Public Health Data in Sanitation Planning

Emory University, TREND Ghana, Kumasi Metropolitan Assembly, Kampala Capital City Authority, Makerere School of Public Health, icddr,b, Lusaka City Council, World Bank

FSM5 Workshop – February 22, Morning Session

Today's Presenters

- Professor Christine Moe, Director of CGSW, **Emory University**
- Ebenezer Ato Senayah, Development Consultant and WASH Analyst, **TREND Group Ghana**
- Joshua Tetteh-Nortey, Senior Development Planning Officer, **Kumasi Metropolitan Assembly**
- Sammy Ejoga, Public Health Officer, **Kampala Capital City Authority**
- Dr. Richard Mugambe, Lecturer, **Makerere University School of Public Health**
- Dr. Md. Mahbubur Rahman, Project Coordinator, **icddr,b**
- Dr. Md. Nuhu Amin, Assistant Scientist, **icddr,b**
- Grace Mwanza Ndashe, Senior Health Inspector, **Lusaka City Council**
- Dr. George Joseph, Senior Economist, **World Bank**

Workshop Overview

- 1) 9:00 – 10:30: Presentations from partners with Q&A sessions
- 2) 10:30 – 11:00: Tea Break
- 3) 11:00 – 12:30: Group discussions and activities

Learning Objectives

At the conclusion of this activity, participants will be able to:

- Recognize potential risks to urban health due to poor sanitation and FSM
- Interpret environmental and public health data from assessments of urban contamination and behavior in the context of sanitation decision-making
- Demonstrate the application of sanitation tool outputs for evidence-based decision-making about sanitation policies and investments
- Describe best practices in interpreting and communicating environmental health assessment results to a wide range of stakeholders.

Data-Driven Decision Making in the Sanitation Sector

Christine L. Moe
Center for Global Safe Water, Sanitation, and Hygiene
Rollins School of Public Health
Emory University
Atlanta, Georgia USA

EMORY | ROLLINS SCHOOL OF PUBLIC HEALTH

SaniPath

CGSW Center for Global Safe WASH | Leading and Learning in WASH

Sanitation Planning Tools

SSWM Toolbox

FSM
Faecal Sludge Management
TOOLBOX

p a s performance assessment system

IFSM Toolkit

City Sanitation Plan

CLUES Planning

SFD

SaniPath

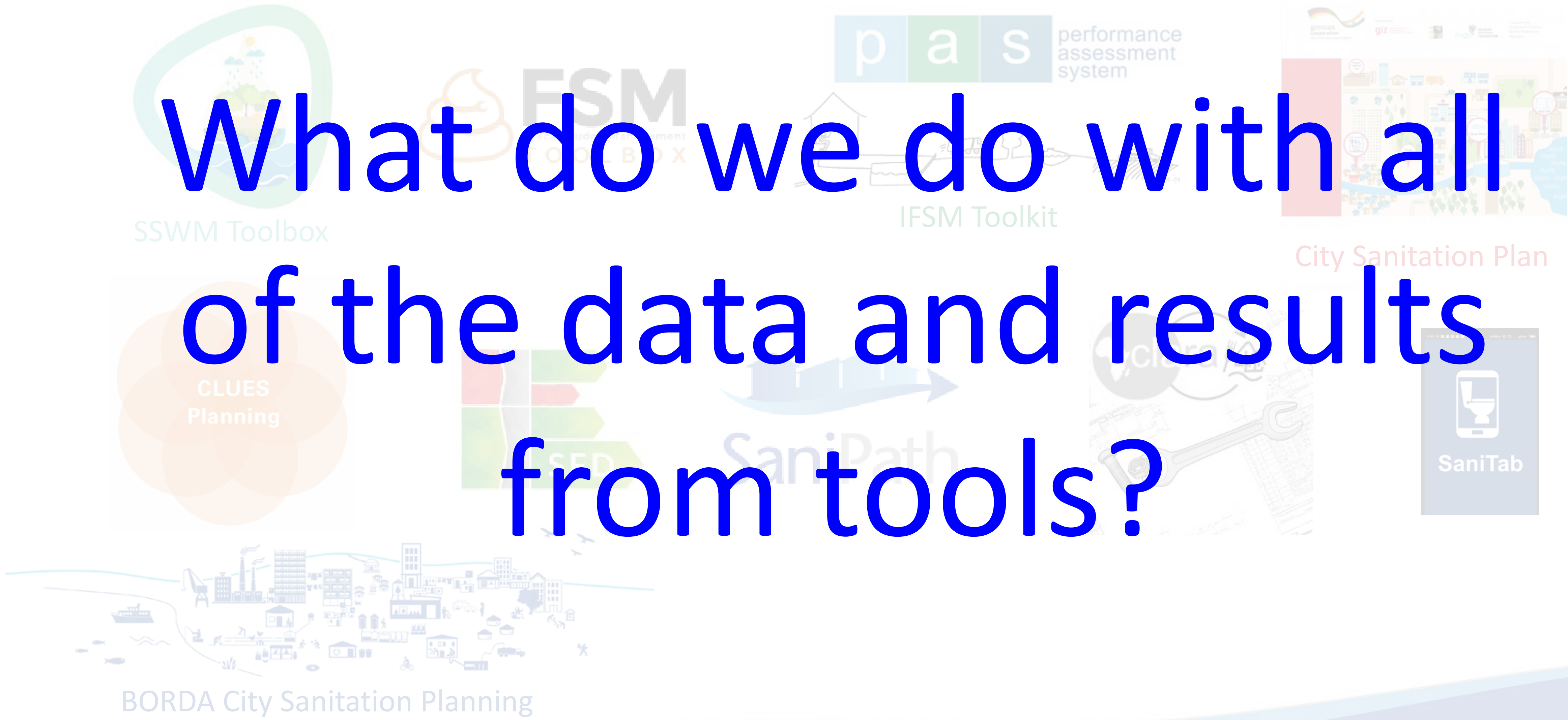
SaniTab

BORDA City Sanitation Planning

and many, many more

Sanitation Planning Tools

What do we do with all of the data and results from tools?



Data and Results

Communicate Findings

Make Decisions

We.....

- Generate reports
- Write journal articles
- Develop blog posts
- Present findings at conferences
- Create a poster
- Hold a stakeholder workshop
- Convene a community results-sharing meeting

- Plan interventions
- Create or influence policy
- Inform investments
- Identify data gaps
- Change behaviors
- Develop targeted programming

In an ideal world…

Data and Results

Communicate Findings

Make Decisions

In the real world…results may not be disseminated or used for decision-making.

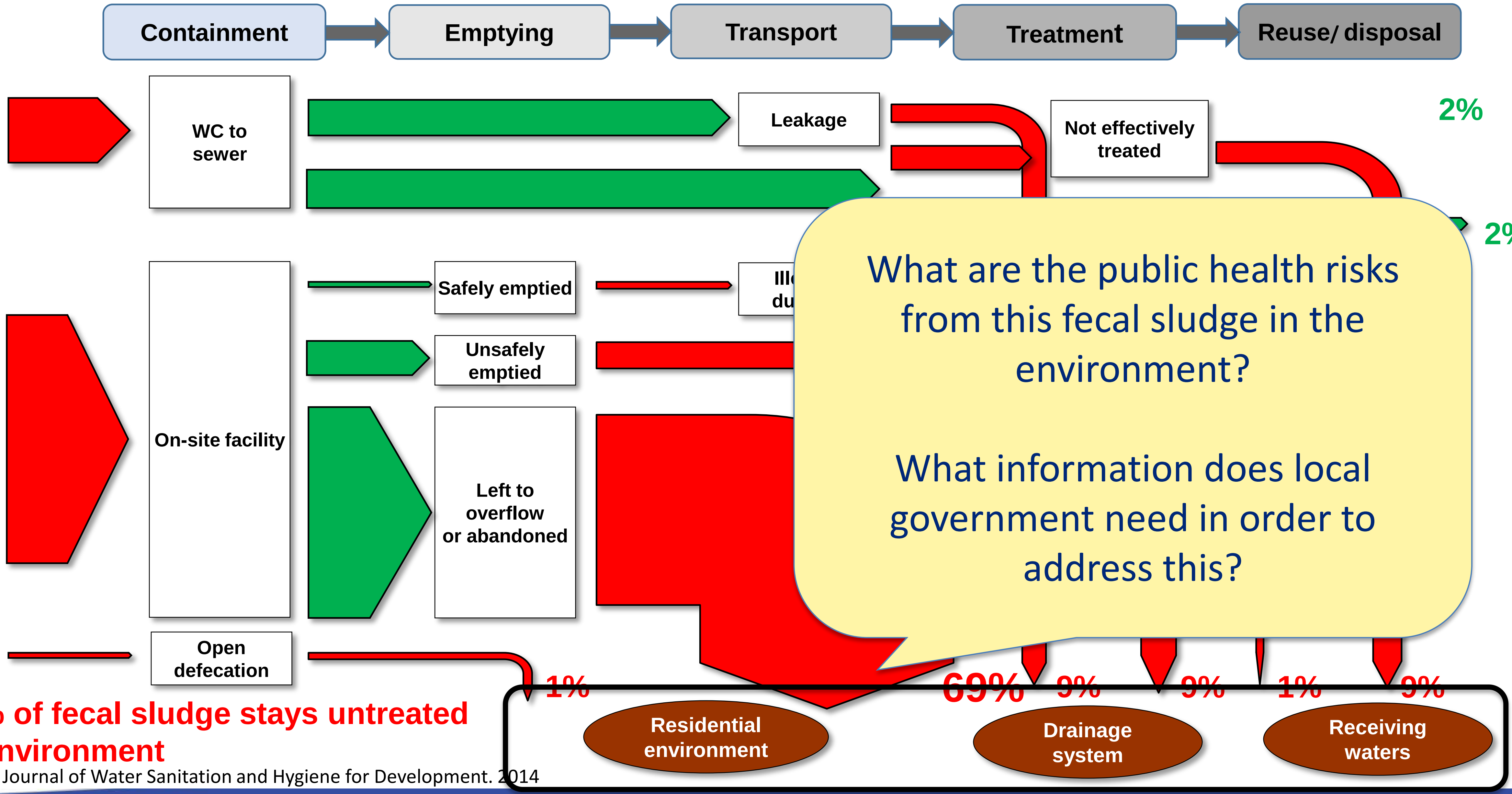
How can we change that?

In this workshop, you will hear from:

* municipal government agencies,
* NGOs,
* academic institutions, and
* funding organizations

on the use and impact of environmental health data on sanitation policies, planning, and decision-making

Shit Flows Analyses show that Fecal Sludge is NOT Contained – Reservoirs in Urban Environment



98% of fecal sludge stays untreated in environment

Peal et. al. Journal of Water Sanitation and Hygiene for Development. 2014

Many ways that people can be exposed to fecal contamination in urban environments

Floodwater

Public latrines

Open drains

Ocean Water

Street Food

Drinking water

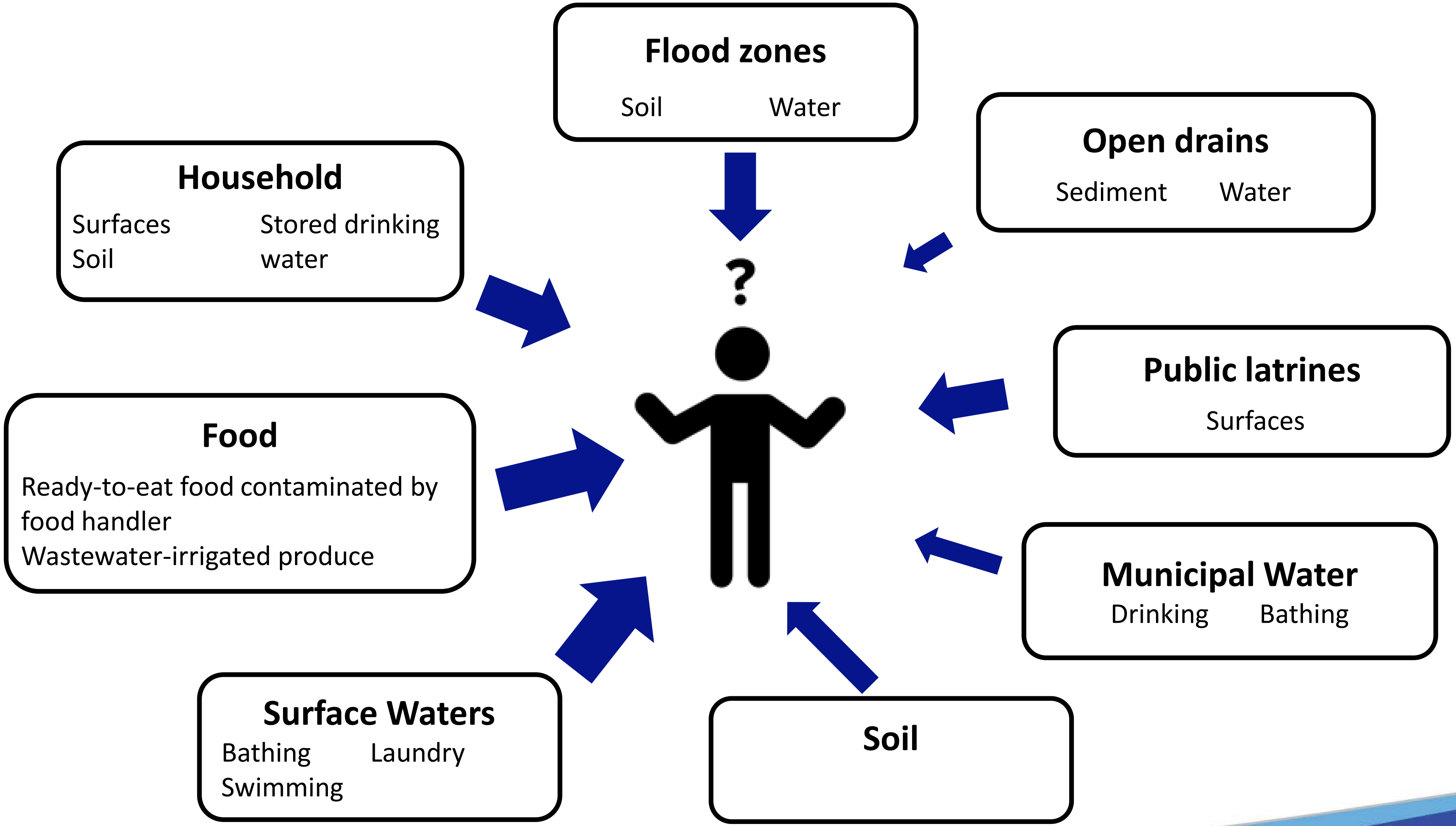
Bathing water

Wastewater-irrigated produce

Soil

Surface Water

SaniPath: What is the risk of exposure to fecal contamination in the urban environment?
Which pathways pose the greatest risk?

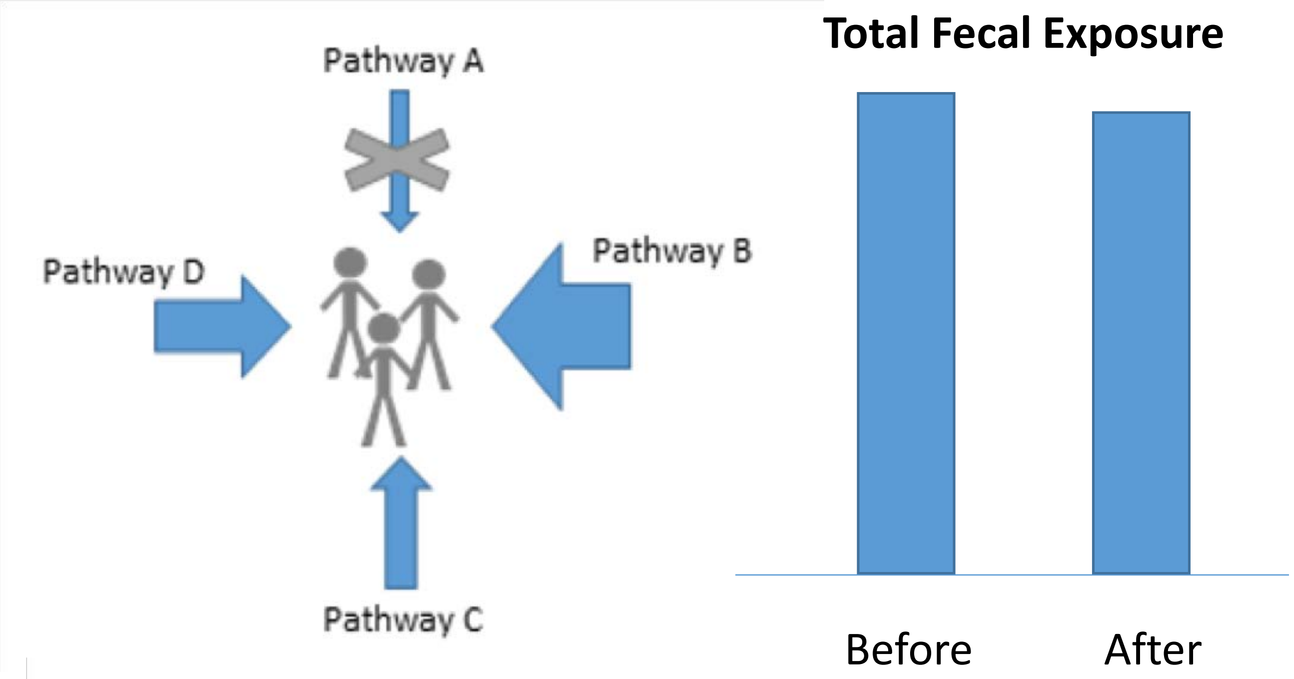


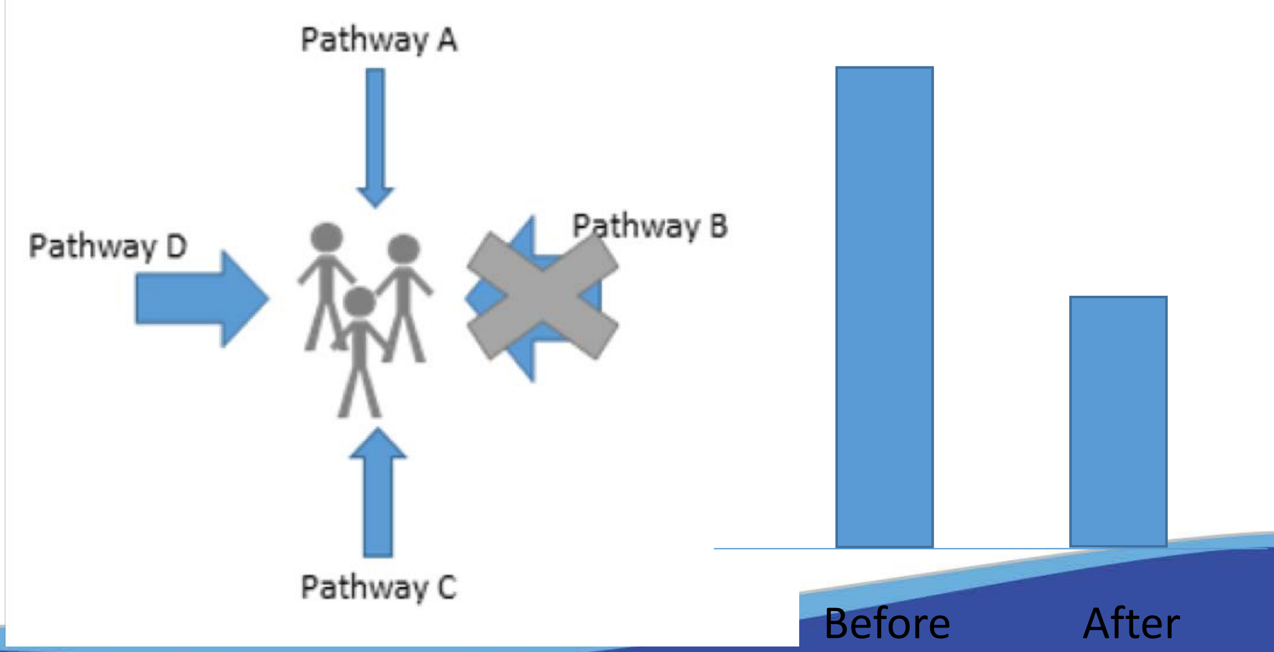
Confused designed by Jessica Look for The Noun Project

Dominant Pathway(s)

The dominant pathway(s) is defined as the pathway(s) that make the greatest contribution(s) to the total fecal exposure.

If we can identify the dominant pathway(s), then we can focus our resources on reducing or eliminating this pathways(s)





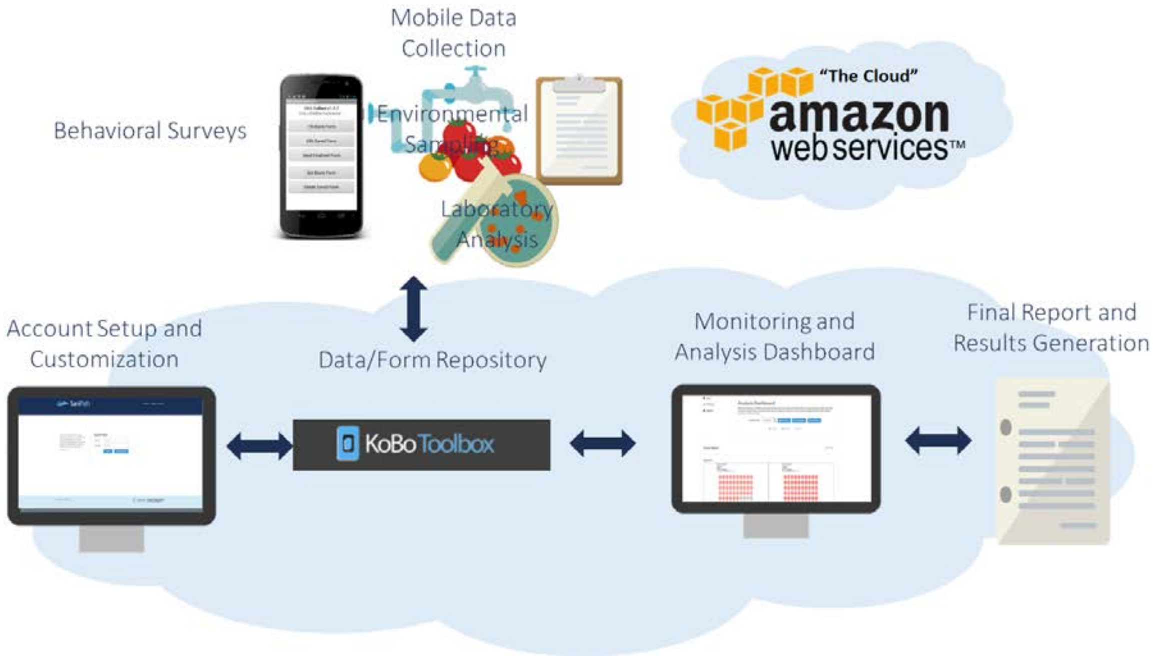
Exposure Assessment Tool

The SaniPath Exposure Assessment Tool is designed to:

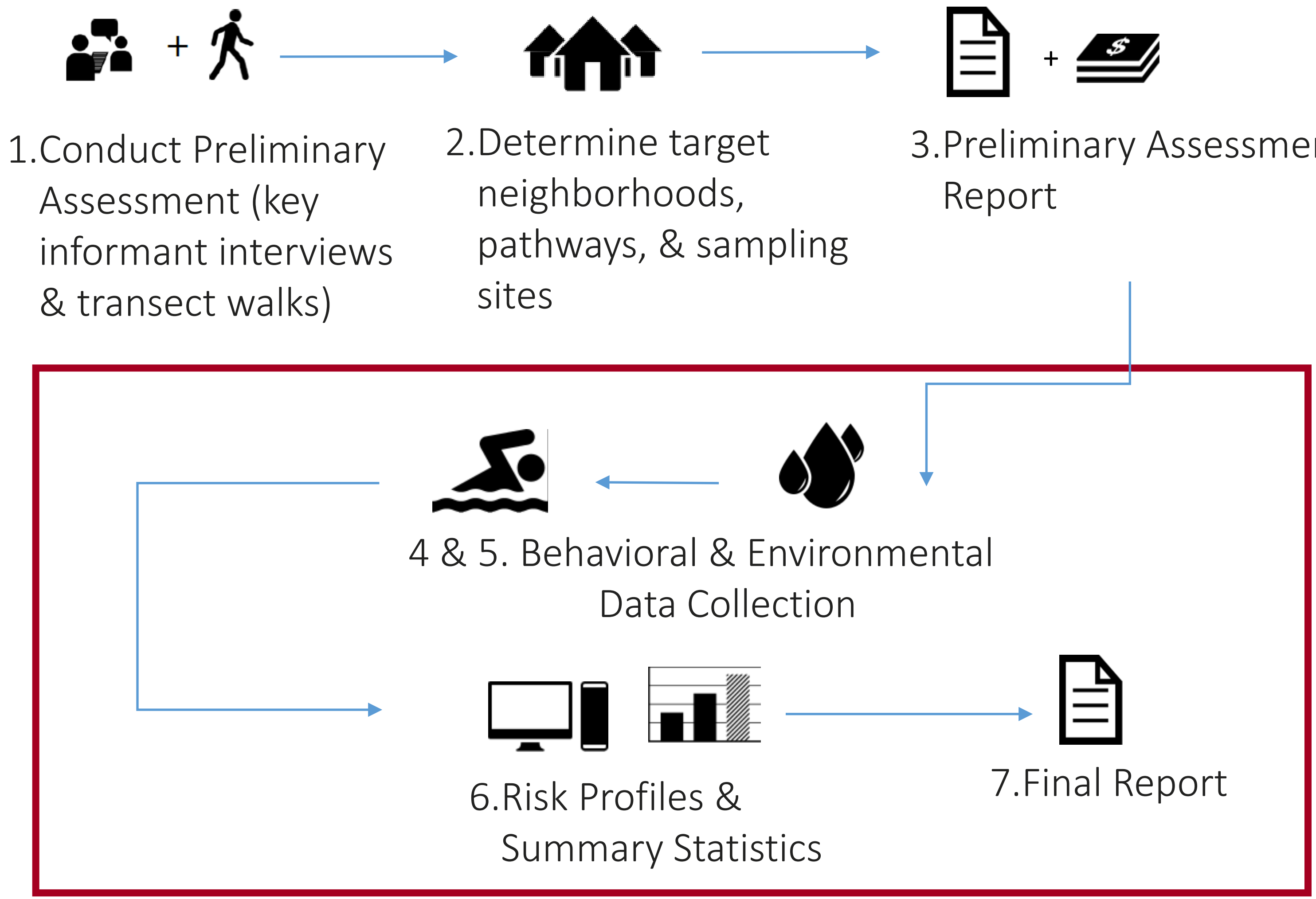
- **Assess public health risks related to poor sanitation and FSM**
- **Identify pathways of exposure to fecal contamination**
- **Raise awareness about these risks among stakeholders**
- **Help prioritize sanitation investments based on the exposures that have the greatest public health impact.**

Tool Design Challenge…

- Use mobile data collection and web-based platforms to make it easier to collect relevant environmental health data and analyze/interpret results in the sanitation sector
- Identify the resources municipal governments, NGOs, and research institutions need to perform a SaniPath Exposure Assessment



Process Diagram



The SaniPath Tool is used to manage all aspects of data collection, analysis, and reporting.

Sarah Abraham, Martha Ormiston, Gilad Fried, and Juan Pablo Bravo from The Noun Project created the icons interview, neighborhood, water, and computer. Schematic created by Suraja Raj

The SaniPath Tool Assesses Risk of Exposure to Fecal Contamination in the Urban Environment

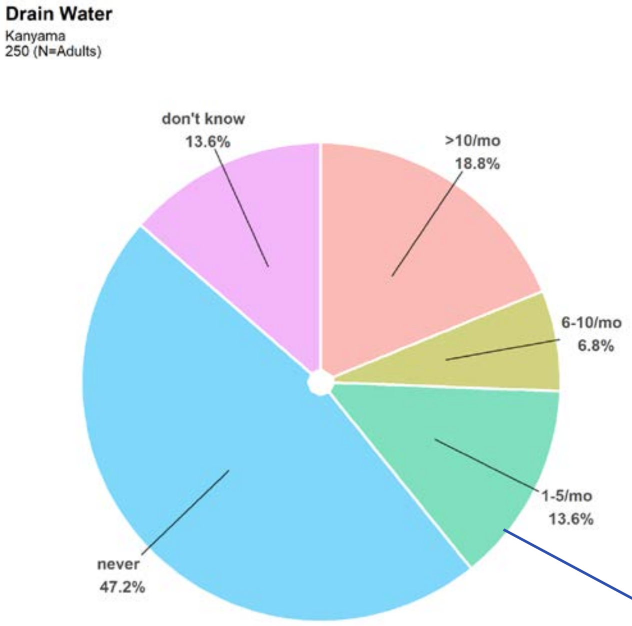
Primary Data Collection

- **Exposure Behavior**
  - Reported frequency of behavior of adults and children that may lead to exposure to fecal contamination
- **Fecal Contamination**
  - Collect environmental samples from relevant exposure pathways
  - Analyze for *E. coli* as an indicator of fecal contamination

Experience from 43 neighborhoods in 10 cities

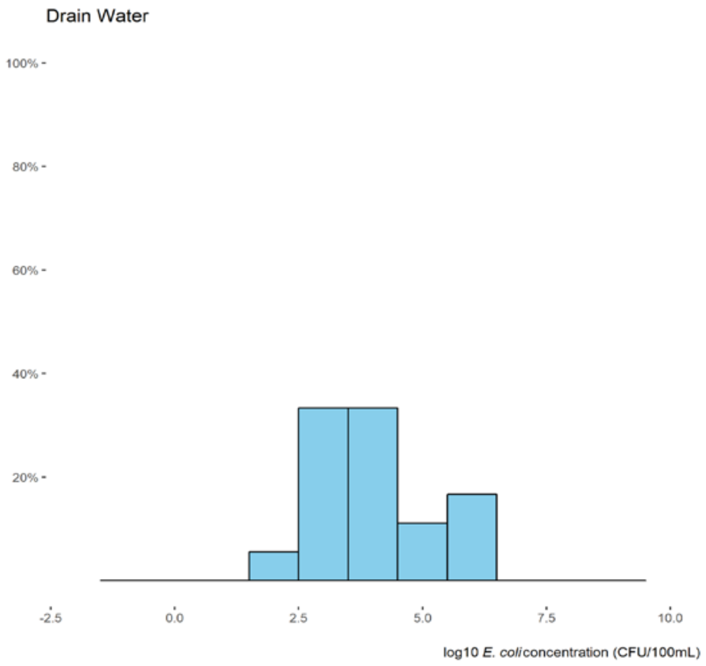
Estimating Exposure to Fecal Contamination

Behavior Frequency



Other parameters: intake volumes, duration of exposure, etc.

Environmental Contamination

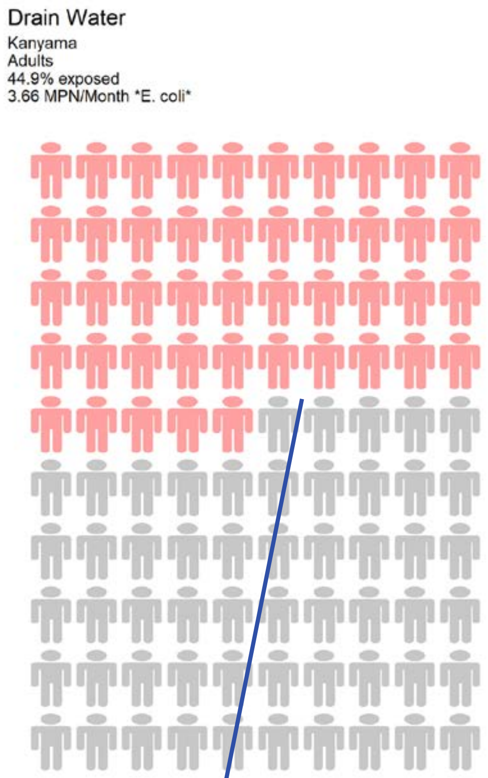


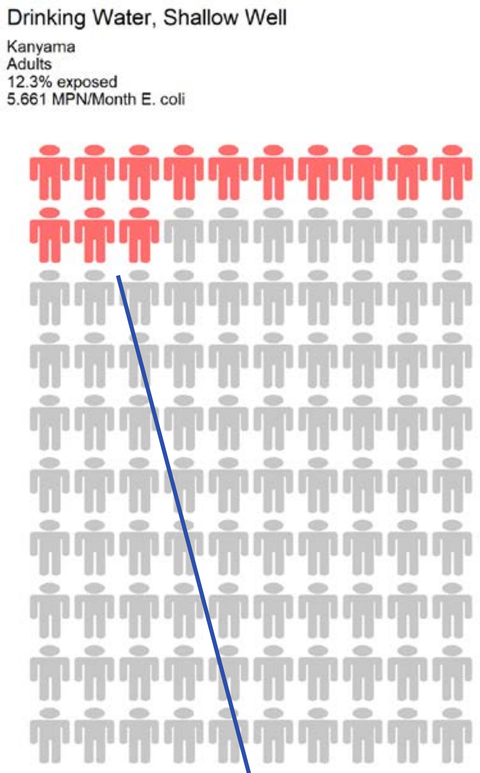
Tool uses Bayesian analysis to estimate the distribution of environmental contamination and frequency of exposure.

The mean dose and proportion of the population exposed are summarized from simulated distributions and displayed in risk profiles.

Results are presented in a normalized and comparable unit – Dose as MPN *E. coli* **ingested** per month

Interpreting the People Plots



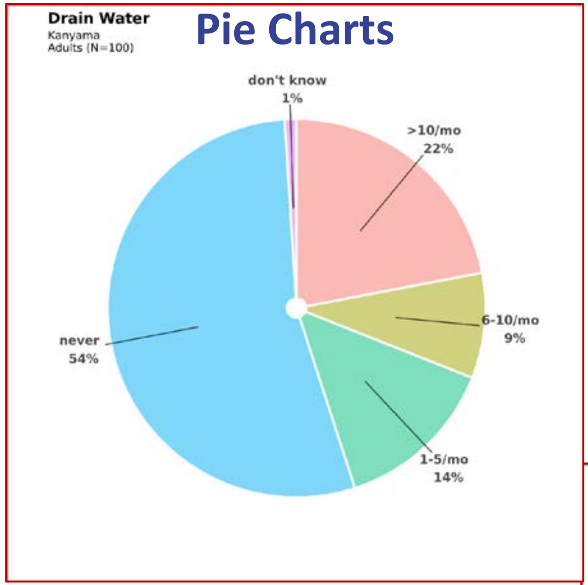


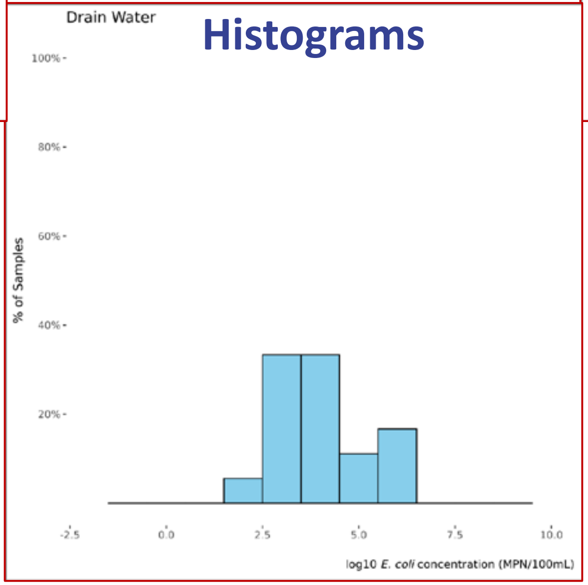
Higher percent exposed indicated by more red people

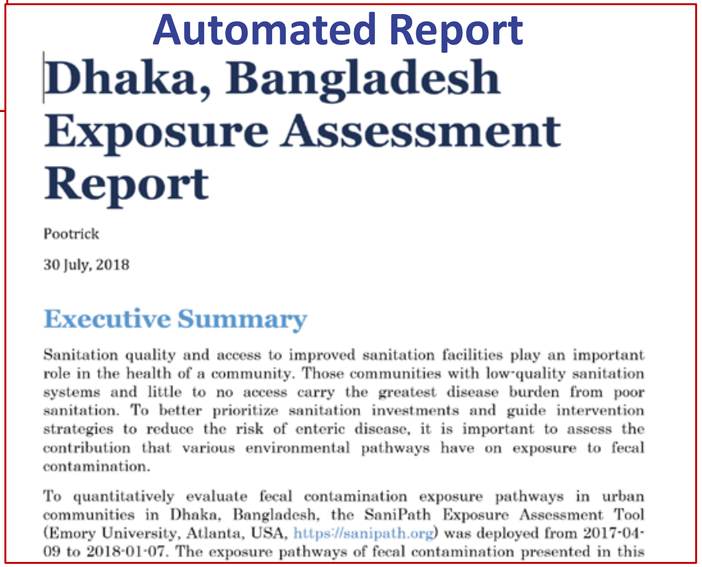
Higher dose indicated by higher intensity red color

- People plots show the percent of a population that is exposed to fecal contamination, as measured by E. coli, and the dose of exposure per month
- The grey people represent the population that have no contact with a pathway in a given month
- The red people represent the population that does have contact with a pathway - whether it be 1 time or 10 times
- The intensity of the red represents the dose, the average fecal contamination ingested per month

Outputs of the Tool







Dhaka, Bangladesh Exposure Assessment Report

Pootrick

30 July, 2018

Executive Summary

Sanitation quality and access to improved sanitation facilities play an important role in the health of a community. Those communities with low-quality sanitation systems and little to no access carry the greatest disease burden from poor sanitation. To better prioritize sanitation investments and guide intervention strategies to reduce the risk of enteric disease, it is important to assess the contribution that various environmental pathways have on exposure to fecal contamination.

To quantitatively evaluate fecal contamination exposure pathways in urban communities in Dhaka, Bangladesh, the SaniPath Exposure Assessment Tool (Emory University, Atlanta, USA, https://sanipath.org) was deployed from 2017-04-09 to 2018-01-07. The exposure pathways of fecal contamination presented in this

How can decision-makers use SaniPath information to set priorities and focus resources?

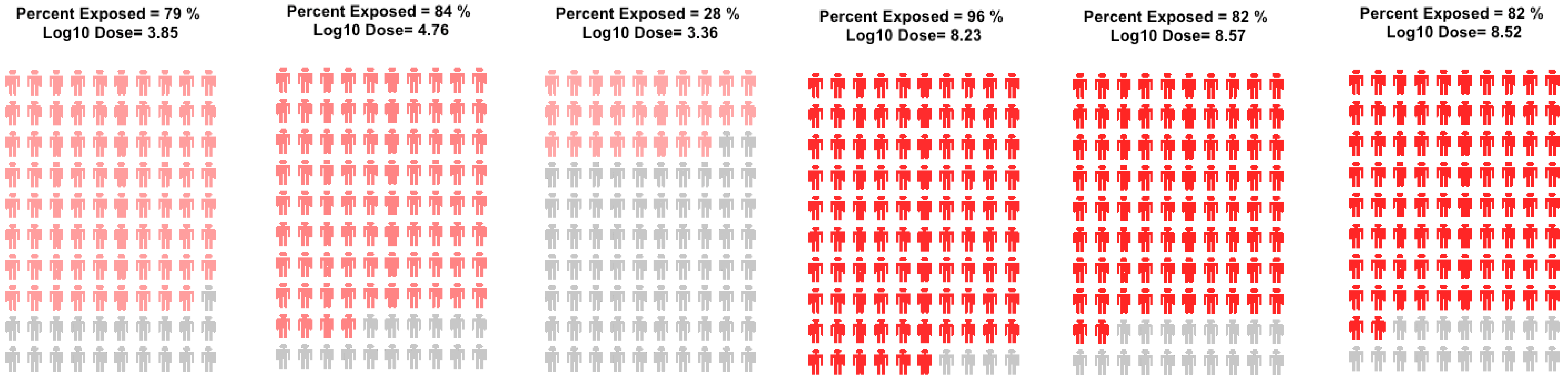
Information needs for advocacy and investment decisions

- What is the frequency and magnitude of exposure to fecal contamination in the urban environment?
- Which exposure pathways pose the greatest risk?
- How do fecal exposure pathways vary in a single neighborhood?
- How do fecal exposure pathways vary across multiple neighborhoods in the same city?
- How do fecal exposure pathways vary across multiple neighborhoods in different cities?

SaniPath results can show differences in fecal exposure across geographic areas

Municipal Drinking Water – 6 neighborhoods in Dhaka

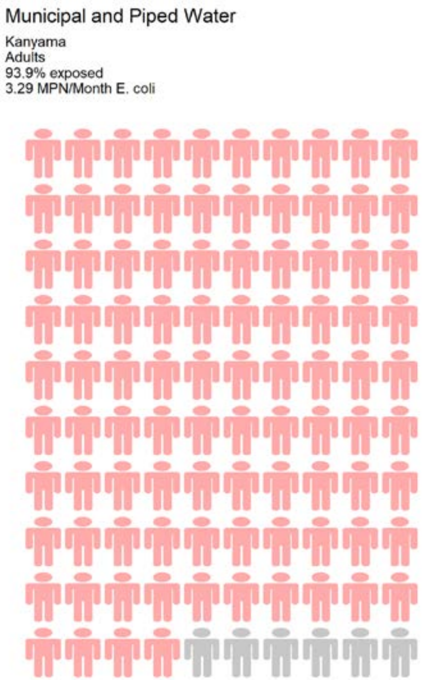
A B C D E F



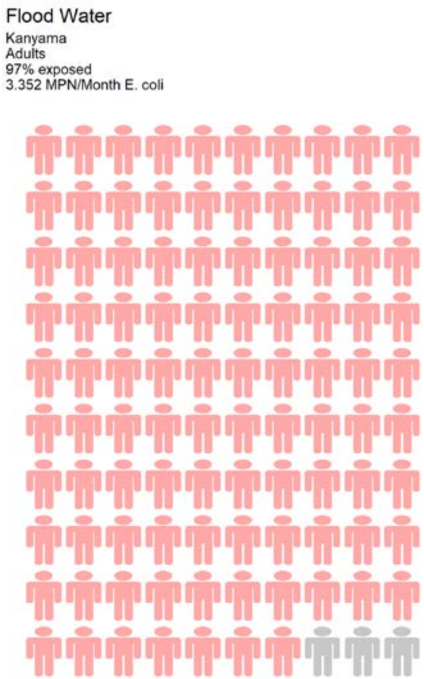
….across neighborhoods

….differences in fecal exposure across pathways in a single geographic area

Municipal Water

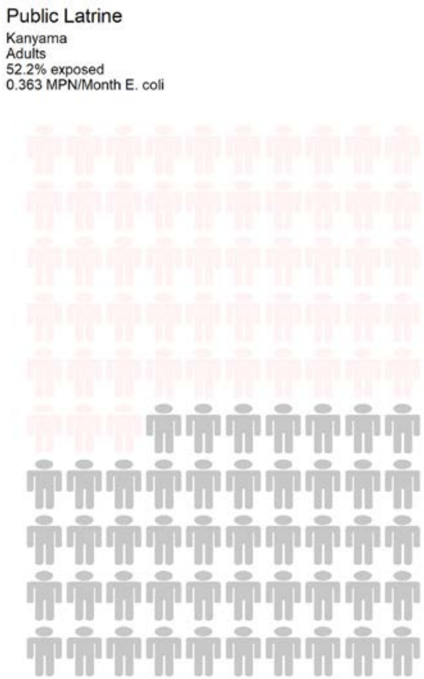


Flood Water



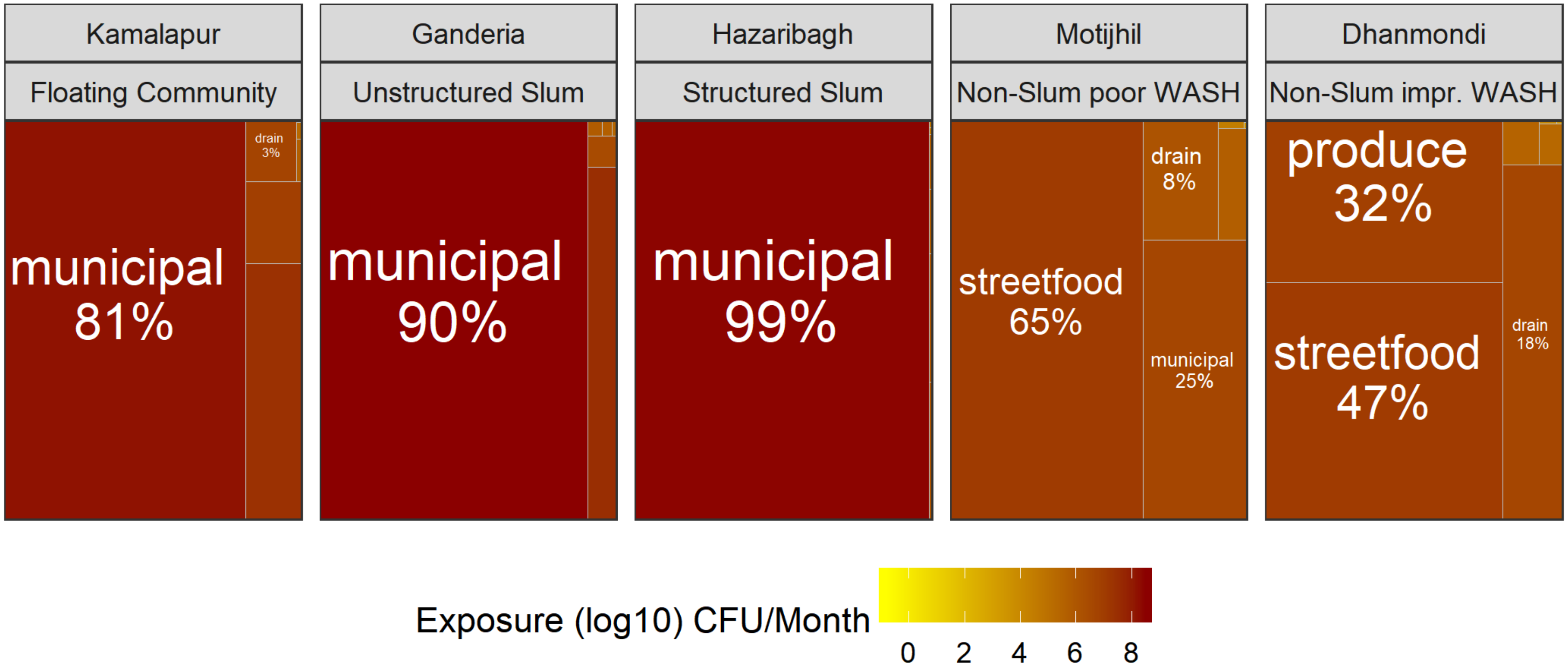
Drain Water

Public Latrines

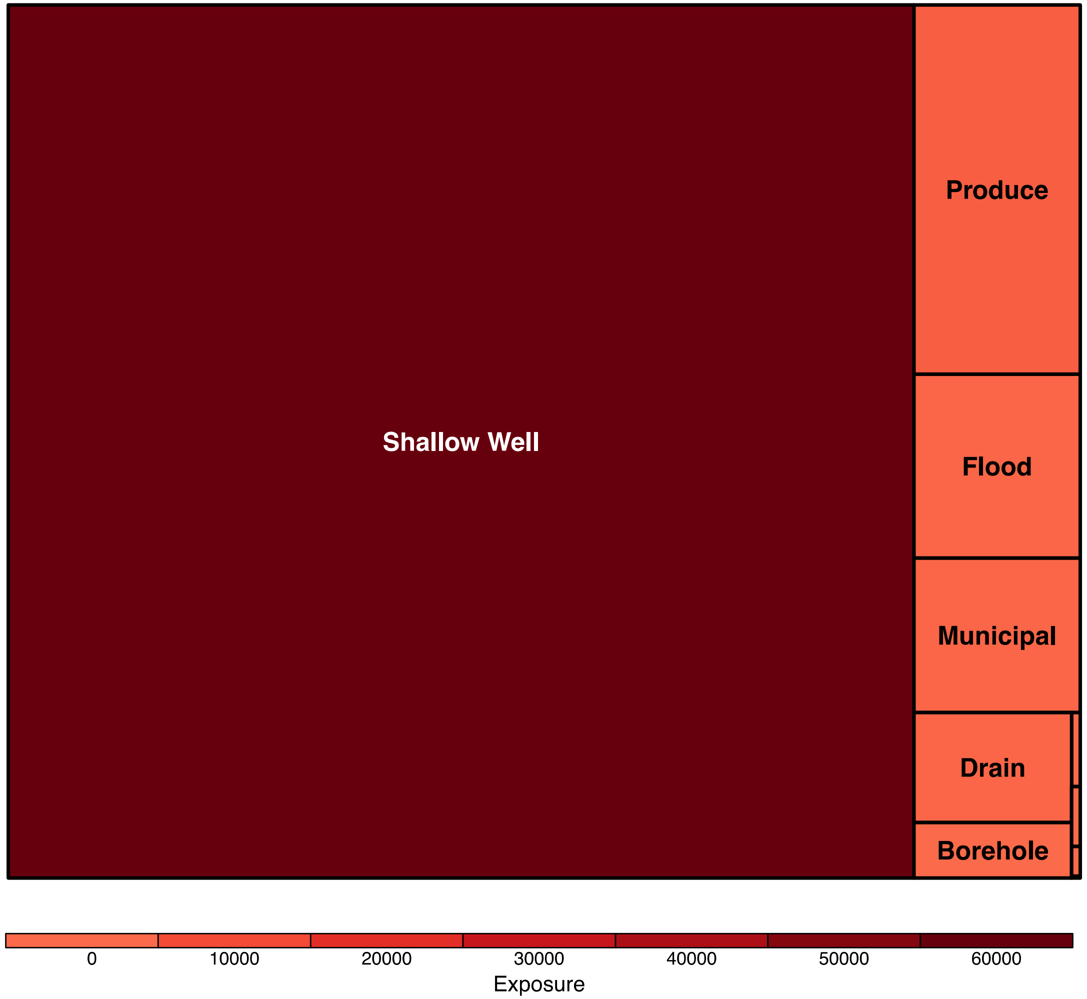


Uncooked Produce

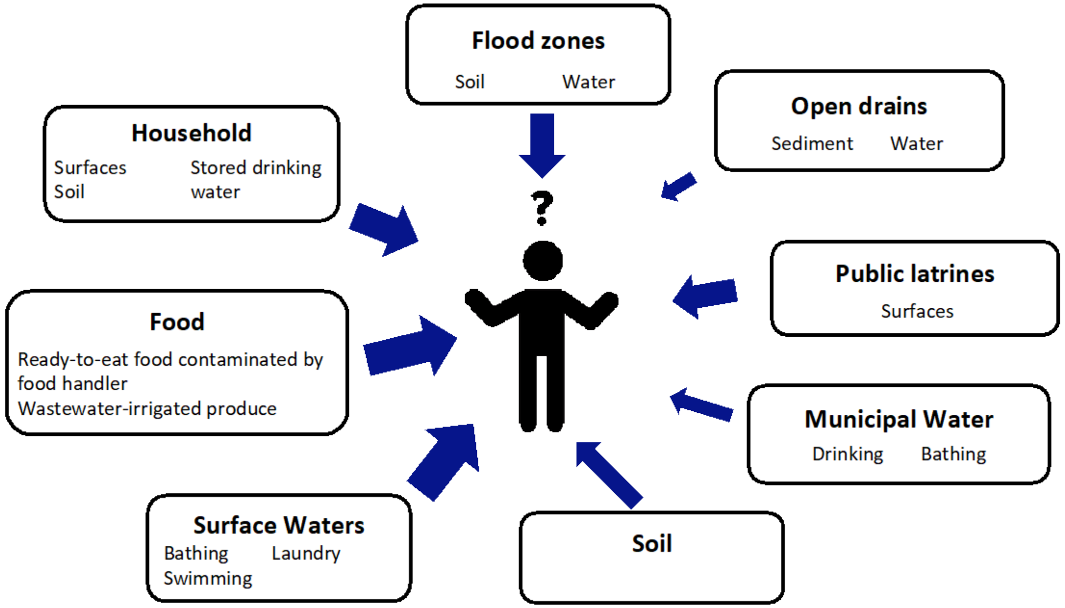
...the contribution of each pathway to total exposure to fecal contamination



Adult Exposure to Fecal Contamination



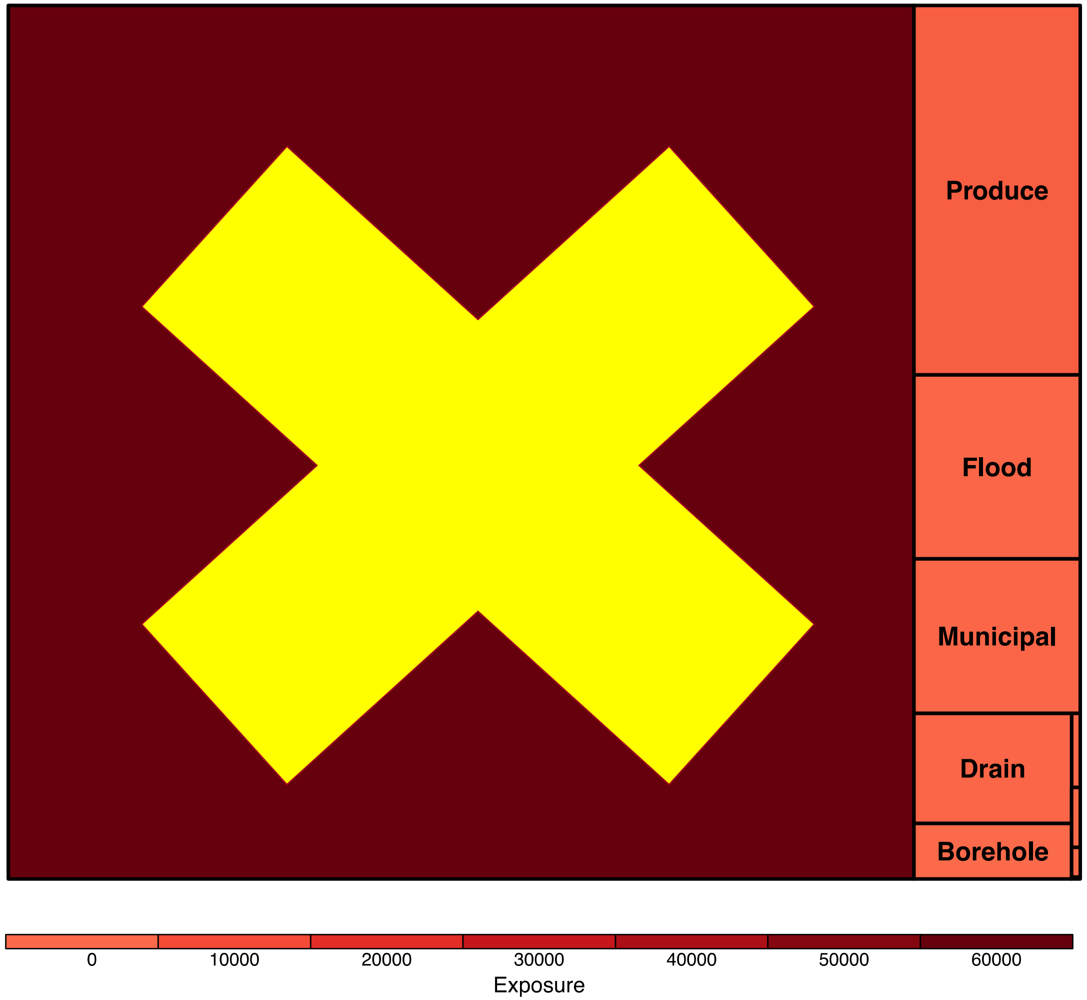
This figure illustrates the relative contributions of 10 different pathways to the total exposure to fecal contamination and shows which pathways pose the greatest risk.



Confused designed by Jessica Look for The Noun Project

*Note: Difference in scale of exposure – Max of 60,000 for adults and 4500 adults without shallow wells

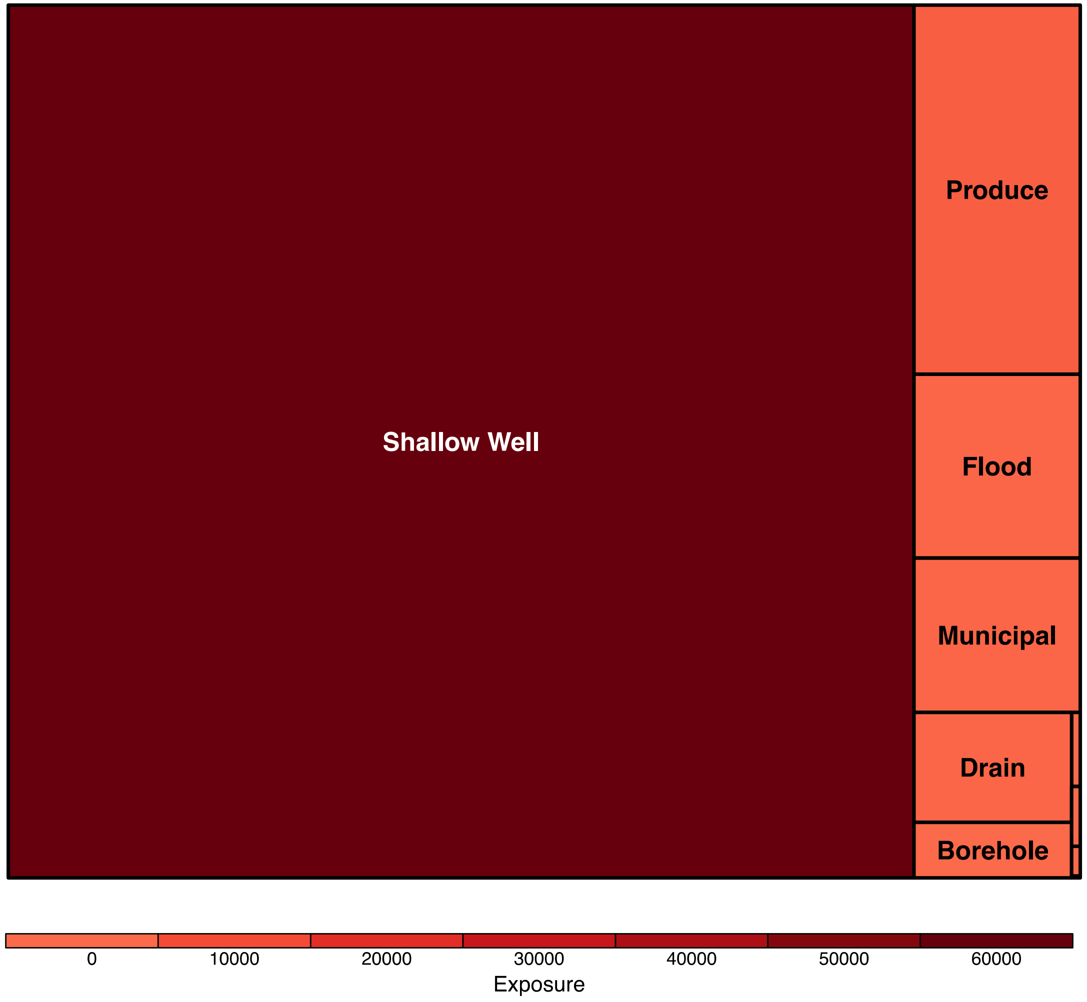
Adult Exposure to Fecal Contamination



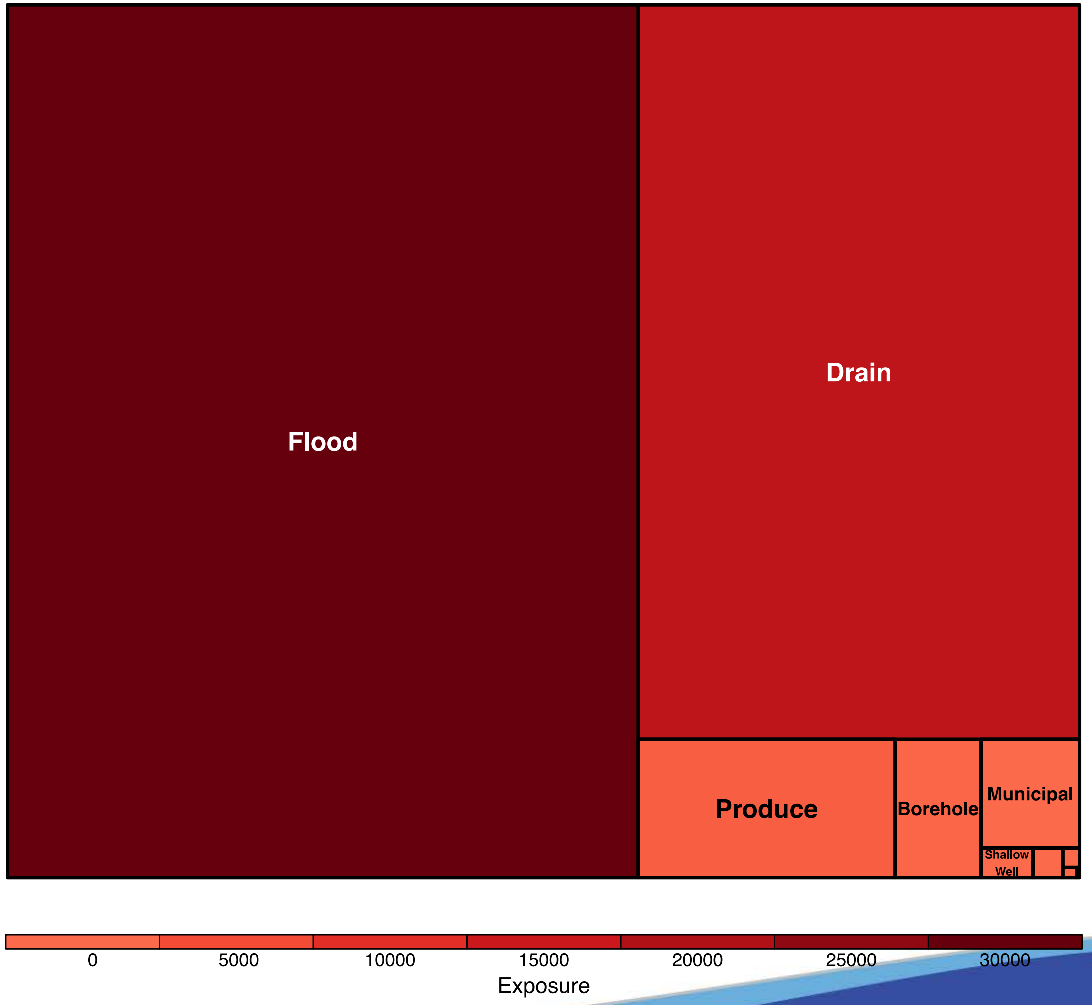
Can we focus resources on the dominant pathway in order to reduce exposure to fecal contamination?

SaniPath results also show how fecal exposure can differ between adults and children

Adult Exposure



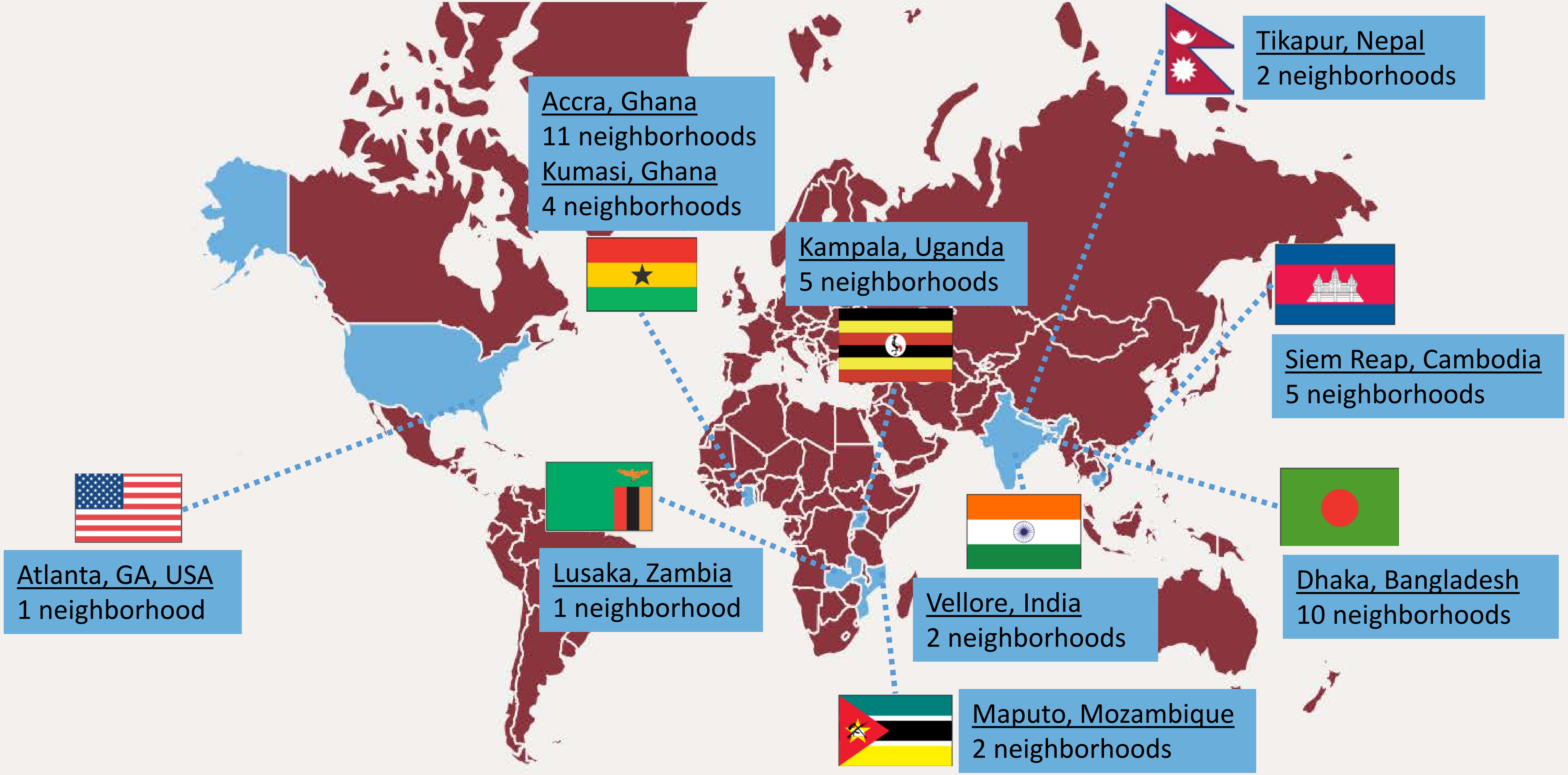
Child Exposure



*Note: Difference in scale of exposure – Max of 60,000 for adults and 30,000 for children

43 neighborhoods
in total and
counting!

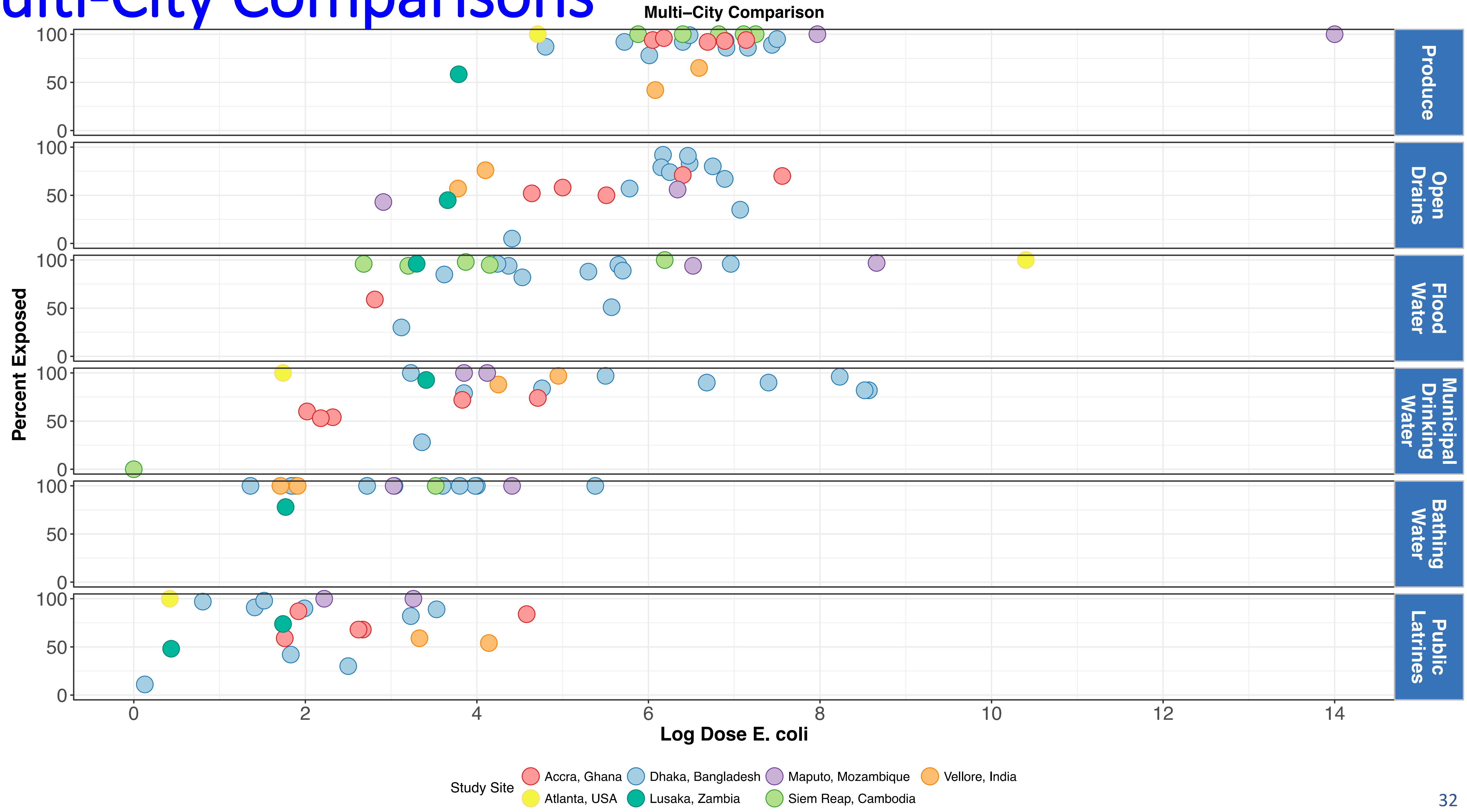
SaniPath Field Sites 2013-2018



Multi-City Data Analyses of Risks of Exposure to Fecal Contamination

- What risks/dominant pathways are "universal" – i.e. Across rich and poor neighborhoods? And across multiple cities?
- What risks/dominant pathways seem to be more specific to poor neighborhoods?
- What risks/dominant pathways seem to be more specific to certain cities?
- Do certain cities have greater overall risk of exposure to fecal contamination than other cities?

Multi-City Comparisons



SaniPath Value:
From Evidence to Action

- SaniPath approach for assessing exposure to fecal contamination in the urban environment provides valuable evidence for advocacy, to guide intervention investments, and to highlight data gaps for further research
    - Risk profiles show how exposure to fecal contamination **varies across pathways in a single neighborhood, varies across neighborhoods in a single city and across pathways for different cities**
- Municipal authorities can use information on geographic differences and pathway differences to set priorities and target resources to areas and pathways with greatest risk

Dissemination of SaniPath Results in Ghana

SaniPath Results Influence Policy in Ghana

- Results from the SaniPath deployments in Accra, Ghana are being used to influence policy change.
- The national urban sanitation strategy being developed will now incorporate waste water irrigated produce as a key pathway to address.
- The SaniPath tool will be recommended as a public health risk tool in the urban sanitation strategy. A national steering committee headed by the Ministry of Sanitation and Water to spur the use of the SaniPath Tool by key stakeholders has been formed.
- Influencing sanitation policy and investments takes years!

SaniPath Results Can Identify Key Data Gaps and Lead to Additional Research Questions to Investigate

Questions:

- High levels of produce contamination found in almost every neighborhood and city (except Atlanta and Lusaka)
  - Why?
  - How is this contamination linked to poor FSM?

Our approach to addressing these questions:

- Conduct a farm-to-fork pilot study with icddr,b in Dhaka
- Add an additional question about produce washing to SaniPath Tool
- Conduct structured observations of food preparation in Kolkata

Acknowledgements

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TREND
Research Triangle Institute
Improve International
Christian Medical College, Vellore
MapSan Study
EpiTech Consultants
Icddr,b
Lusaka City Council
GIZ
Accra & Kumasi Metropolitan Assemblies
Kampala Capital City Authority
Makerere School of Public Health
University of Zambia
Kwame Nkrumah University of Science and Technology
Water Global Practice, World Bank Group
International Expert Committee; Local Expert Committee; SaniPath Advisory Committee

Center for Global Safe Water, Sanitation, and Hygiene

Thank You

For more information visit
SaniPath.org

View the NEW Tool at

tool.sanipath.org

Christine L. Moe
clmoe@emory.edu

View Tool tutorials on YouTube!

SaniPath Exposure Assessment Tool

Connect with us on Twitter!

@SaniPath

Examining Exposure to Fecal Contamination in Low-Income Urban Environments: Findings from the SaniPath Exposure Assessment in 10 Cities

Christine L. Moe
Center for Global Safe Water, Sanitation, and Hygiene
Rollins School of Public Health
Emory University
Atlanta, Georgia USA

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CGSW Center for Global Safe WASH | Leading and Learning in WASH

Lusaka City Council

KCCA KAMPALA CAPITAL CITY AUTHORITY For a better City

MAKERERE UNIVERSITY

icddr,b

Kumasi Metropolitan Assembly Working for a cleaner city

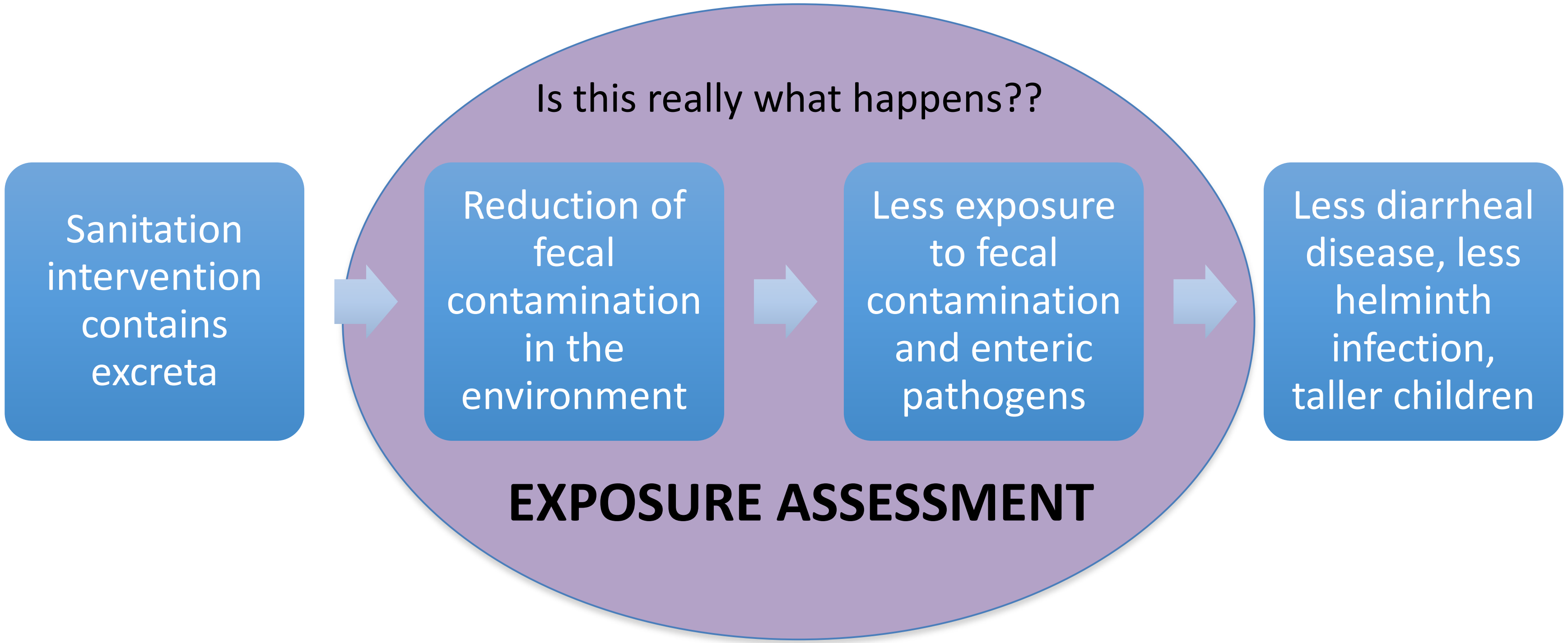
TREND TRAINING RESEARCH AND NETWORKING FOR DEVELOPMENT

WORLD BANK

Expected Impact of Sanitation Interventions

Sanitation intervention contains excreta → Reduction of fecal contamination in the environment → Less exposure to fecal contamination and enteric pathogens → Less diarrheal disease, less helminth infection, taller children

Expected Impact of Sanitation Interventions

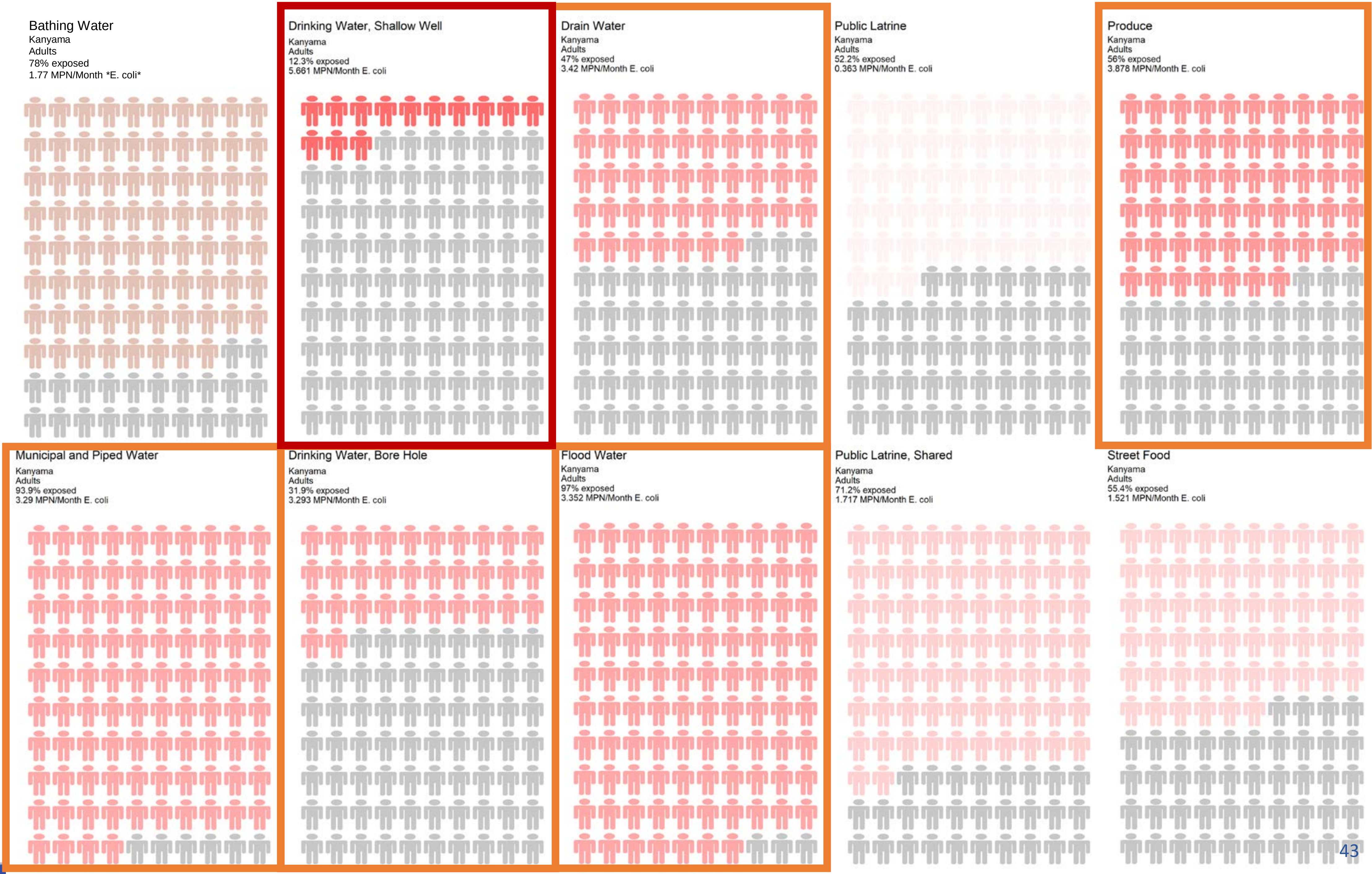


Urban Sanitation is Complex

- Urban sanitation is not just about household toilets
- Need to consider whole sanitation chain
- Need to consider how fecal sludge moves and where the fecal sludge ends up

Need to understand the context, culture, behaviors, environment, and have data to make decisions!

People Plots - Adults



Dominant Pathway

Dominant Pathway after removing Shallow Well

Information needs for advocacy and investment decisions

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- **How do fecal exposure pathways vary in a single neighborhood?**
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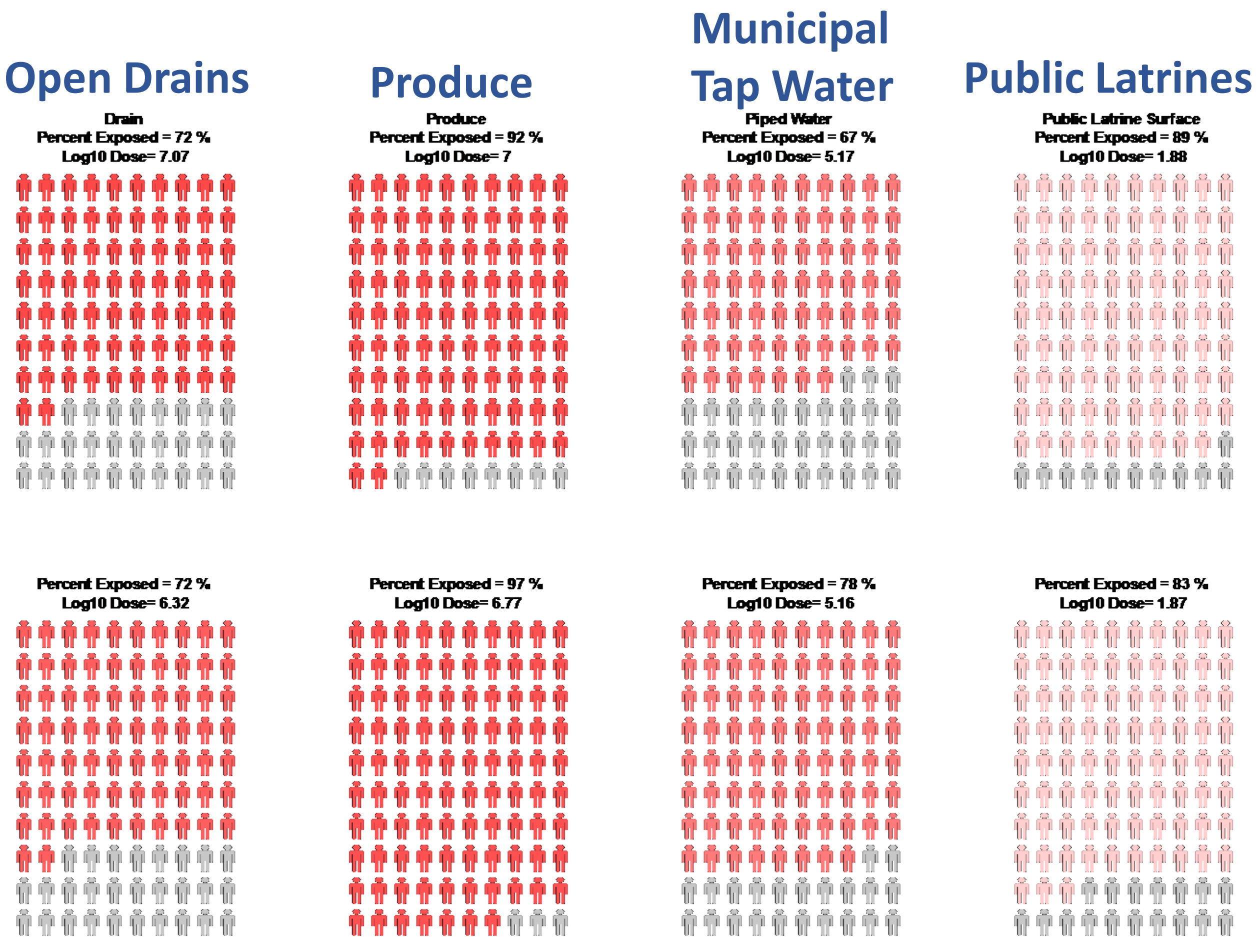
How do fecal exposure pathways vary in a single neighborhood?

Chorkor neighborhood, Accra, Ghana, 2016



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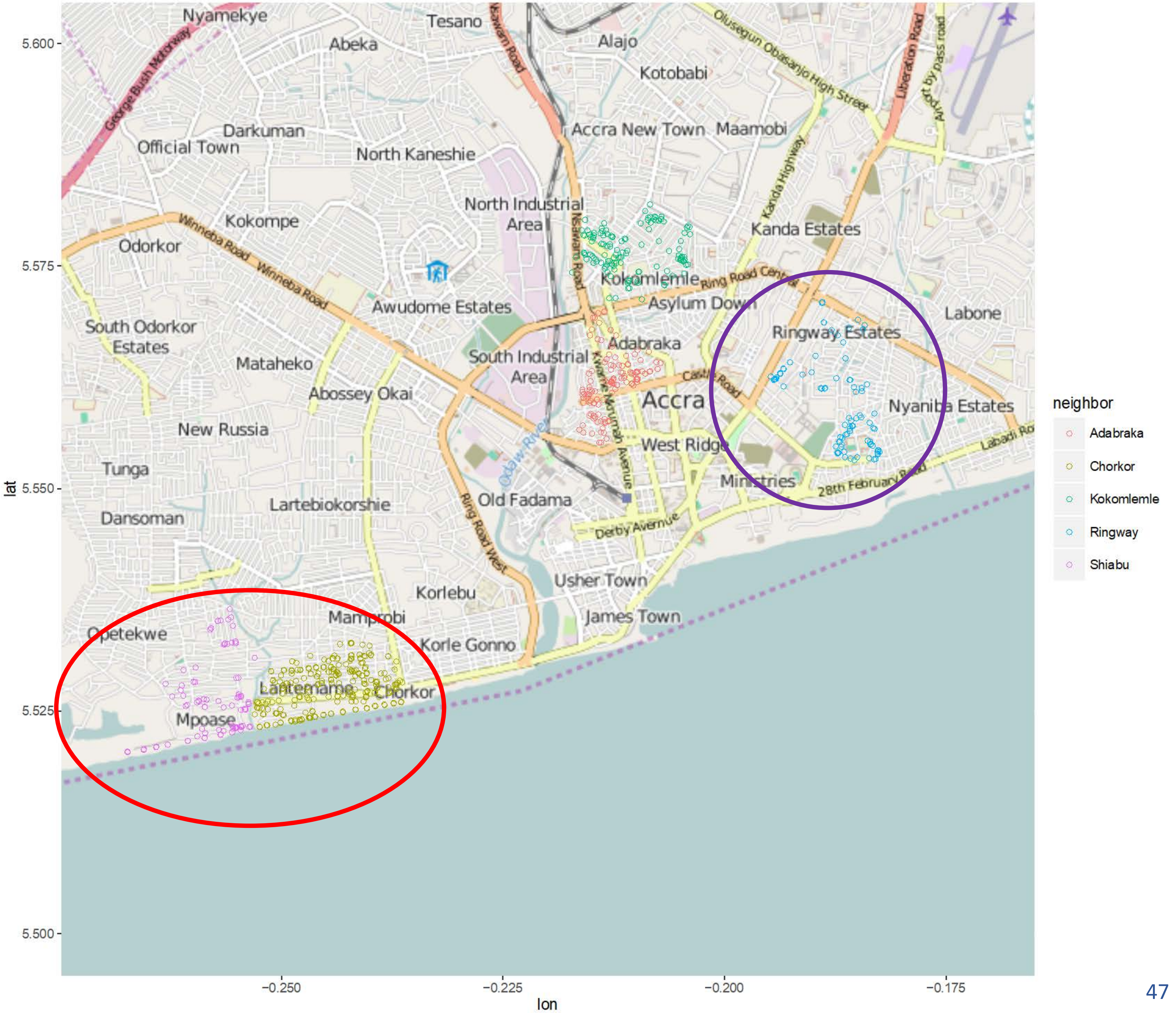
SaniPath Deployment
5 Neighborhoods

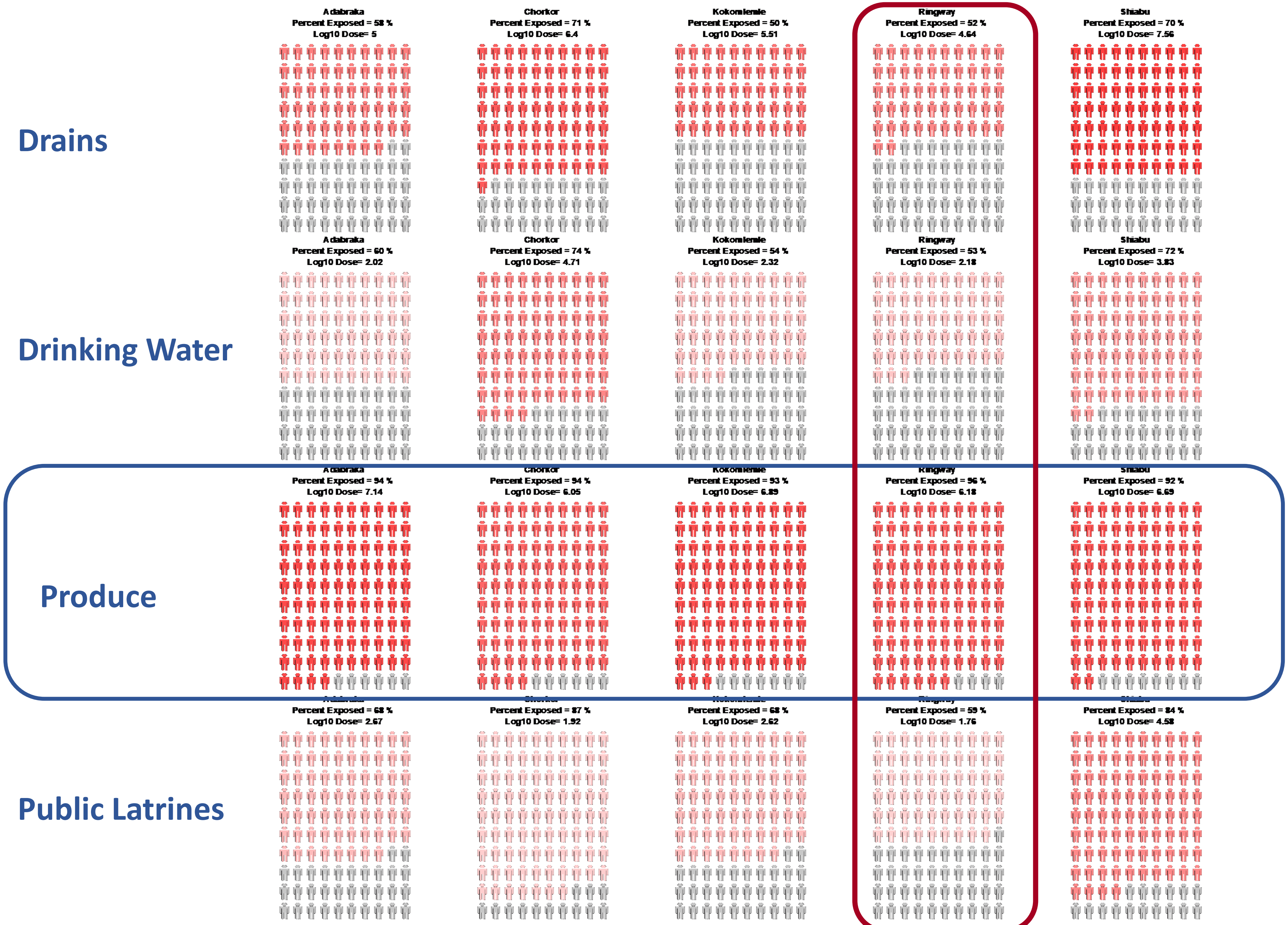
Accra, Ghana, 2016

Two adjacent coastal neighborhoods (Shiabu and Chorkor)

Higher income neighborhood (Ringway)



SaniPath Deployment in 5 Neighborhoods
Accra, Ghana, 2016



Information needs for advocacy and investment decisions

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- **How do fecal exposure pathways vary across multiple neighborhoods in different cities?**

ESTABLISHMENT OF SANIPATH TRAINING HUB:

Municipal Government Engagement, Capacity Building, and Results to Action

Ebenezer Ato Senayah
(TREND)

Joshua Tetteh-Nortey
(KMA)

Eugene Larbi
(TREND)

Benedict Tuffuor
(TREND)

MINISTRY OF SANITATION AND WATER RESOURCES

Kumasi Metropolitan Assembly
Working for a cleaner city

ACCRA METROPOLITAN ASSEMBLY

BILL & MELINDA GATES foundation

CGSW Center for Global Safe WASH | Leading and Learning in WASH

TREND TRAINING RESEARCH AND NETWORKING FOR DEVELOPMENT

WATER RESEARCH INSTITUTE
Quality Research for Sustainable Development

SaniPath

DATE: 22/02/2019

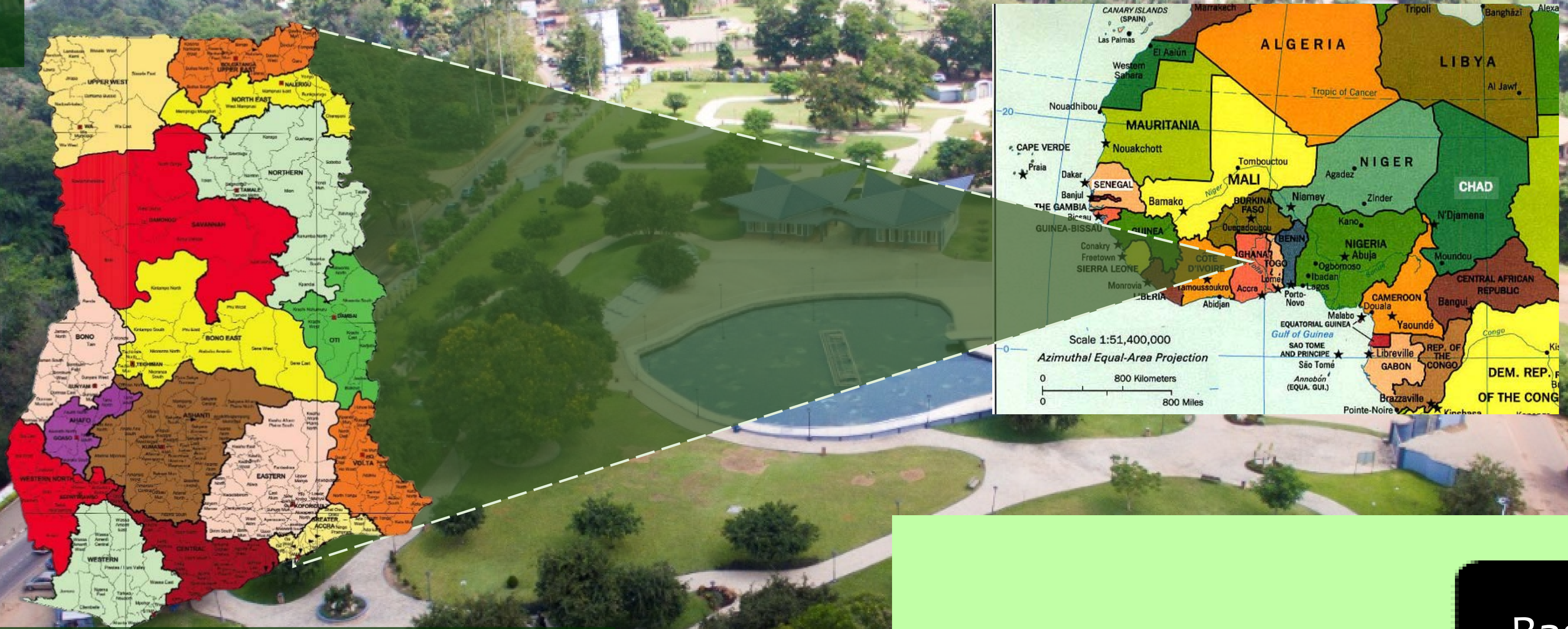
FSM5

Order of Presentation

- The Sanitation Challenge in Ghana – Accra and Kumasi
- Training hub approach and engagement with municipal government
- Results to Action – planning of interventions based on findings
- Communicating Results to Stakeholders

The Sanitation Challenge in Ghana – Background

Key Facts



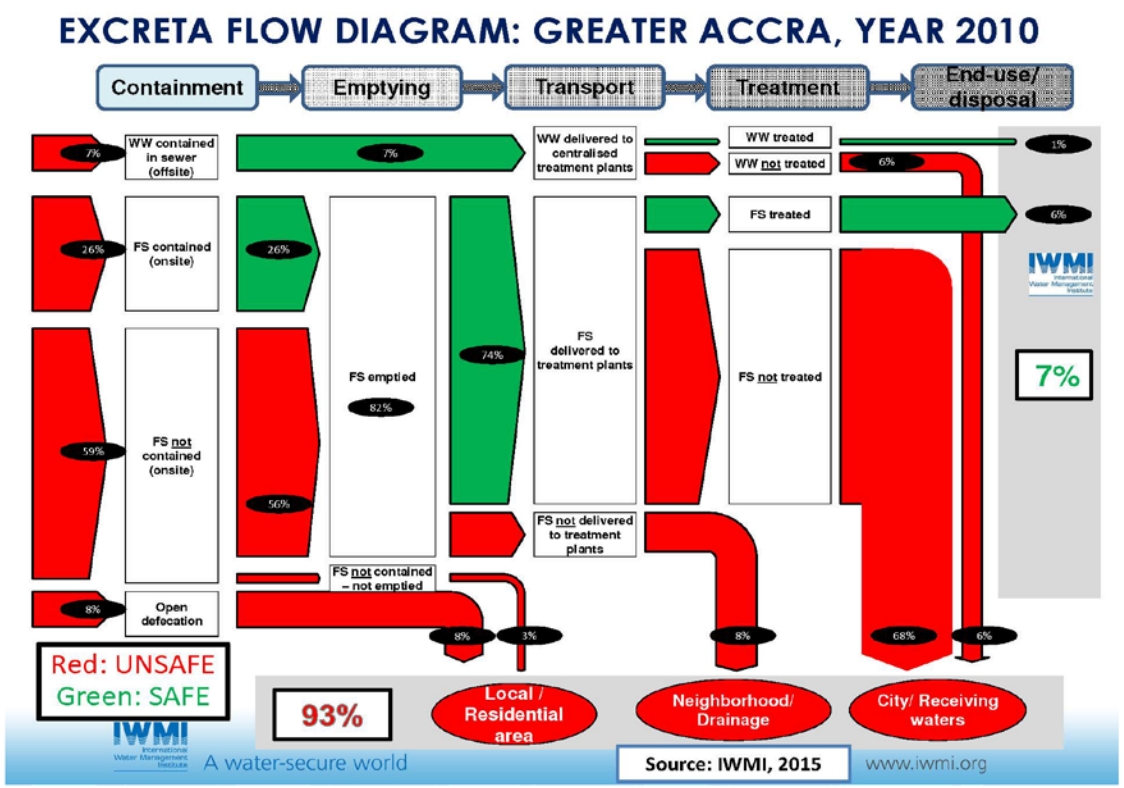
2019 Est. Population	30.1million

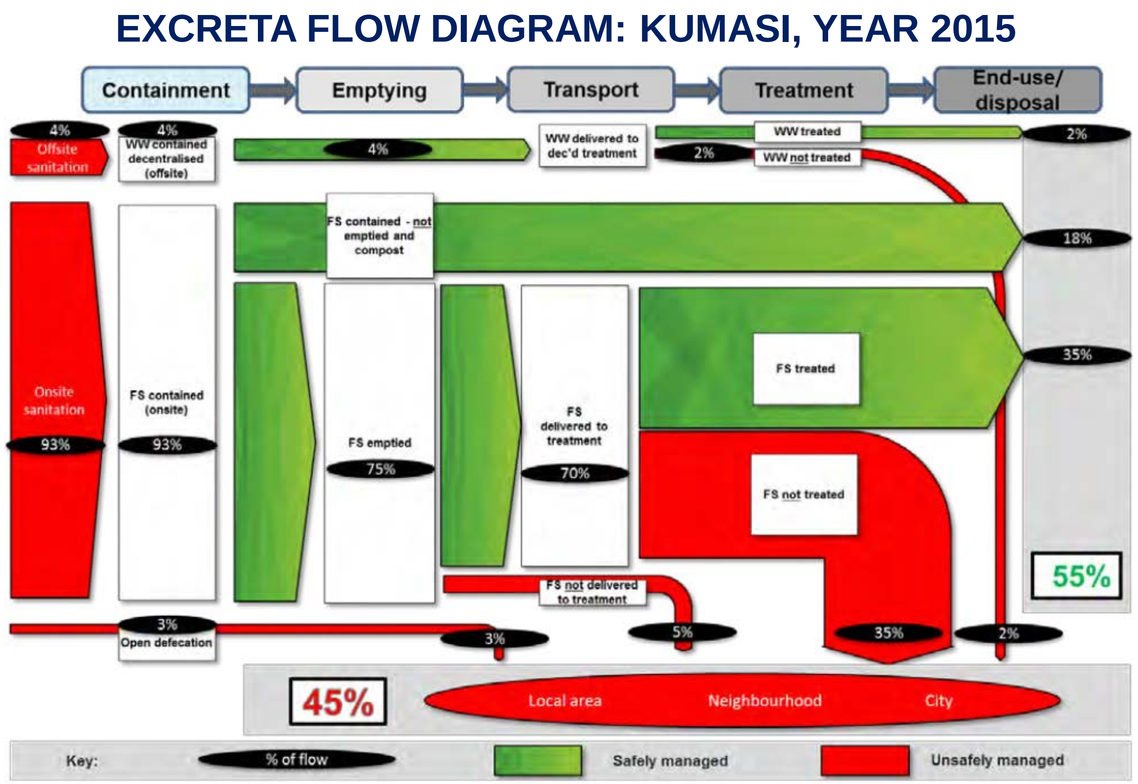
1/3	Population below the age of 12

Basic Sanitation

Less than 20% Households

Focus on Fecal Sludge Management in Accra/ Kumasi





SHIT FLOW DIAGRAM: shows that fecal sludge not contained and ends up in the urban environment

- 1st SFD (2010) – City of ACCRA: 7% is safely managed 93% is unsafely managed
- 2nd SFD (2015) – City of KUMASI: 55% is safely managed 45% is unsafely managed

The Sanitation Challenge in Ghana – Background

8

out of every

10

households have *E.coli* in their drinking water

(GSS, 2018)

- Metropolitan/Municipal **authorities lack the data and tools to track** the fecal contamination exposure pathways and assess the associated public health risks

- Matching these findings to the **SGD 6 Targets shows clearly the extent of sanitation burdens** city managers, policy and decision makers are faced with in Ghana

The Training Hub – Start Up Approach

- **Development of Project Information Materials**

- **Engagement with Key Stakeholders**
  - Meetings with key stakeholders at the National and local level
  - Signing of MoU with 2 beneficiary cities – Accra and Kumasi

- **Setting up Governance Structures for Project Implementation**
  - Establishment of Local Level Project Committees (Working Groups)
  - Establishment of the National SaniPath Steering Committee

- **Organisation of Project Inception Workshops**

The Training Hub – Capacity Building

- **Raising the awareness** of key decision makers
- **Training of Staff** of the 2 municipalities on the SaniPath Tool
- Assessment and selection of Trained officers to **constitute Deployment Teams**
- **Supported** KMA & AMA **staff to manage the deployment** of the SaniPath Tool in 6 neighbourhoods
- **Debriefing sessions with Working Groups** (SaniPath Project Committees) at the Municipal level

The Training Hub – Publicizing the SaniPath Tool

- **Developing advocacy materials** (Brochure, Banners, Presentations)
- **Dissemination on Web-based Channels and Social Media**
  - Twitter – @trendgroupgh
  - Facebook – TREND Group
  - Websites – www.trendgroupgh.org, www.sanipath.org
- **Dissemination through traditional media platforms**
  - Joy News
  - Kessben TV
  - TV3
  - Graphic Communications Group
- **Dissemination through sector fora (Mole WASH Conference in Ghana)**

Contaminated foodstuffs major health risk

By Juliet Akyaa Safo, ACCRA

CONTAMINATED foodstuffs have been identified as one of the major health risks in Accra, surpassing choked drains, public latrines and flood often known for major causes of disease outbreaks.

Therefore, authorities have been called upon to pay more attention in ensuring that raw produce across the country is properly regulated and handled.

This was revealed during a meeting to launch Phase III of a sanitation project dubbed: "SaniPath project" in Accra yesterday aimed at addressing public health risks of the exposures of faecal contamination.

The project is funded by the Bill and Melinda Gates Foundation and supported by the Council for Scientific and Industrial Research (CSIR), Training Research, Networking for Development (TREND), Centre for Global Safe Wash (CGSW) and other government agencies.

Project

According to the Managing Consultant at TREND, Mr Benedict Tuffour, the project had since 2011 conducted studies in areas such as Kokomlemle, Chorkor, Ringway, Alajo, Bukom and Adabraka, all of which recorded high numbers in foodstuff contamination.

He added that the study was conducted using the SaniPath Exposure Assessment Tool.

"The SaniPath Exposure Assessment Tool was, therefore, designed to assess public health risks related to poor sanitation and help prioritise sanitation investments based on exposures that have the greatest public health impact," he explained.

Purpose

The Phase III of the project is an effort to guide metropolitan, municipal and district assemblies (MMDAs) to effectively utilise the limited resources allocated to solving sanitation challenges.

It is also aimed at providing data and tools to track faecal contamination exposures and assess the associated public health risks.

Resources

The Country Programme Manager of SaniPath, Mr Habib Yakubu, in an interview with the *Daily Graphic* said the SaniPath project would also help the assemblies spend money wisely in terms of sanitation interventions across the country.

"Cleaning our environment every Saturday might not be the solution. The solution may be to check the state of our foodstuffs; thus, the SaniPath tool is to help the assemblies focus on their problems and invest accordingly," he stated.

Project

The Deputy Director at the Accra Metropolitan Assembly (AMA), Mr Dey Kukubor, who spoke on behalf of the Chief Executive of AMA, Mr Mohammed Adjei Sowah, said the project came in handy, adding that it would help facilitate the President's vision of making Accra the cleanest city in Africa.

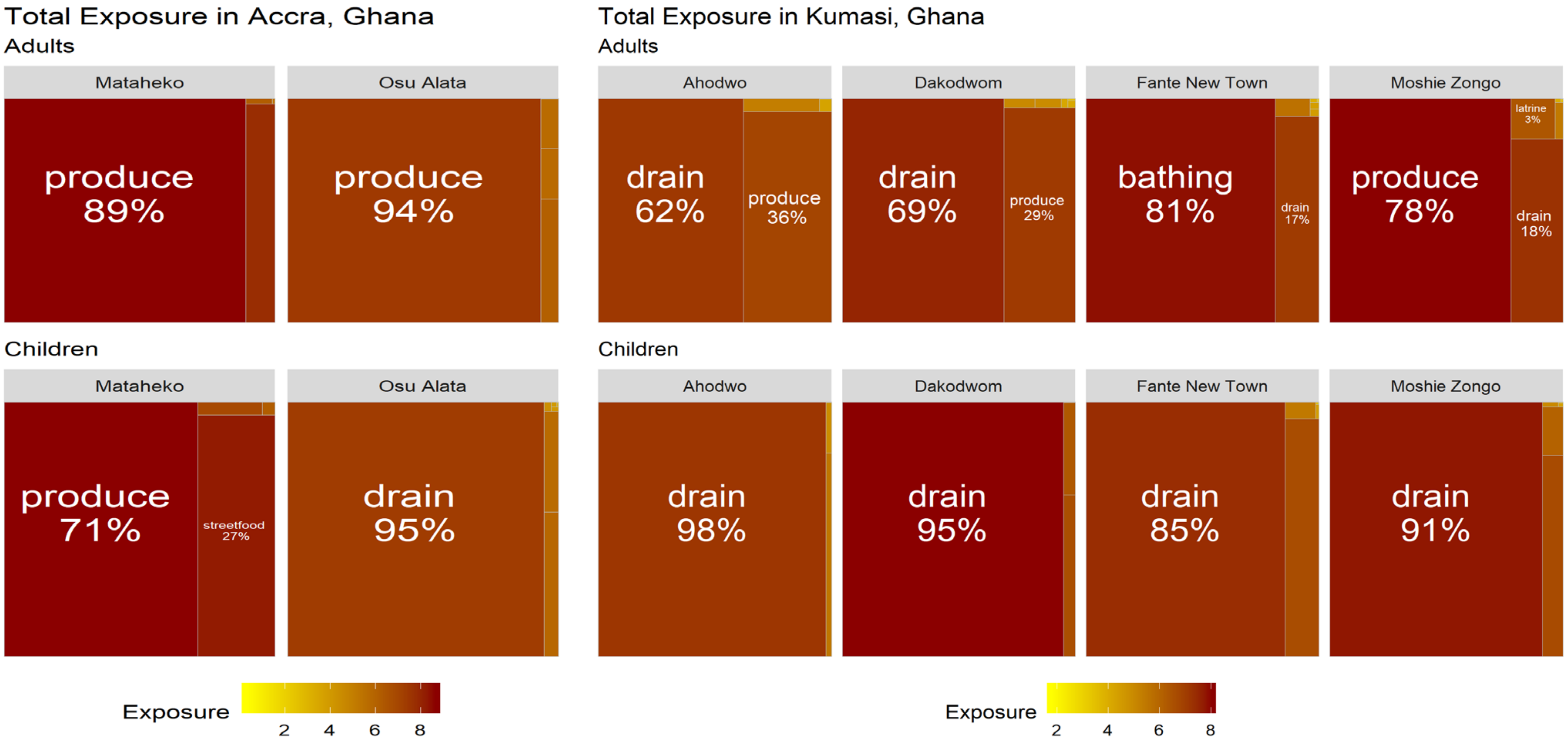
He added that the assembly was doing its best to achieve the President's vision, expressing its readiness to collaborate with organisations to improve the sanitation conditions within the metropolis.

Quick Read

The Phase III of the SaniPath project developed seven years ago was launched in Accra yesterday (Wednesday, August 8) to help MMDAs better prioritise sanitation investments.

• Mr Benedict Tuffuor (right), the Managing Consultant of Training Research and Networking for Development, with participants. Picture: ESTHER ADJEI

Results to Action – Overview of Results



Results to Action – Planning of Interventions

- **Plan for interventions and Implement Interventions**
  - Support Municipal Authorities **to review and understand the data** and Assessment report
  - Support Municipal Authorities to **identify intervention options** necessary to improve situation (both infrastructure solutions and software solutions)
  - Support Municipal Authorities to **develop plans and prioritize interventions based evidence** from the SaniPath Deployment
  - Support Municipal Authorities to **use existing institutional arrangements to roll out** interventions in target Neighbourhoods
  - Support Municipal Authorities to **develop proposals for funding** to implement interventions

Communicating Results – Stakeholder Engagements

- **Stakeholder Engagements/ Dissemination of SaniPath Assessment Results**
  - Consultations with related sector stakeholders – ***to obtain broad acceptance and buy-in***
  - Packaging of Assessment results for dissemination (***Factsheets/ Posters/ Reports/ PowerPoint***)
  - Dissemination workshop at the Municipal Level – ***to trigger local level action***
  - Dissemination at National Level (Sector Ministries and Actors) – ***for policy influencing***

- **Publicize the SaniPath Initiative and promote the SaniPath Tool**
  - National Awareness Campaign on evidence based planning – (***Workshop for 11 Municipalities in the Greater Accra Metropolitan Area***)
  - Meet with key Sector organisations to ***demonstrate the potential of the SaniPath tool*** in Urban CLTS/ CLUES, Water Safety Planning and other ongoing projects in the sector
  - Use outcomes of dissemination activities ***to influence Sector policy and project design***

Key Take Away

- **National Level Influence**
  - Integration into the new "National Liquid Waste Model and Strategy"
  - Planned engagement with the Head of the Local Gov't Service for integration into skills development for Public Health Officers
- **Municipal Level Influence**
  - Quick gains in the work of Public Health Officers in Kumasi (the case of effluence being discharged into a surface water within study community)
  - Input into ongoing hygiene promotion and educational activities

THANK YOU

For more information visit www.sanipath.org

The use of sanitation planning tools and data to inform Kampala city sanitation investment and intervention decision making.

Dr. Richard K. Mugambe
Makerere University School of Public Health

and

Mr. Sammy Ejoga
Kampala Capital City Authority

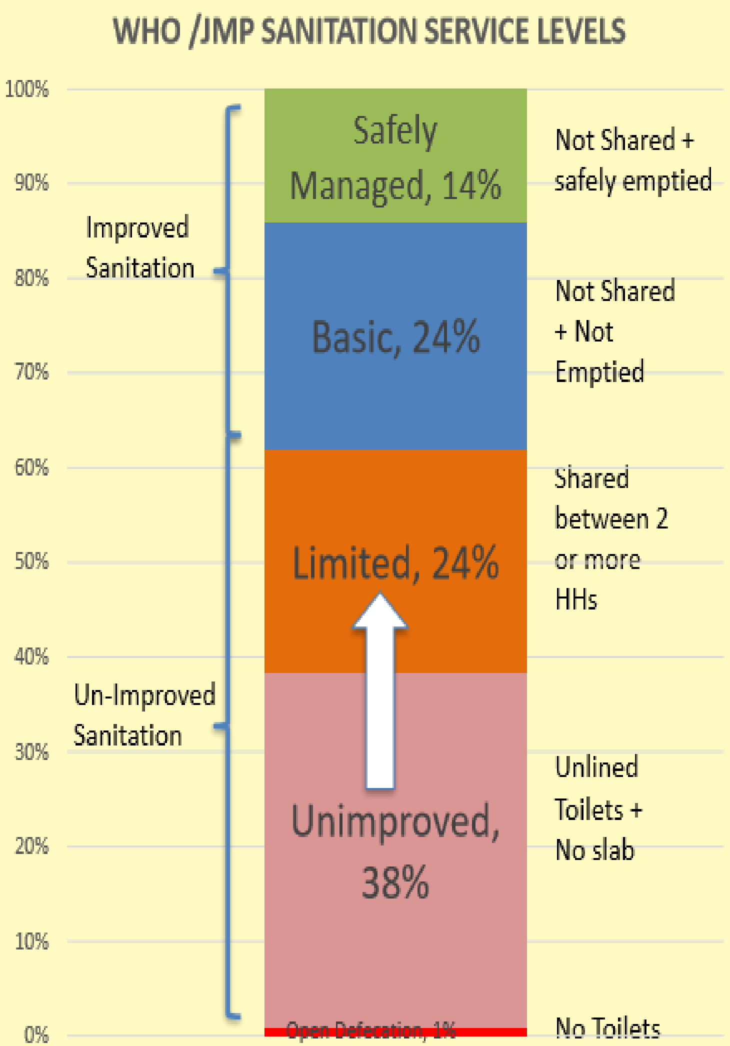
Status of Sanitation in Kampala

- 6% - Centralized sewerage system
- 1% No access to a sanitation facility
- 93% - On-site systems

❖30% Septic tanks
❖62% Pit latrines
❖8% other systems

Status of Sanitation in Kampala II

ACESS TO SANITATION



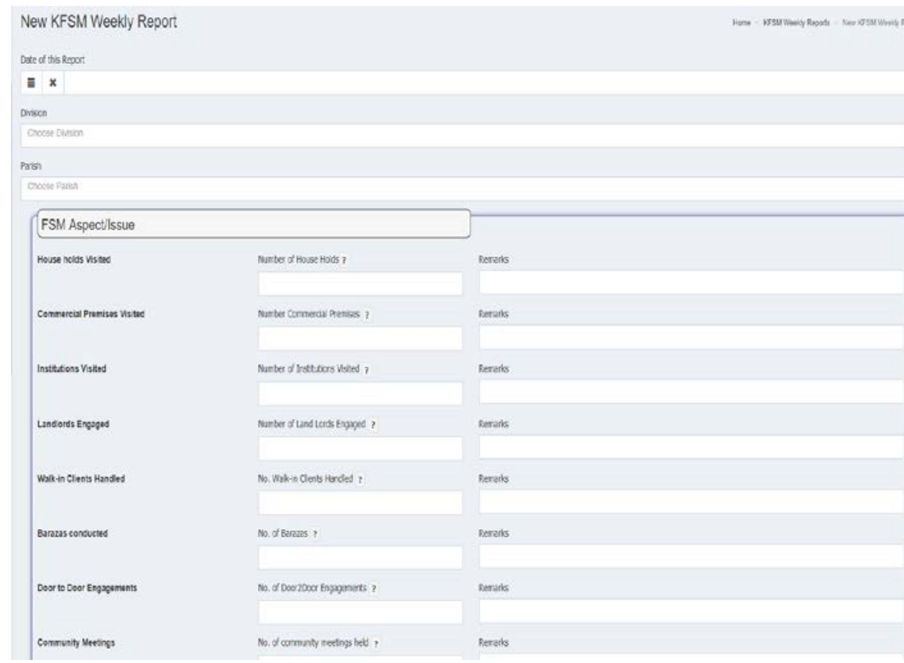
SHIT FLOW DIAGRAM

Use of sanitation planning tools to inform decision making

TRACKING WEYONJE APP

- Establish demand patterns for pit emptying in Kampala
- Ensure feacal sludge is not illegally disposed e.g. into wetlands

MUNICIPALITY REPORTING TOOL



Sanipath Tool

Why the tool?

- Previous outbreaks of Faecal-oral transmitted diseases
- Choice of intervention (s) that cause the biggest Public Health Impact has been a problem

Procedure

- Preliminary meetings: Emory University, MaKSPH and KCCA
- Identified study sites
- Capacity building at KCCA team (Co-funded)
- Data collection

Capacity development within Kampala Capital City Authority

- 60 Environmental Health Officers and other staff were trained:
  - Preliminary WASH assessments
  - Field data collection using mobile phones
  - Environmental sample collection
  - Analysis of environmental samples

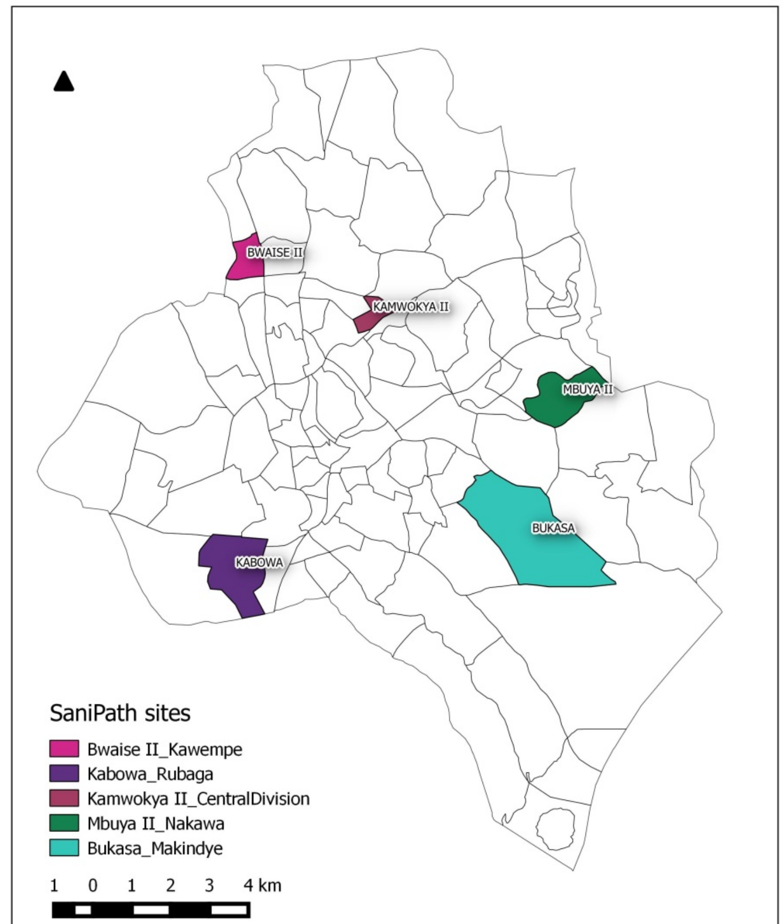
Use of sanitation planning tools to inform decision making II – Sanipath Tool

Data collection

- Preliminary assessments
- Behavioral surveys
  - Households (500 HH)
  - Community surveys (10)
  - School surveys (10)

- Collection and analysis of Environmental samples for E.Coli (Membrane Filtration Method)

Study sites



Environmental Sampling Procedure

Sample Type	Municipalities					Total
	Kawempe	Makindye	Central	Nakawa	Rubaga	
Latrine Swabs	10	10	10	10	10	50
Soil	10	10	10	10	10	50
Drain Water	10	10	10	10	10	50
Bathing Water	10	10	10	10	10	50
Drinking Water	10	0	10	10	10	40
Surface Water	10	10	10	10	10	50
Flood Water	10	10	10	10	10	50
Produce	10	10	10	10	10	50
Street Food	10	10	10	10	10	50
Total	90	80	90	90	90	440

Preliminary Results and decision making

Exposure to E.Coli through open drains in Children

	Environmental exposure
Kawempe (n = 102)	84.6% exposed 8.3Log^{10} CFU/Month E.coli
Makindye (n = 127)	69% exposed 6.8Log^{10} CFU/Month E.coli
Rubaga (n= 107)	57.3% exposed 6.2Log^{10} CFU/Month E.coli
Central (n = 105)	69.4% exposed 6.0Log^{10} CFU/Month E.coli
Nakawa (n = 107)	76.1% exposed 6.0Log^{10} CFU/Month E.coli

Exposure to E.Coli through street food in Children

	Environmental exposure
Kawempe	89.8% exposed 1.6 Log10 CFU/Month E.coli
Makindye	99.8% exposed 11.5 Log10 CFU/Month E.coli
Rubaga	99.6% exposed 4.2 Log10 CFU/Month E.coli
Central	98.5% exposed 9.3 Log10 CFU/Month E.coli
Nakawa	99% exposed 1.8 Log10 CFU/Month E.coli.

Preliminary Results and decision making

Exposure to E.Coli through Flood water in Children

	Environmental exposure
Kawempe (n = 102)	94.7 % exposed 5.1 Log^{10} CFU/Month E.coli
Makindye (n = 127)	61.5% exposed 5.3 Log^{10} CFU/Month E.coli
Rubaga (n= 107)	43.5% exposed 6.8 Log^{10} CFU/Month E.coli
Central (n = 105)	57.1% exposed 5.2 Log^{10} CFU/Month E.coli
Nakawa (n = 107)	72.4% exposed 4.7 Log^{10} CFU/Mon. E.coli

Exposure to E.Coli through Produce in Children

	Environmental exposure
Kawempe	75.2% exposed 3.1 Log10 CFU/Month E.coli
Makindye	60.2% exposed 8.2 Log10 CFU/Month E.coli
Rubaga	60.2% exposed 2.6 Log10 CFU/Month E.coli
Central	59.8% exposed 24.7 Log10 CFU/Month E.coli
Nakawa	67.3% exposed 5.4 Log10 CFU/Month E.coli.

Key messages

- The Sanipath tool is useful in determining pathways that:
  - Expose the biggest number of people to fecal contamination in different areas
  - Have highest levels of fecal contamination

- That information helps decisions on which:
  - Which behaviors to address in controlling fecal-oral exposures

  - Which structural interventions to undertake in order to get the most significant reductions in fecal-oral exposures/diseases

SaniPath assessment of fecal exposure pathways in low-income, high- income and floating communities in Dhaka city, Bangladesh

Mahbubur Rahman

Nuhu Amin

Environmental Interventions Unit

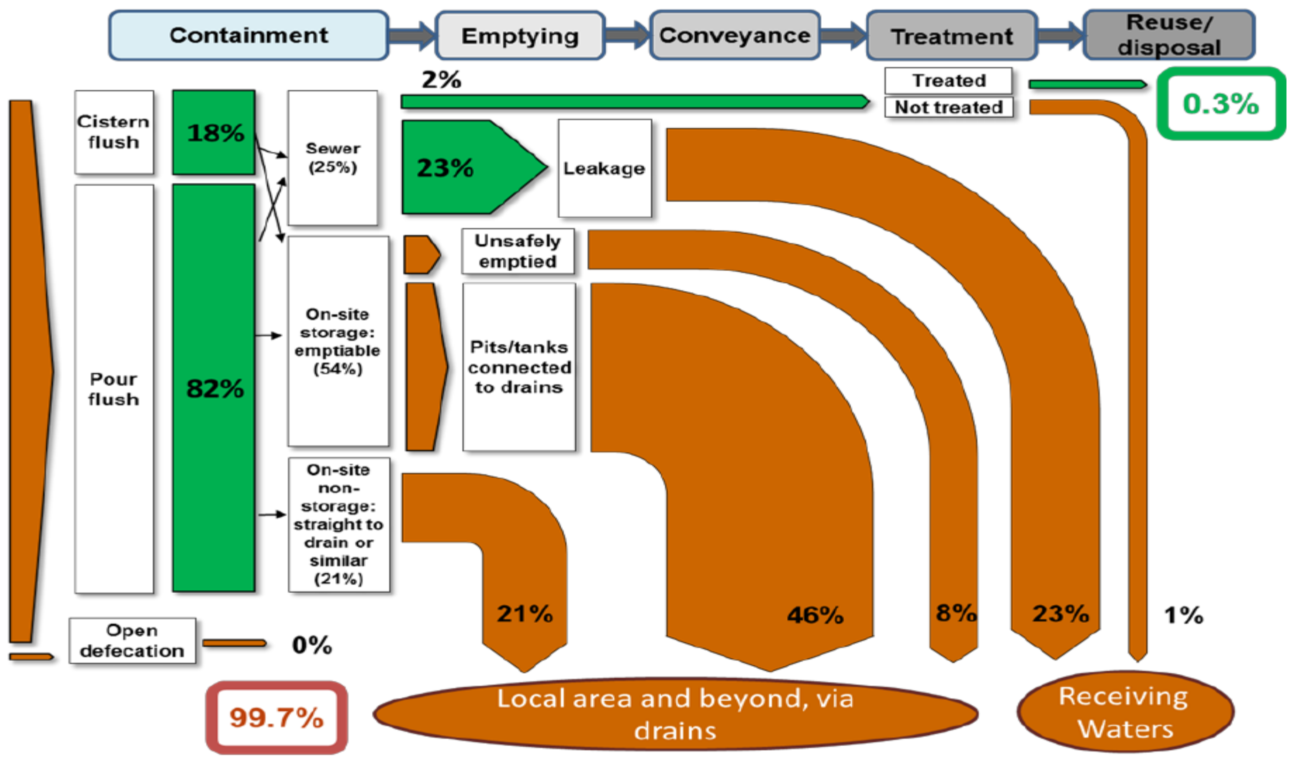
Infectious Disease Divisions, icddr,b

CTICC

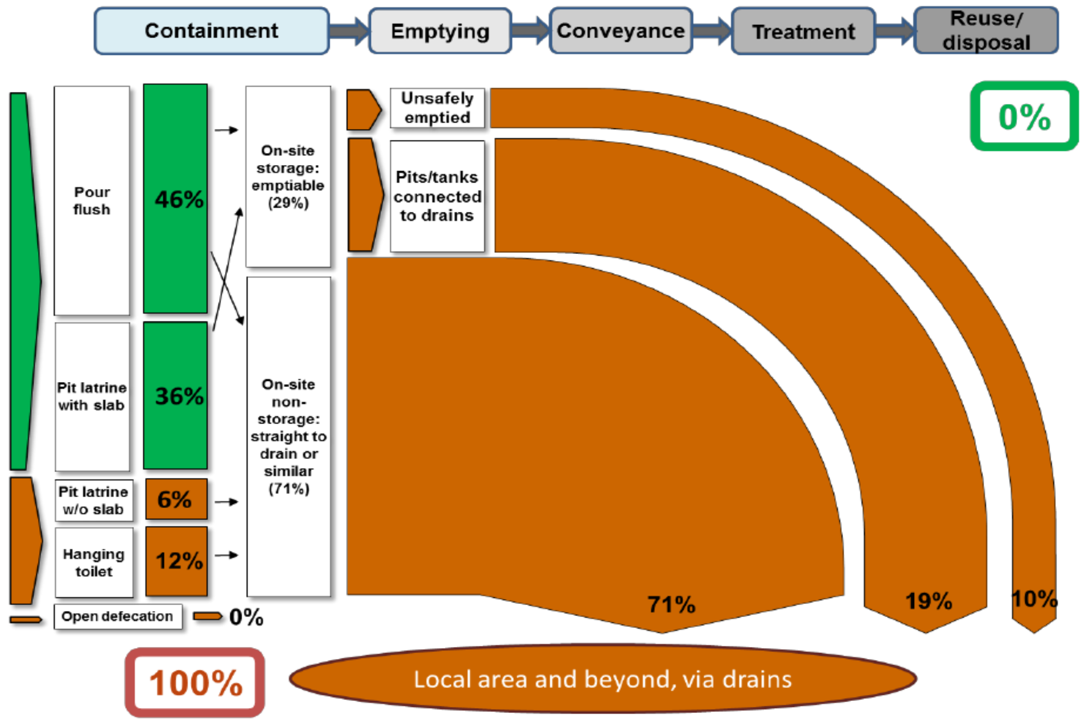
February 22, 2019

Dhaka fecal waste flows analyses

Dhaka City-wide



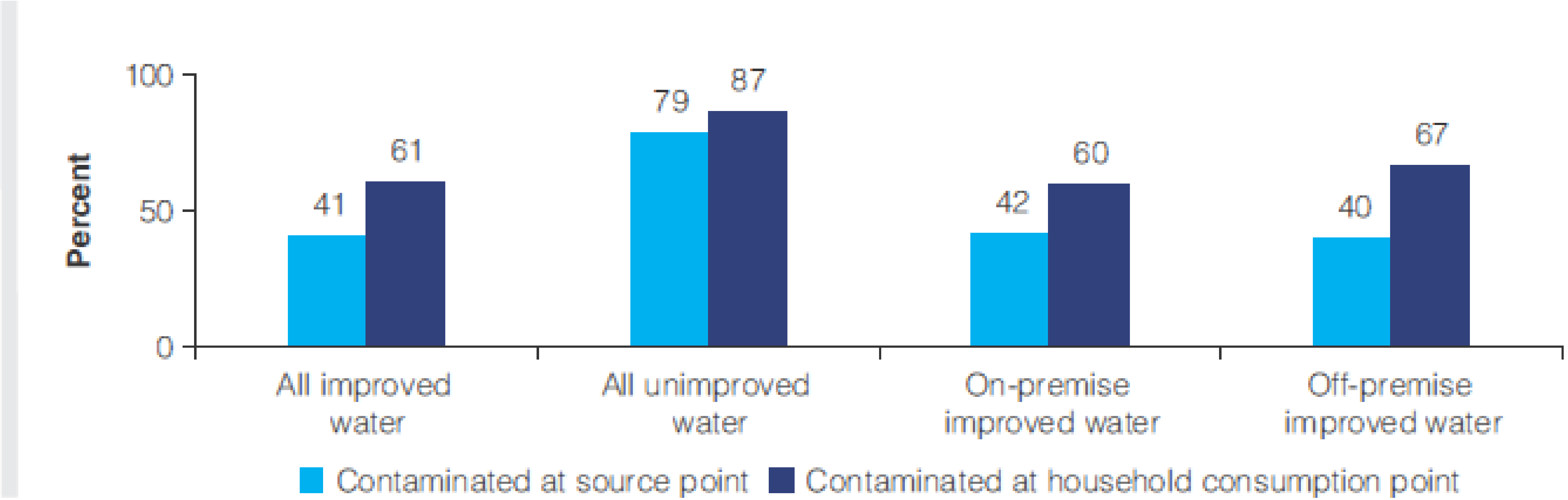
Dhaka Slums



WSP, WB - 2016

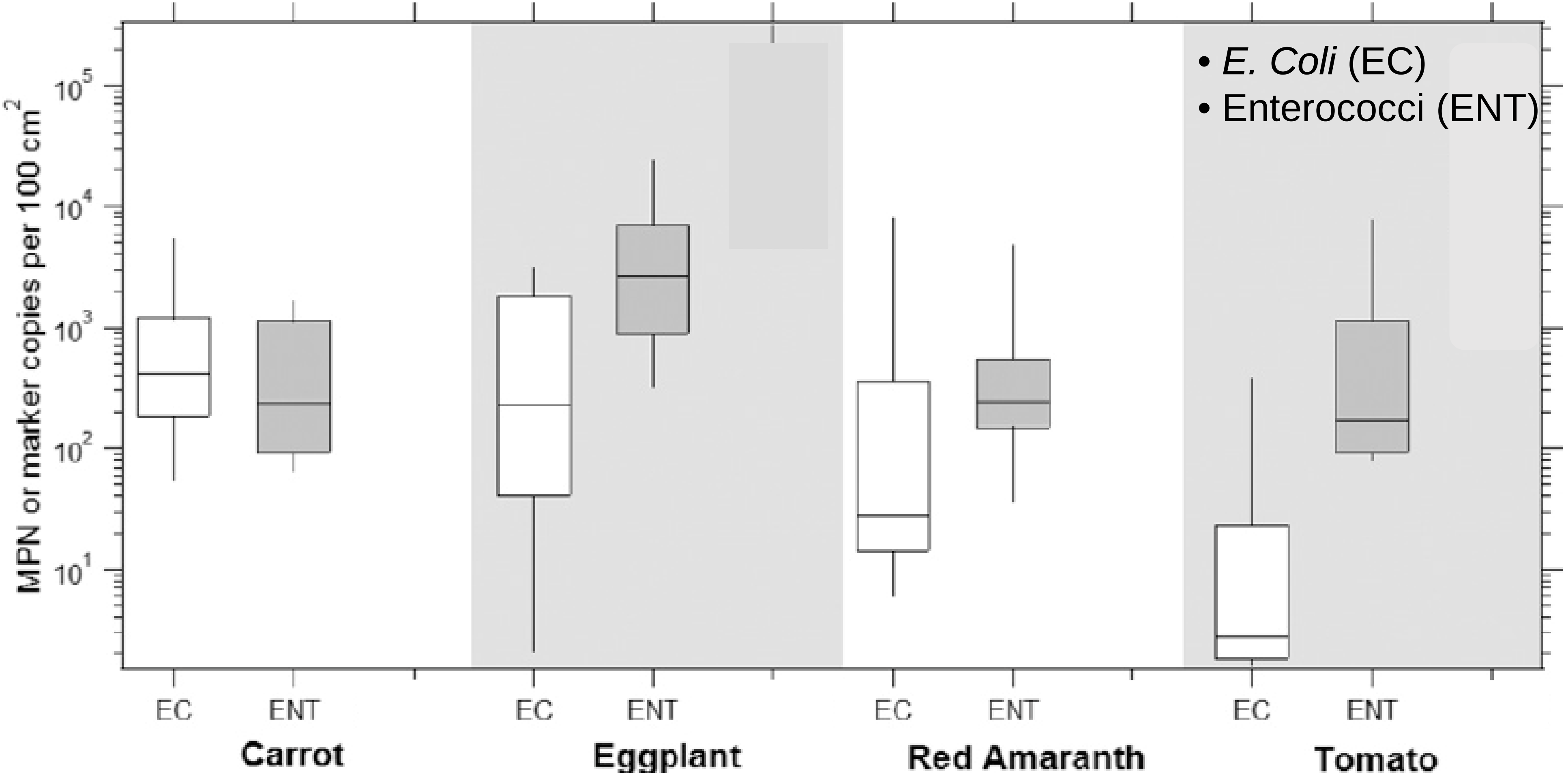
Fecal contamination of the municipal water is common

E. coli Contamination at Source and Household Consumption Points in Bangladesh, 2013



Source: World Bank calculations using Multiple Indicator Cluster Survey (MICS) 2013 data (UNICEF and BBS 2015).

High fecal contamination found on raw **produce** in Dhaka markets



(Harris et al. *Am. J. Trop. Med. Hyg.* 2018, 98:1)

Street food near Dhaka schools found contaminated

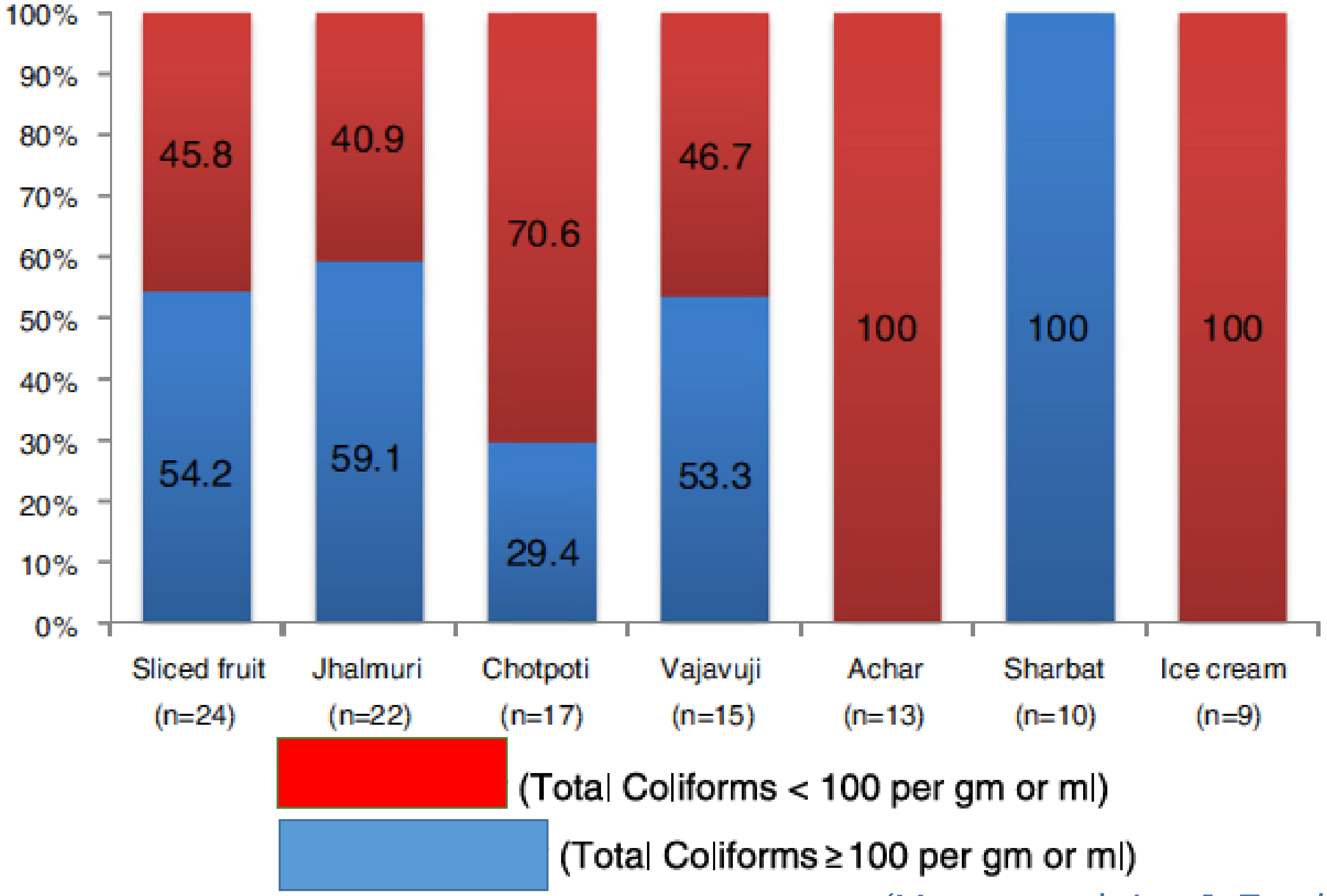


Figure: *Jhalmuri (Puffed rice)*

(Mamun et al. *Int. J. Food Microbiol.*. 2013, 116)

Knowledge gap

- **Limited information** on overall environmental contamination in different neighborhoods of urban Dhaka (Low/high income/floating communities)

- Little data to inform **strategies to mitigate risks of fecal exposure** in low-income countries

- Lack of policy/oversight on produce and street food consumption and risk mitigating factors

Figure: Street food *Fuska*

Objectives

- To explore the potential fecal contamination sources in urban neighborhoods of Dhaka

- To compare the fecal contamination exposures from **different environmental sources** and **in different urban neighborhoods** of Dhaka

Photo: Urban Slum of Dhaka

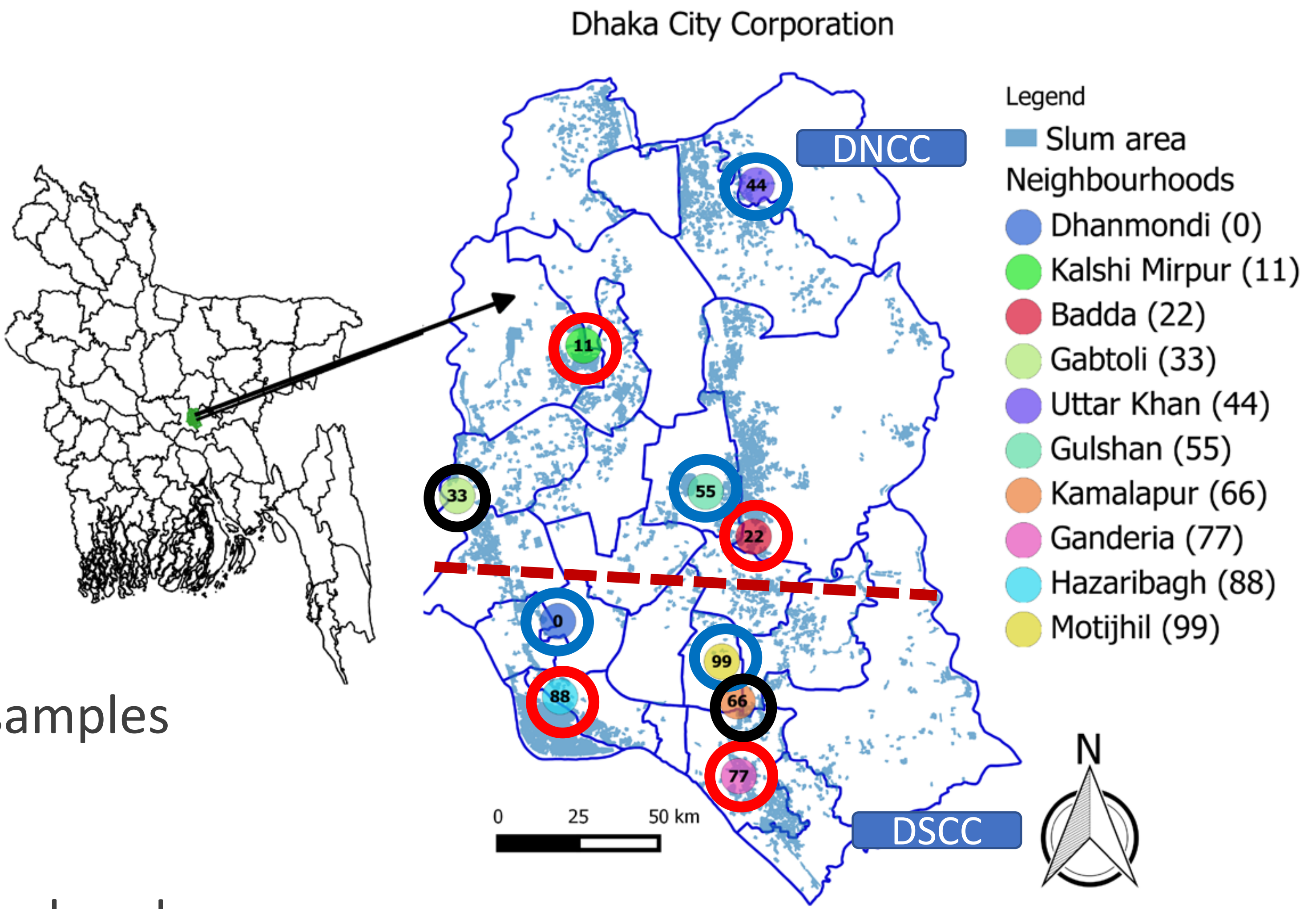
Study sites

- The sampling neighborhoods selected based on
  - ➢ the socio-economic status and
  - ➢ water, sanitation and hygiene (WASH) facilities

- **Ten** neighborhoods in Dhaka city
  - ➢ **4 low-income**
  - ➢ **4 high-income areas**
  - ➢ **2 transient communities**

- Equal number of neighborhood and samples were enrolled from DNCC and DSCC

- >300 HHs in each low-income neighborhood



10 types of environmental samples collected from each neighborhood

Surface water

Non-WASA water

Soil

Latrine Swab

Flood water

Street food

Raw produce

WASA Water

Open drain

Bathing water

Total1000 samples collected

Behavioral and microbial data

- **SaniPath deployment manual used**

- Study period: April 2017 to January 2018

- Conducted 300 Households surveys
- Surveys at 4 schools

- IDEXX QuantiTray 2000 tray containing Colilert reagent

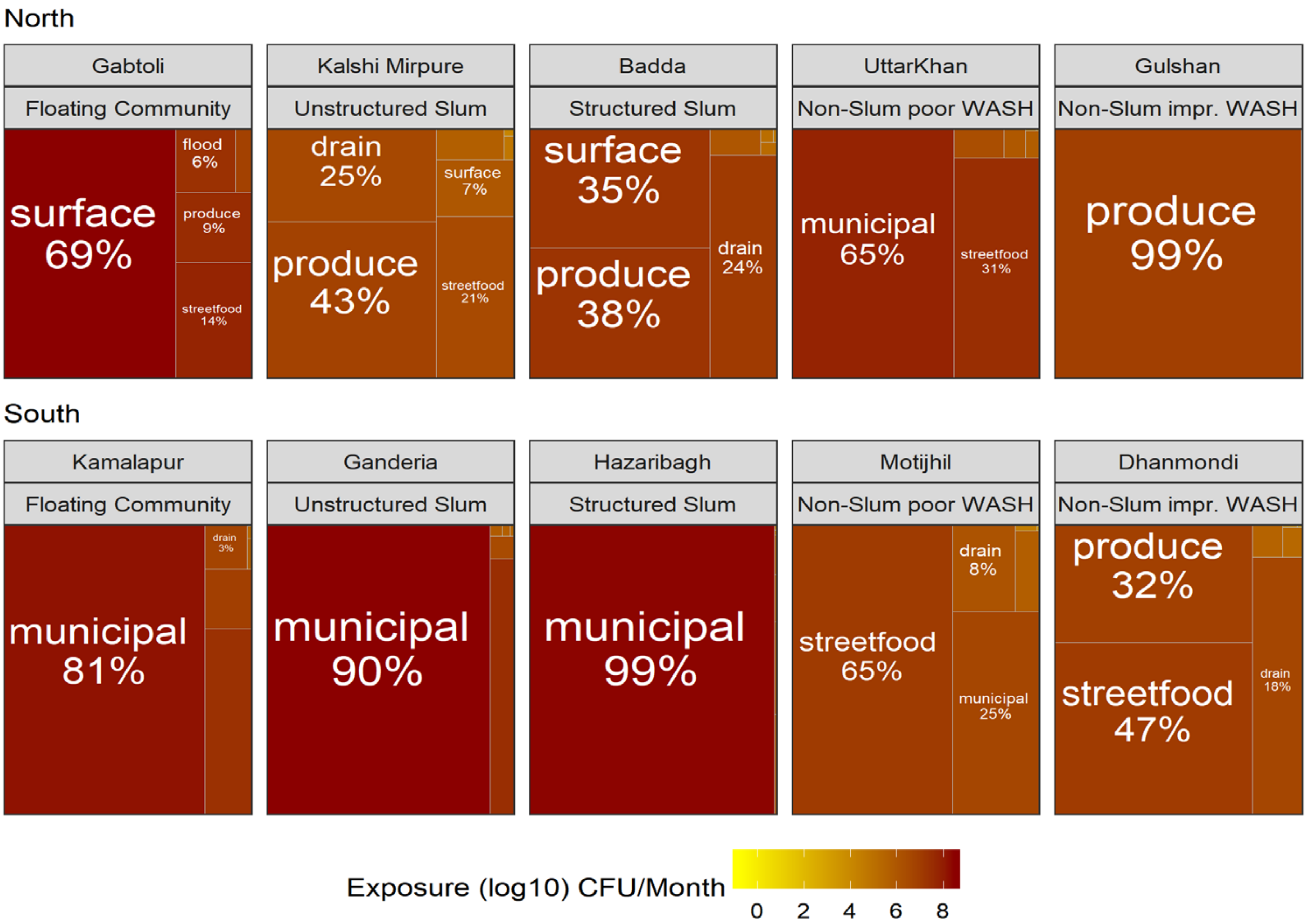
Photo: Conducting school survey

E. Coli positive IDEXX tray

Total Exposure for Adults

Dominant Pathways:

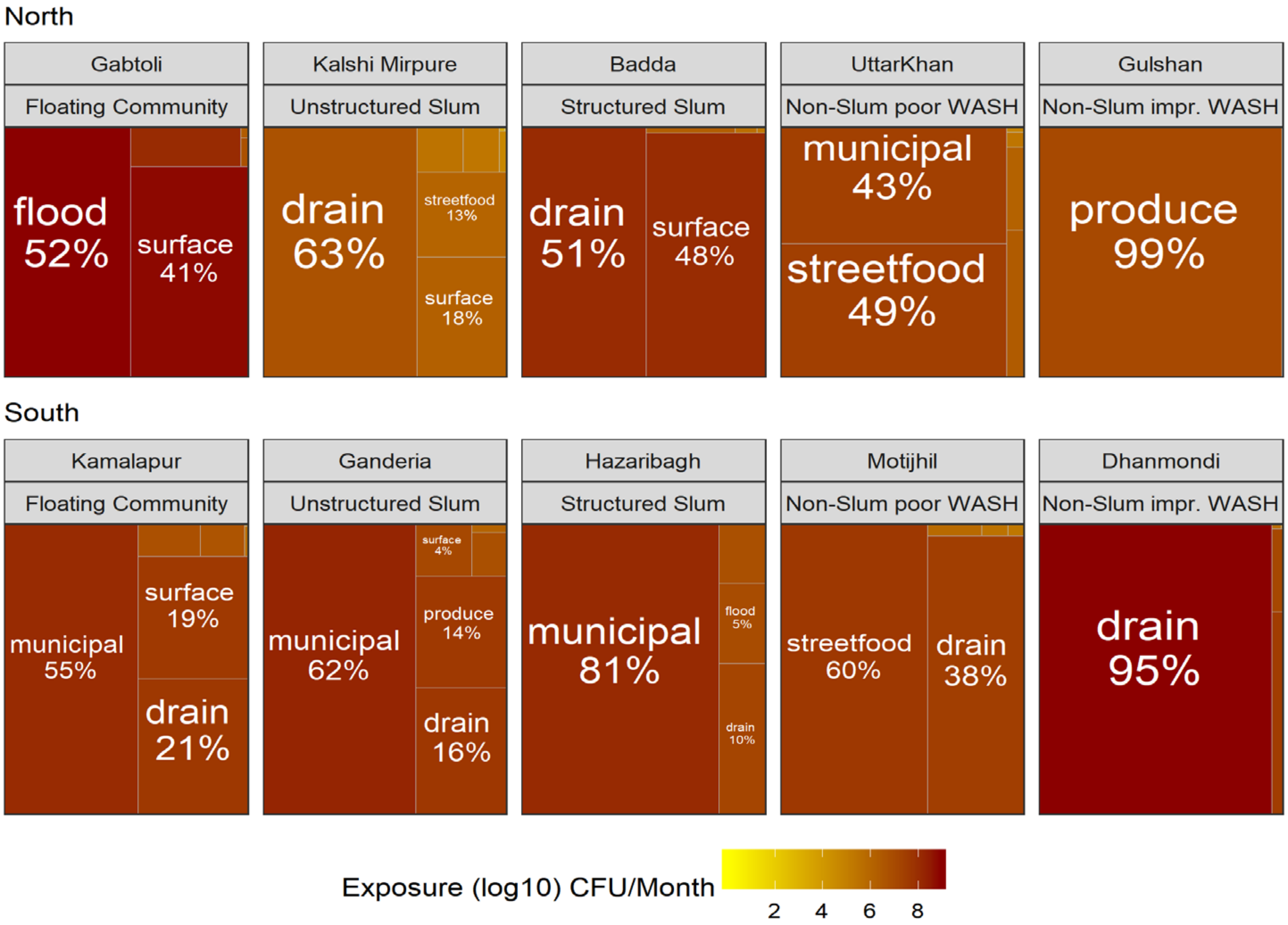
- Produce (6)
- Street Food (5)
- Municipal Water (5)
- Open Drains (4)
- Surface Water (3)



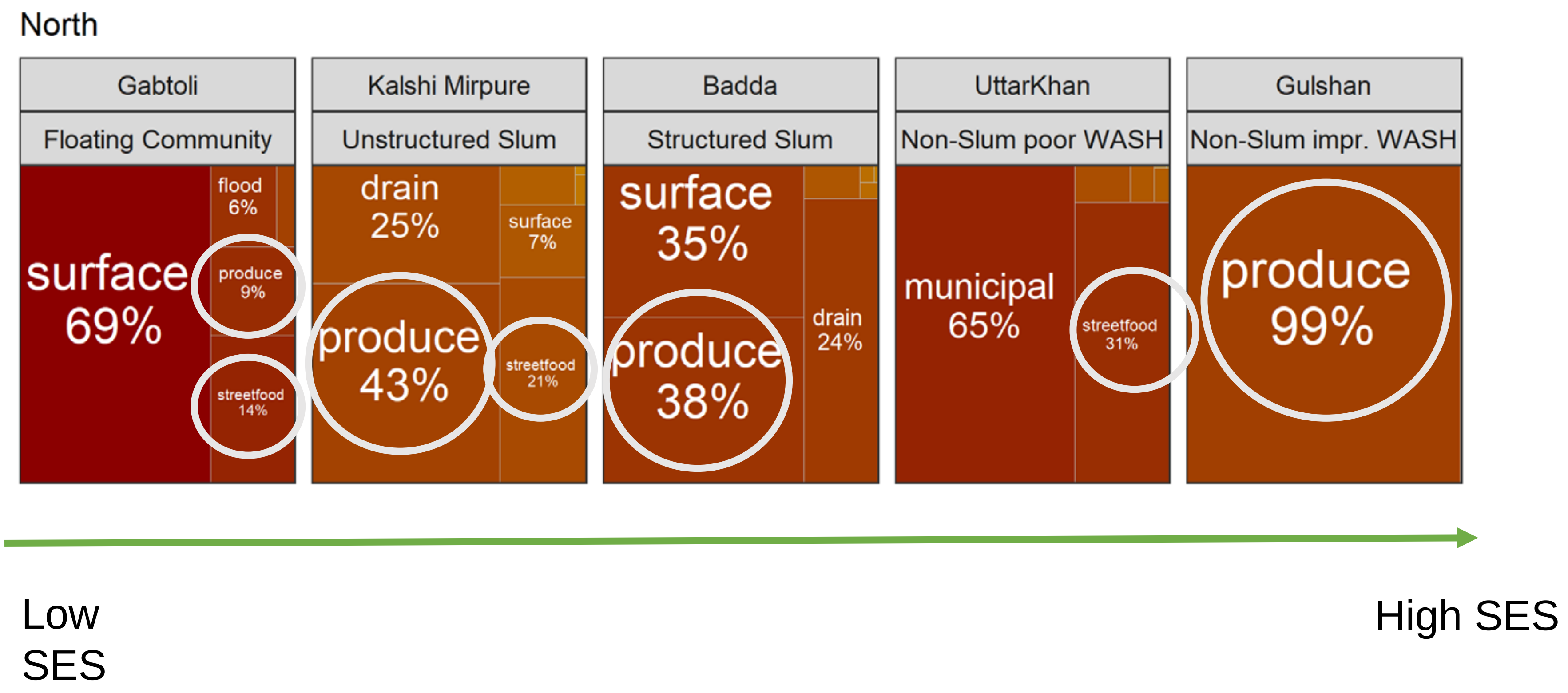
Total Exposure for Children

Dominant Pathways:

- Open Drains (7)
- Municipal Water (4)
- Surface Water (4)
- Produce (2)
- Street Food (2)
- Flood Water (1)



High Income Communities are also Exposed to Contamination through **Produce and Street Food**

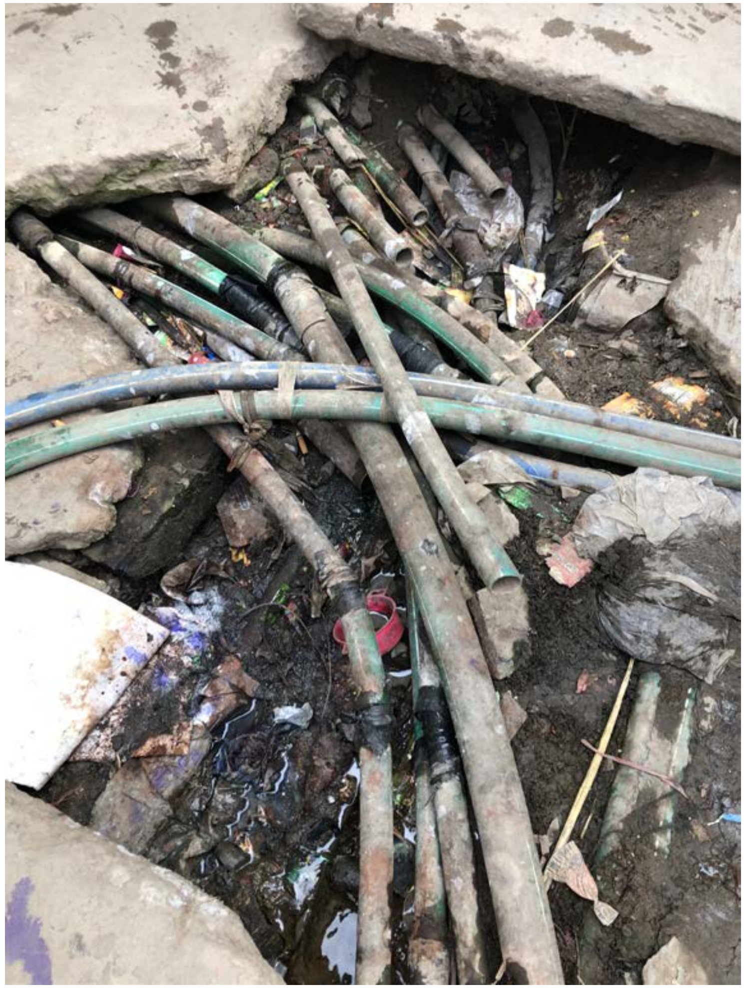


Key Findings and Observations

- All dominant pathways were driven by both high contamination and high frequency of exposure
- **Produce** and **street food** were highly contaminated and frequently consumed across the city in all neighborhoods
- Important differences between risks for adults and children
- SES and geographical location may be good predictors of WASH quality and fecal exposure for certain pathways such as municipal water, surface water, open drains, and flood water

Recommendations and Policy implications

- Identify the sources of the fecal contamination through more rigorous research
- Improving sanitary conditions including sewage system
- Long-term, integrated and sustainable programs
  - Infrastructure development and maintenance
  - Urban services
  - Innovative WASH and food safety technology development
  - Behavior change
- Future studies should assess health impacts of the environmental contamination among the **high-income** and **low-income communities** in Dhaka city



Follow-up funded research

How pathogen flows through the urban Dhaka?

Follow-up funded research

How produce and street food causes the health risk, urban Dhaka?

Follow-up funded researches

How to develop strategy for ensuring sewage connection in urban Dhaka?

WSUP
Water & Sanitation for the Urban Poor

DWASA, Harvard University

Follow-up funded research

What are the indicator criteria for shared sanitation in urban Dhaka?

WSUP

Water & Sanitation for the Urban Poor

EAWAG-SANDEC , ETH Zurich, Switzerland

SaniPath Dhaka team

Acknowledgements

- All co-investigators
- Study participants
- Data collectors and Lab staffs
- All Co-authors
- James Michiel (Emory University)
- Farzana Yeasmin

EMORY UNIVERSITY

The World Bank

BILL & MELINDA GATES foundation

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Government of the People's Republic of Bangladesh

Canada

SWEDEN

UKaid from the British people

Exposure assessment data collection in a Cholera-affected neighborhood and its implications on interventions

Grace Mwanza Ndashe

E.C. Mulwanda, N. Nan'gamba, C. Siesel, S. Raj, H. Yakubu, W. Mairinger, CL Moe, I. Nkhata

LUSAKA CITY COUNCIL

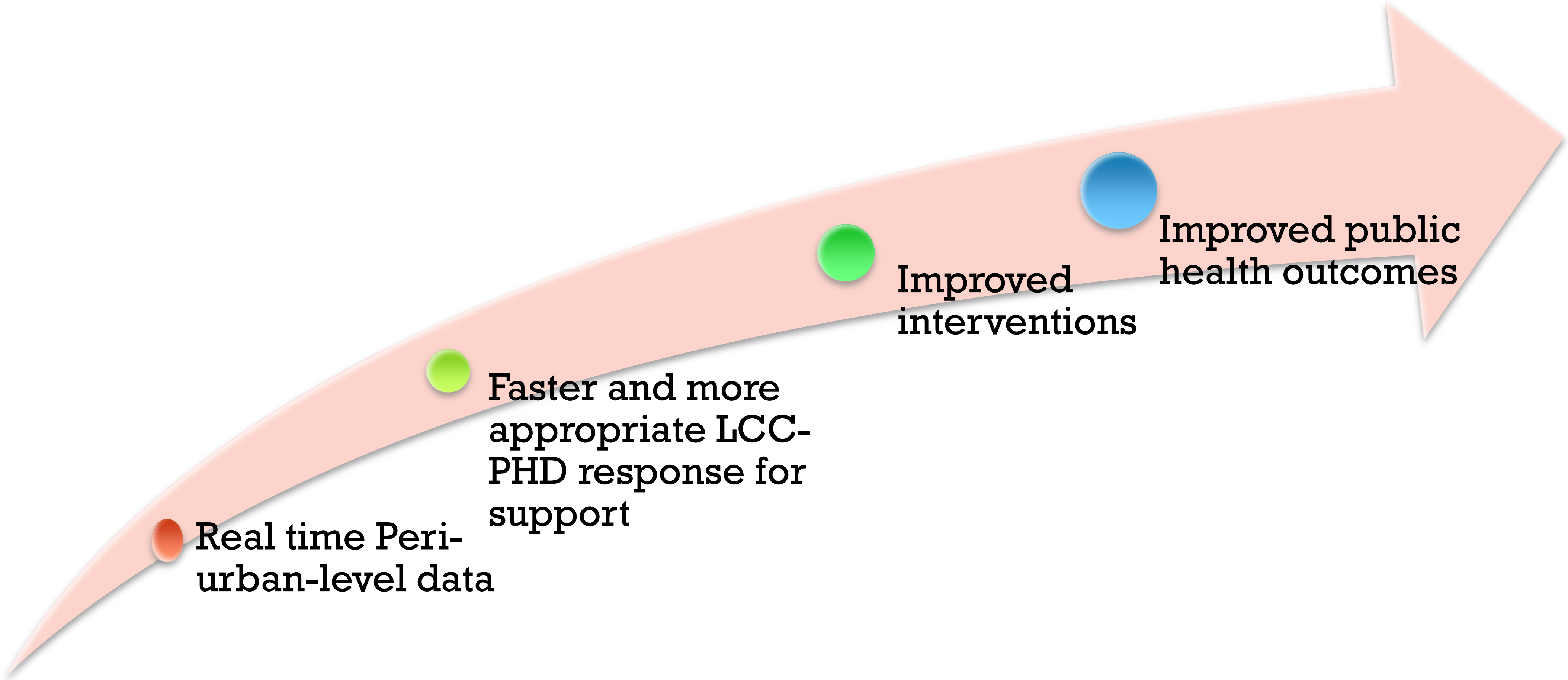
PRESENTATION OVERVIEW

+

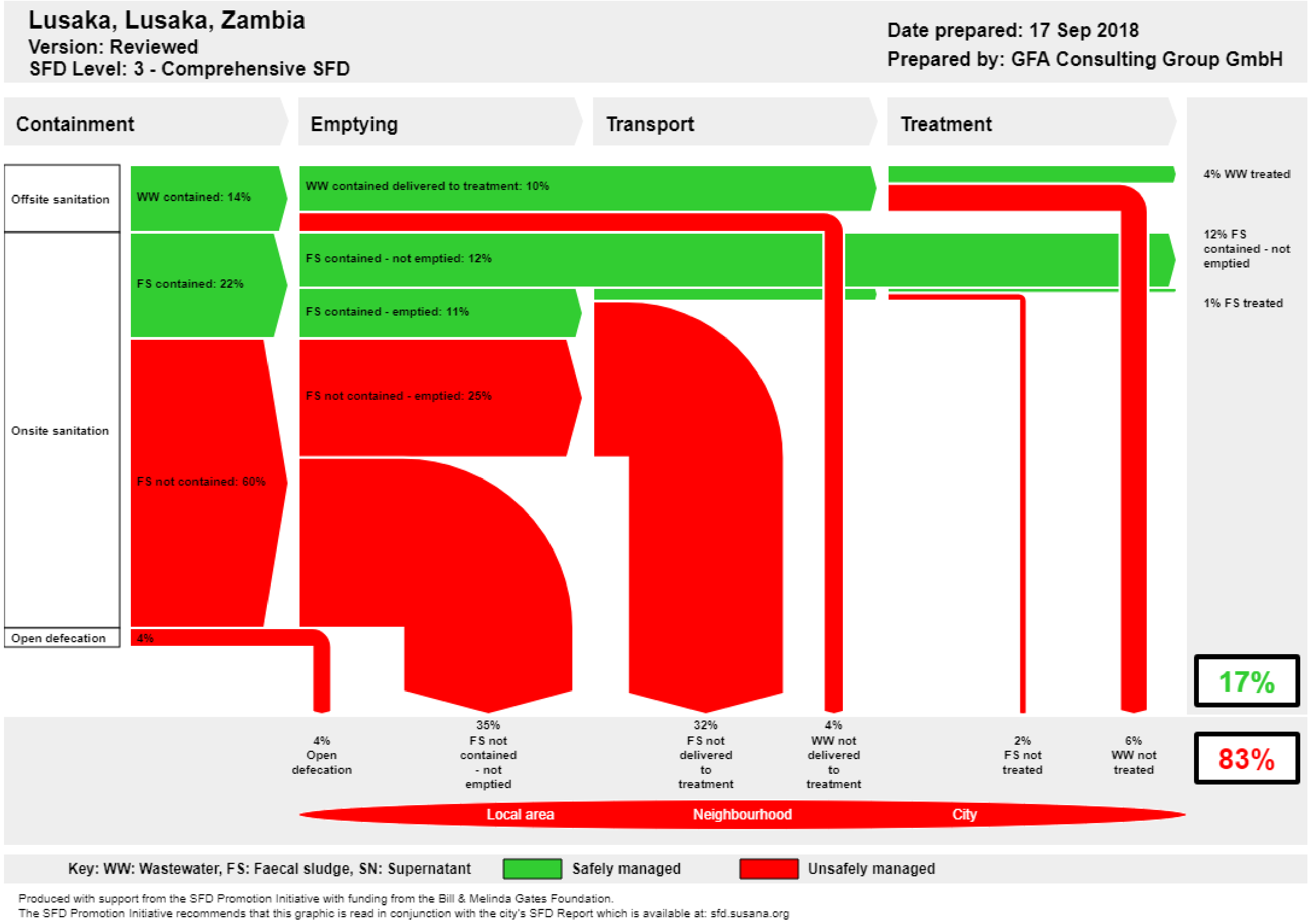
INTRODUCTION
WHY SANIPATH
OVERVIEW OF PILOT
WHAT WE LEARNED
GOING FORWARD

LCC-PHD OBJECTIVE:

To have evidence that would improve the Local Authority's capacity intervene and use information that leads to improved public health outcomes.

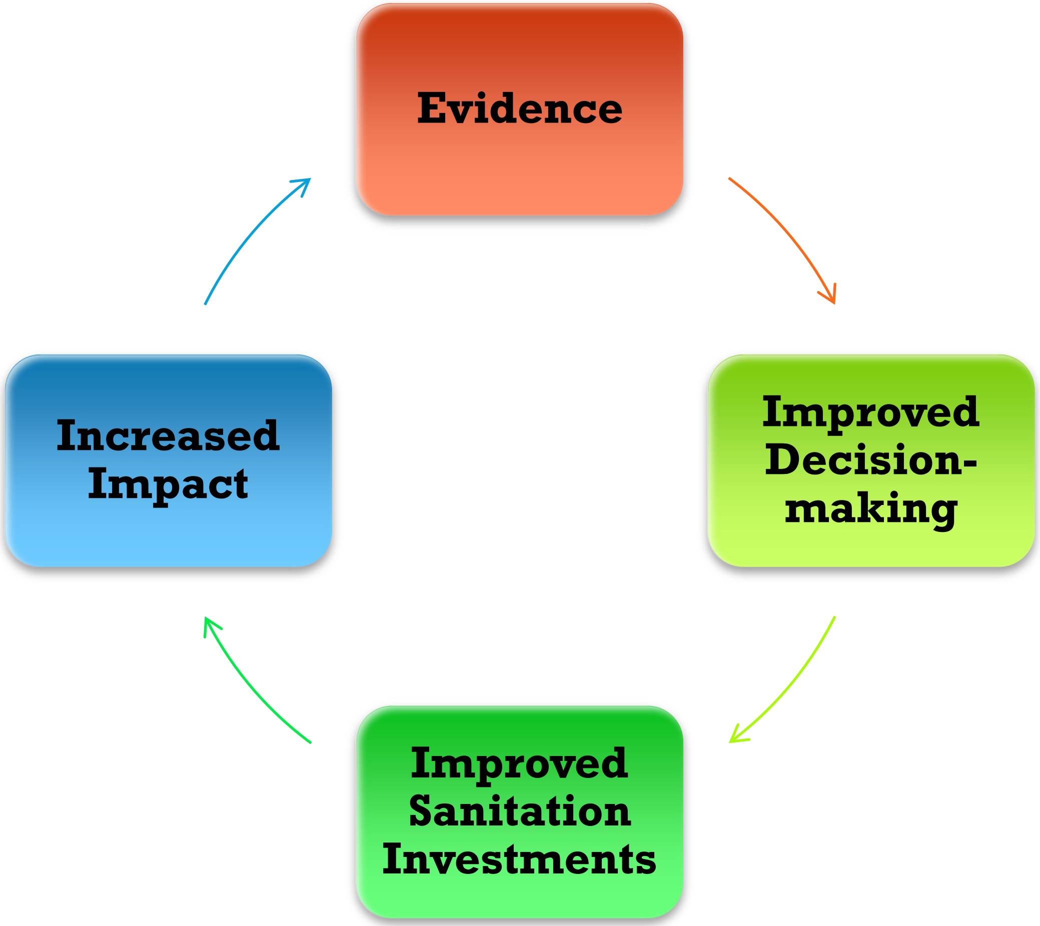


Shit Flow Analyses show that Fecal Sludge is NOT Contained – Reservoirs in Urban Environment



Why SaniPath?

- Exposure Assessment Tool designed to assess public health risks related to poor sanitation
- helps prioritize sanitation investments for greatest public health impact.



Overview of Pilot: Kanyama Compound

- Unplanned, legalized settlement
- Population 169,298 (36,834 households)
- Lies on a highly productive and vulnerable dolomitic karst aquifer
- 4 boreholes that feed 163 individual water points supply water
- Cholera epi-centre 2017-2018 outbreak

Pathways of Exposure – SaniPath Lusaka

Municipal Water

Borehole Water

Shallow Well Water

Open Drains

Soil

Street Food

Raw Produce

Public Latrines

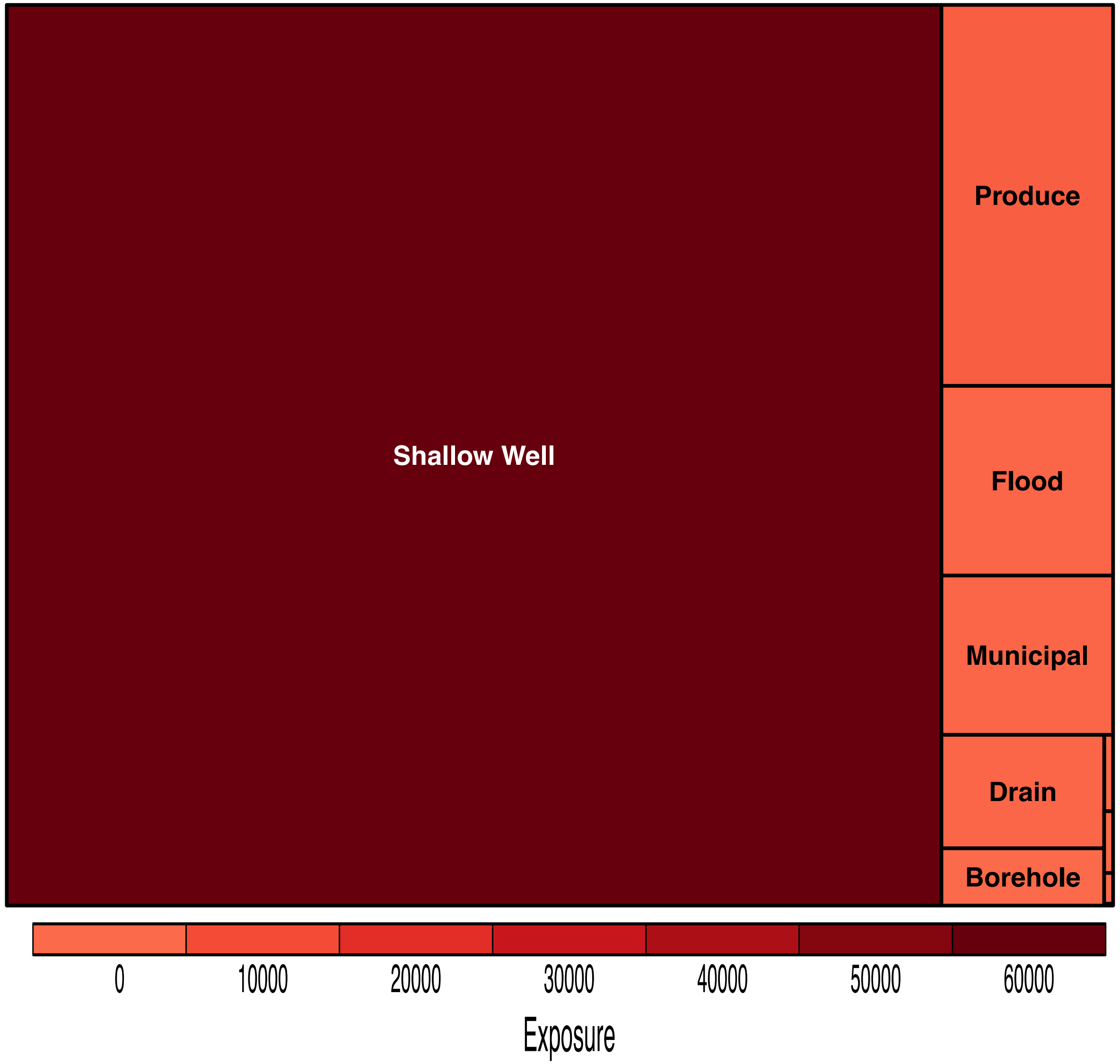
Shared Latrines

Flood Water

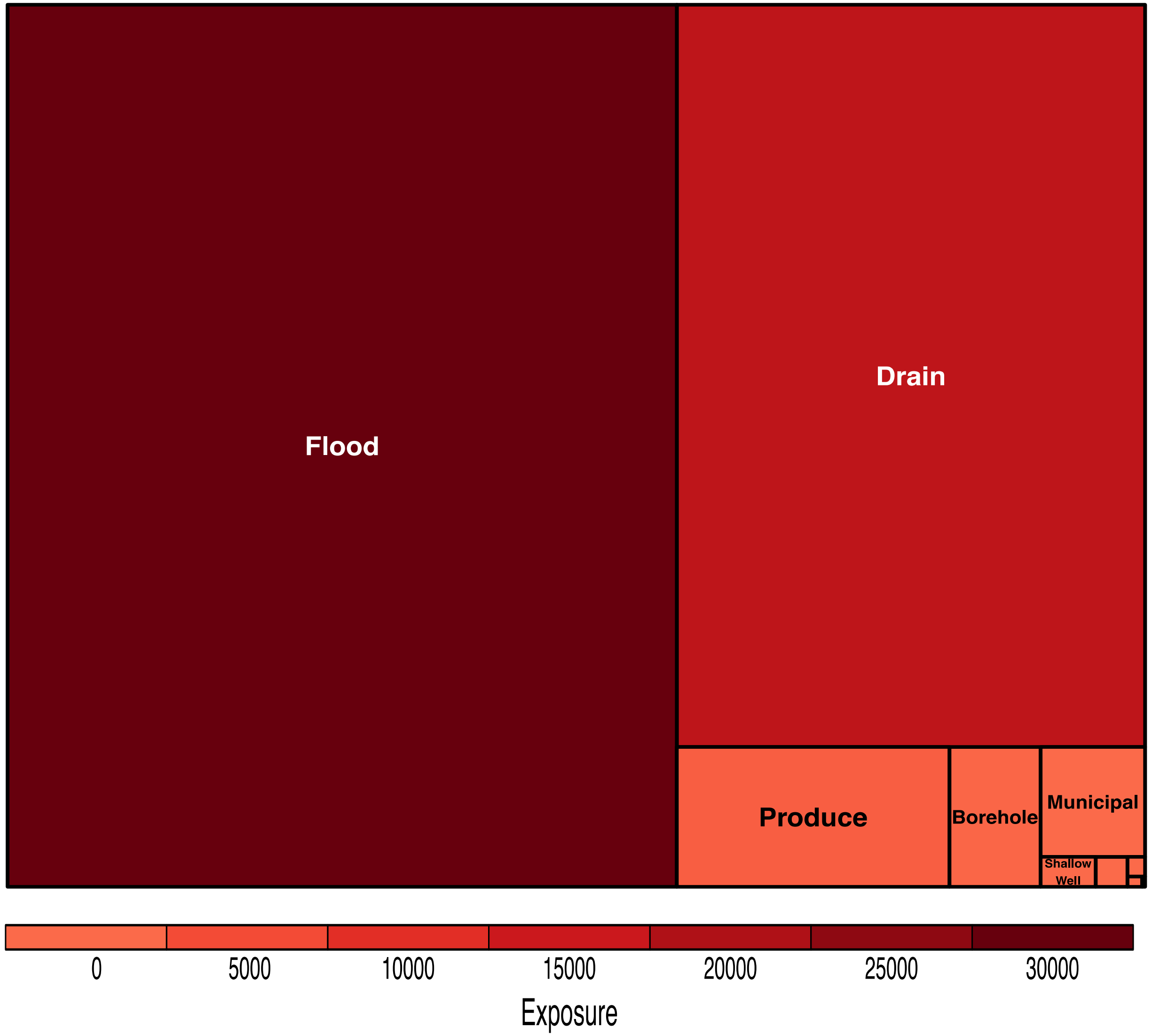
2. WHAT WE LEARNED

Exposure to faecal contamination

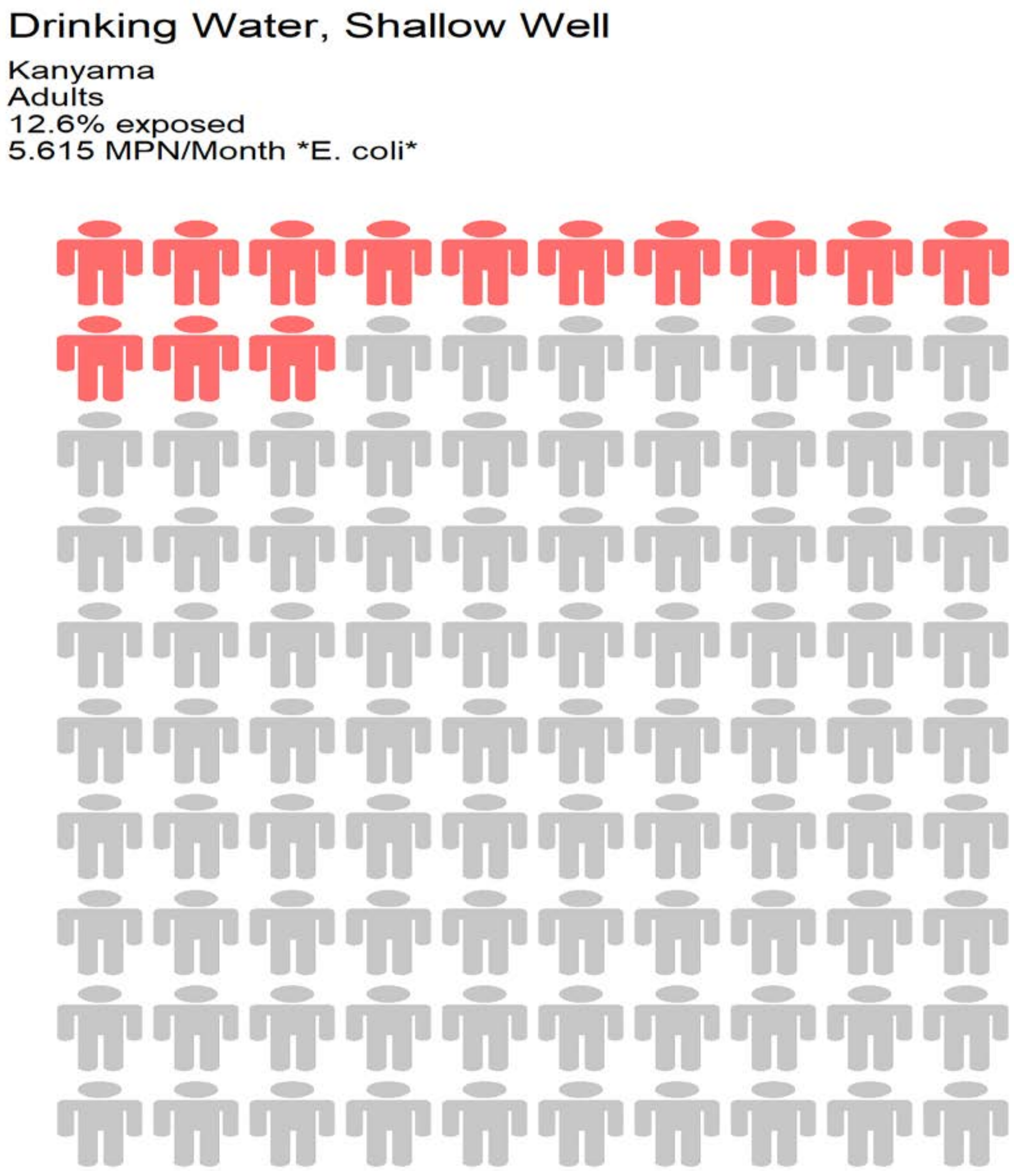
Adult



Children



Action to bury Shallow Wells



Children:
2.2% exposed, 3.811 MPN/Month *E. coli*

Vulnerability of Municipal Drinking Water

Children:
90.2% exposed, 2.798 MPN/Month *E. coli*

LESSONS LEARNED

- Alerts decision makers of critical areas that are not otherwise obvious.

- Informs where "pathways" are .

guides targeted decision making

SaniPath

Results can guide investments to improve public health outcomes

NEXT STEPS

- Scaling up to 3 peri-urban areas in 2019
- Digitising LCC system for easy data collection to compliment SaniPath tool
- Training of all LCC Public Health Inspectors for improved data use
- Validation of SaniPath manual
- Continued collaboration with partners like the University of Zambia
- Scale up sensitisation programmes in schools and communities

QUESTIONS

COMMENTS

CONTRIBUTIONS

CONCERNS

Public Health Data in Sanitation Investment Planning.

Geospatial Analysis of Data on Cholera Outbreak 2017-18 to Improve Project Design & Targeting

George Joseph
Senior Economist, The World Bank

WORLD BANK GROUP
Water

Motivation

- **Proliferation of data and empirical methods**
  - Big data, household surveys, institutional and project data, government data, Public Health Data available from surveillance data sources, specialized efforts and so on
  - Spatial dimensions
  - Available in public- open data initiative by the World Bank

Methods using observational data

- Geospatial methods, machine learning
- Sanipath-Combination of laboratory analysis of environmental samples and behavior surveys to assess the pathways of fecal exposure

How data can be used to determine interventions and target them?

Lusaka, Zambia

Dhaka , Bangladesh

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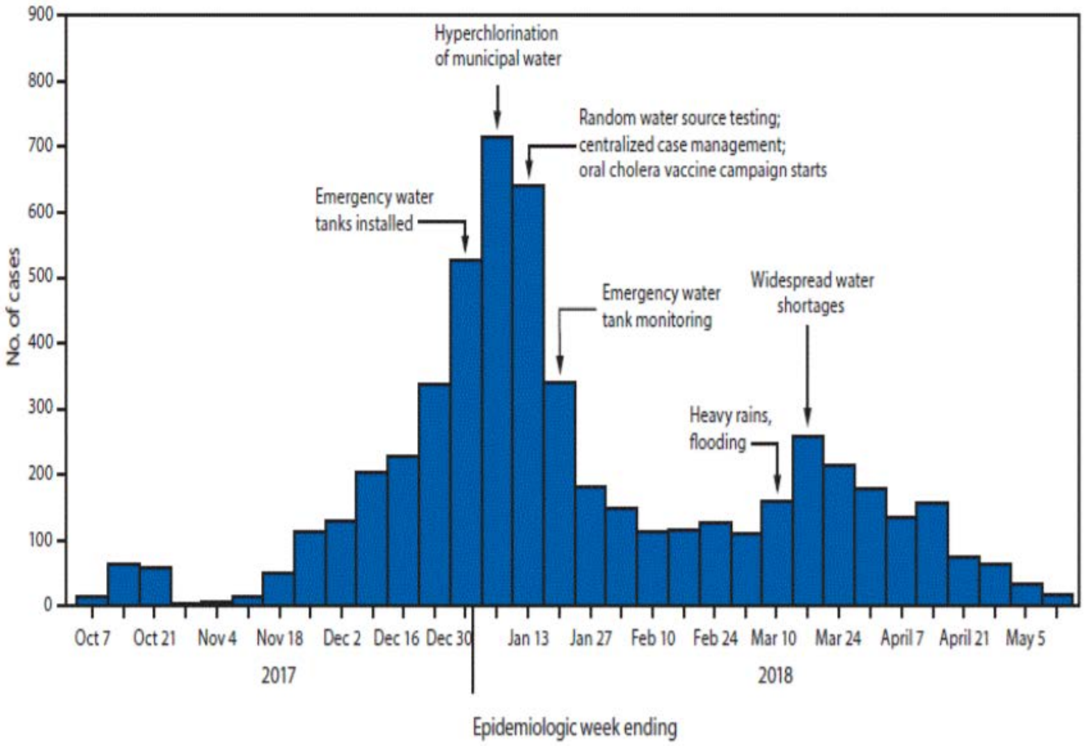
Water

Cholera outbreak 2017 – peaked between Dec-Jan



Number of reported cholera cases and related events, by week — Lusaka, Zambia, October 2017–May 2018[3]

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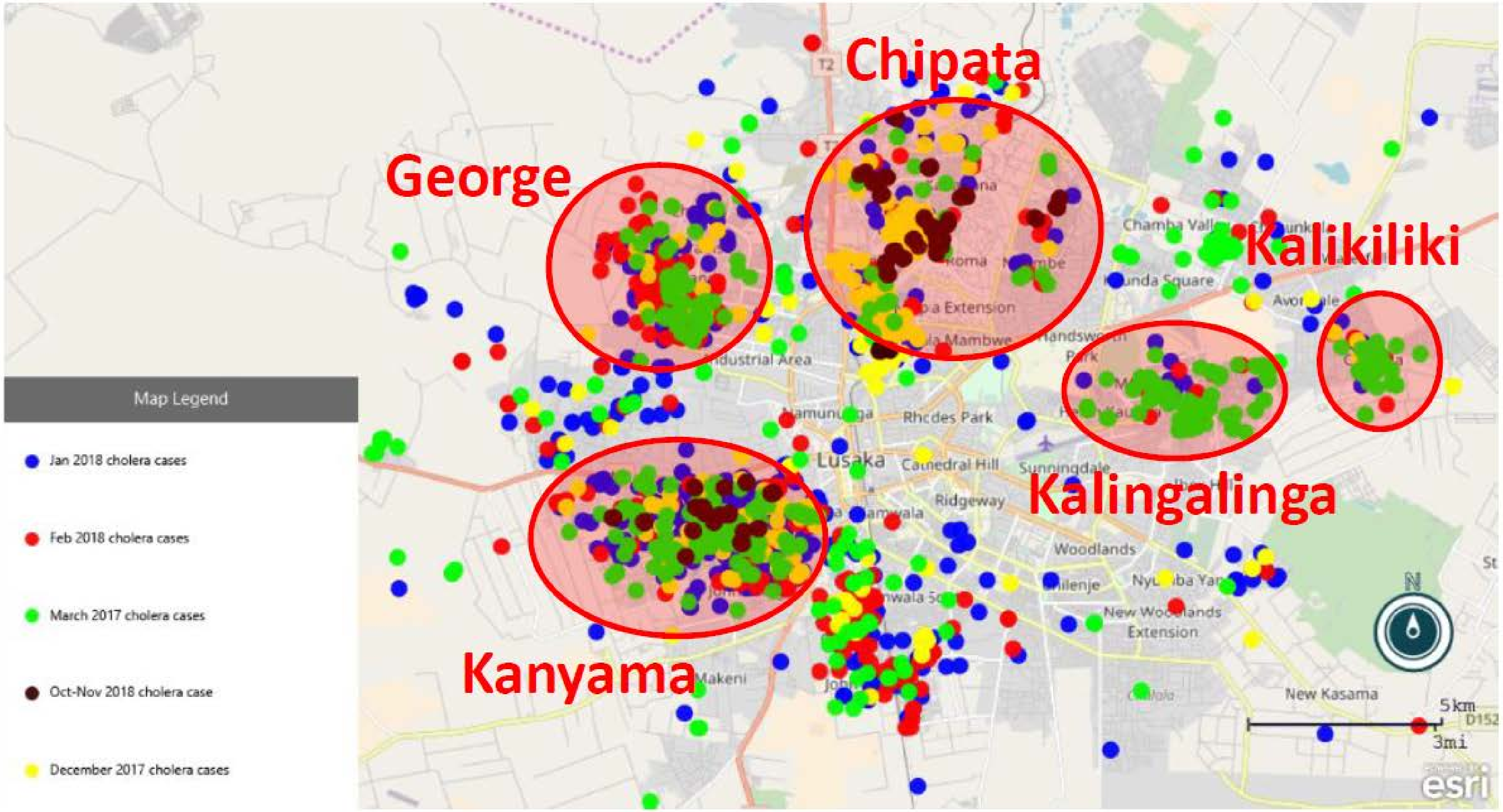
Water

Spatial distribution of cases over time (JICA)



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Water

Risk factors identified from other studies

Studies by JICA, SANIPATH and others have revealed a host of different contamination pathways for cholera:

- Contaminated water sources (both drinking and for domestic use) (Conroy et al., 2001; Dunston et al., 2001; Nygren et al., 2014) (Kwesiga et al., 2018)
- Poor sanitation (Koelle et al., 2005; Jutla et al., 2013; Waldman et al., 2013; GTFCC, 2015; Taylor et al., 2015)
- Contaminated food (Sanipath, 2018)
- Poor personal hygiene (Sanipath, 2018)
- Poor solid waste management
- Poor drainage (Sasaki et al., 2009)
- Increase in temperature and rainfall (Luque Fernandez et al., 2009) (Roobthaisong et al., 2017)
- Water service interruptions (Ashraf et al. ,2017); (Brocklehurst et al., 2013)

This study's contribution

This study gathers and analyzes several data sources from Lusaka to explore how LSP could potentially be better structured to reduce the risk of cholera

The study has done the following:

- ✓ Used cholera case location data and high-resolution spatial covariates (environmental, WASH access) to map cholera hotspots at high resolution.
- ✓ Sought to explain patterns of risk in relation to putative causal factors.
- ✓ Compared current WASH access and infrastructure gap to the pattern of cholera risk and identify priority areas for improved infrastructure.

Methods and Stages of Analysis

Bayesian geostatistical analysis (Taylor, Davies, Rowlingson & Diggle, 2013) was undertaken

Three main stages of analysis to date:

Stage 1: Construction of geospatial WASH and environmental covariates

Stage 2: Development of a geospatial cholera risk map

Stage 3: Simulation analysis to explore impact and targeting of improved WASH infrastructure

Stage 1: Construction of geospatial WASH and environmental covariates

Covariates in the Model

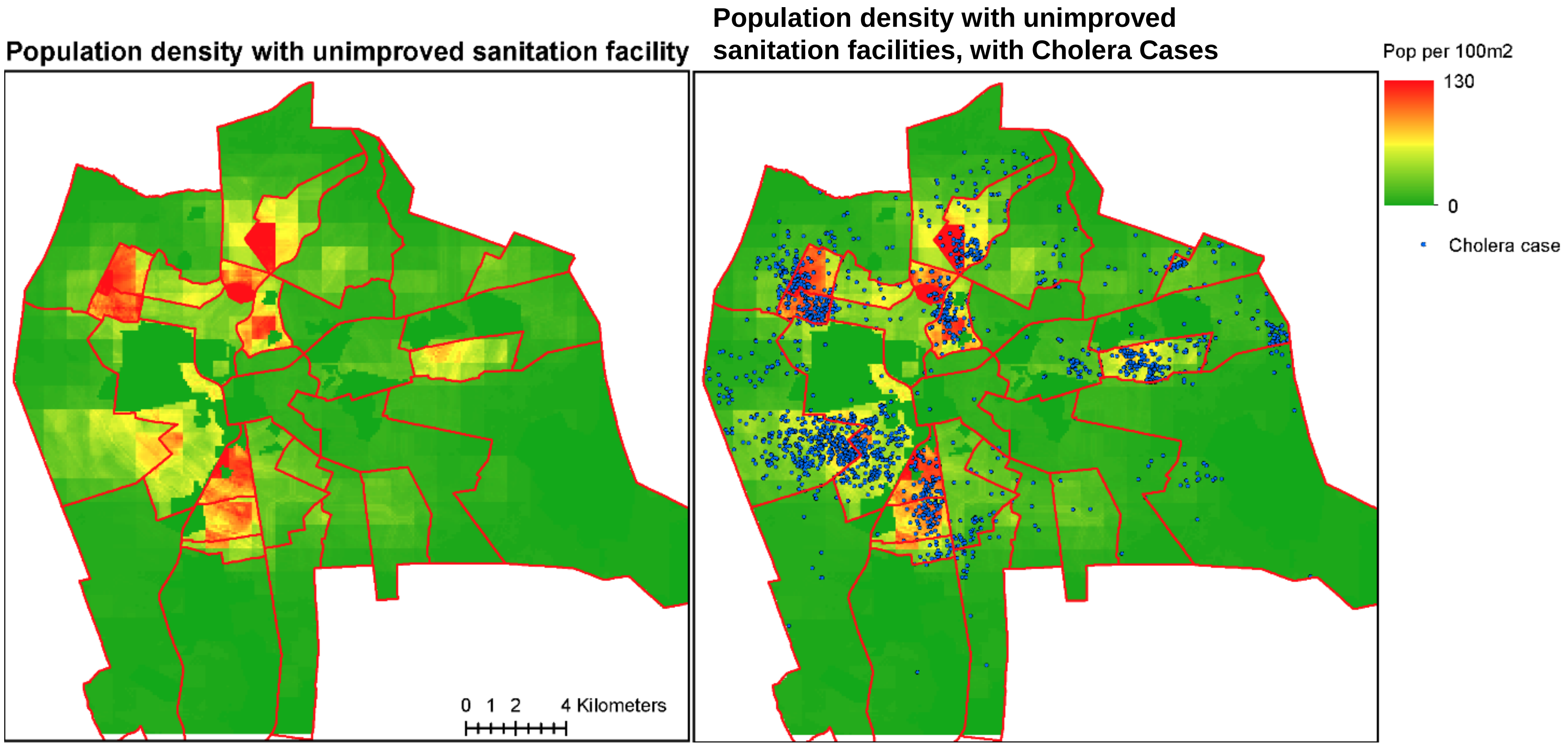
Covariate layers were assembled in one of three ways:

1. Pre-existing geospatial grids were obtained from numerous sources:
    - Poverty rates
    - Household size
    - Night-time light brightness
    - Groundwater vulnerability to contaminants

2. Covariate grids were generated based on GIS data describing relevant WASH infrastructure or natural features:
    - Distance from sewer network
    - Distance from water network
    - Distance from stream/river (based on hydrological analysis of Digital Elevation Model data)
    - Distance from cemetary/burial ground

3. WASH covariate grids were generated by implementing a Bayesian geostatistical model applied to household or other survey data describing water and sanitation facilities, water quality, and flood risk
    - % HHs with soap in toilet
    - % HHs not treating water
    - % households with unimproved sanitation
    - Density of population with unimproved sanitation
    - Composite risk index for water source
    - Composite risk index for toilet facility
    - Prevalence of *E. coli* in drinking water sources
    - Risk of flooding (poor drainage)
    - Frequency of complaints regarding sewer network, water supply/quality

Overlaying Cholera Incidence with a Geospatial Data Surface: Population Density with Unimproved Sanitation



WASH indicator surface derived from household survey data and geostatistical model. Plot on right shows cholera case locations overlaid for visual comparison.

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Water

Overlaying Cholera Incidence with a Geospatial Data Surface: Prevalence of E-Coli in LWSC Drinking Water Sources

Prevalence of E.coli in LWSC Drinking Water **Prevalence of E.coli with Cholera Cases**

Indicator surface derived from CDC water testing data on presence of *E.coli* in water sampled from LWSC sources. Data were then interpolated using a Bayesian geostatistical model to create a continuous surface. Plot on right shows cholera case locations overlaid for visual comparison.

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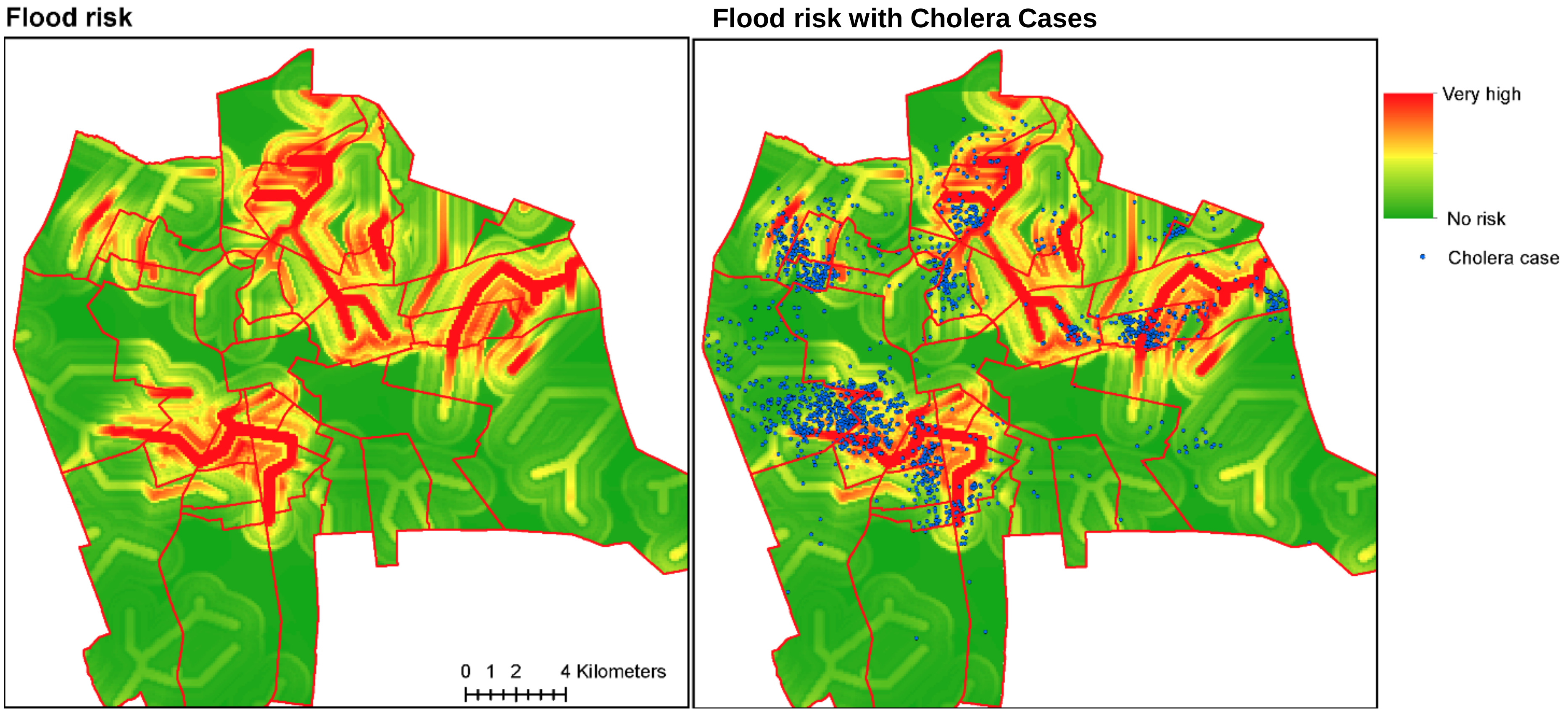
Overlaying Cholera Incidence with Geospatial Data Surface: Flood Risk



Indicator surface derived from data on reported flood risk interpolated using a Bayesian geostatistical model. Plot on right shows cholera case locations overlaid for visual comparison.

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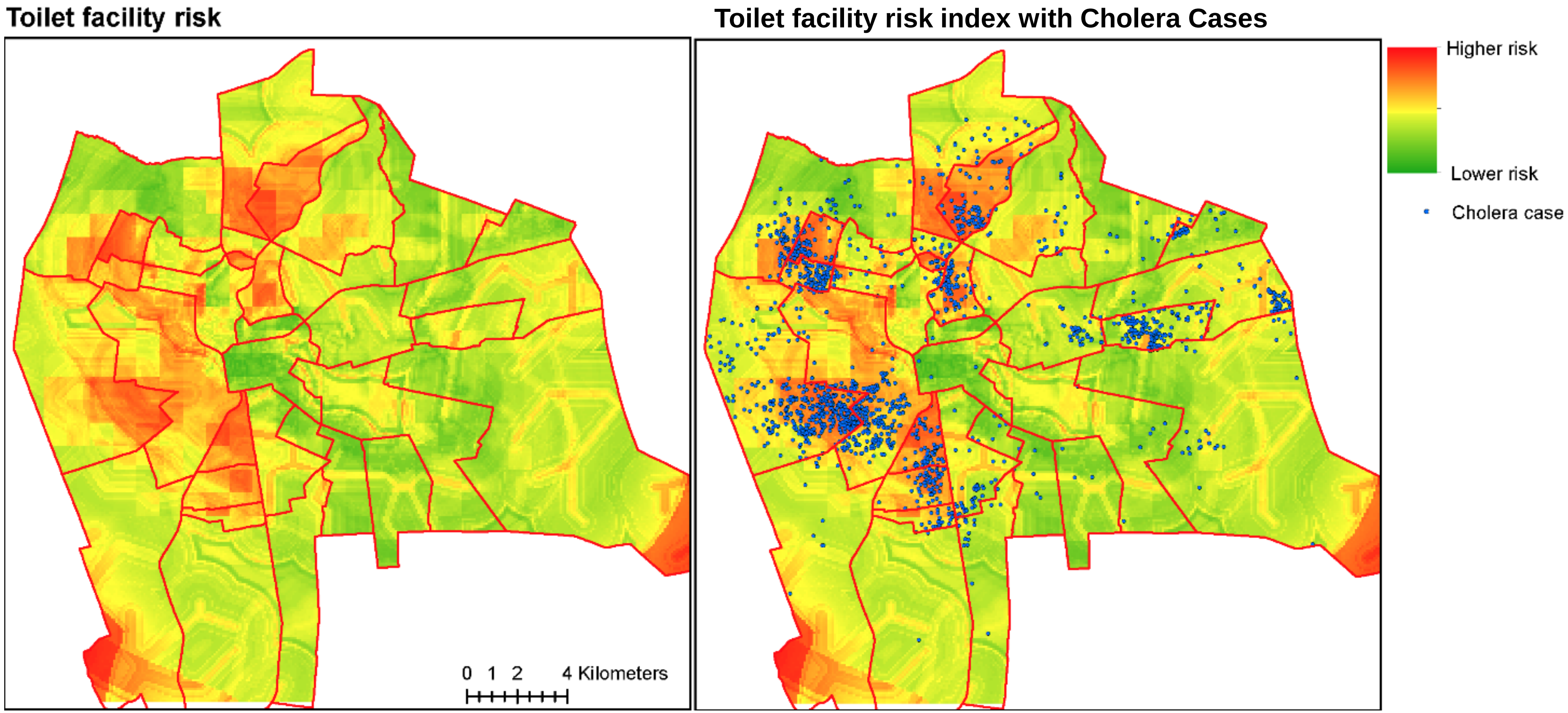
Toilet Facility Risk (Constructed Index)



WASH indicator surface derived from household survey data and geostatistical model. Plot on right shows cholera case locations overlaid for visual comparison.

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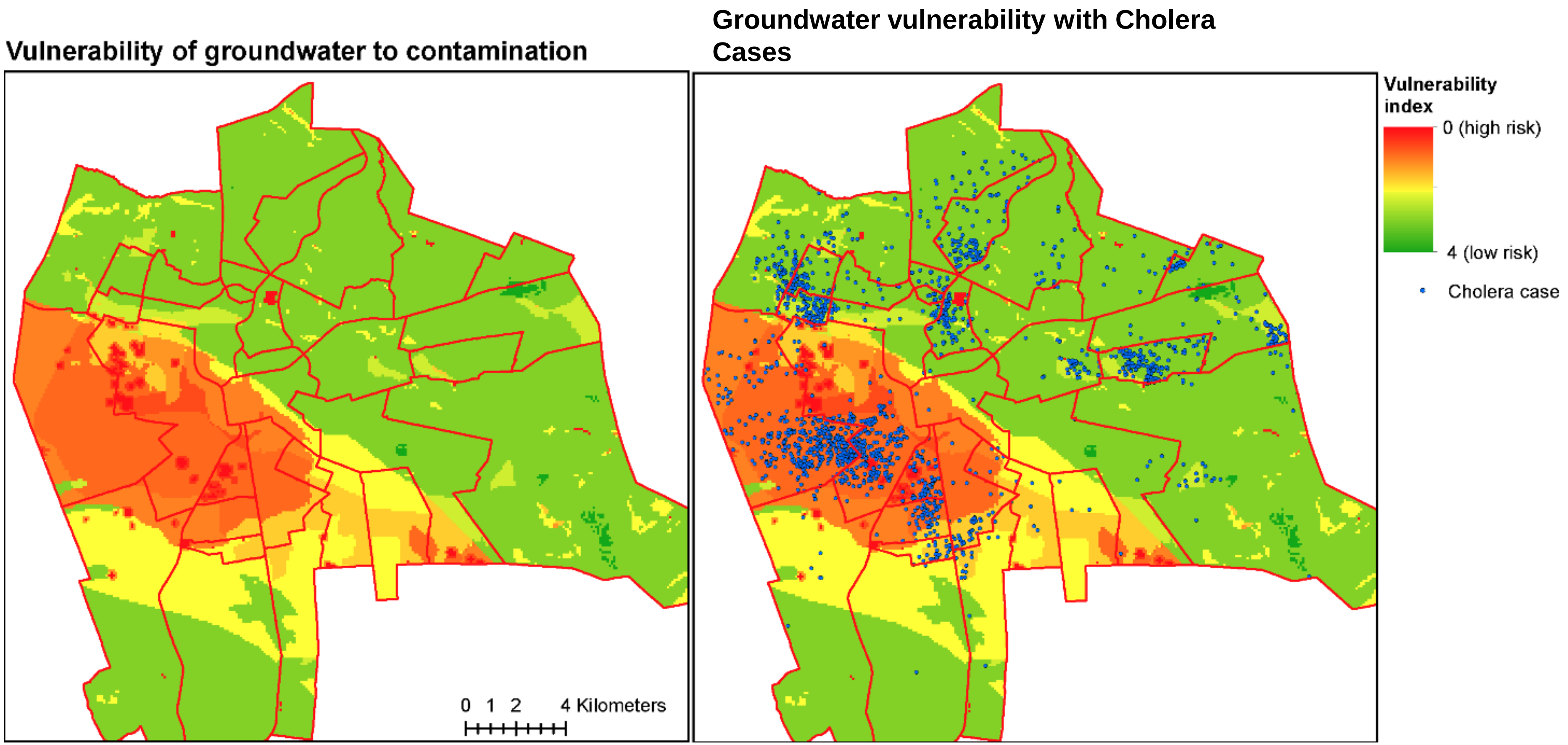
Groundwater Vulnerability Index



Indicator surface derived directly from external data source. Plot on right shows cholera case locations overlaid for visual comparison.

Stage 2: Development of a geospatial cholera risk map

Stage 2: Methodology

Response data:

- Spatial locations of reported cholera cases across Lusaka

Covariate data:

- Geospatial WASH and environmental data surfaces described in previous Stage

Result:

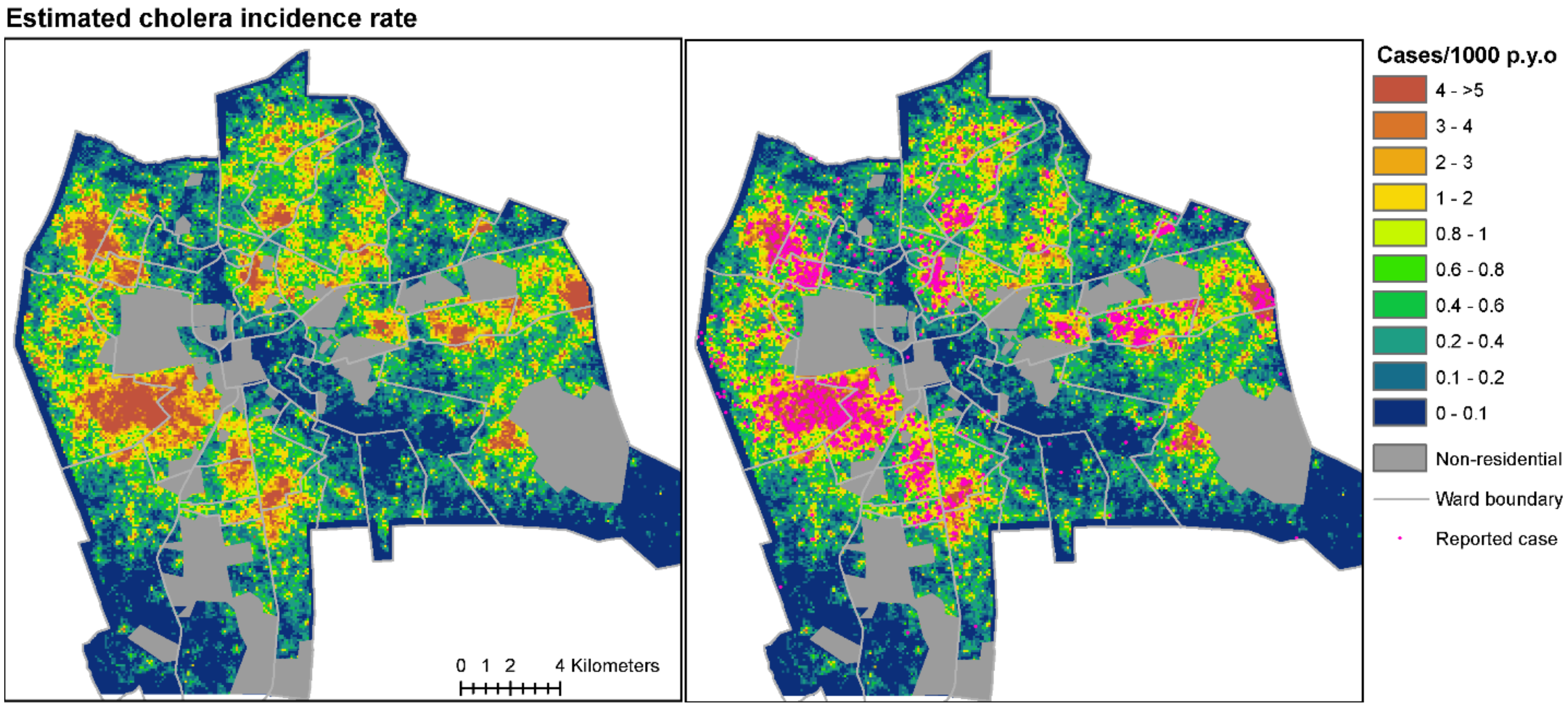
- Predicted map of cholera cases

Validation

- Comparing actual and predicted cases, mean squared error, AIC, BIC and so on

* Peter J. Diggle, Paula Moraga, Barry Rowlingson and Benjamin M. Taylor (2013) Spatial and Spatio-Temporal Log-Gaussian Cox Processes: Extending the Geostatistical Paradigm, *Statistical Science*, 4, 542-563.

Model Estimated Incidence (left) vs. Cholera Cases (right)



Output of LGCP model: a predicted surface of cholera risk at 100sqm resolution. Right-hand map shows raw cholera case data overlaid for visual comparison

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Stage 3: Simulation analysis to explore impact and targeting of improved WASH infrastructure

What reduction in Cholera risk might be achieved by different improvements to WASH infrastructure and environment?

Methodology

1. A predicted cholera risk map was generated
2. The simulated incidence rate $R_c(x,y)$ was then recalculated by replacing the actual covariate X_a with a counterfactual version X_c. In this example, that would be a spatial map with a value of 100% access to piped water in each pixel (or in particular target regions of the city).
3. The hypothetical reduction in cases caused by implementing this improvement was calculated
4. The size of population requiring the improvement was calculated

Exercise in Two Rounds

Use modelled relationship between WASH indicators and cholera incidence to generate ‘counterfactual’ incidence maps under different scenarios of improved WASH indicators

Round 1: Model the effects of having separate water, sanitation or drainage interventions for the whole city, or within 1km or 500m of existing networks using univariate modelling technique. Six scenarios are envisaged with spatial subvariants to cover each of these distinct catchments.

Round 2: Informed by the results of round 1 analysis, 3 broad scenarios are considered using multivariate models for the existing World Bank operation which either maintain the project as is “status quo”, provide a limited scale up to the existing project or a full scale up to the existing project. 3 subvariants within the scale up options lead to 8 scenarios in total. Two of these include addressing water quality issues, while 2 include expanding water access on top of the existing sanitation only intervention.

What reduction in Cholera risk might be achieved by different improvements to WASH infrastructure and environment?

Use modelled relationship between WASH indicators and cholera incidence to generate ‘counterfactual’ incidence maps under different scenarios of improved WASH indicators

- **ROUND 1: Six scenarios, each with sub-variants**

	Scenario	Variant
1	Provision of piped water to premises as a drinking water source	• If applied city-wide • If restricted to parts of city within 1km or 500m of existing piped water network
2	Ensuring that households have, as a minimum, access to a pubic tap within 100m	• If applied city-wide • If restricted to parts of city within 1km or 500m of existing piped water network
3	Provision of ‘flush to sewer’ (i.e. connecting households to sewer network)	• If applied city-wide • If restricted to parts of city within 1km or 500m of existing sewer network, or to World Bank project areas
4	Ensuring that households have, as a minimum, access to a shared improved onsite sanitation facility	• If applied city-wide • If restricted to current World Bank project areas
5	Reducing risk of flooding	To zero, to ‘low’, or to ‘medium’ risk (all city-wide)
6	Eliminating *E.coli* contamination in LWSC water sources	If applied city-wide

Round 1 Results: Cholera risk reduction rates by intervention type & location

Action	Location	% reduction in cases city-wide	Population targeted
Provide piped water to premises	**Everywhere**	**-60.89**	**1,761,855**
	<1000m from network	-31.04	770,622
	<500m from network	-25.14	619,937
Ensure at least public tap within 100m	Everywhere	-5.95	532,065
	<1000m from network	-3.24	244,082
	<500m from network	-2.82	210,473
Provide universal flush to sewer	**Everywhere**	**-89.57**	**1,771,116**
	<1000m from network	**-28.78**	**689,562**
	<500m from network	**-12.71**	**412,765**
	Year 1 WB Sewer Area	-0.83	59,094
	Year 1,CSE14,CSE20	-6.25	89,432
	Year 1,CSE14,CSE20,CSE05,CSE10,CSE25	-9.94	172,723
Ensure at least improved shared onsite facility	**Everywhere**	**-56.35**	**1,457,934**
	WB Onsite Sanitation Areas	**-22.83**	**303,500**
Eliminate E.coli risk	**Everywhere**	**-52.00**	**1,771,116**
Eliminate E.coli risk	**Existing piped water network**	**-21.03**	**738,937**
Eliminate flood risk	Everywhere	-29.55	1,771,116
Ensure flood risk does not exceed 'low'	Everywhere	-10.57	748,480

What reduction in Cholera risk might be achieved by a combination of different improvements to WASH infrastructure and environment?

Scenario		Description	Estimated Additional Cost (USD millions)	Estimated total cost (USD millions)
Reduced scope	1	Sanitation highly reduced scope: OSS in WB project target areas + Year 1 sewers	0	65
	2	Sanitation reduced scope: OSS in WB project target areas +Year 1 sewers +Very limited Year 2-5 sewers (Kanyama CSE-20 only). Compatible with option 2 as presented in MTR AM. Involves reallocation of funds to cover cost overruns. Requires no additional financing to the 65 million USD.	0	65
Partial Scale-up	3A	Sanitation – OSS in WB project target areas+ Year 1 sewers+ Limited Year 2-5 sewers A compatible with option 3 as presented in MTR AM. Would require 15 million USD in additional financing.	15	80
	3B	3A+ Water Quality (improving water via addressing E-coli in existing network + eliminating water and sanitation related complaints)	20	85
	3C	3A+ Increased Water Access (improving water access via extension of the existing network with no upgrades to cover the whole population in the top 10 ranked high wards for piped on premises access)	69	134
Project expansion	4A	Sanitation – OSS in WB project target areas + Year 1 sewers +Complete Year 2-5 sewers Original project design adjusting for cost overrun. Includes sewer works packages ready for tender.	36	101
	4B	4A+ Water Quality: improving water via addressing e-coli in existing network + eliminating water and sanitation related complaints	41	106
	4C	4A+Increased Water Access: Compatible with Option 5 as presented in the MTR AM. Improving water access via extension of the water network in its current state in the top 10 ranked high impact target wards for piped on premises access. 90 million USD in additional financing	90	155

Round 2 Results: Cholera risk reduction rates by Investment Scenario

			Population targeted					
	Intervention Type	% reduction in cases city-wide	Provide piped water to premises	Provide flush to sewer	Ensure at least improved+ shared onsite facility	Eliminate E.coli risk	Eliminate sewer complaints	Eliminate water complaints
Reduced scope	Scenario 1 - **Sanitation – WB OSS+Y1**	-23.7		59,094	303,500			
Reduced scope	Scenario 2 - **Sanitation – WB OSS+ YI+ Very Limited Y2**	-28.3		89,233	298,152			
Partial scale up	Scenario 3A - **Sanitation – WB OSS+ YI + Limited Y2**	-28.3		89,432	298,152			
Partial scale up	Scenario 3B - . **Sanitation – Limited Y2 + Water Quality**	-35.2		89,432	298,152	738,937	1,021,299	1,021,299
Partial scale up	Scenario 3C - **Sanitation – limited Y2 + Increased Piped Water Access**	-47.7	947,477	89,432	298,152			
Full scale up	Scenario 4A - **Sanitation – complete Y2**	-31.2		172,723	298,152			
Full scale up	Scenario 4B - **Sanitation – complete Y2 + Water Quality**	-37.6		172,723	298,152	738,937	1,021,299	1,021,299
Full scale up	Scenario 4C - **Sanitation – complete Y2 + Increased Piped Water Access**	-50.6	947,477	172,723	298,152			

Targeting

Given limited resources, investments must be targeted towards areas where the interventions have the greatest effect on reducing cholera risk

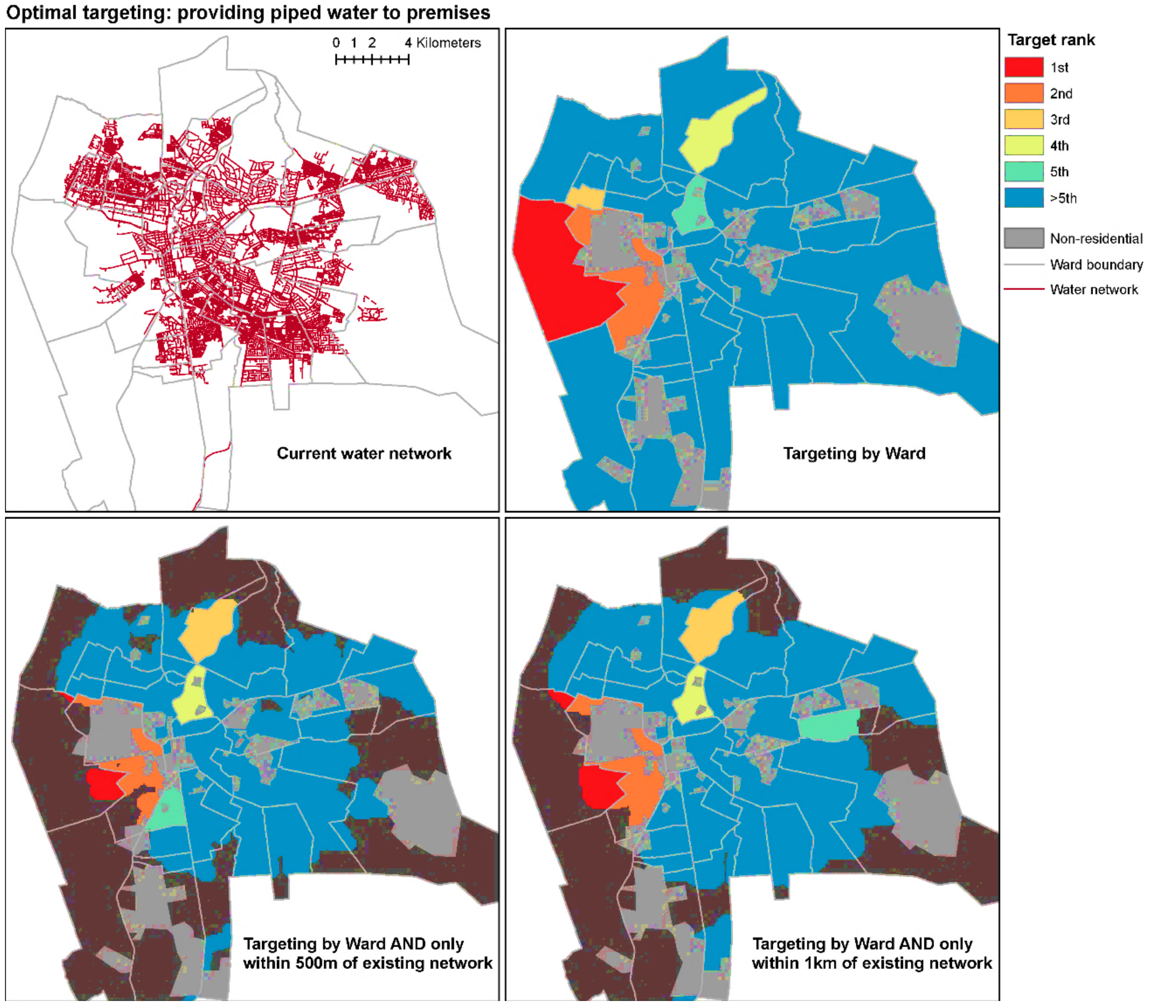
Targeting criteria used in this analysis was as follows:

- The number of cases of cholera was calculated for the whole of Lusaka and for each of the 33 wards
- The number of cases that each intervention is estimated to reduce was calculated for the whole of Lusaka and for each ward
- Those wards with the highest percentage of cases reduced of the total cases in Lusaka were ranked as the highest priority wards, those with the lowest were ranked last.

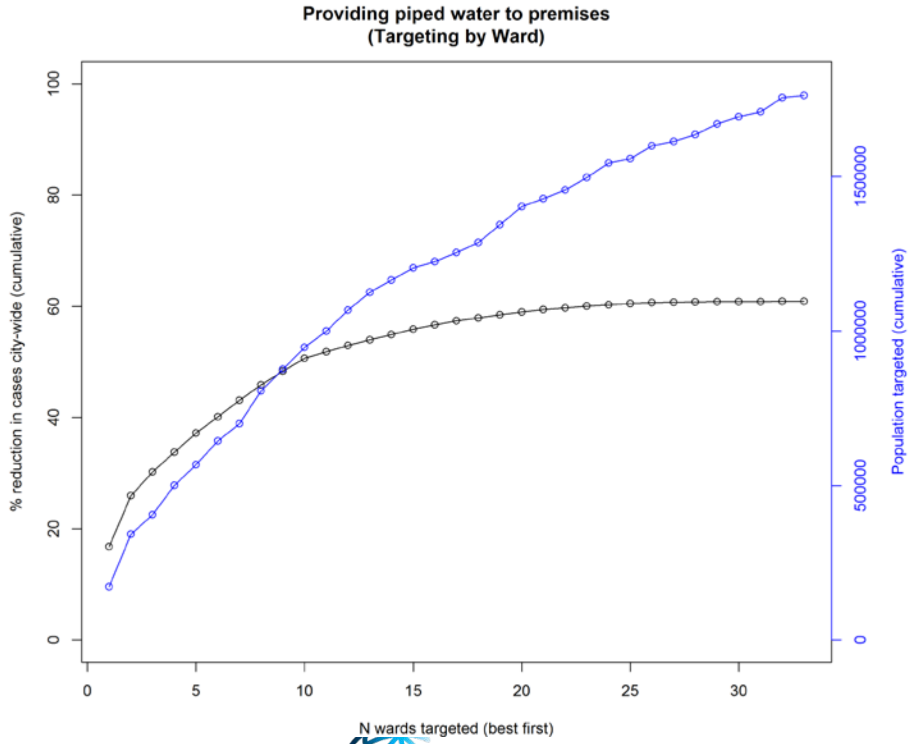
The following graphs and maps illustrate that by targeting the top five or ten wards, you can have a larger reduction in risk before necessarily reaching the whole city.

Targeting Results on Ward Prioritization: Provide Piped Water to Premises

- **Q2: How can each scenario be optimally targeted within the city, ward by ward**



- Provision of piped water to premises



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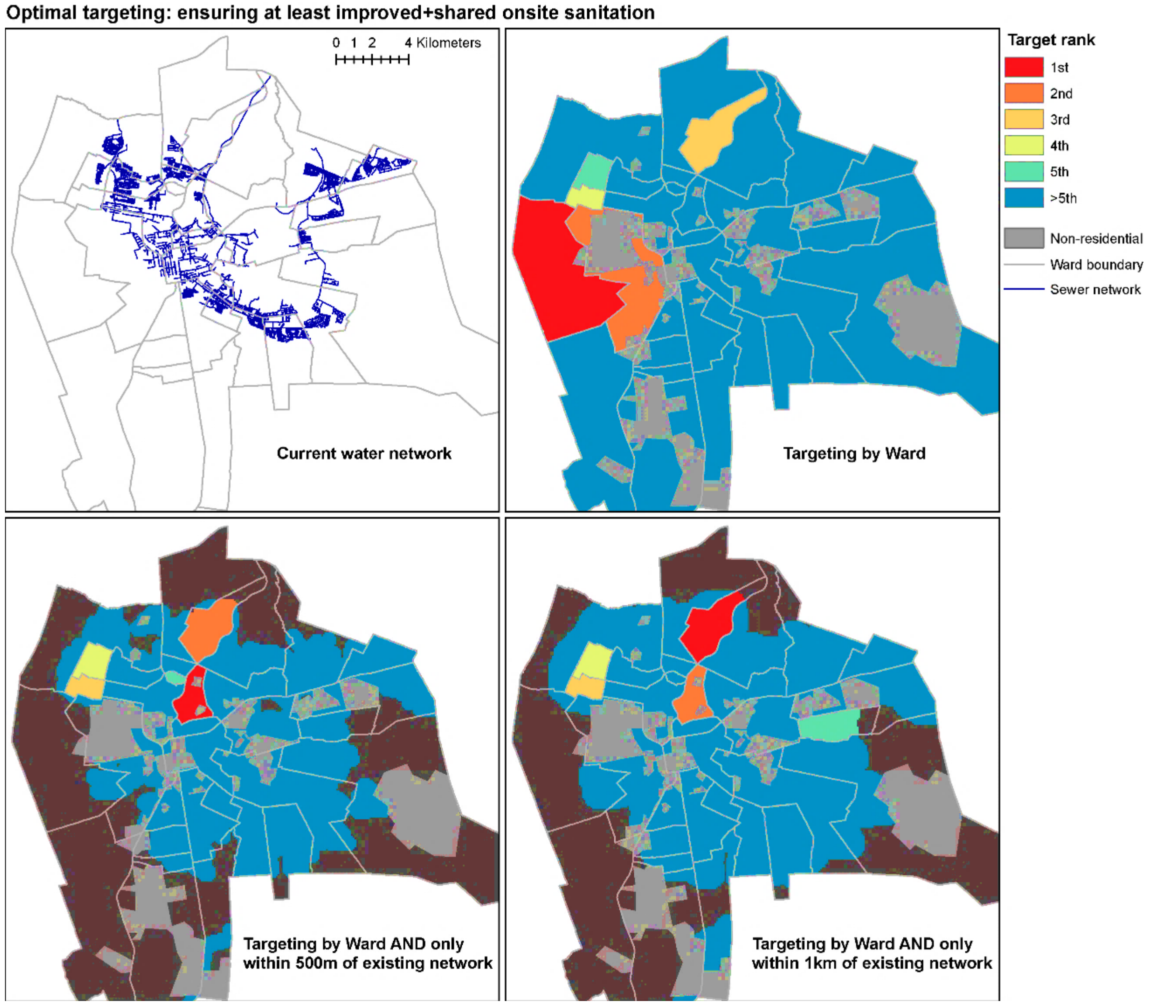
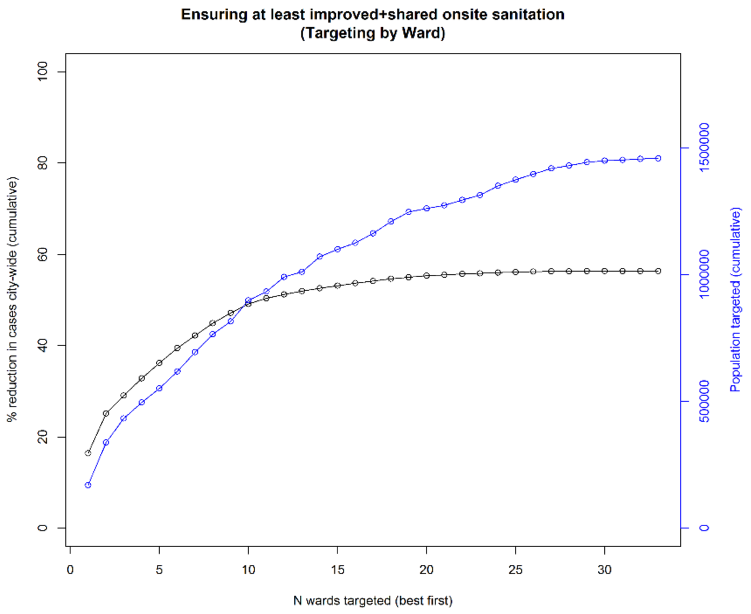
Targeting Results on Ward Prioritization: Access to Improved & Shared Onsite Sanitation

- **Q2: How can each scenario be optimally targeted within the city, ward by ward**



- Ensuring at least improved+shared onsite facility



SANIPATH in Dhaka

SANIPATH examined the fecal contamination pathways in Dhaka City.

- Contributed to the World Bank led analytical work – WASH Poverty Diagnostics which looked into Inequities in access and quality of access to WASH services for the poor and the B40

- Very valuable advocacy tool in highlighting the importance of sanitation in the city and raising its profile among decision makers

- Helpful in informing the World Bank lending project in Dhaka- Dhaka Sanitation Improvement Project (DSIP) which will become active in the coming months.

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Key messages

Data can be particularly helpful in sanitation investment planning. For this to happen:

- Data needs to be public and should be available for wider use
- Whenever possible, data collected needs be georeferenced.

For instance , geospatial analysis as presented here has been used

- to predict the likely risk of cholera outbreak in different parts of Lusaka
- By separating out the relative impacts of different water and sanitation interventions, the relative risk reduction of cholera has been deduced
- The most at risk wards have been ranked and prioritized for different kinds of investment
- Investments can be compared for their health impacts and cost efficiency

This type of analysis, both in terms of disaggregating investment types, and spatially ranking target areas can be used to inform restructuring of this operation and design of other similar projects in emerging cities in Africa and around the world.

Acknowledgements

This work was made possible by the facilitation and provisioning of data from the following local and national stakeholders:

- Zambia National Public Health Institute (ZNPHI)
- Lusaka Water and Sewerage Company (LWSC)
- Zambia Water Resources Management Authority (WARMA)
- Lusaka City Council (LCC)
- Millennium Challenge Corporation (MCC) & Millennium Challenge Account, Zambia (MCA-Z)

Correlation of individual co-variates in the model (subset)

Covariate	Correlation	p-values	Confidence Interval - L95	Confidence Interval - U95
Population density with unimproved and shared sanitation (per 100m2)	0.249265	0	0.240983	0.257511
Population density (per 100m2)	0.237241	0	0.22891	0.245537
Population density with unimproved/and shared sanitation (per 100m2)	0.203758	0	0.195297	0.212189
Sanitation risk index	0.149987	8.58E-247	0.141363	0.158589
Prevalence of E. coli contamination (LWSC drinking water sources)	0.147012	3.40E-237	0.138382	0.15562
% HHs with unimproved and shared/nsanitation	0.143311	2.83E-225	0.13467	0.151931
% HHs with soap in toilet	0.090119	9.79E-90	0.081372	0.098852
Drinking Water risk index	0.087361	2.02E-84	0.07861	0.096098
% HHs in extreme poverty	0.07618	4.23E-65	0.06745	0.084899
Number of complaints – drinking water supply	0.059004	3.06E-23	0.047382	0.070611
% HHs not treating water	0.01338	0.002918593	0.004569	0.022189
Number of complaints – drinking water quality	0.011549	0.052122366	-0.00011	0.023201
Mean size of HH	-0.00129	0.773327794	-0.01006	0.007486
Distance to stream (DD)	-0.04234	3.05E-21	-0.0511	-0.03358
Distance to sewer (DD)	-0.06023	2.57E-41	-0.06897	-0.05148
Prévalence of E. coli contamination (non-LWSC drinking water sources)	-0.06759	3.44E-51	-0.07635	-0.05881
Number of complaints – sewerage	-0.07395	1.37E-35	-0.08553	-0.06235
Distance to piped water network (DD)	-0.08844	3.58E-87	-0.09714	-0.07972
Groundwater vulnerability	-0.09791	1.42E-108	-0.10651	-0.0893
Distance to flood-prone area (DD)	-0.1147	1.68E-144	-0.12338	-0.10599

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