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Simulating large-scale change interventions for WASH services using Agent-Based Modelling

IRC, together with TU Delft, has developed two agent based models for exploration of policy and implementation issues related to the delivery of sustainable rural water services delivery. Both models represent rural water service delivery areas, one in the context of Uganda and the other a generic rural setting.

Agent-Based Modelling offers the potential to identify, select and test promising innovations or policies that are difficult to test in real-world settings. Contemporary modelling and simulation tools provide a powerful means of generating insights in the working of complex water services delivery systems.

Agent-Based Modelling in brief

A cost-effective exploration of implications of water services policy and implementation decisions using service delivery indicators.

Users

(Non-) government policy makers and implementers involved in design and programming of WASH sector investments and implementation.

Indicators

Locally-relevant service delivery indicators that track patterns of change in service levels.

Outputs

Data generated through 'experiments' run in the modelled environment enable 'problem owners' to explore plausible future scenarios and the potential effects of an intervention or innovation upon service delivery levels.

Tool format and language

Computational model built using NetLogo, or similar modelling software, that visually depicts agent behaviour and outcomes in settings with high degrees of uncertainty.

A real-world setting is simulated in which 'experiments' are run allowing practitioners to explore the potential range of outcomes, or unforeseen problems, arising in the simulated scenario.

Generate large-scale patterns of behaviours and outcomes

The first step in creating an Agent-Based Model, is to work with stakeholders, or 'problem owners' to define the problem, or issue into which they seek insight. Once this is clearly articulated as rules in computational code, a visual simulation of the identified problem or scenario is built.

The computational code generates a visual representation of the autonomous agents and the environment in which they exist. The code sets out basic rules and conditions that in turn give rise to the actions and interactions of autonomous agents in the model.

The agents represent the social (people, institutions) or technical artefacts (infrastructure) within the simulated system – such as a water service delivery area. The model is run to simulate relatively simple, individual behaviours which are visually showed.

The tool provides policy makers and implementers with exploratory insights into the implications of policy measures, implementation plans or potential for scaling of innovations in settings where real-world testing is not an option.

Once key stakeholders, or 'problem owners', are satisfied that a model is a reasonable representation of their real-world problem, the model is run over a representative timeframe (e.g., one day, one year, ten years) to generate large-scale patterns of behaviours and outcomes. Various combinations of rules and conditions can be run for comparison between different scenarios or states.

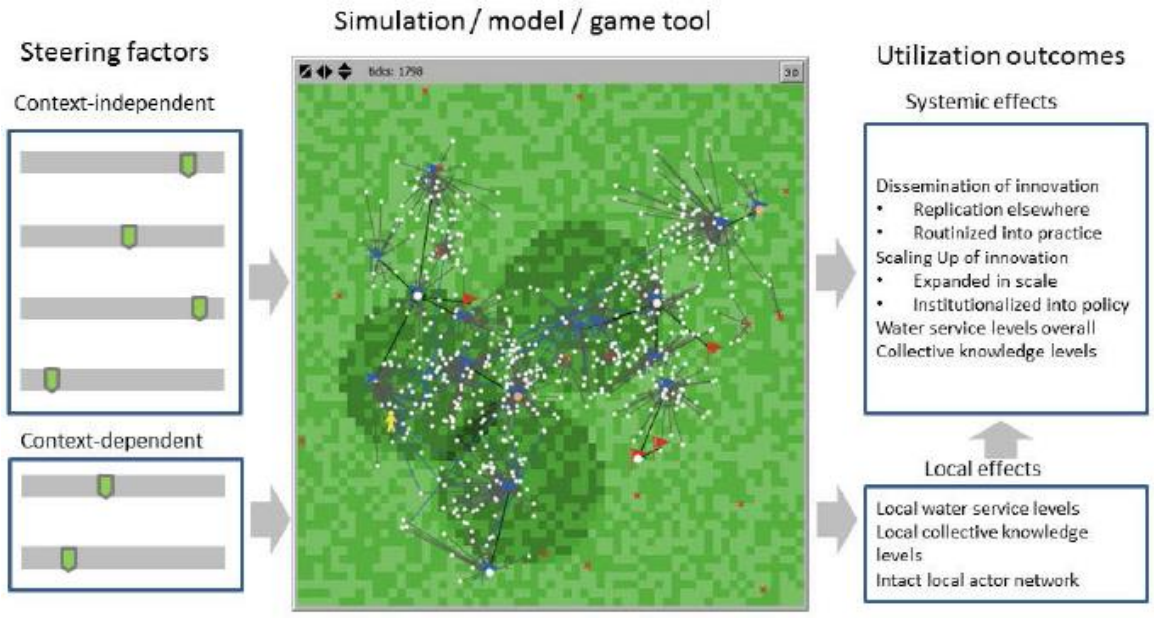
How is the tool being used?

Through its potential to visually depict outcomes in settings with high degrees of uncertainty, Agent-Based Modelling is a powerful tool that explores the range of potential outcomes stemming from policy decisions, new business models and the introduction of innovations on key service indicators.

The insights it offers can be used to support planning and implementation of large-scale change processes.

Two proof-of-concept models have been created to simulate a rural water service delivery area. These models demonstrate the utility of Agent-Based Modelling for testing and identifying potential solutions to complex challenges.

Mobiles for Water experiment: simulation of water services in rural Uganda with mobile telephone monitoring technology



Source: Slinger, et al. (2014) adapted from Jaxa-Rosen and van Staveren (2014).

Mobiles for Water experiment

The model visualises and measures the effect on service delivery indicators of mobile telephone technology to monitor water point functionality in rural Uganda.

The following possibilities are offered:

- Visualisation of the interconnected, dynamic feedback structure between: water point functionality, user willingness to pay, availability of funds to pay for repairs and replacements, user perception of Water User Committees and ultimately water service levels in the simulated service area.
- Ability to observe how positive or negative changes in one feedback mechanism results in changes in all other feedback mechanisms.
- It is possible to implement, trial and test multiple solutions across the water service sector simultaneously and observe their impact over time on basic water service levels.
- The diffusion of knowledge about water point functionality through a social network (community of rural water users as in this model) is simulated with / without mobile telephone technology, and the impact of these scenarios on time-to-repair and service levels can be examined.

Outcomes or patterns of behaviours in the simulated environment are tracked and recorded for analysis and sense making by key stakeholders.

Planning options for sustainable rural water services

A service delivery area is modelled with, and without, planned redundancy of water points. Redundancy refers to extra water points that are not strictly necessary for the delivery of a service, but whose presence (and functioning) in a water service area ensure that services levels do not decrease in the event of failure of one or more primary water points.

This model simulates the potential of redundancy as a suitable policy measure for decreasing mean time between repairs and thereby increasing service levels over time.

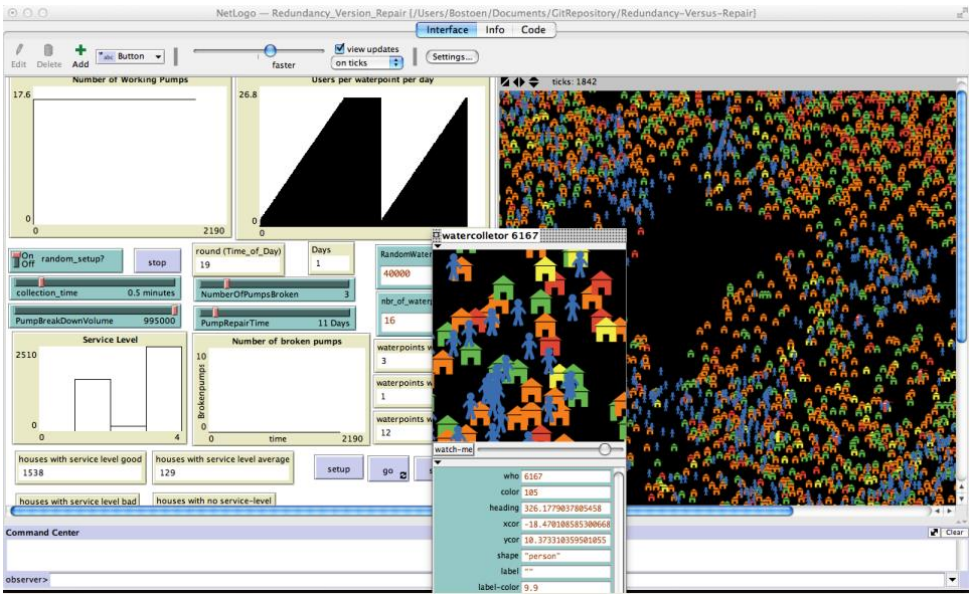
Basic service delivery seems to require much more access points than those that are currently available in a lot of real-world situations.

Lessons learnt in using the tool

No proxy exists for human-sense making.

As with any tool, the quality of the output is reliant upon the quality of the input.

Clear decomposition of the problem to be modelled is essential. Consistent engagement with stakeholders / problem owners at each stage from design through analysis and sense making ensures that the model, and any insights it generates about complex emergent phenomena, are understood to offer just that – exploratory insights and not predictive answers to sector challenges.



Source: Tielens (2014) adapted from Water Services Planning - redundancy vs. repair model, Bostoen and Brown (2013)

Strengths and limitations of the tool

Agent Based Modelling	Use	Don't Use
To create a simulated, visual representation of the emergent effects of a policy or intervention in a defined context, such as in a water service delivery area	X	
To enable problem owners to explore the implications of various scenarios in addressing policy or implementation challenges in a given context	X	
To support identification of potential outcomes of different plausible scenarios when a range of policy or implementation options are applied in a simulated context	X	
To predict outcomes or impacts		X

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FURTHER INFORMATION

- Read more about the IRC approach at www.ircwash.org/news/quick-guide-ircs-approach
- Mobiles for Water experiment in Uganda www.waterservicesthatlast.org/experiments/uganda_experiments/using_mobile_phones_to_improve_functionality_of_rural_water_services and www.waterservicesthatlast.org/media/presentations/m4w_presentations
- Activities of IRC Uganda www.ircwash.org/uganda
- Website of the Triple-S Water Services that Last project at www.waterservicesthatlast.org/