Assessing the limitations of water point mapping in Sierra Leone

Assessing the functionality of rural hand pump wells in Sierra Leone using Water Point Mapping

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Abstract Millennium Development Goal reports published in May 2012 have indicated that the international target to halve the number of people who do not have access to safe drinking water has been met. However, recent monitoring techniques, particularly those making use of advancements in water point mapping (WPM), have indicated that the sustainability of rural water supply is under serious threat. Although rapid progress has been made in developing data collection systems for the use in WPM, data analysis has not yet been fully considered. The purpose of this research is to explore how the functionality of waterpoints is measured in the 2012 Sierra Leone WPM baseline survey. It identifies a number of critical areas that could benefit from a review of existing practices including: (i) measuring the functionality of a waterpoint; (ii) differentiating between instantaneous and long term failure; (iii) the effect of macro systems on water point functionality; and (iv) the ability to quantify the effect of seasonality. This study indicates how these areas can be strengthened through analysis of the baseline survey data and case study comparisons.

Key words: Water Point Mapping, Sustainability, Analysis

INTRODUCTION

In May 2012, the World Health Organisation (WHO) reported that Target 10 of the Millennium Development Goals (MDG) to 'halve the number of people who do not have access to safe drinking water by 2015' had been reached (WHO, 2012). However this announcement has not been received without criticism. Studies have shown that up to a third of all water supply systems included are non-functioning (Sutton 2005; Harvey 2007). By using the number of people who have access to improved sources as an indicator of progress, only an instantaneous assessment of the levels of access can be determined and the risk of future system failure is not accounted for. The recent emergence of Water Point Mapping (WPM) has led to the rapid technical assessment of tens of thousands of water points across the developing world. Many WPM projects have indicated that the rates of failure of water supply systems are in fact higher than previously thought, such as Sierra Leone, whereby 37.4% of their systems were found to be non-functioning (Hirn, 2012). The Waterpoint Atlas of Liberia identified that up to 50% of waterpoints were non-functional in the dry season (De

Waal, 2011). It is therefore evident that the sustainability of water supply systems is one of the most pressing issues with regards to achieving the global target for access to improved water sources. Although WPM offers many benefits with regards to the monitoring and evaluation of waterpoints, the correct methodology with which data is collected and analysed is under intense debate. The purpose of this research is to investigate how the functionality of waterpoints can be assessed using WPM. It discusses the limited conclusions that can be obtained from the current raw data collected in the 2012 Sierra Leone WPM baseline survey. Through case studies and analysis of the WPM data, this research investigates a number of critical areas including: (i) measuring the functionality of a waterpoint; (ii) differentiating between instantaneous and long term failure; (iii) the effect of macro systems on water point functionality; and (iv) the ability to quantify the effect of seasonality.

METHODS

Water Point Mapping

Until recently, large-scale monitoring and evaluation studies investigating the functionality of rural water points involved recording data manually and then converting it to digital format. This method of data gathering is hugely time consuming and can lead to an increase in human error (De Waal, 2011). As a result of this the data can become outdated before it can be accurately analysed and acted upon (World Bank, 2011; UNICEF, 2005); leading to ineffective planning and resource allocation (WaterAid, 2011). The newly developed WPM tool offers the potential to overcome the issues of real time monitoring and evaluation as well as reducing the potential for human error (De Waal, 2011).

WPM is a tool for rapidly monitoring and evaluating the distribution and status of water supply systems in developing countries. It makes use of Android technology to collect geographical and technical data, for each water point, in real time and overlays this data with information such as population density, land boundaries and ground water availability (Margai, 2012). The collected information can then be used to enhance the planning of national and regional water supply strategies, resource allocation and to measure progress (Jiménez, 2008) (Fig. 1). Currently, WPM is still in its development stage and thus it is generally only used by NGOs and external support organizations (RWSN, 2012).

The current focus within the sector has been on establishing data collection techniques, however the Rural Water Supply Network WPM report stressed that the analysis of WPM data deserves more attention (RWSN, 2012). WPM is facing a similar issue to Geographical Information Systems (Cromely, 2012). Since WPM offers an attractive visual and modern way of assessing the water supply crisis, this can lead to people trusting the credibility of what is presented at face value rather than questioning the analysis behind the visuals. Without correctly interpreting the data the sector runs the dangerous risk of ineffective planning and wasting vital resources.

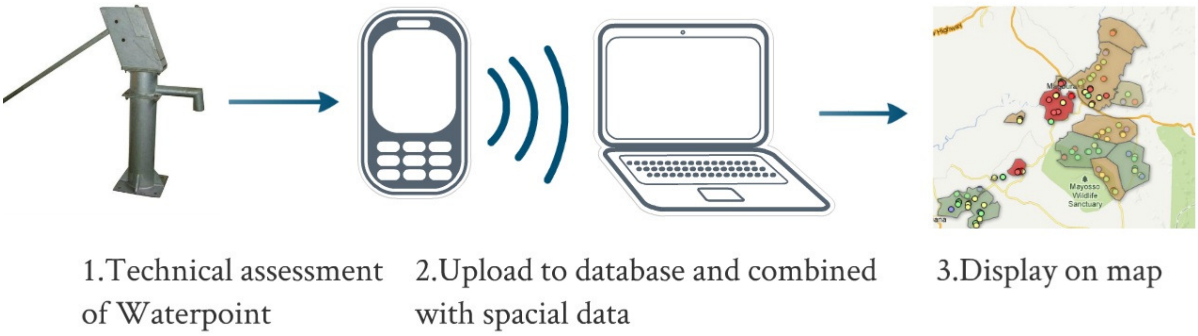

Figure 1 Water Point Mapping Process

The Context of this Research

This research is primarily focussed in Tonkolili, Northern District, Sierra Leone. Currently ranked 180th out of 187 countries in the Human development Index, Sierra Leone is one of the least developed countries in the world (United Nations Development Programme, 2011). Failure rates of water supply systems have been found to be some of the highest in Sub-Saharan Africa (Harvey, 2007). Access to improved water sources in the poorest rural areas can be as low as 10% coverage even though there have been sustained efforts to combat the decline through widespread installation of community level hand pumps (UNICEF, 2012). A WPM baseline survey of 28,000 water points was recently undertaken by the World Bank in Sierra Leone (Hirn, 2012). The results of the survey indicated that 37.4% of water supply systems are either damaged or non-functioning. Tonkolili district had a 57% failure rate of existing water supply systems, the highest failure rate of any district in Sierra Leone (Hirn, 2012). Tonkolili also has the largest population per functional water point, excluding Freetown, of 535 people per waterpoint (1012 seasonally). This is more than double the number of recommended users of 250 people per waterpoint (Munkonge, 2009).

The 2012 Sierra Leone WPM baseline report offers an insight into the condition of rural waterpoints in Sierra Leone. It highlights the need for increased investment, the effects of seasonality and high break down rates of waterpoints. The survey identifies four main categories of water system functionality: (i) *fully functional*, (ii) *partly functional*, (iii) *broken down* and (iv) *under construction*. Although this allows for a simple categorisation of waterpoints, it can hide the true extent of the problem. As observed in recent field trips in Sierra Leone during the period 2010-2012, there are many examples in which waterpoints have been classed as *broken down* but have demonstrated drastically different levels of technical and social issues to other *broken down* waterpoints. This issue can also be seen for waterpoints classed as *partly functional* and *fully functional*. The reasons behind the failure of waterpoints classed as *broken down* can range from missing fast moving parts to missing the entire hand pump, whereas the failure of *partly functional* wells can range from a mildly damaged well apron to having a severely eroded well casing. By not differentiating between these issues, the WPM survey risks providing misleading information and oversimplifying the issue of the high failure rates of waterpoints in Sierra Leone. The purpose of this research was to identify methods for improving the classification of waterpoint functionality within

WPM. It also sought to advance the effectiveness of WPM in Sierra Leone. This research provides new information to improve the current knowledge and understanding, and suggests alterations required for the 2014 WPM baseline survey.

To support this study, research was carried out in Tonkolili district, Sierra Leone. A total of 300 rural hand pump wells were surveyed in the chiefdoms of Kholifa Rowala, Kunike, Tane, Kunike Barine and Kholifa Mabang (Fig. 2). Only community owned rural hand pump wells were assessed. The GPS coordinates for each water point from the WPM baseline survey were compared to the field research GPS coordinates to allow waterpoint data comparison. A waterpoint was only selected for comparison if the GPS coordinates from both surveys were less than 10 metres apart. This measure reduces the risk of a false identification of a well, as several wells can be found in one village (Fig 3).

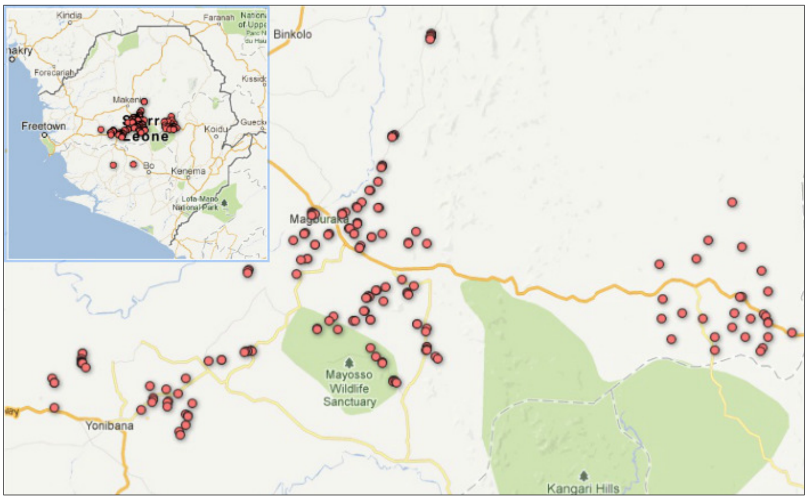

Figure 2 Distribution of Wells Surveyed

A detailed technical survey was undertaken for each system, whereby several components of the hand pump and well were assessed. Discussion groups were also held with the water user committees (WUCs) to assess the characteristics of social support systems surrounding the water maintenance and operation of the system. Case studies are used to compare and contrast the level of functionality of a hand pump wells identified in the WPM baseline survey with the technical surveys carried out for this research.

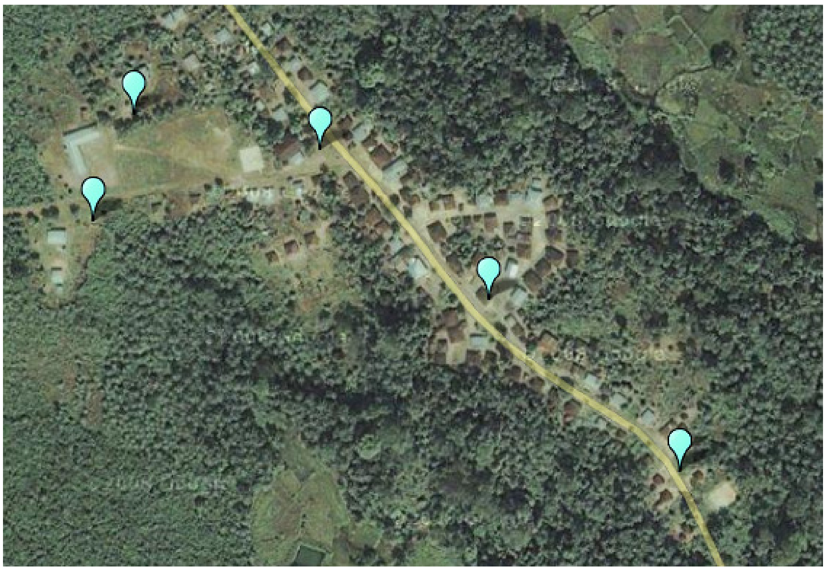

Figure 3 -Distribution of wells surveyed in Petifu Village, Sierra Leone

Benefits of the Sierra Leone Water Point Mapping

The Sierra Leone WPM baseline survey was undertaken between December 2011 and April 2012 by the Ministry of Energy and Water Resources (MEWR). The survey report summarised that over a third of all water points constructed were 'not functional' and up to 40% were only functional on a seasonal basis (Hirn, 2012). The survey identified four main well categories of water system functionality: (i) *fully functional*, (ii) *partly functional*, (iii) *broken down* and (iv) *under construction*. Hirn (2012) defined *broken down* as major damage that renders the water systems unsafe and *partly functional* is classed as either major or minor damage and should still be able to deliver water. The survey offers a useful insight into the condition of rural water systems in Sierra Leone. It highlighted the need for increased investment, the effects of seasonality and high break down rates of waterpoints. It has provided a basic framework in which the coordination of a multi-stakeholder sector can take place; both nationally and regionally. Crucially, the survey demonstrates a fundamental move towards achieving the government's current target for access to improved water sources by 2015.

Limitations of the Sierra Leone Water Point Mapping Survey

There are several areas of concern regarding the data collected in the survey and how the functionality of waterpoints is classified using this data. The limitations which are discussed in this paper, through data analysis and case studies, include: (i) how the functionality of a waterpoint is measured, (ii) differentiating between instantaneous and long term failure, (iii) the effect of macro systems on water point functionality and (iv) the ability to quantify the effect of seasonality.

RESULTS AND DISCUSSION

Defining the extent of failure

Out of a total of 1,742 waterpoints assessed in the Tonkolili region, 28% were listed as *broken down* in the WPM survey dataset. Each broken down waterpoint is assigned a brief description of the main failure characteristics. Therefore for 317 broken down hand pump wells in Tonkolili there were 114 unique descriptions of failure. By assigning each waterpoint a unique description of failure, it is not possible to quantify and compare the level of functionality of each waterpoint in relation to another without vastly simplifying the methodology of comparison. As well as collecting multiple descriptions for the failure of each waterpoint, the WPM survey provides only brief descriptions for 61% of the broken down hand pump wells (Table 1). The same can be seen with wells identified as partially damaged, whereby 65% have only brief descriptions of the type of damage.

Table 1 -Variations of descriptions of water supply system damage in raw data set of 2012 WPM Baseline Survey

Functionality of Water System	Damage Observed
Broken Down	Well damaged, Pulley, damaged water well, dried
Broken Down	Well damaged, Well polluted, Apron damaged, wall sinked
Broken Down	Well damaged, Apron damaged, Lining broken
Broken Down	Well damaged, Apron damaged, Lining damaged Apron, Headwall
Broken Down	Well damaged, Apron damaged, Lining, Sinked Sockaway Pit, All Damaged

The combination of both a wide range of descriptions of failure and a lack of detail in these descriptions offers little chance to identify waterpoints (i) which can meet the basic immediate needs of the country, (ii) that require little rehabilitation and few resources and (iii) that require substantial investment. The ability to assess the technical sustainability of Government and NGO programmes is also severely restricted. Furthermore, without the ability to determine the severity of failure, it is common, as observed in the field, for a new system to be constructed adjacent to existing systems that require only modest rehabilitation.

Case Study 1 – Defining the extent of failure

This case study identifies two systems that were classified as *broken down* in the WPM survey but exhibit substantially different failure characteristics.

A severe case of a *broken down* waterpoint is a hand pump well in the village of Masokah. The well was missing the entire hand pump and the brick well casing had entirely collapsed into the well (Fig.4 & 5). This type of damage greatly reduces the structural integrity of the well and exposes it to the potential of contamination. This well poses a severe risk to the community. The rehabilitation required is complex and would generally result in the construction of a new well system.

Figure 4 Masokoh Village Well

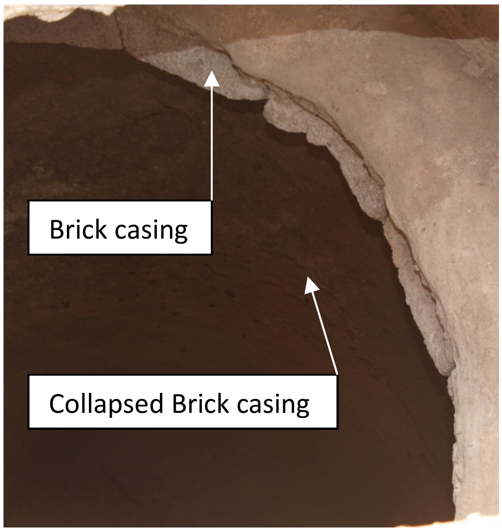

Figure 5 Masakoh Well Casing Collapse

An example of mild failure of a waterpoint that was assessed as *broken down* is in the village of Maworro. The well is not affected by seasonality and the well area and casing are in good structural condition. However, the pump was missing fast moving replaceable parts which affect the immediate functionality of the well. Furthermore, there was no security fence and the spillway was badly damaged. Although there are a number of components that require rehabilitation, they are generally small scale and straightforward to fix. The majority of the repair activities can be undertaken by the community. Thus minimal rehabilitation costs would be required (Fig. 6).

Figure ~~4~~6 Maworro Village Well

The inability to estimate the extent of water supply system failure also greatly restricts how costs associated with the rehabilitation are estimated. Studies have shown that the rehabilitation cost can account for substantial amount of total water supply investment. For instance, the Liberia Water Point Atlas Report (2013) estimated that around 25% of total water point investment is required to repair existing water points.

The two case studies above demonstrate that by not differentiating between the varying level of water supply system failure, the accuracy, effectiveness and efficiency with which planners can allocate investment and resources is greatly reduced. Maybe say something about by simply labelling it as broken down it does not give any indication.

Immediate and Long-term Failure

A waterpoint can develop mild damage that, if not addressed, can lead to severe damage and loss of functionality over time. The WPM baseline data lacks detailed descriptions of the reasons for the loss of functionality of a well and thus it is not possible to differentiate between immediate and long term failure.

Case Study 2 – Identifying Time dependent Failures

This case study identifies three waterpoints that were classed as *functional* in the baseline survey, yet exhibited types of failure that could increase in severity over time to reduce the operational lifetime of the waterpoint.

A hand pump well in Mayossoh revealed large finger width cracks in the apron, in which plants were growing through (Fig. 7). Although this type of structural damage does not reduce the immediate functionality of the well, there is a risk that as the cracks increase in size over the wells lifetime the structural integrity could be severely compromised. In addition to this, the casing of the well has become badly eroded and thus is susceptible to contaminated ground water infiltration (Fig.8). Evidence of this occurring can be seen through the presence of flora around the casing. Until the casing is rehabilitated, there is a severe risk of the casing collapsing and destroying the well.

Figure 7 Plant growing through crack in well apron

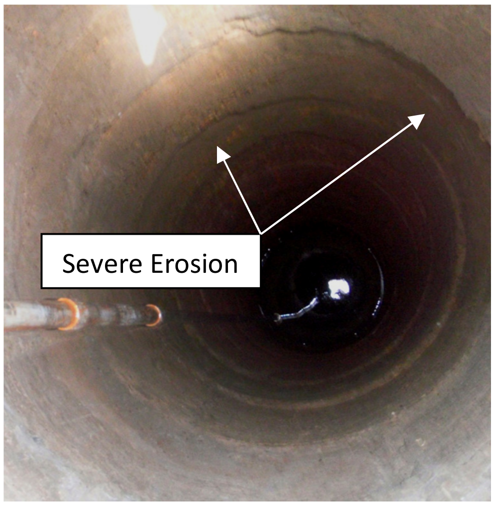

Figure 8 Severely eroded well casing

A hand pump well in the village of Two House was classed as *functional*, however the system was missing a spillway with which to drain the waste water (Fig.9). If no spillway is present, water cannot drain from the system and ponding can occur around the well area. As well as causing stagnant water and raising the possibility of cross contamination of sources, ponding can severely erode the well area and flow back into the wells water source, thus potentially contaminating the entire system.

Figure 59 Two House village well - missing spillway

The third example of potential long term failure is a hand pump in the village of Rowalla. The well had a security casing which had been constructed from reinforced concrete in order to prevent the theft of fast moving parts within the hand pump. Although this prevents thievery, it also prevents any technician from being able to effectively maintain or replace parts, thereby severely jeopardising the operational lifetime of the well system.

Figure 6~~10~~ Concrete Security Casing in Rowala Village

Although this survey was intended to provide a high level summary of the functionality of waterpoints, it is clear from the three case studies above that a well cannot be simply labelled as functional.

Accounting for Macro Level Support Structures

Macro-level support structures are large-scale mechanisms that organize and distribute support throughout an entire society, as opposed to small-scale, or interpersonal, structures (Kirst-Ashman, 2008). Key macro structures regarding water supply in developing countries include: governmental and NGO technical support, supply chains for spare parts and tools and the private sector. The Country Status Overview 2 (CSO2) report for Sierra Leone indicated that it scored comparatively low to similar countries with regards to the functionality of macro systems (World Bank, 2011). The report identified three key areas of concern for Sierra Leone: weak planning and investment strategies, inadequate supply chains and poor support services provided. The WPM baseline survey data specifically focuses on the micro systems of water supply, namely the functionality of a water supply system and the presence of technicians. However by not incorporating, even at a basic level, the functionality of external macro systems, very few hypotheses can be made regarding the sustainability of each water point. During the field based research, an informal discussion was held with the WUCs for each hand pump system to assess the functionality of the macro systems. The survey identified that no WUC was able to collect sufficient capital with which to fix major problems with the system. Only 40% used a tariff system, in theory, and 87% of communities had no access to toolkits. Furthermore, the majority of WUCs believed there was little government support offered.

The dysfunctional nature of the WUCs surveyed in this study raises the critical question that if a WPM survey does not incorporate the functionality of macro systems, to what extent can the sustainability of each water supply system be assessed. Harvey (2007) argued that simply having a Water User Committee (WUC) is no indication of sustainability. Therefore a WPM survey must look beyond the WUCs to the macro support structures they depend on.

Seasonal Variation

The seasonal variation in water table levels can greatly affect the volume of water available from a water system in Sierra Leone (Hirn, 2012). Although the issue of seasonality was recorded in the WPM survey, the extent of the variation was not. Thus the severity of seasonal variation on the failure of each system cannot be effectively determined. This is important as one cannot differentiate between a well that dries up for only 3 months a year and a well that dries up 9 months of the year. In addition to this, 23% of all waterpoints identified as *functional* were affected by seasonal variations in water levels. Therefore that if a well is labelled functional, it is more likely to be moved down the priority list, even though the waterpoint may provide water for less than 6 months a year. This was found to be nearly 15% of the 300 systems surveyed for the purposes of this research.

DISCUSSION

Through analysis of the raw data from the 2012 WPM Baseline survey and using case studies for the Tonkolili district, this study demonstrates the limited insight it offers into the functionality of waterpoints.

It highlights the inability to objectively compare the extent of failure of each well system to others and the affect this can have on investment and resource allocation. The study also addresses the issue of the inability to distinguish between immediate failure and the risk of long term failure as well as the effect of seasonality. Finally it highlights the need to account for macro systems within a WPM survey.

Lamin Souma, Chief Engineer at the Water Directorate within the Ministry of Energy and Water Resources (MEWR), highlighted the dichotomy that currently exists in Sierra Leone regarding the tension between providing long term sustainable services and the basic needs of today. He stated that it '*requires government institutions and those organizations working in the water supply and sanitation sector to deal with short-term needs and simultaneously work on long-term capacity building'* (Day, 2012). It is therefore clear that an essential requirement for the 2014 Sierra Leone WPM baseline is to allow the quantitative grading of each water supply system by the level of rehabilitation required and should be able to identify (i) the systems that require the least rehabilitation and thus can immediately contribute to meeting the basic short term needs and (ii) the systems that require long term investment.

By assessing each component of the system for specific characteristics a straightforward grading system could be introduced. Each grade could be simultaneously ranked by the level of rehabilitation required, the relative cost of rehabilitation and the risk the waterpoint poses to the community. Components could also be ranked by a combination existing standards such as the SPHERE or WHO standards.

A grading of this style removes the potential for a wide range of descriptions pertaining to the functionality of a water supply system. It offers a methodology with which all systems can be compared evenly. It also allows for water supply programmes and initiatives to be quantitatively assessed and compared and allows aspects such as seasonality and macro systems to be measured. A wide range of aspects can also be incorporated into this type of grading system such as water quantity, topography and well security. Crucially, the grading system offers planners the ability to identify wells that can be rehabilitated to meet immediate needs and those that do not. Although this type of grading system will provide a framework with which to objectively assess and compare the extent of technical failure of water supply systems, it cannot be considered a panacea to the problem. It would only be a tool with which to assess the technical functionality of waterpoints within complex social systems.

CONCLUSION

The Sierra Leone WPM survey undertaken by the World Bank was always intended to be a baseline for future monitoring and research. Through analysis of the raw data collected in the baseline survey and case study comparisons, this study has demonstrated the limitations of the survey with regards to classifying waterpoint functionality. It highlights the value of objectively measuring the functionality of a waterpoint. It has demonstrated that the effectiveness of WPM can be enhanced by differentiating between instantaneous and long term failure, assessing the effect of macro systems and quantifying the effect of seasonality. This research identifies a methodology that addresses these issues. By integrating a waterpoint grading system into the 2014 baseline survey, a more objective assessment of waterpoint functionality in Sierra Leone can begin.

Future Work

There are several areas discussed in this paper which require further investigation, currently ongoing. The first area is to indicate how such a grading system could be used to benefit governments, humanitarian agencies, NGOs, and other actors in the water supply sector. The second area is to demonstrate how the grading system would be applied to a practical case study. The third area is to incorporate social aspects that can affect the sustainability of water points with regards to cultures, knowledge, attitudes and practices of those being provided with a water supply.

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