Instrumentation for M&E

Remotely accessible in-situ instrumentation to improve accountability in public health interventions

www.sweetdata.org and www.sweetlab.org

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SUSTAINABILITY & ACCOUNTABILITY

The Challenge

- expert spot checks & surveys are infrequent & expensive
- courtesy bias influences programs
- need for objective, continuous performance & usage data
OUR APPROACH

Purpose built innovation
- in-situ instrumented monitoring
- record performance & use
- “does it work & do people use it?”
- identify successes & challenges in water, energy, sanitation, infrastructure
- inform surveys, technology, projects
Our Technology

- low power – 5 x AA batteries = 6-18 months
- low cost - $100 - $500
- high sampling rate – up to 8 hz on 22 bit A/D
- Customizable - 15 sensor inputs – 8 contact, 7 analog to digital
- triggered event logging
- battery level reporting
- cellular network reporting
- SD card backup
- cloud-based processing
- remote auto calibration
- US Patent-Pending
www.SWEETData.org

Web interface

- Accessible from any browser
- Protected login
- Maps and visualizes data
- Data download
- Can be integrated with other data sets and applications
- Automatic and manual updating of sensor parameters
The SWEETSense / SWEETData System Architecture

Subject
(water filter, water pump, cookstove, latrine, etc)

SWEETSense
(sensors, processor, radio, SD card, power supply, enclosure)

Wireless Transmission to Internet Cloud
raw data text file

Hardware transmits data
and gets updated config

SWEETDatabase
(MySQL holds tables of error-reduced and calibrated data, read-only access for some partners)

Raw Data Processing
(C++ reduces noise, corrupt & repeated data, scales data by & updates config)

Hardware calibration file
(offset, gain, sampling and alarm thresholds, sampling, logging, reporting rates)

Processing code parses data and updates config

Signal Processing
(R-Script on/off-line signal and statistical analysis to generate individual and meta tables, charts)

SWEETAnalysis
(MySQL holds tables of processed output, read/write access for some partners)

SWEETData.org
(website allows permission-controlled users to access/download charts, data)
PARTNERS

- Mercy Corps
- Lemelson Foundation
- USAID (DIV, HESN)
- Gates Foundation
- Coke Foundation
- Water for People
- Living Water International
- Berkeley Air Monitoring Group
- Global Alliance for Clean Cookstoves
- Bridges to Prosperity
- London School of Hygiene & Tropical Medicine
- Stanford University
- UC-Berkeley
- PATH, Cascade Designs
- Vestergaard Frandsen
- DelAgua Health
- DelAgua Testing

200 sensors in 10 countries
(Rwanda, Kenya, Uganda, Zambia, Zimbabwe, South Africa, India, Nepal, Indonesia, Haiti)

- Water pumps
- Village water supply
- Household water treatment
- Chlorine generation
- Water test kits
- Handwashing stations
- Latrine use
- Indoor air pollution
- Cookstove use
SWEETSense™ *PLUM

Latrine Use Monitor

- Motion and/or door monitoring
- 60 units in LSHTM Orissa program
- 40 in TAMU Rajasthan program
- Validated against data collected with earlier versions developed by UCB and LSHTM
SWEETSense™

*FLOW

Differential pressure flowmeter

- handwashing stations
- latrines
- correlate water & sanitation usage
- evaluate behavior change programs
Mercy Corps Indonesia

Latrine and Handwashing Use Frequency

Bekasi

- Latrine Use Only: 34.92%
- Tap after Latrine: 15.96%
- Tap Use Only: 49.11%

Pekojan

- Latrine Use Only: 74.55%
- Tap Use Only: 23.05%
- Tap after Latrine: 2.40%

Utara

- Latrine Use Only: 18.11%
- Tap after Latrine: 9.57%
- Tap Use Only: 72.33%

Kosimbi

- Latrine Use Only: 18.55%
- Tap after Latrine: 7.86%
- Tap Use Only: 73.59%
SWEETSense™ *FIRE

High efficiency cookstoves

- usage
- thermal efficiency
- CO & CO2 emissions
- differentiate between stoves
- evaluate adoption & changes in performance over time
- sampling for carbon finance programs
SWEETSense™

*WATER

Household water treatment

- Two pressure transducers
- usage
- volume
- flowrate
- backwash
- time to end-of-life
DelAgua Rwanda Program

- Rwanda has the fastest decline in u5 mortality - 11.1% annually
- U5 mortality - pneumonia 20%, Diarrhea 12%, malaria 2% AIDS 2%
- Partnership with Ministry of Health
- LifeStraw Family 2.0 filter and EcoZoom cookstove
- Distributions at community meetings followed by household education and periodic survey
- Carbon credits recuperate costs
- Phase I program covered 2,000 households in 11 districts
- Phase II program intended to cover all 30 districts, 600,000 households, of poorest 30% of country
- London School conducting impact study
- Sensors installed within RCT to evaluate uptake and performance
- www.delaguahealth.com
DelAgua Rwanda Program
Structured Observations

- Conducted by trained CHWs, DelAgua and/or PSU Staff
- Consent obtained when in households
- Barcoded in/out form
- Event Timestamps and observed data entered into DoForms smartphone app and uploaded to database
- Database polled directly and correlated against sensor detected events
- One filter/stove/CHW pair per household, per day, 5 days
- 25 Unique households observed
- Issues with CHWs
Data Analysis – LSF 2.0

1. Web-based raw data file polled based on sensor ID
2. Timestamps and data type identified and parsed
3. Pressure readings offset / normalized to max/min (0, 6 liters)
4. Signal processing to remove background and detect peaks/mins

**SWEETSense LifeStraw 2.0 - Signal Spectrum LSF20_39e653**

- **Blue** – raw data
- **Green** – Processed spectrum
- **Red** – Detected volumes
- **Orange** – Observed volumes
Observation and Lab Validation

**SWEETSense LifeStraw 2.0**

- Lab Calibration n = 14
- Line Fit Slope: 0.925 R^2: 0.701
- Field Validation n = 34
- Line Fit Slope: 0.67 R^2: 0.446

<table>
<thead>
<tr>
<th></th>
<th>Lab Verification</th>
<th>Structured Observations</th>
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<tbody>
<tr>
<td>n</td>
<td>14</td>
<td>34</td>
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<tr>
<td>Slope</td>
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<td>R-squared</td>
<td>0.701</td>
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<tr>
<td>Average Absolute Error</td>
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<td>Average Biased Error</td>
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<tr>
<td>Total Error</td>
<td>-0.25%</td>
<td>2.95%</td>
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Comparison to Field Surveys

**SWEETSense LifeStraw 2.0**

- Household Correlation
- Line Fit Slope: 1.384 R^2: 0.16
SWEETSense™ PUMP

Handpumps

- One transducer
- Demonstrated on AfriDev and Mark 2
- Usage
- Duration
- Functionality
Laboratory Verification - Example
Structured Observations

Structured Observation Events (120) v. Sensor Detected Events

\[ y = 0.9997x + 0.0126 \]

\[ R^2 = 0.99999 \]

Difference Between Observed and Detected

average (s) 181
stdev (s) 127
max (s) 673
min (s) 3
n 120

Structured Observation Event - Hours Since Start

Nearest Sensor Detected Event - Hours Since Start
SWEETSense™ Customization

Other Configurations

- Easily configured with various sensors, packaging and analysis
- DelAgua kit – monitors use with GPS
- Cascade Designs electrochlorinator – use and performance
- Water quality – Ph, Conductivity, etc.
- Air quality – Gas emissions, particulate matter
- Energy – efficiency, usage, storage
Future Work

Analysis

- Reduction in cost
- Reduction in form factor
- Customized applications for DIL

Proposed:
“The impact of instrumented monitoring on health behaviors: blinded versus unblinded monitoring of water filter and cookstove usage in Rwanda”
Our Goal

- ‘apples to apples’ data comparability across technologies, sectors, countries
- monitoring of programmatic responses to identified challenges
- inform standards and methodologies for humanitarian development
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