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TRANSFORMATION TOWARDS SUSTAINABLE
AND RESILIENT WASH SERVICES

# Evolving water point mapping to strategic decision making in rural Malawi

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*There is a need to evolve from the simple mapping of water points, now often numerous, to effective decision making using these data. This paper outlines new developments of mWater as the preferred online Management Information System (MIS) tool to analyse significant volumes of water and sanitation data in Malawi. mWater exemplifies an evolving strategic decision-making tool used to formulate rural water supply investment strategies. A time series of 25,000 water points have been mapped since 2011 to build a complete asset register of water infrastructure to support government endeavours to reach Sustainable Development Goal 6. This comprehensive live database allows real-time analysis of over sixty variables, including linkage to concurrent mWater sanitation and waste data. This paper briefly illustrates several emergent uses of the facility to exemplify its potential in strategic decision making using Big Data. It is currently being rolled out across the entire country.*

## Introduction

Vast numbers of water point supplies continue to be installed across the developing world in an effort to meet United Nations Sustainable Development Goal 6 (SDG6) to "ensure availability and sustainable management of water and sanitation for all" (United Nations, 2017). It is paramount these investments are sustainable over time, and that robust management information systems (MISs) are developed to not only map this dynamic proliferation, but to critically use water point data within effective decision making to enable responsive sustainable management of the water resources within surrounding environments. The rapidity of expansion and sheer numbers of water points, coupled with frequent budgetary and resource constraints, causes many parts of the developing world to struggle to keep pace with a clear picture of water point numbers, never mind to be in a position to employ data collected for effective real-time decision making. Our aim is to outline the evolving development in Malawi of a new MIS for the mapping and analysis of significant and rapidly growing volumes of water and sanitation data, and exemplify its use as a critical tool in strategic decision making for rural water supply and investment strategies. The need to enhance such capabilities represents an on-going wider developing-world reality.

Malawi is a central African landlocked country that experiences seasonal rainfall and high temperatures. Most rural households access safe water from protected shallow wells or boreholes fitted with hand pumps (62%), or gravity-fed schemes with taps (8%) (NWRMP, 2017). However, unsafe water sources still constitute 30% of domestic water supply including unprotected wells and surface water. A significant, on-going, effort has been made since 2011 under the Scottish Government funded Climate Justice Fund (CJF) – Water Futures Programme to support the Government of Malawi in meeting these challenges, 1 of 4 CJF work streams is the development of a new, robust asset management system. Central to this agenda has been the mapping of water points and sanitation sites within a bespoke developed MIS that allows effective real-time decision making on management of the groundwater resource and its rapidly growing exploitation by rural communities. Initially the CJF Programme worked exclusively in the Chikwawa District with NGO Water for People and from 2016, expanded to cover eight districts in the Southern Region of Malawi illustrated in

Figure 1.**Error! Reference source not found.** Output from the MIS developed illustrates not only the sheer number of water points, some 35,643, but also the dynamic growth of WASH programmes as 36% of water points with known installation dates are 2010 onwards. The need for MIS that not only map such development but allow effective real-time decision making is obvious.

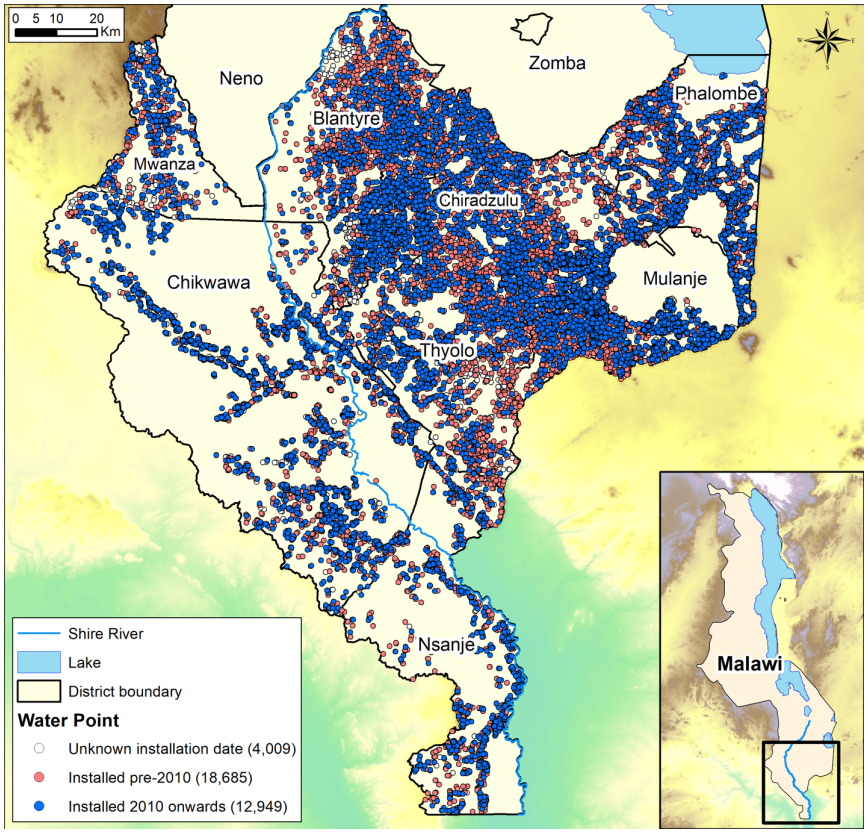


**Figure 1. Map of Southern Malawi with all water point sites mapped between 2011-2018**

## Selection and development of the mWater MIS platform

Given 7 years of CJF Programme experience with other platforms since 2011, the Programme undertook a thorough scoping exercise of all available MIS platforms (www.cjfwaterfuturesprogramme.com/scoping-report-mobile-technology). This included the platforms mWater (www.mwater.co), Open Data Kit (www.opendatakit.org), AkvoFLOW (https://akvo.org/products), COMMCARE (www.dimagi.com/products), E-Soko (www.esoko.com), TEMDAI (www.glohomomw.org/temdai) and RASOR (www.rasor.eu).

Previous platforms used in the study area include WaterAid's 2003-05 compilation of a water point database (WaterAid, 2005). This was succeeded by the AkvoFLOW database (2011-2017), which includes 19,000 CJF mapped water points in Southern Malawi. Engineers Without Borders (Canada) during 2009-13 supported half the districts in Malawi to establish a Monitoring and Evaluation tool using Microsoft Excel (EWB, 2013). While some districts still use remnants of these platforms, water point status can change frequently and knowledge is often lost in the rapid turnover in Government. None of the above evolved to become the single recognised national platform MIS. The ambition and expectation of this new MIS are outlined below.

The scoping led to the CJF Programme adopting in 2017 the online MIS, mWater, to collate data into a single platform. The platform currently (April, 2018) holds data for 46,000 water point surveys and 78,000 sanitation surveys from CJF activities, with future capacity to accommodate data for irrigation, drilling, water systems and water chemistry. Data was collected over three time periods – 9,000 water points were mapped using AkvoFLOW from 2011-2015, followed by the first phase of mapping all 8 CJF districts in 2016-17 to map 25,611 water points and 20,992 sanitation facilities. These data were imported into mWater before the second mapping phase, from 2017-18, which re-mapped 17,037 water points and 56,998 sanitation facilities.

mWater was selected as the preferred option as it offers the maximum sustainability potential after eventual handover to Government and the in-depth data analysis capability needed for routine decision making. It is free after the initial set-up costs (funded by the Scottish Government). The Surveyor App can be simply installed on any Android or iOS smartphone and displays real-time data through a user-friendly database interface in the web-based Portal. Temporal data analysis is possible due to the site-survey arrangement of data collection, whereby sites can have their status updated on any number of occasions. Also, there is unlimited data storage on secure servers with full back-up capacity to previous database versions. Lastly, new software features are encouraged in collaboration with the mWater organisation. Some bespoke development of the mWater system has hence occurred that is expected to have value elsewhere. For example, a tool was conceptualised and built to reduce photo size for faster survey uploading, reducing reliance on internet data.

The MIS offers a platform whereby data collection, quality assessment and analysis are undertaken in a single piece of software. This allows users to easily familiarise themselves with the adaptable user interface to produce a wide variety of graphs, maps and tables from the large and complex database with minimal specialist training. Combining these 'widgets' allows rapid analysis of areas with strained water resources and the potential to hold responsible parties to account. Possible uses of such analysis include the potential for real-time decision making, hitherto not viable, for instance around the following:

- Mapped clusters of non-functional water points installed by a specified NGO or private contractor;
- Spatial analysis of boreholes within a certain radii of groundwater contamination sources (e.g. latrines);
- Prioritisation of areas with poor coverage and significant need for water point rehabilitation; and
- Targeting areas with poor Community-Based Management (no service providers) for additional training.

The first example listed is illustrated in **Error! Reference source not found.**, which displays only the water points funded through the Malawi Social Action Fund (MASAF) to analyse their functionality rates across southern Malawi. The 648 water points attributed to MASAF have a functionality rate of 66%, which is considerably higher than the 48% average for all water points in the eight districts mapped. Similar analysis indicates UNICEF-funded water points have an 81% functionality rate. Using these data, the Government can now commend or challenge funders or drillers, with evidence, including possible specific evidence and reasons that may contribute to functionality observed primarily through questionnaire surveys.

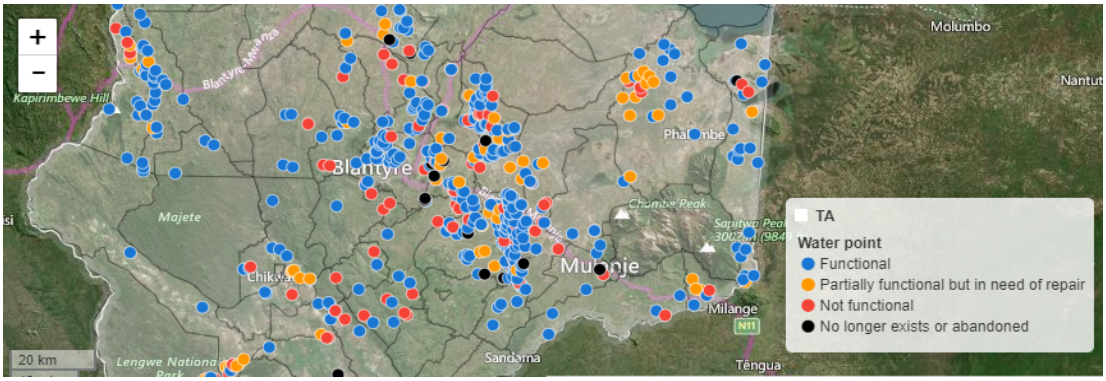


**Figure 2. Map of Southern Malawi showing functionality of MASAF-funded water points**

## Data collection methods

Although mWater is the current MIS platform, mapping started in 2011 using AkvoFLOW and expanded to cover eight districts in November 2016 to July 2017. Over 25,000 water points and 20,000 sanitation facilities were mapped during this period by NGO sub-contractor Water for People. It became increasingly apparent that AkvoFLOW was unsustainable for mapping requirements and mWater was initiated.

All mapping data previously collected using AkvoFLOW was standardised and imported into mWater. The Water Point Functionality Survey and Sanitation Survey were edited and then approved by the Government's mWater Task Force, and reviewed by District Water Development Officers at a workshop (Salima District, August 2017), to facilitate maximum impact for the Government from this mapping. Data collection enumerators were selected by each District Council. Intensive re-training of these ninety enumerators and

distribution of smartphone devices with the mWater software allowed the second phase of mapping the eight CJF districts to commence in October 2017. Comprehensive datasets were collected using questionnaire-based site inspections on themes of water point functionality and availability, reliability and maintenance, access, the surrounding environment and community-based management. In total, up to 67 attributes could be recorded at each water point. As enumerators submitted surveys to the live database, they pass through two tiers of approval to ensure high data quality assurance. Their status then becomes Final and all users of the 'Malawi CJF' platform can view and share the data (currently includes 147 Government of Malawi staff).

## Data interrogation in the mWater portal

The new mWater Portal is readily accessed online and displays up-to-date live data in a variety of formats (mainly maps, tables and charts), which the user builds into dashboards and can share via web-link. Features are editable by the creator, such as map layer rendering, feature colours and sizes and column ordering.

A customised console was developed for local government to analyse all data collected in the 2016-2018 mapping deployments. The dashboard tabs in this console are arranged by survey section, in accordance with the survey themes listed in the section above. Survey responses relating to each of these sections display in graphical and map form. Figure 3 displays an example data subset collected on water point service providers, showing that over 25,000 mapped water points (78%) have a service provider, of which 74% collect a tariff and 55% have financial records. This data can monitor existing service providers and target community training to areas where water points have no management system in place.

Presently, there are two baseline datasets available for the eight CJF districts. However, it is important that data collection is an ongoing process and future mapping will continue on a regular planned basis to provide valuable updates on ever-changing water point status.

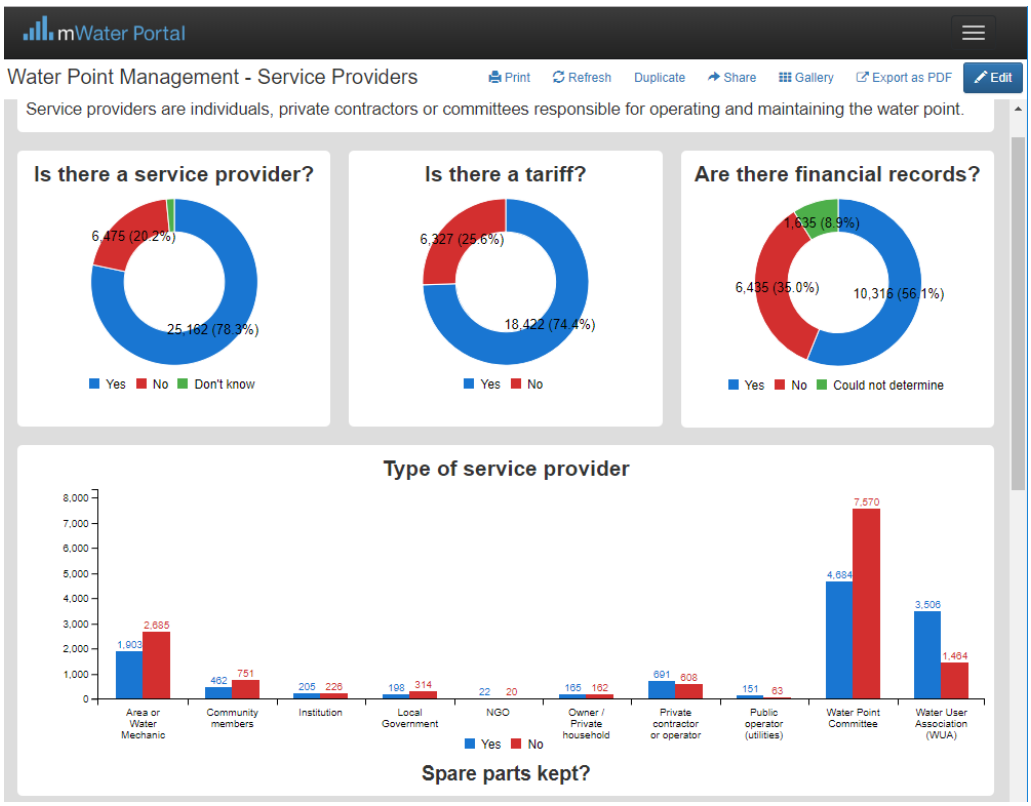


**Figure 3. Dashboard in the mWater portal of live data on water point service providers**

## Envisaged example applications

Key examples of envisaged use of new mWater MIS by government body users were explored in meetings centred on WASH concerns with each District Coordinating Team (DCT) in the eight CJF districts during January 2018 and are briefly outlined below.

### Supporting Malawi to meet SDG6 via underpinning plans

There was generalised agreement by all DCTs of the valuable potential of the MIS data interrogation facility to strategically influence key planning documents such as District Strategic Investment Plans (DSIP) and District Development Plans (DDP), as well as the national planning framework for achieving SDG6. The consoles will display indicators that align with SDG6 sub-goals and Key Performance Indicators. The District Water Office in Chiradzulu has already incorporated a customised mWater console for submission within its Socio-Economic Profile 2018, detailing the district's register of water points and their accessibility.

### Bridging WASH sector gaps

DCT members enthused about using the MIS facility to formulate interventions and bridge gaps in the WASH sector, including proper allocation of resources and writing evidence-based proposals to attract new partners. The new MIS will allow more detailed monitoring of interventions during the implementation phase, enabling the District Water Office to judge successful interventions and observe progress. The comprehensive MIS was foreseen to be of great benefit, for instance, to:

- Delineating areas where infrastructure investment would most benefit from new boreholes/taps or rehabilitation or community training;
- Assessing groundwater supply feasibility in remote upper catchment areas with sparse water points;
- Evaluation of management practices at high risk water points in relation to disease epidemics; and
- Disputing political influences by using maps to show areas with excess or insufficient activity.

District feedback on features in mWater centred on linking population data to assess water infrastructure coverage and WASH decision making. There is universal need for capacity to sustain mWater, particularly internet data, hardware, transportation for enumerators and staff availability for data cleaning and analysis.

### Spatial modelling to underpin decision making

Data analysis may be undertaken using Geographical Information Systems (GIS), for instance, to compute 'heat-maps' of areas with stressed water resource infrastructure. Figure 4 shows a heat-map of risk associated with water availability, based on five input layers – functionality (full/partial/none), current problems (Y/N), service provider (Y/N), groundwater contamination potential (Y/N) and flow rate (acceptable/unacceptable). Each raster is weighted by a user according to the parameter modelled then summed to produce a grid, with each 500 m cell scored between 0-5 for the relative risk of poor water availability. The radius of 500 m is based upon Government policy that requires no household should be further than 500 m from a water access point. Figure 4 illustrates a preliminary analysis; a more complex fuzzy logic analysis will be undertaken using expert-driven fuzzy operators to create predictive maps (Zadeh et al, 1996).

## Continued approach

Since 2016, over 25,000 water points have been mapped and re-mapped by the CJF Programme, resulting in the most up to date and extensive database in existence for the Southern Region of Malawi. The activity is being rolled out across Malawi and will continue to be updated to ensure current evidence-based influence on decision making. Survey designs and parameters hence obtained can easily be updated to accommodate changing needs of the Government. The new mWater MIS platform is also applicable to other sectors and in the next 12 months is moving to incorporate water chemistry, irrigation and drilling data.

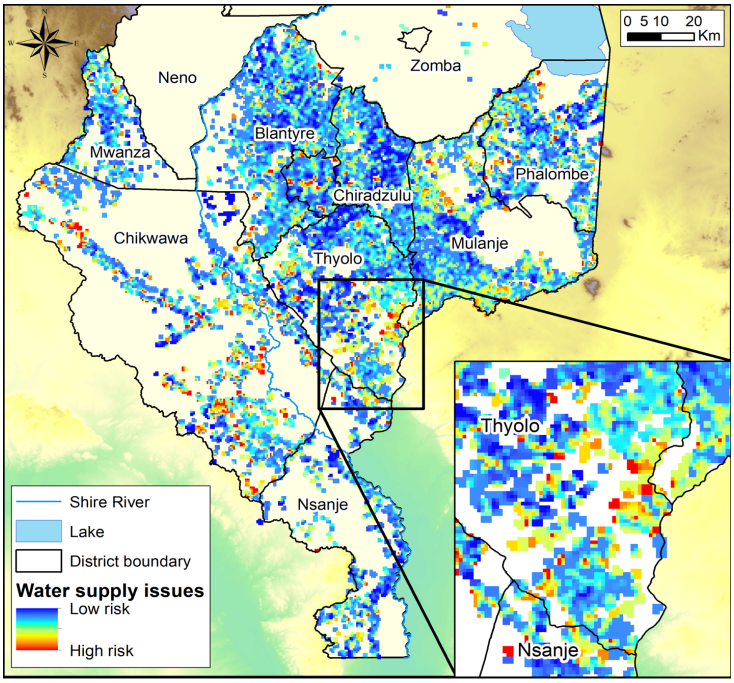


**Figure 4. Heatmap of Southern Malawi for risk associated with poor groundwater availability (using ArcGIS 10.2.2, www.arcgis.com/)**

## Recommendations

Hitherto Malawi has struggled to develop a sustainable MIS that allows effective mapping and decision making on its water points. There is a pressing need given the proliferation of water points and other WASH infrastructure. The ability to efficiently deal with volumes of data that are dynamic and offer real-time decision-making capability is paramount to effectively manage the nation's water asset. The development of the CJF custom configuration of the new mWater MIS builds upon earlier attempts and has evolved as the first viable system offering the Government of Malawi a significant tool to meet such needs. The envisaged versatility of the MIS to provide intelligent decision making on vast volumes of data is endorsed by the views of prospective Malawian users. For example, in their live decision making on formal Plans associated with SDG6 realisation, bridging a variety of WASH sector gap issues and GIS spatial modelling that may more effectively target actions taken, for instance in addressing water point functionality concerns.

The primary recommendation hence arising is that the MIS is fit for purpose and Government roll out nationally. However, to realise its full potential, there must be buy-in at all levels within Government and the water sector. It is also recommended that SDG indicators are employed to model high-risk areas, and to disseminate the data as widely as possible, especially to donors and NGOs, to inform donor-investment strategies. Dissemination of the approach is ongoing in Malawi via the Rural Water Supply Network, the Water Services Association of Malawi (WASAMA), the Joint Sector Review, WASH Sector Working Group, and the Water and Environmental Sanitation Network (WESNET). Ultimately, the Government of Malawi will collect, own and use their own data in order to direct new and existing WASH partners to the areas of greatest need. This is considered a crucial element in Malawi achieving SGD6. The final wider recommendation is that such systems need to be increasingly adopted across the developing world to ensure effective management of its water asset globally.

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