



Using GIS Technology to Mitigate Climate Related Risk to Water Infrastructure in Rural Ghana

October 31, 2023



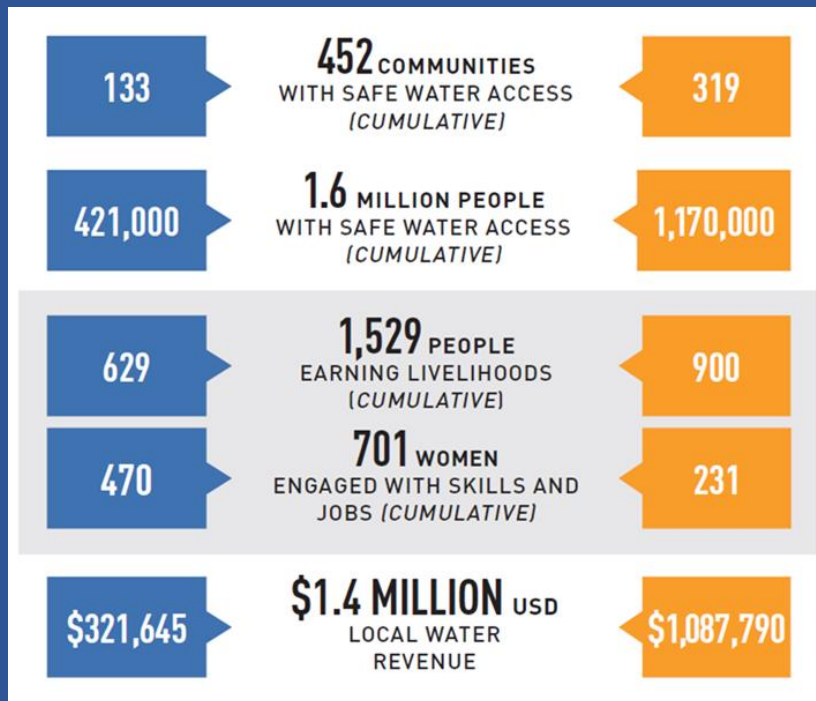
<https://www.safewaternetwork.org/sign-gis-program>

Agenda

- Introduction
- The Need for Efficient & Accurate Feasibility Assessments
- The Need for Risk Awareness During the Planning Process
- Building Resiliency Through Geographic Information Systems (GIS)
- Walkthrough the Toolkit Apps
- Plans for Replication & Scale
- Flood Demo with Q&A

Innovation is a key part of our mission and our success in community safe water supply

About Safe Water Network



The Safe Water Resiliency Toolkit

1. **Feasibility Tool:** Pre-Screen & Assess Optimal Communities
2. **Risk Assessment Tool:** Explore Local & Regional Hazards & Risks
3. **EPANET+ Tool:** Plan Optimal Infrastructure Design
4. **Mitigation Tool:** Creating Infrastructure and Community Resilience
5. **Field Sales Tool:** Building Sustainability and Growth

What happens when we don't plan for climate shocks?



RISK AND HAZARDS TO STATIONS' OPERATIONS

- Limited evaluation of climate change and/or disaster risk metrics in station design
- Flooding and drought impacts stations operations
- Flooding in communities along Lake Volta
 - Inability to access control equipment;
 - Longer pumping hours;
 - Operations shut down for 1-2 months;
 - High expense on maintenance reserves to relocate panels and cables;
- Dry well in communities Ashanti
 - High downtime;
 - Low production volumes and water sales;
 - High operational cost

What happens when we don't plan for climate shocks?

Flooding at water treatment facilities leads to direct and indirect costs

Total Cost of Flood Damage at Station in Volta Region, Ghana

\$615

Lost Revenue

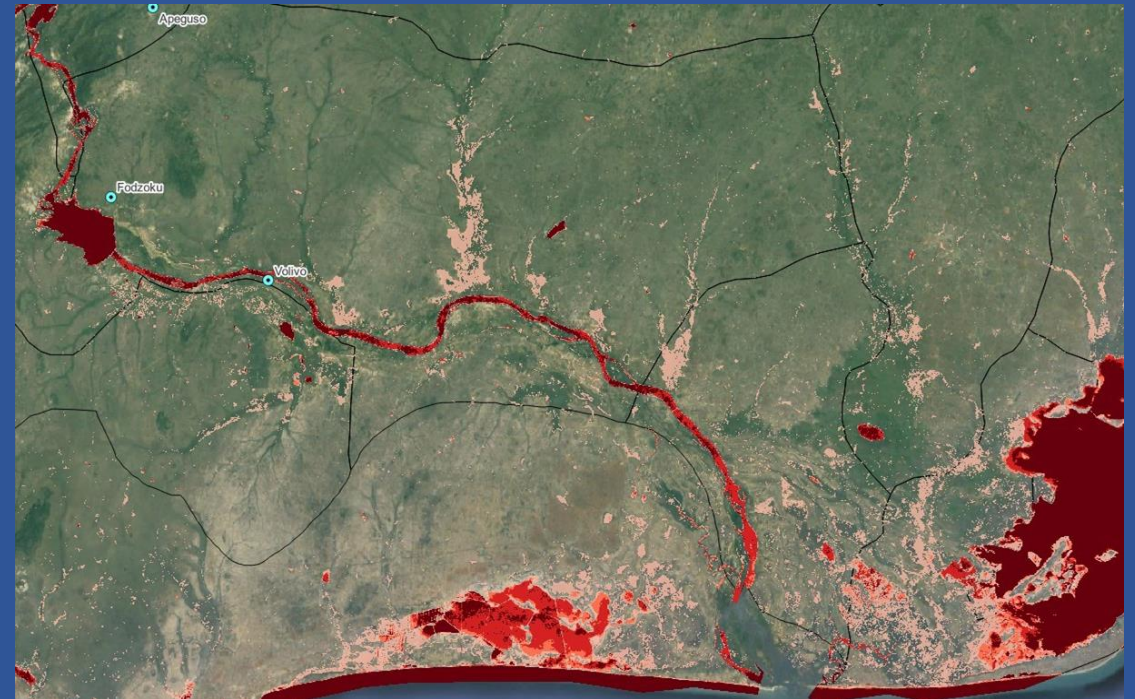
\$3,000

Equipment Repair

\$3,250

Benefits Lost

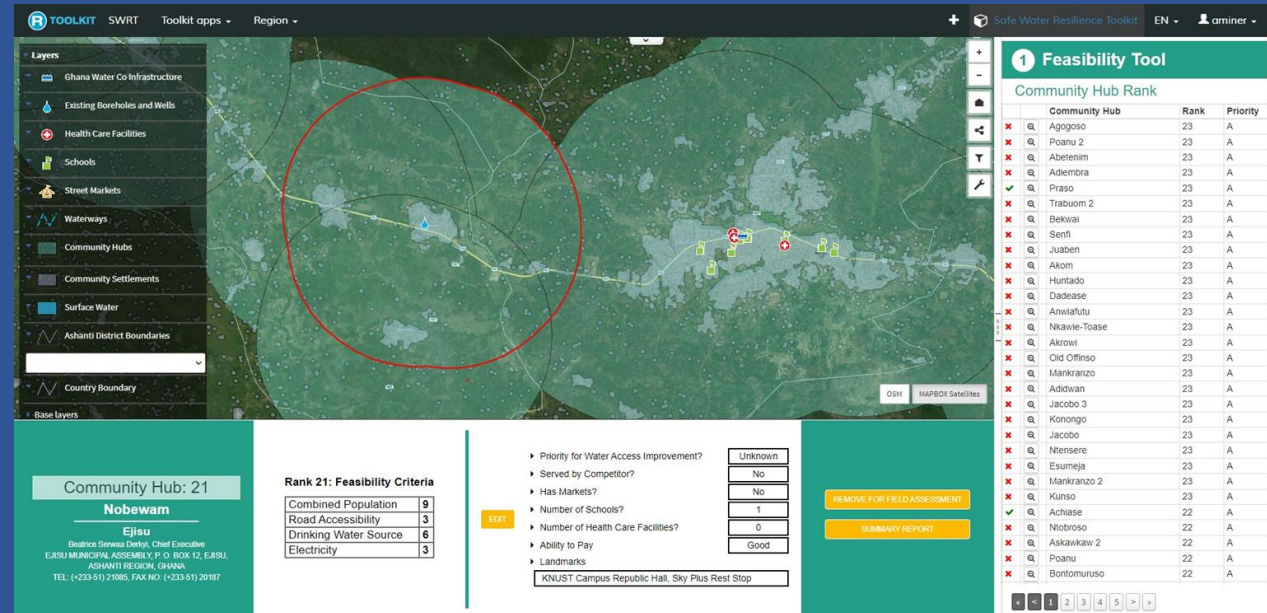
The risk assessment tool identifies areas at risk for flood and displays data visually to improve site planning and mitigate the impact of environmental hazards.



Flood Risk Zones in Volta Region, Ghana

How can site planning technology optimize impact?

- Identify current and potential hazards and incorporate them into station design
- Assess risk on stations' design and make changes
- Assess the suitability of locations for infrastructure
- Prioritize intervention locations based on a more comprehensive assessment of risk factors



Planning Data Visualization for Nobewam, Ghana

THE SAFE WATER RESILIENCE TOOLKIT: WALKTHROUGH OF THE TOOLKIT APPS



Funded by

Toolkit Page



<https://www.safewaternetwork.org/sign-gis-program>

THE SAFE WATER RESILIENCE TOOLKIT: WALKTHROUGH OF THE TOOLKIT APPS

Toolkit Page



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App 1: Feasibility Tool

Prescreening for Optimal Site Selection

FEASIBILITY CRITERIA

Critical Criteria	Definition	Rank
Combined Population	Population of the community and surrounding communities less than 4km away	3
Drinking Water Source	The major sources of water for the community	2
Road Accessibility	The community's accessibility by road in all seasons	1
Access to Electricity	Availability of electricity in the community	1

Additional Criteria:

- People's Ability to Pay
- Priority for Water Access Improvement
- Is Area Served by Competitor?
- Proximity to Markets
- Existing Infrastructure

Current Data Collection Method:

- Physical visit to every community
- Paper data collection form, hand drawn maps
- Manual analysis of results





1 Feasibility Tool

Community Hub Rank

	Community Hub	Rank	Priority
✓	Trabuom 2	23	A
✗	Abetenim	23	A
✗	Mankranzo 2	23	A
✗	Juaben	23	A
✗	Bekwai	23	A
✗	Kunso	23	A
✓	Jacobo	23	A
✗	Akrowi	23	A
✗	Adidwan	23	A
✗	Konongo	23	A
✗	Mankranzo	23	A
✗	Senfi	23	A
✗	Nkawie-Toase	23	A
✗	Anwafutu	23	A
✗	Dadease	23	A
✗	Poanu 2	23	A
✗	Praso	23	A
✗	Adiembra	23	A
✗	Old Offinso	23	A
✗	Esumeja	23	A
✗	Ntensere	23	A
✗	Jacobo 3	23	A
✗	Akom	23	A
✗	Huntado	23	A
✓	Agogoso	23	A
✗	Bontomuruso	22	A
✗	Achiase	22	A
✗	Askawkaw 2	22	A
✗	Poanu	22	A
✗	Askawkaw	22	A
✗	Ntobroso	22	A

Community Hub: 23

Trabuom 2

Bosomtwe

Joseph Akwasin Asuming, Chief Executive
 BOTSOMTWE DISTRICT ASSEMBLY, P. O. BOX 24,
 KUNTANASE, ASHANTI REGION, GHANA
 TEL: (+233-3221) 24859, FAX NO: (+233-3220) 20142

Rank 23: Feasibility Criteria

Combined Population	9
Road Accessibility	3
Drinking Water Source	8
Electricity	3

EDIT

- ▶ Priority for Water Access Improvement?
- ▶ Served by Competitor?
- ▶ Has Markets?
- ▶ Number of Schools?
- ▶ Number of Health Care Facilities?
- ▶ Ability to Pay
- ▶ Landmarks

Check MTDP

No

Yes

0

1

Good

Trabuom Health Center, Twedle Mkt

MEDIUM TERM DEVELOPMENT PLAN

REMOVE FOR FIELD ASSESSMENT

SUMMARY REPORT

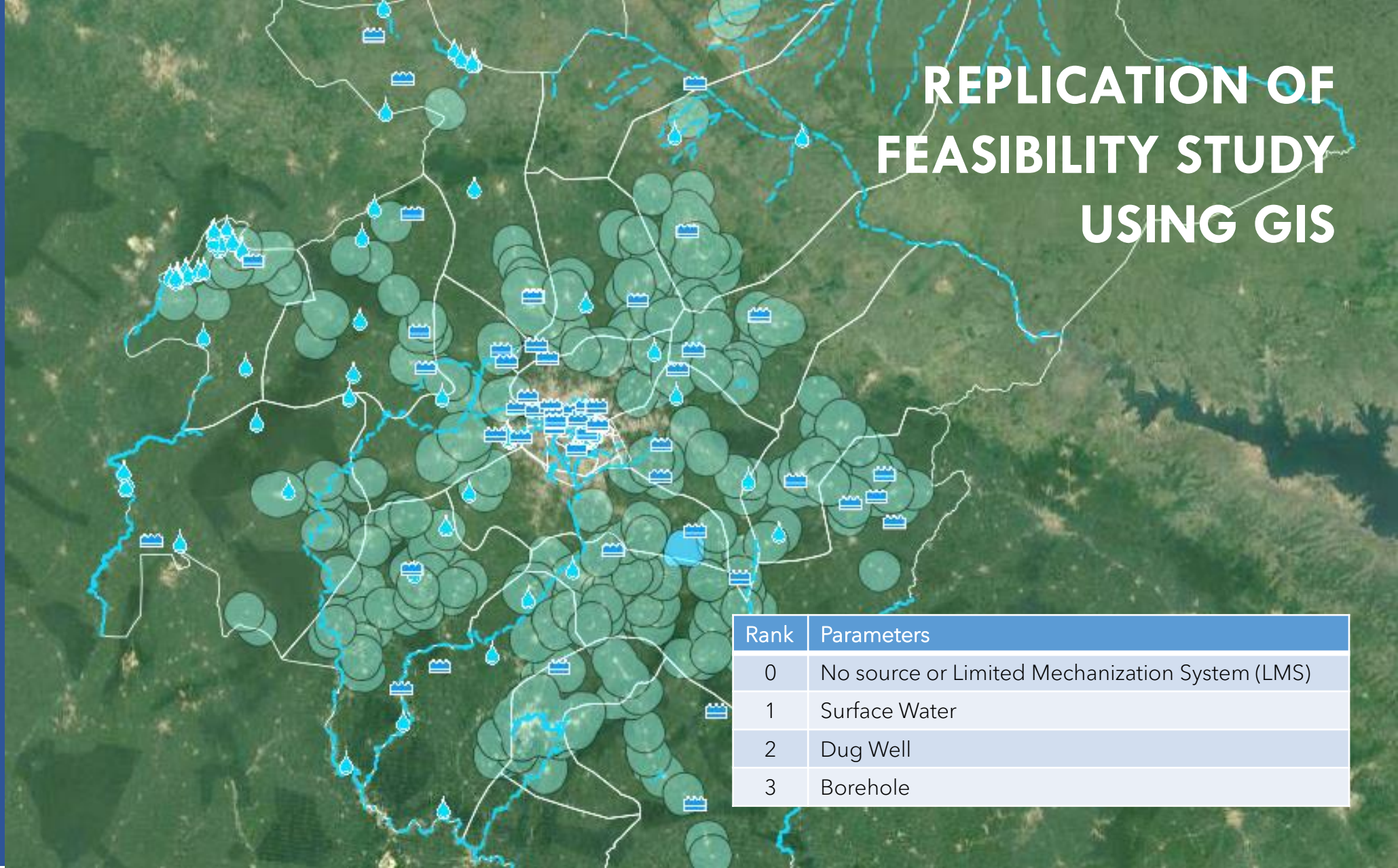




1
Feasibility
Tool

REPLICATION OF FEASIBILITY STUDY USING GIS

Drinking Water Source



Rank	Parameters
0	No source or Limited Mechanization System (LMS)
1	Surface Water
2	Dug Well
3	Borehole



<https://www.safewaternetwork.org/sign-gis-program>

App 2: Risk Assessment

Risk Awareness from the Outset



RISK ASSESSMENT

Why Assess Risk?

If current global patterns of increasing exposure, high levels of inequality, rapid urban development and environment degradation grow, then disaster risk may increase to dangerous levels.

CRED, UNDRR, 2020

Global average annual loss is estimated to increase up to US\$415 billion by 2030.

UNDRR, 2015

How?

- Many great frameworks and manual guides exist, but they are not digital or geospatial tools
- A few digital tools exist that either
 - a) display coarse-scale data (appropriate to Global/Regional/Country-level) or
 - b) only focus on one type of hazard (e.g. floods).
- Safe Water Resilience Toolkit is based on the INFORM Risk Index (Joint Research Center of European Commission), and translated into a geospatial application that is similar in concept to FEMA's Resilience Analysis and Planning Tool (RAPT). The data selected for use in the model is appropriate for use at sub-national and local levels.



INFORM Risk Index

The INFORM Risk Index is a global, open-source risk assessment for humanitarian crises and disasters. It can support decisions about prevention, preparedness and response.

<https://drmkc.jrc.ec.europa.eu/>





2 Risk Assessment

TOOLKIT

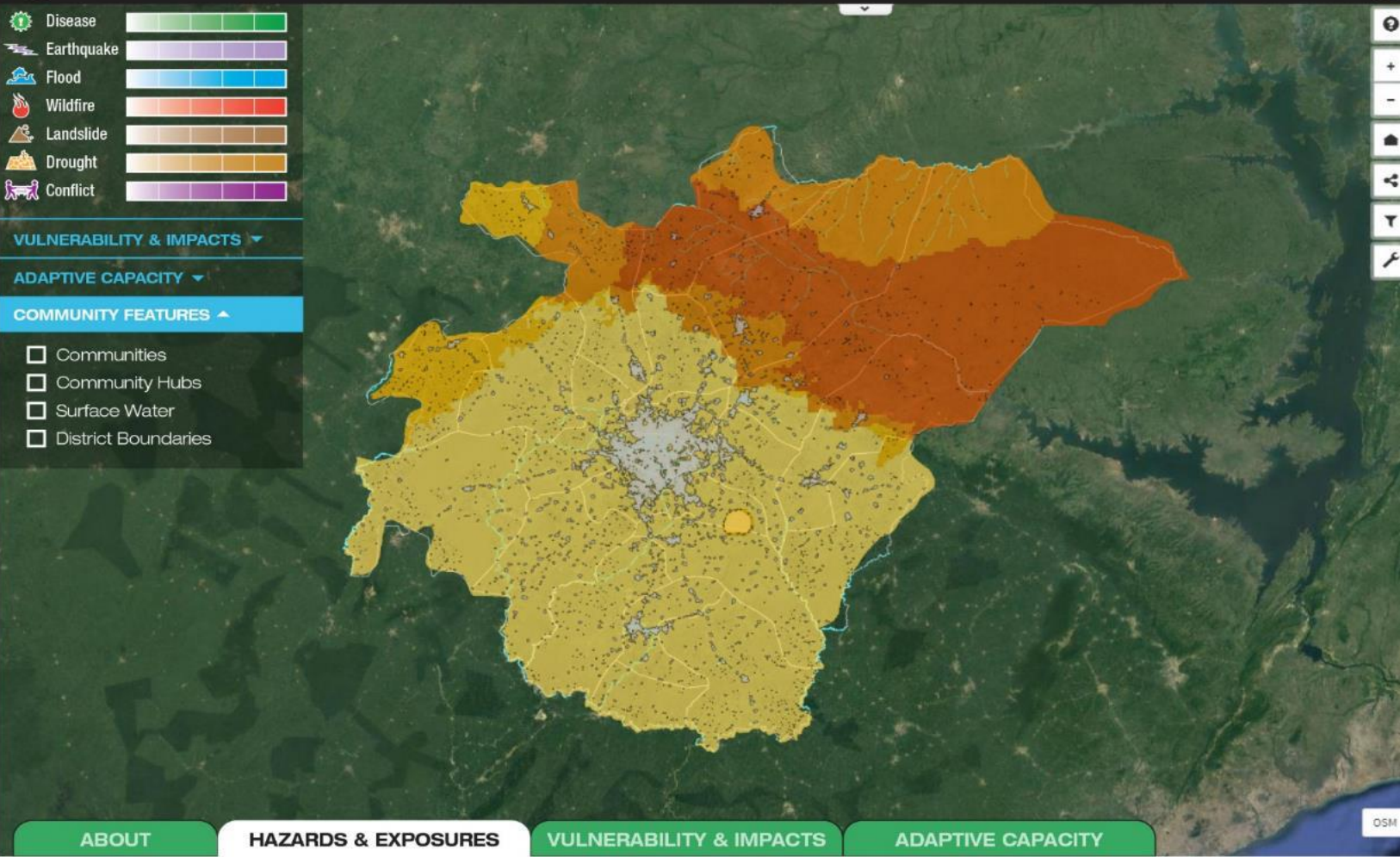
- Disease
- Earthquake
- Flood
- Wildfire
- Landslide
- Drought
- Conflict

VULNERABILITY & IMPACTS

ADAPTIVE CAPACITY

COMMUNITY FEATURES

- Communities
- Community Hubs
- Surface Water
- District Boundaries



ABOUT **HAZARDS & EXPOSURES** **VULNERABILITY & IMPACTS** **ADAPTIVE CAPACITY**

- DISEASE** (Moderate-High)
- EARTHQUAKE** (Moderate)
- FLOOD** (Moderate)
- WILDFIRE** (Low)
- LANDSLIDE** (Low)
- DROUGHT** (Low)
- CONFLICT** (Low)

2 Risk Assessment

Community Hub Rank

	Community Hub	Rank	Priority
✓	Akrofuom	17	B
✗	Sansu	17	B
✗	Apitiso	15	B
✗	Sansu 2	17	B
✓	Odumase	17	B
✗	Ahansowodee	17	B
✓	Apitiso 2	17	B
✗	Kwapla	17	B
✗	Eno Serwaah pharmacy	16	B
✓	Adansi Prasu	17	B
✗	Apeja	15	B
✗	New Edubiase	15	B
✗	Fumso	17	B

Opportunity to Increase Resilience

Akrofuom

2

Points*

* Creation of a mitigation plan will increase resilience further.

Overall Resilience Score



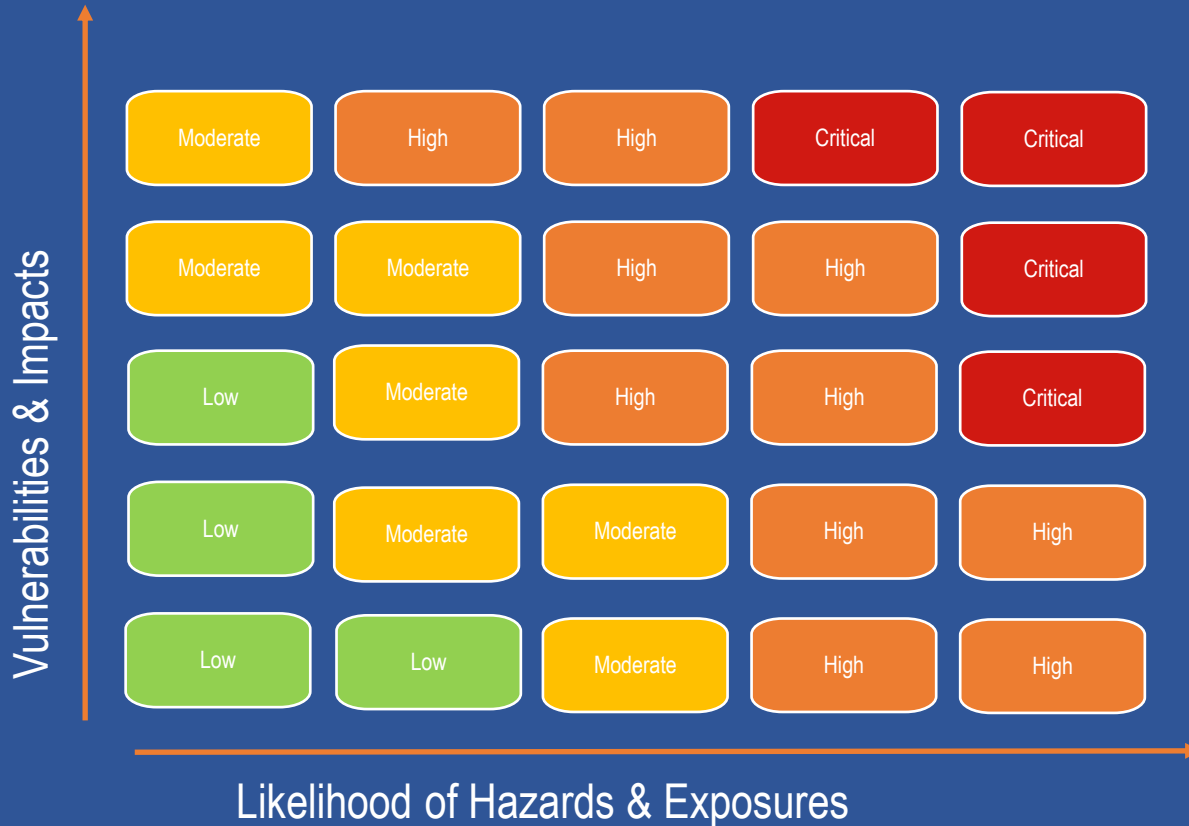
6

Resilience Score*

* Resilience = Risk - Adaptive Capacity



RISK ASSESSMENT



What is Risk?

$$\text{Risk} = \text{Hazards} \times \text{Vulnerability} \div \text{Capacity}$$

Inter-Agency Task Force on Climate Change and Disaster Risk Reduction

What is Resilience?

The goal of a system to continue to function to the fullest possible extent in the face of stress to achieve its purpose; this is a function of both the vulnerability of the system and its adaptive capacity

(Dalziell & McManus)



2
Risk Assessment

RISK ASSESSMENT

HAZARDS & EXPOSURES

Human-Derived (frequency)

Natural & Climate-Related (frequency)

VULNERABILITY & IMPACTS

Socio-economic

Vulnerable Groups

Water Resource Vulnerabilities

ADAPTIVE CAPACITY

Institutional

Infrastructure & Services

Conflict (Intensity & Risk)

Flood

Drought

Earthquake

Wildfire

Landslide

Disease

Development & Deprivation (GDP/HDI)

Dependent Males

Dependent Females

Populations > 2km from Roads

Population Living in Poverty

Groundwater Productivity & Storage

Depth to Groundwater

Governance

Improved Housing

Access to Roads (<2km)

Access to Healthcare

Access to WASH Services

Access to Electricity

+ Mitigation Planning & Activities

RISK & RESILIENCE INDEX (INFORM Model)



<https://www.safewaternetwork.org/sign-gis-program>

App 3: EPANET - Engineering in the Cloud



Benefits of EPANET in the Cloud:

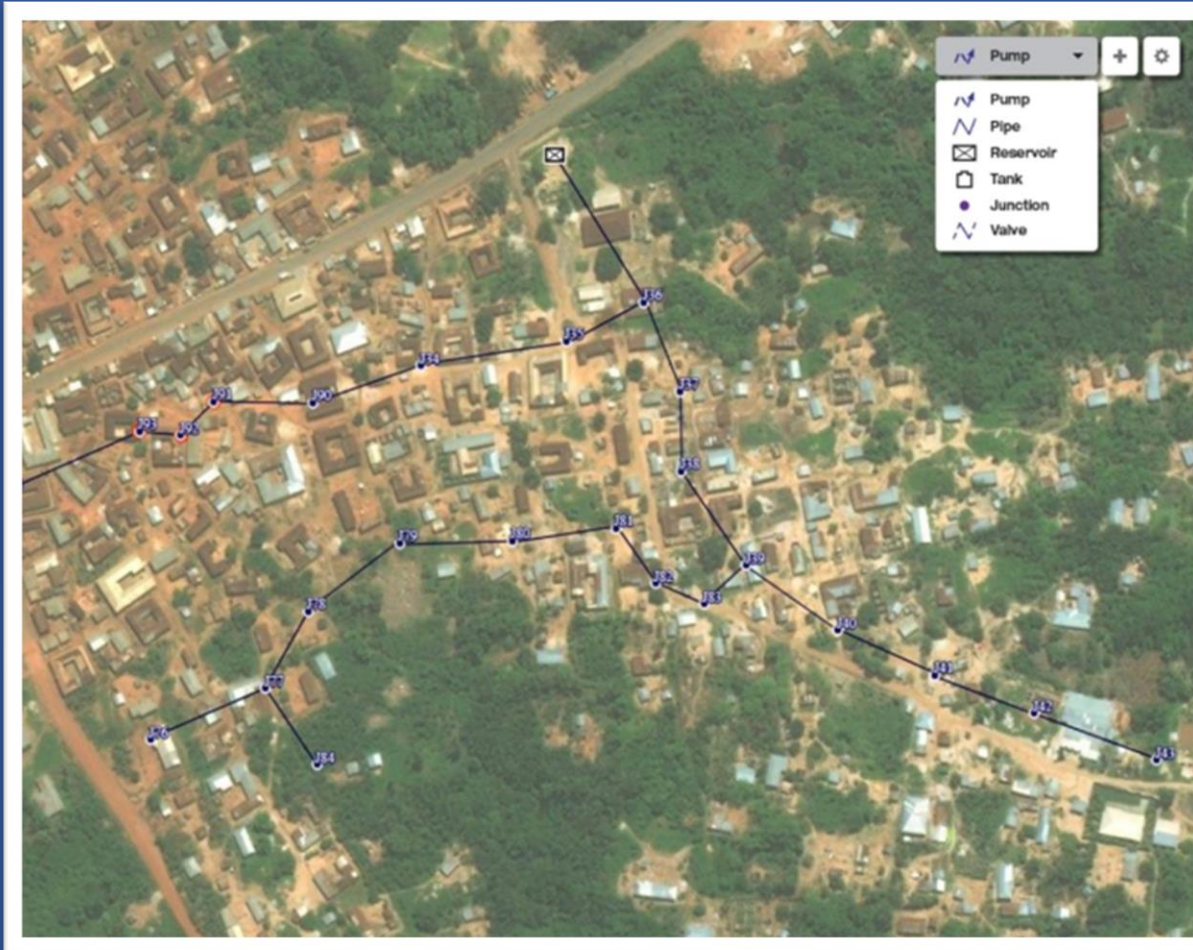
- Whole team has access to infrastructure data
- Systems are designed in their 'true' location - over georeferenced aerial imagery & in the context of other geographic data
- Piped connections to structures can be visualized
- Inclusion of risk data informs decisions for system placement

The screenshot displays the EPANET web application interface. The main area shows a network map overlaid on aerial imagery, with nodes labeled J36 through J43. A sidebar on the left lists various risk assessment tools: Disease, Earthquake, Flood, Wildfire, Landslide, Drought, and Conflict, each with a color-coded progress bar. Below this, there are sections for 'VULNERABILITY & IMPACTS', 'ADAPTIVE CAPACITY', and 'COMMUNITY FEATURES' with checkboxes for Communities, Community Hubs, Surface Water, and District Boundaries. A central dialog box titled 'pipe' shows configuration options for Pipe ID (P3), Start node (J3), End node (J4), Diameter (0.3048), Roughness (100), Loss coeff (0), Initial status (Opened), Length, and Flow. Below this, a 'Hydraulic options' dialog box shows settings for Max head error (100), Max ow change (100), Flow units (LPS), Headloss formula (H-W), Specific gravity (1), Relative viscosity (1), Maximum trials (40), and Accuracy (0.001). A 'Results of the EPANET simulation' dialog box at the bottom offers 'Download' buttons for 'Base report' and 'Result report'. On the right, the 'EPANET Tool' sidebar shows 'Selected Communities' (Akrofuom, Odumase, Apitiso 2, Adansi Prasu), 'Community Hazards & Vulnerabilities' (Disease: Moderate-High, Earthquake: Moderate, Flood: Moderate, Wildfire: Moderate-Low, Landslide: Low, Drought: Low, Conflict: Low), and 'Resilience & Improvement' metrics (Community Resilience Score: 8, Community Improvement from Design: +2). A legend identifies symbols for Pump, Pipe, Reservoir, Tank, Junction, and Valve. A 'Simulation' button is visible on the map.



3

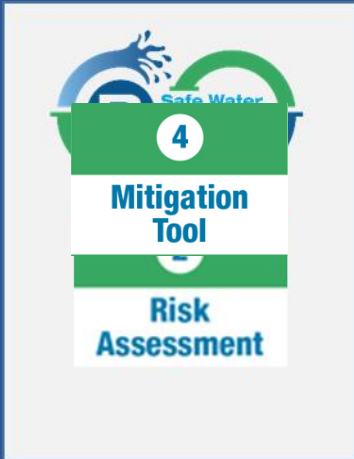
EPANET
Assessment



BETA TESTER INPUT from Professional Users of EPANET

- Engineers Without Borders
 - UNDP Crisis Center
 - Private Company
 - Engineer from Water4
-
- Updating to assist novice users based on their recommendations:
 - Integrating costing
 - Integrating design criteria
 - Automating all IDs
-
- Additional integrations:
 - High resolution elevation data
 - Pre- and Post- Disaster imagery
 - Water Safety Plan to be integrated with the system design

App 4: Mitigation Planning - Creating Program Resilience



R TOOLKIT
Library Admin ▾ Advanced ▾ Region ▾

+ **R** TOOLKIT
EN ▾ aminer ▾

- Disease
- Earthquake
- Flood
- Wildfire
- Landslide
- Drought
- Conflict

4 Mitigation Tool

Selected Communities

Community Hub	
<input checked="" type="checkbox"/>	Akrofuom
<input checked="" type="checkbox"/>	Odumase
<input checked="" type="checkbox"/>	Apitiso 2
<input checked="" type="checkbox"/>	Adansi Prasu

Main Risks and Vulnerabilities

	Disease	Moderate-High
	Earthquake	Moderate
	Flood	Moderate
	Wildfire	Moderate-Low
	Landslide	Low
	Drought	Low
	Conflict	Low

Post-Mitigation Planning Resilience Score

8

Print Plan

ABOUT

DOMAIN

Infrastructure: System Components

Infrastructure: Power Supply

Supply Chain

FLOOD MITIGATION

POTENTIAL IMPACT

Select Impact ▾
 Low - Moderate
 Moderate
 Moderate - High

Select Impact ▾

Select Impact ▾

DROUGHT MITIGATION

MITIGATION OPTIONS

Mitigation Option
 Mitigation Option
 Mitigation Option
 Mitigation Option

OTHER MITIGATION

WHO IS RESPONSIBLE ?

Select Staff ▾
Select Staff ▾
Select Staff ▾
Select Staff ▾

START DATE

Date ▾
Date ▾
Date ▾
Date ▾

FREQUENCY

Select Option ▾
Select Option ▾
Select Option ▾
Select Option ▾

App 5: Field Sales Tool - Building Sustainability & Growth



Household Connection Surveys (Fixed Cost)

Household Survey & Quote | Payment | Install | Issues

Date:

Officer Name:

Household Contact Person:

Number: BA-

Phone:

Address: NA

Cancel Save

37 Nobewam | 30 Bomfa Achlase | 59 Adanwomase | 0 Bonwire



5 Field Sales Tool

Select Community

Community	Count	Officer
Trabuom 2	23	A
Abetenim	23	A
Mankranzo 2	23	A
Juaben	23	A
Bekwai	23	A
Kunso	23	A
Jacobo	23	A
Akrowi	23	A
Adidwan	23	A
Konongo	23	A
Mankranzo	23	A

Number of Contacts by Officer

- 0 Ama
- 27 Bright
- 10 Derrick
- 0 Stephen

Master Household Connection Use Clone Mo... Close

Move

Household Survey & Quote

Payment

Install

Issues

Date of Any Required Maintenance Issues: 2021-10-07 Edit X

Is the Issue Resolved?:

Is Customer Happy?:

Is Customer Willing to Recommend SWN HHC?:

Delete Save

Web Interface

Mobile Interface

Safe WATER NETWORK Official Receipt

Received from: Mohammed Samba

The sum of: 0

Balance Remaining: 300

Cash, Cheque or Mobile Money:

Signature: _____

GHc 0

Receipt

Safe WATER NETWORK

Field Services Entity (FSE) - Ghana
P.O. Box CT 10318, Cantonments - Accra
Telephone: 0302.506497

Customer: Mohammed Samba
Address: NA
Village: Nobewam
Phone: 0248238870
Email: NA

Invoice: INV 111
Customer ID: NBW-E08
Officer and Territory: Bright Opoku (NBW-East)

Item/Description	Size	Quantity	Unit Price (GHc)	Amount (GHc)
Faucet Socket	1"	4	3	12
Faucet Socket	3/4"	1	5	5
Air Valve	1"	1	15	15
Bend	3/4"	3	1	3
Bend	1"	5	1.5	7.5
Reducer	1" x 3/4"	1	1.5	1.5
Hose Tap	3/4"	1	25	25
HDPE 50 x 32mm TEE	-	1	82	82
HDPE Ball Valve	32mm x 1"	1	66	66
Male Adapter	32 x 1"	2	14	28
Female Adapter	32 x 1"	1	14	14
Thread Tape	-	5	1	5
Glue	-	1	20	20
Water Meter Rental	-	1	50	50
Cost of Water	-	1	10	10
INSTALLATION COST SUBTOTAL (in GHc)				344.00
Safe Water Network is subsidizing part of this cost to provide service at a flat fee of:				300.00
TOTAL DUE =				300.00 GHc

PLEASE NOTE: The amount quoted on this invoice is valid for 30 days after the invoice date. Full Payment must be made within 30 days.

Invoice

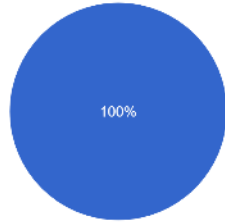


www.safewaternetwork.org/sign-gis-program



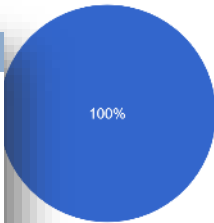
USER FEEDBACK – How Useful Has this Tool Been for the Sales Team?

Is the app easy to use and understand?



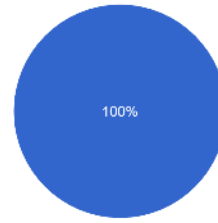
- Yes, it's very intuitive
- For the most part, but it took a while to figure out how to use it
- No, I found it confusing

How helpful is it to see the customers on a map in the field?



- Extremely helpful
- Quite Helpful
- Not Helpful

How helpful was the app for managing contacts and customers throughout the sales process?



- Extremely helpful
- Quite Helpful
- Not Helpful

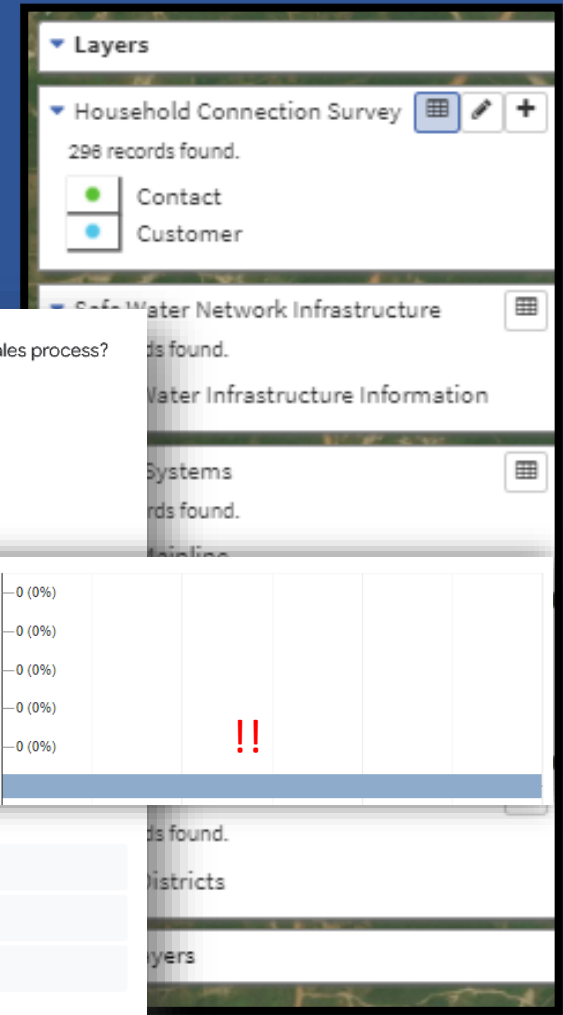
What would make the app better? (optional)

The moment one log in there is no need for that person to select his name again

It will be cool when the field officer log in it automatically provides the field officer name

I think the moment you log in it should automatically know the field officer.

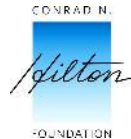
- I had issues with logging in -0 (0%)
- The app would not run -0 (0%)
- The layout of the app looked strange on my screen -0 (0%)
- A feature was broken or not working correctly -0 (0%)
- The app crashed at least once -0 (0%)
- No issues



App Features & Details

Select the level of value that each aspect of the app provides to you for your work: *

	Low Value	Moderate Value	High Value	Very High Value
Seeing where my customer are	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
App layout/ ease of use	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Symbology (icons/colors/labels)	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clarity of data visualization	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Different sections in form	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Automatic calculations (dates, money)	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reminders	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>



PLANS FOR REPLICATION & SCALE UP



- Actively seeking funding partnerships as well as aerial imagery partnerships as we look to scale this Toolkit to assist other users world-wide.
- **Current roadmap seeks to:**
 - Modify the Toolkit to be accessible for more Safe Water Enterprise and Safe Water Infrastructure Programs
 - e.g. build in parameters that can be modified according to address each teams' program criteria, as well as improving location-based market data (proxies)
 - Develop a 'ticketing system' for maintenance (request from other SWEs)
 - Potentially integrate our IoT platform into the Toolkit (e.g. monitor functionality, water quality, etc)
- **Future Roadmap:**
 - We have had some interest in expanding the Toolkit to provide Post-Disaster Assessments for Infrastructure
 - Incorporate AI to improve speed of conducting rapid damage assessments using before and after imagery
 - Add additional engineering software alongside EPANET
 - Generate and integrate feasibility, risk, engineering and marketing data with this level of granularity for greater geographic locations (Ghana? West Africa?)
 - Since the risk and resiliency assessments are relevant to any subject or location, the resilience toolkit is adaptable (e.g. agriculture, conservation/eco-tourism, fishing, sanitation/waste management)

Thanks for Your Attention!



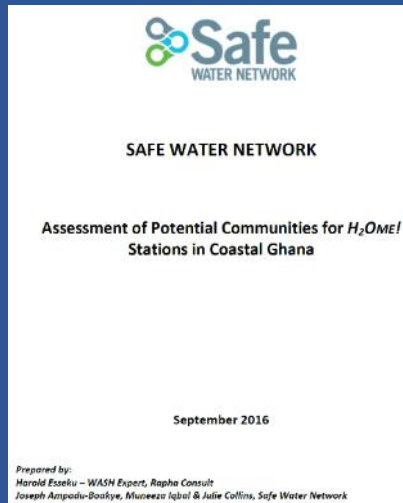
Back Up Slides



<https://www.safewaternetwork.org/sign-gis-program>

The Need for Efficient & Accurate Feasibility Assessments

EXISTING METHODS OF FEASIBILITY ANALYSIS



- Desk review
- Physical visit to Local Government Authorities
- Physical visit to communities
- Complete forms and maps
- Manual analysis of results

The Need for Efficient & Accurate Feasibility Assessments Continue....(1)

CHALLENGES WITH EXISTING METHOD

- Non existent data
- Inaccurate data
- Difficult to collect data
- Resource intensive
- Limited integration of variables

THE SOLUTION – FEASIBILITY TOOL

- Digitize feasibility assessment;
- Time and cost savings
- Flexibility in applying multiple variables;
- Granularity in analysis

The Need for Risk Awareness During the Planning Process



RISK AND HAZARDS TO STATIONS' OPERATIONS

- Limited evaluation of climate change and/or disaster risk metrics in station design
- Flooding and drought impacts stations operations
- Flooding in communities along Lake Volta
 - Inability to access control equipment;
 - Longer pumping hours;
 - Operations shut down for 1-2 months;
 - High expense on maintenance reserves to relocate panels and cables;
- Dry well in communities Ashanti
 - High downtime;
 - Low production volumes and water sales;
 - High operational cost

The Need for Risk Awareness During the Planning Process



BENEFITS OF RISK ASSESSMENT TOOL

- Identify potential hazards
- Assess risk on stations' design
- Ensure stations are designed with consideration of current and potential risk factors
- Assess the suitability of communities for infrastructure
- Prioritize intervention locations based on comprehensive factors
- Determine optimal locations for stations.



THE SAFE WATER RESILIENCE TOOLKIT:

WHAT IS IT & HOW DOES IT SUPPORT THE TEAM?

- Workflow driven set of tools that translate paper workflow into a digital process
 - Creates cost effectiveness and efficiency
 - Non-resource intensive (pre-screens optimal locations)
 - Assimilates multiple variables into usable intelligence
 - Provides granular data for better decision-making and spatial planning
 - Incorporates risk into the planning process
 - Easily scalable for use in different geographic areas