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Open technologies for monitoring systems aimed at disaster risk reduction

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ABSTRACT

This research is spearheading the integration of Free and Open Source Software (FOSS) and Open Source Hardware (OSHW) in the field of agri-meteorology applications to disaster risk reduction, flood and droughts. A Do-It-Yourself weather station based on OSHW standards has been developed from local sources in Sri Lanka, reporting by SMS to tank/reservoir managers when rainfall is higher than 10mm/h. These weather stations are soon going to be reprogrammed to report to istSOS, a FOSS web-based Sensor-Observation-Service compliant system, which will collate live reporting of rainfall every hour and before if intensities are dimmed worrying for flood risks. This is both a scientific, technological, and practical challenge toward a very low cost real time disaster risk notification system in places where climate, economy and maintenance supports are themselves other challenges.

Keywords: FOSS, OSHW, istSOS, DIY, weather station, flood, disaster, risk, reduction

INTRODUCTION

Thanks to the new technologies enabling the production of massive amounts of information, it is possible today to operate toward disaster risk reduction with a more effectively and conscious approach then ever before. The idea of a digital globe, where the Earth and its status is continuously monitored to support the understanding of the phenomena and thus to enable effective management have been mostly realized. Network of sensors, constellation of satellites and procedures for data processing are already in place and collaborating to produce knowledge. Nevertheless, in some specific cases, where information of a specific location is needed in a precise instant or where scarcity of economic resources leads to the failure of regular monitoring system a new approach is required. For this reason, this paper presents two projects that investigate fully open technologies monitoring systems as a potential solution to fill this gap. It worth to be noted that these systems, which are low-cost and not characterized by high precision sensors, has not to be intended as a replacement of authoritative and conventional data. Nevertheless, they could play a key role in complementing existing information or filling the gap of not monitored areas toward a better understanding of risks and disaster mitigation. Ultimately the use of open technology like open hardware for the construction of the stations and open software for the management of the data, may offer long term sustainable solutions which promote local business and services.

METHOD

In order to explore the capabilities of open technologies toward the design and deployment and application of open technologies to fill the gap of monitoring system failure or to densify locally the monitoring two projects and their preliminary results are here presented.

The Challenge Fund - GFDRR in Sri Lanka

The Challenge Fund initiated by the World Bank - Global Facility for Disaster Risk Reduction has selected several innovations in 2015, including the proposition from IWMI in Sri Lanka.

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The awarded project is focused on Open Source mobile weather stations as a means for reducing flood damages and increasing preparedness of communities. The case study is the Nachchaduwa reservoir which is an important source of water for irrigation in the district of Anuradhapura, Sri Lanka. Here reservoir managers generally try to maintain full supply level, to accommodate demands for irrigation water but in the monsoon season their policy change: they try to balance the maintaining of full supply level with the creation of enough storage volume to accommodate runoff from the upper catchment. During the monsoon, the daily reporting of rainfall is too sparse to make timely decisions regarding what volume of water should be released prior to the runoff entering the reservoir. Consequently, often the reservoir spills, and floods the agricultural and residential land in the lower catchment.

According to reservoir managers, with access to timely data on rainfall intensity, they would have more time to prepare the reservoir to accommodate runoff from the upstream catchment during the northeast monsoon and therefore they could reduce damages. To this aims, five open-source mobile weather stations have been installed in the upper catchment of the Nachchaduwa reservoir, and have been programmed to send SMS text alerts when rainfall intensity exceeds 10mm/hr. Since the estimated time of concentration of the watershed (the time needed for water to flow from the most remote point in a watershed to the watershed outlet) of the reservoir is about of 8 hours monitoring at a sampling time of one hour would certainly improve the capacity of better manage floods and reduce risks.

These weather stations use open source hardware and software (Chemin and Bandara, 2014; Chemin et al., 2014, 2015; Bandara et al., 2015). Each station consists of an Arduino microcontroller, a weather shield, a GSM board, weather sensors, and a micro-SD card. Access to the manuals for assembling, maintaining and programming the stations can be found online (IWMI, 2016). Using local parts and labor, the stations cost less than USD 500 per installed unit. A cost-effectiveness study (Hardy, 2015) demonstrates that even if extreme rainfall occurred once every five years, and even if small reductions in area and duration of inundation are achieved through better reservoir management, the post-disaster rehabilitation expenditures of the government would be substantially reduced. The cost of installing these five units would be recovered in 2.5 years.

4ONSE

4ONSE (`www.4onse.org`) is the acronym for "four times open non-conventional system for sensing the environment" but, at the same time, ONSE is an Afrikaans words meaning "ours" so 4ONSE could also be interpreted as "for us": the overarching goal of the project is, in fact, advance in research of open sensing technologies that will belongs to everyone and that can be used to improve the human life. The project is envisioned from September 2016 to September 2019; it has been funded within the Swiss Programme for Research on Global Issues for Development (r4d programme) that is a joint funding initiative by the Swiss Agency for Development and Cooperation (SDC) and the Swiss National Science Foundation (SNSF). The project is coordinated by the Institute of Earth Sciences at the SUPSI (University of Applied Sciences and Arts of Southern Switzerland) in partnership with the University of Moratuwa in Sri Lanka, the University of Gadjah Mada in Indonesia, and the Institute of Space Technology in Pakistan.

The specific objective of the project is to progress beyond the state of the art, providing detailed information on open challenges found in literature for these kind of open and non-conventional systems, specifically: data quality, metadata accessibility and standardization. This will be achieved by integrating and further developing the available technologies to implement a fully open (data, standard, hardware and software) solution and to deploy an experimental monitoring system composed of about 30 stations which will be analysed in term of: (i) data quality; (ii) system durability; (iii) management costs; (iv) performances; (v) sustainability. Moreover the suitability of this type of system will be evaluated in existing climatic-dependent management practices to understand its applicability, advantages and limitations. Tests will be conducted in Pakistan, Indonesia, Sri Lanka and at additional testing partner's locations on voluntary basis.

Enabling key technologies that will be used in the project are:

- **SOS** (Bröring et al., 2012): Sensor Observation Service standard from the Open Geospatial Consortium (OGC) as interoperability enabler;

- **istSOS** (Cannata and Antonovic, 2015; Cannata et al., 2015): open source data management and sharing system, compliant with SOS, as standard data service;

- **Arduino** (Doukas, 2012): Open Hardware pre-programmed microcontroller as sensors data input/output management enabler;
- **ckan** (Doukas, 2012): open source data portal platform as Open Data access point to processed statistical analysis of data;

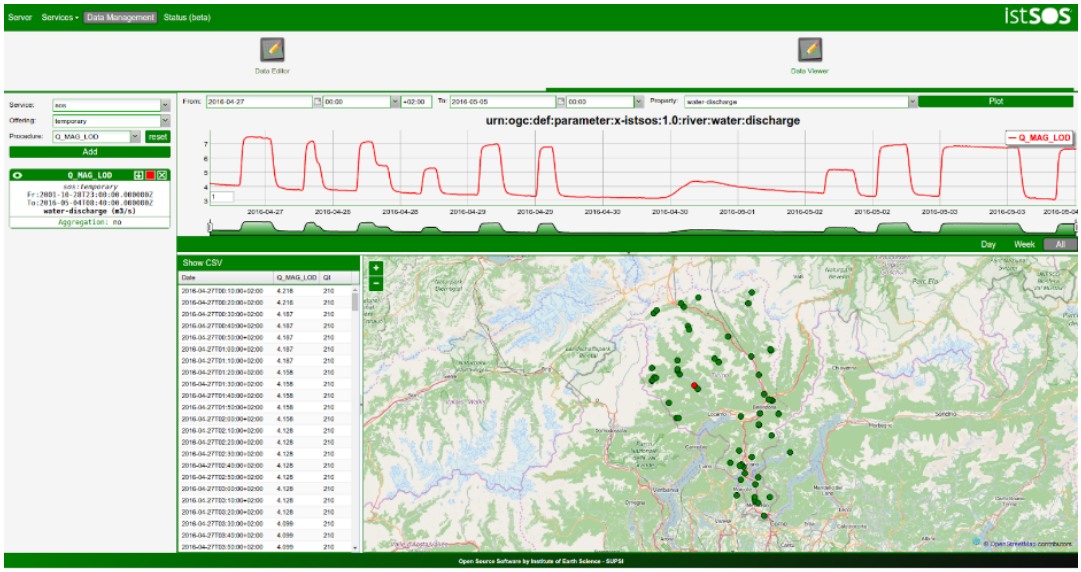

Figure 1. istSOS's data viewer interface. The availability of an easy to use Web based interface to manage and access the data is one of the software key feature.

The general desired impact of this project is to strengthen the capacity of data production, usage and management in developing countries. Filling the gaps that often lead to monitoring network failure in these countries will empower them with the ability to set-up and maintain their own climatic monitoring network. This brings, among other benefits, to: shorter reaction time in case of impending hazards, better understanding of phenomena, wiser definition of management strategies and policies and capacity to evaluate policy implementation effects. In sight of the above mentioned strategic objective, this project intend to contribute to advance in this direction by impacting the capability of developing countries in perform researches in the field of earth observation by means of better understanding of concepts on open technologies and data capabilities. It is also important that a common sense of joint responsibility of governments, international and regional organizations, private sector and civil society is grown in order to boost this process and that the opportunity of using data from dense monitoring system and open standards is well acknowledged as a support tool for the development of new policies and activities.

DISCUSSION

Fully open monitoring systems is certainly an interesting area of research and development in line with the global trends of the Internet of Things and of global monitoring systems. This is evidenced by the attention of international bodies and by the number of projects on this topic that are currently ongoing or have been recently conducted. The presented Open Source mobile weather station in Sri Lanka (Challenge Fund - GFDRR) and the 4ONSE (Swiss Research for Development program) are only two of them. For example, during the Understanding Risk forum (`https://understandrisk.org/event/ur2016/`) an entire focus day was dedicated to open source hardware and software and a number of activities supported by the World bank and the red Cross around the Word has been presented. A project in Tanzania to develop flood inundation scenarios based on open data (`http://ramanihuria.org/`); a project in Togo that implements an innovative approach of pre-funded set of early actions to mitigate flood risks coping with missing historical climate data (Coughlan de Perez et al., 2015); a project in Haiti to develop Open Source applications to collect

and analyse climatic data respecting as much as possible the SOS standard (`https://www.gfdrr.org/reducing-disaster-risk-through-hydromet-technology-haiti`).

Expectations on fully open monitoring solutions is motivated also by Rogers and Tsirkunov (2013) that in a World Bank report highlighted the need of solutions that integrate investments, are long-term sustainable and provide end-users focused services. In this direction, fully open solutions may meet these demands by providing interoperability with open standards, local management and maintenance capabilities with open hardware and services focused on local need with open source software.

Nevertheless, despite the appeal of this solution, it certainly need research and validation in productive system before of being securely adopted in sensitive issues like disaster management or climate change adaptation. Toward this goal and following the Open Source Software principles a dedicated scientific community named "Open-technologies Monitoring-systems Geospatial group" (OMGeo) has been created within the OSGeo's Open Geoscience Committee (`https://wiki.osgeo.org/wiki/Open_Geoscience_Committee`) to facilitate networking and integrate successes, failures, research results, best practices and ideas toward a better, safer and more equitable world.

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