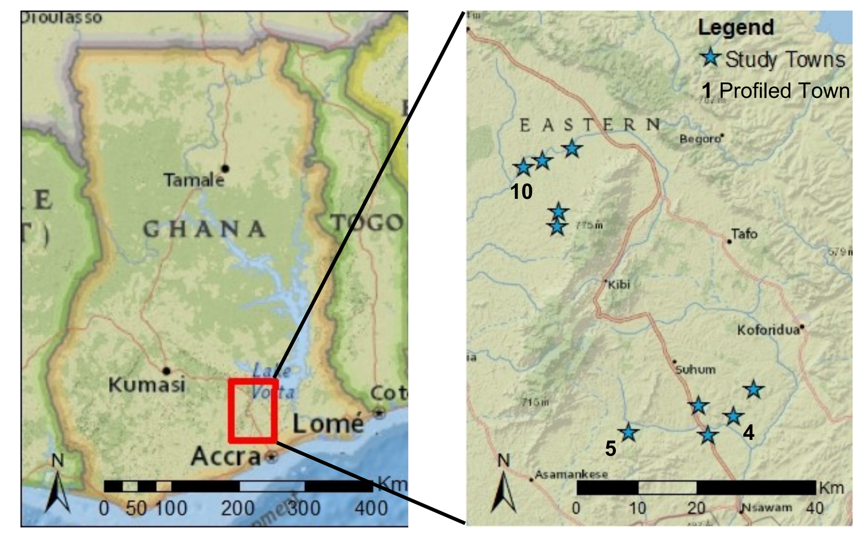
# Borehole Functionality in the Eastern Region of Ghana




## Introduction

Millions have benefited from the installation of water systems such as boreholes (BH) which provide safe drinking water. However, many communities in rural, low-income settings are unable to fix broken infrastructure. An estimated 36% of water systems in rural sub-Saharan Africa are non-functional.

The location of water systems is important to sustained health benefits. Closer water sources result in increased household water use, which translates to improved health outcomes. The location of systems has the potential to affect both health outcomes and long-term functionality, as users will be more motivated to maintain a system that is conveniently located.

Systems are frequently managed by communities, which may lack adequate training and resources. This can affect functionality if sufficient funds are unavailable when repairs are needed. Therefore, good financial management practices are another important component of sustainable infrastructure.

This project seeks to answer the following research questions:

1) What is the characterization of spatial access to all boreholes and functional boreholes in 10 towns in the Eastern Region of Ghana?
2) What management and spatial characteristics affect borehole functionality in these towns?

## Methods

This study took place in 10 towns in 3 districts in the Eastern Region of Ghana, chosen from among a larger sampling frame of 74 towns that were part of a wider study (Kulinkina et al. 2017). The towns were stratified by water quality characteristics: towns 1-5 had high total dissolved solids (TDS) and hardness, and towns 6-10 had high iron concentrations.

Data collection took place in May 2016. In each town, the location of all houses, public boreholes, hand dug wells (HDW), and surface water access points (SWAP) in each town were recorded. Borehole functionality was also recorded. Additionally, an individual from each town's leadership was surveyed about the financial management of their town's water system.

### Town Characteristics

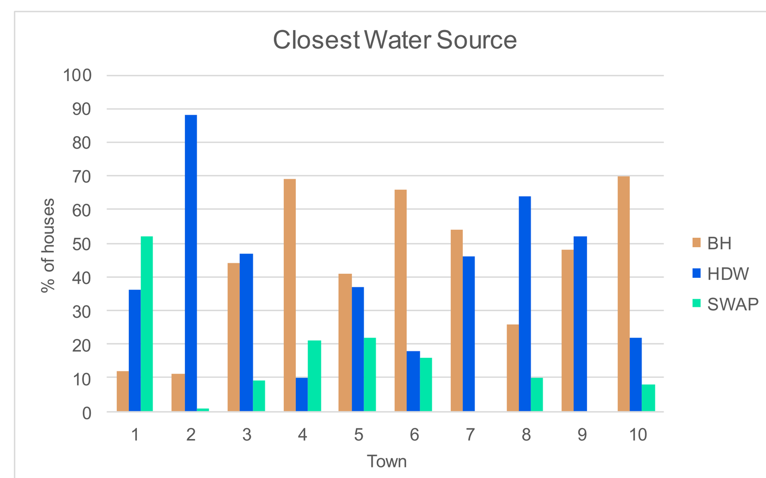
| Town | Total Houses | Total BHs | Functional BHs (%) |
|---|---|---|---|
| 1 | 169 | 2 | 1 (50) |
| 2 | 167 | 2 | 2 (100) |
| 3 | 163 | 2 | 2 (100) |
| 4 | 160 | 3 | 1 (33) |
| 5 | 380 | 5 | 4 (80) |
| 6 | 298 | 7 | 5 (71) |
| 7 | 220 | 6 | 4 (67) |
| 8 | 344 | 7 | 6 (86) |
| 9 | 128 | 4 | 4 (100) |
| 10 | 440 | 11 | 7 (64) |

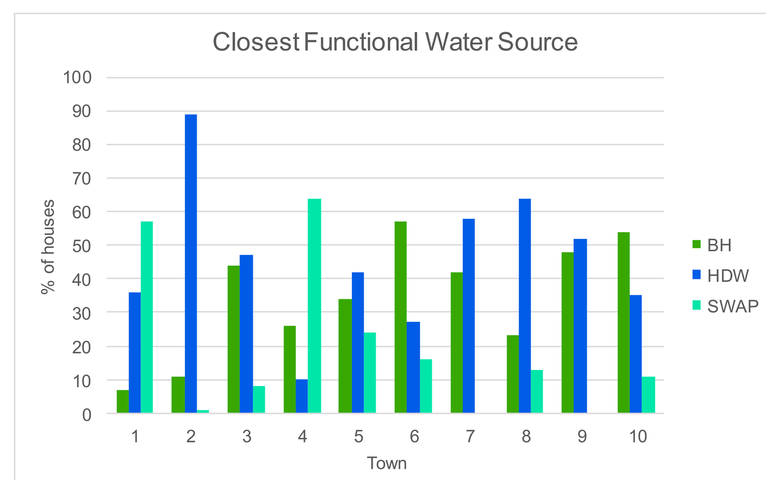
The Near tool in ArcMap was used to identify and calculate the distance to the closest of each type of water source for each house. These data were then exported to Excel, where various descriptive statistics were calculated.

A logistic regression model was developed to predict borehole functionality (Logistic Regression: Borehole Functionality). For distance variables, houses were assigned to the closest borehole. These groups were used to calculate the variables average distance to borehole and percent of houses where borehole is closest water source by borehole.

## Results

The average distance from a house to the closest borehole was 178 m, and the average distance to a functional borehole was 250 m. The figures under Percent of Houses within Distance Buffers of Water Source describe the spatial distribution of water sources by town.




A borehole was the nearest water source for 47% of houses, but when only functional boreholes were included this dropped to 37%. The figures to the right show the distribution of closest water source by town when including all boreholes and only functional boreholes, respectively. Three towns were chosen for mapping display based on the decrease of houses with borehole as the closest water source between these two figures. Town 5 represents a small decrease (< 10% houses), town 10 represents a moderate decrease (10-20%), and town 4 represents a large decrease (> 20%). In general, houses in the high iron cluster were more likely to have a borehole as the closest water source, which is logical considering that these towns are generally larger and have more boreholes (Town Characteristics).

The regression model (below) found that only two variables, payment structure and average distance, were marginally significant ($p < 0.10$).

### Logistic Regression: Borehole Functionality

| Dependent variables | Variable Definition | Coefficient | p-value |
|---|---|---|---|
| Water Quality Cluster | 0 = high TDS, 1 = high iron | -1.175 | 0.49 |
| Average Distance* | Average distance from house to borehole (m) | 0.025 | 0.058† |
| Percent Closest Source | Percent of houses where borehole is closest water source | 0.018 | 0.26 |
| Payment Structure | 0 = reactive, 1 = proactive | 3.997 | 0.091† |
| Water Committee | 0 = no, 1 = yes | -2.2 | 0.133 |
| Financial Records | 0 = no, 1 = yes | -0.222 | 0.823 |
| Separate Water Fund | 0 = no, 1 = yes | -1.914 | 0.15 |

**Footnotes:**
* Houses assigned to closest borehole
† Marginally significant ($p < 0.1$)

## Conclusions

Nine of the ten communities had over 90% of houses within 500 m of a functioning borehole, indicating good overall spatial access to boreholes. Broken boreholes limited immediate access to an improved water source, but these effects were less pronounced with larger buffer ranges (500 m). Spatial access was most affected in town 4, which was partially due to how the houses were situated. However, town 4 was also the only town with a reactive collection system, meaning users were only charged when the borehole is broken. This suggests that the committee is not able to raise sufficient funds to fix the boreholes when they break.

The regression model did not show expected results, with only two marginally significant variables, but it is possible the small sample size contributed to the insignificant results.

## Limitations

According to data from previous studies, five boreholes were missed during data collection, and functionality was not recorded for an additional two. Researchers may have also missed houses in remote parts of towns.

In addition, this analysis assumes that households use the closest available borehole. However, previous research has shown that a variety of other factors such as seasonality and perceived water quality can also influence choice of water source. Ideally, future research would identify which water source(s) each house uses.

## Acknowledgements

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## Cartographer: Olivia Schultes

December 2017

GIS 101: Intro to GIS

Coordinate System: WGS 1984

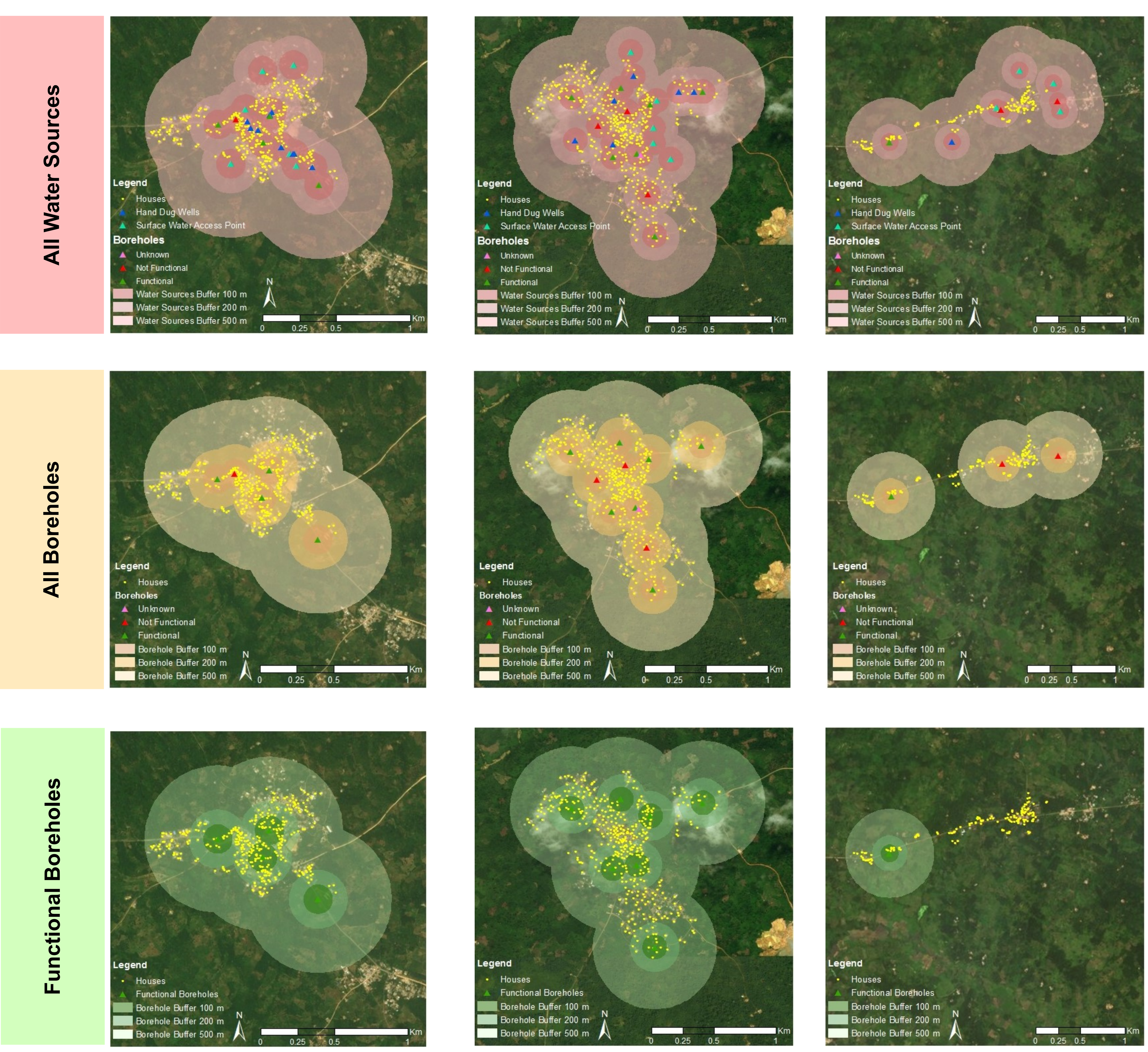
Projection: UTM Zone 30N

Sources: ESRI World Imagery, National Geographic

Tufts UNIVERSITY

## Spatial Access to Water Sources by Functionality

| | Town 10 (low decrease in access) | Town 5 (moderate decrease in access) | Town 4 (high decrease in access) |
|---|---|---|---|




## Percent of Houses within Distances of Water Source