

Change in complex adaptive systems

A review of concepts, theory and approaches for tackling 'wicked' problems in achieving sustainable rural water services

Deirdre Casella, Simone van Tongeren, Igor Nikolic

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Change in complex adaptive systems:

A review of concepts, theory and approaches for tackling 'wicked' problems in achieving sustainable rural water services.

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Key words: agent-based modelling, collective impact, complex adaptive systems, learning alliances, problem-driven iterative adaption, rural water services, socio-technical systems, systems thinking, universal Darwinism, whole system change

This report presents a review of theory, rationale, strategies and methods that underpin approaches to effecting lasting change in complex adaptive systems. The context is the water, sanitation and hygiene (WASH) services sector in developing countries. The report discusses the multi-faceted challenges that the sector faces in delivering sustainable services and summarises the growing calls for a complexity-informed transformation in how the development aid system is conceptualised and how its products are delivered. Whole system change approaches are presented and discussed for their potential to achieve this transformation.

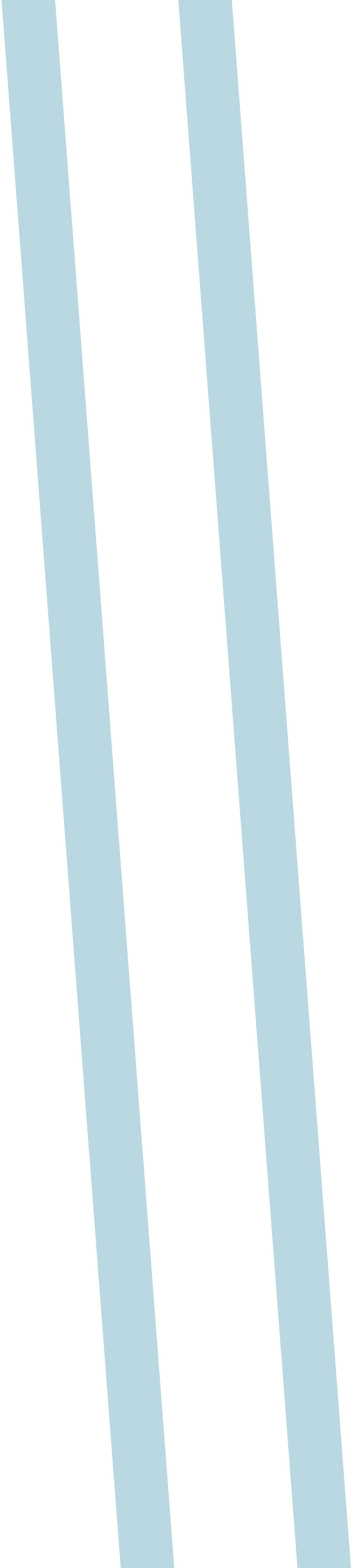
Reviewers: Catarina Fonseca, PhD, and Patrick Moriarty, PhD

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Design and layout: Punt Grafisch Ontwerp

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Abbreviations

ADIC	attributes, deontic, aim, condition
ADICO	attributes, deontic, aim, condition, or else
AIC	attributes, aim, condition
CAS	complex adaptive system
CBO	community-based organisation
GDP	gross domestic product
IAD	institutional analysis and development
NGO	non-governmental organisation
OECD	Organisation for Economic Co-operation and Development
PDIA	problem-driven iterative adaptation
SOHO	self-organising, hierarchical, open
WASH	water, sanitation and hygiene

1. Purpose of this review

This working paper, a product of the Triple-S Water Services That Last project¹, is part of an effort to ground IRC's approach to driving and supporting change processes in the water, sanitation and hygiene (WASH) sector in the theory and methods of complexity sciences and systems thinking. The review of literature from these fields identifies theory, rationale and methods underpinning complexity-informed approaches to effecting change in large, dynamic, complex adaptive systems². The insights gained from this body of literature are discussed in relation to the rural water sector in low- and middle-income countries—a sector facing 'wicked'³ problems whose solution requires changes in the mindset and behaviours of multiple actors (Rittel and Webber, 1973).

The domain of inquiry of this review is the rural water sector in low- and middle-income countries. Section 2 describes a series of generally recognisable attributes of the rural water sector as they feature in low- and middle-income countries. Salient attributes include the roles and responsibilities of key actors and patterns of interaction between and among key actors, institutions and technology in this domain. This section also reflects on the multi-faceted and inextricably linked challenges to delivering sustainable services and on the role of international development aid as an external influence in national development agendas and thereby in how public services are financed, planned and implemented. It reviews the literature on how international development aid can address these challenges by embracing concepts and practices informed by systems thinking and complexity sciences.

Section 3 presents concepts and approaches from the complexity sciences and related fields, including socio-technical systems as a specific type of complex adaptive system, institutional analysis and whole-system change, and explores whether they offer new perspectives on alternatives to prevailing national development and water service delivery policy and practice in particular. Following the reflection on insights offered by the complexity sciences, Section 3 concludes by reconsidering the rural water sector in light of the theory about complex adaptive systems and how change arises in such systems.

Section 4 discusses three approaches featured in the literature for their potential to effect systemic change in complex adaptive systems, as proposed alternatives to current policy making and planning in international development. Given that large-scale systemic change can take several decades, Section 5 presents tools for simulating change processes in complex adaptive systems for the purpose of envisaging, exploring and experimenting with policy and implementation alternatives. Section 6 concludes with a discussion of the insights gained through this review and identifies gaps in the literature about how to foster national systems that can deliver sustainable public services.

¹ Triple-S Water Services That Last is a six-year, multi-country learning initiative to improve water supply to the rural poor that is led by IRC a Netherlands-based mission driven 'think and do tank' pursuing the vision of WASH services for everyone, forever. The initiative is funded by the Bill & Melinda Gates Foundation and has country programmes active in Ghana and Uganda with smaller initiatives supported in Burkina Faso, Mozambique, India and Honduras. Lessons learned from work in countries feeds up to the international level where Triple-S promotes a re-appraisal of how development assistance to the rural water supply sector is designed and implemented.

² Moriarty, Lockwood, Carriger and Duij, series of four blogposts, <http://waterservicesthatlast.wordpress.com/2014/02/24/changing-the-whole-system-to-provide-water-sanitation-and-hygiene-services-that-last/>. March–May, 2014.

³ 'Wicked' describes intractable, not-easily-solved problems—such as climate change, pandemics, poverty or natural disasters—that require changes in mindset and behaviours of a great number of actors (Rittel and Webber, 1973).



2. Water services: A system description

In this section the rural water sub-sector and the challenges it faces in providing sustainable services are described. Section 2.1 looks at the administrative and operational arrangements as well as roles and functions of actors involved in rural water sector in low- and middle-income countries. Section 2.2 presents literature about the role and influence of international development as an external change pressure that influences domestic policy, financial and technical aspects of rural water services in low- and middle-income countries. Section 2.3 provides an overview of the multiple, interlinked and intractable 'wicked' challenges to delivering services, reflecting on the fact that the solutions are not hardware based. Section 2.4 reviews literature arguing that such wicked challenges require alternative approaches grounded in the complexity sciences.

2.1 RURAL WATER SERVICES – FROM GOVERNANCE TO SYSTEMS PERSPECTIVES

The overarching purpose of a national WASH sector is to develop and deliver sustainable water, sanitation and hygiene services to users for domestic and productive purposes (Plummer and Slaymaker, 2007). Although the WASH sector is not clearly demarcated as an entity with precisely identifiable boundaries, a number of salient attributes can be identified across different national and regional contexts that enable us to consider the sector a 'system'. There are also a number of identifiable activities that people must undertake to ensure that water services are delivered. These attributes, activities and interactions, taken together, give rise to a recognisable pattern that, when effectively functioning, results in the delivery of water services. In this section, the rural water sector and its salient attributes are described as the domain of focus of this literature review.

In terms of attributes, there are identifiable legal, governance and organisational arrangements in place within nation states that guide the delivery of water services (Rogers and Hall, 2003). In general, a line ministry or department is the highest mandated authority responsible for ensuring that these services are delivered to all citizens. In addition to developing and managing the natural water resource, this national authority is tasked with developing and delivering water services to the population for domestic and productive purposes. While the national authority for water resources management and

service delivery may also hold the remit for development and delivery of sanitation and hygiene services, for the purpose of this review, we focus in particular on the legal and administrative arrangements pertaining to rural water service delivery.

In the context of decentralised water service delivery models, in addition to the national government, many other organisations and actors interacting on a continual basis are involved in policy making, financial planning and management, regulation and service provision activities across multiple administrative levels (Rogers and Hall, 2003). Depending upon the national context, these actors include sub-national government entities (e.g., provinces, regions, districts, communes, zones, municipalities, woredas, panchayats), water utilities, non-governmental organisations (NGOs), users, community representatives, private operators and capacity-building and financing bodies (de la Harpe, 2007). Among this host of actors, roles and responsibilities can be differentiated. As highlighted by Smits et al. (2011), a key distinction is the role of the service authority versus that of the service provider.

The service authority, generally a government body, holds the legal responsibility for service delivery planning, coordination, regulation and oversight activities as well as technical assistance to water service providers (Smits et al., 2011; Lockwood and Smits, 2011). In contrast, the service provider is the organisation or individual responsible for day-to-day water service, which includes the operation, maintenance and administration of the water system.

How the water service provision role is fulfilled varies widely. Most countries have a range of service provision options, or service delivery models, whereby 'the service authority can opt to provide services itself (through a municipal department or municipal company) or ... delegate this responsibility by contracting an outside agency such as a community-based organisation (CBO), private operator, public sector utility or company, or non-governmental organisation (NGO), who in turn may hire a private person (plumber or mechanic) to carry out parts of the work' (Smits et al., 2011, p.5).

In addition to the legal, administrative and organisational attributes and interactions—that is, the 'social' components of a water service—there is also

the technical component. The physical infrastructure required for the delivery of water supply varies greatly among and even within service areas⁴ depending upon factors such as geographical and hydrological conditions, preferences for certain technologies, available financial resources, and population size and density.

Whether the infrastructure is a stand-alone hand pump or a networked, gravity-fed piped scheme, formal and informal arrangements among the authority, provider, users, civil society and international development organisations are required to ensure sustainable water services (Keohane and Ostrom, 1995; Rogers and Hall, 2003; Plummer and Slaymaker, 2007). These arrangements entail policy- and decision-making processes about responsibilities and actor relationships through which the power, responsibilities, norms, values and formal agreements embedded in laws and policies are negotiated among and implemented by the array of stakeholders, whose roles and responsibilities may overlap (Ostrom and Janssen, 2004).

This view of interdependent networks of multiple actors, or agents, interacting across multiple administrative levels embodies a ‘governance perspective’ (Kooiman, 1993; Stoker, 1998; DFID, 2007). In reflecting on how to provide for a collective interest, such as the provision of public services, the governance perspective offers a ‘framework for understanding changing processes of governing, characterised by processes of adaptation, learning and experiment’ (Stoker, 1998, p.18). This perspective helps to conceptualise how functions related to service delivery are dispersed over a wide array of actors, organisations and coordination platforms spanning different national development sectors and administrative levels. Notably, from a governance perspective, while (central) governments continue to play a role in how public services are provided, as Bache (2003) notes, this role is increasingly one of coordination and steering and is concomitant with an increase in the involvement of non-government actors in policy-making and service delivery. The Global Water Partnership (GWP) defines water

governance as ‘the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society’ (Rogers and Hall, 2003). The literature on governance also highlights the importance of public participation in governance processes for the potential to ‘improve the quality of decision making by opening up the decision-making process and making better use of the information and creativity that is available in society, improve public understanding of the management issues at stake, make decision making more transparent, and might stimulate the different government bodies involved to coordinate their actions more in order to provide serious follow-up to the inputs received’ and potentially strengthen democratic processes where government does not have all the resources required to ‘manage an issue effectively’ (Huitema et al., 2009, p.5).

The prevailing governance approaches in low- and middle-income countries are context specific and have evolved over long periods of time in response to change pressures such as political, social and economic processes (Plummer and Slaymaker, 2007). Irrespective of the governance arrangements in a given national context, the governance perspective as described here makes it possible to introduce a systems perspective⁵ to understanding the rural water sector⁶. This line of inquiry will be addressed in further detail in Section 3.

By framing water services as a system that is open to feedback from its environment, it becomes possible to consider external change pressures increasingly recognised for their effect on how national development agendas—including water service delivery—are formed and implemented. One such pressure is the policy and finance support provided to low- and middle-income countries in the form of international development aid from parties such as UN agencies, international finance institutes, philanthropic organisations, non-governmental organisations and middle- and high-income countries (Rogers and Hall, 2003; Mowles et al., 2008;

⁴ A service area is the area of jurisdiction and population covered by a service authority. Service areas are typically linked to the boundaries of human settlement (towns, villages, hamlets and scattered rural settlements) but may not correspond precisely with administrative boundaries (IRC Glossary, accessed 16 October 2014).

⁵ A systems perspective takes into account all of the behaviours of a system as a whole in the context of its environment and is ‘a non-reductionist approach to describing the properties of the system itself’. A description of the whole must include an explanation of the relationships between the parts as well as any additional information needed to describe the behaviour of the entire system (after Bar-Yam, 1997, 2005).

⁶ A system is defined by Ryan (2008) as ‘a representation of an entity as a complex whole open to feedback from its environment’. Ryan (2008), Burke (2006) and other authors on systems and complexity sciences make the important observation that such representations are idealisations based on simplified assumptions. Thus, although they offer a valid means for identifying and analysing an entity and its dynamics, ‘there are limits to their application’ (Mowles et al., 2008; Ryan, 2008).

Ramalingam, 2013). Given the importance of international development aid in shaping national development agenda priorities, the next section summarises literature discussing its role and reflects on the dynamic arising in the water sector, where it is a main source of finance for service development and a highly influential exogenous change pressure.

2.2 INTERNATIONAL DEVELOPMENT AID: EXOGENOUS CHANGE PRESSURE

In this sub-section, the role of international development aid in shaping national development agendas of low- and middle-income countries is discussed. The international development aid system provides policy, financial and technical support to developing nations for education, health, transportation, energy, and local and regional economic development and trade. A clear understanding of the dynamic created by the involvement of such influential external agents is critical to understanding the current challenges to achieving sustainable water services, let alone the realisation of resilient national systems that can develop and deliver the public services required for sustainable and equitable social and economic development (Mowles et al., 2008). Many researchers have explored how the current architecture of international development aid delivery is hindering the potential of nations to achieve these social and economic development goals.

When developing countries need capital to build infrastructure for public services, international development aid actors—ranging from development banks, funders and bi-lateral government agencies to NGOs and philanthropic organisations (henceforth, ‘development partners’)—may explicitly partner with a recipient government through policy, budget and/or technical support strategies and implementation plans (Mowles et al., 2008; Ramalingam, 2013). It is not uncommon for development partners to bypass nationally led processes and directly implement programmes at the user and community levels (Nimanya et al., 2011).

The visions, missions and mandates of development partners vary greatly and determine the nature of their interactions with domestic partners, including financial investment decisions. In addition to investing in infrastructure, development partners may support organisational, policy and capacity aspects related to the sustainable delivery of a service, including both direct support (monitoring, maintenance, repairs, replacements, training of staff)

and indirect support (macro-level planning and policy making). These essential components of sustainable water services, known as post-construction support or ‘software’, are as important as the infrastructure ‘hardware’ yet often neglected, with actual levels of financial support considered insufficient (Rogers and Hall, 2003; Smits et al., 2011).

Reasons for this neglect include the desire to focus resources on increasing coverage rates for unserved populations (WHO, 2012), perceptions about the risk of corruption, faulty assumptions about the ‘best’ governance arrangements for post-construction activities (Schouten and Moriarty, 2003), and the desire to see tangible, easily measurable results from an investment (Garandeanu et al., 2009).

Understanding the sources of financing provides insight into how WASH policy priorities are determined. The Organisation for Economic Co-operation and Development (OECD, 2009) distinguishes the sources of financing for WASH services as the three Ts: *tariffs*, which are contributions paid by service users; *transfers*, in the form of assistance from development partners; and *taxes*, which are levied by national or regional governments. In many countries, the funding from international aid (*transfers*, to use the OECD nomenclature) is at least as much as the funding from the two domestic sources, *tariffs* and *taxes* (Figure 1).

Financing from transfers is not problematic on its own and in fact does tremendous good in many countries. However, since ‘he who pays the piper calls the tune’, national policy, strategy and governance reform interventions are frequently and significantly influenced by development partners’ priorities (Water Aid, 2011), especially where transfers are collectively greater than domestic sources of financing generated through taxes and tariffs and where transfers are made outside the national policy agenda.

As Figure 1 shows, ‘donor aid to the WASH sector as a percentage of GDP is higher than government budget allocations for WASH in Cambodia, Ghana, Liberia, Madagascar, Rwanda, Timor-Leste and Uganda, indicating both a donor-dominated sector and also that significant amounts of aid to the WASH sector in these countries is not recorded in central government budgets and accounts, or is off-budget’ (WaterAid, 2011, p.35). This disparity in international and domestic funding translates into disproportionate levels of influence by development partners in shaping national and sub-national development agenda priorities (WaterAid, 2011).

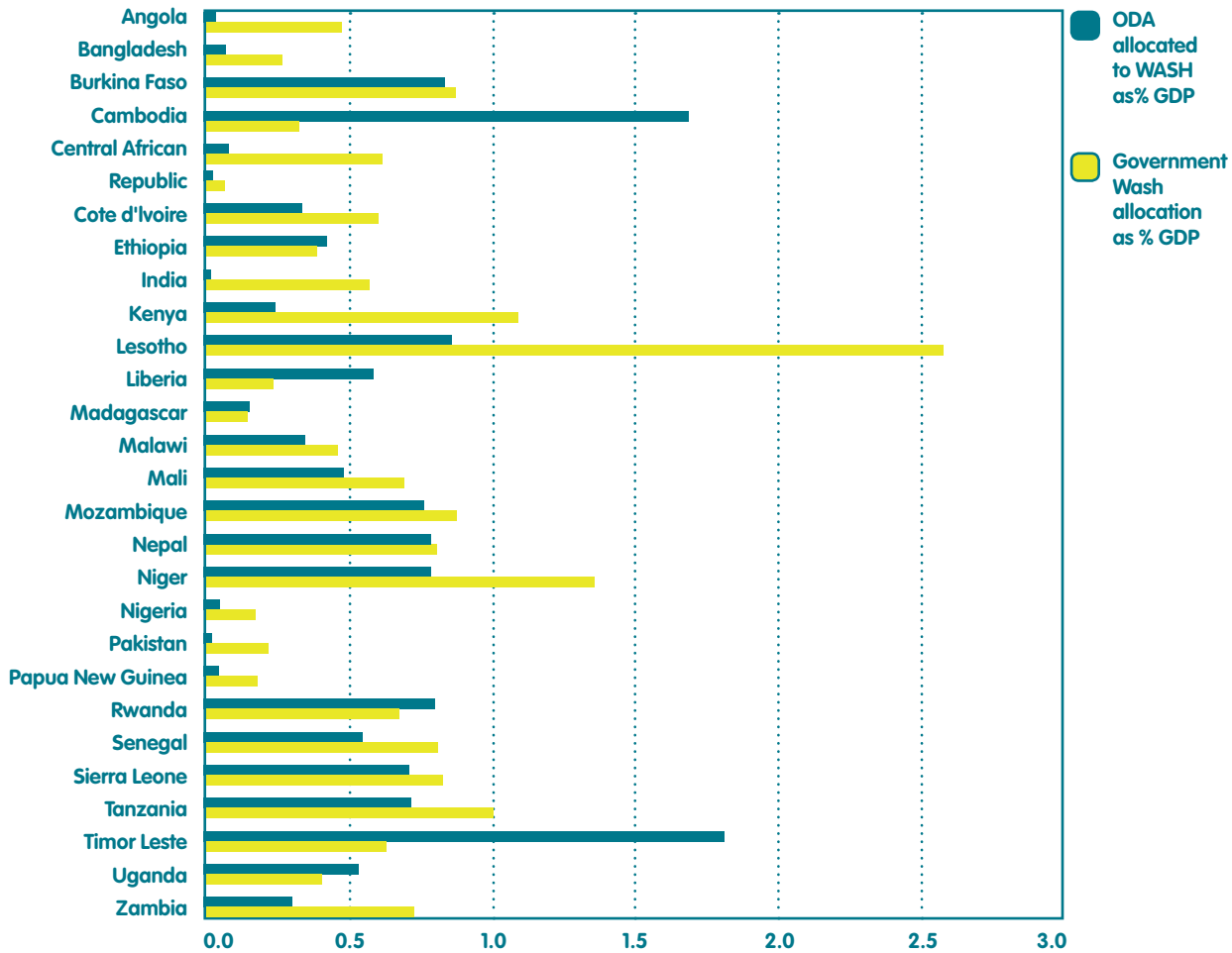


FIGURE 1 DEVELOPMENT PARTNER FUNDING AND NATIONAL ALLOCATIONS TO WASH, AS PERCENTAGE OF GDP

Source: Water Aid, 2011
ODA = overseas development aid

Development partners are a heterogeneous group in terms of organisational visions, missions and approaches to providing development aid resources. Some operate with and through national policy, budget and coordination processes; others work ‘off-budget’ and may provide a significant proportion of investment—30% by one estimation, in the rural sub-sector in Uganda (Nimanya et al., 2011). Development partners are not democratically elected entities, yet their aid to national WASH sectors exceeds domestic sources of financing from mandated public authorities (WaterAid, 2011). Their influence must be accounted for when seeking to understand how systemic change can occur. No rigorous comparisons have been made of how WASH sector policies and outcomes differ between countries based on the proportion of domestic funding to transfers.

Development partners have also made well-intended interventions to strengthen governance, foster resilient national systems and build sector capacity, often by introducing governance structures based on examples of more or less effective national systems in high-income countries. This has been called ‘systemic isomorphic mimicry,’ a concept borrowed from the natural sciences, where it refers to a species that evolves to resemble the form of another species without its functions (e.g., a fly that evolves to look like a bee to avoid predation but lacks the bee’s protection mechanism of a toxic sting) (Pritchett et al., 2010; Andrews et al., 2013). In governance and policy reform, imitation to address ‘capability traps’ is problematic (Pritchett et al., 2010).

A copy-and-paste approach to implementing large-scale policy and organisational reform in one socio-

⁷ Institutions are rules that are accepted by all those involved, are used in practice and have some sort of durability (Ghorbani, 2013).

technical system based on best practices from another setting rarely produces the desired results because the two settings' policy and organisational environments evolved through different social, political, economic and technical selection pressures (Pritchett et al., 2010; Andrews et al., 2013). Moreover, this approach to policy and governance reform undercuts 'indigenous learning, the legitimacy of change and the support of key political constituencies' (Pritchett et al., 2013a, p.1).

A third unintended effect of international development aid arises from the conventional three- to five-year duration of development interventions, even for large-scale institutional change initiatives. Williamson (2000), reflecting on the current state and future offerings of new institutional economics, finds that the rate of change differs by the level, or type, of institution⁷ (Figure 2).

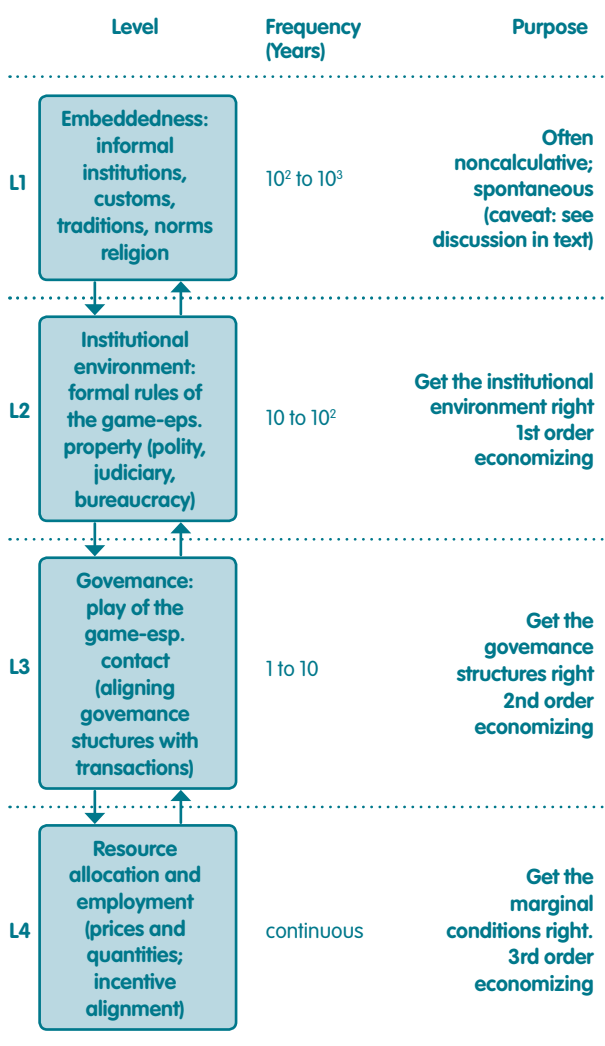


FIGURE 2 ECONOMICS OF INSTITUTIONS

Source: Williamson, 2000, p.597

For informal institutions (norms and culture), change occurs every 100 to 1,000 years. Change to formal rules (laws and regulations) requires 10 to 100 years. Agreements and contracts change in one to 10 years. At the lowest level, operational rules change continually (Williamson, 2000; Ghorbani et al., 2010; Van Tongeren, 2014).

In other words, institutional and governance systems require time to develop: agents within those systems must internalise change and identify their changing roles in the evolving system. The resulting change is an outcome of domestic and possibly also international social, political, economic and increasingly environmental and resource use pressures (Huitema et al., 2009). Acquiring new functions within a system requires not just financial resources but also the time and space to learn from trial and error. So, too, national systems for the delivery of services have evolved in context-specific ways over long periods in response to political, social and economic processes (Plummer and Slaymaker, 2007). Williamson (2000) considers not only institutional levels and their change frequency, but also 'design opportunities' for policy makers to achieve change in formal rules (first-order economizing), play-of-game rules (second-order economizing) and contractual relations, or 'private ordering' (third-order economizing) (Williamson, 2000, pp.598-99).

International development aid is recognised as beneficial in supporting recipient nations as they work towards their social and economic development goals (Barder, 2012; Ramalingam, 2013; Woolcock, 2014). Nonetheless, the dynamics of WASH service systems in low- and middle-income countries cannot be understood without considering the role that international development aid plays in setting national priorities. The literature about the role and influence of international development aid in shaping national development agendas questions the planning horizons maintained by development partners: do they allow sufficient time to achieve lasting systemic change (Rogers and Hall, 2003)? The literature also indicates that policy, finance and political-economic priorities cannot be assumed to be aligned with national development agendas (Rogers and Hall, 2003; Mowles et al., 2008; Ramalingam, 2013).

2.3 CAPITAL INVESTMENTS BUT FAILING SERVICES

Despite significant investments by both governments and their development partners, the rural water sector is far from achieving the goal of safe, reliable, sustainable service for everyone, everywhere—and in particular the very poor. This section reflects on the challenges faced by nations striving to achieve the goal of universal water services.

In 2012, ‘an estimated 22% of the world’s rural population (740 million people) [did] not access a safe drinking water supply’ (RWSN, 2012, p.7). The scope of the problem is vast: ‘more than 600 million of the estimated 700 million people who lack access to improved water services live in rural areas’ (Schouten and Moriarty, 2013, p.7). In 2010, ‘five out of six people without access to a safe drinking water supply reside in rural areas’ (UNICEF/WHO, 2010). And despite trends towards urbanisation, the number of rural dwellers will still be about 2.9 billion by 2050 (UNPD, 2009), with the highest concentration of rural dwellers in Africa and Asia—regions that face the greatest challenges in advancing human and national development agendas.

Following decades of prioritising the construction of new water infrastructure, it is now widely recognised that new construction alone will not solve the problem. WaterAid Tanzania reported that only two years following installation, 25% of systems were already non-functional (Taylor, 2009).

The multiple causes of the failure of the rural water sector are relatively well known (e.g., Lockwood and Smits, 2011). Schouten and Moriarty (2013) list these inextricably interlinked causes:

- Some national governments ignore the rural water supply sector; capital investment comes largely from development partners.
- Interventions by development partners are often uncoordinated, stand-alone projects, each with its own design, hardware type, policies and financing—precluding efficiencies and coordination.
- The usual approach to rural water supply services—village-level operations and maintenance, demand-response, community management—assumes that users can sustain service delivery without outside help.
- National water sectors often lack the vision, strategy and capacity to sustain services.
- Lack of long-term planning for rural service delivery results in irregular, unreliable supply.
- Financial models for sustainable service delivery and eventual replacement of infrastructure are missing, leading to ad hoc provision of services.

- Systems fail before the design lifetime, wasting capital; sometimes multiple reinvestments are made in the same communities.

Clearly, there is no single or linear solution that can or will resolve these interlinked challenges and increase levels of access to water services. As discussed in Section 2.1, the actors, organisations, formal and informal institutions (norms, values, policies, shared strategies—after Ostrom, 2011) involved in service development and delivery in a multi-level, polycentric entity or system have overlapping areas of responsibility. A business-as-usual approach to development—making linear, uncoordinated interventions in an attempt to build resilient national systems that can deliver lasting services—is not working (Ramalingam, 2013; Mowles et al., 2008; Rogers and Hall, 2003).

A range of approaches have emerged that seek to foster systemic change by engaging the whole system of actors and institutions involved in the delivery of common public goods. These are discussed in more detail in Section 4. First, however, Section 2.4 reviews literature on the need to re-think international development aid to gain deeper insight into the challenges to the current aid approaches and to identify alternatives from the perspective of experts in international development aid.

2.4 CALLS TO RE-THINK INTERNATIONAL DEVELOPMENT AID

Many stakeholders have called for change in how international development aid is conceptualised and implemented, to improve performance of the water service and other sectors. Nobel laureate Amartya Sen described the aim of social and economic development as ‘enlarging people’s choices, capabilities and freedoms, so that they can live a long and healthy life, have access to key knowledge, a decent standard of living and participate in the life of their community’ (Sen 1992, cited in Barder, 2012).

This human development perspective is also embodied in the United Nations Development Programme’s Human Development Reports. Indeed, the 2014 report was entitled *Sustaining Human Progress: Reducing Vulnerabilities and Building Resilience*. Another justification for aid is the economic growth perspective, expressed in traditional economic measurements such as gross domestic product. The sustainable development perspective arose from works in the 1970s, consolidated in 1987 in a [United Nations World](#)

Commission on Environment and Development report, **Our Common Future** ('the Brundtland Report'). This perspective has since evolved through the Rio conventions of 1992 and 2012, which developed the Millennium Development Goals and, at time of writing, the draft post-2015 Sustainable Development Goals.

Regardless of the measure one prefers, enlarging people's choices, capabilities and freedoms requires the accessible, affordable provision of basic public goods and services that contribute to people's well-being. Providing such services requires being able to act in an agile, adaptive manner in the face of rapid socio-economic change and future uncertainty about climate change, social stability and economic pressures (Barder, 2012; Mowles et al., 2008).

How, then, can the failures of rural water and sanitation services be addressed?

Calls for a paradigm shift in the way development aid and interventions are conceptualised, organised and function come from Barder (2012), Pritchett et al. (2013b), Andrews et al. (2012), Kania and Kramer (2013), and Woolcock (2014). These researchers discuss theory and practice that are grounded in complex adaptive systems thinking.

Andrews et al. (2012) propose a 'problem-driven iterative approach' (Section 4, below) and advocate a departure from linear, simplistic approaches to implementing 'solutions' in favour of local processes that address specific problems by identifying and testing alternatives (Andrews et al. 2013; Woolcock, 2014).

Barder (2012) finds that complexity theory has implications for development policy. He borrows from Sen's capabilities perspective and defines development as the 'emergence of a system of economic, financial, legal, social and political institutions, firms, products and technologies which, together, provide citizens with the means to live happy, healthy and productive lives' (Barder, 2012). The non-linear dynamics of such a system, Barder believes, can produce startling changes, as agents within the system, as well as the system itself, adapt and co-evolve in response to one another. He suggests the inevitability of 'spontaneous rapid change to a more complex self-organised system which does a better job of supporting the capabilities of their citizens' (Barder, 2012). For these reasons, Barder argues that the instrumental, linear view of development should be abandoned in favour of policy

and implementation practices that enable actors to anticipate and adapt to unforeseen changes.

Ramalingam argues for transformation in how the development aid system works, starting from the level of 'the "rules of the game" that shape what can and can't be done in aid, that shape behaviours and actions, that determine rewards and punishments' (Ramalingam, 2013, p.16). Examples cited by Ramalingam illustrate how the development aid system and its problems are interconnected, diverse and dynamic, spanning layers of social, institutional and political economies in different settings. The aid system is a 'many to many' world, with 'more agencies using more money and more frameworks to deliver more projects in more countries with more partners employing more staff specializing in more disciplines' (Ramalingam, 2013, p.5). But rather than calling this hyper-inter-connectedness a problem, Ramalingam seeks to show 'how the ideas of complex systems research have been used to make aid ideas and aid practices more sensitive to the real-world dynamics of social, economic and political phenomena' (Ramalingam, 2013, p.244). He supports a transformation in 'the fundamental assumptions, ideas and actions of aid', based on the following observations (Ramalingam, 2013, p.360):

- the common mismatch between aid and the challenges it strives to address;
- the imperfect and ambiguous nature of the effect of aid;
- the importance of domestic institutions and political economy;
- the dynamic nature of political transformations and their context; and
- the increasingly rapid pace at which change is taking place.

In this section a range of views articulated by domain experts and leading thinkers from the field of international development has been presented. The literature cited here not only supports the finding in Section 2.2—that prevailing international aid practices are misaligned with national development agendas—but also underscores the value of a complexity-informed approach by development partners. It has also shown the need to delve further into the concepts and theories of the complexity sciences to obtain a more complete and meaningful analysis of the rural water sector and its dynamics as a system.

Section 3 explores how change in a complex adaptive system occurs and presents the central concepts and theories from the complexity sciences.

3. Concepts from the complexity sciences

In Section 3 concepts from literature about complex adaptive systems—and in particular one sub-type of system, a socio-technical system—are presented. Importantly, this section focuses on ways to understand how change arises in such systems and reviews the literature on whole system change. Previous sections have established the domain of inquiry and challenges faced by nations in delivering sustainable water services, including challenges posed by prevailing policy and practices in international development aid. Based upon the literature reviewed, the case is made that prevailing arrangements for development and delivery of sustainable public services as well as for international development aid would benefit from the adoption of complexity-informed policies and practices. This section introduces concepts and theories from the complexity sciences and then, in Section 3.7, frames the rural water sector from a complexity perspective to gain insights into how, and under what conditions, systemic change might occur.

3.1 COMPLEX ADAPTIVE SYSTEMS AND THE SOCIO-TECHNICAL SYSTEM

A complex adaptive system (CAS) is a dynamic network of many agents (whether cells, species, individuals, firms or nations) acting in parallel, constantly acting and reacting to what the other agents are doing. The control of a CAS tends to be highly dispersed and decentralized (Ryan, 2008). If there is to be any coherent behaviour in the system, it has to arise from competition and cooperation among the agents themselves. The overall behaviour of the system is the result of a huge number of decisions made every moment by many individual agents (Waldrop, 1992).

A notable type of CAS, useful for framing the rural water sector from a complexity perspective, is the socio-technical system. Socio-technical systems comprise 'two deeply interconnected subsystems: a social network of actors and a physical network of technical artefacts' (Dijkema et al., 2013, p.1). These systems consist of 'heterogeneous decision making entities and technological artefacts' and 'are governed by public policy in a multi-scale institutional context' (Ghorbani, 2013, p.3).

As the review of literature on the governance perspective in Section 2.1 indicates, the delivery of public services in such a context requires interaction

among many diverse actors. The provision of services, such as energy, solid waste removal, water for domestic or commercial use and hygiene and sanitation services, involves continuous and evolving interactions between the socio-political, technical, financial, environmental and institutional realms:

...[s]ocio-[t]echnical [s]ystems are [a] class of systems that span technical artefacts embedded in a social network...[and] include social elements such as operating companies, investors, local and national governments, regional development agencies, non-governmental organizations, customers and institutions. These develop around, sustain and depend on particular technical systems, be it a single plant, industrial complex or set of interconnected supply-chains. (Nikolic and Ghorbani, 2011, p.1)

Because the WASH sector involves intertwined technical and social systems, it fits the following definition of CAS:

[A] multi-actor network determines the development, operation and management of the technical network, which in turn affects the behaviour of the actors. The interactions within and between technical systems are defined by causal relationships which are governed by laws of nature, while the actors in the social system develop intentional relationships to accomplish their individual goals. At multiple hierarchical levels the technical network is shaped by the social network and vice-versa, with feedback loops running across multiple levels and time scales. All of this together forms a self-organising, hierarchical, open system with a multi-actor, multi-level and multi-objective character (Holland, 1992 cited in Dijkema et al., 2013, p.2)

This understanding of socio-technical systems enables further exploration of how processes concerning water service delivery across a multi-scale institutional context change over time. A CAS perspective makes it possible to identify the macro-level emergent change patterns that arise from micro-level decision-making processes and interactions within a socio-technical system.

In considering the potential for systemic change in the rural water sector, as well as how best to foster this change, a complex adaptive systems perspective is applied 'to stimulate and support the development of more flexible, more reliable and more intelligent infrastructures and services, with respect for public

values and consumer interest, to better serve society in the future' (Dijkema et al., 2013, p.7). The application of a complex adaptive systems perspective connects the literature of this domain with the governance perspective as discussed in Section 2.1. The next section presents a review of literature about how change arises in such systems.

3.2 CHANGE IN SOCIO-TECHNICAL SYSTEMS

The review of literature about the governance and complexity perspectives suggests that change in such systems can be fostered. This section therefore presents an overview of literature about the notion of *whole system change* as a phenomenon that can occur, and has occurred, in the domains of public services and development aid. It reviews studies that propose ways to understand, and speak about how large socio-technical systems evolve and adapt. The remainder of Section 3 provides different perspectives on how such change happens, what is actually changing when a system changes.

The academic literature on the concept of *whole system change* is relatively modest, but over the past two decades, the concept has been increasingly featured in health care reform in the United Kingdom and Canada (Connor and Kissen, 2010; Edwards et al., 2011), educational reform in the United States (Duffy et al., 2006), integrated water resources management (Pahl-Wostl et al. 2007; Pahl-Wostl et al. 2013) and to a limited extent in the development aid sector.

Harman (1995, p.1) has examined the plausibility of 'whole-system change' in the face of what he called 'global dilemmas', such as anthropogenic climate change, chronic hunger, environmental degradation and poverty; he proposes that these dilemmas are 'not so much problems as symptoms of a deeper-level condition that must be dealt with'.

Harman is not alone in proposing that nothing short of whole system change can address wicked problems. Bramson and Buss (2002) published an overview of methods for whole system change in public organisations and communities. Their work refers to 'large group methodologies' as processes that involve 'the whole system, both internal and external stakeholders, in the change process' (Bramson and Buss, 2002, p.212). Some of the large-group methods referenced in the literature include future search, appreciative inquiry, Whole-Scale™ Change, Participatory Strategic Planning Process, Real Time Strategic Change and SimuReal.

Large-group change methods are historically intertwined. One strand emerged from theory about systems and how this has shaped modern views on organisations; the second strand involves the technology for working with large systems and channelling the energy of a group into 'planning for the future, rather than focusing on problems, and involving as much of the system' as possible to identify what works and aim for consensus (Bramson and Buss, 2002, p.214). The works reviewed by Bramson and Buss (2002) have several common elements: the value system of democracy, pluralism, pragmatism, activism, self-expression and open communication as ways to 'overcome unnecessary obstacles to consensus and collective action among people with diverse interests' (Bramson and Buss, 2002, p.215).

Bramson and Buss (2002) also identified the following seven characteristics of whole system change:

- Future driven. Proponents assume that a shared vision enables people to move past conflict and motivates them to action.
- Broadly participative. Large numbers of people (hundreds, thousands) from an organisation or community are engaged in understanding the interconnections among organisations, interests, or relationships. This shared cognition enables them to participate and help make important decisions.
- Planning intensive. Planning features in each of the methods reviewed and is considered the key to fostering stakeholders' buy-in.
- Skilled process facilitation. Although Bramson and Buss (2002) mention this characteristic as a sub-element, it is listed here in its own right to emphasize its importance in ensuring consistent and cohesive design and facilitation of a change process built on coalitions and human competencies. An individual or organisation is required to curate and nurture the change process.
- Information sharing. Commitment to sharing information with the whole system of people and organisations is founded on the belief that the people in the system have the 'wisdom to know what is best' (Bramson and Buss 2002, p.216).
- Appeal to head and heart. The methods reviewed appeal to both the intellect and the ethos of the people within a system so that they see the whole system and play a meaningful role in making things happen.
- Sustainability. A series of connected events with coordinated and coherent agendas, happening at agreed intervals, with each event possibly spanning multiple days, is crucial for the change process, which requires dedicated, ongoing facilitation as

well as follow-up by stakeholders on implementing the agreed strategies and action plans in their own organisations.

Although other criteria may yet be required for a complete understanding of what such an approach entails, those seven characteristics form an initial series of elements that can be used to formalise and compare different approaches to effecting whole system change.

Bramson and Buss anticipate that whole system change approaches will proliferate because of pressure on development organisations to produce desirable results quickly, the availability of facilitators experienced with engaging large groups in systemic change processes and an increase in familiarity with the approaches in different sectors. They also point to wider acceptance of the idea that change in a world of interconnected systems is best understood through systems thinking informed by 'various parts of the relevant system' (Bramson and Buss, 2002, p.218) in the same room and that democratisation—frequently supported by international development aid—assumes that 'better decisions ... result from involving more people in public decision-making' (Huitema et al., 2009).

According to Burns (2007), decision makers need to provide more space for solutions to emerge from inquiry and learning processes, as opposed to deciding in advance what a solution is, testing it, and rolling out the same model in other contexts (Burns, 2007, p.174, 178). Similarly, Brinkerhoff (2010) urges policy makers and implementers to adopt a systems perspective that favours incremental and emergent approaches to policy change that are informed by the voices of the excluded, result from shared inquiry and dialogue, and promote open and transparent decision making and citizen empowerment.

Brinkerhoff summarises the seven design principles that Burns considers necessary for systemic action research: 'emergent and flexible research design, exploratory inquiry phase, multiple inquiry streams at different levels, connecting inquiry to formal decision making, process to identify links across inquiry streams, recognition that inquiry stream membership changes over time, and commitment to distributed leadership' (Brinkerhoff, 2010, p.94). This set of design principles is useful for elaborating on Bramson and Buss's seven characteristics because they introduce the foundations of learning, evolution and adaptation of complex adaptive systems.

The literature also provides case studies that support the possibility of whole system change in their depiction of strategies, approaches and methods for implementation (White, 2000; Manning and De la Cerda, 2003; Dattee and Barlow, 2010). Duffy et al. (2006) provide a protocol for whole system change in school districts. Their iterative process consists of a pre-launch preparation phase and three steps, followed by a recycle to the next pre-launch preparation phase. This seemingly simplified protocol belies their observation that 'a significant change in one part of the school system requires changes in the other parts of the system' (Duffy et al., 2006, p.41).

In the context of integrated water resources management, Pahl-Wostl et al. (2007, 2013) focus on 'transformative change' arising from multi-level social, or 'societal', learning and adaptive management approaches for achieving paradigm changes where system elements, such as actors, organisations, infrastructure, knowledge and power relations, are highly interdependent. Pahl-Wostl (2009, p.354) developed a conceptual framework for use in analysing adaptive capacity and multi-level learning processes to enable deeper insights into 'complex and diverse resource governance regimes'.

Greenhalgh et al. (2012, p.516) describe a 'transferable methodology ... developed to guide the evaluation of a three-year follow up of a large health care change programme' that took place in London during 'a period of economic turbulence and rapid policy change'. This work gives attention to the tension that arises in large-scale change because of the persistence of past practice and the need to adapt to a changing context. Tracking what 'survived' three years after modernisation of a large health service, Greenhalgh et al. (2012) derived five conclusions about approaches to fostering whole system change.

- To assess the effect of a large-scale change on turbulent and dynamic settings, one needs to ask not only 'what has remained' from the originally intended programme outcomes, but also 'how have things moved on, and why?' (p.540).
- A whole system change perspective is critical to ensuring that programme activities and outcomes succeed in '[l]inking the transformation effort more closely to the mainstream-commissioning and business-planning infrastructure' despite the potential for this to slow the rate of change (p.540).
- '[T]he knowledge ... to sustain complex service innovations spanning multiple organizations and sectors appear[s] to be largely tied to individuals, embedded in relationships and strongly value laden' (p.540). Relationships that are 'warm' strengthen

shared priority-setting, and participants identify solutions more rapidly in response to dynamic and changing circumstances.

- '[T]ransferable models' may not be realistic given the need to continually adapt interventions 'in real time as the program takes shape' (p.541).
- A series of questions can prompt a shift in focus from 'logic models', or established and possibly rigid ways of framing an issue, towards individual and group priorities for the allocation of resources, emerging points of convergence and divergence and alignment of the programme with stakeholders' priorities 'in a tight quality cycle' (p.541).

The authors recognise that because many stakeholders may not be familiar with whole system change, its success 'depends upon achieving widespread confidence and capability to go beyond logic-models' that are linear and control-oriented in framing issues or challenges (Greenhalg et al., 2012, p.541).

The case studies indicate that the process of whole system change is neither linear nor simple. The clichés apply: there are no panaceas, silver bullets or quick fixes to address the interconnected failings across a socio-technical system whose problems have evolved over time and largely become intractable. Literature from both the governance perspective and the complexity complexity-informed perspective addresses the need for identifying the context-specific nature of challenges along with locally relevant solutions that receive popular understanding and support (Huitema et al., 2009; Mowles et al. 2008; Burns, 2007; Bramson and Buss, 2002).

What is common among these methods is perhaps best summarised by the categories set out by Huitema et al. (2009): approaches to effecting change that recognise the polycentric nature of public services, involve public participation, employ experimentation and are bioregional in nature. In their work on water resources management, 'bioregional' refers to river basins as the relevant scale at which to conceptualise the system under examination (Huitema et al., 2009, p.9). In essence, their bioregional approach echoes the locally relevant analysis and solution identification described by other researchers.

The literature establishes whole system change as a concept. Several researchers also attempt to distil its essential characteristics, principles or elements that may be applied in analysing and formalising such approaches. Nonetheless, unresolved questions include whether certain approaches are more effective than other approaches and whether, upon inspection

and comparison, specific elements are more effective than others. The following section therefore delves into additional concepts and theory from the complexity sciences that offer both a meta-theory of how systems evolve as well as a grammar about how institutions change. That allows us to describe and analyse the formal and informal rules and shared strategies in human behaviour that guide the micro-level actions and interactions that give rise to overall patterns and trends in a given system.

3.3 UNIVERSAL DARWINISM: A META-THEORY OF EVOLVING SYSTEMS

'One general law, leading to advancement of all organic being, namely, multiply, vary, let the strongest live and the weakest die' (Darwin, 1859)

Commonly referred to as universal Darwinism, the body of theory introduced below provides 'a general, or meta-theoretical framework' (Hodgson, 2008, p.404) to thinking systematically about processes of emergence and change in complex social and institutional systems (Aldrich et al., 2008; Hodgson, 2008; Hodgson and Knudsen, 2010). Universal Darwinism suggests that institutions, information and organisations emerge and evolve in ways similar to those laid out by Darwin: through selection, variation and retention (Blyth et al., 2011).

In 1898, an American economist and social scientist asked, Why is economics not an evolutionary science? (Veblen, 1898). He articulated the view that Darwin's theory of evolution and its associated processes of selection, variation and heredity were relevant to understanding social institutions and how these structures emerge and change over time (Hodgson, 2008, p.44). He considered evolutionary science a 'close-knit body of theory' that could reliably explain the evolution of social as well as biological phenomena (Veblen, 1898, p.404.)

Veblen proposed that social evolution was a natural selection of institutions:

The life of man in society, just like the life of other species, is a struggle for existence, and therefore it is a process of selective adaptation. The evolution of social structure has been a process of natural selection of institutions. The progress which has been and is being made in human institutions and in human character may be set down, broadly, to a natural selection of the fittest habits of thought and to a process of enforced adaptation of individuals to an environment which has progressively changed with the growth of community

and with the changing institutions under which men have lived. (Veblen, 1899, p.188)

Modern scholars have acknowledged Veblen's theoretical contribution while adapting it to examine the fields of political science (Lewis and Steinmo, 2010), institutional evolution and change (Lewis and Steinmo, 2012), learning selection in uptake and adaptation of new technologies (Douthwaite et al., 2002), organisational learning and change (Trist, 1981; Stoelhorst and Huizing, 2006) and human language and business corporations (Hodgson and Knudsen, 2010).

Universal Darwinism enables the following questions to be asked: How do social phenomena act or interact? What patterns of behaviour, habits or beliefs are common? Which actions or interactions adapt, evolve and carry on? Do certain behaviours, practices, habits or beliefs die out? The premise is that social phenomena are subject to Darwinian processes of evolution, as accepted in the natural sciences. However, as Hodgson (2008) notes, additional theories and tools are required to more precisely describe social phenomena, the patterns they exhibit and the pressures that effect change in a particular context as well as to gain insight into the broader line of inquiry of how to foster change within a whole system such as the rural water sector. For this reason, the next section discusses a framework for conceptualising, analysing and structuring institutional change as proposed by Elinor Ostrom in her institutional analysis and development framework (Ostrom, 2011). The framework offers a grammar for making explicit the formal and informal rules, or institutions, that shape human behaviour and patterns of interaction.

3.4 THE LANGUAGE OF INSTITUTIONS: IAD AND ADICO

This section introduces two frameworks that can serve as the basis for the structured identification and analysis of formal and informal institutions. Both were devised by the late Nobel laureate Elinor Ostrom, who sought to explain how institutional rules, norms and strategies change over time (Ostrom, 2011). Institutions are a set of devised rules to organise repetitive activities and shape human interaction (Gardner and Ostrom, 1991. Ostrom, 2011). Understanding institutions in this manner makes it possible to 'conceptualise the dynamic interplay between actors and structures' (Geels, 2004, p.897).

In her doctoral thesis, Ghorbani describes the two frameworks of institutional analysis:

- ADICO—attributes (participants), deontic (obligated,

permitted, forbidden, etc.), aim (action or outcome), condition (parameters when an ADICO statement applies), or else (sanction) (Crawford and Ostrom, 1995). This is the 'grammar' of institutions (Crawford and Ostrom, 1995).

- IAD—institutional analysis and development (Polksi and Ostrom, 1999).

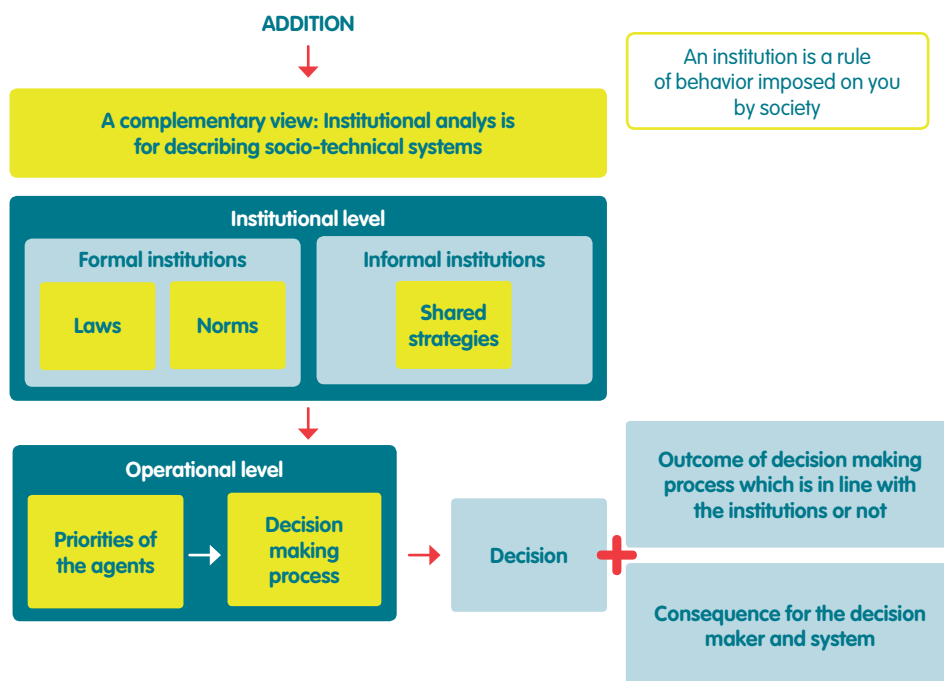
These frameworks offer structure to the analysis of socio-technical systems by recognising that individual behaviour is complex and not easily extractable, whereas formal social rules and institutions are fairly well extractable and therefore measurable (Crawford and Ostrom, 1995; Ghorbani, 2013).

Institutional grammar is useful for examining the different foundations (norms, laws and shared strategies) of different types of institutions (Crawford and Ostrom, 1995). The grammar defines laws as ADICO, norms as ADIC and shared strategies as AIC. That is, unlike shared strategies and norms, laws alone have sanctions (the o from 'or else').

Crawford and Ostrom establish the grounds for considering *institutions as norms* and regulations whereby institutions as norms assumes that many patterns of interaction are based on a group of individuals' shared perceptions about proper and improper behaviour in particular situations (Crawford and Ostrom, 1995), and *institutions as regulations* assumes that many patterns of interaction are based on a common understanding. Forbidden or proscribed actions are likely to be sanctioned or made ineffective (if an authority imposes punishment) (Crawford and Ostrom, 1995).

These frameworks offer a means of understanding why certain regularities of human behaviour exist. It is important to note an institution's explanation for behavioural patterns and locate the responsibility for social order with the individuals who are part of that system, not to some external state or third-party enforcer (Crawford and Ostrom, 1995). This view integrates the analysis of how institutions come into place with the analysis from within. In this manner, an institution may be seen as a pattern of behaviour sustained by mutual expectations of the behaviour of others.

Figure 3 separates the operational level from the institutional level. On the institutional level, the formal institutions and informal institutions are apparent. The operational level shows two boxes: priorities of the agents and decision-making process. Also visible on this operational level are the



An institution is a rule of behavior imposed on you by society

FIGURE 3 IAD FRAMEWORK

Source: Adapted from Polski and Ostrom, 1999

institutions that are imposed on the humans or organizations that are making decisions. Priorities of the agents are also taken into account in decision making (Polski and Ostrom, 1999) and may be rational or irrational; in other words, agents are conscious and capable of self-reflection. The decision may or may not be in line with the institution, and if not, consequences may ensue. For example, a driver who runs a red light places a higher priority on getting to his destination than on obeying traffic laws but risks causing an accident or getting a traffic ticket.

Using the theoretical framework and language of institutions helps us identify and analyse the institutions that guide micro-level behaviours and decisions of agents in a given environment. The ADICO and IAD frameworks offer a means of making explicit regularities of human behaviour, and in combination with universal Darwinism, the language of institutions helps explain how institutions emerge and evolve over time.

Sections 3.1 through 3.4 have introduced concepts and theories from the complexity sciences about what constitutes a specific type of complex adaptive system—the socio-technical system. The literature is explicit about the fact that *whole system change* in such systems can occur, and several sources call for a whole system approach. Additional concepts relate to how institutional change emerges and changes over time. This body of theory makes it possible to test

theories about how the institutions, or ‘rules of the game’, that guide how the social and technical artefacts act, interact and may change. Testing is an important step for furthering the line of inquiry on how to effect change in such systems.

Section 3.5 now reconsiders the rural water sector from the perspective of a socio-technical system.

3.5 RURAL WATER SERVICES AS A SOCIO-TECHNICAL SYSTEM

A system of interconnected social actors, organisations and institutions (policies, norms and beliefs) is required to ensure that water delivery infrastructure operates as intended over the lifetime of the technical system. But is the rural water services sector in fact a complex, adaptive, socio-technical system? This section examines the phenomenon of the rural water services sector in light of CAS and socio-technical system theory.

Drawing on Dijkema et al. (2013; see Section 3.1, above), Van Dam et al. (2013) characterize complex adaptive systems as follows:

- Multi-actor: many different (heterogeneous) actors or agents act and interact with intention through social networks.
- Multi-objective: different actors within the system hold different priorities.

- Feedback loops: connections (e.g., information or financial flows) run across the hierarchical levels, time scales, individuals and social networks (Dijkema et al., 2013, p.2).
- The system is self-organising, hierarchical and open (SOHO):
 - a. Self-organising: ‘the process by which a system develops a structure or pattern without the imposition of structure from a central or outside authority or when a system displays a different output as a result of internal processes’ (Prigogine and Stengers, 1984; Kay, 2002, cited in Nikolic and Kasmire, 2013, p.50);
 - b. Hierarchical: multiple hierarchical levels; and
 - c. Open: ‘where matter and energy [and information] flow in and out, and where things inside the system are affected by the environment outside the system...’ (Nikolic and Kasmire, 2013, p.15)

As an example, Figure 4 depicts the landscape of actors and institutions in the rural water service delivery sector in the Republic of Uganda: a vast constellation of interconnected agents across multiple levels (community, district, municipal, regional, national), all with the shared aim of ensuring access to water services by rural populations.

From this image several features of a complex adaptive system are immediately observable. The rural water services sector comprises multiple actors or agents who act and interact through social networks. These actors hold different but occasionally overlapping priorities. Each agent—individual, organisation or network—has capabilities, beliefs, values, skills and resources that evolve over time and guide how it acts and interacts with others. This high degree of interconnectedness creates multiple feedback and feed-forward loops: actions, interactions and networks are interconnected through information, financial and human resources, trust, directives, etc. spanning hierarchical levels and time scales (Dijkema et al., 2013, p. 2). The multi-stakeholder platforms depicted in Figure 4 play a key role in shaping sector priorities, and thus this water sector is self-organising. Lastly, the system receives and provides flows of information, financial and other resources—international development aid, water from the ecosystem, macro-level economic systems, etc.—ensuring that the system is open and may be shaped or affected by the ‘environment outside the system’.

It is not possible to depict the dynamic and evolving nature of Uganda’s rural water sector in a two-dimensional image. Nevertheless, Figure 4 provides a

starting point to understand what is inside versus outside this socio-technical system. Such an image can also help identify bottlenecks to innovation, change or improved services as well as weak points in the interconnections and feedback and feed-forward loops.

Following this framing of the rural water sector as a complex, adaptive, socio-technical system, Section 4 presents three specific approaches and their guiding tenets, principles and strategic objectives for whole system change. These three approaches are generally considered well suited for fostering systemic change in the context of national and international development initiatives and public service delivery processes.

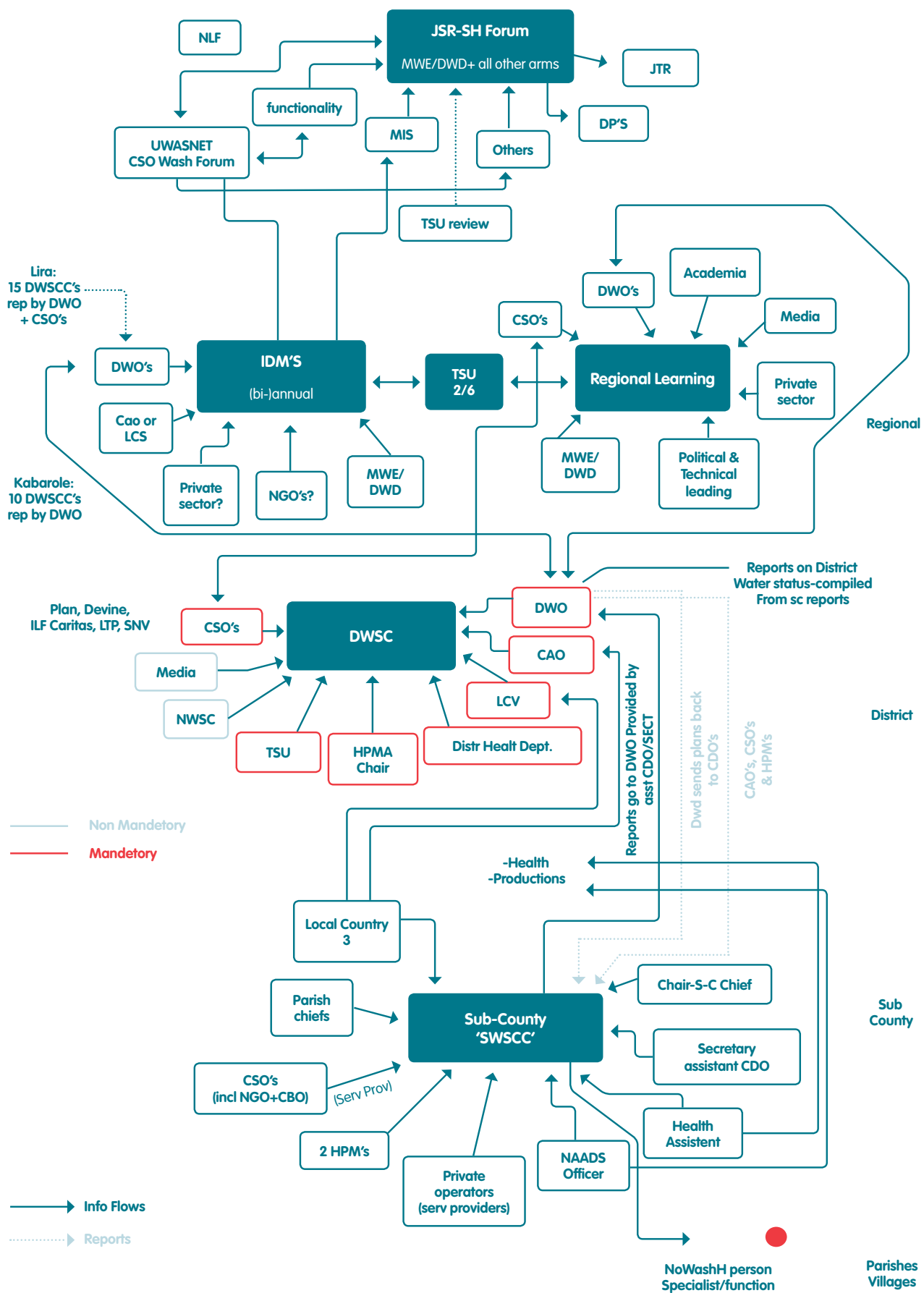


FIGURE 4 REPUBLIC OF UGANDA, RURAL WATER SECTOR ACTOR LANDSCAPE

Source: Casella et al. (2013)

4. Approaches to whole system change

In Section 3, theory and concepts from the field of complexity sciences enabled the framing of the rural water sector as a complex adaptive system. The notion that change in such systems is possible and that whole system change approaches are suited for fostering such change was discussed. In this section three approaches to fostering large-scale change in complex systems are described: collective impact, problem driven iterative analysis and learning alliances. These approaches have been documented in various papers as having relevance to fostering change, promoting innovation and scaling up promising solutions in different public service sectors.

4.1 COLLECTIVE IMPACT: CREATING LARGE-SCALE SOCIAL CHANGE

The first approach to effecting social change is called collective impact, a term coined by Kania and Kramer (2011) following a decade of experience and research on effective social change processes. The approach is based on their observations of public education system reform in the United States. They frame the case example and its analysis in the language and concepts from complexity sciences and chaos theory.

Their 2011 case study details the experience of Strive, a nonprofit, to ‘bring together local leaders to tackle the student achievement crisis and improve education throughout greater Cincinnati [Ohio] and northern Kentucky’ (Kania and Kramer, 2011, p.36). The crux of the case study is that those seeking to effect the change realized that ‘fixing one point on the educational continuum ... wouldn’t make much difference unless all parts of the continuum improved at the same time’ (p.36). Strive therefore focused the educational community on one set of goals, measured in the same way. The Strive experience had ‘collective impact’ because the initiative involved ‘a centralized infrastructure, a dedicated staff and a structured process that leads to a common agenda, shared measurement, continuous communication and mutually reinforcing activities among all participants’ (p.38). Other collective impact initiatives include watershed restoration along the Elizabeth River in Virginia, a childhood obesity prevention programme in Somerville, Massachusetts, and agricultural sector reform for private and social benefits in Cote d’Ivoire. The unifying element of these examples is that large-scale social change ‘comes from better cross-sector coordination rather than from the isolated intervention of individual organisations’ (p.38).

In earlier work, Kania and Kramer (2004) distinguished between adaptive and technical problems. In the latter, the problem and its solution are commonly known, and change can be made by one or a few organisations. An example of a social problem that they define as ‘technical’ is running a scholarship programme. In contrast, ‘adaptive problems ... are complex, the answer is not known, and even if it were, no single entity has the resources or authority to bring about the necessary change’ (Kania and Kramer, 2011, p.39).

Moving from isolated impact, where success in one location cannot be replicated or scaled in another setting, to collective impact is ‘not merely a matter of encouraging more collaboration or public-private partnerships’:

[Collective impact] requires a systemic approach to social impact that focuses on the relationships between organizations and the progress toward shared objectives. And it requires the ... organizations that have the skills and resources to assemble and coordinate the specific elements necessary for collective action to succeed. (Kania and Kramer, 2011, p.39)

That is, the ‘process and results of collective impact are emergent rather than predetermined, the necessary resources and innovations often already exist but have not yet been recognised, learning is continuous, and adoption happens simultaneously among many different organisations’ (Kania and Kramer, 2013, p.2). Based on additional examples of the structured approach, the authors identify the following five conditions for collective impact (Kania and Kramer, 2011):

- a common agenda or shared vision for change among all participants based on a common understanding of the problem and a joint approach to solving it;
- a shared measurement system that captures data in a short list of indicators that are agreed and reported by all participants as the measures of success;
- mutually reinforcing activities that recognize the interconnectedness across organisations, actors and outcomes and are coordinated even though they may be highly diverse;
- continual communication that builds trust and creates a common vocabulary as the basis for the shared measurement system, including face-to-face communication, newsletters, minutes and other records of meetings and public fora, and

- exchange of information and experiences among participants; and
- backbone support organisations staffed by dedicated people with highly specific skills who can manage, drive and coordinate the previous four criteria.

Although those criteria seem to focus on the process required to achieve change, as Kania and Kramer observe, when emergent solutions begin to meet the intentional outcomes, ‘the process becomes the solution’ (Kania and Kramer, 2013, p.7).

There are also challenges to creating lasting change through collective impact, whereby capturing learning does not necessarily lead to acting on the lessons learned; adequacy (or lack thereof) of resources, such as money, time and capacity; and the difficulty of securing funding for ‘intentional change with emergent solutions’ approaches in current development and public services paradigms (Kania and Kramer, 2011, 2013).

A review of case study examples of collective impact approaches was not conducted as part of this literature review. Several such cases have been documented, however, and method reviews variously extol or critique the collective impact approach. This line of inquiry will be researched in more detail in subsequent steps in this ongoing research project as the research progresses towards analysis and comparison of the approaches to fostering systemic change for insights into their relative similarities and differences.

4.2 LEARNING ALLIANCES

The second approach to fostering large-scale socio-technical system change involves learning alliances. In the WASH sector, *learning alliances* were identified in

the early 2000s as a promising approach for scaling up innovations. The term learning alliance has, however, been in widespread use in the business world since the end of 1980s (see Iyer, 2002, and Khanna et al., 1998). In other areas of development, especially in agro-enterprise development, learning alliances were used in the 1990s so that people could come together to analyse problems, address the challenge of mismatched expectations and interests and seek solutions. The term is also used in health and education—for example, in the National Health Service in the United Kingdom (Connor, 2001).

The Colombia-based Centro Internacional de Agricultura Tropical defined learning alliances as follows:

[a] process undertaken jointly by research organizations, donor and development agencies, policy makers and the private sector through which good practices, in both research and development, are identified, shared, adapted and used to strengthen capacities, improve practices, generate and document development outcomes, identify future research needs and potential areas for collaboration and inform both public and private policy decisions. (Lundy et al., 2005, p.3)

Centro Internacional de Agricultura Tropical follow this approach in the Rural Agro-enterprise Development Project (Lundy, 2004; Lundy et al., 2005) and advocate its use more widely in the Consultative Group on International Agricultural Research as a means of increasing the effectiveness and relevance of research, the impact of development work and the formulation of better-informed policies.

Learning alliances foster feedback loops that are both ‘horizontal’ (among stakeholders working at the same

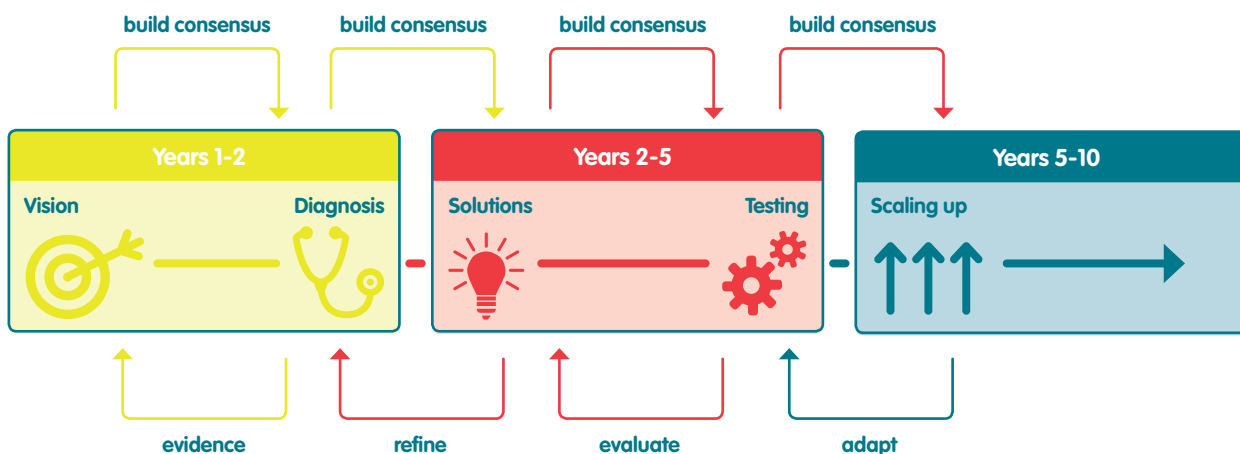


FIGURE 5 SECTOR CHANGE AND INNOVATION PROCESS

institutional level—e.g., civil servants and NGO staff) and ‘vertical’ (e.g., between citizens and national government officials) across private, public and non-governmental organisations, academic and research organisations, development partners, civil society and other actors at different administrative levels. This potential ‘to bridge the gap between people on the ground, organisations at district or provincial level with responsibility for service provision and support, and national policy makers’ (Smits et al., 2007, p.xiii) is important for facilitating the scaling up and uptake of innovative solutions: it engages actors in developing and testing solutions to problems (Figure 5).

The definition of a learning alliance used by IRC recognises the layered structure of the WASH sector and refers to platforms at different institutional levels (Figure 6).

Moriarty et al. (2005, p.9) define a learning alliance as a series of interconnected ‘multi-stakeholder platforms at key institutional levels (national, district, community, etc.), designed to break down barriers to both horizontal and vertical information sharing and thus to speed up the process of identification, development and scaling up of innovation’. Da Silva Wells (2012) lists the strategic objectives for learning alliances:

- To provide dedicated space for deep reflection by groups of stakeholders on specific WASH issues
- To create feedback mechanisms between existing multi-stakeholder platforms—both horizontal (e.g., between districts) and vertical (e.g., between district and national levels)
- To generate evidence on WASH challenges, solutions, innovations and opportunities to inform decision making and scaling up of proven and promising approaches to service delivery

- To facilitate joint reflection, analysis and action planning
- To embed results of action research in the appropriate sector institutions or agencies
- To create and support a critical mass of change agents
- To accelerate the process of generating information, joint reflection, sense making, planning and adaption through dedicated facilitation, knowledge and information sharing
- To influence policy processes

As with the principles of the collective impact approach, those eight strategic objectives of learning alliances will serve in subsequent research steps as the basis for decomposition, analysis and comparison of the three approaches discussed in this section.

Learning alliances are a cornerstone of IRC’s approach to whole system change for sustainable water services. Experiences in rural and urban settings across more than a dozen countries over the past decade have been documented by IRC and its partners in published case studies demonstrating the different forms and functions of learning alliances in a range of contexts. The value and validity of the learning alliance approach have been assessed in various studies (Nkum et al., 2014; Kahangire et al., 2012). Approximately US\$ 1 million per annum was required to support national and regional learning alliances in Ghana over six years (Duti and Lockwood, 2015). Smits et al. (2011), however, find that few development partners—domestic or international—have been willing to invest in making this ‘software’ part of national WASH sectors.

Given the availability of several case studies and documented examples of learning alliance

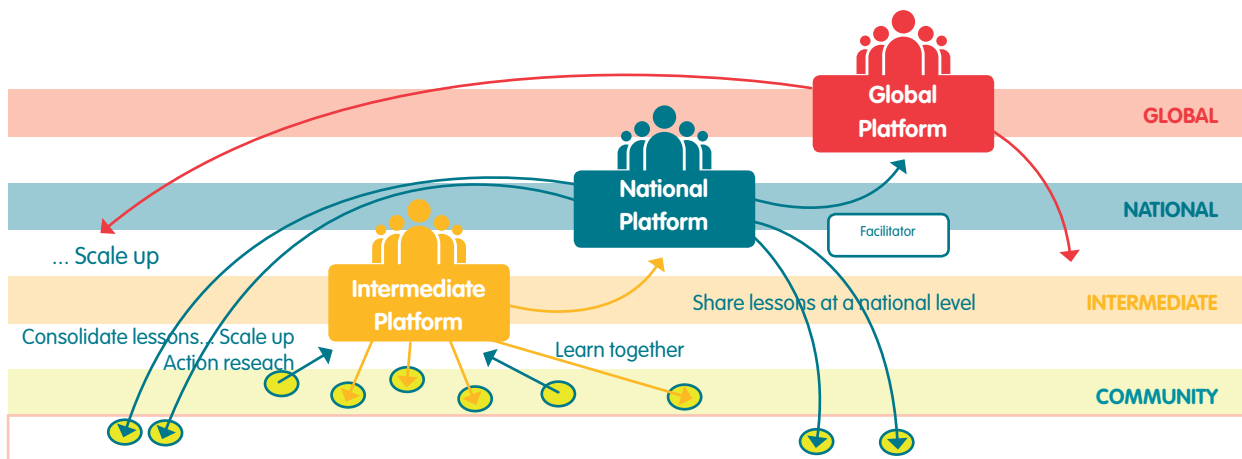


FIGURE 6 LEARNING ALLIANCE APPROACH TO SCALING CHANGE ACROSS INSTITUTIONAL LEVELS

approaches to delivering water services in different national contexts, this approach is selected for analysis and comparison with collective impact, discussed above, and problem-driven iterative adaptation, discussed below.

4.3 PROBLEM-DRIVEN ITERATIVE ADAPTATION

Problem-driven iterative adaptation (PDIA) is the third complexity-based approach to fostering change and innovation in complex systems such as the delivery of public services.

Andrews et al. (2012) highlight the ‘capability traps’ that are the bane of institutional reform initiatives in developing countries. In this and related work (Pritchett et al., 2010; Pritchett, et al. 2013b; Andrews et al., 2013), researchers investigate the sources of ‘implementation failure’ despite decades of institutional reform initiatives and attempts to scale up successful implementation practices from one context to another.

Systemic isomorphic mimicry—the ‘fake it till you make it’ strategy of adopting the appearance of another country’s successful institution (see Section 2.2 of this review)—is highly problematic (Pritchett et al., 2010) as an approach to economic and social development. The desired result—in the case of the WASH sector, the sustainable delivery of WASH services to all citizens—cannot be achieved by simply creating attractive organograms of government entities when these entities lack human capacities, financial resources, reformed legal systems, and enhanced public management systems (Pritchett et al., 2013b). Andrews et al. (2012, p.7) therefore call on the international development sector to focus not on the form of organisations but their function, and to shift towards ‘a constant process through which agents make organizations better performers, regardless of the form adopted to effect such change’.

Following the review of literature ranging from Senge’s (1990) work on ‘learning organisations’ through Grindle’s (2004) ‘good-enough governance’, Briggs’s (2008) ‘democracy as problem solving’ and Pritchett et al.’s (2013a) ‘experiential learning’, Andrews et al. (2012) propose the following four principles for problem-driven iterative adaptation for overcoming these problems of governance reform:

- aim to solve particular problems in particular local contexts via
- the creation of an ‘authorising environment’ for decision making that encourages experimentation and ‘positive deviance’, which gives rise to

- active, ongoing and experiential (and experimental) learning and the iterative feedback of lessons into new solutions, doing so by
- ‘engaging broad sets of agents to ensure reforms are viable, legitimate and relevant—that is, politically supportable and practically implementable.’ (Andrews et al., 2012, p.8)

Noting progress achieved through development assistance over the past decades, Andrew’s colleague and fellow PDIA author, Woolcock (2014, p.24), advocates for further ‘institutional change’ and offers a more concise set of PDIA principles:

- local solutions for particular local problems;
- pushing problem-driven positive deviance, or a ‘purposive crawl of the design space’, as opposed to implementation of exhaustive plans made in advance;
- try, learn, iterate, adapt following the ‘integration of rigorous “experiential” (and experimental) learning into tight feedback loops’; and
- scale up learning through diffusion ‘of feasible practice across organizations and communities of practitioners’ (adapted from Andrews et al., 2013).

Like collective impact and learning alliances, PDIA is apparently a process-oriented approach. However, as noted explicitly by Kania and Kramer, there comes a point at which the process steps start to merge with the intended outcomes of an intervention and the ‘process becomes the solution’ (Kania and Kramer, 2013, p.7).

PDIA recognises that interventions intended to achieve change have varying levels of complexity: building a school is “easy”; ‘building capabilities of the human systems ... [is] ... more difficult’ (Andrews et al., 2013, p.234). Knowledge about the context and the nature of a problem is fundamental, as is the involvement of all stakeholders. Robust, legitimate public institutions are at the heart of the process of achieving change. Functioning public institutions with the capacity to implement and adapt in the face of uncertainty is a critical aspect of overcoming the problems of the ‘capability trap’ and ‘implementation failure’ (Pritchett et al., 2013b, p.2).

5. Simulating complex problems: Tools to test and learn

The above three approaches feature in the literature about change and innovation in complex systems, such as socio-technical systems for public services in low- and middle-income countries. An analysis of the extent to which they, let alone other approaches not reviewed here, overlap or conflict was not found in the literature. However, for a policy maker or practitioner, such insights would be invaluable for making decisions about how to allocate resources. The literature is clear that development of new infrastructure alone will not achieve the goal of universal water services that last. More resilient and adaptive national systems—where the ‘process becomes the solution’—are required.

To address this gap in the literature and knowledge base, a framework for analysis and comparison of these approaches, based upon Ostrom’s institutional analysis and development framework (described in Section 3), will be developed. The aim is to gain insights into the commonalities and differences across the approaches to whole system change. An important line of inquiry is whether specific elements—or even entire approaches—are more relevant or effective in fostering change.

In this section tools for simulating complex problems and experimentation with alternative scenarios are presented. These tools, documented in the complexity sciences literature, simulate the dynamics and emergent properties of complex adaptive systems, including socio-technical systems, and therefore offer a means for exploring the approaches reviewed in Section 4.

Simulation is a powerful tool for learning and reflection when real-life testing and experimentation are not a realistic option (Ryan, 2008; Flood, 2010). This section reviews the available computational and non-computational modelling and simulation tools commonly used in the complexity sciences to support policy makers, researchers, practitioners and other stakeholders in exploring complex challenges. Simulation of a problem offers opportunity for learning, probing and testing policy or design assumptions, or as Flood (2010, p.277) suggests, for

arriving at a ‘meaningful understanding’ of the dynamics of a socio-technical system, its actors and the prevailing institutions. It offers a safe setting in which potentially promising solutions can be implemented—and their effects observed and analysed—without the risks or costs of testing in situ. Using one or a combination of simulation methods in rigorous and structured approaches can provide insights into drivers and barriers to change in socio-technical systems.

Two simulation tools well suited to exploring the effects of different interventions in the rural water sector through *in silico*⁸ experimentation are agent-based modelling and serious games (Ryan, 2008; Ramalingam, 2013), both of which generate macro-level outcomes arising from the individual behaviours, decisions or actions of actors. A review of the literature on agent-based modelling (Section 5.1) is followed by a review of the potential of serious games (Section 5.2).

5.1 AGENT-BASED MODELLING

This section presents literature that explains and discusses the value of agent-based modelling as a suitable tool for simulating and exploring complex challenges.

In the 1960s Tom Schelling sketched maps of fictional racially segregated neighbourhoods to understand how ‘individual behavioural choices could aggregate into system-wide social phenomenon that were unintended, unexpected and, in this case, undesirable’ (Ramalingam, 2013, p.174). This application of social science to examine a social phenomenon, as opposed to earlier applications in the physical sciences of genetics and biology, was a first (Epstein et al., 1996; Ramalingam, 2013).

Agent-based modelling has since evolved from Schelling’s paper-and-pencil graphics to computer simulations of macro-level social patterns, change or distributions that arise from micro-level processes, actions and interactions in complex adaptive systems (Epstein, et al., 1996; Miller and Page, 2007; Nikolic and Ghorbani, 2011; Van Dam et al., 2013). Agent-based models ‘are constructed to discover possible

⁸ “in silico”: [an action] done or produced by using computer software or simulation. Merriam-Webster.com. 2015. <http://www.merriam-webster.com> (13 May 2015).

emergent properties from a bottom-up perspective. They attempt to replicate, in silico, certain concepts, actions, relations or mechanisms that are proposed to exist in the real-world in order to see what happens' (Nikolic and Kasmire, 2013, p.55). The modeller has no desired state or task to achieve; instead, the model 'merely describe[s] the entities and observe[s] how they interact in order to explore the system's possible states' (Nikolic and Kasmire, 2013, pp.55–56). Scientists, policy makers and practitioners now widely 'use agent-based models to analyse socio-technical problems and explore policy alternatives' (Ghorbani, 2013, p.3) in fields as diverse as energy markets, public health care systems, urban planning, teamwork in organisations, greenhouse agriculture systems, supply-chain optimisation and financial markets (Van Dam et al. 2013; Nikolic, 2009).

Agent-based models are not predictive, but they offer a means of exploring the arising dynamics in a defined problem space. To arrive at a model that provides useful or meaningful insights, a modeller begins by identifying the problem and then determines the agents, rules, states, actions, environment and flow of information as they are observed in the real world. The simplified rules, or institutions, that are simulated guide how agents act and interact with one another and with the environment (Ghorbani, 2013). Because of the bottom-up generative approach of such models, the micro-level processes in turn

emerge as macro-scale patterns, which may be non-linear (disproportional) to the initial micro-level processes, as with the example of financial market booms. Feedback loops may also be represented, depicting the processes by which agents 'learn' and adapt their behaviours over time. Algorithms form the narrative of the simulated agents, where actions and interactions follow from rules simulating a simplified representation of a real-world challenge or issue, and various scenarios are tested. Analysis of the data generated by running huge numbers of tests in this simulated environment provides insights into patterns that emerge from the introduction of a policy decision, an innovation or other socio-economic, technical, political or environmental phenomenon.

The structure of an agent-based model is visualised in Figure 7.

As an example, Table 1 displays these behavioural rules and subsequent (inter)actions as set out for a computer simulation of the Uganda rural water services system. The first 'theme' is the 'water service basis phase', which entails potentially replacing the current water user committee. The second phase describes how the local government can be asked to assist in collecting money for the repair or maintenance of a water point. The remaining four phases describe how the local government informs the district water officer about

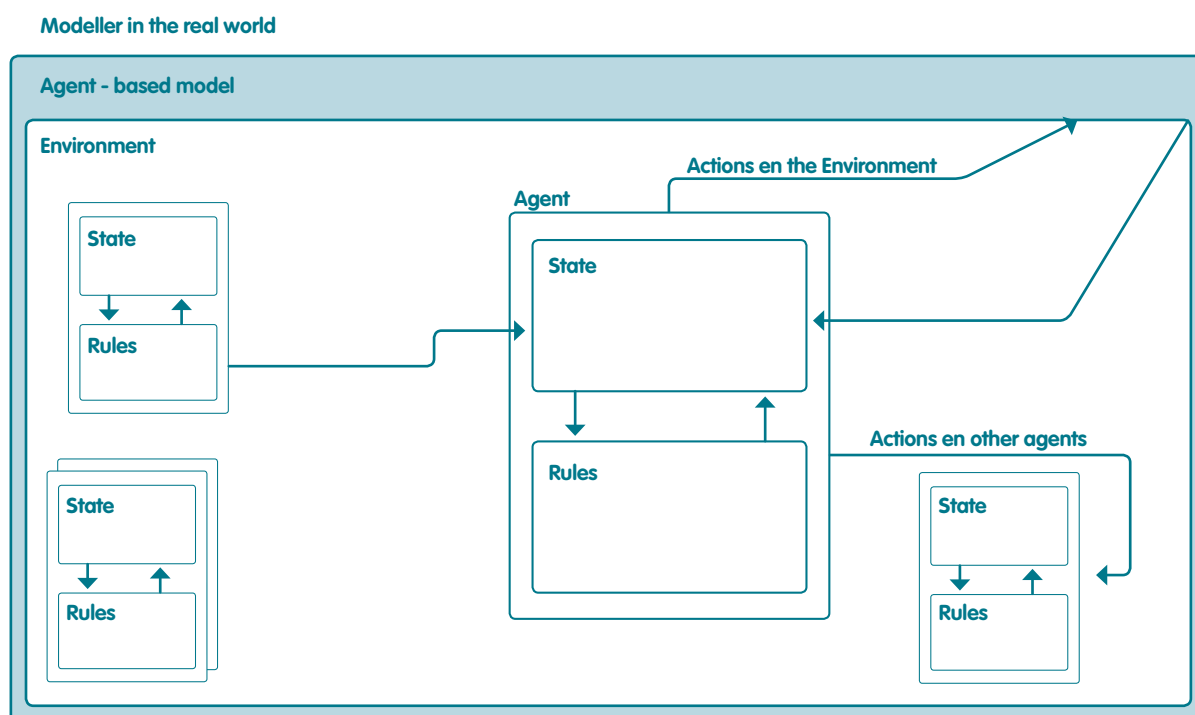


FIGURE 7 STRUCTURE OF AN AGENT-BASED MODEL

Source: Nikolic et al., 2013, p.58

requests for a new water point or major repairs and the conditional grant proposal.

An agent-based model developed by Ghorbani (2013) combines the IAD framework of Ostrom (see Section 3.5) with theories from the field of sociology on the structure of human relations, human agency and the influence of institutions on society to form an agent-based modelling framework through which socio-technical systems can be simulated. A model created using the IAD framework is 'a diagnostic tool [which] starts from outcomes' (Yu, 2014, p.56). Working backwards from one or more desired policy outcomes, stakeholders can evaluate possible policy outcomes and revise policy objectives (Yu, 2014, p.56). Further, they can 'identify patterns of interactions' and change the rules, physical conditions, actors and policies 'to understand how these variables affect the action arena and policy outcomes' (Yu, 2014, p.56). By using Ghorbani's modelling tool, called Modelling Agents using Institutional Analysis, researchers can analyse current policies or compare alternatives, following a structured approach to decomposing the institutions (laws, policies, rules, norms or shared strategies) that inform the behaviour of agents in the system. For the purposes of this research project, this tool offers a means for making explicit the requirements that the systemic change approaches discussed in Section 4 must satisfy to be formalised and simulated for further exploration and experimentation.

The literature notes potential trade-offs between flexibility (the model can depict many types of behaviours with greater levels of ambiguity) and precision (the model accurately depicts the real-life system) (Miller and Page, 2007, p.79). Of critical importance is the process of model creation (Van Dam et al., 2013). The effort to simulate a complex problem must engage domain experts and stakeholders in identifying the problem, conceptualising the model and validating the model design so that the simulation generates useful results and insights for informing policy choices. An issue that is not addressed in the literature about agent-based models is whether the results obtained by simulating and testing a range of future scenarios are easily understandable and actionable for policy makers, politicians, civil society representatives, practitioners and other stakeholders involved in delivering public services. The gap in the knowledge base about the acceptability and accessibility of agent-based modelling for decision makers involved in rural water services will be examined in the course of this research project.

In Section 5.2 the literature about serious games is reviewed for its potential to bridge the gap between the simulated results of agent-based models and the reality of decision-making processes for public services.

5.2 SERIOUS GAMES

Serious games, or workshop gaming approaches, are 'a special type of model that uses gaming techniques to model and simulate a system' (Duke and Geurts, 2004, cited in Duke and Kriz, 2014, p.145). With serious games, concepts and technologies derived from computer-based and other entertainment games are used for non-entertainment purposes, such as research, policy development and analysis, decision making, training and learning.

Serious games simulate the physical, technical, economic, information, communication and social elements of a real-world setting. In this virtual environment, actors can interact and engage, in a competitive or non-competitive manner, without the 'risk of real-world consequences' (Lukosch and Bekebrede, 2014, p.145). Gaining insight into the effect of large-scale changes before implementing them is of great value in policy making, action research and programming in dynamic, complex systems. As noted by Chappin and Dijkema in Van Dam et al. (2013, p.217), a serious game about the European Union's energy market made participants 'more receptive to the fundamental complexity of the socio-technical electricity system' and helped them envision alternative scenarios (which were also enacted in serious games) before applying energy market trading strategies in the real world.

A serious game may be as simple as pen and paper, such as the participatory rapid appraisal methods common in the development sector. But serious games may also be highly sophisticated, high-fidelity computer-generated environments, like those used to train medical professionals and aircraft pilots (Lukosch and Bekebrede, 2014).

One serious game toolkit with decision support and didactic potential is Wat-A-Game, developed by the Institut national de recherche en sciences et technologies pour l'environnement et l'agriculture (IRSTEA). It can be used to design participatory simulations (i.e., role-playing games) for water management, policy design and education. The game has been used in sub-Saharan African countries as well as in the Mediterranean region over the past decade to explore water-related issues by depicting water flows, pollution, resource sharing and uses.

TABLE 1 AGENT-BASED MODEL CONCEPTUALISATION: RULES OF LOCAL GOVERNMENT

Rules Table 30 Rules of local government		
Theme	Action / information	Timing
Water service basis	Check received 'inactive Water User Committee' information	1x day
Phase	If False:	
	Go to next phase	
	If True:	
	Check if particular Water User Committee Motivation < Motivation threshold	
	If False:	
	Go to next phase	
	If True:	
	Determine to replace Water User Committee or not	
	If False:	
	Go to next phase	
If True:		
Send Water User Committee replacement information		
Monthly contribution	Check received request money collection support	1x day
Phase	If False:	
& Request	Go to next phase	
Maintenance phase	If True:	
& Assessment phase	Check water point User list	
	Send Obligation to pay Water User Committee the requested amount	

Source: Van Tongeren, 2014, p.185.

Game participants—farmers, household water users, policy makers, researchers, implementers—decide how they wish to use or allocate water resources, as individuals or collectively, and then observe the consequences for macro processes, such as local economies, user satisfaction, labour and the environment. After playing different scenarios, groups of stakeholders engage in facilitated reflection and planning processes to inform the design of new water resource management policies.

Just as for agent-based models and their results, a question arises about the accessibility of serious games and their results and thus their utility to policy makers and practitioners. The literature suggests that some combination of the two methods may have potential—something to be explored in further research on achieving systemic change in the rural water sector.

6. Discussion and conclusion

This review of literature has summarised findings from the domains of rural water services, governance, international development aid and its role in influencing local development processes and priorities as well as theory and concepts offered by the fields of systems thinking and complexity sciences. The insights gained from this review include the validity of applying a complexity sciences perspective to framing the rural water sector as a system—specifically, a socio-technical system.

At the outset of this exercise in mid-2013, the initial line of inquiry was whether the complexity sciences literature had addressed whole system change as a phenomenon, whether concerted approaches to fostering whole system change had been documented and whether the elements of such approaches had been identified or otherwise formalised. The hope was that those elements could be compared or assessed for use in scaling up in other contexts.

The review confirms that the notion of whole system change exists and has been evident in the literature from 1970s onwards. The literature reviewed offers the concepts and theory from complexity sciences, and in particular socio-technical systems, as a more precise means for communicating about the rural water sector in low- and middle-income countries. Framing this sector as a socio-technical system creates the possibility of examining how large-scale change may emerge and evolve in dynamic and complex systems.

The literature also documents concerted approaches to achieving change in such a setting. As applied in other public service contexts, such as education, health and water resources management, approaches to whole system change include the following common elements:

- A commonly held vision of change among stakeholders that has a broad base of support
- Dedicated, funded facilitation to guide and curate a high-quality change process
- Evidence generated from monitoring, policy and action research
- Collective, or social, learning and decision making about alternative options and pathways to achieving the vision
- Timely information feedback loops based on common monitoring systems and research across all levels of the system to keep stakeholders engaged and informed

The literature does not compare the different approaches or their elements, however. It is also not clear whether certain elements, principles or strategic objectives are more critical or effective than other. The literature indicates the value of competencies and methods that enable actors and actor networks to learn and reflect on what works and adapt to emerging change pressures in specific contexts, but offers no set menu of options or principles that constitute a single approach.

The literature does describe tools well suited to simulating and experimenting with complex problems for the purpose of identifying policy options and potential solutions. These methods, rooted in complexity sciences, are powerful tools for exploring ‘problem spaces’ and complex global problems, to use the terminology of Harman (1995).

The wider insights from this review—for practical application—is another matter. The Triple-S Sustainable Services That Last project, which provided the context of this inquiry, concluded its six-year programme cycle in November 2014. In addition to developing research reports, tools for monitoring and policy analysis and development for sustainable delivery of rural water services, Triple-S also sought to make explicit and to analyse its own programmatic approach to fostering change from an infrastructure-oriented approach to an emphasis on service delivery.

Two Triple-S case studies document the approaches pursued by programme partners, including government actors, to create whole system change in Ghana [URL] and Uganda (forthcoming 2016). Additionally, a series of blogs [URL] by Triple-S partners describe the implementation and testing of these approaches to systemic change. Taken together, these manuscripts—including this literature review—document an evolution in the initiative’s approach and its partners’ collective thinking on how to achieve large-scale, systemic change. The goal of whole system change is now more explicitly articulated as the need for strong national systems (following Ryan’s definition of a system, page 9) that have the capacity to act, learn and adapt in the face of future uncertainties.

Approaches to fostering whole system change exist and have been tested in different settings to overcome challenges and achieve a range of development goals. Three approaches, each grounded in complexity sciences—collective impact, problem-

driven iterative analysis, and learning alliances—are well suited to effecting change in socio-technical systems. Particular aspects of these approaches, such as the imperative of practitioners and policy makers to experiment and learn from different interventions and ideas, are highlighted as strategic objectives and principles. Involving a broad range of interested parties is crucial for attaining richer and more appropriate results, as is willingness to adapt actions and plans according to emerging dynamics and signals.

Furthermore, the literature from the complexity sciences offers concepts and methods for exploratory inquiry into change processes in socio-technical systems. The concepts from ADICO (Ostrom) enable the formalisation of the prevailing institutions in a given socio-technical system, and simulation methods, such as agent-based modelling, provide a way to anticipate agents' behaviour and the emerging macro-level patterns. Researchers can thus experiment with approaches to fostering systemic change over long periods of time and under varying conditions—something not possible in real time.

What the literature review has not revealed is which elements of the approaches to fostering systemic change are most effective. Additionally, no comparative study of the approaches' strengths and weaknesses, or even a framework for such a comparison, was found. Note, however, that this literature review predates the more recent articulation of the notion of *national systems strengthening* by the research team as the overarching aim of engaging with a whole system for improving public services.

Next steps in the research programme will therefore focus on addressing gaps in knowledge about what is required to achieve change in national systems dedicated to delivering public services. The three approaches discussed in Section 4 will be analysed and compared for their efficacy. An additional line of inquiry will consider whether and how exploratory agent-based modelling and analysis can generate insights for policy makers and practitioners, or whether other methods, such as serious games, would make results from agent-based simulations more accessible and useful.

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