Climate Resilient WaSH in the Pacific

Improving rural water supply in the Solomon Islands via rainwater tanks

PROGRAMMING BRIEF

Research statement

A computer modelling approach called a Bayesian Belief Network (BBN) can be used to contribute new knowledge and assist decision-making in situations of high uncertainty and when available data is limited. This method is of particular relevance in Pacific Island Countries (PICs) where there is uncertainty around the impacts of climate change, and limited data available on other factors of variables within a catchment system that might affect the quality or availability of water for drinking and other purposes, such as sanitation and hygiene. In this study, a BBN was used to integrate household survey data into our understanding of water and sanitation systems in floodplain communities. The information from the BBN contributes to our understanding of how to improve water supply in rural communities in the Solomon Islands.

Findings

1. A quantitative model can assist in simplifying and understanding the complexities around multiple water sources and the factors influencing how they are used.

2. A BBN model shows that increasing the availability of rainwater tanks at both household and community level, and promoting sustainable use and management, could increase proportional access to adequate water at critical times in rural Solomon Islands communities.

Background

Climate change is a serious threat to PICs and their freshwater resources. Sea level rise, saltwater intrusion, increasing evaporation rates and changing rainfall patterns will all affect the water cycle and, potentially, the availability of water for human use. This poses significant adaptation challenges for development and human health in PICs.

Methods

A BBN is essentially a diagram that shows what we understand about the primary cause and effect relationships between different variables in a particular system, and includes probabilistic information on how much, and in what way, each of the variables affects the others. In this study, BBN models were developed representing two extreme ends of the environmental spectrum in PIC's, flood-prone and drought-prone atoll environments.

Research described in this brief was conducted as part of the Pacific Adaptation to Climate change for Water, Sanitation and Hygiene (PACCWASH) Project, investigating adaptation to climate chnage for WaSH in PICs. This research was funded by the Australian Government Department of Foreign Affairs and Trade, and managed by the International WaterCentre. Research partners included the Water Institute at the University of North Caroline, Griffith University, Monash University, University of Alabama, and University of the South Pacific.

A BBN model was developed using primary data collected from five communities in flood-prone areas of the Solomon Islands (Figure 2). Causal diagrams to inform the model were developed through multiple participatory exercises and discussions one-on-one and in focus groups with both men and women.

Who is this brief intended for?

The findings in this brief are intended for rural water, sanitation and hygiene program managers and policy-makers in the Solomon Islands.

Supported by

Australian Government
Department of Foreign Affairs and Trade

International WaterCentre
Griffith University
UNC Water Institute
Monash University
The University of Alabama
USP The University of the South Pacific

The primary concern identified by all communities involved was whether they would have enough drinking water of adequate quality, and this was used as the focus or "endpoint"for the floodplain BBN. The relationship information is based directly on data collected through a household survey, using Bayes' probabilistic theorem that incorporates whatever quantitative information is available to calculate the likelihood of a certain variable behaving in a certain way, given how the other variable/s linked to it are behaving.

Decision-makers, including program managers and policy-makers, need to balance the desirability of an outcome against the chance that a particular management action may not lead to the outcome expected. BBNs are relatively easy to adapt and to update as our understanding of a system, or the data collected about it increases. The model can "learn" from additional data and become better at predicting outcomes. The more evidence that is available on how the system has behaved in the past, the more certain the BBN will be that it will behave in a similar way in the future. This explicit accounting for uncertainty is useful given the complexity of the natural world and the difficulty in making precise predictions of the effects of management actions.

For more information on BBN and household survey methods used in this study, please see associated briefing notes:

- Developing Bayesian Belief Network models for water and sanitation
- Using mobile survey tools to understand multiple water sources and uses

Finding 1: A quantitative model can assist in understanding water use characteristics and influences on use

Rainwater use is complex, with both private household rainwater collection and public or communal rainwater tanks (RWT) used in Solomon Islands communities as part of a mix of multiple drinking water sources (Figure 1). Rainwater tends to be preferred for drinking, but a number of conditions determine whether it is used. Understanding how rainwater fits into household water usage behaviour and reasons behind patterns of use can inform more targeted WaSH interventions. RWT implementation and sustained use are a key focus of many government and non-government organisations looking to increase water security for rural communities in the Solomon Islands. However, rainwater use (including both private/household and public/communal level collection) is only part of a mix of multiple sources used under a range of conditions.

A BBN model was developed using primary data collected from five communities in flood-prone areas of the Solomon Islands (Figure 2). A number of scenarios were analysed leading to the findings below.

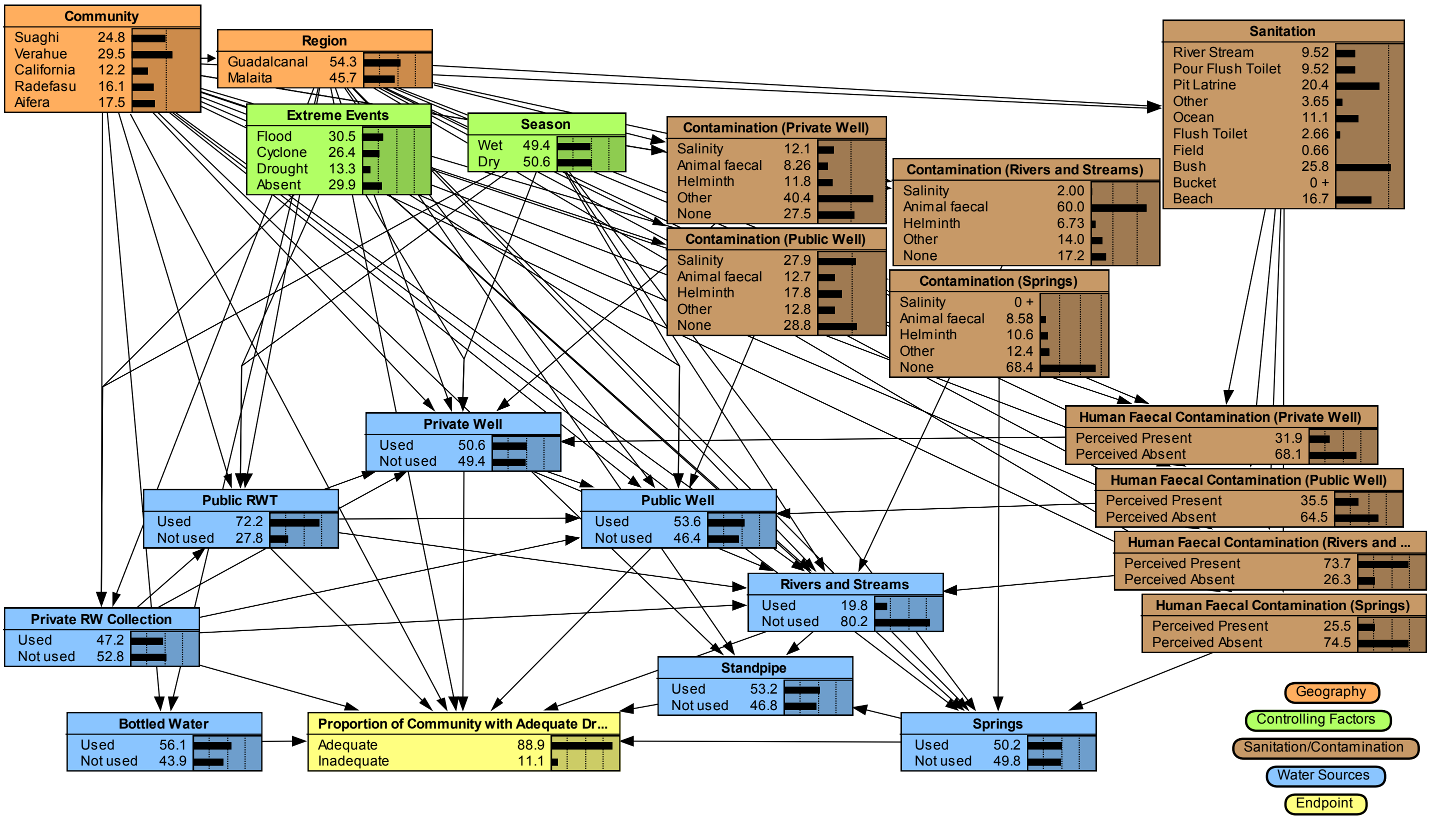
- Rainwater tends to be preferred overall for drinking, but a number of conditions determine whether or not it is used, including the season, the presence or absence of an extreme event and its type (i.e. flooding, drought or cyclone), the availability of other sources (e.g. wells), and community perceptions of the quality or potential contamination of each of these sources.
- Use of both private and public RWTs increases under flood and cyclone conditions, as water quality and the accessibility of wells and rivers or streams decreases. However, use of rainwater does not entirely make up the shortfall and the overall proportion of the community with adequate drinking water decreases.
- The number of households using rainwater decreases during drought, as may be expected due to lack of rain. The shortfall is largely met by increasing use of other sources (e.g. wells and rivers) which persist unless a drought is particularly long. This increased use of other sources occurs despite concern over increased contamination of these sources during periods of drought.

The BBN assisted in determining how communities use multiple water sources under different environmental conditions. The ability of the model to quantify variables also allows comparison (and therefore prioritisation) of the impact of different management scenarios, as described in Finding 2. These applications can provide direct decision-making support to WaSH program managers and policy makers.

Figure 1: A communal/public rainwater tank in a flood-prone community in the Solomon Islands.

Photo credit: Terence Chan, 2015

Figure 2: Baseline (current) use of water sources



Finding 2: Community use of rainwater can be improved by increasing availability and sustainable use of RWTs

Sensitivity and scenario analysis of the floodplain BBN for the Solomon Islands indicates that the proportion of any community with adequate drinking water is most highly influenced by use of private and public rainwater collection. The analysis provides a ranking of the variables with the most influence on the management endpoint i.e., the proportion of community with adequate drinking water. Use of privately collected (household) rainwater was the most influential factor, followed by standpipes (which are not an option in many rural communities), and then public or communal rainwater collection. Other factors, including other water sources and perceived contamination of any one source, were all less influential on the proportion with adequate drinking water.

The impact of rainwater use is more simply illustrated in a comparison between the BBN endpoint outcomes for improving rainwater use, in Figure 3, and an individual BNN scenario, in Figure 4, corresponding to the rightmost blue bar in Figure 3. These figures illustrate that despite rainwater use during a flood or cyclone event being higher than during baseline conditions (the absence of an extreme event), a further increase in both private and public rainwater use under these extreme conditions further improves community water supply (see the green bars in Figure 3). Anecdotally, rainwater tank failure during extreme conditions occurs because of hardware failure, such as damage to roofs, piping taps, and tank frames or structures. These hardware failures also occur due to normal deterioration over time.

Figure 3: Increasing the use of rainwater tanks

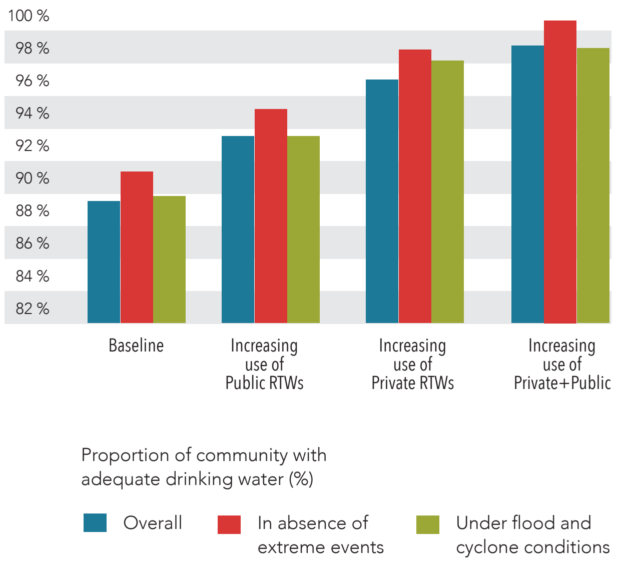
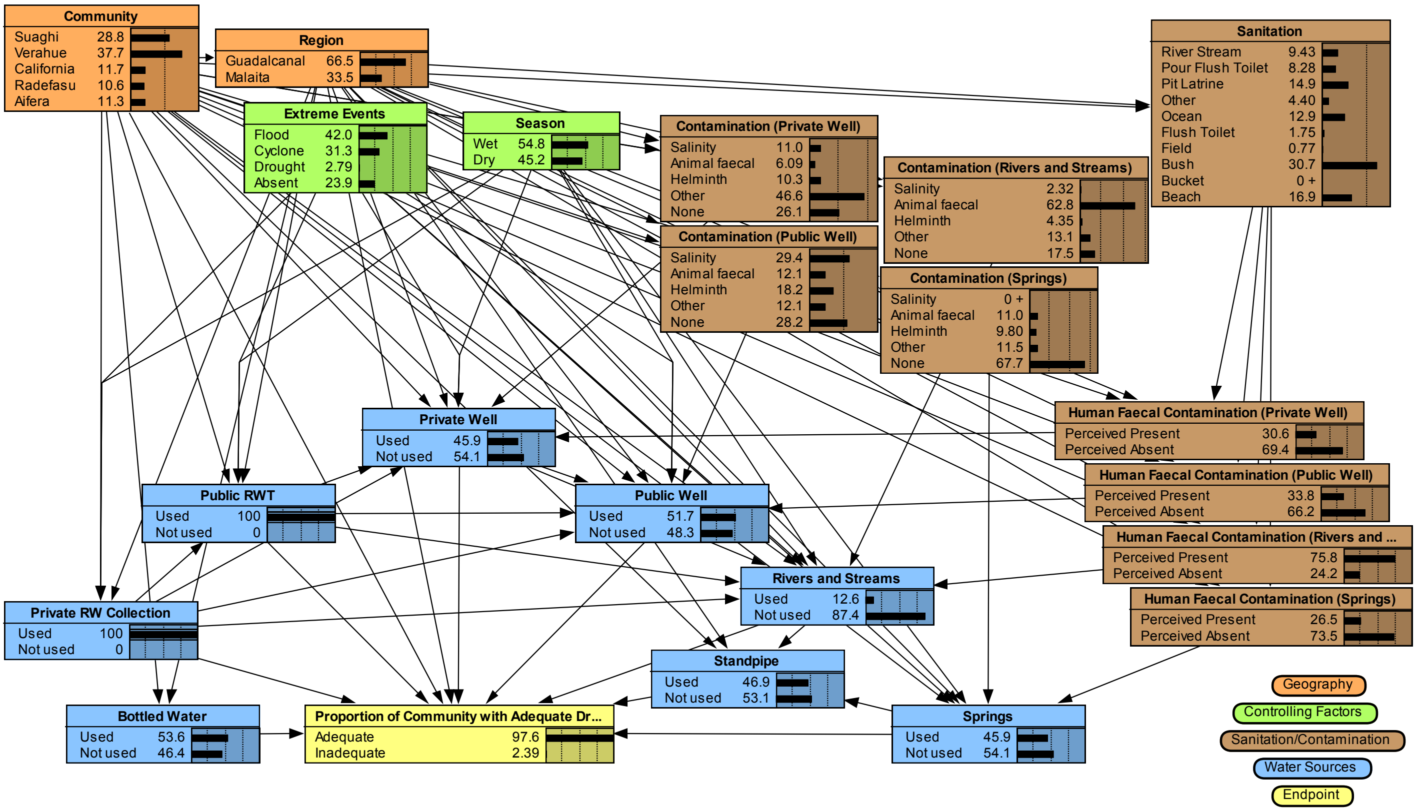


Figure 4: Water use with increased use and reliability of RWTs



Changing the baseline use of private rainwater collection (currently used 47% of the time) and public or communal rainwater collection (currently used 72% of the time), to "always used" could improve the endpoint adequate drinking water from a likelihood of 89% to 98%. Improving rainwater tank use to 100% use is unlikely to be practical, and increasing effort and resources to do so are likely to be met with exponentially decreasing improvement. Rainwater use is a key component of drinking water supply in many rural communities, however, hardware interventions are not always delivered in a sustainable manner.

In this study, we identified numerous cases of failed hardware interventions, including the uncoordinated provision of rainwater tanks in the Solomon Islands following disaster events, and without the provision of necessary parts, such as piping, for installation or ongoing maintenance. Software support, such as training in operation and maintenance, and social arrangements for management of communal water systems, was often lacking. An informed increase in this type of support alongside hardware interventions would be beneficial.

Want to know more?

This brief describes findings from the Pacific Adaptation to Climate Change for Water, Sanitation and Hygiene (PACCWASH) Project. For more information, please contact Principal Investigator, Dr Wade Hadwen, at w.hadwen@griffith.edu.au, or visit www.watercentre.org/portfolio/wash-and-climate-change-adaptation-in-the-pacific

Acknowledgements

The Australian Government is acknowledged for its support of this research through the Australian Development Research Awards Scheme (ADRAS) within the Department of Foreign Affairs and Trade. The research team would also like to thank all of the study participants without whom this research would not have been possible, as well as local research assistants, Dustin Langidrik, Hilda Tango, Trevor Palusi, Malynne Joseph, Patricia Kennedy and Adelma Louis, for their exceptional work in the field and keen insights into community life.