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DELIVERING WATER, SANITATION AND HYGIENE SERVICES
IN AN UNCERTAIN ENVIRONMENT

Understanding WASH through complex adaptive systems theory

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The development community has looked to engineering, social action, planning and evaluation to understand the often inexplicable outcomes of water implementation projects. This paper gives an overview of research that uses Complex Adaptive Systems theory as a framework to investigate the unpredictability of outcomes for community water supply projects. Preliminary interviews and surveys in a remote village in East Timor are used to investigate the viability of social network analysis and system dynamics as tools to make sense of WASH program outcomes.

Introduction

There is no doubt that WASH programs are of global value in improving the quality of life for millions of people every year. We understand that provision of water and sanitation infrastructure are crucial to improvements in quality of life, including reduction of poverty and access to education and health outcomes (Larson, Minten & Razafindralambo 2006). In contemplating this, Richard Carter says:

> "*Do we not know enough by now that further justification for investing in and improving WASH should be unnecessary? Who would seriously argue against the proposition that all should enjoy safe, affordable, and reliable water and sanitation services, and the opportunity to practise good hygiene? What we need to know is how to implement WASH services more effectively, cost-effectively, and above all, sustainably*." (Carter, R 2013)

This clearly indicates that the issues around WASH are not about whether WASH is needed or useful, they are about the practicality of implementing WASH systems that continue to work long after the NGOs or other organisations have moved on. Knowledge and practice in the WASH sector should be constantly growing and changing in response to new information and practical successes. Complex adaptive systems (CAS) theory as a framework for understanding development practice and policy is growing in acceptance within the development community (Barder 2013; Ramalingam et al. 2008; Rihani, Samir 2005). One of the standout messages from CAS theory is that there is a need for flexible and inclusive planning when it comes to working with complex adaptive systems (Hummelbrunner & Jones 2013). The implications of CAS theory have not been investigated specifically in regard to planning, implementation or evaluation of WASH programs. This paper introduces some of the theory of complex adaptive systems and goes on show how communities and WASH projects can be understood to be complex adaptive systems and what this means for development practitioners working with unpredictable community responses and uncertain outcomes in WASH implementation projects.

This research has been conducted as a preliminary investigation towards a PhD thesis that positions sociological theory and WASH practices within a framework of complex adaptive systems theory. The methodology applied is based on the pragmatic use of mixed methods to integrate theory and practice from complementary fields of study. The research applies instrumental case studies of villages in Timor Leste to explore the actions and relationships of individuals under different conditions of water supply.

The research referred to herein was undertaken in 2012, it included interviews with staff of government and non-government organisations in Australia and Timor Leste. It also involved a community meeting, community surveys and individual interviews in a small aldeia (village) which is seasonally isolated, 12km from its nearest township in Timor Leste. Results of surveys and interviews were used to create social network maps and preliminary analyses using NodeXL software.

Complex adaptive systems theory

Complex adaptive systems theory has developed over a relatively recent timeframe and comes predominantly from the study of ecological sciences. Most recently it is being applied within the social sciences, business, marketing and economics to enable a non-linear understanding of social and ecological phenomena (Byrne 1998). The ideas within complex adaptive systems theory point us towards developing a network understanding of our world. This varies greatly from traditional views in many fields, where the application of linear positivist viewpoints have left us with a legacy of "unsolvable" or "wicked" problems (Rihani, S. & Geyer 2001). Although difficult to define precisely, complex adaptive systems are systems which are composed of many parts or agents, where understanding the system requires looking at it from multiple scale perspectives and where the system is responsive to its environment at different scales. CAS have emergent properties, such that actions at one level will cause the evolution (emergence) of structures at a higher level. Effectively they are systems where there are many interconnections and feedback loops and where agents may act or react in a variety of ways. The outcome of the actions of many agents in a CAS tends to create an emergent pattern – an overarching structure or behaviour that can be predicted despite the unpredictability of individual agents (Urry 2003).

WASH programmes as complex adaptive systems

It is fair to say that almost any social grouping is a complex adaptive system. Some of the main features of a complex adaptive system are:

- The whole is more than the sum of the parts.
- CAS interact with other CAS, they may be nested within other CAS, and they co-evolve with each other (see Figure 1).

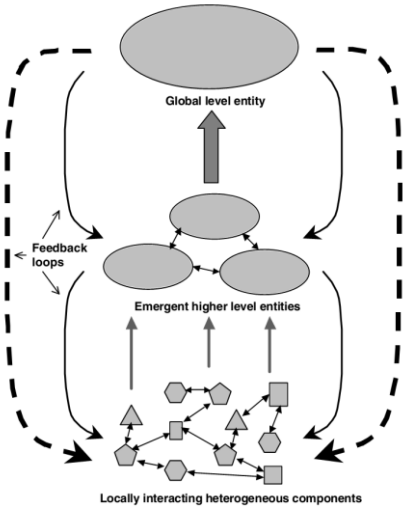

Figure 1. Hierarchy of organisational levels in a complex system.
Locally interacting components give rise to emergent, higher-level entities, whose existence, in turn, affects the behaviour of lower-level entities.

Source: Parrot (2002)

- CAS are emergent – higher levels of organisation emerge from interactions at lower levels (see Figure 1).
- It is difficult to predict how a CAS will respond to events over time:
    - sometimes small events cause large impacts on the system (the butterfly effect)
    - sometimes large events have almost no long term impact as systems are resilient to change.
- CAS are subject to feedback loops and therefore respond to their environment in non-linear ways.

All of these points could also be used to describe a country, a society, or a community.

Tools to understand WASH in communities

Accepting that communities are complex adaptive systems opens up the methods that we use to understand and to work with communities on WASH implementations. The current most used methods and frameworks appear to include participatory development, community model building, peer pressure techniques such as CLTS, infrastructure subsidy, pro-poor development, women's engagement, accessible WASH etc.. These method and frameworks have all developed over a period of time in response to experimentation, observation and evaluation of historical programs. All are still plagued with problems of sustainability in at least some implementation locations. The aim herein is not to critique the current methods in WASH or to assess any particular program. The engineering and the social programs that agencies use are each effective in their ways and each is appropriate to different situations. The aim is to use the tools that CAS theory leads us to, in order to understand why programs that seem to have been well implemented are inclined to provide clean, accessible water for *shorter time periods* than is anticipated in the planning stages (Carter, RC, Tyrrel & Howsam 1999). This focus on water supply is not to marginalise the importance of sanitation but responds to the observation by Larson et al (2006), that the proximity and accessibility of water supply is a predictor of the amount of water used for household hygiene purposes.

System dynamics and social network analysis are two tools that can be applied to complex adaptive systems problems. In applying these tools to the issue of temporal sustainability of water systems, the question of **how** to achieve long term positive outcomes, we first need to gain an understanding of **why** some water systems are abandoned in the short term, and why others are not only sustainable, but progress to unforeseen positive outcomes in health, education or economic livelihoods? In situations where there has been community participation in planning and implementing a project, where the technology is appropriate, and where there are resources and skills available to make repairs, what factors contribute to such variability of outcomes?

Social network analysis

Being able to answer the question *"why are some water systems abandoned?"* requires an understanding of the community that a WASH program has been implemented in. It is important to know how knowledge is transferred between community members, who has access to government and NGO resources and who is likely to know about broken taps etc… Interactions within a community create the environment that will support or oppose, the use and maintenance of a WASH program, including its water system, just as interaction between agents in any complex adaptive system will lead to both emergence of higher structures (like water management groups) and resilience to change. The use of social network analysis (SNA) allows community relationships around water (or other areas) to be mapped and described.

A household survey, conducted in a remote community in Timor Leste and analysed simply using NodeXL, shows fairly conclusively that in answer to the question –"who would you talk to about the water system in your village?" the most common response is the chefe aldeia (village chief) even though almost every person interviewed knew and had access to the water users group which didn't include the chefe aldeia. In Figure 2 the nineteen outer dots represent the survey respondents (one from most households) and the dots inside represent aggregated data, where individuals from each group may have been indicated by their name or position. Each line represents a connection "I would discuss the village water system with this person/group" reported by either agent. The size of each dot correlates with the number of direct connections reported.

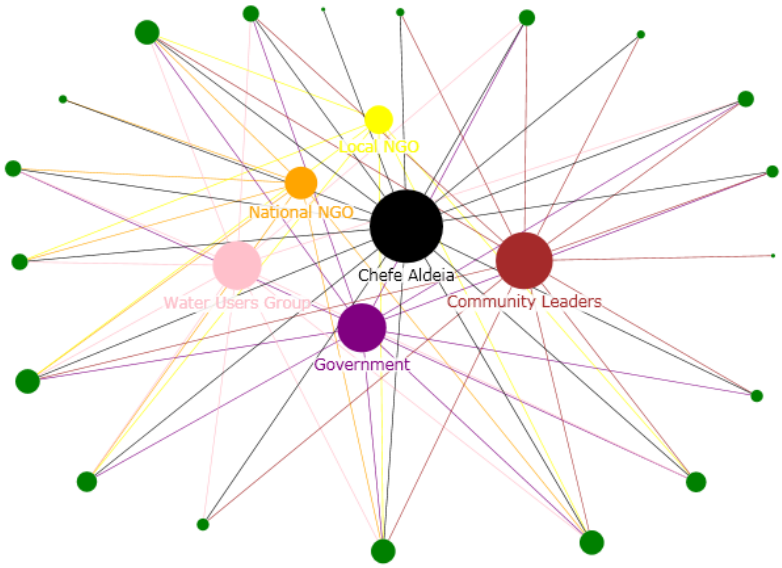

Figure 2. Social Network map of water discussions in a village in East Timor

Figure 2 makes it clear that discussions around water may take place with a variety of people from both inside (Community leaders, Water User Group, Chefe Aldeia) and outside of the village (NGOs and Government). It also becomes clear that some community members are much "better connected" than others. While the survey results indicated that discussions about water would almost certainly occur within a household – with spouse, parent or child, there were no indications that discussions about water would be had on a casual basis with neighbours or friends, although as this was not asked as direct question, that may have influenced the results somewhat. Casual conversation with neighbours and friends is of interest here, as the emergence of higher order structures is directly related to community mobilisation which is logically related to the act of casual conversation (and complaint?). The existence of the water user group in this community, instituted by the implementing NGO, may have reduced any perceived need for community mobilisation around water system maintenance, despite a high number of taps being reported as broken. Urry (2003) explains similar effects "the Titanic effect" as being caused by the attempt to create a perfect system, which is both impossible and self defeating. So an attempt by external agents (NGOs) to build a social structure (water users group), which normally would be emergent in course of things, may be inherently flawed.

System dynamics

System dynamics is a technique that has arisen within engineering disciplines and has already found some use in the development literature (Clark, Perez-Trejo & Allen 1995; Elwert & Bierschenk 1988; Ulrich 2010). Of particular note is the first step in using system dynamics, which is to create an influence diagram that describes the problem. This can be done using stakeholder input to ensure that various points of view are accounted for. Further steps allow us to observe feedback loops and take note of any potential tipping points, or leverage points where the system may be acted upon to create change.

It is generally acknowledged that women have the most to gain from WASH implementation programs, as the burden of water collection usually falls to them (Fisher 2006). It is less often acknowledged that women may also have the most to lose in this situation. Figure 3 leads one to question the value to women of the time spent in collecting water. If women do find value in spending time together collecting water, washing clothes and bathing, then a valued social activity may be lost during the implementation of a WASH program. If women then also find that they are responsible for the undesirable task of cleaning or maintaining a smelly, fly blown latrine, it would seem possible that a social walk with your friends to collect water may actually be more desirable. It is unlikely, that at the planning phase of a WASH program, women would have, or express, concerns about the loss of social cohesion etc.. that might occur as the result of the program. Results of the research indicate that several years after the implementation of a particular WASH program, this concern is, in fact, expressed by a number of community members.

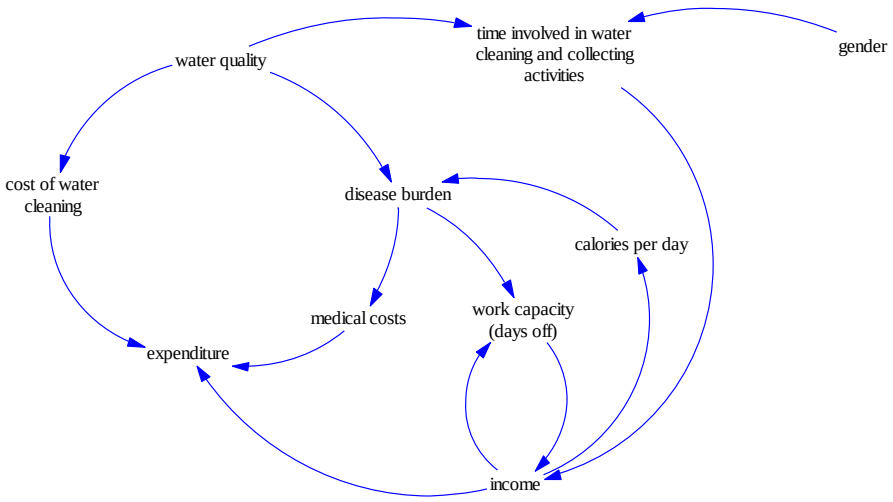

Figure 3. Influence diagram focussed on family expenditure related to water quality and access

This is just one situation where there has been an unexpected negative impact (community conflict over water systems) as a result of an intervention. Acknowledging the social, political and personal dynamics of communities is essential to understanding why the outcomes from WASH implementation are remarkably variable – between premature abandonment and being the foundation for ongoing economic and lifestyle improvements. Once we understand this, then we need to create plans and strategies that are flexible and acknowledge that we cannot know everything and plan for all eventualities in a WASH program.

Conclusion

For any community, and the development agency that works with them, there is value in understanding that even apparently simple objective, such as installing and maintaining a water system, is not a linear process with predictable outcomes. Unanticipated feedback loops and existence or emergence of social cliques may confound or compound the desired outcomes of any policy or program. Complex adaptive systems theory gives us a framework to explore the unexpected and inexplicable outcomes of WASH projects. It allows us to conceptualise knowledge, social structures, the natural environment and NGO's as part of integral system with an immense field of possible pathways. Applying our knowledge of complex adaptive systems to WASH projects can only advance our ability to understand and cope with uncertainty in community WASH implementation.

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