.0 mm of which >90% falls between June and September (WMO, 2017). Evaporation rates are high throughout the year and groundwater recharge occurs only during intense rainfall or in locations where water naturally concentrates, as in the sediments found in wadis (valleys with groundwater recharge during rainfall). Due to lack of water, vegetable gardens are found only along the wadis. The main sources of income are livestock (including sheep, goats, camels and cattle), as well as trading, construction and the civil service.
In addition to water shortage, there has been an ongoing conflict in the area since early 2012. Despite a peace agreement signed in 2015, the main armed groups remain in the region maintaining their political and juridical recognition (Tamboura, 2016). Due to the insecure context, all government technical services left in 2014. There are some temporary streams

and wadis available, as well as few boreholes connected to water towers. However, water supply remains limited and some districts can remain without water for periods of time.

The ICRC has been providing water to this population through its Sub-delegation based in Kidal City. Through the use of GIS, a suitable borehole location was identified, which proved to be very useful. The main objective of this study is to use remote sensing and GIS capabilities to identify the water capture and groundwater zones that would be best suited and sustainable as water sources for Kidal.

4 Methodology and findings

Knowledge on water resource availability is a key issue in developing countries. Water information, measurements and monitoring are usually obsolete or non-existent (Meijerink, 2007). In conflict contexts, the little data available is either destroyed or inaccessible. Fortunately, remote sensing can help both to identify potential resources for better observation, and to provide more systematic analysis of various geomorphic units and lineament features for the identification of potential groundwater zones (Nag, 2008). In addition, remote sensing techniques can help the ICRC to work in remote areas where access is denied due to security and safety issues.

There are many methodologies that can be applied to identify water resources. Thematic layers can be generated using ancillary data and digital satellite images in arid areas (Mukherjee et al., 2015). A weighted overlay analysis applied to specific parameters allows potential groundwater zones to be identified. Cheng-Haw worked on an integrated analysis based on lithology, land cover/land use, lineaments, drainage and slope indicators (Cheng-Haw, 2008). The possible presence of groundwater is identified by an analysis of each indicator that contributes to its recharge. Waikar and Nilawar identified further indicators, such as the geomorphology, plateaus, pediments/pediplain complex, and anthropogenic terrain weighted factors (Waikar & Nilawar, 2014). The main output is a GIS-ready layer that can be used for map creation and other means to help identify potential groundwater availability. While many of these parameters are necessary for good groundwater analysis, most of this information is largely missing or not easily accessible in crisis contexts, as is the case in Kidal.

Similar studies have been conducted in India and other Asian countries, including Thailand; in sub-Saharan Africa, work has been done in the Lake Chad Bassin (Leblanc et al., 2003) (Sibanda et al., 2015). Most of this work has been developed and used in non-conflict environments, but there is no reason why this methodology cannot be used in a conflict context.

In the Kidal project, use of remotely sensed data and information systems is not only providing the information required, but also creating a GIS for environmental management of water which can help to better understand the vulnerabilities and needs of the people with regard to access to water (EO4HUMEn+, 2017). The map created during the Kidal project (Figure 1) is a good example of well-organized and well-illustrated information about available water resources.

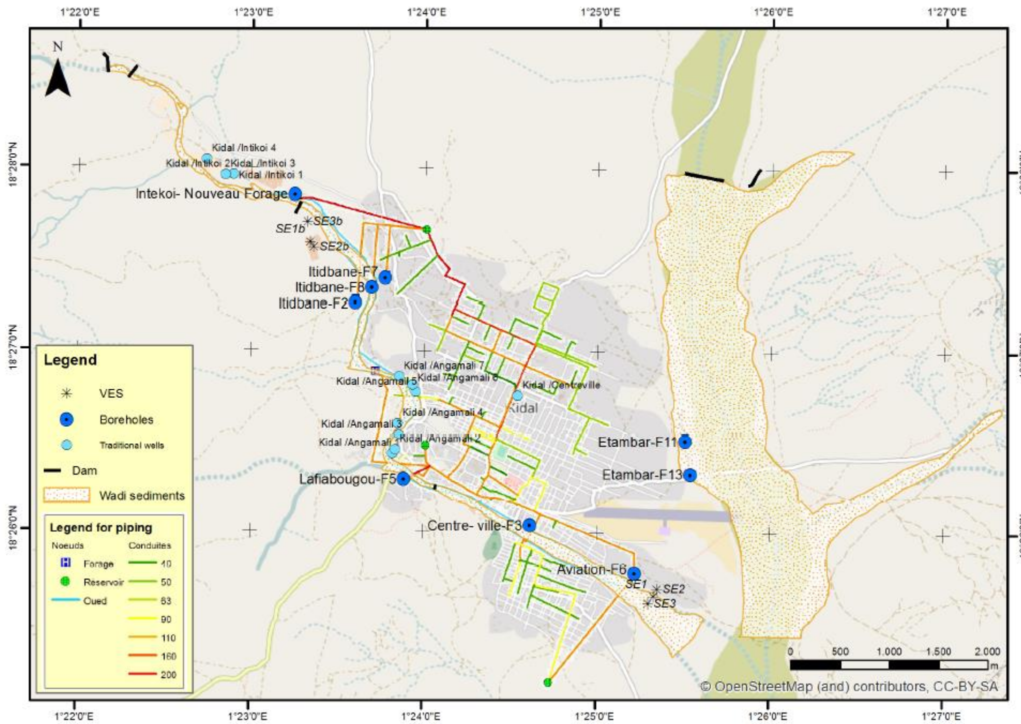

Figure 1: Groundwater infrastructures – Kidal (Ground Water Relief, 2016)

The Kidal project shows that working with GIS can greatly help monitor facilities, follow up leaks, facilitate the water network design, and enhance knowledge.
Another good example where the ICRC has helped to implement and monitor water resources using GIS techniques is in the city of Aleppo in Syria. In this project, the current information about boreholes in the city is gathered by remote data collection using smartphones and displayed in a special web application (Figure 2). Based on the information gathered, the authorities can take decisions and implement actions as required.

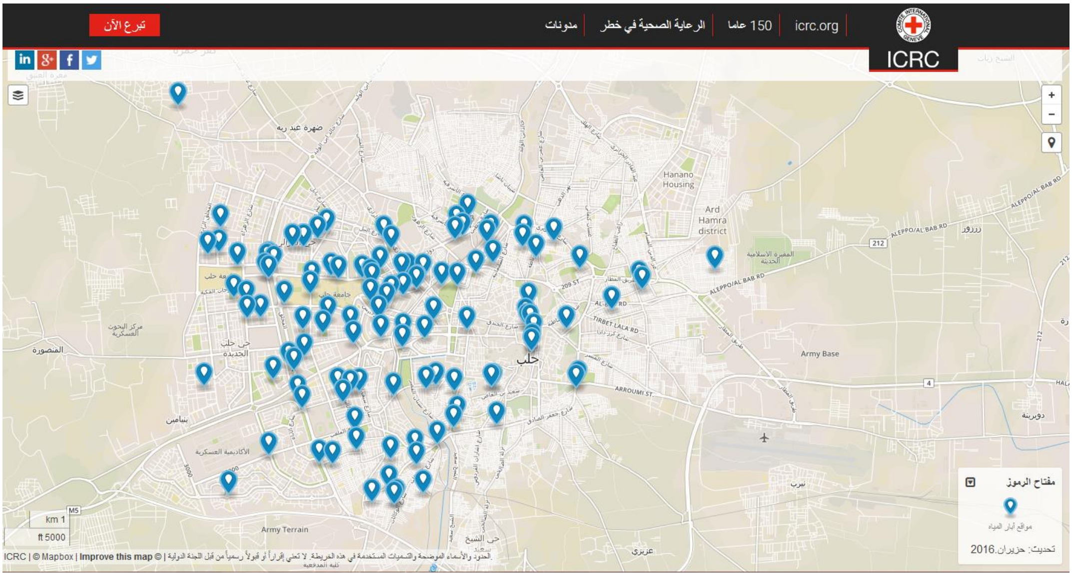

Figure 2: Aleppo borehole monitoring, where volunteers from the Syrian Red Crescent (SARC) collect data and synchronize it to a remote server in order to take action (ICRC, 2017)

Kidal and Aleppo are just two of several places where the ICRC has successfully used the advantages of GIS techniques. However water monitoring in semi-arid areas or conflict zones remains challenging.

5 Conclusion

The use of satellite imagery and GIS in an urban context is a powerful tool, often used in ICRC projects.

Creating a good GIS base is usually the preliminary step before carrying out feasibility studies. To ensure the validity of the information, the results should always be proof-tested in the field.

Remote sensing and analysis using GIS are good tools for assisting research teams in looking for water sources in semi-arid areas. It is therefore worthwhile providing financial and technical support to water authorities to help them manage their own water networks. Such support can help them to generate data on consumer habits, leaks and possible interventions over time. The extraction of buildings from the satellite images in order to estimate the population density in combination with GIS and mapping can facilitate the development of town and city planning for new water networks.
Using Geographic Information Systems has become a standard way to manage different types of information related to water resources. A well-structured GIS database can greatly assist in understanding the water network's behaviour, can help to identify the critical zones within the network, as well as to minimize their cumulative impact (ICRC, 2015). The use of GIS helps to identify problems in cases of breakdown and to provide speedy solutions,

thereby improving network maintenance; it also has the potential to pinpoint general improvements to the water infrastructure.

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