WATER ENERGY ENVIRONMENT

# Instrumentation for M&E

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

*www.sweetdata.org and www.sweetlab.org*

SWEETlab

*Evan A. Thomas, Ph.D., P.E.*
*Assistant Professor, Director*
*Portland State University*
*evan.thomas@pdx.edu*

# SUSTAINABILITY & ACCOUNTABILITY

## *The Challenge*

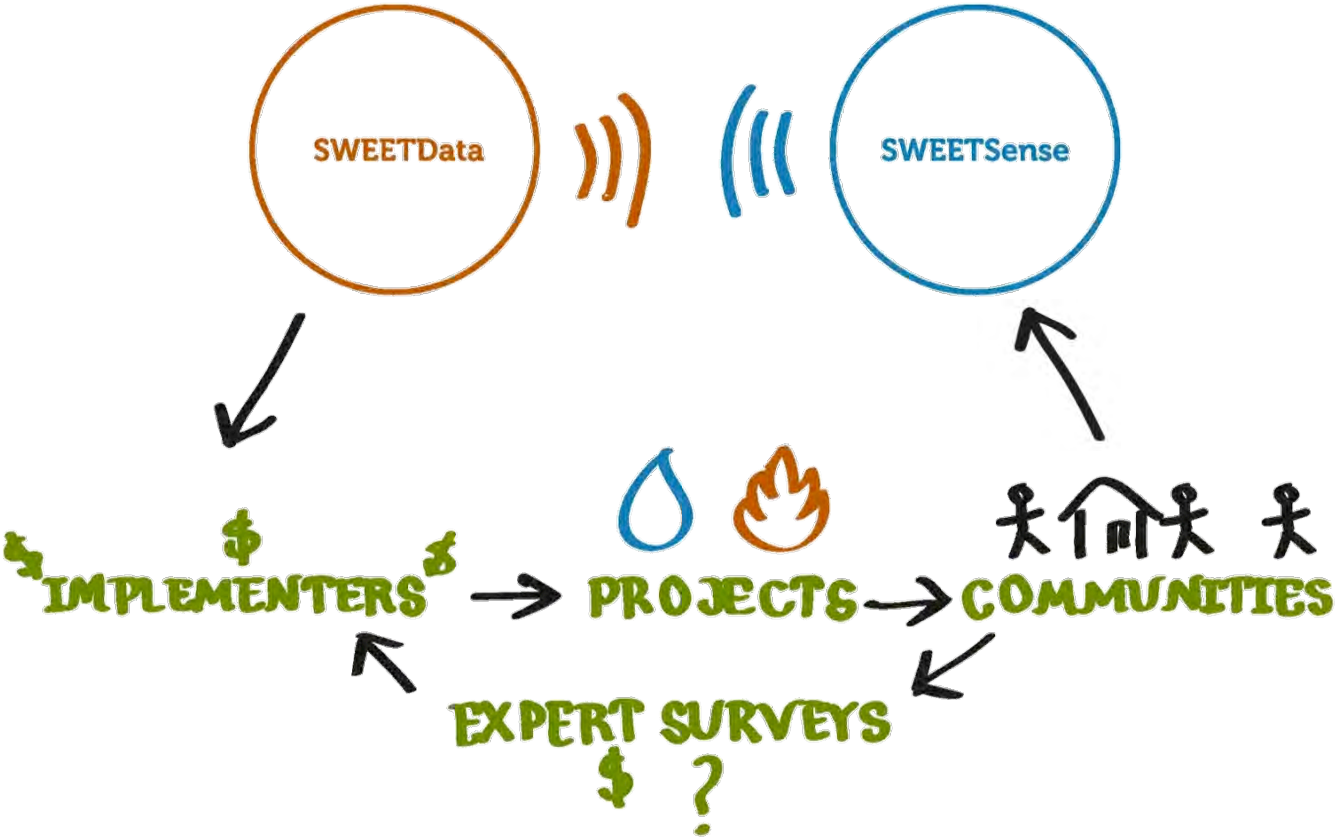
- *expert spot checks & surveys are infrequent & expensive*
- *courtesy bias influences programs*
- *need for objective, continuous* ***performance*** *&* ***usage*** *data*

# 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 APPROACH

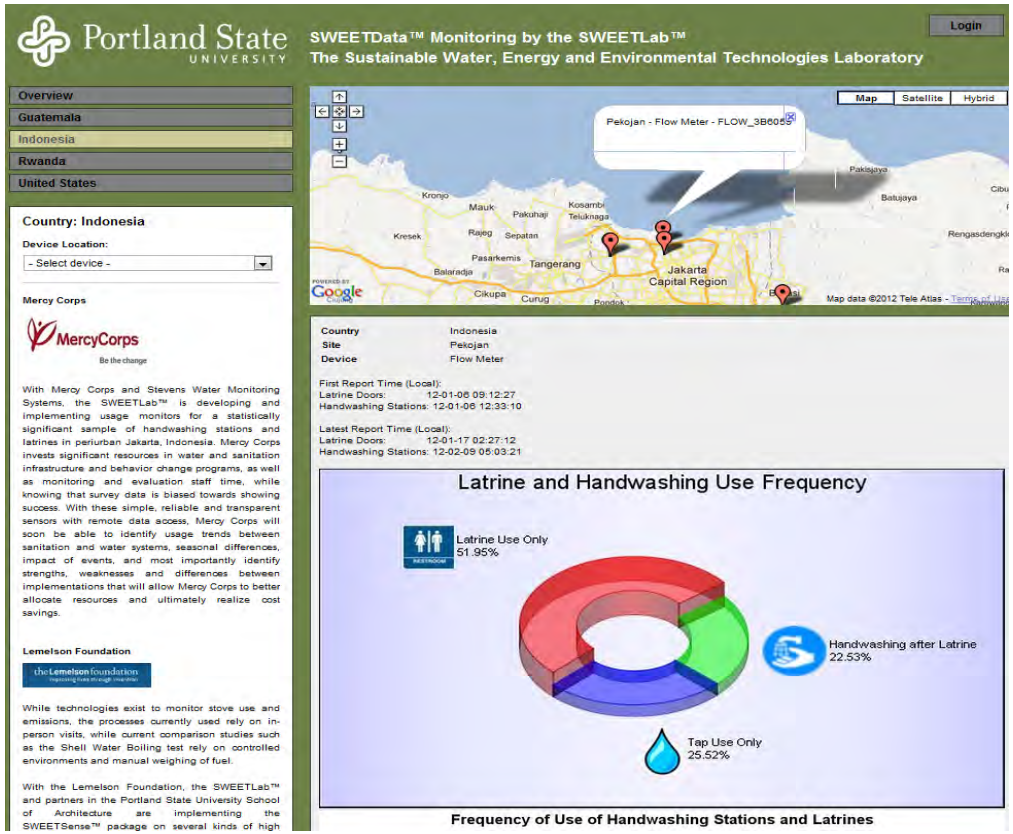


# SWEETSense™


## 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

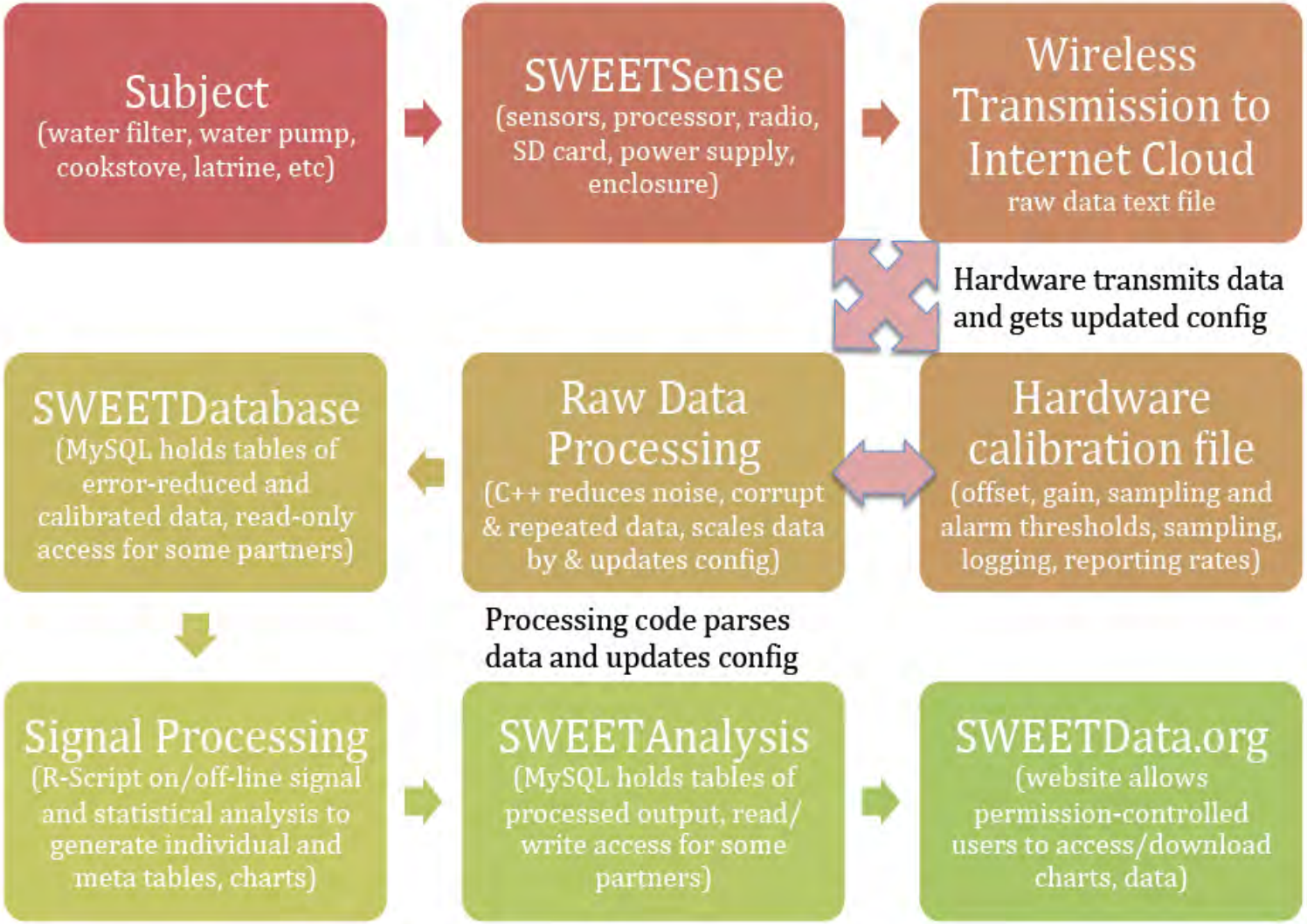
# www.SWEETData.org




## *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



# PARTNERS

- *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*

- *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*

# SWEETSense™ *PLUM

## *Latrine Use Monitor*

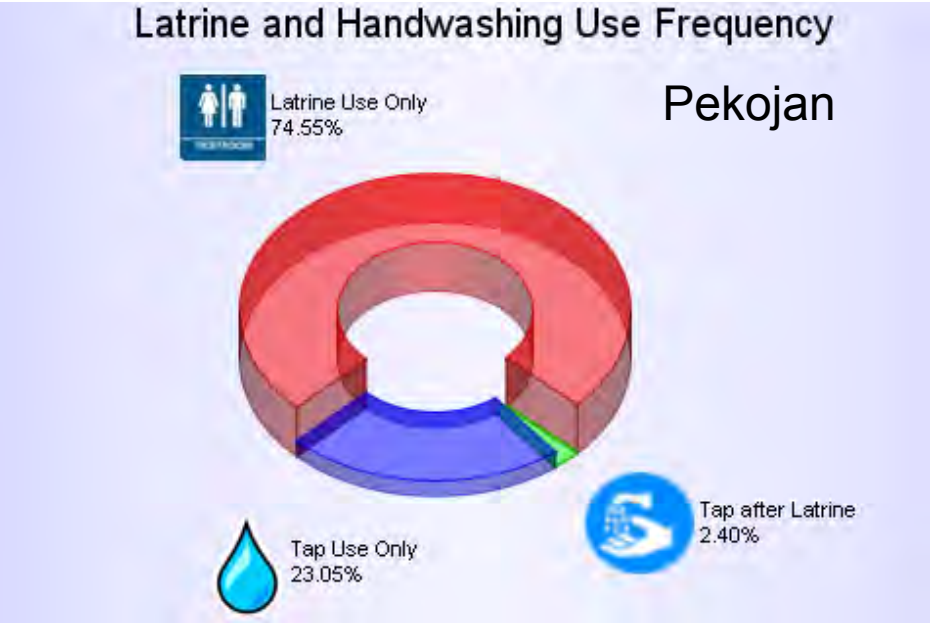
- *Motion and/or door monitoring*
- *60 units in LSHTM Orissa program*
- *40 in TAMU Rajasthan program*
- *Validated against data collected with earlier versions developed by UCB and LSHTM*

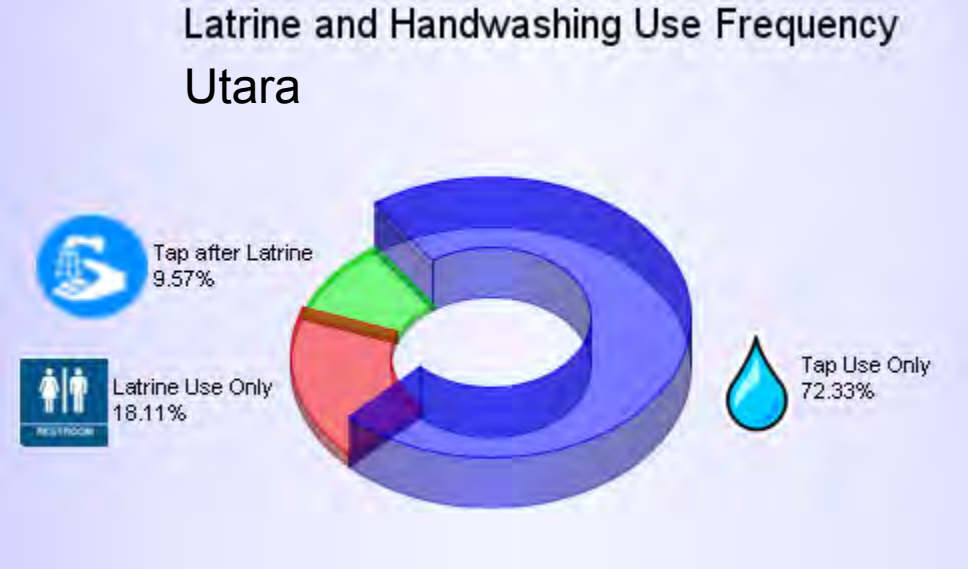
# SWEETSense™ *FLOW

## *Differential pressure flowmeter*


- *handwashing stations*
- *latrines*
- *correlate water & sanitation usage*
- *evaluate behavior change programs*

# Mercy Corps Indonesia


# 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*

VESTERGAARD FRANDSEN

DISEASE CONTROL TEXTILES

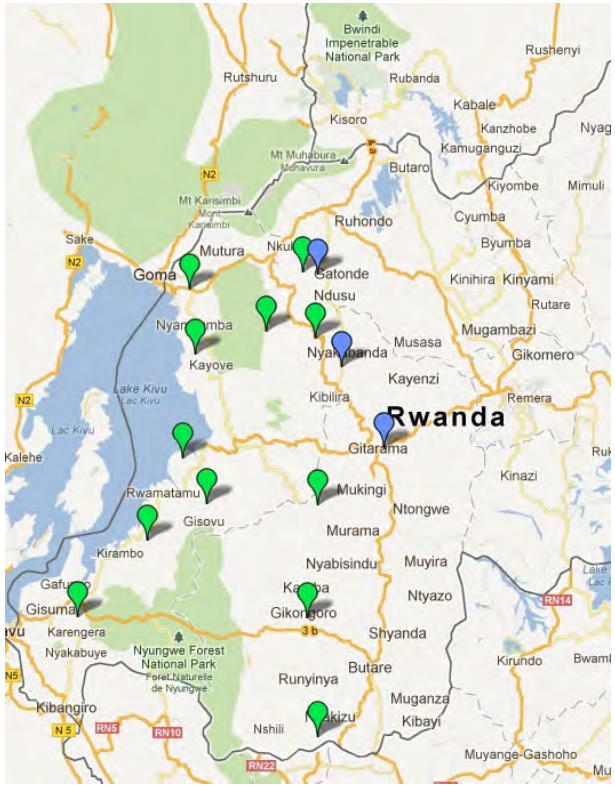
# SWEETSense™ *WATER

## *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*

## Igenzura (Structured Obsvtn)

**Wemeye kugira uruhare muri ikigikorwa? / Do you agree to particpate?:** Yego

**Waba ufite imyaka18 cyangwa irenzeho? / Over the age of 18?:** Yego

**Fata ibipimo by'ikirere muri telephone / Record GPS coordinates on phone (see attached map):**
Latitude (degrees): -2.2074
Longitude (degrees): 29.8049
Altitude (meters): 1604.9 meters
Accuracy (meters): 5.0 meters

**Fata ikirango cy'akuma ka gihanga kari kw'ishyiga / Scan barcode of the SWEETSense stove:**
SSenseStoveRW_110
*Niba ikirango cy'akuma ka gihanga kari kw'ishyiga itinjira, kanda imibarwa 3 ya nyuma iri ku kirango / If barcode does not scan enter last three digits from barcode*

**Fata ikirango cy'akuma ka gihanga kari kuri Firitire / Scan barcode of the SWEETSense LifeStraw filter:**
SSenseFilterRW_016
*Niba ikirango cy'akuma ka gihanga kari kuri Firitire itinjira, kanda imibarwa 3 ya nyuma iri ku kirango / If barcode does not scan enter last three digits from barcode*

**Igikorwa / Event(1):** Mena amazi / Draw Water

**Draw Water Time(1):** 08:54:33 GMT+02

**Aho amazi ageze mu agasorori ko hasi mbere yuko bavoma amazi / Water level in bottom bucket before water is drawn(1):**
4

**Water level in bottom bucket after water is drawn / Aho amazi ageze mu agasorori ko hasi bamaze kuvoma amazi(1):**
2

**Igikorwa / Event(2):** Sukurira inyuma / Backwash

**Backwash time(2):** 08:57:14 GMT+02

**Igikorwa / Event(3):** Shyiramo amazi / Add Water

**Add water time(3):** 09:00:39 GMT+02

**Aho amazi ageze mbere yo gusukamo andi mazi mugasorori ko hejuru / Water level in top bucket before water Is added(3):**
0

**Aho amazi ageze bamaze kogeramo amazi mugasorori ko hejuru / Water level in top bucket after water Is added(3):**
5.5

**Igikorwa / Event(4):** Gutagira gufatisha umuriro / Fire Started

**Fire Started Time(4):** 09:09:05 GMT+02

**Igikorwa / Event(5):** Kogeramo inkwi / Wood Added

**Wood Added Time(5):** 09:12:00 GMT+02

**Igikorwa / Event(6):** Kogeramo inkwi / Wood Added

**Wood Added Time(6):** 09:12:35 GMT+02

**Igikorwa / Event(7):** Kogeramo inkwi / Wood Added

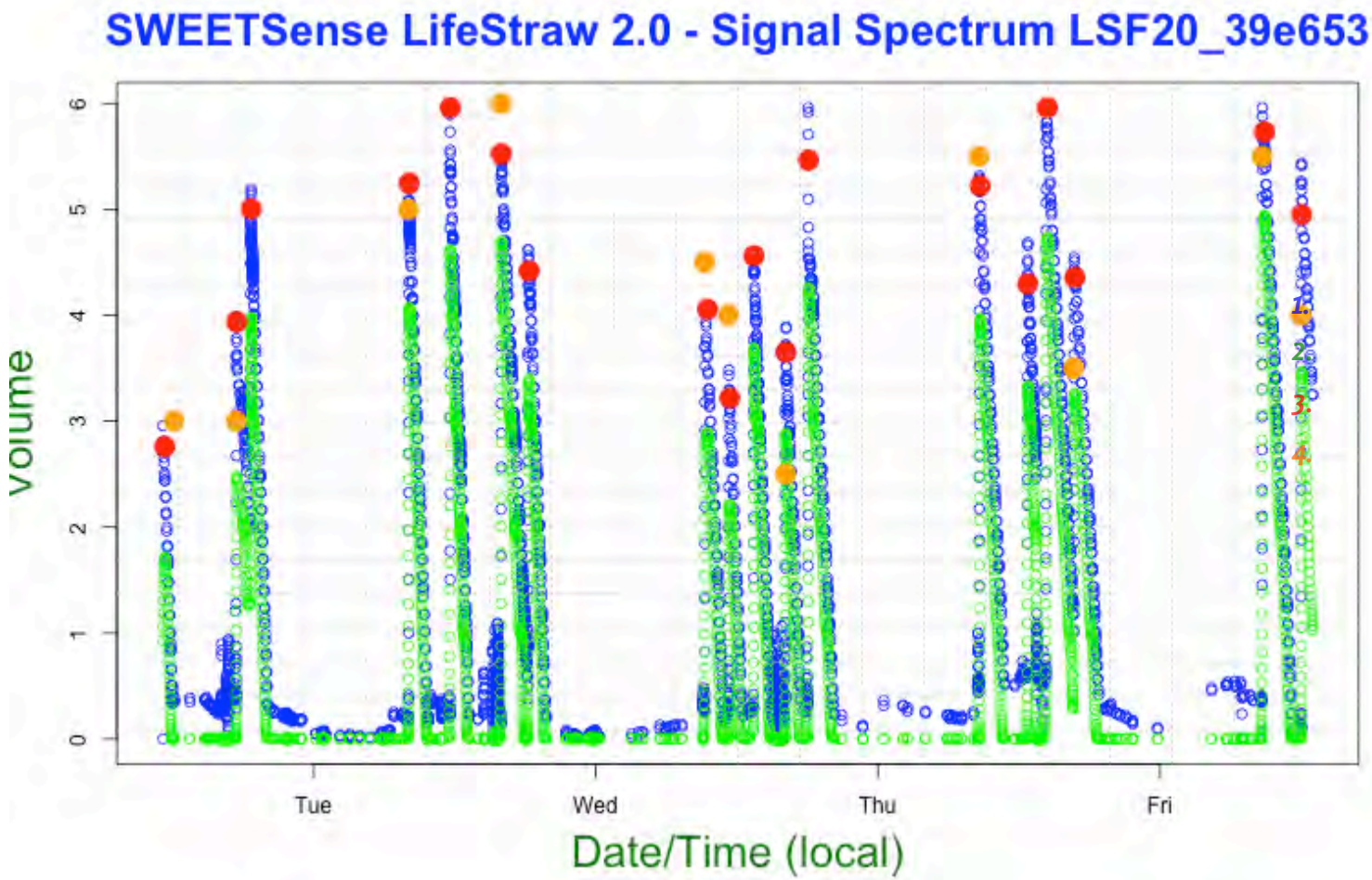
**Wood Added Time(7):** 09:24:02 GMT+02

**Igikorwa / Event(8):** Kwenyenyeza umuriro cyangwa gukoronya / Fire tended without adding wood

**Fire tended time(8):** 09:27:31 GMT+02

# 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*



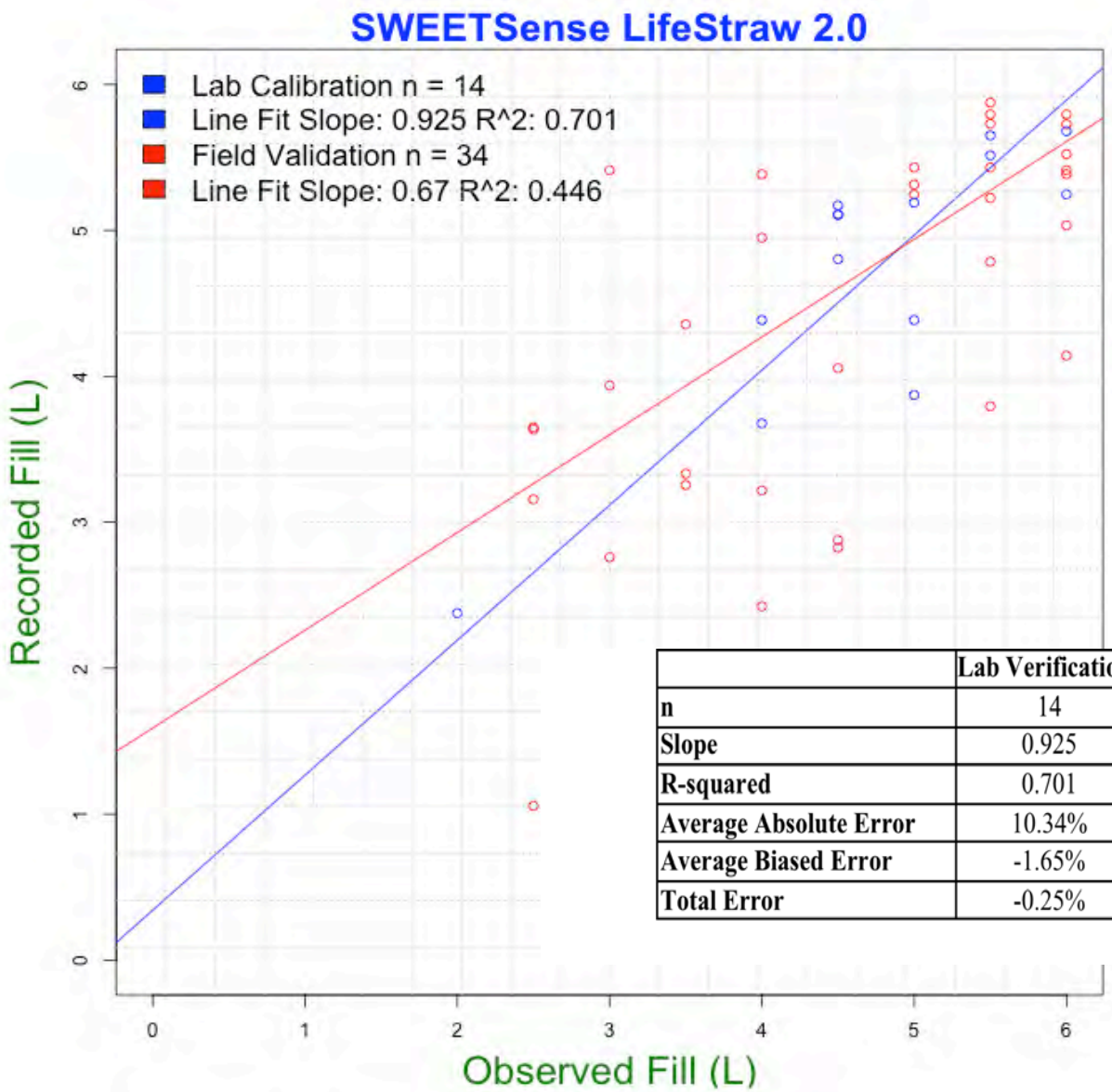

*Blue – raw data*

*Green – Processed spectrum*

*Red – Detected volumes*

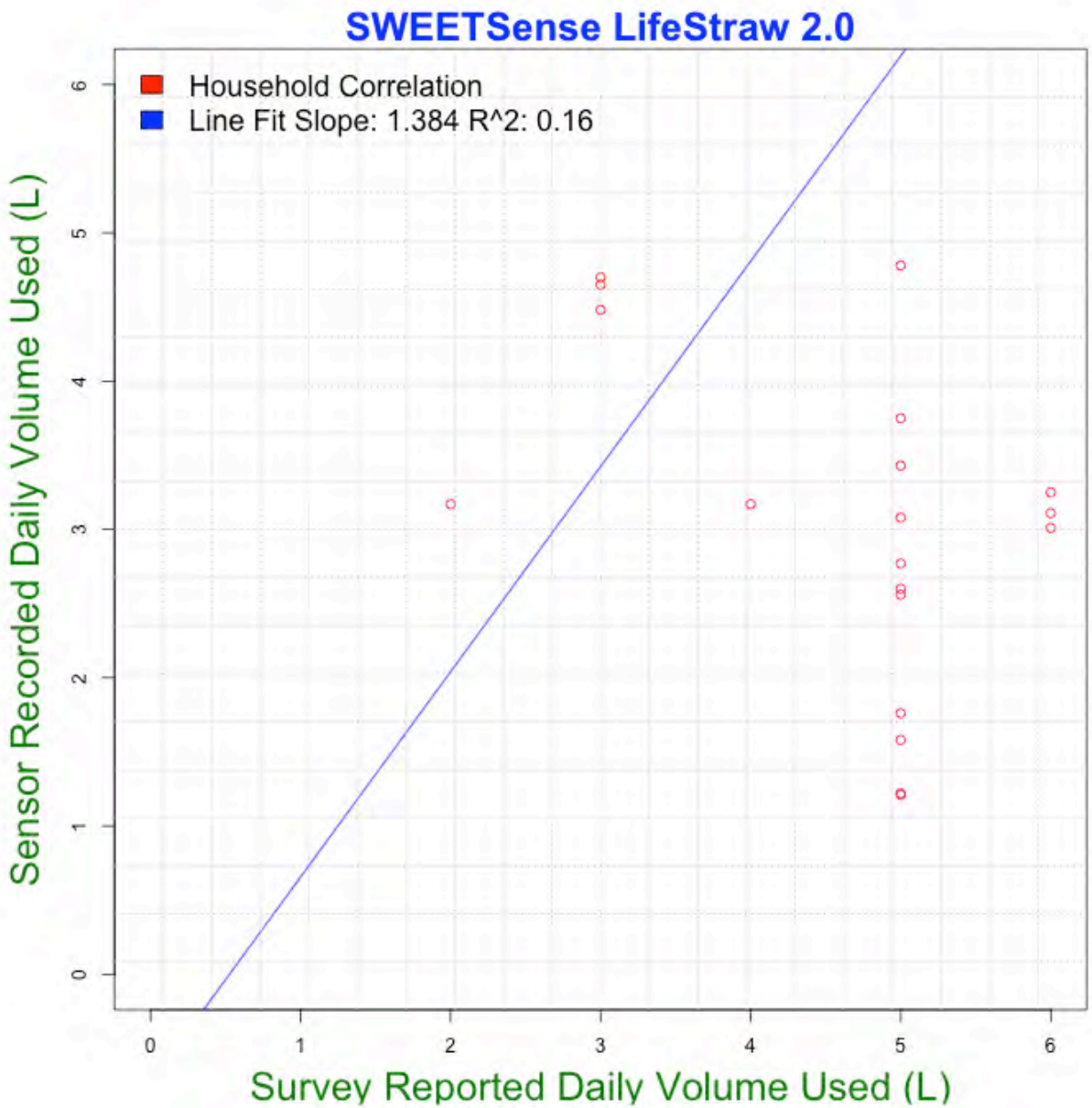
*Orange – Observed volumes*

# Observation and Lab Validation




| | Lab Verification | Structured Observations |
|---|---|---|
| n | 14 | 34 |
| Slope | 0.925 | 0.67 |
| R-squared | 0.701 | 0.446 |
| Average Absolute Error | 10.34% | 20.62% |
| Average Biased Error | -1.65% | 0.13% |
| Total Error | -0.25% | 2.95% |

# Comparison to Field Surveys



# SWEETSense™ *PUMP

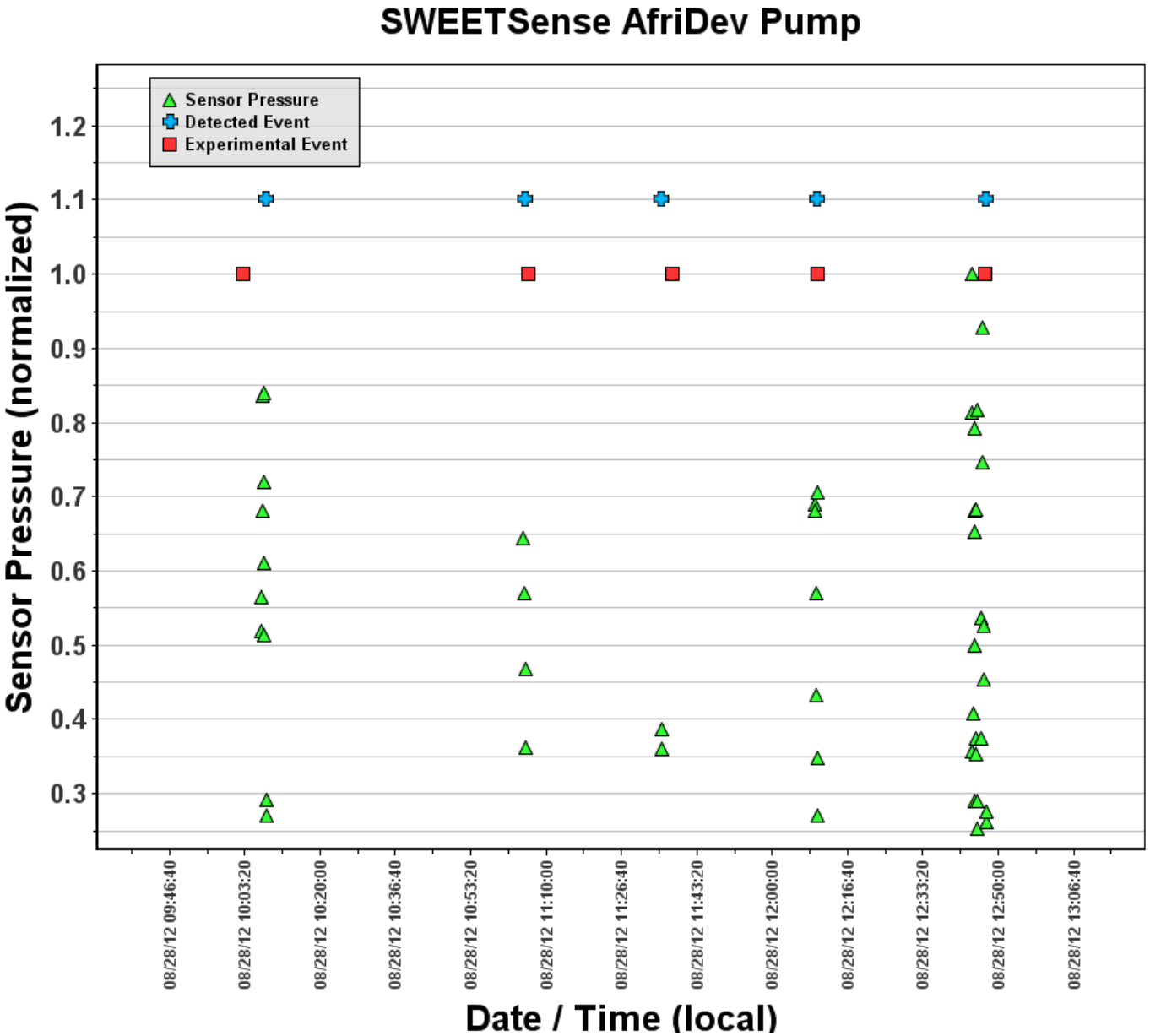
water for people

## *Handpumps*

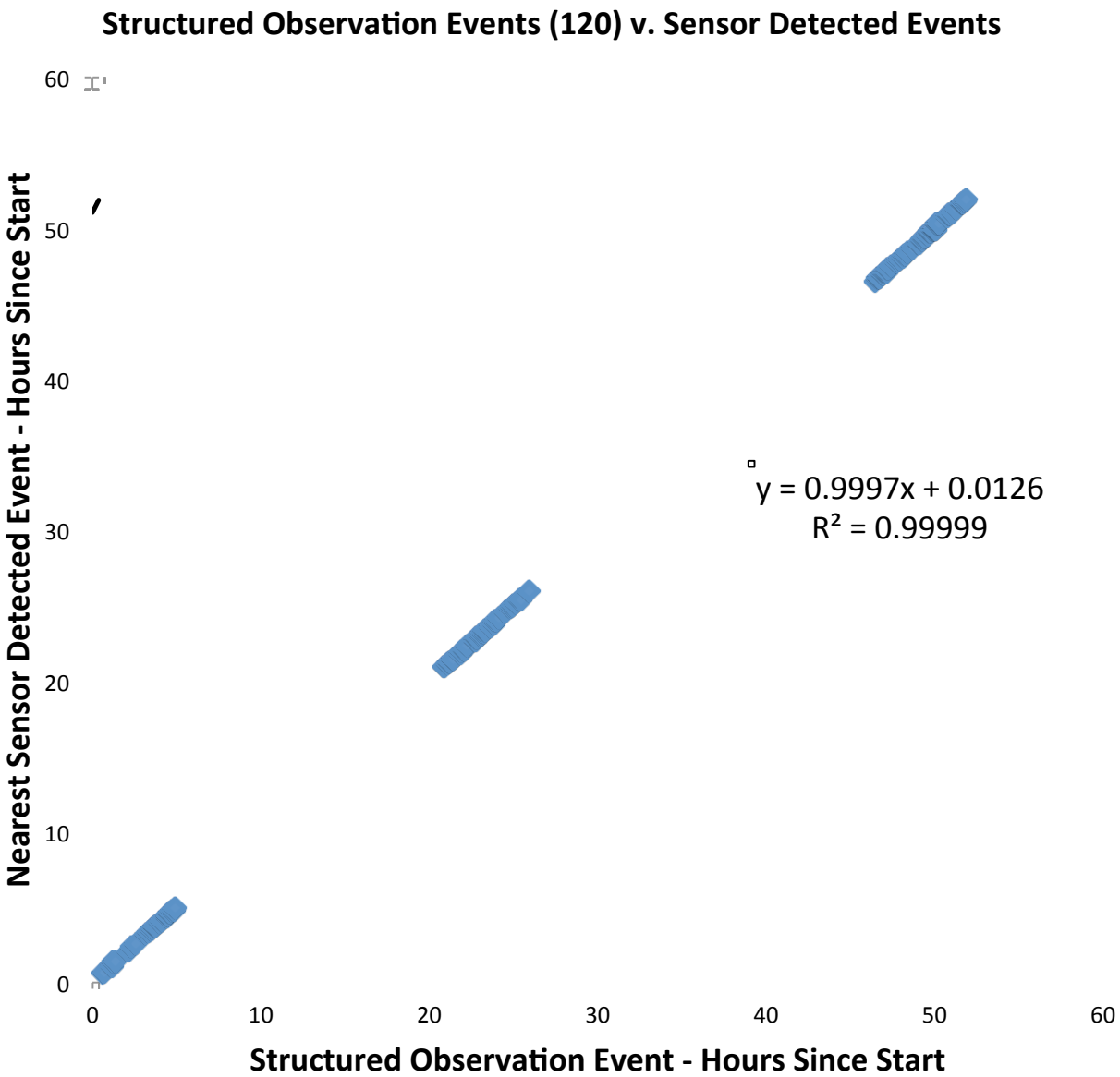
- *One transducer*
- *Demonstrated on AfriDev and Mark 2*
- *Usage*
- *Duration*
- *Functionality*

LIVING WATER INTERNATIONAL

# Laboratory Verification - Example



# Structured Observations




| Difference Between Observed and Detected | |
|---|---|
| 181 | average (s) |
| 127 | stdev (s) |
| 673 | max (s) |
| 3 | min (s) |
| 120 | n |

# 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"*

# STANDARDS DEVELOPMENT

## *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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