GAMA Technical Group
Webinar

10th March 2016
#GAMAreilience
Agenda

1. Welcome and introductions - Ghana & London
2. Update on resilience.io programme - Stephen Passmore
3. resilience.io engagement - Sampson Madana
4. Results calculations and assumptions of resilience.io WASH in GAMA, Ghana - ICL & IIER
5. MLGRD briefing on resilience.io - Eric K Afornorpe
6. Zoomlion briefing on resilience.io - Dr George Rockson
7. AOB
8. Next steps and Close

http://ecosequestrust.org/GAMA
resilience.io programme

- **June 2016**
  - 8th - 17th June
  - 3 WASH prototype results workshops to be confirmed with hosts
  - Grand resilience.io WASH prototype ‘debut’ event (Global first) - likely 16th May
  - Potentially also FCA activities tbc

- **Objectives**
  - Evidence prototype is functional and benefits
  - Municipal interest in using WASH findings to inform decision making
  - Interest to continue to develop resilience.io - WASH, other sectors
Programme Update

Ghana
- UNSDSN Thematic Network 09 Workshop - Roadmap for Habitat III - Financing and implementing the Global Goals in Human Settlements and City Regions by 2030 attended by:
  - Sylvanus Adzornu, MLGRD
  - Hope Dziekpor, TMA
  - Lydia Sackey, AMA
- Application for Readiness Funding from the GCF being made in collaboration with AfDB to extend resilience.io modelling to full city scale

Dorset / UK
- ESA funding to combine earth observation and other space data into an online portal for resilience planning.

Mongolia
- Met with Golomt Bank and the Green Climate Fund in Seoul to progress funding applications for Ulaanbaatar
The Ecological Sequestration Trust
resilience.io model

Engagement strategy on
Greater Accra Metropolitan Area
WASH Sector Use Cases

March, 2016
ENGAGEMENT STRATEGY
MARCH-MAY, 2016

1. LEAFLET FOR TOP MANAGEMENT
2. MEETING WITH TECHNICAL STAFF (MMAS, MLGRD, MWRWH, PRIVATE SECTOR)
3. MEDIA ENCOUNTER
   - TV PROGRAMME
   - NEWSPAPER PUBLICATION
   - RADIO DISCUSSION
   - MOUNTING OF BANNERS
Results, calculations, and assumptions of the Resilience.IO WASH sector in GAMA, Ghana

Resilience.IO platform

Harry Triantafyllidis, Xiaonan Wang, Rembrandt Koppelaar and Koen H. van Dam

Department of Chemical Engineering, Imperial College London, UK
IIER – Institute for Integrated Economic Research

10 March 2016
Outline

- **Current Status** (Rembrandt Koppelaar)
- **Water Demands** (Xiaonan Wang, Koen H. van Dam)
- **Infrastructure construction** (Rembrandt Koppelaar)
- **Toilet usage** (Xiaonan Wang, Koen H. van Dam)
- **Idea:** use a simulation model of a *synthetic population* to experiment with different scenarios to generate *demand profiles*, which can then be used to *optimise the technologies and networks* with key *performance metrics*.

- A *data-driven platform*
Where are we now

<table>
<thead>
<tr>
<th>Functionality since January Webinar</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final set of technologies for prototype incorporated</td>
<td>Completed</td>
</tr>
<tr>
<td>Addition of possibility to set new water/sewage network connections</td>
<td>Completed</td>
</tr>
<tr>
<td>Incorporation of water rationing effect on demand</td>
<td>Completed</td>
</tr>
<tr>
<td>Effects of implementation of on-going project and plans are completed</td>
<td>Completed</td>
</tr>
<tr>
<td>Calculation of toilet usage based on infrastructure access</td>
<td>Completed</td>
</tr>
<tr>
<td>Addition of tariffs and rates for water use and toilet use to estimate affordability of new infrastructure</td>
<td>Completed</td>
</tr>
<tr>
<td>Inclusion of floating population in the model</td>
<td>On-going</td>
</tr>
<tr>
<td>Generation of population and economic scenarios</td>
<td>On-going</td>
</tr>
<tr>
<td>Calibration and testing of output results</td>
<td>On-going</td>
</tr>
</tbody>
</table>
Today’s discussions

• To demonstrate results, how they are calculated, and to discuss underlying assumptions

• Comments about results?

• How confident are you in the presented assumptions?
  • Assumption example → average demand for low income household member of 15+ years set at 32 liters per day
  • Value based on study/guesstimate/calculation
Water Demand calculations

Speaker: Dr Xiaonan Wang, Dr Koen H. van Dam
Results

- Total residential demand profile per MMDA over 24 hour period

- Total residential water demands (annual): 108.0 million m$^3$
Results

- Drinking water demand profile per MMDA over 24 hour period

- Total drinking water demands or water intake (annual): 2.9 million m$^3$
Calculation method (simplified)

- Initialize population as agents by socio-economic characteristics (age, household income, infrastructure access) and generate a synthetic group by distribution.

- Estimate for each agent water use throughout the day, based on a time dependent function, which is related to their characteristics:

  - Polynomial Function example:
    \[
    \text{Demand} = 2.0 \times 10^{-10} \times (\text{theTime}+\text{delay})^5 - 1.3 \times 10^{-07} \times (\text{theTime}+\text{delay})^4 + 3.0 \times 10^{-05} \times (\text{theTime}+\text{delay})^3 - 2.4 \times 10^{-03} \times (\text{theTime}+\text{delay})^2 + 0.042 \times (\text{theTime}+\text{delay}) + 4.1836;
    \]

  - Catch peaks, average and uncertainties of demand profiles.

  - Other regressive functions in use:
    \[
    f(x) = a1 \times \sin(b1 \times (x+d)+c1) + a2 \times \sin(b2 \times (x+d)+c2) + a3 \times \sin(b3 \times (x+d)+c3)
    \]

- Multiply output to aggregate total water demands of the whole population.
Assumptions

- How confident are you on the following assumptions?

<table>
<thead>
<tr>
<th>Assumption: Average total water demand for household member of 15+ years</th>
<th>Value</th>
<th>Source</th>
<th>Your Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low income household member</td>
<td>51 - 66 litres/day</td>
<td>Literature</td>
<td>Low</td>
</tr>
<tr>
<td>Medium income household member</td>
<td>70 - 90 litres/day</td>
<td>Literature</td>
<td>Medium</td>
</tr>
<tr>
<td>High income household member</td>
<td>109 - 140 litres/day</td>
<td>Literature</td>
<td>High</td>
</tr>
<tr>
<td>Time/activity dependent water demand regression curves</td>
<td>polynomial/sins</td>
<td>Calculation</td>
<td></td>
</tr>
</tbody>
</table>

**Confidence Scale:**
- Uncertain
- Low
- Medium
- High
### Assumptions

**• How confident are you on the following assumptions?**

<table>
<thead>
<tr>
<th>Assumption:</th>
<th>Value</th>
<th>Source</th>
<th>Your Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact of water rationing on water use</td>
<td>- 20% usage reduction</td>
<td>Literature</td>
<td></td>
</tr>
<tr>
<td>Waste water generation as a percent of residential water use</td>
<td>80%</td>
<td>Literature</td>
<td></td>
</tr>
<tr>
<td>Estimated water use per company in commercial sector company</td>
<td>14.5 m3 per day</td>
<td>Literature/Calculation</td>
<td></td>
</tr>
<tr>
<td>Estimated water use per institutional establishment</td>
<td>1.9 m3 per day</td>
<td>Literature/Calculation</td>
<td></td>
</tr>
<tr>
<td>Estimated water use per industrial plant</td>
<td>100 m3 per day</td>
<td>Literature/Calculation</td>
<td></td>
</tr>
</tbody>
</table>
Proposed infrastructure investments to meet targets

Speaker: Rembrandt Koppelaar
What the RTN model simulates:

- Allocated infrastructure of pipes and technological units for both potable and untreated waste water for 15 MMDAs.
- Resources available to flow as potable water and influent waste water among other types of resources and inputs required (raw water, electricity etc.)
- 4 year simulation of gradual demand satisfaction (25%->50%->75%->100%) for both potable and treated waste water.
- Demands are being generated from the Agent Based Modelling (ABM) platform and directly linked to the decision support side.
- The model includes all conversion processes from one form of input to the output and the required materials for this (coefficients, costs etc.)
- Pipe extensions have associated costs based on pipe type and distance of construction.
- Flows are bounded based on pipe existence or not: \( Q - Q_{\text{max}} Y \leq 0 \), where \( Y \) either 0 or 1.
- Production rates are upper bounded based on current hardware.
- Leaks are defined on pipes to simulate loss of resource flows.
- Resource balance takes place in each MMDA:
  \[ P + IM + Q_{\text{in}} - Q_{\text{out}} = D + \text{Leaks} \]
- We try to minimize the aggregated CAPEX-OPEX and \( CO_2 \) emissions WHILE meeting the demands.
Calculation method (simplified)

- Initialize model with demands (as shown before), initial infrastructure (facilities, pipes, their technology, capacity), and capital and operational cost values.

- Set desired objectives for calculation: a) to meet % demands for potable water and b) to achieve % wastewater treatment, at c) the lowest cost and emissions.

- Model calculates how to meet these targets based on a large number of settings such as current existence of pipes, cost of electricity and labour, cost of new pipe and treatment infrastructure.

- Limit pipe extension for both potable and un-treated waste water to neighbouring district only.
Capital expenditure costs per year - demands met: 25%->50%->75%->100%
Visualized results – Production of potable water in 2010

Production rates per district and technology for year: 2010

- ADENTA
- ACCRA_METROPOLITAN
- ASHAIMAN
- GA_CENTRAL
- GA_SOUTH
- GA_WEST
- GA_EAST
- KPONE_KATAMANSO
- LA_DADE_KOTOPON
- LA_NKWANTANANG_MADINA
- LEDZOKUKU_KROWOR
- TEMA_METROPOLITAN
- AKWAPIM_SOUTH
- AWUTU_SENYA_EAST
- NSAWAM_ADOAGYIRI
- VOLTA_RIVER
Visualized results – Investments in year 2011
Visualized results – Investments in year 2012
Visualized results – Investments in year 2013
Visualized results – Investments in year 2013
Visualized results – graph of optimal flows on potable water

GAMA cells – Optimal flows (minus the leaks) of potable water on edges and total demand of clean water (thousands of m3) per district as vertex size
Visualized results – graph of optimal flows on waste water

GAMA cells – Optimal flows (minus the leaks) of un–treated waste water on edges and total supply of waste water (thousands of m$^3$) per district as vertex size
**Assumptions**

- How confident are you on the following assumptions?

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Value</th>
<th>Source</th>
<th>Your Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaks on pipes</td>
<td>27% of flow</td>
<td>Available data</td>
<td></td>
</tr>
<tr>
<td>Upper bound on flows ($Q_{\text{max}}$)</td>
<td>~1800m$^3$/h</td>
<td>Available data</td>
<td></td>
</tr>
</tbody>
</table>
Toilet Usage and human sewage Calculations

Speaker: Dr Xiaonan Wang, Dr Koen H. van Dam
Results

- **Toilet demand per district over a 24 hour period**

- **Sewage and solid wastes flow from toilet use per day**
Calculation method (simplified)

- Initialize population as agents by socio-economic characteristics (age, household income, infrastructure access) and generate a synthetic group by distribution.

- Estimate for each agent toilet use throughout the day, based on probability-of-activity model:
  - Initialize the probability to use a toilet at wake-up time: 0.5
  - Every 5 min, examine the probability increase (0.018) and compare with the standard probability (random number between 0-1) to determine whether the agent uses a toilet or not
  - Poo behaviours considered separately with pee

- Multiply toilet use times by amount of urine and excreta generated per use to yield total amount of accumulation at a toilet site, and total human sewage generated per day.
Estimates

- How confident are you on the following model estimates?

<table>
<thead>
<tr>
<th>Estimate</th>
<th>Value</th>
<th>Source</th>
<th>Your Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of times a toilet is used per day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>for urination for 15+ year person</td>
<td>6.25</td>
<td>Model calculation</td>
<td></td>
</tr>
<tr>
<td>for defeacation for 15+ year person</td>
<td>1.14</td>
<td>Model calculation</td>
<td></td>
</tr>
</tbody>
</table>

Frequency of daily toilet use times (10,000 agents simulated)
Assumptions

- How confident are you on the following assumptions?

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Value</th>
<th>Source</th>
<th>Your Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilet use and waste generated</td>
<td>Urine per day</td>
<td>1.6 litres / day</td>
<td>Literature/Calculation</td>
</tr>
<tr>
<td></td>
<td>Faeces per day</td>
<td>0.34 kg / day</td>
<td>Literature/Calculation</td>
</tr>
</tbody>
</table>

- Total sewage waste from toilet (annual): 1.68 million m³
- Total solid waste from toilet (annual): 0.455 million metric tons
FCA GAMA Water & Sanitation: Use Case Development for the resilience.io model

Eric K. Afromorpe
MLGRD
Thursday, 10/03/2016
OUTLINE

- Background: Country’s context
- Efforts in Water and Sanitation Sector
- The Brighter future
- Resilience Model for WASH
- Resilience Model: Approach
- Use Cases: Model Component and focus
- Model Design Outlook
- Model Frame work
General Background

Transformation in the socio-economic growth in Ghana:
- Lower income status to a middle income,
- Poverty reduction
- Infrastructure growth

At same time:
- Rapid increase in population especially in the urban communities
- 44% urban population in 2000 is over 51% since 2010.

Pressure and demand:
- Existing and increasing social and economic infrastructures
- Utilities (water, electricity)
- Opportunities (employment).
- Services such water and sanitation

Environmental risk, hazards and disasters:
- Climate, Flood, breeding and outbreak of diseases.
General Background Cont..

Level of Water and Sanitation

- Only about 15% of Ghanaians with access to proper sanitation
- Backlog of waste
- Poor sanitation and poor water quality and water supply (very critical).

Open defecations

- About 19% of the Ghanaian population engage in open defecation
- The rest accessing flush toilet, ventilated-improved pit, latrine pan/bucket and public toilet.
- Limited and poorly functioning sewer systems for which wastewater ends up in drains, broken pipes, etc.

The MDGs and Water & Sanitation

- Implementation of MDGs
- Preparedness of the implementation of SDGs
Efforts in Water and Sanitation Sector

Policy direction:

- A National Environmental Sanitation Policy, 2009
- National Environmental Sanitation Action Plan and Investment Plan (NESSAP).
- A National Urban Policy, 2012
  - To harmonise, consolidate efforts and guide urban agenda (incl. water and sanitation).

Project/Programme

- The ADB Accra Sewerage Improvement Project (ASIP)
- The World Bank GH-GAMA Sanitation and Water Project (GH-GAMA)
- The DANIDA Sludge Treatment Project at “Lavender Hill” and Bolah-Bondeh project.

These efforts would be expected to improve the WASH sector, providing data for better planning and management of WASH in Ghana.
The Brighter future

Ensure availability and sustainable management of water and sanitation for all (SDG 6):

Indicators

• Universal and equitable access to safe and affordable drinking water for all by 2030; access to adequate and equitable sanitation and hygiene for all, and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situation by 2030; improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and increasing recycling and safe reuse by x% globally by 2030

Ghana’s capacity, capability

• Very prepared, experience in planning
• The need for development of robust development tools, systems for further planning, implementation, monitoring, evaluation, projection.
• Resilience Model, the needs
Resilience Model for WASH

The Model and support process

- Since 2015, several meetings held
- From 6 thematic areas to 3
- Institutional supports (Cities Alliance, MLGRD, MWRWH, MESTI, CERGIS, GWC, GRCC, MMDAs, etc)

Purpose of the Model

- An objective comparison of the implementation of all current large-scale projects in WASH sector in the GAMA to assess to what extent these fulfill current targets in national/regional policies and international development goals, also taking into account socio-economic development of the population in GAMA.
- A more detailed, spatially informed view of the current situation and remaining gaps after implementation of present projects, to identify additional technologies and their capacity to meet the desired targets.
- The ability to take into account different socio-economic scenarios and their influence on water demands and waste water flows.

Considering also that:

- complexities and difficulties faced in planning and implementation of the WASH sector resulting from increasing urban population and the changing pattern of WASH challenges in cities and towns in the Country
Resilience Model: Approach

Computer base
- reducing human influence
- Reducing complexities
- Easy to make changes
- Easy to make projection
- Regression statistic
  - Enable analysis of cost benefit, prediction (that what may happen if there is further increase in population in the cities)

In practice, expecting of a simple process
- Treatment of water, distribution and consumption
- Waste water treatment and distribution
- Analyzing population change, demand needs
- Including long term economic scenarios

The development of the Model depends the choice of components, valid data and stakeholders support.
Use Cases: Model Component and focus

- At the initial stage in 2015, six potential WASH model use cases for the Greater Accra Metropolitan Area (GAMA) were selected. However, there similarity among the components lead merging the six to three use cases in November, 2015.

- **Use Case 1**: Assessing the outcomes of ongoing WASH projects and assessing gaps towards meeting macro-level targets
  - Use Case 2: Examine possibilities and costs to increase household access to improved potable water sources
  - **Use Case 3 (now 2)**: Calculate capacity needs to end water rationing issues within the existing water pipe network area
    - Use Case 4: Facilitate infrastructure that will meet the challenge of waste water and fecal sludge collection and treatment
    - Use Case 5: Resolve health issues caused by unimproved water access and absence of sanitation infrastructure
  - **Use Case 6 (now 3)**: Increase availability of clean, accessible, and affordable toilet infrastructure
Model Design Outlook

Focus of the Use Case:

- Assess outcomes of ongoing WASH projects and gaps towards meeting macro-level targets for planning

Inputs

- Capacities and time frame of all ongoing projects
- Targets and goals from local, national policies and international agreements

Model Use

- Calculate combined effect of on-going projects when fully completed
- Estimate gaps remaining to targets
Model Framework

Scenario data
Agent based Model
Generated demand
Resource Technology Network Optimization
Optimal Allocation

<table>
<thead>
<tr>
<th>Scenario data</th>
<th>Agent based Model</th>
<th>Generated demand</th>
<th>Resource Technology Network</th>
<th>Optimal Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data on population, real or simulation. Including gender, income, location, activities</td>
<td>Relating analysis of various agents that interact in the environment, including water use, infrastructure, price, state and behavior. Access to WAS-cleaned water. With Model map</td>
<td>Accessing demand and excess demand annually (31.9 mill m3), Amount of waste water generation. This will be optimized</td>
<td>Availability of infrastructure and technology capacity, able to satisfy the current demand and future demand. Considering the tech specification, cost, benefit and access.</td>
<td>Provisions available for meeting current and future demand possibility in terms of cost.</td>
</tr>
</tbody>
</table>

Using a simulation model of a synthetic population to experiment with different scenarios to generate demand profiles, which can then be used to optimize the technologies and networks with key performance metrics.
Going Forward

- Need to refine and improve on the current Use Case 1 which assesses the ongoing project (GAMA WASH) for its finalization.

- When done well, will set good basis for analysis and modelling the infrastructure demand for the current and future demand for water (Use case 2) and toilet facilities (Use case 3).

- All stakeholders including the Ministries involved, the MMDAs and the private and CSO must enhance the efforts at supporting the process.
THANK YOU
(FOR YOUR ATTENTION)
The Impact of Resilience Modelling on Private Sector WASH Participation

The Ecological Sequestration Trust (TEST) For GAMA WASH Sector

Presentation By Dr. George NK Rockson
(Research, Innovation and Development Department)

10th March, 2016
Issues Begging for Sustainable Solutions

Whether it is sewage being discharged into waterbodies or waterbodies are being contaminated.....
What Factors are being Impacted which requires Scenario Analysis?

- **Land Use issues**: Spatial Planning, Infrastructure Accessibility, Long-term Plan Approach;
- **Water use Issues**: Accessibility, Service Quality (packaging/transportation), Waste(Plastics);
- **Sanitation Management**: Treatment and Resource Circulation of Wastewater & Faecal Waste;
- **Price and Fees**: Fee fixing, Permit/connection fees, Income levels, and access to finance/funding;
- **Behavioural Change issues**: Culture, enforcement of laws, Capacity building and incentives creation.
The Private Sector Private Sector Solutions

1. TOILET CABINS (2000 Units)
2. Recycling of Selected plastic into Waste Bins
3. Lavender Hill Sewage Treatment with Biogas Generation: 2000 m³ per day – 200 Trucks per Day
4. MUDOR LIQUID WASTE TREATMENT PLANT
(>20000m³ for sewage)
5. ACARP- Sewage Treatment for GAMA WEST:
600 m³/day – 60 Trucks per day
6. Capacity Building and Knowledge Transfer

KNUST-Africa Institute of Sanitation and Waste Management [KNUST – AISWAM]
Would Ghana achieve its SDG targets on time?

THANK YOU!

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george.rockson@aiswam.org
Thank you