A mixed methodology for the assessment and planning of public systems for drinking water and sanitation services: learning from local systems to plan for change at a larger scale.

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Thesis submitted 9 August 2021

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Doctor of Philosophy in Civil Engineering and Applied Mechanics.

Abstract

Safe drinking water and sanitation are basic needs for human health and livelihoods, yet in parts of the world these services are lacking. Sub-Saharan Africa has low rates of access and the existing services are often rudimentary and characterised by unreliable infrastructure, frequent failure shortly after construction, and with only marginal control of contaminants. Significant progress has been made to increase access and improve sustainability, but globally investments have failed to deliver the anticipated outcomes. The challenge of achieving universal service delivery in sub-Saharan Africa was investigated by reframing the water and sanitation services as the product of a public service system. A framework for defining and measuring the wider support systems needed to maintain infrastructure was developed and applied in six countries with the aim to foster greater alignment of implementing actors and improve practice.

In the first phase of the research, interviews and field visits to promising and failed sanitation interventions in East Africa revealed the importance of both local participation and government buy-in to achieve sustainability and to be able to scale up the intervention. Fragmentation of knowledge and an incomplete understanding of the problem by many practitioners suggested the need for a more shared understanding of how services can be provided and improved.

In the second phase of the research, a conceptual and analytical framework was developed based on a review of the literature and case studies in east and west Africa, field visits and interviews with water and sanitation experts in service delivery and research. The framework defined the water and sanitation system according to nine sub-systems: institutions, policy and legislation, finance, planning, regulation, monitoring, water resource management, learning and adaption, and infrastructure. These were determined to be a logical way to divide the overall system into manageable parts, based on iterative problem analyses with local and national actors. It is posited that these functionalities must be present in the national framework and understood and implemented at decentralised levels.

In the third phase, the framework was applied using mixed methods participatory action-research to assess drinking water service delivery in Uganda using the case of Kabarole District in

the western region. The research was carried out with a nationally registered NGO (IRC) and a learning alliance of stakeholders dedicated to supporting the local and national governments' objective to provide universal access to basic water by 2030, and to extend piped water to all households by 2040. Qualitative policy assessments, a review of statements from national level officials and the results from a quantitative analysis of the drinking water services in Kabarole in 2017 and 2019 were used to identify emerging trends in service delivery. Service delivery models present in Kabarole were self-supply, community management, and two different variants of a public utility model. Uganda has made progressive policy reforms in recent years and is in the early stages of a transition to professionalized utility water supply systems. At this stage, institutional roles overlapped as new service authorities were established and many service delivery models were present.

The research investigated the social learning of stakeholders in a learning alliance tasked with identifying strategies to achieve the 2030 service level and service coverage targets. The multi-level perspective for socio-technical systems transitions was used to analyse bottom-up and top-down innovation in Uganda. The learning alliance was engaged in a participatory scenario development process making use of GIS maps, interviews, workshops and focus group meetings to identify the most important and uncertain factors that may influence progress toward the 2030 targets. The most likely scenario was identified, and several strategies were developed to adapt to anticipated changes while pursuing the goal of universal services.

The final phase of research was a critical reflection on the WASH systems framework and assessment methodology. A public systems approach to analysis and planning was found to be useful for structuring collaborative work in a complex environment. The use of nine subsystems to define the larger system helped to reduce the complexity and so aid in analysis. Participatory assessment of these subsystems was effective in helping local, national, and international actors to establish a more common understanding of the problem and to develop future visions for public service delivery.

Résumé (Français)

L'eau potable et l'assainissement sont des besoins fondamentaux pour la santé et la subsistance, mais dans certaines régions du monde, ces services font défaut. L'Afrique subsaharienne a un faible taux d'accès à ces derniers. Les services existants sont souvent caractérisés par une infrastructure peu fiable, qui tombe fréquemment en panne peu après la construction et qui ne permet qu'un contrôle marginal de la pollution. Des investissements majeurs ont été réalisés pour en accroître l'accès et la durabilité, mais ils n'ont souvent pas atteint les résultats attendus. Cette étude analyse les enjeux d'accès universel relativement à la prestation et au développement des services publics en Afrique subsaharienne. Un cadre pour définir et évaluer les déterminants qualitatifs de la fonctionnalité des infrastructures a été élaboré et appliqué dans six pays dans le but de favoriser une meilleure coordination des acteurs et d'améliorer la planification des améliorations de tels services sur le terrain.

Dans la première phase de la recherche, des entretiens et la visite d'interventions prometteuses ou défaillantes dans le domaine de l'assainissement en Afrique de l'Est ont révélé l'importance de la participation locale et de l'implication des instances gouvernementales pour assuré la durabilité des infrastructures et des services, et pour favoriser leur implantation a grande échelle. Ils ont aussi permis d'observer que les informations sur les situations problématiques étaient fragmentaires aboutissant à leur compréhension incomplète par de nombreux acteurs. Ces observations suggèrent la nécessité d'établir une compréhension partagée de la manière dont les services peuvent être fournis et améliorés.

Dans la deuxième phase de la recherche, un cadre conceptuel et analytique a été élaboré sur la base d'une revue de la littérature, de visites sur le terrain et d'études de cas en Afrique de l'Est et de l'Ouest, ainsi que d'entretiens avec des experts. Ce cadre définit les service publics d'eau et d'assainissement en fonction de neuf composantes clés: arrangements institutionnels; politique et législation; finances; planification; réglementation; suivi-évaluation; gestion des ressources en eau; apprentissage et gestion des connaissances; infrastructure. Ces composantes se sont révélées être un moyen logique de diviser le système global en parties plus facilement abordables, sur la base d'analyses itératives des problèmes avec les décideurs politiques et les

autorités locales. Il a été postulé que ces fonctionnalités doivent être présentes dans le cadre réglementaire national et être comprises et mises en œuvre de manière décentralisé.

Dans la troisième phase de la recherche, le cadre d'analyse a été appliqué en utilisant des méthodes mixtes de recherche-action participative avec des autorités locales, des acteurs du secteur privé et des représentants de la société civile. La prestation de services d'eau potable en Ouganda a été étudiée à travers le cas du district de Kabarole, dans la région ouest. La recherche a été menée avec la branche nationale d'une ONG internationale (IRC) et un groupe de réflexion local (*learning alliance),* qui se consacre à aider le gouvernement à atteindre son objectif de fournir un accès universel à l'eau d'ici 2030. Une évaluation qualitative des politiques et une revue des discours des responsables nationaux ont été utilisées en parallèle aux résultats d'une analyse quantitative des services d'eau potable à Kabarole en 2017 et 2019 afin d'identifier les nouvelles tendances en matière de prestation de services. Les modèles de prestation de services à Kabarole étaient l'auto-approvisionnement, la gestion communautaire, et deux variantes de prestation par des organisme publics (régional et national). L'Ouganda a procédé à des réformes politiques progressives au cours des dernières années et montre les premiers signes d'une transition vers une gestion professionnelle par des organismes de services publics. L'étude a mis en évidence un manque de clarté dans les rôles institutionnels, en particulier pour les acteurs décentralisés qui doivent suivre les changements pilotés par l'administration centrale.

La recherche a favorisé l'apprentissage collaboratif des parties prenantes par la discussion et l'analyse itérative des problèmes et des solutions (*social learning)*. La prise en charge en groupe de la définission des questions de recherche-action et de leur réponse a permis d'identifier les voies à suivre pour atteindre les objectifs de 2030. Une approche à plusieurs niveaux a été utilisée pour analyser les transitions des systèmes socio-techniques en Ouganda (l'approche «*multi-level perspective for socio-technical systems transitions* » de Geels), en considérant les dynamiques d'adoption de l'innovation par le haut (gouvernement) ou depuis le bas (citoyens). A l'aide de systèmes d'information géographique (SIG), d'entretiens, d'ateliers et de groupes de discussion, un processus participatif de développement de scénarios a permis d'identifier et de classifier les facteurs qui peuvent influencer les progrès vers les objectifs de 2030 en fonction de leur importance et leur degré d'incertitude. Le scénario le plus probable a été identifié, et plusieurs stratégies ont été développées pour s'adapter au changement tout en poursuivant l'objectif d’accès universel.

La dernière phase de la recherche a permis une réflexion critique sur le cadre conceptuel et la méthodologie d'évaluation des services public d’eau et d'assainissement. L’approche d'analyse et de planification fondée sur l'eau et l'assainissement en tant que services publics a été considérée comme efficace pour structurer le travail collaboratif dans un environnement complexe. L'utilisation de neuf composantes clés pour définir le système global a permis de réduire la complexité. L'évaluation participative de ces sous-systèmes a permis aux acteurs locaux, nationaux et internationaux d'établir une compréhension commune du problème et des visions pour la prestation de services publics d'eau et d'assainissement.

Acknowledgements

First, I wish to acknowledge that McGill University is situated on the traditional territory of the Kanien’kehà:ka, a place which has long served as a site of meeting and exchange amongst nations. I recognise and respect the Kanien’kehà:ka as the traditional custodians of the land and waters, and honour the resilience of indigenous nations across Canada, the United States, and globally.

I am immensely grateful for the privilege of doing research, and the support I have received from many individuals and institutions to make it possible.

Funding for this research was provided through the McGill Engineering Doctoral Award: the Laurent Trottier Engineering Fellowship, The McConnell Memorial Fellowship, the Graduate Excellence Award, and my supervisor’s grants (S. Gaskin), a Discovery Grant (RGPIN-2016-02273) from the Natural Science and Engineering Research Council of Canada and a McGill Internal Social Sciences and Humanities Development Grant. I benefited from the receipt of McGill’s Graduate Research Enhancement and Travel Award.

Through IRC, I received financial support and access to field research and data thanks to The Netherlands Ministry of Foreign Affairs, the Conrad N. Hilton Foundation, and the United States Agency for International Development. This was made possible by executive leadership at IRC, Patrick Moriarty, Rutger Verkerk, and Bryony Stentiford, and the support from my managers, John Butterworth, René van Lieshout, Ingeborg Krukkert, and Catarina Fonseca.

Most importantly, I thank my supervisors, Susan Gaskin and Patrick Moriarty, for the incredible support through all stages of research. They have placed their confidence in me to design and lead this work, while providing invaluable feedback and mentorship. Thank you for going above and beyond doctoral supervision to invest in my development as a researcher and professional.

I also thank my Thesis Committee Members Ronald Gehr and Mary Kang, and Sun Chee Wong of the Civil Engineering Office for guidance and support. I thank John Butterworth at IRC for creating space for me to complete this work and backing it wholeheartedly.

I am incredibly grateful for the support I have received from Jane Nabunnya, Martin Watsisi, Florence Anobe, Peter Magara, and the entire IRC Uganda team. Your expertise on the technicalities and social nuances of driving change in public services increased the quality of this research enormously. You have supported me as mentors, colleagues, and friends.

Many collaborators and stakeholders in Uganda contributed to study design, data collection and analysis: Peter Opwanya at the Ministry of Water and Environment; District Councillor Aaron Byakutaga, Pius Mugabi, Bruno Basude, Daniel Musinguzi, Olive Tumuhairwe and technical staff at the Kabarole District Local Government; Stephen Balyabuga and the Kabarole Handpump Mechanics Association; Engineers and staff at the Midwestern Umbrella for Water and Sanitation, and the National Water and Sewerage Corporation. The Akvo Nairobi team supported survey design. Katherine Marshall (Aquaya) shared focus group data on willingness to pay and indulged in critical discussions of this research. Kenneth Wallace helped with the sourcing and compilation of GIS maps for administrative and geographic features in Uganda.

This work was made possible by many individuals in Uganda, Kenya, and Tanzania who have generously shared their time and expertise in granting me interviews, field visits, and permission for my research. I am humbled.

IRC as an organisation and a community has been instrumental. I thank René van Lieshout for his work in structing the WASH systems benchmark assessment and leading the Planning, Monitoring and Learning team, along with Stef Smits, Marieke Adank, Erick Baetings, and Patrick Moriarty. Veronica Ayi-Bonte, Michael Abera, Hélène Figea, Peter Magara, Maricela Rodriguez, and Ruchika Shiva (IRC) helped to refine the conceptual model and indicators, and led the analysis and documentation in Ghana, Ethiopia, Burkina Faso, Uganda, Honduras, and India respectively. I thank Arjen Naafs for his work on the data architecture and visualisation, in particular the six country data summary in Chapter 8. Dechan Dalrymple and Punt Grafisch Ontwerp helped with graphic representation of the WASH system. Harold Lockwood (Aguaconsult) contributed to conceptual development and provided advice.

I have been blessed with opportunities for different degrees of collaboration with many brilliant people and institutions. I am grateful to collaborators at the University of Colorado Boulder, Environmental Incentives, and the USAID Sustainable WASH Systems Learning

Partnership who have interrogated and championed systems approaches to push this body of work forward, as well as Mike Morris. The thematic leads, co-convenors, and participants of the All systems go! Symposium in 2019 helped to take stock of WASH sector priorities and steer the direction of research. Cooperative work with the Stanford Woods Institute, with support from the Conrad N. Hilton Foundation, helped refine my thinking and methods. Sara Gabrielsson and the LUCSUS programme of University of Dar es Salaam and Lund University was instrumental to the scoping research and a catalyst for this journey. Thank you to Philippe Reymond for the thoughtful review of my French (and English) abstracts.

A special thanks is due to the many brilliant colleagues in the Agenda For Change collaboration who have worked to advance WASH systems theory and practice. I hope this thesis is seen as progress toward our shared goals. I also thank Louis Boorstin, who was an early proponent for my research, and the Osprey Foundation for supporting this movement.

With my small contribution of a PhD, I stand on the shoulders of giants: The aforementioned colleagues and contributors; Fidelis Folifac and Jennifer Thomson and their work from Cameroon, and Magdaline Agbor of CHAMEG; The work of Deirdre Casella on complex adaptive systems laid a foundation; Vida Duti, Lemessa Mekonta, Juste Nansi and their leadership in national systems development and change. I must also mention my first scientific mentor, Russ Flegal at the University of California Santa Cruz, who taught me about passion in research, and the importance of incorporating athletics, beer and humour at just the right moments.

I give thanks to the ancients and contemporaries of yoga, and the wheel of teachings offered to me. Also, l'Institut du Développement de la Personne in Québec for deepening my practice while teaching me French.

And finally, I thank my family, parents, and grandparents for believing in me and being proud of the process without question or concern. And my fiancé Moritz Gold for endless support, while making this feel like just another manageable part of the adventure.

Contribution to original knowledge

1. Synthesis of theory and knowledge on water and sanitation systems in low- and middle-income countries.

The theory and approaches from civil engineering, the systems sciences, public management, and the social sciences are integrated to provide a contemporary perspective on challenges in water and sanitation service delivery. Knowledge from development partners, governments, and international organisations in the water and sanitation sector in low- and middle- income countries are documented and applied within an academic research process making them available to new audiences. A synthesis of methods from engineering and social sciences is achieved by using a methodology that combines quantitative analysis of infrastructure performance with qualitative analysis of the current use and future vision for the services provided. The use of inclusive participatory methods and an action-research methodology applied with an NGO and local partners brings critical perspectives on aspects of service delivery that may be otherwise left out of the study frame.

2. Analysis and policy recommendations on the sanitation challenges in East Africa using the lens of Sustainability Science

The sanitation sector in East Africa is analysed using principles from Sustainability Science. This provides insight on the conditions required to design sustainable solutions and results in a recommendation to use more interdisciplinary and participatory methods (Chapter 4). Sustainability Science involves the transdisciplinary study of how human, environmental, and engineered systems interact and influence human development and environmental futures. From this perspective, thematic content analysis of the factors influencing ‘cyclic failure’ in sanitation are identified; these include bias in infrastructure designs and the oversimplification of the problem by experts. Promising sanitation interventions demonstrate compatibility with principles from sustainability science: they are co-designed with engineers, social scientists, and communities and based on systems thinking to address social, technical, environmental, and economic drivers.

3. A conceptual framework and methodology for WASH system assessment is produced and tested for use by practitioners and researchers.

A conceptual and analytical framework for the WASH system that characterises it according to nine subsystems was developed (Chapter 5). This responds to the findings from Chapter 4 and the tendency of those designing interventions to be blind to these systems in which they are implemented. The framework is developed collaboratively with practitioners and academics, resulting in a tool that is appropriate for use by local actors and valid for research. The WASH systems framework is tested and its criteria found to be valid in six countries (Chapter 8). It has been used as an entry point or baseline for working in new contexts and has been applied iteratively to monitor changes in the system. The framework can be adapted either to use in different contexts or to focus on additional aspects of the system (e.g. civil society participation or demand for services). The analytical framework can be modified depending on the scope of the study, and can be revised to match the policy framework in particular contexts by changing the terminology or re-calibrating the scoring method.

4. A comprehensive analysis of the changing landscape of drinking water services in Kabarole District, Uganda.

The case study in Kabarole District, Uganda provides a comprehensive and current analysis of rural and peri-urban service delivery in Uganda (Chapters 6 and 7). The use of mixed methods allows for a qualitative analysis of the diverse drivers of drinking water system performance and a quantitative assessment of the performance of the services provided. The definition and analysis of each of the five service delivery models present enables comparison of the models. The recent extension of utility models into rural areas in Kabarole is a significant centrally (nationally) led change. Use of a participatory methodology and interviews with national, regional, district, and community actors reveals implications of the change at different levels. Conducting the research with a Ugandan-based organisation (IRC Uganda) means that the research findings have become available to local stakeholders as they have been produced, and recommendations can be followed up and further disseminated after the completion of this dissertation.

5. Realistic alternatives to the dominant (but failing) community management approach are evaluated.

This research supports the growing consensus that the community management model for rural water supply is inadequate, and through the case study of Uganda, demonstrates alterative strategies for rural water management (Chapters 6 and 7). The poor performance of the community management model is quantitively and qualitatively demonstrated, while the two utility models perform at a higher level within the same area. The extension of professional piped water services into rural areas in Uganda is a new development since 2016; this is the result of the establishment of a new regional utility model and the development of a new model for rural extensions by the established national utility. Scenario development with a learning alliance of stakeholders is used to explore the implications of these changes, and five additional strategies for improving service delivery are produced. Uganda is planning further consolidation and professionalization of rural water supply, making this analysis valuable for policy considerations and planning in sub-Saharan Africa and in other contexts.

Contribution of Authors to the Publications

I designed and coordinated all of data collection, with the exception of the 2017 household survey that was led by IRC Uganda. Where enumerators were hired, I oversaw and developed their contracts, and led the development of survey instruments, the training and pre-testing, as well as leading the sampling design, data analysis and interpretation. I led the participatory methods analysis that was done with the learning alliance in Kabarole. The four results chapters (Chapters 4,5,6, and 7) have co-authors and the contributions of the authors are detailed below.

Chapter 4: I am the co-first author for the book-chapter with Sara Gabrielsson (equal contribution); my supervisor Susan Gaskin is third author. The chapter contains analysis from my independent doctoral research field work (June – August 2016), and field work by Sara Gabrielsson that was conducted separately. The book chapter topic and structure were conceptualised and drafted by Sara Gabrielsson and I working together equally. Susan Gaskin contributed to the writing and revision of the chapter.

Chapter 5: I am the first author of the journal manuscript, with co-supervisors Susan Gaskin and Patrick Moriarty as co-authors. It is based on a working paper published by IRC for which I am first author (Huston and Moriarty, 2018). For the working paper, I performed extensive literature review on systems theory and on existing frameworks for WASH sustainability. I led on structuring and writing of the paper. Patrick Moriarty had been a major contributor to the existing framework which formed the basis for the paper; he provided suggestions to steer the literature review and contributed to the writing and revisions. In Chapter 5, I build on the working paper by refining its description and including additional data analysis and a discussion of responses and critique. Chapter 5 was completed with guidance, conceptual contributions, and reviews from Susan Gaskin and Patrick Moriarty.

Chapter 6: I am the first author and led the research design, data collection, and analysis to classify the service delivery models and analyse their performance and support systems using the framework from Chapter 5. I completed extensive review of existing documents from IRC Uganda and organised the field work. Through interviews and dialogue, Jane Nabunnya provided information on national changes, observed through her role as a national stakeholder. I worked closely with co-author Martin Watsisi (IRC Uganda) during the field work and research design. Co-authors Susan Gaskin and Patrick Moriarty contributed to the writing and revision of the manuscript; Martin Watsisi contributed to the review and revision of the manuscript.

Chapter 7: I am the first author and led the research design, data collection, and analysis to develop scenarios and potential strategies to achieve universal access to drinking water in Kabarole. This was achieved through meetings, interviews, and dialogue with local stakeholders who contributed ideas, perspectives, and direction on the strategies; I led on structuring these into concise scenarios and strategies, validated through consultation and multi-stakeholder meetings. Patrick Moriarty, Jane Nabunnya and Martin Watsisi provided feedback on the methodology during the research design; Martin Watsisi and Jane Nabunnya helped organise the fieldwork and provided insights and contributions to the strategy elements. Co-authors Susan Gaskin, Patrick Moriarty, Jane Nabunnya, and Martin Watsisi contributed to the writing and revision of the manuscript by providing feedback, comments, and suggestions.

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Acronyms

Abbreviation	Meaning
AMCOW	African Minister's Council for Water and Sanitation
ASP	Area Service Provider
CBMS	Community Based Management System
CCI	Centre for Community Initiatives (Tanzania)
CEO	Chief Executive Officer
CIA	Central Intelligence Agency
CLTS	Community Led Total Sanitation
CSO	Civil Society Organisation
DAWASA	Dar es Salaam Water and Sanitation Authority
DGIS	Directorate-General for International Cooperation (Ministry of Foreign Affairs of the Netherlands)
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GIS	Geographic Information System
GLAAS	Global Analysis and Assessment of Sanitation and Drinking Water
IMF	International Monetary Fund
INCOSE	International Council on Systems Engineering
IRC	IRC is a Netherlands-based NGO
IWRM	Integrated Water Resource Management
JMP	Joint Monitoring Program (WHO/UNICEF)
MDG	Millennium Development Goals
MoLG	Ministry of Local Government (Uganda)
MWE	Ministry of Water and Environment (Uganda)
NGO	Non-Government Organisation
NWSC	National Water and Sewerage Corporation (Uganda)
OECD	Organisation for Economic Co-operation and Development
PPES	probability-proportional-to-estimated-size
ppp	Purchasing power parity
PSP	Public Stand Post
RWSN	Rural Water Supply Network
SCAP100	Service Coverage Acceleration Project (Uganda)
SDG	Sustainable Development Goal
SDG6	Sustainable Development Goal 6: Clean water and sanitation for all
SPSS	Statistical Package for the Social Sciences
SWA	Sanitation and Water for All
TSU	Technical Support Unit of the Ministry of Water and Environment (Uganda)

UBOS	Uganda Bureau of Statistics
UGX	Ugandan Shillings (official currency of Uganda): 1 CAN$ = 2890 UGX (March 2021)
UN	United Nations
UNDP	United Nations Development Program
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
USD	United States Dollar : 1 CAN$ = 0.79 USD (March 2021)
WASH	Water, Sanitation and Hygiene
WEDC	Water and Engineering Development Centre (Loughborough University, United Kingdom)
WHO	World Health Organization
WSP	Water and Sanitation Program (The World Bank)
WSSB	Water Supply and Sanitation Board (Uganda)

Chapter 1: Introduction

Water, Sanitation and Hygiene (WASH) have been defined as basic human rights essential for health and dignity, yet an estimated one out of four people around the world still lack access to these services (WHO & UNICEF, 2017). After three decades of international investment, the WASH sector in many countries is still in at low levels of service and poor performance (Foster, 2013; Majuru et al., 2012; Moriarty et al., 2013; Sansom & Koestler, 2009). Infrastructure failure in low- and middle-income countries persists at a high level; it is estimated that more than 60,000 handpumps are installed in sub-Saharan Africa each year and that one in three existing handpumps are non-functional (RWSN, 2009; Sansom & Koestler, 2009). Infrastructure failure is typically associated with a lack of adequate demand-assessment and lack of context-appropriate models for operation and maintenance (Butterworth et al., 2010; McDonnell, 2008; Moriarty et al., 2013). It is also associated with weak governance and institutions (Bakker et al., 2008). Engineering initiatives to improve performance have frequently been based on supply side management and infrastructure solutions, neglecting 'soft' aspects of the system (management, monitoring, institutional capacity, end-user demand, democratic participation in decision making) necessary for sustainable maintenance and realisation of the anticipated health outcomes (Gleick, 2002; Hjorth & Bagheri, 2006; Rogers & Hall, 2003; Smits et al., 2011; Walker et al., 2014; Xue et al., 2015).

The 46 countries of sub-Saharan Africa are home to approximately 1.08 billion people (WHO & UNICEF, 2017); the region includes 22 out of the 25 poorest countries in the world (IMF, 2019). Despite significant progress during the period of the Millennium Development Goals the region is not on track to meet the Sustainable Development Goal (SDG) targets. As of 2015, over half of the global population using untreated surface water as a drinking water source lived in sub-Saharan (despite making up only 17 percent of the global population) and the region has among the lowest rates of access to 'at least basic' sanitation and handwashing facilities in the world (WHO & UNICEF, 2017). Approximately 33 percent of sub-Saharan Africans had access to piped water and 17 percent had access sewerage or a septic tank; the remainder use rudimentary facilities such as boreholes and hand dug wells or surface water, and pit latrines or no sanitary facilities at all (WHO & UNICEF, 2019). The quality and quantity of services delivered has improved since 2000 and key development and economic indicators have shown improvement over the same period, but the continuing high rates of population growth lead to slow progress or even regression in the proportion of the population being reached (Canning et al., 2015; WHO & UNICEF, 2019).

In the case of rural water, engineers and governments have frequently dismissed responsibility for operation and maintenance by the pragmatic adoption of a community-based-management model. This shifts responsibility to local volunteer structures that have varying levels of capacity to cope with the long-term maintenance of water systems (Whaley & Cleaver, 2017). The community management approach was an attempt to be more responsive to demand by including end-users in management and decision-making, however the model, in its current form, has been strongly questioned and criticized, due to its persistent and well-documented failure to sustain infrastructure (Foster, 2013; Moriarty et al., 2013; Van den Broek & Brown, 2015; Whaley & Cleaver, 2017). In the case of urban water, throughout the early 1990s development banks pushed for privatisation of public water supplies, which largely resulted in failure—in part due to the absence of adequate regulatory and monitoring systems, and a failure to reform utility institutions internally and incentivise performance (Araral, 2009; Castro, 2008; Hall & Lobina, 2006).

Whether supply-side or demand-responsive, interventions to improve water and sanitation supply that are developed without adequate understanding of and integration with the socio-economic and political context tend to fail (Hueso, 2016; Lockwood et al., 2016; Northover et al., 2014; Taylor, 2009). Institutional capacity to operate, manage and regulate services still needs to be built. Since users are increasingly expected to help cover the costs of service delivery, effective demand for professional services needs to be developed (Bakker et al., 2008; Franceys, 2019; Werbeloff et al., 2017).

In the past two decades, a more holistic *service delivery approach* has emphasised the importance of measuring service delivery according to indicators for water quality, quantity, reliability, affordability and service provider performance (Huston et al., 2019; Lockwood & Smits, 2011; Moriarty et al., 2013). The complex and interlinked system of people, laws, political and financial institutions, private companies, technology, data, markets and regulations that contribute to water, sanitation, and hygiene service provision have been conceptualised as the *WASH system,* the drinking water service delivery system, and/or the sanitation system (Galli et al., 2014; Huston & Moriarty, 2018; Lockwood et al., 2016; Valcourt et al., 2019; WHO, 2019). While relatively new in the WASH sector, the view of public service sectors as complex systems is well-understood in public health ('health system'), education ('education system'), transportation ('transport systems'), telecommunications ('telecom systems') and others (Best et al., 2007; Castellani, 2018, 2018; Moore et al., 2011; Rhodes & MacKechnie, 2003; Tuominen & Ahlqvist, 2010). Recognizing that WASH services are provided by a public system avails the use of theory and tools from systems thinking, the complexity sciences, and public management to rethink the sustainable provision of these services (Hall & Lobina, 2006; Whaley & Cleaver, 2017). Following Taylor (2013), sustainability of WASH services is defined as whether the impacts of service expansion last beyond the initial period of project inputs; this includes infrastructure longevity as well as the adaptive capacity of the surrounding system to meet end goals even as conditions change.

Viewing drinking water service provision as a complex public system has implications on the strategies to improve outcomes and on how results are monitored and measured (Skilling & Battle, 2015). Monitoring is often focused on the service provided (via infrastructure surveys) or the service received (via household and user surveys). These metrics can only show a discrete moment in time and do not indicate the likelihood of sustainability of the service (Carter & Ross, 2016). To respond to the sustainability crisis in sub-Saharan Africa and elsewhere, several initiatives seek to map and measure the large set of factors thought to influence service delivery (Boulenouar et al., 2013). These include checklists or benchmarking tools to assess the different institutional, financial, technological, environmental, or social dimensions that are associated with sustainability, and/or scorecards to rate the performance of service providers and authorities (Boulenouar et al., 2013). Several tools have been developed and tested by The World Bank, UNICEF, and others global actors that can be used to assess the interdisciplinary factors influencing performance of the WASH sector (UNICEF, 2013; UN-Water & WHO, 2010).

Despite this progress, there is still an absence of monitoring and measurement approaches framed by the understanding of WASH as a complex public service system. Such tools are in demand from sector financers, who wish to support the gradual capacity building of local and national systems, but need time-bound evidence of the return on investment. Systems monitoring and assessment tools are also in demand by practitioners seeking more systematic ways to assess sector performance to identify entry points and track progress (Skilling & Battle, 2015). Systems level metrics can help to identify the bottlenecks and constraints in these systems that impede progress, and to reveal opportunities to improve performance. Objective metrics for WASH system performance also serves as a basis for multi-stakeholder planning (Sondeijker et al., 2006). The SDGs call for multi-sector partnerships and collaborations; all of which depend on agreeing on a shared vision, on clear roles and responsibilities, and on a common understanding of key dimensions of the system that contribute to WASH service delivery (Schrecongost et al., 2020; WHO & UNICEF, 2017). Participatory and collaborative approaches to planning and improving outcomes are more effective when an objective set of data characterising the problem and potential solution pathways are available. Since the SDGs do not define how and by whom services will be provided, a contextualised target, and metrics to track progress (including the public systems upstream of service delivery) are important.

1.1 Research objectives

The aim of this research is to develop a conceptual and analytical framework based on an understanding of WASH as a complex public service system and apply it within a participatory multi-stakeholder action-research methodology. A replicable methodology will be developed to map and analyse how the WASH system functions, what constrains its performance, and what strategies might improve service level outcomes. The ancillary objectives of the research are to use the WASH system assessment to promote social learning in the case study areas, to engage stakeholders in the analysis and solution-development, and to produce empirical results and recommendations for the WASH system in the study areas.

The specific objectives are:

1. To develop a transferrable and adaptable framework for measuring the behaviour and performance of the water, sanitation, and hygiene (WASH) system, with a focus on drinking water.
2. To develop a methodology for evaluating change over time in WASH systems at the district level that is adaptable and replicable.
3. To investigate the efficacy of the measurement approach for stimulating learning and adaptation of different stakeholders
    - that is relevant to local and national systems
    - and that supports planning, decision-making and adaptive management of the WASH system.

To support this inquiry, specific research questions were developed. The knowledge gaps and research questions for each chapter are presented in Table 1. These research questions are not explicitly stated within the chapters but were used to guide the direction of research. The results of research directed by these questions are discussed in Chapter 8 and Chapter 9.

The research was conducted with IRC using participatory methods in 7 countries and 10 partner districts: Burkina Faso and its commune of Banfora (Nansi et al., 2018), Ethiopia and the woredas of South Ari and Mile (Adank et al., 2019), Ghana and its Asutifi North District (IRC Ghana, 2018), Honduras and 15 focal municipalidades (Smits & Rodriguez, 2018), India and its Chatrapur block in Ganjam district (Shiva & Krukkert, 2018), Niger at national level only (Boukari, in prep), and Uganda and its Kabarole District (Magara et al., 2018). This dissertation focuses on the in-depth case study of Kabarole District, Uganda.

In this thesis, water, sanitation, and hygiene (WASH) are discussed as a single sector as is commonly done in sub-Saharan African and the context of development. Chapter 4 focuses on sanitation in both rural and urban contexts; Chapter 5 is on WASH as a whole with a focus on rural and peri-urban contexts; and Chapters 6 and 7 focus on drinking water delivery in rural, peri-urban and small town contexts. In the research case study of Uganda, many of the same institutional actors are responsible for both water and sanitation service delivery, making findings about policy, planning, and management approaches transferrable across sub-sectors. Chapter 8, the discussion section, revisits the findings from each chapter to discuss the transferability across subsectors and to assess the applicability of the research framework in urban and rural contexts. Chapter 9 provides additional reflections and a short commentary on prospects for future work.

Table 1: Summary of knowledge gaps and research questions for each of the results chapters of the thesis.

Thesis chapter	Knowledge gaps	Research questions addressed	Shorthand for questions
Chapter 4	• Lack of framing and analysis of sanitation through a sustainability science lens • Absence of transdisciplinary mapping of dynamics and factors that perpetuate failures in sanitation	1. What are the main "building blocks" of a healthy WASH system, and are they the same/similar in all contexts? a. Why do many solutions fail, and what is needed for success?	What works in WASH?
Chapter 5	• Need for a method that recognises complexity but is simple and appropriate for use with local actors • Need for an approach to participatory research that produces locally owned results but is efficient for getting to scale and recognises top-down power dynamics	2. What does a resilient WASH system look like, what are the main sub-systems or 'building blocks'? 3. How can each sub-system be objectively measured or assessed? 4. Is a systems assessment (through its sub-systems) an effective approach to identify pathways to change, and to	What comprises the WASH System? How can WASH system performance be measured?

	• Gap in understanding WASH services as public services preventing transfer of ideas across sectors	support a network of stakeholders to use systems thinking to plan, innovate, and promote public system transformation for WASH?	Is measuring the WASH system useful?
Chapter 6	• Need for a methodology to navigate the complexity of multi-level systems and synthesise sometimes conflicting or unclear information from different sources • Need for a holistic and transdisciplinary analysis of the Uganda drinking water sector transition	3. How can each sub-system be objectively measured or assessed? 4. Is systems assessment (through its sub-systems) an effective approach to identify pathways to change, and to support a network of stakeholders to use systems thinking to plan, innovate, and promote public system transformation for WASH?	Is measuring the WASH system useful? How can the performance and sustainability of WASH systems be improved?
Chapter 7	• Lack of framework for describing how to scale local systems improvement; no analysis of water service delivery models and model innovations from a transition management perspective. • Lack of systematic analysis of factors that affect ability to achieve SDG6 targets in Uganda	5. How can a national WASH system transition from a paradigm of low quality unreliable services toward one that delivers universal access to safe water?	.

1.2 Dissertation Format

This thesis is written in the manuscript-based dissertation format. Each of the results chapters of the thesis (Chapters 4,5,6,7,8) is written as a standalone publication; these manuscripts are connected as a unified whole by the introduction, methods, connecting material, and conclusions. Chapter 1 is the introduction in which the rational and objectives of the research are stated. Chapter 2 is a review of the literature used in the thesis. Chapter 3 describes the methodology the research strategy, context and specific methods. Each of the results chapters also contain a brief introduction, theoretical framework and/or methodology. Chapter 4 (book chapter) provides the analysis and results from the scoping research in Phase 1. It provides background on the context and sustainably challenges in East Africa, with a focus on sanitation. The insights and conclusions from this research were used when formulating the research questions and approach for the rest of the thesis research. Chapter 5 (journal article) develops the theoretical framework for the WASH system and the methodology used in Chapters 6 and 7; it discusses findings and critiques the theoretical framework based on experiences from early testing in Uganda and expert review of the approach in six other countries and globally. Chapter 6 (journal article) describes the results from application of the theory and methods from Chapter 5 in a case study of Kabarole District, Uganda. Chapter 7 (journal article) builds on the findings of Chapter 6 to identify solution pathways for achieving the desired service delivery outcomes in Uganda. Chapter 8 (journal article) discusses the overarching findings from the research and provides answers to the research questions. Chapter 9 presents reflections on the implications of the work for the wider WASH sector and future directions. Chapter 10 presents the research summary and conclusions. Supplemental information for each chapter is presented in appendices at the end of the dissertation.

There are five appendices for the Thesis. Appendix 1 contains the complete list of indicators in the WASH subsystems benchmarking framework. Appendix 2 contains the survey instruments for the household questionnaires conducted in Uganda (Chapter 6). Appendix 3 contains the survey structure and instruments for the asset inventory of water points and piped networks conducted in Uganda (Chapter 6). Appendix 4 contains the supplementary materials includes detailed data, factors, and scenarios from Chapter 7.

Chapter 2: Literature review

This chapter provides an overview of the water, sanitation, and hygiene sector in Africa and a review of approaches to improving services. It also provides a review of strategies for applied academic research in WASH and provides background material on mixed methods and action-research.

2.1 The global water and sanitation challenge

Safe drinking water and sanitation are basic needs for human health and dignity. It has been estimated that at least one tenth of the global disease burden would be eliminated if all people used adequate water, sanitation, and hygiene (WASH) services (WHO, 2008). Safe water supply and sanitation, when provided together and accompanied by domestic and personal hygiene, prevent humans from ingesting faeces and other pathogens. These pathogens can lead to morbidity and mortality from chronic and acute diarrhea, malnutrition, respiratory infections and to the spread of communicable disease (Pruss-Ustun, 2014; Murray and Lopez, 1997; Rytter et al, 2014). In addition to preventing illness, increasing access to WASH services reduces the time burden for people who travel long-distances or spend time searching for drinking water or a place to defaecate. The burden of inadequate WASH interferes with school attendance and employment which has economic consequences for society (WSP, 2011; UN-Water, 2008).

Improving access to water and sanitation has been a central part of the development agenda since the late 1970s (O'Rourke, 1992). As of 2008, the global economic gains associated with improving WASH were estimated at US$84 billion annually, compared to an estimated US$11.3 billion annual investment required. There have been global initiatives dedicated specifically to improving access to water and sanitation, including the 1980 to 1990 'International Drinking Water Delivery and Sanitation Decade' and the 2005 to 2015 'International 'Water for Life' Decade for Action' (UN-Water, 2011). Specific targets for water and sanitation access were included in the 2000-2015 Millennium Development Goals (WHO & UNICEF, 2017). In 2010, the human right to water and sanitation was explicitly recognised as an independent right by United

Nations Resolution 64/292, establishing a binding obligation for all 122 signatory countries to ensure adequate services for all citizens (United Nations, 2010).

Despite significant investments and some progress, as of 2015 only three out of four people globally had a safe water supply in their home and less than half had a safely managed sanitation service (WHO & UNICEF, 2017). Nearly one billion people still lacked access to a basic water service (defined as a protected supply within 30 minutes of the home) and 2.3 billion people did not have access to a basic sanitation service (defined as a pit latrine with a concrete slab); 892 million people were practicing open defecation. In 2016, the United Nations launched the Sustainable Development Goals (SDGs), a global agenda for poverty reduction, peace, and livelihood improvements outlined by 17 specific Goals. The SDGs replaced the former MDGs, while raising the level of ambition for drinking water supply and sanitation services, calling for universal access to safe and sustainable services. This included indicators to track the entire service delivery chain, from river or aquifer to household for water, and from latrine back to the environment for sanitation. The SDGs explicitly recognise the need for more than infrastructure to achieve these goals, and emphasise the importance of strong public systems, multi-sector partnerships, and government leadership (United Nations, 2017). Figure 1 shows the JMP global baseline for access to at least basic drinking water. Figure 2 shows the global baseline for basic sanitation services. Figure 3 shows the global baseline for access to basic handwashing facilities, defined as the presence of water and soap in the household.

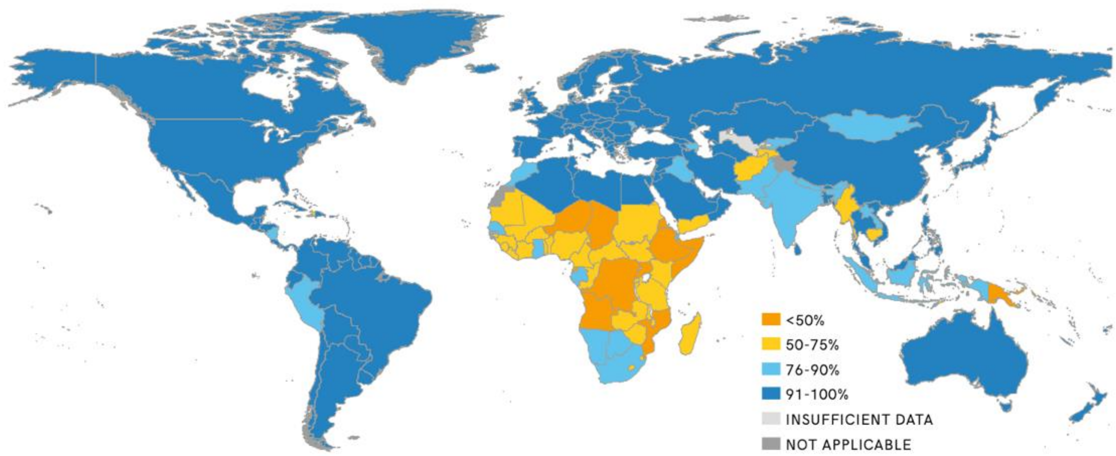


Figure 1: Proportion of population using 'at least basic' drinking water services, 2015 (WHO and UNICEF, 2017). 'At least basic' refers to access to a source that is protected from contamination that is within 30 minutes return trip from the home (including queuing); it also includes people who have 'safely managed' services, defined as water guaranteed to be free from contamination and located at the home.

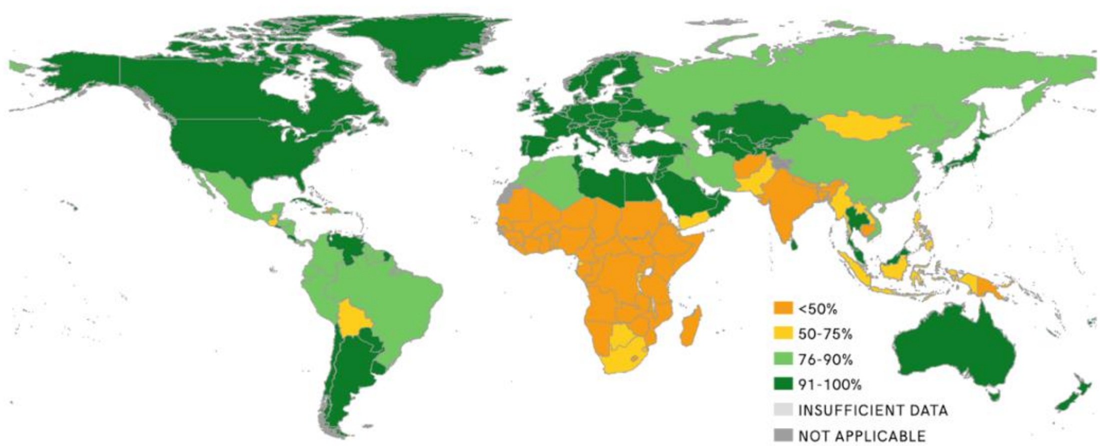


Figure 2: Proportion of population using 'at least basic' sanitation services, 2015 (WHO and UNICEF, 2017). 'At least basic' refers to access to an improved facility that is not shared with other households; it may be transported and treated (as in emptied pit latrine or sewerage) or unemptied and contained onsite.

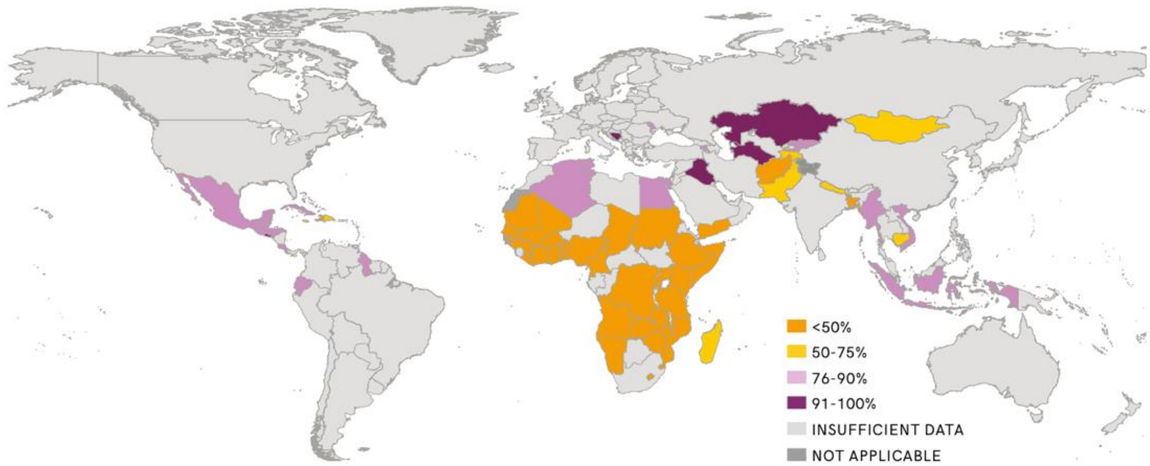


Figure 3: Proportion of population with handwashing facilities including soap and water at home, 2015 (WHO and UNICEF, 2017)

Hidden behind these statistics is the well-documented reality that many of the services, particularly in low- and middle- income countries, are unreliable, dangerous to use, experience frequent breakdowns, and do not adequately protect users from contaminants (UNICEF, 2012; Evans, 1992; Onda et al., 2012; Schouten & Moriarty, 2013). Global initiatives like the MDGs led to a push by international actors to increase access to WASH technology in low- and middle-income countries. Construction of facilities was in many cases done without building the capacity of local and national institutions to operate and sustain the services; it followed a supply side management approach (Gleick, 2002; Moriarty et al., 2013). Infrastructure-focused approaches often neglected to address the 'soft' aspects of the system such as demand management, instructional capacity, operation and maintenance models, governance, and the cultural and social dynamics that influence use of infrastructure (Bakker, 2008; Butterworth et al., 2010; Gleick, 2002; Moriarty et al., 2013). Many infrastructure development programmes and projects failed to plan for post-construction support and some facilities became inoperable shortly after project completion (Lockwood & Smits, 2011). As a result, water supply and sanitation facilities in many low- and middle-income countries still provide low levels of service. The sector has been characterised as existing in a permanent state of 'crisis-mode'; uncoordinated actors implement fragmented resource-intensive interventions aiming to rapidly improve supply without planning for long term sustainability (Bayliss & Adam, 2012; Grafton et al., 2013).

2.2 The progression of water supply and sanitation in sub-Saharan Africa

Sub-Saharan Africa is a region of concern. The region includes 22 out of the 25 poorest countries in the world (IMF, 2019) and has the fastest population growth of any region (United Nations, 2019). Over half of the global population that drink untreated surface water live in sub-Saharan Africa (despite making up only 17 percent of the global population) and the region has among the lowest rates of access to sanitation and handwashing facilities in the world (WHO & UNICEF, 2017). Despite a doubling of the urban population between 1990 and 2014, sub-Saharan Africa made 'little to no progress' in increasing piped water access to households during the same period. The majority of the population still rely on rudimentary community point sources for water and traditional pit latrines (Teye, 2018; WHO & UNICEF, 2015, 2017). Only 4.6% of the sub-Saharan African population is connected to sewers. Besides a lack of access, failure of existing infrastructure in sub-Saharan Africa is particularly high; it has been estimated that while 60,000 boreholes with handpumps are constructed every year, approximately one in three are non-functional (RWSN, 2009).

Water and sanitation services in sub-Saharan Africa have transformed in line with broader historical changes. Prior to colonial intervention, water in sub-Saharan Africa was typically provided through natural legacy and accessed by traditional means and/or through community level initiatives to improve basic access (Nilsson & Nyanchaga, 2009). During colonialism and early post-colonialism (approximately 1890-1970), some colonial governments assumed responsibility for the provision of public services such as water, even if to a very limited extent and focused in colonial trading centres (Njoh & Akiwumi, 2011; Osei-Hwedie, 1998). The declaration of water and sanitation as part of the Human Rights agenda in 1977 made service provision a responsibility of post-colonial governments, but development agencies and charity organizations assumed key roles whilst many governments had limited capacity, commitment, or authority over the development agenda (Naiga et al., 2015; United Nations, 2010). The supply side approach followed by these actors led to the construction of infrastructure even when no explicit interest was present in the targeted end users (Niaga et al, 2012).

2.2.1 The demand-responsive approach

The demand-responsive approach emerged worldwide in the late 1980s as a response to the failure of supply side management (Arku, 2010). This new approach, led by Organisation for Economic Cooperation and Development (OECD) countries, donors, think tanks and academics, was part of neo-liberal structural adjustment programmes that significantly reduced the role of government in essential public services and industries (Castro, 2012). By 1992, the Dublin Statement on Water and Sustainable Development presented the consensus that water (and sanitation) were economic goods that should be paid by users with cash payments or through physical involvement in the construction and management (Boydell, 1999; Ekane et al., 2014; P. A. Harvey & Reed, 2007; Naiga et al., 2015). This meant more effort was made to increase citizen's demand for services, with the intention that they would be able to make more informed choices about the services they would receive once they became paying customers.

The demand responsive approach championed ideals of community ownership and empowerment while offering a possibility to overcome the government's financial constraints by mobilizing households to pay for improvements (Annette Bos, 2001; Cairncross et al., 2010). In rural areas, it implied that facilities should be provided only when communities make a substantial contribution to capital costs (evidence of demand). It aimed to make communities and households the owners of facilities and fully responsible for operation and maintenance (Arku, 2010; Boydell, 1999). In the urban sector, the demand-responsive approach brought privatisation as a solution to under-resourced and poorly performing public utilities, with the belief that tariff collection and private sector efficiency would improve service delivery outcomes and attract new investments (Castro, 2012; D. Hall & Lobina, 2006).

Community and household management of rural water and sanitation

In rural water supply, the demand-responsive approach was primarily applied with the community-based management system, which over the past 3 decades has become the dominant paradigm throughout sub-Saharan Africa. Community based management aimed to increase local ownership and unlock community resources free-of charge by engaging volunteers to operate and maintain infrastructure (Moriarty et al., 2013; Naiga et al., 2015). There are several variants of the community management model, usually based on a identifying a small group of designated community members (a water committee) to manage an individual water point by collecting tariffs from users and performing basic maintenance. The volunteers are identified during or shortly after construction, by the local government or an implementing NGO, then given various degrees of training (Whaley & Cleaver, 2017). In parts of Africa, community-based management was celebrated as a way to incorporate pre-colonial traditions of addressing shared problems collectively, though it has been argued that this idea was based on western idealisation of traditional communities rather than real observations (Osei-hwedie, 1998; Harvey & Reed, 2007). Some scholars suggest that the model was favoured because of its apparent ability to solve the problem of post-implementation support for donors and non-profit organisations operating in a project-based paradigm, rather than its fitness as a sustainable model for public service management (P. A. Harvey & Reed, 2007; Van den Broek & Brown, 2015).

Success of the community management approach has been documented (Arku, 2010; Prokopy, 2004) but highly disputed (Castro, 2008; P. A. Harvey & Reed, 2007). Rural Africa now has stable or slightly increasing levels of access to drinking water, but few countries have been able to address the problem of frequent infrastructure breakdown, or to raise the standards of service above the basic minimum (Foster, 2013; Moriarty et al., 2013; Van den Broek & Brown, 2015; Whaley & Cleaver, 2017). Rates of infrastructure failure under community management in sub Saharan Africa range from 30% to 60% in some countries (P. A. Harvey & Reed, 2007; RWSN, 2009; Van den Broek & Brown, 2015). While some suggest this is due to a failure to properly implement and financially support community management (R. C. Carter et al., 1999), others argue that the model itself is unfit and unable to deliver services that meet today's standards. This is attributed to its reliance on principles of volunteership that do not exist or never-existed (Foster, 2013; Moriarty et al., 2013; Van den Broek & Brown, 2015; Whaley & Cleaver, 2017). Despite its prevalence today, community management in its current form is widely understood to be unable to meet expectations or to provide services that meet the standards called for in the Sustainable Development Goals (Moriarty et al., 2013; Van den Broek & Brown, 2015; Whaley & Cleaver, 2017).

For rural sanitation, demand-driven approaches are similar but place more emphasis on community mobilisation to generate demand for improved sanitation and handwashing facilities (whereas demand for drinking water was assumed). The community-led total sanitation approach aims to achieve this through ʻʻtriggeringʼʼ events to raise public awareness about the dangers of open defecation; this is followed by the identification and support of community leaders to develop comprehensive plans to ensure all households adopt hygienic practices and construct or purchase latrines (Sah & Negussie, 2009). Community health clubs (Waterkeyn & Cairncross, 2005) and participatory hygiene and sanitation transformation (Dumba et al., 2013) are similar in trying to change behaviour then empower communities and households to act to improve services. ‘Market-based approaches’ follow, aiming to overcome problems in the supply-chain revealed by built demand by encouraging local entrepreneurship for sanitation businesses (Munkhondia et al., 2016). These initiatives have often developed local markets in the contexts were they are applied, but most struggle to scale up or deliver the country wide transition called for in SDG6 targets (Hueso, 2016; Schrecongost et al., 2020). In many cases, construction of sanitary infrastructure at the household or community level is done poorly, and a lack of government involvement or regulations means facilities do not adhere to norms and standards for quality and safety. In addition, demand-responsive efforts have focused on latrines and toilets but have not produced solutions for the entire faecal waste and wastewater management chain: emptying of latrines, collection, transport, treatment and safe disposal or reuse (Mulumba et al., 2014; Northover et al., 2014).

Privatisation of urban utilities

In urban areas, sector reforms made way for the privatisation of water utilities and sanitation service providers (Castro, 2008, 2012). This reflected the demand-responsive approach and the declaration of drinking water as a commodity. Privatisation was promoted by the World Bank, the International Monetary Fund (IMF), and other major development actors during the 1990s. The aim was to bring new finance into the sector and increase efficiency, which effectively reduced the role of government. For drinking water services, private take-over of public utilities or private contracts for certain aspects of service delivery was affirmed through the establishment of public-private partnerships (Bayliss & Fine, 2008). In many cases, the state retained asset ownership and the entity received a long-term lease contract for operation, maintenance, and customer management (Saussier, 2013). Legally, many public utilities in sub Saharan Africa had responsibility for both water and sanitation, however the focus was almost always on water supply; sanitation was either ignored or excluded from the private contracts due to the 'poor state' of infrastructure at the time of privatisation (Brocklehurst & Janssens, 2004). The demand-responsive approach in urban areas also included programmes to support entrepreneurs to own and operate public toilets as a business, and frequently included small scale private operation of public utility standtaps who could manage consumption by the public and collect tariffs while paying a certain portion of profits back to the utility (Castro, 2012).

Despite high hopes, a lack of interest from private investors in sanitation and water, and a lack of proper regulation by the state meant that these reforms ultimately had little effect on urban service delivery. Worldwide, privatisation may have led to a decrease in public confidence in (and demand for) utility services, reducing the responsibility taken by the government, and decreasing the level of investment from the World Bank (who anticipated a surge of private sector finance) (Bayliss & Fine, 2008; Bayliss & McKinley, 2007). The risk was assumed by the state, not the private entity, and private operators were not incentivised or mandated to invest profits into improvement and expansion of infrastructure (Castro, 2008). As of 2012 there was only one case of private investment in sewerage in Africa, through a concession for 35 kilometres of sewer mains in Nelspruit, South Africa (Castro, 2012). While major players in the water and sanitation sector still have interest in generating private sector investment in WASH services, the privatisation efforts of the 1990s and early 2000s have widely been considered a failure (Bayliss & McKinley, 2007; Castro, 2012; D. Hall & Lobina, 2006).

The effectiveness of the demand-responsive approach in improving water and sanitation services is disputed (Arku, 2010; Castro, 2008; P. A. Harvey & Reed, 2007; Prokopy, 2004). It is associated positively with a change in the sector away from reductionist infrastructure-focused approaches toward a more interdisciplinary approach recognising the social, cultural, and institutional determinates of success (A. Bos & Deverill, 2001; Annette Bos, 2001; Pahl-Wostl, 2002; Peal et al., 2010; Schouten & Moriarty, 2013). It brought attention to the end-users of infrastructure, and demonstrated the importance of investment in the 'soft' aspects of WASH management (Bos, 2001; Moriarty et al., 2013; Whaley & Cleaver, 2017). Though calls for an interdisciplinary and user-centred approach existed much earlier (Cairncross et al., 1980), the principles of "soft path" water management helped this become mainstream by the mid 2000s (Gleick, 2002). Still, throughout the Millennium Goal Period of 2000 to 2015 many governments, development banks, and influential institutions invested heavily in increasing infrastructure coverage to reach the targets of MDG7 in the fastest way possible, without considerable planning and monitoring of the functionality, sustainability, or use of these services (Langford & Winkler, 2014).

2.2.2 Systems approaches and the Sustainable Development Goals

During the MDG period from 2000 to 2015, safe drinking water was defined as that provided by an 'improved source' which included piped water protected from contamination or rainwater; basic sanitation defined as sewer connections, septic tanks, or pit-latrines (UN-Water, 2014). Rather than ensuring safety, the presence of infrastructure was used as a proxy, since improved facilities are expected to be safer than facilities defined as unimproved (e.g. open wells or latrines with open pit) (Onda et al., 2012).

The eight integrated water and sanitation targets defined in 2016 in Sustainable Development Goal 6 (Figure 1) demonstrate a more complex understanding of how services are delivered, including recognition of the many stakeholders at global, national, and local levels, who are involved (UN-Water, 2016; WHO & UNICEF, 2017). Targets 6.1 and 6.2 are for universal access and show the importance of water treatment and availability in the home (rather than collected and carried) to make supply safer. Target 6.3 calls for the adequate treatment of wastewater and solid waste to reduce pollution and contamination. Targets 6.4 and 6.5 calls for water-use efficiency and sustainable water resource management, and transboundary cooperation, respected in all relevant sectors, and Target 6.6. calls for ecosystem restoration and preservation. Targets 6.a and 6.b focus on the financial and human resources for implementation of water and sanitation targets, and, together with cross-cutting SDG17, call attention to systemic issues such as the importance of international cooperation, capacity building, and stakeholder participation.

Sustainable Development Goal 6 (SDG6)

6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all	**6.1.1** Percentage of population using safely managed drinking water services
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	**6.2.1** Percentage of population using safely managed sanitation services, including a hand-washing facility with soap and water
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	**6.3.1** Percentage of wastewater safely treated **6.3.2** Percentage of bodies of water with good ambient water quality
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	**6.4.1*** Percentage change in water me efficiency over time **6.4.2*** Percentage of total available water resources used, taking environmental water requirements into account (level of water stress)
6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	**6.5.1*** Degree of integrated water resources management implementation (0-100)
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests. wetlands, rivers, aquifers and lakes	**6.6.1** Percentage of change in the extent of water-related ecosystems over time
6.a By 2030, expand international cooperation and capacity-building support to developing countries in water–and sanitation-related activities and programmes including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies	**6.a.1** Amount of water–and sanitation-related official development assistance that is part of a government coordinated spending plan
6.b Support and strengthen the participation of local communities in improving water and sanitation management	**6.b.1** Percentage of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management

Figure 4: Sustainable Development Goal 6 Targets and Indicators (UN, 2016)

In sector discourse and literature, this wider understanding of WASH service delivery as a complex social, technical, and ecological phenomenon has come to be known as a 'systems approach' (Liddle & Fenner, 2017; Lockwood et al., 2016; Neely, 2019, 2013). A growing number of WASH practitioners use systems approaches as a strategy to improve the sustainability and universality of service provisions. By emphasising the interconnectedness of the actors and dynamic factors and functions involved in service delivery, implementing actors can more effectively support improved coordination and collective action (Valcourt, 2020; Amadei, 2016; Casella et al., 2015; Neely, 2015; Hovmand, 2014). Systems approaches are not clearly defined and take many forms; at the core they use systems-thinking to try to understand the factors influencing services, and then use this understanding to try to improve outcomes (Galli et al., 2014; Huston et al., 2019; Liddle & Fenner, 2017). Systems approaches are contrasted to piecemeal or siloed approaches (Liddle & Fenner, 2017; Lockwood et al., 2016). This transition in the water and sanitation discourse corresponds to the broadening of the definition of systems engineering over the past three decades to take into account the role of human and environmental factors in engineered systems (Lamb & Rhodes, 2008; D. Rhodes & Hastings, 2004).

2.3 Systems science

A system is a "regularly interacting or interdependent group of items forming a unified whole…under the influence of related forces…or serving a common purpose,''(Merriam-Webster, 2019). The constituent parts can be physical, conceptual, or a combination of both (INCOSE, 2019). Systems science is a broad interdisciplinary field that studies the nature of systems, either natural or manmade, and ranging from simple to complex (Mobus & Kalton, 2015). Systems thinking can be traced back to Taoist philosophy 2600 years ago, but the study of systems as an academic discipline developed in the early to mid 20th century (Mobus & Kalton, 2015). General system theory was proposed by biologist Ludwig von Bertalanffy in the 1940s (first published in English in 1968). Bertalanffy described phenomena observed in different kinds of systems through mathematics, attempting to connect insights emerging from different disciplines (Von Bertalanffy, 1968, 1972). General systems theory rejected the reductionism observed in conventional scientific methods of the time, and provided a theory to describe the similar behaviours recognised in biology, sociology, engineering, and other disciplines. A central observation was that a connected system was more than the sum of its parts. The general concepts and principles of systems theory such as synergy and emergence gave rise to different branches of related theory later used in biology, chemistry, engineering, psychology and management (Mobus & Kalton, 2015).

Systems engineering is aimed at designing and managing effective and efficient systems throughout their life cycle (Blanchard et al., 1990). While systems engineering is now seen to fit within systems science, and was developed during the same period as general systems theory, it is understood to have a different origin than Bertanffly's general systems theory (A. D. Hall, 1962; Schlager, 1956). The term 'systems engineering' is first attributed to Bell Laboratories in the 1940s, where research on communications and radar systems to be used in World War II revealed novel behaviours that were different than those observed in the individual components (Buede & Miller, 2016). Systems engineers study how the integration of and dynamics between complex subsystems, including physical, electrical, and chemical components, affect the performance (and cost of operation of) of a system over its lifetime (Buede & Miller, 2016; Mobus & Kalton, 2015; Schlager, 1956). Since its origin at Bell Laboratories, the definition of systems engineering has evolved and broadened in scope to encompass social, environmental, and institutional aspects of systems design and operation. The International Council on Systems Engineering (INCOSE) defines systems engineering as 'working artfully to bring something about' through the design, realisation, use and retirement of engineered systems (INCOSE, 2019). It entails using systems thinking and related principles and concepts from different disciplines to pursue a specific end-goal (INCOSE, 2019; Oliver et al., 1997; Vallero & Brasier, 2008).

The complexity sciences are a branch within systems science concerned with the classification and interpretation of the unpredictable nature of certain types of systems, particularly those systems which adapt over time (Honour, 2008). The complexity sciences developed from general systems thinking in the 1960s and 1970s in response to newer observations that discrete mathematical models (e.g. cellular automata) could produce unpredictable, but not random, patterned results that could be adapted by small manipulations to individual elements in the system (Murray, 1998). Complex adaptive systems (CAS), the focus of complexity science, are characterised by non-linearity, high connectivity, and distributed control (Casella et al, 2015). Complex adaptive systems are comprised of independently acting *agents* that learn and adapt whilst self-organising and giving rise to collective behaviour. These patterns are not present in the individual parts themselves; this trait is called emergence and keeps the system in a constant state of evolution influenced by the actors within it (called agents) (Casella et al., 2015; Kania & Kramer, 2013; Moore et al., 2011). Complex Adaptive Systems are both resistant to change and evolutionary, as they are governed by feedback and patterned behaviour (De Savigny et al., 2009; Sterman, 2006; Meadows et al, 1982). They are said to exist 'at the edge of chaos' ; the boundary between chaos and order. This is due to their unpredictable and difficult to control behaviour, while at the same time they remain responsive to knowable rules (Kauffman, 1993). Complex adaptive systems are classified as open systems, influenced by and interacting with the surrounding context.

Complexity thinking differs from conventional systems thinking by recognizing that in addition to feedback-driven patterns, systems are also influenced and forever changed by one-off events, disruptions, and tipping points (Boulton, et al., 2015). In contrast to standard systems thinking, this suggests that complex systems cannot be carefully engineered to produce a desired output or achieve an end goal. Instead, they can be studied and mapped to observe processes and patterns in order to develop an understanding about how change takes place; that understanding is then used to foster change in a desired direction (Murray, 1998). It also suggests that influencing the mechanisms of feedback and information exchange between agents, by altering their relationships and rules, can have an effect on the future system state, though it is not fully predictable (Stroh, 2015). Complexity thinking converges with systems engineering when systems engineering is defined in its broadest sense; incorporating human and political behaviour into engineering architecture, which necessarily introduces an element of unpredictably and adaptation once it is acknowledged (Honour, 2008). The disciplines of emergence engineering, and transition management have been proposed as newer approaches to manipulating and fostering emergence in socio-technical systems to pursue desired outcomes (Elzen et al., 2004; Ghorbani et al., 2012).

Systems science offers tools and theory that can inform the design and development of water and sanitation systems (Casella et al., 2015; Liddle & Fenner, 2017; Neely, 2019; Pollard et al., 2011). Applications of systems thinking include the study of rules and choices that govern system organization, the mapping of networks, and modeling of dynamics and patterns of change (De Savigny et al., 2009). Both complexity-oriented tools and general systems thinking may help to identify factors undermining sustainability of WASH interventions and to illuminate new ways to overcome constraints and improve outcomes (De Savigny et al., 2009; Neely, 2019; Schouten & Moriarty, 2013). The WASH system has been characterised as a socio-technical system and complex adaptive system (Casella et al., 2015, Neely, 2015; Lockwood et al., 2016; USAID, 2014). It can be referred to as a system-of-systems; for simplicity the singular is used when referring to a particular context. This marks a fundamental divergence from conventional WASH projects in which the linear causality between actions and results (A causes B causes C, etc.) is assumed using a logical framework (GOPC et al., 2016). Understanding WASH as a Complex Adaptive System explains why several different reactions to a single action are possible (dynamic complexity), and why the same system can produce different behaviour under the same perturbation when it takes place at different times or in different contexts (Richardson, 2011; Hovmand, 2014).

2.3.1 Application of complexity science for water and sanitation service delivery

Complexity science has been applied to drinking water service provision, particularly in rural contexts, as both a tool for analysis and as a strategy for stimulating change (IRC, 2019; Neely, 2019; N Valcourt et al., 2019). Liddle and Fenner (2017) reviewed applications of complexity science tools to address water point failure in sub-Saharan Africa (Liddle, & Fenner, 2017). They determined that quantitative tools and modelling approaches have the potential to provide new insights, particularly for revealing hidden causes and mapping how known dynamics might play out in different scenarios. Whilst quantitative expert analysis can produce useful results, WASH systems are typically studied using at least some participatory and inclusive methods that can incorporate the perspectives and analytical insights of multiple stakeholders. For example Walters (2015), McNicholl (2017), and Valcourt (2019) used participatory dynamic modeling and social network analyses to explore factors influencing sustainability and institutional development for rural water. Still, the technical expertise and data requirements for quantitative modeling often prohibit field-level practitioners from applying them which can limit their impact (Liddle & Fenner, 2017). Qualitative tools that prompt practitioners to think about causal relationships and underlying dynamics can produce equally relevant insights but are more accessible to a range of actors (Liddle & Fenner, 2017). Since agents (stakeholders) in a complex system can learn and adapt, intuitive approaches to participatory knowledge-creation and social learning that build a group's mental model of complexity can be used as ways to identify leverage points, where small changes or solutions may force largescale change in the system (Dyball et al, 2007; De Savigny, et al., 2009; Neely, 2013). Such approaches can also build the collective capacity of the stakeholder network to respond effectively to the future unknown changes which are inevitable in complex systems. Regardless of the tool used, methodologies that can be implemented together with local systems actors tend to increase sharing of perspectives among stakeholders and build systems thinking capacity (Liddle & Fenner, 2017). A theoretical understanding of how systems work can help practitioners refine their mental models of how change takes place, which can in turn can help to shift collective system behaviour and improve outcomes (Burns & Worsley, 2015; D. P. Stroh, 2015).

2.3.2 Applications for public services

Water and sanitation provision have characteristics similar to other public services. Public services are defined as "multiple organizations engaged in the provision of a specific set of goods and services that are of value to the majority of consumer-citizens" (Rhodes, & MacKechnie, 2003, p 61). These services are understood to be delivered by cross-sectoral and multi-organizational systems (Osborne et al, 2013), and their quality is influenced by relationships between several different actors, including the society or the ultimate users of those services (McLaughlin et al, 2009). This notion that no single service provider or institution, nor the government alone, can entirely control service delivery, suggests that understanding and improving the performance of the entire system is an essential part of improving public services (H. Dickinson, 2016). This more networked understanding of public service delivery is referred to as New Public Governance, which is closely related to the New Public Management approach that emerged in the 1980s and was applied around the world especially in OEDC nations (Klijn, 2012). New public management embraces neo-liberal ideals that the public sector should be run as a 'business-like' market, which has been associated with the 'hollowing out' of state and government institutions and authority (H. Dickinson, 2016). The newer New Public Governance approach recognises the market-like nature of public services delivery, but maintains the role of government for technical and political leadership, including complex network governance and the management of relationships between state and non-state actors at different levels (Asthana, 2003; Awortwi, 2010; Kahkonen & Lanyi,2001). The recognition of the importance of working with diverse actors to improve outcomes has led public service thinkers to look to complexity science as a way to study public systems and improve results; examples include health (Beran et al., 2019; Burton et al., 2018; De Savigny et al., 2009; Long et al., 2018; Moore et al., 2011; Thompson et al., 2016), education (Burns & Worsley, 2015; Weick, 1976), tobacco control (Best et al., 2007), energy (Verbong & Geels, 2007), community development (Neely, 2015).

Methodologies for improving public service outcomes that embrace complexity thinking include collective impact (Lockwood and Duti, 2014; Pugel, 2020), learning alliances/hubs (Darteh et al., 2019; Butterworth et al., 2008; Moriarty et al., 2005), transition and strategic niche management (Kemp et al., 1998), soft systems methodology (Checkland, 2000), sustainability science (Wiek et al., 2012), theories of change (Funnell & Rogers, 2011), multi-stakeholder dialogue facilitation and vision development (Heijden & Schlange, 1997; Moriarty, Batchelor, et al., 2005). These typically include some form of visioning and agenda-setting to get multiple actors to share their perspectives, then build a shared understanding of the problem and its possible solutions. Within these, classical approaches to studying complex systems are often used to break apart the system into simpler components that can be studied, understood, mapped, and manipulated (Long et al, 2018). Qualitative tools such as naming subsystems, 'building blocks' or classifying key 'factors' in the system are often used in place of more complex modelling because they enable participants to improve and align their understanding while avoiding the need for a expert or computational analysis that can exclude some stakeholders (Galli et al., 2014; Mason et al., 2019; USAID, 2016).

2.3.3 Socio-technical transition management

The term ‘transition’ is used to describe the structural transformation that takes place in a society over decades—it could be social, demographic, or economic (Rotmans et al., 2001). Research on societal transitions emerged in the late 1990s, much of it focused on sustainability and the transformation of global systems of production, technology, and social behaviour (Papachristos et al., 2013; Geels & Schot, 2007). Transition studies have described how public services transform over time as a result of changes in technology, institutions, demographics and/or economics. Transitions result from the continuous interaction of factors and adaptative behaviour of actors at different levels (Elzen et al., 2004; Geels & Kemp, 2007; Osborne et al., 2013). In most countries that have reached high standards of water or sanitation service provision, these were not planned from the start but were instead developed through a process of socio-technical co-evolution, over decades or centuries (Franceys, 2019; F. Geels, 2005; F. W. Geels, 2005; Goodwin & Doeksen, 1984; US Water Alliance & UNC, 2019; Zetland & Colenbrander, 2018).

When describing transitions in socio-technical systems, a multi-level perspective is often used to conceptualise how the predominately meso-system ‘regimes’ shift over time as the result of macro level (context, landscape) and micro level (niche) influences (F. W. Geels, 2002). These three levels, shown in Figure 2 , are heuristics for studying the competing dynamics within socio-technical systems; they do not correspond to definitive administrative levels, national boundaries, or organisational limits (Geels, 2005). The regime level is the center of the current public system and includes the social actors and their behavior: the national policy and service delivery frameworks, the technology and models for service delivery that are formally in use, and social norms. The niche level refers to learning and innovation processes, new markets, and early socio-economic or political deployment of new concepts (Kern, 2012). The landscape level refers to larger environmental, governance and socio-economic drivers such as globalisation and deeply held cultural dynamics (Geels, 2005). Change is conceptualised to take place as a result of interactions between these different levels; innovations go to scale when they are matched with opportunities for change within the current regime, and when they exploit pressures or opportunities emerging at the landscape level (Geels & Schot, 2007). The dominant regime tends to resist change (lock-in), but overtime it can be transformed or replaced by an alternative regime as a result of niche-level innovation (e.g. new technology), and/or pressure and shifts at the landscape level (macro-economics, deep cultural or political changes) (Geels & Schot, 2007).

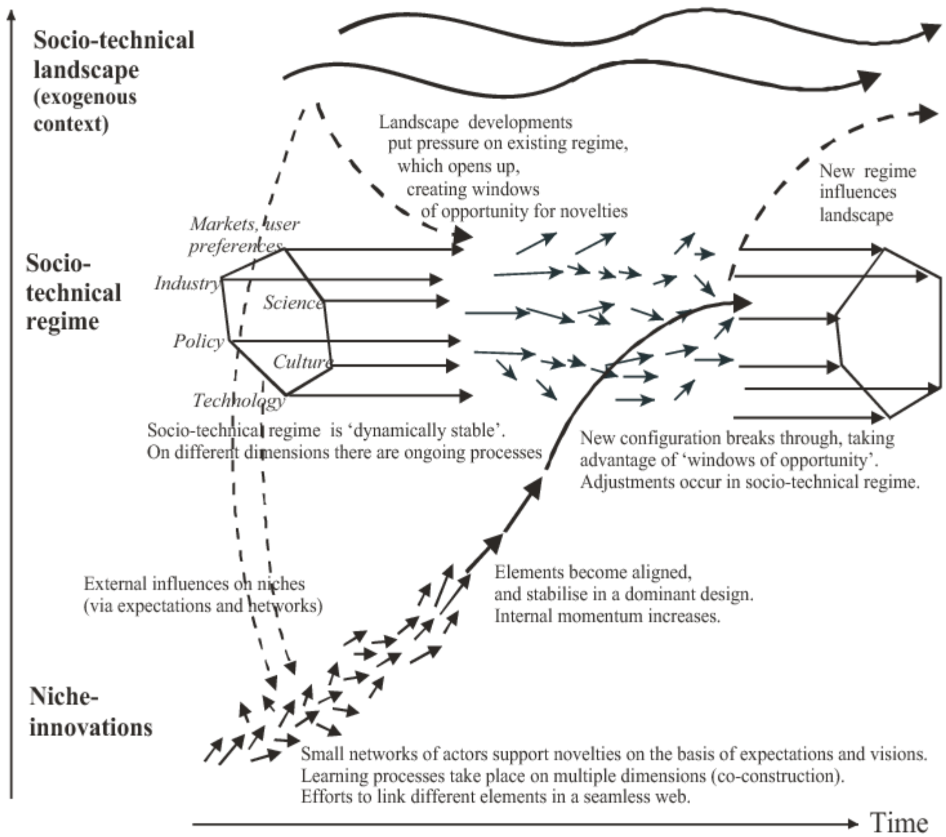


Figure 5: The Multi-Level Perspective for socio-technical systems change (Geels, 2002)

Transition management is a governance approach to fostering intended transitions in socio-technical systems. Though change is emergent and cannot be fully controlled, governments can steer the process by using multi-level feedback processes and monitoring systems. Information feedback helps to identify and observe emerging results, to find opportunities for action, and to adapt policy and governance instruments as change progresses (Elzen & Wieczorek, 2005; Kemp et al., 2007). Transition management suggests that leadership is both 'top-down' and 'bottom-up'. Governments can establish long term meta-goals then use policy instruments to adapt to emerging innovations and societal demands, and guide actors to contribute to progress toward the desired future. 'Leveraged incrementalism' (Quin, 1980) or 'directed incrementalism'

(Grunwald, 2000) describe how a series of linked governance actions can be used to pursue this vision while responding to evolving realities (Kemp et al., 2007). The term ‘social learning’ describes how groups of people learn. This focuses on how the social dynamics and the way in which information is developed, presented and shared, influences the effectiveness of learning (Ison et al., 2013). Transition management often includes the development of formalised process for social learning, which may be done through the establishment of monitoring systems, joint sector review processes, or ethe establishment of mechanisms knowledge exchange, adaptive planning, and capacity building (Tolley et al., 2016).

2.4 Systems monitoring and measurement

Monitoring is the systematic collection and analysis of information on specific indicators over a period of time; its aim is to improve efficiency and effectiveness (Smits et al., 2013; UNDP, 2009). The understanding of water and sanitation as public services provided within socio-technical systems suggests that monitoring and analysis of emerging outcomes are important for adaptive management and facilitating change (Darteh et al., 2019; Geels & Kemp, 2007). Monitoring data are used in multi-stakeholder processes as an objective foundation for dialogue and support public accountability. Since public systems are provided by multiple actors, monitoring systems are used to provide an objective basis for dialogue and discussion, and to help develop a shared understanding of problems and solutions (Aceves-Bueno et al., 2015; UNDP, 2009). The data demands are different for a service provider, a regulator, and a government planning agency, therefore data may need to be analysed and communicated in different ways to enable the relevance for different actors (da Silva Wells et al., 2013).

WASH service delivery monitoring is done many ways. Since the 1981-1990 International Drinking Water Supply and Sanitation Decade, international efforts have been made to harmonise indicators, and to collate and share information for comparison and learning across contexts (Butterworth et al., 2013). WASH services are often built up through a series of projects and programmes, each of which is tracked according to the targets and intended results of the project and funding source, which leads to fragmentation of information (Garandeau et al., 2009; Smits et al., 2013). Programme/project monitoring schemes are conventionally based on Logical

Frameworks that use linear causality to link inputs with outputs and outcomes. These have limitations when applied in complex systems and may not provide data that are immediately relevant to national actors (Smits et al., 2013; USAID, 2016; Umhlaba, 2017; Apgar et al., 2016). Conventional approaches tend to focus on what can be measured most objectively, which has often resulted in the counting of the number of facilities constructed rather than assessing the quality or appropriateness of instructed, and whether they are functional and used as intended (Davis, 2016). Since WASH systems approaches often include ‘software’ interventions such as capacity building, monitoring systems, or multi-stakeholder consultations and planning, the impact of these interventions on service delivery outcomes may occur years after the initial input (de Sauvegny et al., 2016).

For many organisations, logical frameworks have been phased out in favour of ‘theories of change’. A theory of change is a causal model linking programme inputs and activities to a chain of intended outcomes that lead to the end goal. In contrast to a logical framework, assumptions and contextual factors expected to influence results are explicitly stated and may be monitored as well (Rogers, 2008). Indicators are developed for each stage in the process, often using qualitative methodologies such as narrative-based monitoring, collecting stakeholder feedback, and story-based approaches that seek to identify the most significant changes (USAID, 2016). These more flexible and adaptable approaches also aim to overcome the impossibility of monitoring ‘sustainability’ at a discrete moment in time (Boulenouar et al., 2013; Foster, 2013). Sentinel or proxy indicators can also be used to track complex phenomena through indirect but quantitative measurement (Garandeau et al., 2009; USAID, 2016). Proxy indicators may be defined to measure *leverage points*, or key places in the system linked to overall system performance (Foster, 2013).

2.4.1 Service level and asset monitoring

Monitoring of WASH services levels is ultimately the responsibility of government but should be a core concern for all actors involved in service delivery or aiming to improve sustainability. During the MDG period from 2000 to 2015, safe drinking water was defined as that provided by an ‘improved source’ which included piped water protected from contamination or rainwater; basic sanitation defined as sewer connections, septic tanks, or pit-latrines (UN-Water, 2014).

Rather than ensuring safety, the presence of infrastructure was used as a proxy, since improved facilities are expected to be safer than facilities defined as unimproved (e.g. open wells or latrines with open pit) (Onda et al., 2012).

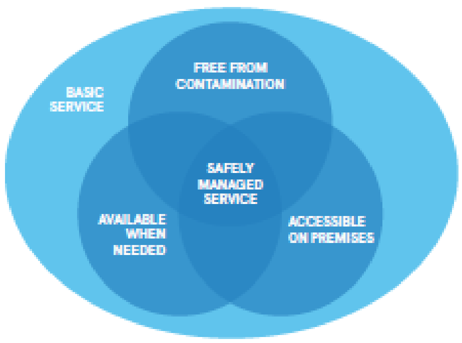
A combination of household surveys and administrative reporting on infrastructure construction were used to track progress during the MDGs, coordinated by the Joint Monitoring Programme (JMP) of the UNICEF and the WHO, which was established to support consistent monitoring in and across countries (WHO & UNICEF, 2015). Household survey data, which asked households about their access and use patterns, collected by national governments were intended to be produced every two to three years. However, the quantitative and easily accessible nature of administrative data on facility construction were prioritised. This ultimately resulted in a monitoring system that was primarily based on infrastructure inventories, which were compared to population data to estimate coverage (UN-Water, 2014). The progress made in water and sanitation during the MDGs is significantly less when accounting for the pervasive non-functionality of infrastructure and the affordability and quality of the services provided (Foster, 2013; Onda et al., 2012; RWSN, 2009). In addition, the MDG indicators were associated with perverse incentives resulting from the prioritisation of investment for rapid infrastructure construction, often targeted at easy to reach populations where more demonstrable improvement could be made toward the target at a lower cost (Langford & Winkler, 2014).

To improve the level of services provided, a more robust set of indicators for measuring accessibility, reliability, water quality, and affordability is needed (UN Water, 2014; Bain et al., 2012; Onda et al., 2012; Moriarty et al., 2010; Lockwood & Smits, 2011). A new monitoring framework for tracking the targets in Sustainable Development Goal 6 was developed by the JMP that sought to overcome the limitations of the MDG indicators (WHO & UNICEF, 2017). An index of service levels was defined that could be measured as a composite indicator calculated using several variables related to the service provided, as shown in Figure 6 (Kayser et al, 2013). The key parameters that describe the service level are the technology type, accessibility (distance from household to source, as estimated by return trip walking time), availability (hours per day, used only for qualification as 'safely managed'), and affordability (portion of household income spent on water and sanitation) (WHO & UNICEF, 2017). Inequality is studied with a comparison of disaggregated WASH data linked to demographic information, for example urban versus rural contexts, for different regions, by gender or wealth quintile.

The JMP provides a globally recognised methodology for calculating the SDG service levels for each country through synthesis and manipulation of national data sets including household surveys and demographic census (WHO & UNICEF, 2017). The data are obtained from household surveys in a sample of households across a country, and do not include visits to drinking water facilities other than possible spot checks to validate the infrastructure options in a given context to ensure consistent use of terminology. Accessibility, availability, and the level of service are based on household responses to questions about the amount of time spent collecting water, the presence of a household connection, and the type of facility used. This provides an estimate of the levels of service in use nationally. The JMP sampling methodology does not permit disaggregation to district (or more local) levels, and cannot be used by service providers to monitor the status and performance of specific assets, since they are based on household responses. Due to the origin of the data, the indicators do not robustly track reliability, continuity or functionality of facilities. It provides a rough estimate, but a better assessment can be obtained by visiting facilities directly (Adank et al., 2016). The definitions and surveys developed by JMP are publicly available and can be adapted and used to conduct a localised assessment in a single district or smaller area. Other methods used to monitor service levels are based on visiting and monitoring the water and sanitation assets, which are then compared against population data. A sample of users at water points can also be interviewed to obtain data on usage patterns instead of surveying households (Adank et al., 2016).

SERVICE LEVEL	DEFINITION
SAFELY MANAGED	Drinking water from an improved water source that is located on premises, available when needed and free from faecal and priority chemical contamination
BASIC	Drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip, including queuing
LIMITED	Drinking water from an improved source for which collection time exceeds 30 minutes for a round trip, including queuing
UNIMPROVED	Drinking water from an unprotected dug well or unprotected spring
SURFACE WATER	Drinking water directly from a river, dam, lake, pond, stream, canal or irrigation canal

Note: Improved sources include: piped water, boreholes or tubewells, protected dug wells, protected springs, and packaged or delivered water.



SERVICE LEVEL	DEFINITION
SAFELY MANAGED	Use of improved facilities that are not shared with other households and where excreta are safely disposed of in situ or transported and treated offsite
BASIC	Use of improved facilities that are not shared with other households
LIMITED	Use of improved facilities shared between two or more households
UNIMPROVED	Use of pit latrines without a slab or platform, hanging latrines or bucket latrines
OPEN DEFECATION	Disposal of human faeces in fields, forests, bushes, open bodies of water, beaches or other open spaces, or with solid waste

Note: improved facilities include flush/pour flush to piped sewer systems, septic tanks or pit latrines; ventilated improved pit latrines, composting toilets or pit latrines with slabs.

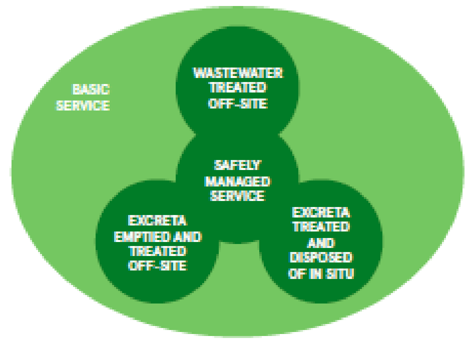


Figure 6: The service levels as defined by the WHO/UNICEF Joint Monitoring Programme for Sustainable Development Goal 6 for drinking water (left) and sanitation (right).

2.4.2 Sustainability monitoring

Given the history of infrastructure failure in the sector, significant effort has been made to improve the monitoring of sustainability, or to identify proxies for the sustainability of interventions. The notion of *resilience* refers not only to longevity but the ability of a system to recover from perturbations (Carpenter et al, 2001; Fiksel, 2006). The application of resilience in complex human-environment systems requires a departure from pure robustness of facilities towards the *adaptive capacity* of the system to perform its function under a changed set of equilibrium conditions. For WASH, this includes the ability of the local actors to repair or replace infrastructure when needed. “Flexibility in Engineering Design” is the concept that past practice solutions will not withstand unknown futures, necessitating planning with a mind-set of uncertainty in order to be prepared for adaptation (Neufville as cited by De Savigny et al., 2009).

The functionality of a water or sanitation facility at a single moment in time when the survey is carried out has often been used as a proxy for service sustainability, but this conflates sustainability with reliability (intermittency). It may also skew results since service assessments are routinely carried out during or shortly after project interventions, and thus not representative of the infrastructure performance during normal conditions (Foster, 2013; Whaley & Cleaver, 2017). Other sustainability monitoring tools assess upstream factors such as service provider and service authority performance, or broader dimensions of sustainability including institutional, social, financial, environmental, and technical capacity of the service delivery system (Boulenouar et al., 2013; Lockwood & Allely, 2017). A similar set of indicators are observed within tools aimed at monitoring service sustainability, sector performance, the enabling environment, and more recently the WASH system 'strength' (AMCOW, 2011; P. Harvey & Reed, 2004; Huston & Moriarty, 2018; Lockwood et al., 2003; Mason et al., 2019; Sanitation and Water for All, 2017; Smits & Lockwood, 2011; The World Bank, 2017; UNICEF, 2016).

2.5 **Mixed methods research on water and sanitation in low- and middle-income countries**

Both qualitative and quantitative methods can be used to study water supply and sanitation service delivery systems. Quantitative methods are used to assess the quantity and performance of services from an engineering perspective, and to statistically estimate service levels. Qualitative methods are used for analysis of the social, political, and contextual factors that influence service delivery, sustainability and use. Mixed methods research (both qualitative and quantitative) has been common for over a century, particularly for applied research (Clark & Ivankova, 2015). An early example in WASH is John Snow's discovery of the Broad Street Pump handle as the source of a Cholera outbreak in London the 1850s (Guest, 2013). Mixed methods help to study complex phenomena that require multiple perspectives, triangulation, and iteration. Qualitative assessments inform quantitative methods design, and quantitative results lead to new questions for qualitative inquiry (Chambers, 2015). In socio-technical systems, use of qualitative and quantitative data together can provide a deeper understanding of how technical and social aspects are interdependent (Clark & Ivankova, 2015).

2.5.1 Paradigms for mixed methods research

Within the overarching research paradigms (quantitative, qualitative, and mixed methods) there are additional philosophical decisions to be made that influence the choice of methods and analytical techniques. Most important are the methodological concepts of ontology, epistemology, and axiology (Durant-Law, 2005). In engineering research, these philosophical choices are rarely discussed since the quantitative nature of inquiry almost certainly defines it as objective, empiricist and either applied or theoretical. In qualitative or mixed methods research, an explicit discussion of philosophical choices at the start of the research helps to develop the methodology and ensure the continuity of analysis and drawing of conclusions (Doyle et al., 2009). The ontology describes the nature of reality as either absolute (essentialist, positivist) or socially constructed (foundationalist, constructivist). Epistemology describes whether knowledge is subjective (idealist), objective (empiricist) or in between (realist). These have implications on whether a deductive (hypothesis-based) or inductive (question-driven) research strategy will be chosen. Axiology refers to the values and purpose of research: value is either inherent (Aristotelian School, theoretical) or is created by the use of research to inform real world decisions (applied school).

Pragmatism is a research philosophy common for mixed methods (Feilzer, 2010; Flood, 2010; Morgan, 2007). Since mixed methods research may combine diverse methods to explore the research topic in a practical and results-oriented approach, many of the classical binary choices are viewed as simply didactic tools but not observed as a strict set of rules (e.g. positivism versus constructivism, objectivism versus subjectivism, inductive versus deductive) (Feilzer, 2010; D. P. Stroh, 2015). Pragmatism is based on systems thinking and is common for research in complex human systems, where trying to control the behaviour of multiple stakeholders or rigidly applying theory could be counterproductive to improving outcomes (Long et al., 2018). Pragmatists argue that methodological legitimacy is derived from a closeness between theory and practice, and suggest that rigid commitment to a single theory often requires researchers to smooth over the realities of field work when writing up (Feilzer, 2010; Hanson, 2008; Morgan, 2007). Pragmatic research is both inductive and deductive; theory is seen as a tool for planning and communicating research but is open to continual evolution and adaptation based on findings and feedback from stakeholders (Yardley et al., 2013). Pragmatism is well-suited to participatory research that is co-designed with other actors, in particular action-research (Jackson, 2010; Saunders et al., 2009; Ulrich, 2007).

2.5.2 Participatory action-research

Participatory action-research is a strategy for applied research where local actors and researchers work together to define the problem and develop and test solutions (Smith, 1996). In contrast to conventional research where the researcher avoids influencing the observed processes, in action-research the researcher is embedded in the study context and is active in trying to improve outcomes. Action-research tends to be pragmatic and take place through a series of short cycles of data analysis and planning that allow for adjusting and adapting the research strategy, and further developing theory based on what is learned (Folifac, 2012). Action-research is conceptualised as a continuous four-step cycle: questioning (reflection), planning, acting/intervening, observing/analysing (Smith, 1996). This cycle is similar to the John Dewey model of experiential learning which demonstrates how ideas are generated and tested through trial in real contexts, leading to the continual development of the theory based on experiences in practice, over time (Morgan, 2014). Action-research is collaborative in nature and performed together with local stakeholders, in contrast to other approaches which produce research 'about' or 'on' local stakeholders ('Collaborative Research', 2008; Folifac, 2012). Group work and collective decision making are central to the process, but may be supported by the work of individuals to conduct critical analysis and test results between group meetings (Kemmis, 1988; Smith, 1996). There are many related approaches to action-research that vary in terms of the structure (rigidity versus flexibility of action-research cycles) and the degree to which the researcher steers the agenda, versus more freely following local ideas in a fully participant-led approach (Heron & Reason, 2006). Folifac's Participatory Transformative Advocacy Research (2012) adapted the notion of action-research to add significant amounts of training and capacity-building of participants as part of the methodology, to increase their ability to contribute to the research process; he also suggested a larger role for the researcher as a vocal advocate for participants (Folifac, 2012).

The active role of the researcher in embedded action-research can introduce bias (Folifac, 2012). This bias may lead to selective engagement of stakeholders, such as only professionals or government without adequate involvement of the citizen voice; or may lead researchers to prioritise the participation of stakeholders who willingly accept the researchers guidance rather than those who hold opposing viewpoints (Kemmis, 2006; Kemmis et al., 2013). Without adequate reflexivity, action-research can perpetuate dominant ideas, even if they are incorrect, and may avoid confronting 'uncomfortable realities' about the status quo that would be disruptive in the field (Kemmis, 2006). When working with embedded practitioners, there may also be a bias toward showing positive results or outcomes, and de-emphasising undesirable results (Mayoux & Chambers, 2005).

Bias is mitigated through rigour; there are several ways to build rigour in participatory action-research. Chambers (2015) describes a set of approaches to achieving rigour through inclusivity, such as selection of methods that can be understood by all stakeholders involved, and visual representation of the research topic and methods to support comprehension by diverse participants (Chambers, 2015). The inclusion of different types of stakeholders throughout the research process, including during design and writing, can be used to 'reality check' findings and ensure the researcher's emerging conclusions are representative of local expert experiences and respond to collective challenges. The researcher's capacity for systems thinking can also reduce bias, if it is applied periodically to reframe problems through different lenses—to consider contextual factors and to redraw the boundaries of the study to consider constraints at different levels and scales. Mixed methods research allows for triangulation by comparison of findings from both qualitative and quantitative methods (Burns & Worsley, 2015; Chambers, 2015). Bias can be further mitigated by working in research teams in which the members of the team alternate roles and engage in critical debate. The transparent reflection and communication of the positionality of researchers, including their potential biases (e.g. gender, cultural, international NGO) helps to mitigate it (Chambers, 2015; Garcia-Iriarte et al., 2009). The role of the researcher as an insider and/or outsider at different stages of research should be acknowledged and considered in terms of how it may influence interpretation of results (Robson & McCartan, 2016).

2.5.3 Methods for water and sanitation systems research

This section provides a review of common methods for studying water and sanitation service delivery, with a focus on those applied in this thesis.

Literature review

Literature review is used to identify what has already been written on a specific topic, to aggregate and analyse trends, and to identify topics required for further exploration (Paré et al., 2015). Since practitioners, industry actors, and global development organisations play major roles in the WASH sector there is a significant volume of relevant literature that is not located in scholarly databases (Nicholas Valcourt et al., 2020). The fragmented cataloguing of knowledge and experiences from these actors requires an iterative search process. Bibliographic hand searching is the manual scanning of relevant documents to identify related studies and cross-referenced authors and literature, referred to as 'snowballing' (Craane et al., 2012). Participation in sector learning platforms and events, conferences, and expert consultations can also be used to identify research threads to follow up using the snowball method. It is common for academics to include grey literature in reviews and meta-analysis for WASH, however care is needed to ensure only credible literature is considered (Ramesh et al., 2015; Slesinski et al., 2019; Valcourt et al., 2020). The grey literature available in WASH ranges from scholarly peer reviewed documents, to United Nations and global reports to un-reviewed conference presentations, expert blogs and journalistic popular literature. In general, there is more concern over use of quantitative results from literature that has not undergone peer review as such reports may draw conclusions on non-statistically significant data (Conn et al., 2003). Qualitative findings can be individually assessed for credibility, as is done with results from key informant interviews through triangulation and inclusion of multiple perspectives.

Conferences, meetings and sector events

Conferences and topic-oriented meetings are common for any academic discipline, however in the WASH sector they are particularly relevant because they bring together different types of stakeholders including academics, government, non-government organisations, civil society organisations, community representatives, external support agencies, the private sector and development banks. Such events provide the opportunity for multiple stakeholders to exchange knowledge and critically discuss specific topics, and to present and discuss data for feedback and validation (Folifac, 2012). Conferences in the WASH sector typically include one or more of the following types of activities: presentations, interactive discussions, workshops/facilitated group work, and informal networking. Workshops may be carried out with the objective to build collective ownership of processes and activities, for capacity building, or as part of project planning or periodic progress review. Not all the results from such events are documented in way that produces written outputs, and some content may be presented only in a conference presentation that is not available afterward. While efforts are being made to improve documentation in the sector, conference participation remains an important method of sector inquiry and participatory research (Van Soest et al., 2015).

Workshops range in length from two hours to several days; typically, an agenda and objectives are shared with participants before the meeting and a combination of plenary and small group sessions are used to achieve the workshop objectives. A variety of facilitation techniques may be used such as panel discussions, the world café, games, debates, etc (Heijden & Schlange, 1997; Moriarty, 2007). Workshops and interactive meetings differ from formal meetings in that they are designed to allow participants to contribute actively to the proceeding of the meeting. Workshops may also allocate time for informal interviews, triangulation of data, critique of emerging research findings, and multi-stakeholder synthesis of different experiences through critical discourse. At the end of a workshop, participants are typically invited to give their feedback, reflections, and suggestions for the organisers in either written or oral format.

Key informant interviews

Key Informant Interviews are a common technique used to obtain necessary information, ideas and insights on a subject. Interviews range in formality from a structured set of pre-defined questions to a more informal interview style that is more reflective of a conversation (Feldman, 1999). In mixed methods research, interviews are often used during scoping to identify and define the quantitative survey instruments, and again for results interpretation and contextualisation of findings. In collaborative action-research, they may be used throughout the process to obtain factual information and to gain insights as to where additional data and information could be found (snowballing); they are also used to collect data on the perceptions, opinions, perspectives, and insights of stakeholders. Key informant interviews can be used to add rigour, for triangulation and to identify potential sources of bias in other methods (e.g. 'courtesy bias' that individuals tend to over report hand-washing or disinfection of water to public health workers because it is 'correct') (Freeman et al., 2014; Hart, 2018).

Focus groups

Focus groups are semi-structured discussions used to get the views and perspectives of several individuals while observing the social responses and interactions of the group (Kitzinger, 1994). In participatory and mixed methods research , focus groups can be used to invite participants to help make sense of the results obtained from different methods and to reflect on the overall research questions (Catterall & Maclaran, 1997). Focus groups vary in structure and formality and are sometimes referred to as focus group interviews, or as round table discussions, to convey their integration into public dialogue rather than their formal convening within a controlled study. For any variation of the method, careful moderation is a key feature to ensure the perspectives and unspoken social dynamics of participants are able to emerge, and that they are inclusive (Longhurst, 2003). Focus groups may include either homogeneous or heterogenous groups of stakeholders as long as the researcher is knowledgeable about how pre-existing relationships and social and cultural dynamics (such as gender) may influence the outcomes of the discussion (Pini, 2002).

Transect walks

Transect walks are a standard method for rapid gathering of qualitative information which is similar to observation but often includes visiting and interacting with people or groups to learn about the context (Lorenzo & Motau, 2014). The standard is to walk along a specifically chosen route to observe social, environment, cultural, technological, or economic factors and behaviours in that environment. The researcher may stop along the way to engage or speak with people or groups encountered. Transect walks are especially important for rapid studies or multiple case studies, where the researcher may have little exposure to the research environment beyond the formal research methods such as interviews, quantitative data collection, or workshops. They are similar to 'spot checks', which are a triangulation method for many WASH surveys used to ensure the researcher is properly interpreting descriptions of facilities or field realities that are described by various stakeholders, or to validate findings (Huda et al., 2012; Martin et al., 2018; Parvez et al., 2018).

Questionnaires

Questionnaires are a quantitative tool to ask a fixed set of questions to a specific sample of the population in an optimised way (Krosnick, 2018). They can contain both open-ended and specific questions including a mixture of multiple choice, free answer, ranking and Likert scale questions. In WASH, questionnaires are typically administered to a representative sample of households—either to women or heads of household—or to water users at a public water point. Designing a representative sampling strategy is essential if the data are to be used for generalised conclusions. For household surveys in low-income countries, stratified multistage cluster sampling is often used to achieve representation when there is no registry of households (addresses), while keeping costs as low as possible. Primary sampling units are typically based on administrative units or identifiable urban and rural areas within or between administrative boundaries (United Nations, 2005). When census data is available but not certain to be precise, a probability-proportional-to-estimated-size (PPES) technique can be used to select households in each primary sampling unit according to either a fixed rate (consistent frequency of household selection) or to select a fixed number of households in each area (variable sampling frequency) (United Nations, 2005). Without a list of households, completely random selection is impossible; in this case selection is made as random as possible using systematic random approaches such as use of satellite imagery to identify households at specific intervals, or a zig-zag method to select households throughout the sampling unit at desired distances and sampling frequency (Adank et al., 2018; Giné-Garriga et al., 2013; Pérez-Foguet & Giné-Garriga, 2017)

Questionnaires for water and sanitation typically collect demographic data, data about respondents' WASH services, and data about perceptions and preferences. This allows for cross-tabulation and both descriptive and analytical statistics (Folifac, 2012). Increasingly, questionnaires in the WASH sector are administered using smartphone applications such as AkvoFLOW or mWater where surveys are pre-loaded onto smartphones and enumerators enter the data directly into the database in the field. This eases data entry and analysis, reduces the risk of errors, allows for validation of the sampling approach by including geospatial data and the inclusion of site photos (e.g to demonstrate infrastructure condition) (Adank et al., 2016). Enumerators typically speak the main local languages and offer respondents the option to respond in their preferred language.

WASH asset registry and mapping

An asset registry is a complete inventory of all water infrastructure in an area including information about location, type, condition, value, and performance (Boulenouar & Schweitzer, 2015). It can be carried out as a one-off data collection activity but is intended to be regularly updated. Updating can be done through systematic surveys or intermittently during infrastructure maintenance or other field activities. An asset register can be used to estimate service coverage when combined with population data, and to estimate functionality rates and assess the performance of service providers. The data can be used for geospatial analysis of infrastructure coverage, gaps, service area overlaps, and inequities in access using geographic information systems (GIS) software (Smith et al., 2007). Techniques range from descriptive statistics, vector-based analysis (layered map overlay), buffering (identifying regions or features within a certain distance of a specific feature), to simple visualisation or complex modelling combined with other programmes. If asset data are combined with data on costs, it can be used to model and plan for construction and maintenance using life cycle costing techniques (AECOM & IRC WASH, 2018).

A regularly updated asset registry is needed for infrastructure management, however in many low- and middle-income contexts this does not exist. For this reason it may be necessary to conduct one as part of a research inquiry (Dickinson et al., 2017). Wherever possible this can be conducted with the service provider, regulator, or service authority to ensure selection of a methodology that fit the national policy framework. This suits an action-research methodology as it promotes use of the data for both research and for local processes. Since asset components and infrastructure type vary between contexts, working with a local enumeration team who is familiar with the location, norms, and different types of assets likely to be encountered in the field is important to ensure a systematic and relevant data survey (Adank, 2017; Boulenouar & Schweitzer, 2015).

Participatory visioning and scenario development

Participatory methods in which scientists and stakeholders work together to has proven effective for a range of water resource, environment, and public planning (sustainable development) challenges (Lienert et al., 2006; Moriarty et al., 2005; Schneider & Rist, 2014). Vision and scenario techniques provide a means to systematically exchange knowledge and priorities while co-developing new knowledge and identifying shared opportunities and likely future conflicts. This helps to address underlying issues efficiently and effectively within a systemic and facilitated process. Scenario development techniques define and describe alternative hypothetical futures as a means to study and learn about the past, current situation, and plan future developments (Van Notten, 2006). The term 'scenario planning' is loosely applied to range of different techniques from discursive analysis to predictive modelling (Bishop et al., 2007; Wright et al., 2013). When applied within organisations or as a multi-stakeholder process, scenario development is typically a response to three main objectives: 1) to better understand how the future may unfold in order to inform strategic planning; 2) to provoke new ways of thinking and reframe perceptions and 3) to improve decision making and planning (Wright et al., 2013). In the context of climate change and human socio-economic futures, there are an infinite number of possible scenarios, so scenario methods are typically used as a learning and planning tool rather than an attempt to be predictive (Shackley and Deanwood, 2003). Scenario development is used as a tool for facilitating 'strategic conversations' about the nature of change (Heijden & Schlange, 1997) and may reveal differences among stakeholders' perceptions about likely futures and opinions about what is optimal (Holway, 2012).

Participatory scenario methods typically start by identifying and prioritising the factors deemed to be highly influential, yet uncertain, then combining the factors in different arrangements to produce several possible scenarios (Bishop et al., 2007; Moriarty et al., 2005;

Wright et al., 2013). Planning strategies can then be tested against the different scenarios, and new strategies can be developed to achieve the vision under alternative scenario conditions. Sometimes this leads to adjustment of the vision itself. A range of qualitative and quantitative scenario techniques have been applied to water resource management and WASH (Giné-Garriga et al., 2018; Moriarty et al., 2005; Scott et al., 2012).

2.6 The case of Uganda

As in other sub Saharan African countries, Uganda is undergoing a transition from the lower levels of services provided by community management toward higher levels of professional services that offer more reliability, safety, and equity for the population (Magara et al., 2018). Uganda was an early example in sub-Saharan Africa of a progressive government-driven approach to potable water service delivery (Sinclair, 2004). It ranked as a top ten country in the world for improvement in rural water services between 1990 and 2006 (Sinclair, 2004; WHO and UNICEF, 2008) and maintains an ambitious set of objectives and dynamic sector learning and assessment platforms (Eyatu, 2019), despite its ranking as a Least Developed Country (United Nations, 2015). The Government of Uganda aims to provide 100% of households with piped water by 2040 (Government of Uganda, 2013), and has stipulated water provision as a social (universal) and economic (efficient) service (MWE, 2018). Still, more than half the population do not have access to basic services (UN/WHO,2019) and large gaps are observed between national policy, strategy, and implementation (Magara et al., 2018). As of 2017, approximately 81% of the population have access to an improved water sources, with 42% meeting minimum standards for basic supply, defined as a water source within 30 minutes round trip walking time from the home (WHO & UNICEF, 2017). An estimated 21% of people, mostly urban, are served by either public or private connections to a piped network.

Uganda is a landlocked country in East Africa with a population of 43 million; the population is inordinately young (47% of the population are 0-14 years old) and rural (76%) (World Bank, 2019). The growth rate of 3.3% overall and 5.7% in urban areas means the current population of 43 million is expected to reach 100 million by 2050 (CIA Factbook, 2017; World Bank, 2019). Urbanization is a major part of the country's economic strategy (Le Seve, 2018), however an estimated 72% of the population rely on subsistence agriculture (FAO, 2018). While the percentage of the population living in poverty has decreased to a rate of 21.4% of the total, national income per capita has also declined since 2015 to a current rate of US$2,187 (in purchasing power parity, constant 2017 USD) (World Bank, 2019). Uganda is relatively abundant in natural water resources with two annual rainy seasons producing a mean annual rainfall of ranging from 1000 to 2000 mm in different regions (Kisakye et al., 2018).

The Ministry of Water and Environment (MWE), (Figure 7), is responsible for setting national policies, standards and priorities as well as for the monitoring and regulation of the drinking water and sanitation sector (Eyatu, 2019). Ten deconcentrated arms of the MWE called Technical Support Units (TSUs) provide technical support to communities and all 134 districts in Uganda as well as to utilities (Quin et al., 2011). There are two main approaches to service delivery in Uganda: the community based management system (CBMS) for rural areas, which serves approximately two thirds of the population, and the utility approach for cities first established in 1972 (Kiwanuka & Sentumbwe, 2015).

The combination of urbanization, modernization, and progressive sector leadership within a context of poverty, limited resources, and rural subsistence livelihoods make Uganda a good case to study how service delivery systems can be developed equitably to meet a range of needs.

2.6.1 Decentralised service provision

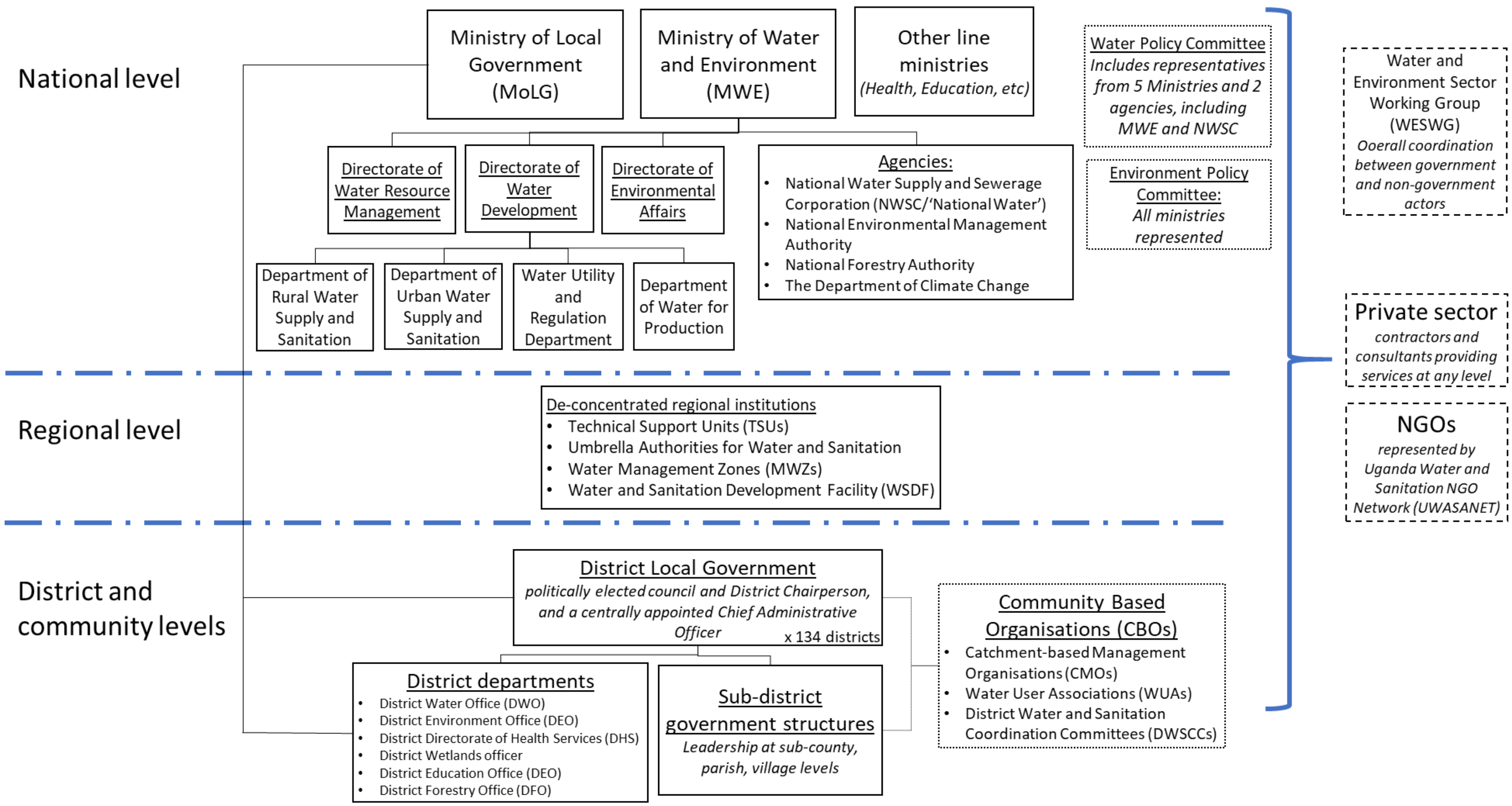
Under the Constitution of Uganda and the provisions for decentralisation in the Local Government Act of 1997, the District Local Government is the responsible service authority for the delivery of public services including health, education, and drinking water and sanitation. The exception is in cases where specific areas or aspects of service delivery are ‘gazetted’ (legally assigned) to other providers (The Local Governments Act (Chapter 243) (Uganda), 1997; The Water Act (Chapter 152) (Uganda), 1997; MWE, 2013). As service authority, the District Local Government is responsible for ensuring that all residents get access to adequate services. For drinking water, this includes several tasks: managing the environment and natural resources and providing water services (Local Government Act, 2000); planning and budgeting for construction of new sources and capital maintenance; designating service providers for operation and maintenance (or performing this role directly); monitoring and overseeing all service delivery in the jurisdiction; and coordinating local actors to ensure services provided match demand (MWE, 2013). All these responsibilities are to be carried out with a very limited budget, and the resource and capacity limitations of Districts are known to inhibit their performance (Bey et al., 2014; Mirembe, 2014).

A district's administrative structure includes both political and technical units: The District Council is the highest body and is headed by the District Chairperson as the political leader, and by the Chief Administrative Officer (appointed by the central government) as the technical leader. District governance practices are set by the Ministry of Local Government and the specific legislation for the drinking water subsector is determined by the Ministry of Water and Environment, and described in an implementation manual for districts (MWE, 2013). The District Water Office is the technical office responsible for WASH. It is supported by a District Water and Sanitation Coordination Committee, comprised of technical and political leaders as well as non-government and civil society organisations, community-based organisations and utility representatives, for advising, reviewing workplans, and coordinating stakeholders. Under the authority of the local government, service providers are responsible for operational management of services.

Community management has been used in Uganda since 1969 under the name Community Based Management System (CBMS). Rural point sources and smaller schemes are procured and constructed by the District Water Office then gazetted for community management by water source committees or community water supply and sanitation boards. Since 2016, an increasing number of piped schemes in small towns and rural areas have been gazetted to utilities for operation and management. The challenges with rural water point functionality and community management are well documented in Uganda (Harvey & Reed, 2007; Kiwanuka & Sentumbwe, 2015).

Figure 1 (next Page): Uganda water and environment sector institutional framework. Adapted from Lockwood et al. (2018).

Water and Environment sector institutional framework, Uganda



2.6.2 Urban service delivery and utilities

The utility model serves about 80% of residents in cities in Uganda, and utility coverage reaches a total of 687 small towns and rural growth centres out of a total 1050 (World Bank, 2006; MWE, 2018). There are two main utility service providers in Uganda: the National Water and Sewerage Corporation (NWSC) and six rural utilities called Umbrella Authorities for Water and Sanitation ('Umbrellas') (MWE, 2017). In addition, there are an unknown number of smaller or more informal private utilities in small towns. Uganda, like many countries around the world, is looking increasingly to utilities to raise the quality of service delivery by consolidating the total service provision under a smaller number of actors to achieve gains in efficiency and access economies of scale (Franceys, 2019).

The National Water and Sewerage Corporation (NWSC) was established as a parastatal organisation in 1972 to serve the three largest cities with piped water. Although it exhibited the same low performance as other water utilities in sub-Saharan African in the 1990s, NWSC avoided privatisation and in the last two decades underwent significant reform to progressively improve performance through commercialisation (Schwartz, 2009; Muhairwe, 2009; Amayo, 2018). NWSC operates as a commercial entity but receives approximately 40% of its funding from the Government of Uganda to support fulfillment of its mandate (NWSC, 2019). NWSC customers are served through either private connections or subsidized Public Stand Posts (PSPs). Since 2016, the mandate of NWSC has been expanded to include service provision to small towns and rural growth centres (NWSC, 2019). It has gone from serving 23 towns in 2013 to serving 253 towns in 2019 with a further 274 planned by 2020 (MWE & NWSC, 2017; NWSC, 2019). This rapid acceleration is in part financed by the 100% Water Service Coverage Acceleration Project (SCAP100: from 2017-2020), which plans for 140,000 new water connections and 20,000 PSPs to serve over 12,000 villages across Uganda.

The six regional Umbrella Authorities for Water and Sanitation were formed in 2016 from existing Umbrella Organisations, a federated organisation that had a support role to community managed schemes. The new Umbrella Authorities are given the mandate to progressively take on direct management of existing small piped schemes in small towns and rural growth centres that were previously under community management (MWE, 2017). A total of 434 schemes previously managed directly by CBMS (WSSBs) had been gazetted to the Umbrella Utilities as of August 2018. The six Umbrella Authorities are each responsible for a single region; all have the same initial institutional structure. Since 2016, they have been given permission to innovate and develop their own operational approach with the intention that the utilities will share experiences and select the most favourable strategies. The aim is for these regional utilities to develop their capacities gradually and eventually scale up to cover all rural piped schemes, and possibly to take on management of all point sources in their operational areas (MWE, 2017).

2.6.3 Self-supply

Some households and small groups take steps to provide water for themselves (Sutton, 2009). An estimated 19% of the population in Uganda do not use an improved source; instead accessing surface or ground water directly or purchasing water from a local vendor or a neighbour. Self-supply in Uganda ranges from very basic (e.g. fetching surface water with a bucket) to fairly sophisticated (e.g. hand dug protected wells or rain water harvesting, sometimes with water quality treatment) (Carter et al., 2005). The Government of Uganda does not actively support self-supply, but it has been designated as an acceptable option in the absence of other services (MWE, 2013). With systems in place to promote water treatment and monitor safety of supply, self-supply can be part of a landscape of service delivery models, as it is in countries like Scotland and the USA (Adank et al., 2013; Sutton & Butterworth, 2021).

2.6.4 The case of Kabarole District

Kabarole district is a mountainous district in western Uganda with an estimated population of 341,000 in 2019 (World Bank, 2019) in a land area of 1,814 km^2. Kabarole experiences two annual rainfall periods and has weather patterns directly influenced by the Rwenzori Mountain range, which runs along the western side of the District along the border with the Democratic Republic of Congo (Kisakye et al., 2018). The relative abundance of surface and ground water in Kabarole makes it easy for local technicians to construct community sources or adopt self-supply, through hand-dug shallow wells. Surface water is used when protected sources are absent, too costly, have long queues, or are non-functional. Kabarole has many crater lakes and ponds throughout its hilly geography and is a popular tourist destination within Uganda. Kabarole is part of the Toro Kingdom, with Rutooro as the predominant local language and English as the language of education and business (Kabarole District Council, 2018). Kabarole has one urban Municipality (Fort Portal Town, population 61,000), four urban town councils (total population 46,000) and eleven rural sub-counties (total population 233,000). Figure 8 shows the different administrative units in Kabarole. Town-Councils (red) are zoned as urban and Sub-Counties (blue) as rural. Fort Portal Municipality (green) is also urban. Kabarole District Council is primarily responsible for the Town-Councils and Sub-Counties, while Fort Portal Municipality has an independent governance structure.

National data show that the rate of access to improved water sources for residents of Kabarole is above the national average (80% in Kabarole compared to 68% nationally). The functionality of water schemes is average (82% in Kabarole compared to 85% nationally), but instances of non-functionality due to technical breakdown are high relative to other districts, suggesting operation and maintenance are weak (61% of breakdowns are due to technical problems) (MWE, 2019).

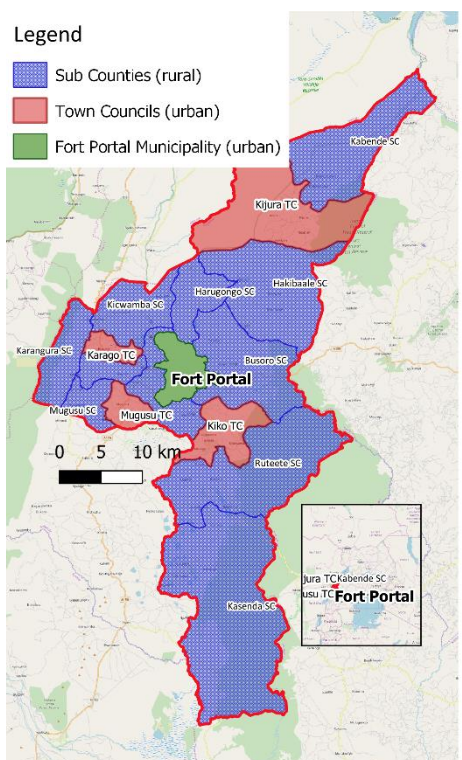


Figure 8: Kabarole District Sub Counties and Town Councils and the Fort Portal Municipality.

Chapter 3: Methodology

The research process was completed in four phases each using a different combination of methods (Figure 9). The phases of research were closely linked and overlapping in time. An applied axiology was used; the objective was to improve service delivery outcomes in the research context while also producing theoretical and practical research results that can be applied by others (Flood, 2010; P. D. Stroh, 2000).

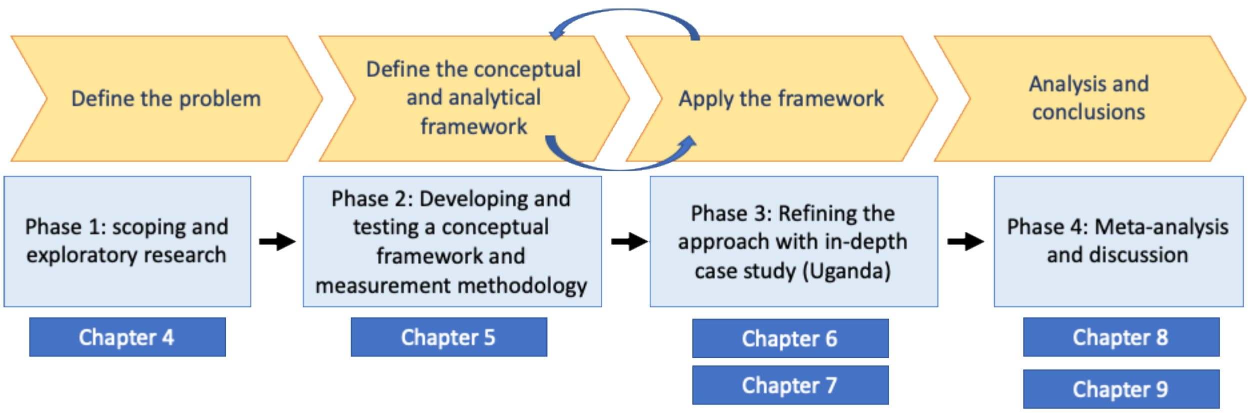


Figure 9: The phases of the research and the associated chapters

3.1 Context of research and collaborators

The WASH system within a single country or even a single district involves many stakeholders. In a collaborative and participatory action-research model, these stakeholders are involved at all stages including research design, data collection, analysis, and development of recommendations. Accessing and engaging these stakeholders, including government, presents a challenge for an independent researcher on the timeline of a PhD particularly when doing research in a foreign country. It requires an understanding of the power dynamics, and the politics, behaviour, and cultural factors that influence access to information. This knowledge is also needed to interpret the responses of stakeholders during research. For this reason, the research was conducted with a collaborator, who is embedded in the African WASH sector, who could provide access and help guide the research to remain relevant to those it is seeking to serve.

Potential research partners for the research were identified during Phase 1. A formal research collaboration was established with IRC in mid-2016. I was hired as a Programme Officer in the International Innovation and Influencing Department with an agreement between IRC and McGill to continue my research. IRC is a Netherlands-based WASH organisation who applies a systems approach and conducts action-research, often in partnership with international universities and governments in the implementing contexts. IRC was founded in 1968 by a joint agreement between the Government of the Netherlands and the WHO and now has six semi-autonomous national offices directed by national staff. These are Burkina Faso, Ethiopia, Ghana, Honduras, India and Uganda.

Following the independent scoping research, from late-2016 all field research was carried out in collaboration with IRC, building on the IRC knowledge base and that of my PhD supervisory committee at McGill University. I am the author and intellectual owner of the research presented in this dissertation, but many of the research activities were planned and carried out with other IRC staff, including the CEO, who is a co-supervisor. Three main projects contributed to this research by funding field activities, collection of data, and/or fostering project level learning that contributed to my methodological and analytical developments.

The 2017-2021 Safe Water Strategy Programme is an initiative funded and founded by the Conrad N. Hilton Foundation to help achieve SDG6 in six countries in sub-Saharan Africa: Burkina Faso, Ethiopia, Ghana, Mali, Niger, and Uganda. The approach is based on a) advancing proven and promising solutions b) strengthening water governance and in-country systems and c) building and disseminating credible and actionable evidence. The project seeks to overcome sustainability problems of status quo approaches by supporting collective action and building the capacity of government led systems (Hilton, 2018). IRC has the role of change facilitator in five of these countries, helping coordinate and align stakeholders to formulate and collectively pursue a shared vision. Within IRC, I contribute to monitoring and learning process as well as the development of the strategy for IRC's approach and synthesis of learning and research priorities across the six countries. This programme partially funded development and application of the WASH systems conceptual framework presented in this thesis, contributed to funding of the All

Systems go! WASH Systems Symposium, and contributed to funding the development of the WASH Masterplan in Kabarole District as well as related meetings and workshops.

The Sustainable WASH Systems Learning Partnership is a five year (2016-2021) evidence-based learning project funded by the United States Agency for International Development (USAID). It aims to develop, test, and document high-potential ‘systems approaches’ to overcome barriers for improving WASH service sustainability, and to influence how USAID and other influential actors invest in WASH. The consortium is led by the University of Colorado Boulder Mortenson Center in Engineering for Developing Communities, with implementing partners in Cambodia, Ethiopia, Kenya and Uganda, including IRC in Ethiopia and Uganda (USAID, 2018). This project funded several meetings and convenings of the Kabarole District WASH Task Team during the research period, and related action-research on payment models for community-managed water points. It supported learning alliance activities such as use of the Kabarole Masterplan as a tool to increase political prioritisation and community support for WASH. In this project, I had the role of monitoring and learning facilitator for IRC in Uganda and Ethiopia, which supported my engagement and participation in sector processes in Uganda for this research.

The Watershed–empowering citizens programme is a strategic partnership between the Dutch Ministry of Foreign Affairs (DGIS) and IRC, Simavi, Wetlands International and Akvo. It aims to build the capacity of civil society organisations (CSOs) in six countries: Kenya, Uganda, Mali, Ghana, Bangladesh, India and also at international level and in The Netherlands. Capacity is built for evidence-based lobbying and advocacy on Water, Sanitation and Hygiene (WASH) and Integrated Water Resource Management (IWRM) issues. The Watershed programme funding contributed to stakeholder meetings and funding the asset analysis carried out in Kabarole in 2019, with a focus on water quality testing. Water quality results are not analysed in detail in this thesis. The Dutch Ministry of Foreign Affairs (DGIS) also provide core support funding to IRC and partially funded the All systems go! WASH systems Symposium, both of which enabled this research.

3.2 **Research design**

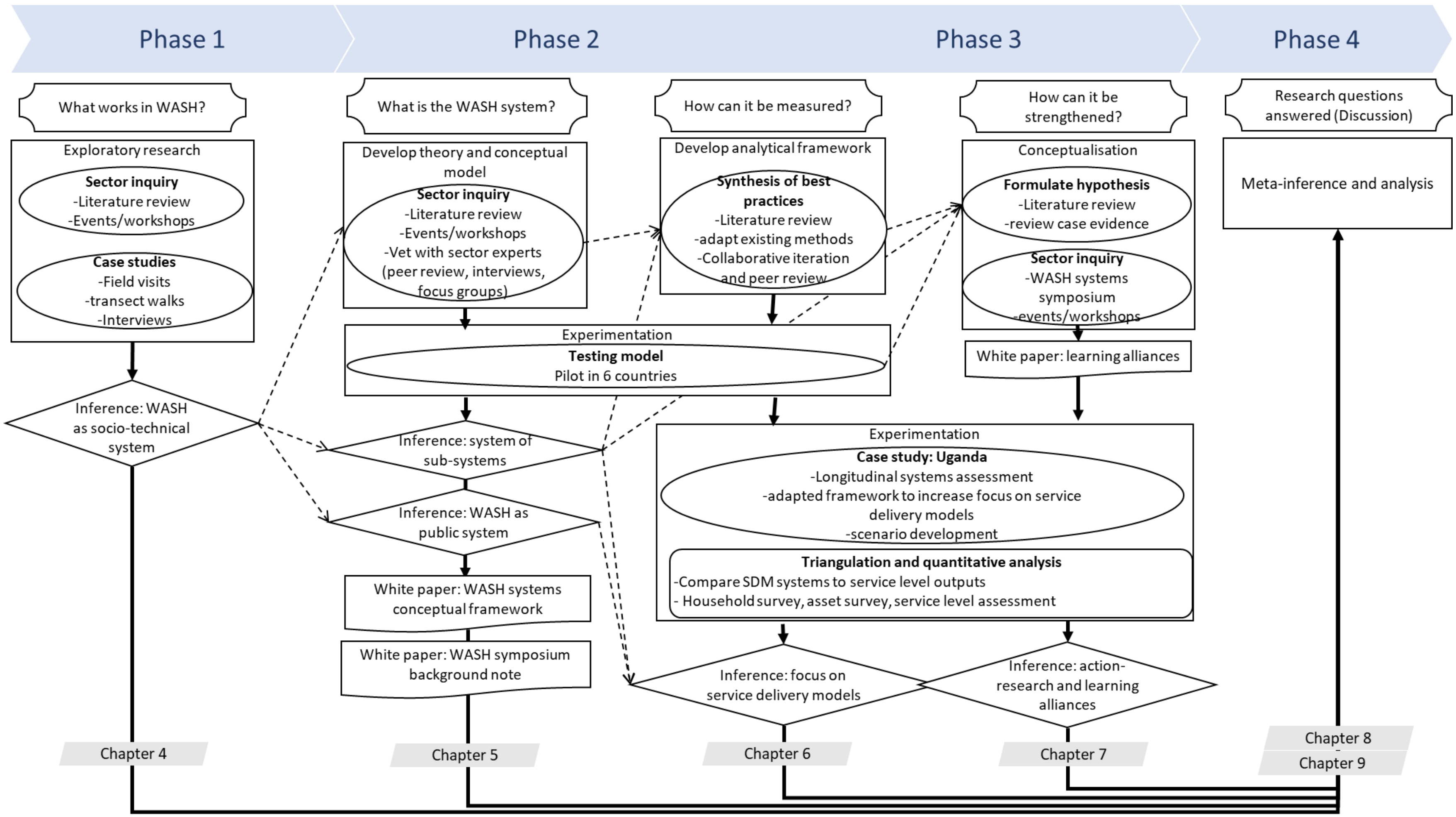
The research uses a pragmatic mixed methods approach that includes the analysis of both qualitative and quantitative information (Feilzer, 2010; Morgan, 2014). This allows for adaptation and selection of final methods in the field to respond to emerging results. Qualitative information is used to interpret quantitative results and quantitative results generate new questions for qualitative inquiry (Clark & Ivankova, 2015). A collaborative and participatory action-research strategy was used, whereby I was embedded in the research context and actively contributing to strategic activities to improve outcomes (M. K. Smith, 1996). This model built on the Participatory Transformative Advocacy Research model by Folifac (2012), which emphasises capacity building of stakeholders as a way to empower participants to more actively contribute to the action-research objectives (Folifac, 2012). This approach reflects my nature as both an independent researcher and a staff-member of IRC, a non-profit organisation committed to improving WASH outcomes through facilitated sector learning. It also builds on a large body of work using interdisciplinary and participatory methods in WASH (Moriarty, Batchelor, et al., 2005; Mayoux & Chambers, 2005; Butterworth et al., 2010; Cairncross et al., 2010; Lockwood & Smits, 2011; Folifac, 2012; Gabrielsson, 2012; Schouten & Moriarty, 2013).

The field research and all data collection were carried out and approved under the ethical permissions of IRC Uganda. IRC Uganda is a registered organisation that receives annual license renewal and permission to operate in Uganda based on its stated mission, scope of work, and annual workplan. Data collection that involved households and community members was approved by Kabarole District Council and permission letters were obtained at District, sub-district, parish and village levels prior to carrying out fieldwork.

The research strategy was conducive to conducting rigorous research while supporting local and national stakeholder objectives. It was cost-effective due to the ability to conduct research and implementation activities in parallel. Given my concurrent role as a stakeholder in the research context (IRC), it was important to be reflexive and minimise potential bias, as is the case with all action-research (Folifac, 2012). Bias could lead to dominance of the researchers perspective and overshadowing of stakeholder objectives and voice, or over-emphasis of positive outcomes due to the objective to demonstrate success (Kemmis, 2006). Bias was mitigated through 'inclusive rigour' in which multiple stakeholders participated throughout the research process, which included analysis, transparency of methods and results (Chambers, 2015). A research team including staff at different levels of the organisation, my supervisor at McGill, and influential stakeholders at district level ensured critique of the research by actors with different levels of involvement and avoided excessive steering of participatory analysis by any one single stakeholder. As recommended by Long et al. (2018), the purpose of the research is clearly communicated in each results chapter: to contribute to the development of public systems in low- and middle-income countries that can provide adequate water, sanitation, and hygiene services to the entire population. As recommended by Creswell (2016), the methods used are transparently communicated for each research phase using graphics (Figure 10). My theoretical understanding is that public systems develop over time through social learning and with government leadership, therefore applied academic research should aim to support, not undermine, this process.

Figure 10 shows the research process that took place from 2016-2020 in more detail. The shorthand research questions (shown at the top) loosely align with the phases of research, however they were asked iteratively and do not map directly to the different chapters of the thesis. In Chapter 8 (Discussion), the overall research objectives are discussed by synthesizing the results from the earlier chapters.

Figure 10 (next page): A flow-chart of the research process from 2016-2020. The research strategy in each phase is a box; qualitative methods are in circles; quantitative methods are in rounded squares; diamonds are inferences where solid arrows show application of inferences to produce research outputs and dashed arrows show their application in the next research phase. Across the top are the shorthand research questions.



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3.2.1 Phase 1: Scoping and exploratory research

The first phase was exploratory research intended to further define the problem statement and formulate my research questions and approach. The guiding questions during the scoping research were, ‘What dynamics or constraints in the WASH sector are preventing the development of sustainable systems at scale?’; ‘What are the key aspects or components of an intervention that are needed for success?’; and ‘Why does WASH fail (and fail to scale up from pilot projects)’, and ‘Does a comprehensive approach to WASH exist?’. These questions were answered using two mixed methods strategies: sector inquiry and case studies.

The term *sector inquiry* is used to describe the critical review and analysis of the ‘state of the WASH sector’ which was performed through a combination of literature review, participation in conferences and events, professional networks, interviews, and field visits. The WASH sector analysis broadly encompasses the global and local networks involved in drinking water, sanitation, and hygiene service delivery in low- and middle-income countries (UNICEF, 2020). As the WASH sector is a public service (whether provided by a public or private entity), plans and implementation reports are not always possible to find in online databases. In the rural context in low-income countries, provision of WASH is often done as a commercial endeavor, development aid or charity; the client, a low-income country government, has little ability to hold the provider to account, which means that failures and challenges are underrepresented in the literature and tend to be ‘smoothed over’ in written documents (Davis, 2016). It is important to accurately assess the success of WASH interventions through participation in knowledge networks and face-to-face interaction with practitioners and stakeholders in different parts of the system.

A series of case studies were carried out from June to August in 2016 in East Africa. Nine WASH organisations and project implementation sites were visited; two in Uganda, four in Kenya, and three in Tanzania (Table 2). These sites were selected through snowball sampling and due to their identification as a ‘promising approach' that was locally embedded and demonstrated a concerted effort to overcome barriers to sustainability or scaling. The visits consisted of a transect walk, a facility tour, one or more key informant interviews, and in one case a multi-stakeholder workshop. These case studies were of sanitation services in urban and rural contexts. The analysis and results from Phase 1 are presented in Chapter 4.

Table 2: Sites visited during exploratory field work in 2016, noting the location and methods used at each site.

Organisation or project	Location	Method used
Environment Alert/ ActTogether	Kabalagala, Kampala, Uganda	Transect walk, facility tour (community WASH centre), key informant interviews
WASH Agenda for Change (IRC)	Kampala, Uganda	Workshop, presentations, key informant interviews
Sanivation	Naivasha, Kenya	Transect walk, key informant interviews, facility tour (faecal sludge treatment facility)
Nithi Water and Sanitation Company	Chuka, Kenya	Transect walk, facility tour (wastewater treatment plant, drinking water treatment facility), key informant interviews
Sanergy	Nakuru, Nairobi, Kenya	Transect walk, facility tour (latrine construction site, urine treatment lab), key informant interviews
Umande Trust	Kibera, Nairobi, Kenya	Transect walk, facility tour (community WASH centre), key informant interviews
Centre for Community Initiatives	Dar es Salaam, Tanzania	Presentation, key informant interviews,
Local NGO project site	Lumuli, Tanzania	Transect walk, key informant interviews
ACRA	Iringa, Tanzania	Transect walk, site visit (faecal sludge composting), key informant interviews

3.2.2 Phase 2: Developing and testing a conceptual and analytical framework

In the second phase, the conceptual model and analytical framework for the WASH system were developed using a mixed-method sector inquiry and action-research. The findings from Phase 1 led to the conceptualisation of WASH service delivery as taking place in a complex socio-technical system. The objective of Phase 2 was to develop and refine a conceptual and analytical model of the WASH system, guided by the questions: 'What does a resilient WASH system look like, what are the main sub-systems or 'building blocks'?'; 'How can each sub-system be objectively measured or assessed?'; 'Is a systems assessment (through its sub-systems) an effective approach to identify pathways to change, and to support a network of stakeholders to use systems thinking to plan, innovate, and promote public system transformation for WASH?'.

Phase 2 (and Phase 3) followed a collaborative research model in partnership with IRC ('Collaborative Research', 2008), whereby IRC staff and partners were involved in research activities. The research was conducted within IRC's programme implementation cycle; data collection and analysis took place through interventions intended to study or improve different aspects of the system and/or to build the capacity of stakeholders to plan and implement improvements in the WASH system. As a researcher within a 'learning organisation' (Marsick & Watkins, 1999) I played a role as learning facilitator with IRC staff and partners, who included local government, by formulating action-research questions, helping to collect data, and facilitating group analyses and reflection (and adaptive planning) on the findings in workshops or meetings. I also held a position as co-chair of the Technical Working group for the Agenda for Change collaboration (a multi-country multi-organisation initiative focused on local WASH systems strengthening), which provided opportunities for expert consultation. I was also the chair of the Sanitation and Water for All Results Framework Task Team, responsible for developing a framework to monitoring national level WASH systems development of a multi-stakeholder government-led collaboration in 70 countries. The conceptual framework for my research evolved and matured through the conversations, meetings, and strategic project workshops carried out during three years. By working with IRC, it built on over 10 years of iterative research and systems praxis development prior to my research. These expert insights and experiences in the field contributed to the knowledge development and the analysis presented in this thesis.

The sector inquiry aspect of Phase 2 included a mapping of 20 different sustainability and system monitoring tools to identify best practices and remaining gaps in the emerging field of

'WASH systems monitoring' (Lockwood & Allely, 2017). I convened a round table discussion with representatives from eight global organisations involved in WASH systems monitoring initiatives to pose my research questions and to enquire about other promising approaches to classify and monitor the system. Both activities helped to ensure the framework aligned adequately to sector needs and would add value to stakeholders playing different roles in the WASH system.

In 2018, I authored a white paper (called a 'working paper' and published by IRC) with my co-supervisor which detailed my theoretical and conceptual understanding of WASH as a system (Huston & Moriarty, 2018). This practitioner-oriented publication was used to generate sector dialogue and expert feedback that contributed to further refinement of the approach. The conceptual framework was structured by nine building blocks that defined the key subsystems of the WASH system (Figure 11), later referred to as 'windows into the system' (Chapter 5), which formed the foundation for an analytical tool for the WASH system.

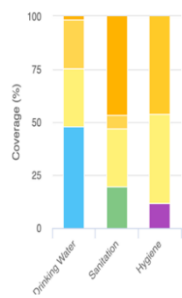
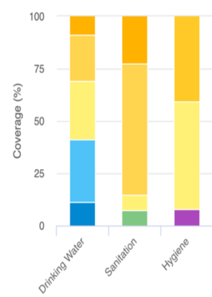
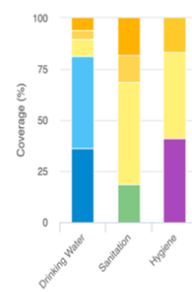
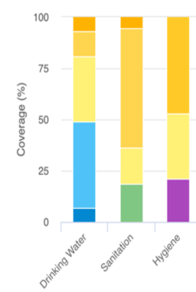
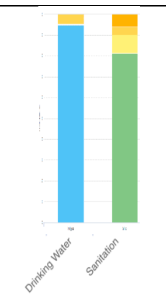
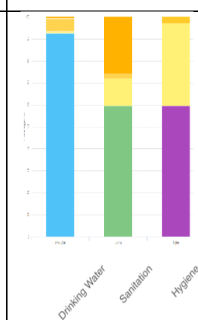
Figure 11: The nine building blocks of the WASH system (Huston and Moriarty, 2018)

The action-research in Phase 2 included practical experimentation through the application and refinement of the conceptual framework in IRC's six focus countries. This dissertation focuses on the experiences from four sub-Saharan African countries where IRC has offices and staff: Burkina

Faso, Ethiopia, Ghana, and Uganda, with a detailed study of Uganda undertaken in Phase 3. These four countries represent four distinct contexts whose key features are presented in Table 3. However, they are not a representative sample of sub-Saharan Africa. Honduras and India are included for comparison from Latin America and South Asia; these are discussed in Chapter 8.

The analytical framework, based on the definition of indicators for each of the building blocks, was made into a scoring template in Microsoft Excel and given to IRC staff in each country. They then completed the scoring and provided references or data sources for each, working with local stakeholders for scoring and validation of the assessment results. Both the results of the WASH systems analysis and the qualitative feedback from IRC staff and stakeholders completing the assessment tool contributed to answering the research questions. The analysis followed a convergent design whereby quantitative results were interpreted and used to inform the qualitative scoring assessment (e.g. financial analysis determined whether the capital expenditure budget was adequate). The conceptual framework is presented in Chapter 5, and the results are discussed in Chapter 8.

Table 3 (next page): Overview of six countries and focus districts involved in development and piloting of the conceptual framework. Abbreviations and References: GDP=Gross Domestic Product in 2019 (in purchasing power parity, constant 2017 USD) (The World Bank, 2017). The Governance Effectiveness Index measures quality of public services, civil service, policy formulation and implement, and credibility of the government’s commitment to improve these (World Bank, 2019). The Human Development Index assesses development according to people and capabilities using key dimensions such as life expectancy at birth, education, and income (UNDP, 2018). Population data comes from the 2019 Revision of World Population Prospects by the United Nations. Available at https://population.un.org/wpp

	Burkina Faso	**Ethiopia**	**Ghana**	**Uganda**	**Honduras**	**India**
Sub Region	Francophone west Africa (land locked)	Horn of Africa (landlocked)	Anglophone west Africa (coastal)	East Africa (landlocked)	Central America, (coastal)	South Asia (large, diverse, coastal)
Geography	Sahelian	Highly diverse	Equatorial	Equatorial, diverse	Tropical	Tropical, mountainous, diverse
Population (2019)	20.3 million	109 million	30 million	42.7 million	9.8 million	1.4 billion
GDP (ppp constant 2017 USD)[1]	2,178	2,221	5,413	2,187	5,728	6,700
Governance effectiveness index (percentile in 2018, where 0 is lowest and 100 is highest)	31%	29%	46%	30%	28%	60%
UNDP Human Development Index (HDI) and Rank[3]	0.434; Rank 183 (low)	0.470; Rank 173 (low)	0.596; Rank 142 (medium)	0.528; Rank 160 (low)	0.632; Rank 132 (medium)	0.645; Rank 131 (medium)
2017 Household WASH service levels (JMP) 						
Sub-national geography for district analysis	Commune de Banfora	Mile, South Ari woredas	Asutifi North District	Kabarole District	15 municipalidades	Chatrapur block in Ganjam district, Odisha State
Population of case district[4] **, (density in ppl/km²)**	153,600 (117)	Mile: 90,600 (17) South Ari: 238,000 (27)	52,300 (70)	325,000 (179)	285,000 (total)	22,000 (429)

3.2.3 Phase 3: Refining the approach with an in-depth case study

Phase 3 was an in-depth case study of the drinking water system in Uganda using a participatory action-research strategy. The conceptual framework developed in Phase 2 was applied in Uganda to obtain empirical results on the WASH system in Kabarole, and to further refine the conceptual framework and methodology for WASH systems assessment. The objective was to characterise the drinking water system in Uganda and to identify pathways for its transition from a starting point of low levels of unreliable services toward an SDG6 vision of universal safe piped water for all. A methodological objective was to test the use of the conceptual framework as a means to structure a participatory systems-level analysis and to identify strategies for improving service delivery jointly with stakeholders. The analytical framework provided probing questions for qualitative data collection and informed quantitative research design. Phase 3 was guided by two main research questions: 'Is a systems assessment (through its sub-systems) an effective approach to identify pathways to change, and to support a network of stakeholders to use systems thinking to plan, innovate, and promote public system transformation for WASH?'; and 'How can a national WASH system transition from a paradigm of low quality unreliable services toward one that delivers universal access to safe water?'.

The research was embedded in the locally-driven change process that took place in Kabarole from 2017-2019, as shown in Figure 12. In late 2016, District stakeholders agreed on an SDG6 vision for universal and sustainable WASH services to be provided by 2030. To help achieve this, a group of stakeholders formed the Kabarole District WASH Task Team, with the aim to be a 'think-and-do' tank for the WASH sector by driving innovation and progress toward the vision of universal services. The Task Team was formed of 26 stakeholders representing District Government, traditional and religious leaders, NGOs, and technocrats from the health, education, water and environment sectors. IRC was asked to help build the capacity of the Task Team by acting as the learning facilitator and supporting key activities with financial and technical assistance. The Task Team started by completing a comprehensive assessment of the WASH system in Kabarole (with funding from the Conrad N. Hilton Foundation and the USAID Sustainable WASH Systems Learning Partnership), some of which is presented in Chapter 6. Results from the assessment were used to develop the Kabarole WASH Masterplan for 2018-

2030, a political and technical initiative championed by the local government, which was a milestone in planning and taking action to improve WASH services in Kabarole.

The multiple assessments shown in Figure 13 were used to build the capacity of the Task Team to diagnose problem areas within the WASH system, to identify potential leverage points to improve performance, and to develop innovative solutions and strategies for the Kabarole Masterplan and its implementation. These assessments also served as a baseline for monitoring change in system performance and service delivery. In concert with the assessments and action-research taking place in Kabarole, research was pursued to answer my research questions through additional mixed methods data collection and analysis including field visits and transect walks, key informant and group interviews, participation in workshops, surveys, and questionnaires. The activities and analyses identified with an asterisk in Figure 12 were carried out specifically for this PhD research and are discussed in the results chapters. The assessments without asterisks were carried out as part of related activities of IRC and collaborators; these are mentioned because they contributed to the understanding of the WASH system in Uganda and to the social learning of stakeholders. The outputs of these assessments (meeting minutes, reports) were included in our reviewed documents but were not used as core methods for this research.

Figure 12 (next page): A summary of the action-research process in Kabarole 2017-2019. *starred methods indicate those that contributed directly to this research, and are those explicitly discussed in the methods and results sections of the PhD.

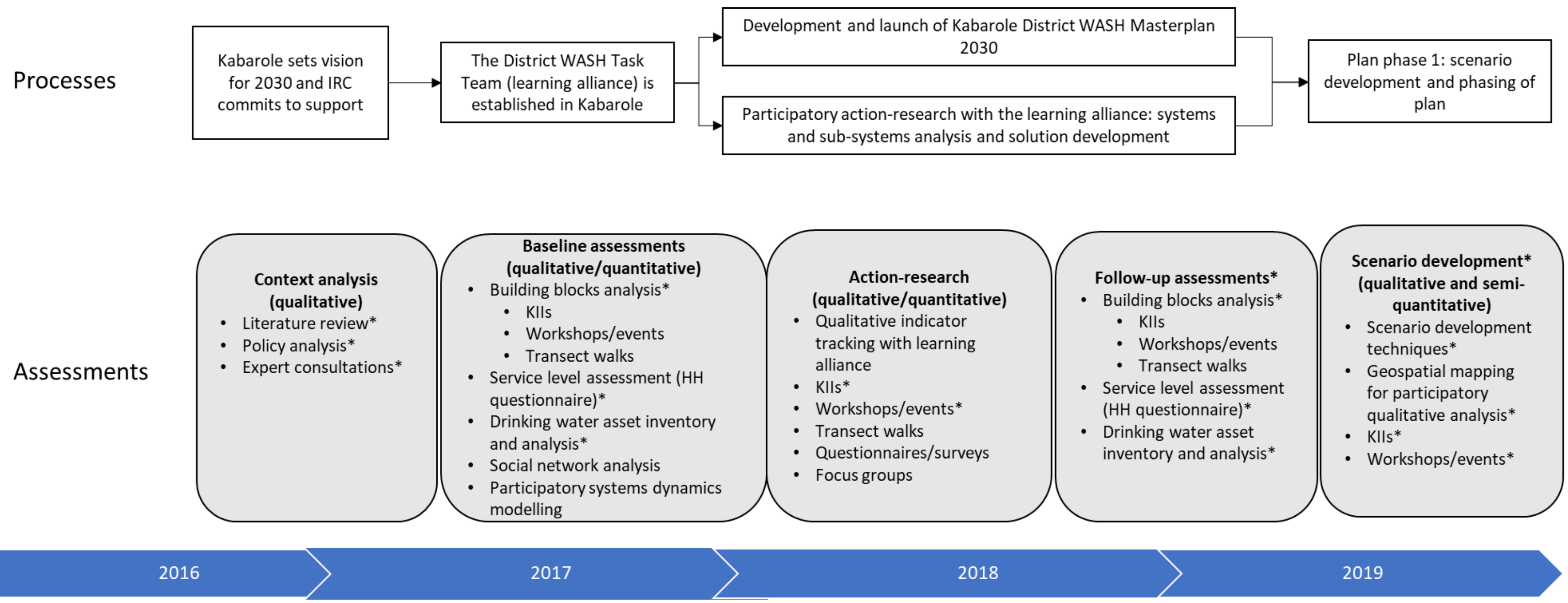


Figure 12: A summary of the action-research process in Kabarole 2017-2019. *starred methods indicate those that contributed directly to this research, and are those explicitly discussed in the methods and results sections of the PhD.

Local stakeholders and members of the Task Team were involved in survey and assessment design, data collection, analysis, and the development of recommendations. The conceptual building blocks from the WASH system framework were used to code data from the mixed methods and to structure the integrative analysis. The benchmarking analysis was completed at the national and a district level for each service delivery model; and the drinking water assets and level of services delivered in Kabarole were analysed in 2017 and 2019 to allow a time series analysis and identification of trends. Results from the systems analysis in Kabarole and Uganda are presented in Chapter 6.

A participatory scenario and strategy development process was carried out to identify key trends, likely scenarios, and preferred strategies for achieving the WASH Masterplan Targets under a range of possible future conditions. Scenario planning was tested as a tool for social learning among stakeholders in Kabarole and at the national level. The analysis was guided by theory from the field of public sector transition management, based on an understanding of drinking water as a socio-technical public system (Kemp et al., 2007). The method used was based on those of Bishop et al. (2007), Wright et al. (2013), and Moriarty et al. (2005), in which qualitative narrative scenarios were developed by trying different combinations of the extremes for factors mapped to be highly important to obtaining the future vision yet highly uncertain. Strategies were then developed to help achieve the service delivery targets for 2030 under different possible and likely scenarios. The scenario development methodology and results are presented in Chapter 7.

3.2.4 Phase 4: Meta-analysis and discussion

The fourth phase of research was the meta-analysis of the findings from the earlier phases. This was qualitative and achieved by an integrative analysis of the findings from each chapter in order to answer the overall research questions. This included insights from expert consultation including IRC staff who led the assessment in the six countries. Data from the 6 countries were reviewed. The integration of results was done through the narrative and weaving approach, whereby the merged results are critically discussed according to the themes presented in the research questions, rather than by grouping according to data type (Fetters et al., 2013). These research questions are answered and discussed in Chapter 8 followed by a brief forward looking reflection in Chapter 9.

3.3 Research Methods

This section provides a brief description of each of the methods used in the research. Figure 13 summarises the methods used in each phase of the research, indicating the overarching research methodology and strategy for each phase. This section distinguishes between standard methods and novel methods. Several of the standard methods were modified in this research. Novel methods were developed specifically for this research. The methods are also presented in the individual results chapters and the associated supplementary materials.

Literature Review

Practitioners, industry, and global development organisations play major roles in the WASH sector. There is a significant volume of relevant literature that is not located in scholarly databases (Valcourt et al., 2020). Bibliographic hand searches, participation in sector learning platforms and events, and expert consultations were used to identify individuals or threads of research that could be followed up using the snowball method. The grey literature relevant to WASH ranges in quality and rigour: scholarly peer reviewed documents, United Nations and global reports, un-reviewed conference presentations, blogs and journalistic popular literature. Peer-reviewed documents, global reports, and blogs from credible sources (e.g. World Bank, leading sector thinkers) were prioritised as well as information sources curated by technical sector working groups such as the Rural Water Supply Network, the Sustainable Sanitation Alliance, and the International Water Association. Some non-scholarly work, such as blogs or media pieces, was used to study the public perception about WASH issues and to obtain expert practitioner perspectives.

Conferences and sector events

The conferences attended as part of the sector inquiry and research development are presented in Table 4, with a list of the key stakeholders represented at each conference. During these events, I was exposed to the political and financial dimensions of the sector and to leading work by researchers and practitioners. I conducted informal interviews and engaged in critical dialogue with different stakeholders. I also presented my early research concepts through formal presentations and informal meetings to get feedback from experts and refine my research questions. Findings from these interviews contribute significantly to the evidence base and analysis made in Chapter 4.

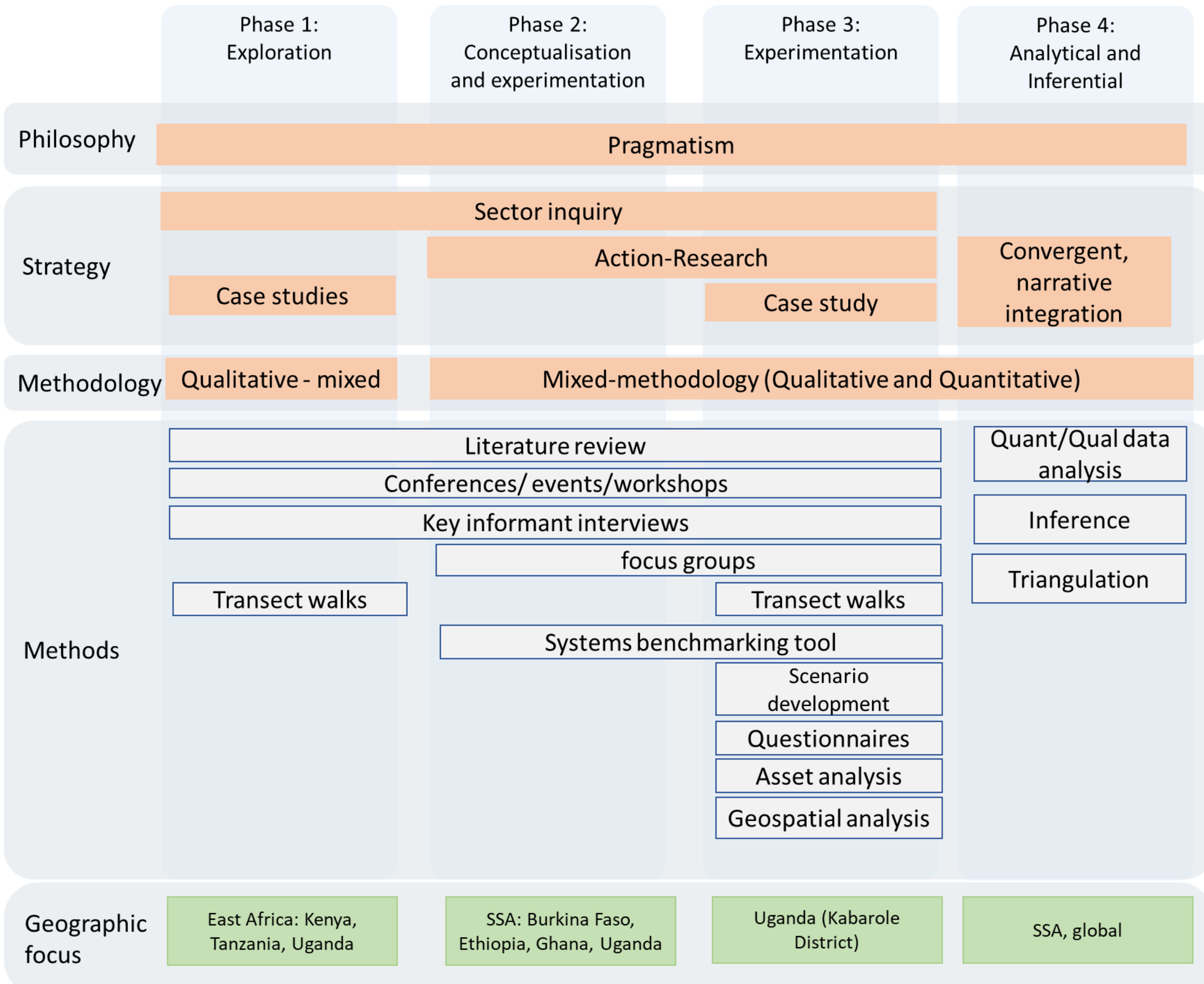


Figure 13: The methods used in each research phase, and the associated research philosophy, strategy, methodology, and location.

The All systems go! WASH Systems Symposium

In March 2019, the first conference dedicated specifically to the topic of WASH as a system was convened by IRC in The Hague, the Netherlands. I was responsible for planning and coordinating the 62 technical sessions organised under 6 thematic areas related to WASH systems. The *All* *systems go! WASH Symposium* included papers and sessions that were curated (requested by me or other thematic leads) and others selected from an open call. Over a year of preparation including designing sessions, reviewing papers, and working with thematic experts, created the opportunity for expert discussion, synthesis, critique, and 'refinement through argumentation' of my emerging understanding of WASH as a system. The theoretical framework for the WASH system developed in Phase 2 was proposed as a key organising framework for the sector during the symposium, which generated significant feedback and response used to further refine my concept of the WASH system as discussed in Chapter 8. Approximately 350 WASH practitioners, researchers, and government representatives attended the symposium, and I led the writing and publication of the conference proceedings that documented and analysed the discussions, presentations, and emerging conclusions from all sessions (IRC, 2019).

Table 4: Conferences and sector events participated in as part of the research development. Key stakeholders represented are based on my observation as a participant of the attendees and the orientation of the topics and sessions in the programme.

Conference	**Date (month, year), location**	**Key stakeholders represented**
Stockholm International Water Institute World Water Week	August 2015, Sweden	financiers, bi- and multi-lateral development agencies (e.g. UNICEF, national development agencies), technocrats, elected officials NGOs, and researchers
Sanitation Stakeholders Workshop (organised by Lund University, Sweden and University of Dar es Salaam)	March 2016, Tanzania	Technocrats, researchers, CSOs, NGOs
Kampala Sustainable WASH Forum	June 2016, Uganda	technocrats, NGOs, politicians, CSOs, bi- and multi-lateral development agencies
African Water Week, organised by the African Ministers Council on Water (AMCOW)	July 2016, Tanzania	elected officials, technocrats, financiers, bi- and multi-lateral development agencies, NGOs

Water and Engineering Development Centre (WEDC) Conference at Loughborough University	August 2017, United Kingdom	Researchers, NGOs, CSOs, technocrats, bi- and multi-lateral development agencies, technocrats
Water and Health Conference, organised by the University of North Carolina at Chapel Hill	October 2017, United States	Researchers, NGOs, CSOs, technocrats, bi- and multi-lateral development agencies, technocrats
All systems go! WASH Systems Symposium, organised by IRC	March 2019, The Netherlands	NGOs, technocrats, financiers, bi- and multi-lateral development agencies, CSOs, elected officials,

Key informant interviews

In Phases 2 and 3, interviews were used to obtain expert feedback on the conceptual framework, and learn about trends and factors influencing the observed service delivery results. In semi-structured or informal interview I could probe at and document possible strategy recommendations from different stakeholders. Key informant interviews in research are susceptible to bias on behalf of the interviewee and the interviewer and should be analysed with caution (Kumar, 1989); therefore multiple informants and triangulation with other data sources were important for interpretation.

Focus groups and round table discussions

In this research heterogenous focus groups participants were selected based on their knowledge of the subject matter. Focus groups and roundtable discussions were used in each phase as part of sector inquiry and to invite stakeholders to contribute to the design and interpretation of research methods, analysis of findings and development of recommendations. I acted as moderator of the focus groups; first presenting basic information or results, then prompting and subtly moderating the conversation to allow the responses, conversation, and interactions between participants to unfold as naturally as possible.

Interactive meetings and workshops

Workshops do not appear in the literature as a standard qualitative research method, however many participatory and multi-stakeholder methods are carried out through a series of workshops for both data collection, analysis, and validation. Meetings with colleagues and WASH experts took place weekly and a topical workshop approximately monthly. For the research in Uganda, I participated and facilitated ten workshops (1 to 3 days each), and remotely prepared and performed analysis for an additional five workshops. These were part of qualitative data collection and participatory analysis of action-research results. Thirteen of these were held in Kabarole District and two were in Kampala organised with national stakeholders. A variety of facilitation techniques were used including panel discussions, world café, debates, small group work, plenary dialogues, and games/quizzes. Facilitation was shared between me and the research team including other IRC staff or collaborators. Workshops and interactive meetings differ from formal meetings in that they are designed to give space for participants to contribute actively to the proceeding of the meeting. During these meetings, notes were typically taken on a laptop or by hand, and large sheets of papers were made available to participants ('flip-charts') for documenting key ideas. Meeting minutes and/or a short workshop report were shared with participants after meetings, and used for further analysis. Workshops always include a short snack or meal break that was used for informal discussion, and/or interviews with individual participants.

Transect Walks

Transect walks were formally arranged as part of the case study visits during the scoping research (Phase 1),but were routinely employed throughout this research to build contextual understanding and provide additional background information for interpreting results from other methods. Transect walks were used as an informal means to gather additional perspectives from ordinary community members not involved in the research, and to triangulate the perspectives of key informants about WASH service delivery and use in the research areas.

Household Questionnaires

In Phase 3 of the research, two comprehensive household questionnaires (surveys) were carried out in Kabarole, Uganda. District and sub-county health assistants and extension workers were hired to help design the survey instruments and to enumerate the survey. These actors were chosen due to their experience working with communities on WASH issues, and experience administering other demographic and public health surveys. The health assistants supported design and translation of the surveys, which were written in English but conducted orally by using a combination of English and Rutooro (the main local language in Kabarole). A training workshop and pre-testing of tools were carried out to ensure uniformity of questionnaire delivery and translations, and of the field sampling approach and techniques. The surveys were preloaded onto GPS-enabled Smartphones using the AkvoFlow application. All enumerators carried written permission letters from the District Council as well as written explanations of the survey, the confidentiality agreement, and contact information for the local IRC Office and District government contact person.

A representative sample of households were selected using three stage stratification and probability-proportional-to-estimated-size (PPES) cluster sampling (United Nations, 2005). The first stratification was by town council/municipal division/sub-county (corresponding to urban/urban/rural); the second and third were according to parish and village levels. In the selected villages, 15 households were selected using purposeful random sampling techniques aimed to cover a range of households at different distances from the main footpaths. The distribution of selected households was verified using GPS data to ensure enumerators had covered main areas in the village (Pérez-Foguet & Giné-Garriga, 2017; United Nations, 2005). A total of 2289 households were sampled in 2017 (95% Confidence level for average margin of error of 2%) and 775 in 2019 (95% Confidence level for average margin of error of 3.5%) (Figure 9). The smaller sample size in 2019 was due to the acceptability of a larger margin of error to reduce the costs of the survey. Surveys included questions about basic demographic data; primary and secondary sources of drinking water; the type of infrastructure use; costs and management of services; accessibility; availability; perceived water quality; and satisfaction with services (see full survey in Appendix 2). The water, sanitation, and hygiene service levels, user preferences, payment habits, and satisfaction were analysed in Microsoft Excel, and the Statistical Package for the Social Sciences (SPSS). The data were analysed using frequency and cross-tab functions to observe the relationship between variables. Non-parametric tests using Kendall Tau-b (for ranked ordinal variables), and chi-square (categorical variables) were used to analyse the correlation between variables and determine the statistical significance using permutation tests (where a p-value of 0.05 or less was a significant result) (Berthouex & Brown, 1994).

Table 5: A summary of the number of villages selected from each sub-County and Town Council in Kabarole for the 2019 survey.

Sub-county/town council	Estimated population 2019	Number villages selected (epps)	Total number of hh surveys
Bukuku sc	15,436	3	45
Busoro sc	29,216	5	75
Hakibale sc	30,056	6	90
Harugongo sc	15,586	3	45
Kabende sc	12,700	2	30
Karambi sc	29,271	5	75
Karangura sc	13,905	3	45
Kasenda sc	27,117	5	75
Kicwamba sc	22,588	4	60
Mugusu sc	17,348	3	45
Ruteete sc	20,205	4	60
Subtotal rural	**233,427**	**44**	**645**
Karago tc	10,986	2	30
Kiko tc	13,460	3	45
Kyaitamba tc	12,037	2	30
Mugusu tc	9,932	2	30
Subtotal urban	**46,415**	**9**	**135**
Total	**279,842**	**53**	**780**

Asset Registry and Analysis

For Phase 3, a census of improved water point facilities (tap stands, deep boreholes, shallow wells, protected springs, rainwater harvesting tanks) in Kabarole District, Uganda was done. This collected information on the location, age, and condition of infrastructure components, and on their performance, operation, and management. Questions that could be answered by observation were answered by the enumerator (hand pump mechanics), and questions about use, age, and management of facilities were answered by the caretaker of the water point. All enumerators were members of the Kabarole Handpump Mechanics Association, an organisation of professional water supply technicians who have a standard level of training and agreed ethics and norms for operation. They were selected as enumerators because of their specialised knowledge of water point technology and the locations of water supply infrastructure in Kabarole. The enumerators helped to design the survey instruments to ensure that the questions and terminology used for assets, components, and condition were locally relevant and consistently applied in the survey. A training workshop and pre-testing of survey instruments were held with enumerators. The survey of piped infrastructure was carried out in collaboration with the managers and caretakers of the piped schemes (water boards or utility engineers, managers, and technicians). For all surveys, enumerators were equipped with a GPS enabled smartphone and the questionnaires preloaded on the AkvoFlow app.

To ensure all water points were found, enumerators were assigned to data collection in the sub-district areas where they regularly work, and were given a list of all villages to be covered. On arrival at a village the enumerator contacted the village chairperson to describe the project, present the survey tool and obtain their permission to implement the survey. The village chairperson would typically provide an (oral or written) list of water points in the village to the enumerator.

In total, 1,077 improved water points were mapped in 2017, and 1,118 in 2019. These were in 435 villages. In 2019 the main components of all 12 piped schemes were also mapped (sources/catchments, reservoirs, pumping stations, treatment infrastructure, break-pressure tanks) working closely with the managers and operators of the schemes. Prior to this survey, no comprehensive registry of geographically tagged data existed for the water facilities in Kabarole. An effort was made to combine the data collected in 2017 and 2019 with the Uganda Ministry of Water and Environment water point database (Uganda Water Atlas), however the coordinates in the existing database did not prove to be adequately accurate to allow matching of water points, and there is no water point identification (numbering) system in use in Uganda. The 2017 and 2019 data were merged. The data were analysed in Microsoft Excel, and the Statistical Package for the Social Sciences (SPSS) using frequency and cross-tab functions to observe the relationship between variables. Non-parametric tests using Kendall Tau-b (for ranked ordinal variables), and chi-square (categorical variables) were used to analyse the correlation between variables and determine the statistical significance using permutation tests (where a p-value of 0.05 or less was a significant result) (Berthouex & Brown, 1994). The complete surveys for the asset register are available in Appendix 3.

Geospatial analysis

In Phase 3, GIS data from the asset registry in Kabarole, Uganda were overlaid with vector layers of administrative and water basin boundaries, population density, contoured poverty concentrations, water resources, land use and roads and open source data sets from the Uganda Bureau of Statistics (UBOS, 2016), The Uganda Ministry of Water and Environment (MWE, 2019), Open Street Maps (OpenStreetMap contributors, 2019), and AfriPop (Afripop, 2013) analysed in QGIS (QGIS, 2019). Visualisation and manipulation of the data were done to identify trends and demonstrate characteristics of the data that were not easily interpreted or communicated with stakeholders using tabular data, such as showing which parts of the district had denser or sparser coverage of water infrastructure. In another example, 100 meter radius circles were drawn around each water point and standtap to identify where gaps in coverage left some households further than the maximum 100 meter distance from a water point. Maps were generated from both 2017 and 2019 asset data to enable comparison and identification of change, and various hypothetical maps were drawn to represent different possible scenarios for water and population coverage in 2030.

WASH System Benchmarking tool

The WASH systems benchmarking tool was developed as a means to transfer larger amounts of qualitative data into a semi-quantitative set of metrics that represent the key features of the WASH system. The objective is both for monitoring and tracking change and also for stimulating discussion and reflection with stakeholders in the context in which it is applied. Besides producing a semi-quantitative output, the tool can be used to structure and design data collection from mixed methods. Multiple data sources can be used to obtain the necessary information to complete the assessment. The tool is based on the conceptual framework developed in Phase 2, which introduced nine building blocks for the WASH system that theoretically exist at national, district, and *service delivery model*[1] level. Three to five benchmark scoring indicators were developed to represent the key features of each building block (see examples in Table 6, Figure 14, and the comprehensive list in Appendix 1). Indicators are modified slightly for each WASH sub-sector (water, sanitation, hygiene). Each indicator is scored on a Likert scale of 1 to 5, 1 is the lowest (benchmark statement is completely false) and 5 the highest (benchmark is well-developed and criteria are effectively applied). The national level indicators primarily assessed existence and formalisation of the building blocks for the sector, and the district level indicator assessed the application, and degree of implementation of the national systems building blocks at the decentralised level. In Chapter 6, each service delivery model in Uganda was analysed according to its level of development in the Ugandan policy framework and its implementation in Kabarole District. The Likert scoring was informed by the qualitative analysis and the quantitative performance results from the household survey and asset inventory (e.g. the average performance of community service providers).

The scoring of the indicators was done either by individuals or within a multi-stakeholder process by discussing each indicator and assigning a source and justification for the score in small discussions groups or a workshop. The scores are recorded in a database, and when combined they produce a heat map summary of the results that can be used to facilitate a discussion with stakeholders. At minimum, the scores were validated by more than two people to encourage reflection, avoid bias, and increase the likelihood that new analytical insights are obtained through discussion.

[1]Service delivery models refers to the system behind a specific mechanism for service delivery with a specific focus on management model. For example, a public water utility with a piped network, or a household pit latrine emptied by a private entrepreneur.

Table 6: Example of indicators for the building blocks. A complete list is available in Appendix 1.

Building block name	Included components	Example indicators (each scored on a Likert scale)
Policy & Legislation:	Sector policy and strategy, legal framework, norms and standards, by-laws	**National**: Norms and standards for quality of works and service delivery are in place. **District**: By-laws, local strategies, ordinances for service delivery are in place
Institutions:	Coordination, roles, responsibilities, capacity, sector mechanisms	**National**: Responsibilities of the national and decentralized level bodies are clearly defined, and there are no gaps or **overlaps** between them. District: The service authority receives regular back-up or support from higher levels of government.
Infrastructure:	Development and maintenance, project cycles, asset management, roles	**National**: The project delivery models and procurement procedures for capital investments projects are clearly articulated in government-sanctioned implementation manuals. **District**: An inventory exists of all (or most) water infrastructure assets, including age and current physical state of assets for the focus district.
Monitoring:	Framework and routine implementation, service levels, use of data	**National**: The data from the monitoring system are analyzed and used at sector level, e.g. for macro-level planning, trends analysis, policy making. **District**: he data from the monitoring system are analyzed and used at district level, e.g. for local level planning, technical assistance.
Planning:	Planning and budgeting, capacity & frameworks for planning	**National**: Plans take into account in-country differences (geography; demography; water resources), recognizing the different SDMs. **District**: Plans are costed with reasonable indication of source of financing
Finance	Flows and responsibilities, clear frameworks incl. life-cycle costs and source identification	**National**: The funding mechanisms and flows be identified for all the cost components; it is clear who is responsible for paying CapEx and CapManEx **District**: There are subsidies/subsidy mechanisms to address equity: e.g. cross subsidy, targeted subsidy for latrines.

Regulation & Accountability:	Accountability mechanisms, regulatory framework and capacity	**National**: The entity equipped with regulatory functions sets (1) tariff regulations and provide tariff calculation guidelines; (2) service level requirements; and, (3) rules that protect consumers **District**: A mechanism for citizens (CSOs) to hold service providers to account is in place
Water Resource Management:	Allocation and managment of resource abstraction, water quality, coordinated efforts	**National**: There are national and sub-national water resource management institutions in place and able to undertake their mandated functions for water resource management (e.g. catchment authorities, river basin authorities). **District**: Service providers in the district plan for and carry out source protection and preservation activities, such as water and sanitation safety/water security plans.
Learning & Adaptation:	Capacity and frameworks to capture and feedback lessons learned, update and adapt building blocks	**National**: There are institutionalized learning platforms and/or mechanisms at sector level, e.g.: Joint sector reviews, donor platforms, donor-government platforms, national learning alliance, thematic working groups, resource centres, sector web sites, etc. **District**: District learning mechanisms are linked to the national level

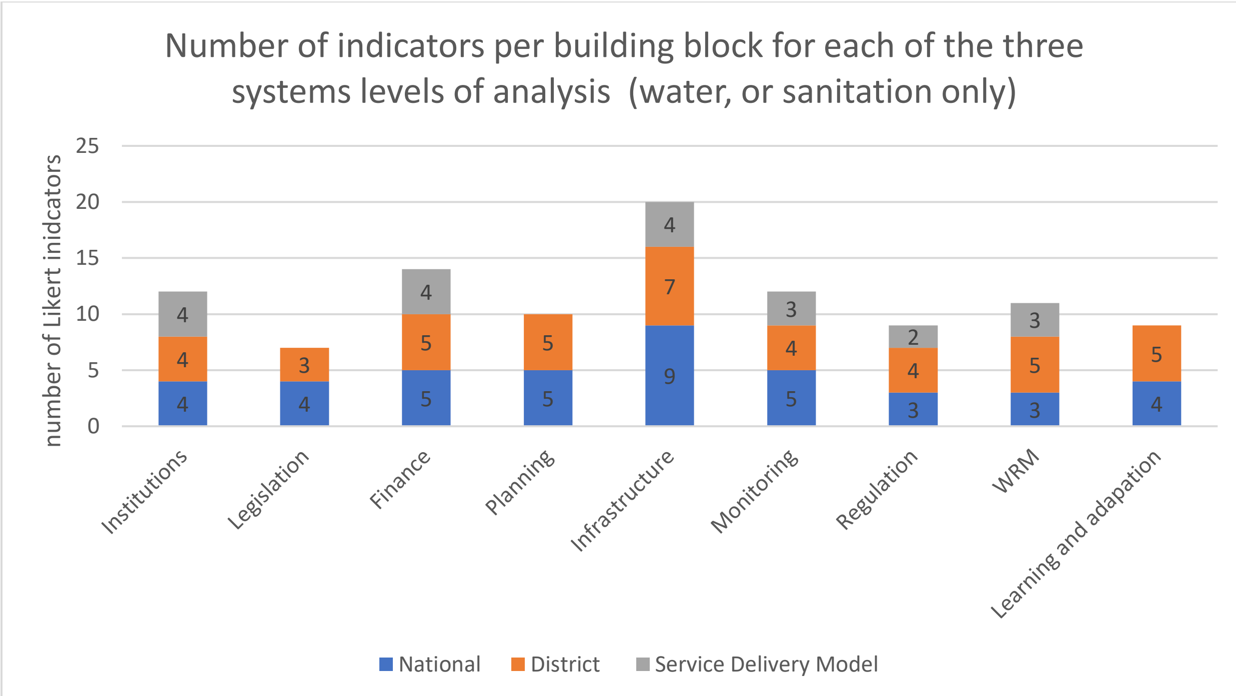


Figure 14: A count of the number of benchmark statements in the analytical framework for the WASH system. For each subsector (i.e. Water, Sanitation) there 42 at national level, 42 at district level, and 19 for each of the service delivery models present in the country

Chapter 4: (Paper 1) Using Sustainability Science to reframe the challenges and opportunities for improved sanitation services in east Africa

Published book chapter

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Published as : Gabrielsson, S., Huston, A., & Gaskin, S. (2020). Reframing the challenges and opportunities for improved sanitation services in eastern Africa through sustainability science. In *Sustainability Challenges in Sub-Saharan Africa II.* P 83-111. Science for Sustainable Societies. Springer, Singapore. https://doi.org/10.1007/978-981-15-5358-5_4

Abstract

Sustainable sanitation services are still unavailable to the majority of people in Africa despite decades of sanitation projects implemented across the continent. Using Sustainability Science principles, this chapter discusses the drivers for and shortcomings of business-as-usual sanitation approaches that tend to fail, using examples from east Africa. A particular challenge for sanitation projects is to find and establish an enabling environment for success; we attempt to identify critical elements required to support this process. Using data from key informant interviews with

sanitation implementers, focus group discussions with sanitation facility users, and visits to sanitation project sites in Kenya, Tanzania and Uganda, examples are provided of characteristics and competencies conducive to breaking the cycle of failure and to developing sustainable sanitation systems in the future. The sanitation approaches presented, although different, all exhibit the shared characteristics of adaptability to the context with local participation, mechanisms to ensure financial viability, technologies that are culturally appropriate and an emphasis on environmental sustainability.

Finally, we offer several policy recommendations for governance structures responsible for sanitation, for external support agencies and for implementers. The examples discussed show promise, but do not guarantee success, as all solutions will require several iterations of adaptation as well as financial and governance support for application at a larger scale.

4.1 Introduction – a new approach to improve sanitation delivery is needed

The availability of Water, Sanitation, and Hygiene (WASH) services is essential for a healthy and dignified life, but these services are astonishingly still unavailable to one out of three people in the world (WHO & UNICEF, 2015). The main purpose of WASH programs is to separate humans from contact with feces (and associated pathogens) to prevent disease transmission through faecal-oral pathways. WASH related diarrhoea is the most widespread and dangerous of these diseases, estimated to have caused the death of 842,000 people in 2012 alone (Pruss-Ustun et al., 2014). The need for sufficient quantities of clean drinking water has long been recognized, but the long-term public health benefits of clean water provision will only be sustained if hygienic sanitation conditions are present (Bartram and Cairncross, 2010). However, recently collated sanitation statistics (2015) indicate that out of the total 962 million people living in Sub-Saharan Africa as many as 220 million (23 %) still practice open defecation, 300 million (31 %) rely on unimproved sanitation facilities, 172 million have limited sanitation services (18 %) and only 270 million (28 %) have access to basic sanitation (e.g. an improved pit latrine not shared with other households (JMP, 2017)). In addition to presenting a health risk, inadequate sanitation is known to have a high negative impact on earnings and the financial benefits to the overall economy from proper sanitation investments are well documented (WSP, 2012, UN-Water, 2008). The World Bank Water and Sanitation Program estimate that poor sanitation costs 18 African countries USD 5.5 billion per year, the greatest proportion of this is associated with premature death due to diarrheal diseases (WSP, 2012).

Approaches and frameworks for implementing sanitation services are abundant, but evidence of long-term success in sanitation interventions remains scarce (Davis, 2016). Across Africa the international development community and national governments have been not been able meet the sanitation demands of rapidly growing populations despite billions invested over the past decade (Davis, 2016; WHO & UNICEF, 2015; JMP, 2017). Although the Gross Domestic Product (GDP) is increasing rapidly in many African countries, the continent is simultaneously coping with the impacts of climate change, high rates of population growth, massive migration into urban areas and expansion of informal settlements. This is resulting in increasing economic inequality, leaving millions of people without the basic human right to sanitation (Cross and Coombes, 2014; UN-Habitat, 2015; Oates, et al., 2014).

From 2000 to 2015 the Millennium Development Goals (MDGs) were driving the international development agenda. This included MDG 7c that aimed to half the number of people globally without access to an improved water source and sanitation facilities (Hickling, 2014). In 2015 it was evident that the majority of sub-Saharan African countries, including Kenya, Tanzania and Uganda, had failed to meet their targets for water, sanitation, and hygiene (WASH), the largest gap being that for basic sanitation (JMP, 2017). While this failure is due in part to the chronic underfunding of sanitation, it is also due to investments, from both African governments and donors, remaining fragmented, inconsistent, and unsupported by national policy (Galli et al., 2014; Ekane et al., 2016). Commitment to improve sanitation coverage was an important step of MDG targets, but the headline indicators drove a focus on infrastructure construction without promoting sufficient investment in supporting systems promoting sanitation use and providing system maintenance (Davis, 2015). The MDGs also limited their scope to the toilet itself and did not consider the entire *sanitation chain*[2], which must be addressed to achieve the long-term health benefits (Galli et al, 2014; Mulumba et al, 2014). Furthermore, the MDGs did not target household and community hygiene practices that must be understood and addressed at the same time as technological sanitation solutions in order to effectively break the fecal-oral disease pathway (Tilley et al., 2014). The newly adopted Sustainable Development Goals (SDGs), through SDG 6, aim to overcome the shortcomings of MDG 7c by including targets for universal coverage, fecal sludge management and wastewater treatment (UNICEF, 2017). These are ambitious targets, that will motivate significant investment. Even with deep understanding of the current challenge and significant global investment, these targets are unlikely to be met in most African countries without a radical paradigm shift in how we *view* and *do* sanitation.

Sustainability Science may help to reframe the sanitation challenge by offering insights about the requirements necessary to implement and maintain sustainable sanitation services in Africa and elsewhere. It is an emerging discipline with a vibrant research community that brings together scholarship and practice from different perspectives (e.g. global and local, north and south) and disciplines from the natural sciences, social sciences, engineering and medicine (Clark and Dickson, 2003; Ziegler and Ott, 2012). Sustainability Science aims to find solutions to 'wicked' problems, i.e. problems characterized by a high degree of complexity, damage potential, urgency, and having no obvious optimal solution (Rittel and Webber, 1973; Wiek et al., 2011). Solutions are sought by attempting to generate, integrate and link use-inspired knowledge and channel it into transformative action through participatory, deliberative, and adaptive techniques (Kates et al. 2001; Bäckstrand 2003; Clark and Dickson 2003; Komiyama and Takeuchi, 2006; van Kerkhoff and Lebel, 2006; Sarewitz and Kriebel 2010; Jerneck et al, 2011; Wiek, 2011; Talwat et al., 2011). The strength of this approach lies in redefining the functions, mandate and scope of scientific inquiry, and understanding human-environment systems as integrated (coupled) rather than separable or even separate (Clark, 2007, Kates et al., 2001).

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[2] The *sanitation chain* refers to the series of processes necessary in order to safely manage human waste. The steps are capture, containment, transport, treatment and disposal/reuse.

Sustainability Science adopts a systems thinking perspective. It is *problem-driven* and *solution-oriented,* making it conducive to understanding and responding to the 'wickedness' posed by poor sanitation in Africa. Using this approach for the sanitation challenge first requires the identification and description of the entire sanitation chain in a particular geographic setting, i.e. how does the system function and perform interventions, while considering the different value-laden goals and objectives (Shultz et al., 2008). For example, one could investigate the balancing and reinforcing feedbacks between the generation, removal, disposal and potential reuse of feces and urine, and the motivation for and impacts of different sanitation interventions on humans and ecosystems. Such an inquiry would require extensive place-based knowledge and use of theories, methods and tools from an array of disciplines (Jerneck et al., 2011) produced in a *transdisciplinary* manner with the involvement of wider societal actors such as NGOs, private sector, national/local government and local communities (Galli et al., 2014). Once the sanitation system is understood, practical solutions to the sustainability challenges identified are sought. Solutions-oriented principles first require questioning the sustainability of existing solutions and then exploring alternative pathways suggested by strategic and operational questions to identify which transition pathways are viable (Loorback, 2010; Jerneck et al., 2011). In the context of sanitation implementation in Africa, this step could include a critical analysis of the applicability and sustainability of water-based sanitation systems (also called wet sanitation)[3] considering their reliance on reliable piped water supply and sewer networks. Wet sanitation may not be appropriate for the water-scarce future anticipated from climate change in much of Africa, and, in addition, only 4.6 % percent of the African population have access to sewers (Oates, 2014; JMP, 2017). This begs at least an investigation into alternative options as a means to meet the SDG goals. As another example, the Sustainability Science approach could be used to explore the *synergistic effects* of turning human waste into valuable products (e.g. biogas,

[3] Wet sanitation refers to a system of capture and transport of excreta that uses water as a carrying medium. This is the Victorian era model used in western style flush toilets and sewer networks. Dry sanitation does not use water and hence does not require sewers but needs an alternative transport and treatment method for the more solid medium composed primarily of faeces.

fertilizers, animal feeds), and how this could contribute to transformational change through the environmental and income generating benefits it could offer (Diener et al., 2014).

Our aims in this chapter, which are approached using sustainability science thinking, are twofold. The first is a heuristic analysis of how the sanitation problem and its solutions are commonly conceived and how this perpetuates cyclical failure in the African context (Section 3). The second is to offer empirical examples from east Africa of a few practitioners who are breaking out of this failure cycle by adopting new and innovative approaches to improve and sustain sanitation service operation and maintenance in the region (Section 4). A description of the methodology precedes the analysis and following it, we discuss the governance implications of reframing the sanitation challenge in the region and make policy recommendations for the future (Section 5).

4.2 **Methodology**

The lack of priority for and the competitive nature of funding for sanitation in Africa reduces the opportunity to talk openly about failure and explains why so few failed projects are reported and documented (Davis, 2016). Not only does this diminish potential learning from failure but also it encourages stakeholders to understate and oversimplify its causes. Our methodological approach, guided by the principle of the systems thinking of Sustainability Science, is two-fold: critical and exploratory. It is critical in its attempt to understand the drivers of systemic failure from a sector perspective and exploratory as it presents particular sanitation schemes whose characteristics allow them to break out of this failure cycle.

4.2.1 Data collection and analysis

Our analysis of the drivers of systemic failure in the sanitation sector incorporates information from academic and grey literature as well as the authors' own experiences from practical sanitation work and research in the region during the last 5 years (2013-2018). Our focus is to identify and discuss crosscutting aspects of cyclic failure in the sector that persist across rural and urban contexts in the region (rather than doing detailed analyses of 'failed' sanitation projects and programmes across east Africa).

An overview of the sanitation context in each country was obtained by conducting seven transect walks combined with informal interviews of different actors. These walks took place in one rural village: Lumuli, Tanzania; and two peri-urban settings: Naivasha, Kenya; and Chuka, Kenya; and four informal urban settlements: Keko in Dar es Salaam, Tanzania; Kibera in Nairobi, Kenya; Kiwanja Ndege in Naivasha, Kenya, and Kabalagala in Kampala, Uganda (see Figure 16).

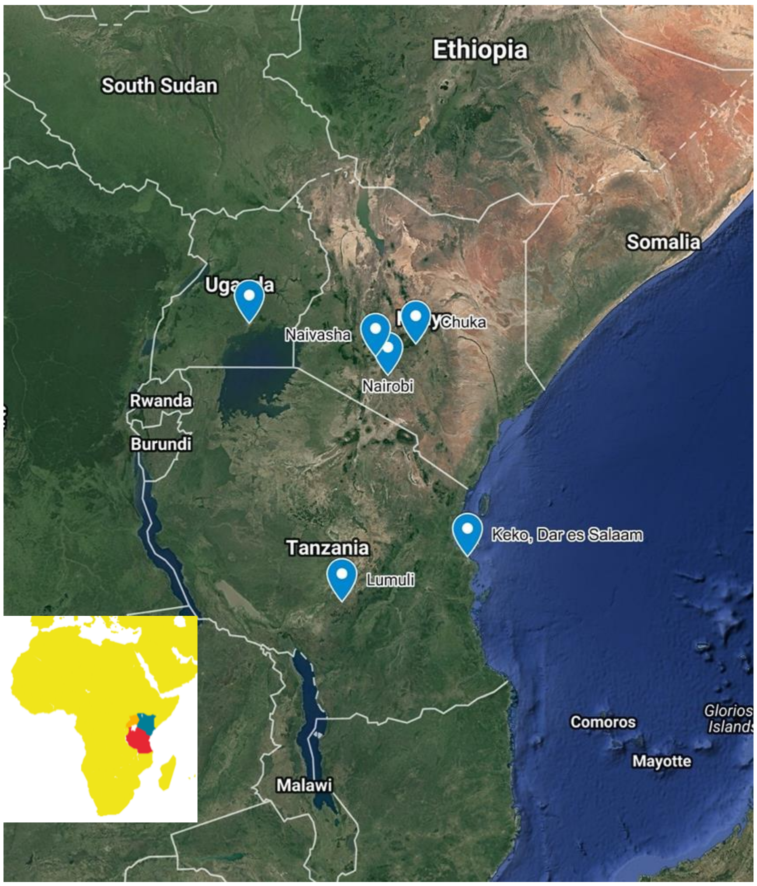

Figure 2: Site visits in Kenya, Tanzania, and Uganda

Case specific data from six implemented WASH schemes in the three countries were analyzed to identify characteristics conducive to breaking out of the failure cycle. The empirical data were collected during fieldwork in Tanzania in July of 2016; in Kenya during June of 2015 and 2016 and in Uganda in June of 2016. The sanitation schemes were selected in communities currently under-served by sanitation services, which had adopted an innovative on-site technology in either a rural or an urban setting. They needed to be self financed (i.e. not charity activities) and could be WASH schemes based on profit-making business models or community-owned and managed schemes. A snowball sampling method was used to identify the schemes to be analysed. The selected cases are summarized in Table 8 and are a representative rather than an exhaustive list of sanitation schemes in the region.

The sanitation schemes were analyzed using qualitative data collected from in-person key informant interviews with staff, from visits to project sites and from focus group discussions with community members participating in the sanitation schemes (Table 7). A desk review of available documentation about each organization's approach, and published peer-reviewed articles about their progress was also conducted. The empirical data were analyzed and synthesized using a Sustainability Science approach, which is founded in an iterative learning process, to identify systemic properties that improve or inhibit sustainability.

Table 7: Key informant interviews. Identified by their position and the date of communication.

Summary of case study data collection

Who	Actor	Where	How
Research officer	Umande Trust	Kibera, Nairobi, Kenya	Key informant interview
Project manager	Umande Trust	Kibera, Nairobi, Kenya	Key informant interview
Deputy director	Umande Trust	Kibera, Nairobi, Kenya	Key informant interview
Soweto High Rise Savings group	Umande Trust	Kibera, Nairobi, Kenya	Focus group discussion
Teacher, St. Christina school	Umande Trust	Kibera, Nairobi, Kenya	Informal interview
Muvi self help group members	Umande Trust	Kibera, Nairobi, Kenya	Focus group discussion
Government relations specialist, management team member	Sanergy	Makuru, Nairobi, Kenya	Key informant interview
Engineer	Sanergy	Makuru, Nairobi, Kenya	Key informant interview
Director	Centre for Community Initiatives	Keko, Dar es Salaam, TZ	Key informant interview

Sanitation engineer	Centre for Community Initiatives	Keko, Dar es Salaam, TZ	Key informant interview
Tumainiletu group	Centre for Community Initiatives	Keko, Dar es Salaam, TZ	Focus group discussion
Co-founder	Sanivation	Naivasha, Kenya	Key informant interview
Energy production, team member	Sanivation	Naivasha, Kenya	Key informant interview
Programme assistant, decent living project	Environment Alert	Kabalagala, Uganda	Key informant interview

4.2.2 Scope and limitations

Our analysis focused on the qualitative aspects of sanitation provision in east Africa. We did not perform a comprehensive technical and financial analysis of the approaches. A rapid assessment approach identified key aspects, that affect the technical and financial viability of the schemes, obtained from key informant interviews with service providers, service recipients, and independent sector actors familiar with the programmes. The aim was to identify novel ideas being implemented in innovative ways that exhibited institutional learning and adaptive capacity. The goal was to identify *promising* approaches that had the potential for long term sustainability. Rather than using a formal definition of *success,* approaches were described as *promising* due to their transformational change potential, in-built flexibility, and suitability for scaling up. These characteristics were obtained using a snapshot from a small selection of schemes in the sanitation sector in Kenya, Uganda, and Tanzania during this research period.

Lastly, it must be recognized that the authors were born, raised and educated in the global north. Therefore, despite our profound recognition of the western bias as a contributing factor for systemic failure it is not removed from our research and perspectives despite having spent significant time living and working in the African context (periodic stays of several months since 2006). We aim to mitigate the influence of the bias by undertaking a context-laden and systemic approach to this analysis.

4.3 Results and Discussion

We first present our critical analysis of the business-as-usual approach to sanitation through a lens of sustainability thinking, and identify persistent shortcomings and trends associated with inadequate solutions. Secondly, we introduce several key ideas/aspects to consider to avoid common pitfalls, which are demonstrated using examples from the literature and field observations from east Africa.

4.3.1 Lack of systems-based thinking

When linear or single-issue thinking is applied, only one possible outcome is considered for a given intervention. In reality, there are many possible long-term outcomes of a single activity. Solving a single issue is likely to reveal problems elsewhere, so solutions are approached iteratively by adjusting, and supplementing them in order to eventually achieve the desired outcome. For example, construction, maintenance, and sustained use of latrines are separate but related issues that much each be addressed in order to achieve the health outcomes associated with improving WASH access. A *systems approach* acknowledges that the overall functioning of systems is more than just the sum of their parts (Stroh, 2015). Such an approach demands a good understanding of the complex interactions within a system prior to developing interventions that aim to shift its dynamics (Stroh, 2015). Systems-based solutions are holistic rather than symptom-based. They are achieved more slowly and their endpoint is more variable than conventional (single-issue) solutions (Galli et al, 2014). However, they are also more flexible because the dynamic and unpredictable nature of the system is recognized. In the context of sanitation, the sustainability of sanitation service provision depends on the interrelated factors of robustness of the economic conditions, effective governance, supportive social systems, and sufficient natural resources (Galli et al, 2014).

4.3.2 Outsider biases

The problems caused by short-term thinking are exacerbated when solutions are designed by outsiders having little or no long-term experience in the implementing context, who are unaware of and unable to predict the possible outcomes of a given intervention. An example from the sanitation sector is community-led total sanitation (CLTS), which seeks to change sanitation habits by triggering shame in communities that practice open defecation, and thus catalyse the construction and sustained use of latrines (Myers and Chambers, 2016). This method was developed in Asia and applied broadly across much of sub-Saharan Africa with little consideration of the different but related needs. While CLTS will produce a peak in toilet construction and use, inadequate consideration of the specific needs for expertise, environmentally appropriate technologies, spare-parts, and context-specific public health behaviour training will limit its sustainability over the longer term and hinder the achievement of the desired health impacts over time (Davis, 2016).

Sustainability Science calls for an increased understanding of the perspectives of the many stakeholders and their capacity to fulfil their roles and responsibilities (Jerneck et al., 2011). In the west, where sanitation systems are well established, sanitation is usually the responsibility of the state (municipality) with its highly trained functionaries. Its operation and maintenance is financed through taxes or user fees, while capital projects are financed by loans and partnerships with upper levels of government. The in-house user interface with the sanitation system, the toilet, is bought by homeowners, but mandated and regulated by public building codes and health standards. These multiple stakeholders and their interactive roles for developing and maintaining a sanitation system suggest that deep knowledge of the context, social behaviours, political economy is necessary in order to understand and remove the multiple barriers to sanitation success. Path dependence refers to the constraint, that the identified set of options/solutions for any given sustainability challenge is limited by past decisions and visions of success that emerge from other contexts and under different conditions (Rip and Kemp, 1998).

The outsider biases, which can be a key cause of the cyclic failure of sanitation systems resulting in a lack of sustainable services in Africa, can be classified as: (a) western bias, (b) expert bias, (c) male bias.

W*estern bias* is the ‘myth of catching up development’ (Mies, 1985), which assumes that the development of all countries will evolve along the same path to reach the same endpoint. For sanitation, the progression is to advance up the ‘sanitation ladder’ from open defecation, via pit latrines and pour flush toilets and finally to toilets connected to a sewerage system (WHO & UNICEF, 2015). Many large-scale projects are locked into the bias of water-based sewerage (Tilley, 2008), and a financial and technological dependency that may not be appropriate or relevant in the east African context. Currently 20 % of the population in East Africa use sewers (JMP 2017[4]), however the majority of strategic plans and legislative frameworks emphasise expansion of these systems as the central infrastructure solution. The bias toward the western standard of a water-based sanitation system fails to recognize the unsustainability of this technology for water-stressed regions, such as east Africa (Penner, 2010). The pursuit of this ideal hampers the organic development of locally appropriate sanitation systems and instills a sense of inferiority or 'backwardness' when a country fails to advance up the linear sanitation ladder (Penner, 2010). Questioning the environmental sustainability and financial viability of the top rungs of the ladder, some scholars are now calling for a revision of the concept of the sanitation ladder to add alternative benchmarks for improved WASH services, which recognize other more sustainable and/or appropriate sanitation technologies for countries of the global south (Kvarnström et al., 2011).

Expert bias is due to outside 'experts' from the global north (or south), often sanitation engineers, who advise local communities on the construction of a pre-determined sanitation technology. Challenges may arise when the outside experts fail to understand the local cultural context and behaviour or practices of the non-'experts', particularly for local decision-making processes in the planning and execution of activities. In one example from Iringa, Tanzania unnecessary conflicts arose when the sanitation engineer from India declared to the village leadership, exerting his power as an expert, that he knew the local needs better than the community who was to use the WASH system. This eroded the established trust between the outsiders and the community, further complicating the implementation of the system, which ultimately led to the abandonment of the project (Project Manager, personal communication, July 4 2014).

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[4] Data from JMP 2017 baseline. Mean estimate for sub-saharan Africa as a whole.

Male bias reflects the domination of men in the sanitation sector across all levels of implementation (Seager, 2010). This poses a major challenge for sanitation sustainability. While women and girls are disproportionately affected by inadequate WASH services due to their biological needs, their roles as caretakers of domestic tasks, and established societal taboos; they have the least power to change this situation (Taylor, 2009; Gabrielsson and Ramasar, 2013; WaterAid, 2015). Males hold the decision-making power in east Africa at all levels, ranging from the individual household, to the sub-village, village, district, region and in government ministries (Gabrielsson and Ramasar, 2012). Unless the men in power fully understand and prioritise the importance of sanitation at all these levels, the sustainable implementation of sanitation systems will be difficult to achieve (Seager, 2010). A typical example of this lack of priority is the fact that the majority (63 %) of school toilets in Tanzania lack facilities to dispose of menstrual hygiene care products, forcing school-girls to dump them inside the latrines (causing clogs and overfilling) or bring the soiled and smelly pads back home (NIMR, 2016).

There are many specific consequences of these outsider biases, but the overall effect is the development of poorly designed, disjointed and misaligned sanitation strategies based on short-term goals. In addition, many sanitation strategies disregard or neglect the needs, priorities, voices and participation of the most vulnerable community members in sanitation projects and related national policies. The pathways leading from sanitation-related problems to the identified solutions are either inadequate and/or inflexible (linear) and therefore cannot access alternate visions of the future.

Inflexible approaches and outsider biases contribute to sustainability challenges for sanitation in east Africa and that may partly explain why current solutions to ‘fix’ the problem(s) are not working. In the next sections, we look more broadly at the enabling environment—the political-economy and governance framework—in which sanitation interventions take place using a sustainability science lens.

4.3.3 Weak governance and inadequate long-term financing

Sanitation interventions and services require the involvement of individuals, households, local communities (and/or schools), operators, and multiple levels of government (Galli et al., 2014).

Many actors must be engaged to coordinate between sectors, however sanitation often remains a low priority even for actors with the legal responsibility for it. In Tanzania, the responsibility for sanitation is divided between the Ministry of Health, Community Development, Gender, Elderly and Children, the Ministry of Water and Innovation and the Ministry of Education, Science and Technology. This contributes to fractured governance and financing as problems are often dismissed as 'somebody else's problem' (Kimwaga et al., 2014; Ekane et al., 2014). Despite large increases in the Gross Domestic Product (GDP) in Kenya, Tanzania, and Uganda, (8-fold, 10-fold, and 6-fold, respectively, since 1990) the sanitation sector has not kept pace in terms of service level improvements and remains chronically underfunded; the population with access to sanitation has only slightly increased[5] from 2000 to 2015 (World Bank, 2017). UN Water found that 80% of countries report insufficient financing for the sanitation sector, which perpetuates the tendency to look externally for *solutions* to the sanitation challenge instead of developing new and robust local financing schemes and owner-operator-regulator relationships (UN Water cited by Davis, 2016). Although sanitation is widely recognized in national-level policies as the responsibility of the government (UN Water, 2014), the international development and non-profit communities play a large role in both financing and implementation in east Africa. The extensive, but often inconsistent, investment from external support agencies have taken over the responsibility of the governments and allowed national and local sanitation systems to remain weak. Sanitation is often bundled with, but as a second priority to drinking water and broader WASH sector activities, while donor-investment remains fragmented, inconsistent, and unsupported by national policy (Galli et al., 2014; Ekane et al., 2016).

The typical 3-5year project funding cycles of NGOs, outside initiatives, and even government programmes, limits long-term planning for sustainability. In a survey of 48 US-funded WASH NGOs, 89% and 96% reported limited timeframe and lack of funding for long-term monitoring, respectively, as key hindrances to their ability to contribute to sustainable water and sanitation services (Davis, 2015). Too often, we observe 'better-then-nothing' solutions that

[5] The percentage of the population with basic satntation services has increased from 25% to 30% in Kenya, from 7% to 16% in Tanzania, and from 6% to 13% in Uganda from 2000 to 2015 (World Bank, 2017)

improve the situation for a short period and then fail, which are repeated and subsequently marked as successes (Jenkins & Sugden, 2006). For example, continuing the CLTS example, communities were successfully triggered to build their own latrines, however many were poorly constructed and could not withstand seasonal floods. After as little as one season, many of the new latrines became open holes filled with human waste presenting safety hazards to the community. Furthermore, without resources to rebuild, although some communities may be triggered to build better sanitation options, without the means to act, they develop a feeling of lesser dignity (Sanitation Engineer, CCI, personal communication March 30 2016). Inability to recognize the systemic inadequacy of linear and piecemeal solutions can lead to cyclic failure and prevent the development of alternative and more sustainable sanitation solutions (Waterkeyn and Waterkeyn, 2013; Strande et al., 2014).

Measuring performance accurately and beyond the initial project period is critical for a data-based learning cycle to increase sustainability. All-or-nothing indicators that report only on the presence of infrastructure and the progression of service provision (linearly) up the sanitation ladder neglect the complexities of sanitation provision. Building on lessons learned from CLTS, we observe that merely counting the number of activities or events triggered is insufficient to track and understand actual improvement. For sustained success, it is important is to monitor if (and how) actual sanitation practices are sustained over time. Many sanitation schemes that have used CLTS to trigger change in sanitation behaviour rarely provide dedicated funding and time for monitoring and reporting (Davis, 2016). This makes it difficult to assess the overall impacts and performance of such schemes.

Monitoring can also lead to perverse incentives. The strong focus towards meeting the MDG targets drove sector initiatives toward improving their national statistics in the fastest way possible, instead of working holistically to reach the most vulnerable and to make sustainable progress (Fukuda-Parr et al, 2014). For example, we saw that in peri-urban areas of Nairobi, Kenya provided subsidies to replace existing latrines with 'improved latrines' in order to improve MDG statistics. However, it was suggested by a local staff member of an involved NGO that these funds may have been better used to address the inadequate transportation and treatment options for waste available in the locality.

4.3.4 Supply-driven solutions

Sustainability science and systems thinking provides a lens to investigate not only the challenges of the broader enabling environment, but also those of the sanitation interventions themselves. Strategies that aim to *solve* sanitation sustainability challenges in Kenya, Tanzania and Uganda continue to be dominated by supply-driven solutions (Nyonyintono and Musembi, 2011). This is reinforced by the outsider biases, where incoming *solutions* may be driven by funding, expertise and technology from donor-countries rather than by the local needs. Such *solutions,* developed with an incomplete understanding of the sanitation system and local context, share certain characteristics that may help explain the limited success of sanitation interventions in the past.

Supply-driven sanitation solutions are typically biased towards the use of hardware. They tend to focus more on the design and construction of sanitation technologies (e.g. toilets), rather than their adoption, sustained use and contribution to change in hygiene behaviour (Strande et al., 2014; Andersson et al., 2016). Generally, a bias towards hardware solutions also implies that the proposed sanitation technology is imposed by the implementing organisation, rather than selected at the local level. A study in Rwanda found, when revisiting households who had received advanced sanitation technologies in their homes (urine diversion dry toilets), that many were not in use or were used improperly, thus negating potential benefits (Ekane et al, 2012). Large investments in technology can also lock the users into a specific technology pathway, limiting their avenues for adopting alternative and new sanitation technologies and behaviours. It may also reduce options to use locally available and more affordable construction materials (Rip and Kemp, 1998; Kvarnström et al., 2011).

This bias was present in the implementation of an integrated water and sanitation scheme by an Indian-based NGO in rural Iringa, Tanzania. The organization insisted on using porcelain-made squatting slabs for their pour flush toilets, to replicate the system they implement in India. However, Tanzania lacks a porcelain factory, so porcelain sanitation ware had to be imported and transported by trucks to the interior of the country. Good quality PVC pipes to distribute water or sewage were also imported. As a result, the costs for this seemingly low-cost sanitation scheme were higher in east Africa than in south Asia, where such construction materials are locally produced. The extra costs in Tanzania must then be borne by either the organization, or the users. If there is no financial mechanism and strategy to enable users to save for this investment or pay for it incrementally over time, it becomes impossible for users to pay. In the Iringa case, the Indian organization did not account for these high material costs at the start of the project, nor make any attempts to enable villagers to pay for the porcelain ware. Costs therefore outgrew the project budget, and funds had to be diverted from other planned activities, such as masonry assistance, which had to be paid by the villagers. Ultimately, this was one of the reasons why many members of the local community opted not to participate in the scheme.

In addition to potentially limiting the availability of (and accessibility to) affordable construction materials, a hardware bias also runs the risk of being culturally inappropriate. A typical example of this would be to insist on building dry toilets in Muslim communities where anal cleansing using water is the norm (Nawab et al., 2006). Another example would be to build only communal toilets in areas where female mobility is constrained and their safety may be at risk, thus limiting their access to and use of WASH facilities (Nallari, 2015).

Many supply-driven solutions are also market-based, and hence managed by private sector stakeholders. Private sector investments offer some promising opportunities, but a disadvantage of such solutions is that the responsibility for the management and costs are borne by the individual, rather than the broader community (Ekane et al, 2014). One example of this is the implementation of Eco-san (ecological sanitation) toilets in Uganda, where households are asked to purchase on-site treatment technologies. While this is promising for the containment of wastes, marketing to household shifts the responsibility to the individual and allows the state to neglect its role in developing services for its citizens. Market-based sanitation initiatives, therefore, allow the government to neglect its responsibility in the sanitation service chain. In Tanzania, as in much of east African, the regulatory environment is under-resourced and thus market-driven solutions run the risk of the private sector exploiting the citizens and neglecting those most marginalised (Ekane et al, 2014). Omitting the most vulnerable segments of society may not only limit the potential increase to the sanitation services to the un-served, but also fail to reach the adopted SDG 6 target of ensuring sanitation for all by 2030.

Ultimately, to develop and sustain sanitation services there is a need for individuals from different backgrounds to use systems thinking for long-term planning to identify the core issues and implement transformative change. Institutional development is important, but human capacity is required to fill and use even the most effective institutional, governance, and financial structures. When capacity and resources are continuously supplied from the outside, the outsider bias persists and there is insufficient investment in human capacity at the local level where it is ultimately needed to sustain change. A study to identify the human resource needs to meet Tanzania's water and sanitation MDG targets found a shortage of 4,501 water supply and sanitation engineers, 447 social development professional and 7,589 O&M professionals (Kimwaga et al., 2013). The development in 2016 of the first local PhD program in sanitation is promising but demonstrates the lack of government priority for capacity building in the sector and the monumental challenges ahead to meet future sanitation demands in the country.

Figure 17: Cyclic failure of the business-as-usual model for sanitation *solutions* in east Africa maps the relationship between the factors and challenges described above and demonstrates how they create a reinforcing cycle of failure for the business-as-usual sanitation sector in east Africa. *Solutions* that start from an incomplete understanding of the problem and rely on path-dependant and often supply-driven strategies are unable to break out of this cycle to find success in the complex environment within which they are implemented. A lack of learning from failure and inadequate space for iteration and adaptation based on inclusive perspectives perpetuates the outsider bias and prevents development of more holistic and sustainable approaches. This prevents strengthening of the enabling environment and makes it difficult to seek support and operate within governance structures.

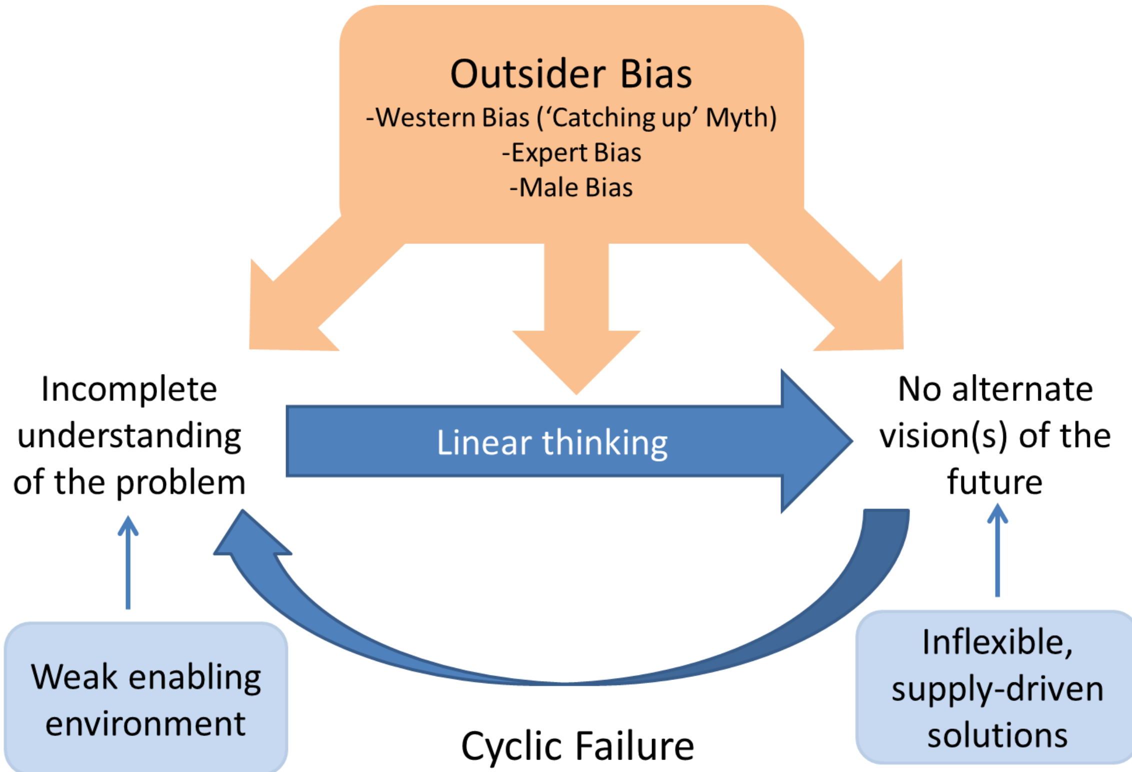

Figure 16: Cyclic failure of the business-as-usual model for sanitation solutions in east Africa

4.4 Breaking the cycle of sanitation failure

In the previous section, we made a heuristic analysis of the key components causing sanitation failure in an African context. A number of actors in east Africa are taking alternate approaches to navigate and overcome these challenges (See Box 1). We identify the characteristics that make them different to the business-as-usual approach, that their adaptive systems incorporate 'soft' elements, and broader systems strengthening builds and supports an environment conducive to sustainability. These cases are similar in three ways. Firstly, they are deeply embedded in the local context; secondly, they have a balanced approach to meeting human needs and assuring environmental sustainability, thereby taking a *service delivery approach;* and thirdly, they recognize the need to move away from aid-based approaches and toward financially viable sanitation futures. Using these three aspects, it is demonstrated how these organisations start from a complex and dynamic understanding of the current situation which allows them to consider alternative future scenarios, rather than being limited to the business-as-usual approach adopted by mainstream sanitation implementers.

These examples are a small selection of examples of *promising* approaches, which are not yet defined as sanitation *successes*. These interventions holistically address several different aspects causing cyclic failure within the sector; nothing however is fail-proof. Their iterative learning-based approach makes them robust and resilient. Particularly successful aspects of their model demonstrate the use of critical sustainability science thinking to overcome the challenges described in the previous section.

Table 8: Selected cases of sanitation actors in East Africa

Umande Trust is a rights-based agency that works in informal settlements ('slum' communities) in and around Nairobi, Kenya. Umande uses a multi-level approach that focuses on delivering a 'product' (e.g. access to urban water, bio-sanitation, solid waste management services) by creating a raft of community-led processes to support it. Such processes are, for example, partnerships for change, integrated urban environmental planning, sanitation governance, human rights and urban services financing. The Umande Trust team is comprised of community organizers, academics, geospatial analysts, urban planners, human rights advocates, civil engineers, social scientists, environmental scientists, and gender, youth and enterprise development resource people (For more information refer to www.umande.org).
Centre for Community Initiatives (CCI) is a national support NGO formed in Tanzania. Its aim is to provide technical and financial assistance to local communities in informal settlements. CCI focuses on building resilient communities and supporting them to meet their needs. Their work could entail the provision of direct help to local communities through the installation of sanitation infrastructure or through provision of complementary support from the community such as establishing savings schemes; community resource mobilization and organization; enumeration and mapping support; exchange visits; partnership support; technical assistance; capacity-building, leadership and management support; outreach, advocacy, action-oriented research and documentation (For more information refer to www.ccitanzania.org)

Sanergy is a social enterprise that provides low-cost hygienic sanitation facilities that are rapidly installed and designed to function in dense informal settlements in Nairobi Kenya. Sanergy employs a franchise business model that provides business training and micro-credit loan opportunities to small-scale sanitation engineers, who then maintain, operate, and expand access to toilets in high-demand areas. Sanergy toilets are urine-diverting dry toilets and the waste is captured for reuse in agriculture and energy production (For more information refer to www.saner.gy)

Sanivation is a social enterprise that installs container-based toilets in homes in communities near Naivasha, Kenya. The toilets are installed for free and Sanivation charges a small monthly fee to empty them, subsequently transforming the waste into a clean burning alternative to charcoal. The enterprise focuses strongly on providing a *service* rather than simply a toilet or charcoal alternative. Thus they focus on the wants and needs of local communities, while at the same time addressing the entire sanitation chain in an effort to reduce fecal contamination hazard in urbanizing communities (For more information refer to www.sanivation.com).

The Decent Living Project in Kampala, Uganda, is a project that aims to improve the lives of people living in informal settlements through the development of WASH services for people's needs. The project takes a three-pronged approach combining advocacy for WASH needs and services, construction of facilities with local artisans, and business enterprise development for supporting a range of sanitation and water-related business models. Environment Alert, the implementing NGO, works a with local entrepreneurs and youth groups to identify and understand local needs and then supports the development of business models to fill these gaps in an equitable manner (e.g. brick-making for improving facilities, waste treatment for use in urban agriculture). For more information see http://envalert.org/phase-2%E2%80%B2-decent-living-dl/).

4.4.1 Place-based solutions

A key aspect of breaking the cycle of failure is to develop sanitation solutions that are appropriate for the physical, socio-economic and cultural context within which they will be deployed (Tilley, et al., 2014). While this sounds like common sense, experience on the ground suggests that sanitation solutions rarely fully fit the characteristics of the area, unless local communities and experts are closely involved in the implementation process (Mbaria, 2014).

CCI in Tanzania now involves the local communities and experts to identify and develop interventions after initial failures to scale-up use of specific and favoured technologies. They acknowledge that when entering a new context, a problem that may initially look the same as one previously encountered is in fact likely to be unique and may require a different approach. There is no ’one size fits’ all solution. This strategy seeks to avoid falling into the trap of promoting sanitation solutions that are eventually abandoned or fall into disrepair shortly after deployment (Stephen, 2013). At the start of each intervention, CCI spends a considerable amount of time to understand the community in which they are planning to work, and then engages directly with individuals and groups within the community to develop the most appropriate solutions. For example in Keko in Dar es Salaam the ground water table is very high, so a water-based system or even an improved pit latrine is not appropriate. With the local community participating in a close consultation, CCI designed and constructed a urine-diversion toilet with three holes that accommodates both the physical constraints of the area (the high water table), as well as the cultural issues (provisions for anal cleansing). Another local community wanted to explore ways to reduce the need for costly pit emptying for household latrines. Families unable to afford emptying services experience seasonal overflow leading to the spread of pollutants through the local environment and the possibility of contaminating the surface and ground water sources (Strande et al., 2014). Working with CCI, they adapted a version of a tiger toilet, an onsite system using worms to process faeces (Furlong, 2016), to reduce the volume of waste, with the added benefit of reducing smell and being able to reuse the vermin-compost for local horticultural production. The combination of demand for the service and the involvement of the community in adapting the technology meant that it was used and appreciated.

Sanivation and Sanergy also have built-in flexibility in their place-based sanitation solutions in Kenya. In their case this flexibility in in the use of local materials for the construction and manufacturing of their services and products. Sanivation relies on simple and locally available machinery to manufacture bio-charcoal derived from human waste, making it possibly to hire local operators without the need for intensive training. This makes the technology scalable and reduces the overall production expenditures, keeping the price of the bio-charcoal lower than its wood-based alternative. This provides consumers with a significant incentive to switch their domestic fuel use (usually fuelwood or charcoal) to bio-charcoal with the added benefit of reducing deforestation and reducing related greenhouse gas emissions (Mwema, 2015).

Sanergy also uses local materials to construct their Fresh Life toilets. These are pre-fabricated at the Sanergy headquarters in Nairobi and are then assembled on-site in two days. As the urine diversion dry toilets can be disassembled (into their cement block components), there is flexibility in use location as they are easy to transport to otherwise difficult to reach areas, characterised by high population density, erratic house planning and lack of access for cars and trucks. The quick assembly time also reduces costs and risk of theft of the materials during the construction process. Moreover, the design of the collection buckets (for both urine and faeces) inside the toilets and the meticulously planned daily collection of the waste keeps the toilets from overflowing. This improves cleanliness and facilitates maintenance for the franchise operators. A few specific components must still be imported, however Sanergy is working to achieve sufficient scale so that it is feasible to establish manufacturing of all parts locally in the Nairobi area (Engineer, Sanergy, personal communication, May 10 2016).

4.4.2 Situating sanitation within broader governance systems

Implementers of sanitation interventions must not only focus on the infrastructure, but also on the social and cultural context in the targeted communities. This means that, in addition to completing the targeted intervention, support is provided to local systems for monitoring, regulation, and maintenance, as well to develop demand for the services (Moriarty et al., 2013). This dual focus can better situate sanitation interventions within the larger system within which the targeted local communities work, live and thrive. Sanitation interventions can be perceived as entry point activities, or stepping-stones, to achieve broader sustainable development goals. Several of the organizations whose approach towards sanitation delivery is more successful, are also involved in issues beyond sanitation. They usually link sanitation delivery to other important sustainability issues related to agriculture, energy, gender empowerment, and livelihood/income diversification, to name a few.

For example, the bio-centers of Umande Trust provide both public access to pour flush toilets and facilities for hand-washing and showering, as well as spaces for cooking, banking, community meetings, houses, and space for the development of local business enterprises. The bio-centers, therefore, offer local communities a place to access affordable sanitation, hygiene services and cooking facilities fueled from the biogas generated from the human waste. The local community is responsible for managing and maintaining the bio-centre, in the process having an opportunity to obtain financial literacy, engage in leadership training, and have alternative income sources. These co-benefits enhance the feeling of ownership and capacity building, and, in particular, build trust among diverse stakeholders. The integration of these communal activities helps overcome community conflicts and is a powerful tool for gender equality, as it can enhance the voices and decision-making power of women (Floret, 2017).

Similarly, the Community WASH Centres in Kampala initiated by Environment Alert (in partnership with WaterAid), are closely managed by a caretaker from within the local community. As a result, users gain access to not only a toilet but also a clean shower and a reliable service for refilling drinking water containers.

4.4.3 Multi-stakeholder collaboration and coordination

As discussed in Section 2, in order to enhance the effectiveness of sanitation interventions it is important to engage with many different stakeholders on different levels. Sanitation provision in urban slums, in particular, exemplifies the need for creative collaboration between different actors, who interact in the geographically and financially constrained environment of informal settlements.

The Umande Trust developed its first community water and sanitation biogas centre in Kibera slum (in Nairobi) in 2004, at a period when the Kenyan government did not recognise such community facilities as safe or viable sanitation options. Umande realized that the sanitation technology options outlined in policies at that time (e.g. household latrines and septic tanks) were not feasible options for residents of Kibera. It immediately began advocating for both improved sanitation from a rights-based approach, as well as to gain legitimacy for their technological solution as a sanitation option that could meet the needs of the most vulnerable residents of the slum. Umande simultaneously built up the business skills of the groups operating the toilets and advocated to be recognized as a formal stakeholder for urban sanitation in Nairobi in order to increase their voice and influence within the sector. This was essential to ensure recognition of their community sanitation centres as a safe and viable options to prevent any future conflict with the government, and to prepare the ground for possible future collaborations with the government.

Sanergy followed an entirely different approach to sanitation in informal settlements prioritising change at the policy level. They employed more than six full-time staff members to work on building a relationship with different levels of government through involvement in ministry working groups and municipal planning teams. These staff members are advocates for policy change, who promote the harmonization of Sanergy’s activities and targets with those of the government. They also work to support the development of capacity in the government for the regulation of their services as a step toward a more sustainable and scalable model of service provision (Government Relations Specialist, Sanergy, May 10 2016).

In addition to working closely with community members and local organisations, CCI also works in partnership with Dar es Salaam’s public water and sewerage utility company DAWASA on several projects. CCI is also a member and avid participant in activities and conferences organized by Slum Dwellers International, a network of community-based organisations that advocates for the human right to land and to basic services in informal settlements by sharing lessons from other organizations working in similar contexts.

4.4.4 Alternative funding mechanisms

The public financing gap for sanitation in east Africa combined with the unpredictability of donation-based finance models suggests the need for innovative funding mechanisms to increase the financial viability of sanitation service delivery models. The western model for sanitation is defined by government laws and regulations and is financed by a robust taxation and public financing system to operate and maintain the infrastructure (and its management) for the transport and treatment of waste, while the user invests directly in toilets in the home. In the long-term, it is the responsibility of the government to provide basic water and sanitation services. However, the severe limitation of government budgets and capacity in east Africa, due to a great extent to the enormous rate of population growth and urbanisation, means that in the interim demand for the service is provided by a market of sanitation service providers, who are independent organisations, private businesses and social enterprises.

Sanergy's approach is robust as its innovative resource-recovery technology establishes a value chain that integrates the demand for toilets, need for employment, development of business opportunities, production of organic fertilizers and provision of a source of low-cost energy. By using a franchise model of individually-owned public pay-per-use toilets, Sanergy remains scalable and adaptable to the diverse and changing needs in densely populated urban settlements. Micro-credit loans are available for new franchise owners, who are supported with training in business management and accounting. Toilet owners pay a monthly fee to Sanergy, who in return hires individuals to clean and empty the urine-diversion dry toilets on a daily basis and makes a profit by converting the 'waste' into fertilizer and bioenergy. Thus, both the business model and the technology are suitable for dense informal settlements and are flexible and adaptable to the changing urban landscape. Sanergy has received extensive financial support from donors, and the initial investment was important for overcoming the hurdles of developing an innovative start-up business. Its social enterprise model aims to achieve financial independence for both the company and the franchise owners. Rather than only providing the sanitation infrastructure, the *service delivery* model considers the complex system of the operating environment and can become an established private service provider for unplanned settlements that cannot be served by municipal governments.

Like Sanergy, both CCI and Umande Trust have developed pay-per-use systems for shared toilets that generate revenues to meet operational and maintenance costs. The concept of paying to use a toilet is not new, but there are many aspects to be considered to increase the sustainability and financial viability of this model. Umande Trust also recognizes the danger posed of walking outside at night carrying cash to use a toilet. To reduce this disincentive to use the toilet, payment can be made with a personalized no-cash punch card that reduces the risk of robbery. In addition, they choose only to work with pre-existing community groups as managers for new facilities to reduce the potential conflicts between group members jointly managing the community WASH business.

These three organisations work with an innovative financial model to support sanitation service delivery. In addition, they invest in the people needed to operate them. Rather than, or parallel to direct financial support, they facilitate skills training, entrepreneurial coaching, leadership development and business management. As the deputy director of Umande stated 'We don't build toilets we build communities' (Deputy Director, Umande, Personal communication, July 10 2015).

4.4.5 Enhancing value addition and co-benefits

One common thread in the more holistic approaches to sanitation discussed above is the recognition that human feces can potentially be a valuable resource rather than merely a waste flow whose environmental impacts have to be mitigated. Human waste can be transformed into either organic fertilizer, animal feed or an energy source (Drechsel et al, 2011).

For example, CCI and Sanergy convert human urine and faecal waste into fertilizers to be used for agricultural purposes, which are in high demand in east Africa, because soil fertility is low and chemical fertilizers are expensive (Diener, 2014; Andersson, 2015). Sanivation develops bio-charcoal and Umande biogas derived from human waste, both of which can be used as a domestic fuel for cooking. As a co-product of the sanitation service, it provides an added income stream, while it also reduces the demand for conventional cooking fuels such as charcoal and fuelwood. The use as an energy alternative has substantial co-benefits related to reducing pressure on ecosystems and reducing the time needed by women and girls to procure fuel (Drechsel et al. 2011, Diener et al., 2014, Semiyaga et al., 2015).

The above are good examples of Sustainability Science thinking, where adoption of both a problems-focused and solutions-oriented mindset provides solutions to both persistent social and environmental sustainability challenges (Turner, 2003). The vision is of an alternate future--where human waste becomes part of a larger resource recovery value chain--and coordinated action by multiple actors are combined to enact behaviour change (Tilley, et al., 2014).

The examples illustrate that the actors promoting resource recovery in east Africa tend to adopt a systems-thinking approach as part of their promising operational models. These models have *solutions* that are deeply embedded in the needs of the local communities, and that recognize that sanitation service provision depends on a system that is made up of many different actors and users. Flexibility and adaptability are key elements of their operational models as they invest both in people and in infrastructure.

In summary, these examples illustrate that breaking the cycle of failure is possible if the enabling environment is enhanced and supported in the long term by developing the key competencies needed to respond to wicked sustainability challenges.

The enhancement and support entail being *descriptive* in how specific needs and linkages to other systems are identified; by being *critical* to universally accepted sanitation solutions; by being *cooperative* in the design, implementation, management and monitoring of activities; and by being *visionary* through the inclusion of new ways of handling waste and turning it into value for the benefit of people as well as the environment (Wiek et al., 2011).

4.5 Policy implications and recommendations

Given the complexity and heterogeneous nature of the sanitation challenge in east Africa, coupled with a growing population, urbanisation and increasing environmental concerns, we suggest that future sanitation policies avoid taking a one-size fits all approach. The examples discussed show how awareness and use of place-based knowledge, flexible financial mechanisms, systems-thinking and value-addition in the sanitation chain can enhance the likelihood of sustainability of a given intervention. Given the importance of a supportive enabling environment for success and scale-up of such ideas, particularly in the form of government recognition and oversight and creative mechanisms for long-term financing, a critical policy recommendation is for small scale trials of a range of sanitation interventions followed by a comprehensive analysis of the context in which they are implemented. Furthermore, it is essential at all stages to create meaningful ways to include diverse local voices not simply through a consultative process but through equal partnerships and/or leadership positions. By including diverse voices that counter-balance the three types of outside bias (expert, male, western), it becomes possible to understand how infrastructure, management, and awareness-raising approaches can be integrated to fit local needs. Expertise within Kenya, Tanzania and Uganda needs to be recognised, and the critical resource gap should be targeted not only with solutions-oriented projects to treat 'symptoms' of the inadequate sanitation system, but also with long term investments to build local knowledge and human resource capacity within the sector. These areas include, but are not limited to: integrated sanitation management, environmental engineering, hygiene education, menstrual hygiene management, community leadership and facilitation, faecal sludge management, resource recovery technology development, sanitation financing, sanitation marketing and sanitation business development.

Recognising the continued and significant support from external agencies, a key recommendation for donors and international actors is to couple all projects and programmes with genuine efforts to support local systems and support government initiatives. Clearly, short-term funding cycles and a need to show immediate and measurable results present a challenge to even the most well-intentioned donors, but creativity can help pair shorter term interventions with sustainable local systems building. While the SDG headline indicators are important, care should be taken to develop and use more holistic monitoring approaches that reflect the messy nature of progress in complex environments, and the multiple factors needed for sustainable change. A series of 'sustainability indicators' are available that aim to evaluate the likelihood that an intervention or a piece of infrastructure will last over time. Some donors, such as The Netherlands Ministry of Foreign Affairs (DGIS) has implemented a clause to all of their funding contracts that requires implementers to perform an annual assessment of sustainability indicators, in addition to taking other planning and long term funding measures, to guarantee that projects function a minimum of ten years after initial completion (Ward, 2017). When applied properly, such measures promote the development and support for local systems from the beginning that will then adopt and maintain improvements made during the project period.

The fragmented nature of the governance of sanitation can be addressed by strengthening cooperation and coordination between national agencies and ministries responsible for or with synergies to sanitation, and by developing sector learning platforms and review mechanisms to provide space to jointly discuss and plan to address critical issues. These same mechanisms can offer opportunities to identify common challenges and inadequacies, but also to highlight successes and share learning from promising examples such as the case studies included here. Certainly, this can only happen when multiple actors are able to recognize the limitations of the existing sanitation service delivery models, particularly in informal settlements in growing urban areas, which requires documentation of successes and failures. Innovative approaches and ideas can be used in advocating for and updating national policies to be more supportive of scaling up successful projects. Furthermore, efforts should be made to develop technology policies that do not favour one technology over another but rather encourage customized designs appropriate to the diverse urban and rural landscapes. Policies can be developed to guide private sector investment, but care should be taken that an effective regulatory mechanism is in place for these actors at both national and local levels. Minimum norms and standards must be set for design and construction, as well as pro-poor policies instituted that promote affordability, longevity and environmental sustainability. Sanitation interventions need to be integrated into the broader set of policies that recognises the diverse needs and contexts across a single country or city.

Sector learning platforms can encourage collaborative partnerships between research institutions, NGOs, government and private companies to explore and finance new innovative sanitation pathways through mechanisms such as sanitation working groups, and learning teams. Financial support for convening learning platforms can be built in or annexed to donor-financed projects.

Civil society organisations can contribute to developing documentation recording the realities of current inadequacies, as well as contributing comments on and advocating for options more suited to their needs. As many CSOs are constrained by resource limitations, partnerships with research institutions, private enterprises, and other parties with common interests can be helpful in supporting this grass-roots advocacy. Human Rights organisations around the world can be engaged to invest in sanitation issues.

The promising examples presented here all found ways to remove the economic constraint to their work. Effort was made to establish sustainable business models, however, all still required and received seed funding—or even long-term donor support—through the development phase. It is once the economic constraint is removed that innovation is possible. Donors and investors should consider offering financing options in the form of start-up grants and loans to more diverse implementers. These can be accompanied by financial training to small and medium sized private companies wanting to start a sanitation enterprise to promote innovation in the sector. For financial sustainability, sanitation service schemes must include consideration of different mechanisms for revenue generation, including user contributions or service payments for the building and maintenance of the sanitation services offered.

4.6 Conclusions

Using Sustainability Science as a guiding lens, we have attempted to reframe the sanitation challenge in east Africa to not only identify factors that perpetuate sanitation failure but also to identify characteristics and competencies conducive to the development of sustainable sanitation systems in the future. Through cases study examples, we have shown how a number of actors in the WASH sector in east Africa have managed to break the cycle of failure and develop alternate sanitation pathways that fit the geographical, cultural, and financial realities of each context. The sanitation approaches used, although different, all demonstrate adaptability to the context, mechanisms to ensure financial viability, technologies that are culturally appropriate and an emphasis on environmental sustainability through resource recovery and closed loop thinking. However, the scale of the sanitation challenge is enormous and it must be tackled by large-scale government initiatives with significant investment in capacity building at multiple levels to create an enabling environment that recognizes that challenges are trans-disciplinary and multi-scale, affected by governance, finance, and sector coordination.

While the empirical examples from east Africa show promise for scalability, they are still small scale relative to the scope of the problem. They show that alternatives to the business-as-usual approach to sanitation service delivery are both feasible and desirable. We can learn from both their strengths and their limitations when investing in new ideas and alternative sanitation futures.

By demonstrating the multiple benefits of improved sanitation, not just on health and dignity, but for livelihood income diversification, gender empowerment, and on protection of water sources and potentially on food and energy systems, we have demonstrated potential use of sanitation as a stepping stone for reaching a number of the sustainable development goals. If the demonstrated systemic linkages and mutual benefits are recognised beyond the community scale to become anchored in east African government policies and funding priorities, they could create the right enabling environment at the regional, national and sub-national level for success at scale. However, to achieve universal sanitation coverage, a radical paradigm shift in how we *think about* and *do* sanitation, supported sustainability science principles, is required. Only then will we be able to learn from past failures and build capacity in human resources locally in the present, to enable investments in futures that we have not yet imagined.

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Logical bridge 1 (connecting material)

In Chapter 4, characteristics associated with failure or success of sanitation interventions in East Africa were identified. Recommendations were made on how to overcome cyclic failure, based on case studies of promising approaches. One key finding was the need to have a more complete understanding of the context, which can be accomplished through participatory and transdisciplinary methodologies and local leadership. The promising approaches had overcome barriers to sustainability by finding ways to avoid linear thinking and account for complex social, institutional and financial factors.

Sustainability science as a theoretical lens is not retained in Chapter 5, but many of the insights and recommendations from Chapter 4 are taken forward. A pragmatic participatory action-research strategy is chosen for Chapter 5 and the remainder of the thesis. In Chapter 5, I show that the findings on sanitation from Chapter 4 align with wider findings from the water, sanitation, and hygiene (WASH) sector. The scope of research is expanded to include a general discussion of the WASH sector in other low- and middle-income countries.

The guiding research questions in Chapter 5 are 'What does a resilient WASH system look like, what are the main sub-systems or 'building blocks'?' and 'how can they be objectively measured?'. To answer these questions, the WASH sector is conceptualised as a public service system. The public service framing helps to reject the project-based paradigm and mitigate outsider bias described in Chapter 4 by focusing on national systems. A conceptual and analytical model for the system is developed, with the aim to be usable by practitioners and local actors. The framework developed in Chapter 5 is applied in an in-depth case study in Uganda in Chapters 6 and 7.

Chapter 5: (Paper 2) A conceptual framework for viewing rural and informal water and sanitation delivery as public service systems

Journal article submitted and in review at Water Policy (International Water Association)

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Abstract:

The case is made for viewing drinking water, sanitation, and hygiene (WASH) as public services delivered by complex public service systems, with a focus on the 'informal' WASH sector in low and middle-income countries. A conceptual framework for describing and analysing WASH in rural and peri-urban contexts as a complex public system is developed based on 12 years of emergent praxis, refined through expert consultation and action-research in six countries during 2017-2019.

The complexity of the WASH system is simplified to nine sub-systems that can be thought of as windows onto, or building blocks of the whole system: policy and legislation, institutions and coordination, regulation and accountability, monitoring, planning and budgeting, infrastructure development and maintenance, finance, water resource management and learning and adaptation. In the analytical framework, the main actors, functions, and components are assessed.

The objective of developing the tool is to support stakeholders to understand their system well enough to identify strategies to influence and improve outcomes. The framework can also be used to organise and guide multi-stakeholder dialogue within collective action initiatives, and

as a communications and advocacy tool for national and international decision-makers to encourage use of more holistic approaches.

5.1 Introduction

Access to water and sanitation services is a human right widely understood to be the responsibility of national governments (United Nations, 2010). As with other public services, water and sanitation provision has been described as networks of stakeholders working together to plan, operate and improve services over time, under the leadership and direction of government (Rhodes & MacKechnie, 2003). In many low- and middle-income countries, however, there is a divide between the urban sector where the formal corporate management of utilities and importance of supply chain management are unquestioned, and the rural and peri-urban sector, which is institutionally weaker and less structured. Our focus is on the latter, which has come to be known as the water, sanitation, and hygiene (WASH) sector. Under the decentralisation policies in many countries, responsibility for WASH and other public services is typically formally assigned to local government (Lockwood & Smits, 2011). However operationally in many countries, the rural and peri-urban WASH sector is not so much an actual sector with a defined budget and fixed set of actors, but rather a loosely connected set of objectives that span several sectors including water supply, health, environment, and agriculture. Developing and sustaining WASH services requires the coordination and collaboration of both public and private actors, although the frameworks for doing so are often poorly defined.

Globally, more than 90% of water and sanitation services are provided by the public sector (Hall & Lobina, 2006). Water and sanitation have the attributes of other public services, such as intended universality, a reliance on public finance, and co-production through a network of institutions and supply chains with the objective of achieving a common benefit for consumers (Hall & Lobina, 2006; Rhodes & MacKechnie, 2003). The public nature of piped water and sewered sanitation within the formally defined and regulated urban sector is largely undisputed. Yet in the WASH sector of many lower and middle income countries, the notion that these are public services delivered by public systems is not widespread, in part due to the influence of international development actors over the past several decades. Use of WASH services ultimately happens at the household level making it possible to dismiss the provision of such services as individual or community level responsibilities, despite their designation as human rights (Schouten & Moriarty, 2013). The historical and sometimes spiritual understanding of water as a natural gift, followed by decades of charity water by international actors, adds complexity to the understanding of drinking water as a public good, both for communities and for governments (Schouten & Moriarty, 2003).

In the rural, peri-urban and informally managed WASH sector throughout the 1980-2010 period, responsibility for WASH was often transferred to volunteers under various models of community management in an attempt to minimize costs and achieve cost-recovery (Schouten & Moriarty, 2003). Sanitation improvements through community-led initiatives such as Community-led Total Sanitation and 'market-based approaches' similarly shift responsibility to individuals, volunteers, or bottom-of-the pyramid entrepreneurs (Munkhondia et al., 2016). Despite recognition of the importance of institutionalised capacity support for community level supplies and systems since the 1980s (Cairncross et al., 1980), until recently many WASH actors have overlooked the importance of permanent government support to ensure service sustainability (Schouten & Moriarty, 2013). In short, they have been blind to the WASH system.

The decentring of government and focus on individual and community responsibility for WASH service provision is slowly starting to change. Since 2010, seventy national governments of low- and middle- income countries have joined the Sanitation and Water for All partnership for accelerating government-led service provision (SWA, 2020). The partnership includes a role for international actors, but is based on the understanding that WASH service delivery takes place in a complex, government led system, which can only be improved by supporting this system in its entirety (SWA, 2016). A leading voice and financier in non-sewered sanitation, the Bill and Melinda Gates Foundation, recently published an unambiguous statement that their work will take place within a public service framing (Schrecongost et al., 2020). While many look to the private sector and non-state actors, Schrecongost et al (2020) claim that the essential nature of WASH requires a significant role of government in structuring and regulating the market.

The interdisciplinarity and complexity of water and sanitation service provision as a multi-actor system makes a shared framework for guiding progress important (Wiek et al., 2006). A growing number of practitioners now use 'systems approaches' and systems thinking as a way to acknowledge the complexity in local and national systems, and to ensure their interventions are responsive to, and supportive of, public systems development as way to sustainably improve services (Valcourt et al., 2020; UN-Water & WHO, 2019). Still, there is no consensus on what the system for WASH service delivery is comprised of or what the standards and benchmarks should be for assessing its development and performance.

Our objective is to present a practical framework for understanding and systematically supporting local and national public service delivery systems. Systems-thinking is used to understand and reduce the complexity of the WASH sector. We report on our work as IRC, an internationally operating Dutch NGO that describes itself as a 'think and do tank', dedicated to supporting public systems in pursuit of universal and sustainable WASH services in line with the targets of Sustainable Development Goal 6. IRC's experience is primarily in the peri-urban and rural 'informal' WASH sector, working toward both bottom-up change through collective action and advocacy driven top-down policy change and investment (Huston & Moriarty, 2018).

5.2 Developing theory and practice for WASH systems strengthening

Although ultimately the responsibility of government, public services are delivered by a network of organisations and institutions; the quality of the services is influenced by the relationships between the actors and with the society as a whole (McLaughlin et al, 2009; Rhodes & MacKechnie, 2003). Services are improved when there is a demand by society, and they are changed over time as the quality and specification for services demanded by both citizens and the larger network of service providers shifts (Kemp et al., 2007). To develop more effective service delivery systems, involving the wide network of stakeholders in a collaborative process to improve services helps to both learn about the system (Butterworth et al., 2011) and to co-create a shared strategic direction for the intended change.

A detailed and shared understanding of the current situation and the desired change trajectory is central to success of organisations and collaborations (Wiek et al., 2006). Whether collective action is pursued through formal sector coordination mechanisms or through facilitated social learning alliances, it is important that stakeholders have the tools and vocabulary to systematically define the scope of the shared challenge and the anticipated solution and/or end goal (Butterworth et al., 2011; Pugel et al., 2020). Mapping the system and collectively framing the challenges according to different viewpoints helps individuals and groups to broaden their perspectives, identify new solution pathways, and change behaviour (Wiek et al., 2006). When government decision-makers, planners, and public servants are engaged in this social learning process, it becomes a way to shape the future of public service delivery.

For universal water and sanitation services, this vision needs to include specific targets for the type and standard of services to be delivered to each segment of the population, and a clear articulation of how and by whom these services will be developed, paid for, maintained, and upgraded over time (Moriarty et al., 2011). The aims and targets of the Sustainable Development Goals and the service standards defined by the Joint Monitoring Programme provide a foundation for this vision (WHO & UNICEF, 2017), however these global standards are not intended to specify precisely how service are delivered or what the system should look like.

Our hypothesis is that formalisation of sector processes (together with a more universally understood framework for WASH systems) is necessary to ensure that adequate standards of services are provided to the entire population. This is achieved through simplifying the perceived complexity of WASH systems through the development of a conceptual framework that introduces a core set of language and concepts. With a shared framework, multi-stakeholder networks have a more coherent and detailed understanding of the current situation and the future visions, which informs planning and action for greater sector efficacy.

5.3 Methods: A framework to understand WASH as a system

Grounded in a complexity informed and action-research based development philosophy (Flood, 2010), as researchers and practitioners, our objective was to support stakeholders to understand public systems well enough to identify leverage points for action to influence and improve outcomes.

The conceptual framework presented was developed and refined by experts on the planning, monitoring, and learning team at IRC, together with staff across IRC's six focus countries of Burkina Faso, Ethiopia, Ghana, Honduras, India, and Uganda. A working paper on the concept was published and disseminated in 2018 to generate additional dialogue, feedback and critique from sector stakeholders at both the global level and in the countries where IRC works (Huston & Moriarty, 2018). Other actors in the WASH sector are using similar frameworks (see for example Drabble et al., 2018; SWA, 2016; Tillett et al., 2020; UNICEF, 2016).

In line with our praxis, the approach to developing the framework was pragmatic, participatory, co-designed with stakeholders, and included both quantitative and qualitative methods (Feilzer, 2010; Boulton et al., 2015). As action-researchers, we were not in a position to try to control the behaviour of stakeholders or to rigidly apply theory in the different country contexts (Long et al., 2018). By designing a conceptual and analytical framework intended to be applied flexibly and adapted for use with both qualitative and quantitative methods, our aim was to produce something that was above all useful: a reliable framework grounded in theory but driven by purpose (Long et al., 2018). The framing and definitions provided by such a framework can be see as a heuristic tool to help navigate the complexity of service delivery when viewed as part of an interlinked public system.

Our thinking has been influenced by and connected to broader efforts in the sector to define the key dimensions for 'progress,' 'sector performance', 'sustainability,' and the 'enabling environment' for WASH services (AMCOW, 2011; SWA, 2016; The World Bank, 2017; UNICEF, 2016). Both Lockwood and Allely (2017) and Mason et al. (2019) have recently mapped the use of such frameworks in the WASH sector. Roots of this thinking within IRC can be traced to 2003 (Schouten & Moriarty, 2003). By 2008 an early version of the framework presented here was used to study rural water sustainability and scalability in Ghana, Uganda and, by 2012, in Mozambique (Schouten & Moriarty, 2013). Our thinking has also been influenced by the continued pursuit, particularly by some WASH sector funders, of a more comprehensive approach to measuring and monitoring the (likelihood of) sustainability of services (Boulenouar et al., 2013; Lockwood & Allely, 2017).

Outside the water and sanitation sector, we drew on the complexity sciences (Boulton et al., 2015), public administration (Haynes, 2015), transition management (Kemp et al., 2007), and sustainability science (Komiyama & Takeuchi, 2006) to shape our thinking. Given the similarities between WASH and other public services such as health, education, energy, and transportation, we also looked at examples of how these sectors have been conceptualised as multi-actor and multi-level systems to improve the coordination of interventions and to improve outcomes (see for example Long et al., 2018; OECD, 2017).

5.4 Results: A conceptual framework for WASH service delivery

The WASH system boundary is defined by identifying the people, institutions, processes, and functions that are involved in the lifecycle delivery of WASH services. Water and sanitation services are delivered by different 'service delivery models,' such as utility provision through piped networks, community-based management of point sources, professionally operated sewerage networks or on-site sanitation facilities managed by households (Lockwood & Smits, 2011). Each model has its own system of technology, actors and institutions, although these are not always clearly defined in national policy frameworks. The system boundary includes the subsystems needed to support all of the service delivery models present in a given context.

A public service system is an open system connected to and influenced by the surrounding political economy (Haynes, 2015). Details about the broader national context are left outside the WASH system boundary in our conceptual model to keep the complexity of the framework to a manageable level, yet these dynamics affect public sector work and stimulate adaptive behaviour of stakeholders, and are commonly cited reasons for investment failure (Lockwood & Smits, 2011). They are, therefore, analysed descriptively when the framework is applied in a specific context.

The framework we have developed is reported on here as a model for the WASH system as whole. It can also be used to separately assess water, sanitation, or hygiene as individual systems; this produces a more nuanced and practicable result as each sub-sector is comprised of different actors, factors, and functions for service delivery. Hygiene service delivery requires both infrastructure and behaviour change interventions, so some adaptations to the framework are required for optimal use.

As for other public services, drinking water and sanitation are the product of decisions and actions taken at multiple levels (OECD, 2017). In each country these services are provided through unique structures of administrative, fiscal and political decentralisation; at minimum there are two key levels: national and 'district'. In most countries, sector policy and strategy is determined by the central (national) government, with specific functions such as service planning, oversight, and monitoring allocated to local government, which operates at an institutional level that for simplicity we refer to, generically, as the 'district' (The World Bank, 2017). The framework can be further adapted to look at state, regional or other key administrative levels at which key WASH functions are assigned.

The word 'district' itself is used to refer to the administrative level where the majority of service authority[6] functions are found and where the responsibility and a budget for public service delivery lies. It could be the commune level as in Burkina Faso, the woreda as in Ethiopia, or the municipalidad as in Honduras.

A public service systems perspective in WASH requires an understanding of both the intended processes for the sector set by central government and the application of central policies in practice at decentralised levels. Mapping out roles and of responsibilities for key functions according to the administrative levels at which they are assigned can help to identify inconsistencies or shortcomings in the overall WASH system architecture. Actions undertaken to improve outcomes may take place at either level—through top-down reforms or bottom-up capacity building and innovation—but it is important to understand the system's overall structure well enough to plan actions at the appropriate level, and to achieve impact and scale up the actions.

5.4.1 Introducing nine windows for viewing the water and sanitation systems

Nine key elements or sub-systems of WASH as a public service system are introduced (see Figure 17). We refer to these elements as 'windows' here and as 'building blocks' in other work. Both are useful but imperfect metaphors; the former demonstrates their value for reframing and looking at the system from different perspectives, the latter emphasizes their essential nature as part of the system. Though complex systems cannot be fully understood by looking at their

[6] Service authority is defined as the entity legally responsible for ensuring the quality of WASH services in a defined area and the performance of the service provider(s). The authority may hold delegated functions of regulatory power. In practice, the service provider may also be granted some service authority responsibilities.

requisite parts, breaking the system down into smaller sub-systems that can be viewed individually is a common way to confront the bounded rationality of our ability to interpret complexity (Mason et al., 2019; Valcourt et al., 2019; WHO, 2010). By looking systematically through each window, a more comprehensive understanding of the whole is gained. This can be done by coding mixed data sources per window for a descriptive and thematic assessment; we also developed Likert scale indicators that are used to assess the minimum and desirable attributes for each window. Our understanding is that core functions in each of these windows must be developed to at least a minimum level (i.e. the criteria in the Likert indicators) in order to achieve sustainable and universal WASH services through a public system.

The nine windows are:

- Policy and legislation
- Institutions and coordination
- Regulation and accountability
- Monitoring
- Planning and budgeting
- Infrastructure development and maintenance
- Finance
- Water resource management
- Learning and adaptation

The exact boundaries of each window may be fuzzy and certain parts of the system can be seen through more than one window. This selection of these nine emerged from our praxis as IRC and experience that these are useful and practical delimitations for analysis and planning; other sets of 'building blocks' exist in the sector and are used by other organisations and initiatives (see for example Gensch & Tillett, 2019; Mason et al., 2019; SWA, 2016; Tillett et al., 2020; UNICEF, 2016). While there is agreement on the importance of most of the features of the WASH system, there is no commonly agreed set of such key descriptors of the WASH system globally and they receive varying levels of attention and investment. In this, the WASH system differs from the more formal utility service provision of drinking water, where a well developed and globally accepted set of standards and benchmarks exists (Lockwood & Smits, 2011).

When viewing the WASH system through these windows (Figure 17), it is important that the essential role of service delivery models and the level of service provided are not lost. These models define the mechanisms by which the subsystems work together to deliver services. The performance of the systems must be judged by the quality and universality of the services provided. The windows can be used to study each service delivery model individually to provide detailed information, since the body responsible for the different sub-system functions can vary between service delivery models, even within a geographic area. For example, the legislation, monitoring, and regulation for utility services tends to be much more clearly defined than that for community managed services or self-supply.

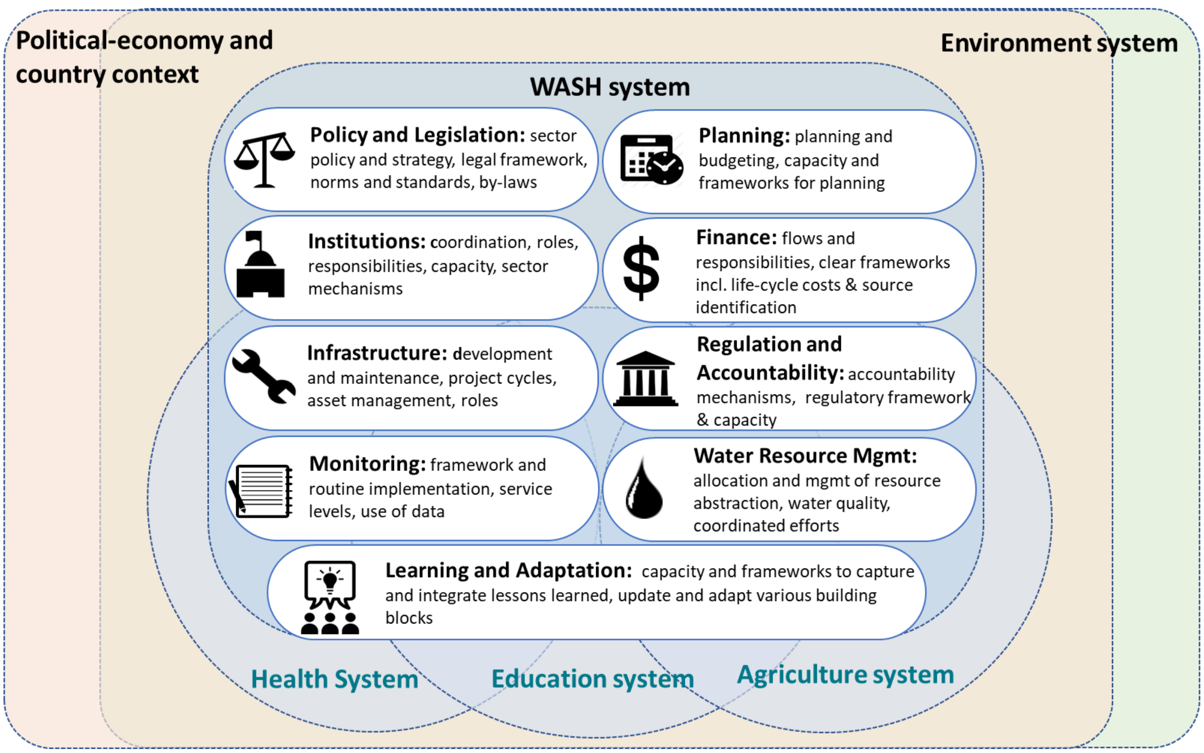

Figure 17: A conceptual framework for the WASH system, which is open to and interacts with the surrounding context and related sectors.

Each window is briefly introduced, while further discussion and elaboration of these descriptions is available in Huston and Moriarty (2018).

Institutions and coordination

For each actor in the WASH system to work together, the roles and responsibilities for each actor in the WASH system must be coordinated, each with the capacity and resources to fulfill their mandates. Service delivery models, and the roles of service provider and service authority, tend to be poorly defined in the rural and peri-urban sector, as compared to urban utility sector, even though the boundaries of institutional responsibilities in this context tend to be more complex since several service delivery models may overlap in a single geographical area (Lockwood & Smits, 2011). The presence and coordination of non-state actors also shapes WASH system behaviour: civil society associations, private sector, independent research and learning institutions, and bureaus of statistics (SWA, 2016). This subsystem provides a direct link between the WASH system and the broader context, since many actors may be formally or informally part of related sectors such as those for the environment, public health or agriculture.

Policy and legislation

Policy is a government's mechanism for setting out its vision and strategy; legislation provides the rules and laws to implement policy (Hall & Lobina, 2006). With a sector strategy in place, technical ministries establish the legal mechanisms for achieving it and place boundaries to which actors must adhere. Policy and legislation provide the foundation for the public service system and the service delivery models, and are the starting point for formalising and operationalising Human Rights commitments according to Van de Lande & Fonseca (2018). It is the place where the allowable and preferred mechanisms for WASH service delivery are defined in addition to norms and standards. Subsidiary legislation, such as bylaws, help to translate national policy into rules that are context appropriate and can be enforced at local levels (Lockwood & Smits, 2011).

Finance

WASH facilities require investment throughout their entire life-cycle: initial capital assets, operation and maintenance cost, capital maintenance, and direct and indirect support costs such as software and information systems, institutional developments and staff costs (Fonseca et al., 2011). Finance in WASH typically comes from three main sources: taxes collected by government, tariffs from users, and development grants or transfers (Fonseca & Pories, 2017). Private sector investment and credit may also be used, but these eventually have to be repaid from one of the three base sources. A well-developed finance subsystem includes a long-term strategy that matches the ambition of national policy and legislation, and accounts for the projected lifecycle of existing facilities, of changing demographics, of the economic and environmental conditions, and of financial procurement mechanisms (Fonseca & Pories, 2017). As the WASH sector is overwhelmingly funded by public means, overall GDP and especially the efficiency of tax revenue collection are critical factors that, even though they lie beyond the boundary of the WASH system, should be considered and accounted for by national leadership and be included in efforts to strengthen public service delivery systems (Hall & Lobina, 2006).

Regulation and accountability

In systems theory, regulation refers to the rules that determine the system behaviour, often a mix of formal orders and informal rules that emerge through self-organisation (Boulton et al., 2015). For public services, regulation is a management tool for guiding stakeholders to conform with the vision set out in policy and legislation. For WASH, regulation is only fully possible once the allowable service delivery models are clearly agreed and codified in law. Government regulation is accomplished through secondary legislation and the assignment of enforcement authority to specific bodies, which are independent from service provision responsibilities. Regulation protects the equity and quality of service provision through antitrust laws and tariff regulation, and mechanisms to ensure environmental and public health standards are met (Trémolet, 2013).

When formal regulatory mechanisms are weak, non-governmental accountability mechanisms such as collaborative agreements, joint committees, social audits, or memoranda of understanding can also be used (Van de Lande & Fonseca, 2018). These tools, even if not legally binding, can increase transparency and help regulate behaviour in rural parts of the sector where capacity is low and ad hoc service delivery models and arrangements are in use. These offer an alternative to punitive measures and can be more forward-looking with the aim to influence future actions.

Monitoring

Monitoring is the basis for the information-driven feedback loops that ensure effectiveness and allow for adaptive change (Boulton et al., 2015). Quality data enable problem identification and the joint development of solutions, and are needed for routine monitoring and progress evaluation (IRC et al., 2016). It is important to know what services are being delivered to whom, at what level of quality, but increasingly monitoring also covers assessment of upstream factors influencing services or intermediate outcomes (Lockwood & Smits, 2011).

Authors such as Van de Lande & Fonseca (2018) say that clear definitions of indicators and protocols for analysis and publication of data are necessary to counter the fragmentation and inconsistencies that arise in WASH due to a legacy of time-bound projects and many stakeholders working toward different objectives. Global monitoring initiatives such as the Joint Monitoring Programme and the Global Analysis and Assessment of Sanitation and Drinking-Water (GLAAS) support the consolidation of different sources of data and the standardisation of indicators, but in the long term these systems rely on national systems that will be responsible for monitoring in the long term (UN-Water & WHO, 2019).

Planning and budgeting

Structured planning and budgeting cycles are tools for fostering public service improvements and systems change (Lockwood & Smits, 2011). Several planning cycles and horizons are relevant to WASH systems development, and the alignment of these plans can increase efficiency: Multi-year, or decades-long strategic plans provide meta-goals and targets; short-and medium-term plans detail the activities and costs. These medium- and long-term plans can be used to justify and solicit funding. Annual operational plans are made based on known or expected budgets, and are the practical means for implementing longer-term plans. In WASH, project, organisation, or agency specific plans may also contribute significantly to WASH systems development; so a strong planning subsystem provides guidance and tools for aligning these plans to sector plans, for example open and transparent budget meetings and consultation processes. At local levels, technical planning and budgeting use tools to plan both capital investments and direct and indirect support costs, as well as longer term planning for capital maintenance for infrastructure rehabilitation (approximately every 10 to 20 years) and replacement (every 20 to 50). The planning subsystem is thus intricately linked with monitoring and infrastructure subsystems.

Infrastructure development and maintenance

Water service infrastructure must be managed over its lifecycle, which requires a reliable register of the existing infrastructure and its condition for a professionally managed system (Fonseca et al., 2011). A clearly defined capital investment cycle supports efficient procurement, construction and management of assets. Ownership and responsibility for assets (even among different public institutions and departments) should be clear at the time of implementation and for the long term, and a clear differentiation needs to be made between responsibilities for operations and minor maintenance, and major replacements and rehabilitation (The World Bank, 2017). Rehabilitation and replacement times can be estimated based on the age and condition of assets, and the useable life of infrastructure can be extended through preventative maintenance. This subsystem requires the establishment and use of aligned asset management systems, which requires that actors from facility to national levels have competency in engineering, business and information management (Fonseca et al., 2011).

Water resource management

Water resource management describes a set of interconnected functions and objectives, including protecting sources, sharing water resources and managing wastewater (Moriarty et al., 2010). Water use and wastewater disposal must be controlled, managed (with enforcement of regulations), monitored, accounting for seasonality, climate change, projected demographic change, and industrial activity. For WASH infrastructure development, the quality and availability of water resources are assessed at the start of a project and regularly throughout a facility's lifespan. Agencies responsible for water resource management are typically different from those charged with drinking water and sanitation, and they may sit at a different administrative levels and deal with different physical boundaries (e.g. basin level). When financial and institutional resources are limited, and formal mechanisms for water resource management are weak or unclear, multi-stakeholder dialogue using relatively simple planning tools, oriented based on best-practices and available data, can be an effective foundation for a shared strategy and plan. Contemporary 'soft path' approaches to water resource management depend on inclusive multi-stakeholder processes, and systems thinking for planning and decision making (Gleick, 2002).

These can be institutionalised through the establishment of mechanisms and protocols for addressing conflicts and encouraging cooperation among state and non-state actors (Moriarty et al., 2010).

Learning and Adaptation

The context, environment, demographics, technology options, and socio-economic conditions are continuously evolving; the WASH system and subsystems will require adjustment over time (Butterworth et al., 2011). The learning and adaptation subsystem describes structured learning processes, the presence of reliable monitoring and information flows, and use of evidence-based adaptation and course-correction. Multi-stakeholder dialogue in the form of joint sector reviews, 'peer to peer' learning exchanges, open planning and budgeting process, and social learning platforms may be included as they can be used to connect WASH actors from different sectors and at different administrative levels. Such platforms may be aimed to build transparency and improve collaboration and technical performance; and research and learning institutions or the private sector may be structurally engaged to help identify and scale up innovations to improve public service delivery (Butterworth et al., 2011). The effectiveness of learning processes to refine policy and sector strategy ultimately depends on the willingness of high-level stakeholders to accept failure and respond to diverse perspectives, both of which can be promoted by engaging these actors early in the process, such as through learning alliances.

5.4.2 Application and response to the framework

The framework consisting of the nine windows has been refined through iterative development and implementation cycles since 2008, initially based on identification of the components that would enable sustainable rural water supply at scale for action-research (Schouten & Moriarty, 2013). A condensed version of five building block was used for a 16 country study of rural water services delivery models carried out for the World Bank (The World Bank, 2017). The current version was first published by IRC in 2018 (Huston & Moriarty, 2018), and used for a WASH systems assessment and annual monitoring in IRC's six countries and focus districts: Burkina Faso and its commune of Banfora (Nansi et al., 2018), Ethiopia and the woredas of South Ari and Mile (Adank et al., 2018), Ghana and its Asutifi North District (IRC Ghana, 2018), Honduras and 15 partner municipalities (Smits & Rodriguez, 2018), India and its Chatrapur block in Ganjam district (Shiva & Krukkert, 2018) , Uganda and its Kabarole District (Magara et al., 2018).

For these assessments, a series of benchmarks (Likert indicators) were developed to assess the effectiveness of each of these subsystems at national and sub-national levels, and for each of the service delivery models in the country. See Table 9 for some examples. Groups of stakeholders in each country were able to perform a coherent and collective analysis against the nine windows, with facilitation from IRC staff in those countries using both secondary data and primary data from key informants during interviews and/or workshops. The results were used, together with data on the quantity and quality of services provided, to discuss the strengths and weaknesses of the system and to identify priority areas for investment (analysis available in aforementioned reports for each country). These initial baseline assessments have been updated with subsequent annual assessments for the priority subsystems and the changes in the scores have been used as part of IRC's monitoring system to track and assess change in the sector (IRC, 2020).

The WASH systems approach is a natural evolution of efforts that focus on sustainability and ensure that governments are in the lead, and as such, it has been quickly taken up beyond IRC. Similar frameworks have come into use by other international NGOs recently (Casey & Crichton-Smith, 2020; Drabble et al., 2018; Tillet et al., 2020), either stemming from this work or emerging simultaneously with it. Our 2018 'working paper' first describing the framework (Huston & Moriarty, 2018) has been downloaded by 2,100 unique users within two years, and three discussion papers have been written on applications of the WASH systems framework in different contexts: one with a focus on hygiene and sanitation (Gensch & Tillett, 2019), one exploring the applicability in fragile states (Tillet et al., 2020), and one exploring the use of a building blocks approach as a monitoring tool (Mason et al., 2019). The scoring methodology was adapted to support WASH planning in Nepal (Tillet et al., 2019) and was merged with a five part sustainability framework for use as a monitoring tool for local systems change in a five year programme in Ethiopia, Uganda, and Kenya (Hollander et al., 2020). WASH systems was chosen as the theme for the GLAAS 2019 WASH Global Status Report (UN-Water & WHO, 2019).

Table 9: Example Likert Indicators for the Institutions, and Infrastructure windows.
Note: Each is scored on a scale of 1-5, where 1=statement is false, undeveloped or undefined; 2=poorly developed/defined or not in place; ; 3=developed/defined but poorly applied or not functioning as intended; 4=in place and usually functioning as intended and 5=in place and functioning.

Window	**Sample Likert indicators for national and district levels**
Institutions:	**National**: Responsibilities of the national and decentralized level bodies are clearly defined, and there are no gaps or **overlaps** between them. **District**: The service authority receives regular back-up or support from higher levels of government.
Infrastructure:	**National**: The project delivery models and procurement procedures for capital investments projects are clearly articulated in government-sanctioned implementation manuals. **District**: An inventory exists of all (or most) water (and/or sanitation) infrastructure assets, including age and current physical state of assets for the focus district.

Across these frameworks, there is increasing agreement as to the main subsystems of WASH. A recent analysis by the WASH Agenda for Change found that more that 75% of its fourteen international NGO members had begun monitoring aspects these of the WASH system between 2017 and 2020: policy and institutions, planning, finance, regulation, monitoring, infrastructure, water resources and environment, coordination, and WASH related social norms and behaviours (Fogelberg & Lockwood, 2020). These aspects align closely with the nine subsystems presented here, with the main differences being in the choice of boundaries between subsystems, or the methods used to analyse them, rather than substantial disagreements on the foundational components for a WASH system.

The framework has shaped IRC's and other WASH actors' understanding of how WASH services are delivered. It has become a mental model that helps stakeholders to communicate their perspectives, expertise, plans, and investment strategies. For example, a recent presenter introduced their work on a webinar by saying 'We work on the policy and legislation building block, which demands strong institutions and works through good regulation.' During multi-stakeholder dialogues, these windows have helped broaden the discussion of service failure from considering infrastructure failure, or a failure in the responsibility of the community or individuals, to a discussion considering systemic factors such as government investment and regulation more consistent with public service thinking. Applying the conceptual framework at several levels (national, district, and service delivery model) helps to identify the factors influencing performance at each level and to recognise who has responsibility for service provision at each level. Problems that appear to be local, such as poorly performing service providers, can be a symptom of national level policy issues, such as lack of support and regulation that are better addressed at the central government level. The nine windows provide structure to the understanding that WASH services are the result of a complex system, and have been used to advocate for systems thinking and a more explicit recognition of the need to invest in water and sanitation as a public service systems, particularly to donors and development organisations who have a history of projectized and piecemeal investments in infrastructure only.

5.5 Discussion of limitations and future adaptation

The framework is a useful tool for introducing, analyzing and understanding complexity within WASH, and it is still evolving as we adapt it using lessons learned during its implementation. Through our experience, and that of others applying this or similar frameworks, critiques emerge.

Earlier iterations of the framework were used to study individual service delivery models, typically rural community managed water (see The World Bank, 2017). The current version retains service delivery models as a central concept, but the subsystem descriptions have been generalised to be applicable at the level of an entire district or at the national level, and also to services for sanitation and hygiene. In many places, WASH services in rural and peri-urban areas are provided by a mix of models, including piped utilities, community managed handpumps and self-supply. In the case of sanitation, there are a combination of different on and off-site models and technology types (Huston et al., 2021 (Chapter 6)). Prior to a generalised assessment of the WASH system at district or national level, it is essential that the models are clearly and concretely defined. A clear understanding of the allowable models and their relative performance is required to objectively analyse the suitability of institutions, legislation, monitoring systems, and other subsystems. Where the service delivery models are poorly defined in national frameworks, the gaps and ambiguities must be articulated as part of the WASH systems discussion. Without this, a single assessment for the district or country may lack the granularity necessary for precise intervention design. Detailed information on services provided and used, either from household or infrastructure surveys, are also needed to complete the picture.

This area-wide view (e.g. district, or national), may be helpful for studying the coordination and mix of different service models, for example, to address how monitoring and regulation systems look at the overlap and gaps between models, or to consider if integrated public investment planning to reach different population segments with different models is in place. However, the analysis of each service delivery model separately, through each of the nine windows, and with an additional assessment of the quality and quantity of services provided by each, remains essential to studying the WASH system and is crucial to retain, and potentially give additional attention to, in the framework. A major emergent finding of applying the framework, is that the lack of clearly defined service delivery models is, in and of itself, a major impediment to progress.

Secondly, the framework focuses on those elements of the system involved in service provision, neglecting to consider the role of demand and user behaviour, both of which are widely understood as essential for sustainable public service systems (McLaughlin et al., 2009). Gensch and Tillet have proposed an additional building block for citizen demand and behaviour that covers demand development and public health outreach to ensure safe WASH practices in the home (Gensch & Tillett, 2019). This reflects contemporary thinking of public service organisations, who consider the pro-active marketing of services and the building of trust between customers and service providers as core to their sustainability (McLaughlin et al., 2009), and could be added to a future iteration of the framework development or more strongly represented within the existing subsystems definitions.

Thirdly, the framework focuses primarily on the key functions for service provision and service authority, and the roles and responsibilities of different actors for completing them, but does not include an analysis of power dynamics or social aspects such as 'lack of trust,' corruption, or perverse incentives which can have significant influence on the performance of public systems. These topics could be addressed more systematically by adding an additional window or by using a complementary analytical tool. The choice to focus on more formal and standard aspects of public systems was intentional to increase the relevance and acceptability of this framework to government actors who may be less inclined to spend time analysing intangible social dynamics. However, depending on the objective for a specific application of the framework, this could be adjusted.

Lastly, the approach has been critiqued as implying that a complex system can be understood through its requisite parts without consideration of the interactions between them (Mason et al., 2019; Valcourt et al., 2020). Adaptive behaviour among actors is a defining feature of complex adaptive systems, and of contemporary public service delivery, since it is these dynamics that ultimately determine whether a series of connected subsystems will collectively lead to service delivery. The interactions between subsystems can be seen throughout the subsystem descriptions (for example the use of monitoring information in regulation and budgeting), however these dynamics have been overlooked by some when referring simply to the diagram or when viewing them as a checklist rather than an integrated conceptual model. The tendency to neglect these interactions was a central reason we began referring to them as windows (into a connected whole), instead of building blocks (which implies a lack of interaction), to encourage participants to view and address the system as an integrated whole.

Ultimately, the framework was not intended to identify specific solutions to systems problems, but to facilitate stakeholders or leaders to make more informed and holistic decisions. In our view, stakeholder and government priorities are valid motives for action; we posit that use of the framework for a systematic and participatory analysis of the WASH system will support more informed and better decision making by these stakeholders. Our understanding of the WASH system suggests that all aspects of the system need to be developed and there is no ideal sequence for doing so.

Overall we view these limitations as compromises found in a framework designed to simplify a very complex situation into a model applicable by diverse practitioners, without the need for specialised facilitation and without the use of automated analysis tools. At the outset we recognised that trying to represent all of the important factors and dynamics relevant for water supply services within a single framework would have produced a highly-complex tool unusable by practitioners, as often happens in systems-based research (Boulton et al., 2015). With the exception of our recommendation to add a tenth window for demand, other limitations can be addressed through use of complementary tools or approaches designed to fit the specific objectives for applying the framework in a given context. They can also be addressed through thoughtful facilitation and explicit communication of the need to mitigate the risks. Though this framework is applicable in a wide range of contexts, other frameworks such as network analysis or dynamic modelling may be better suited for studying specific localised problems with a smaller number of actors or in a project context (Valcourt et al, 2020). It is important to recognise that this qualitative assessment is subject to the bias of the researcher and stakeholders, and the results will be influenced by the ability of the researcher to 'facilitate' the larger group of stakeholders and to synthesize and interpret data objectively.

5.6 Conclusion and future work

Systems thinking has become increasingly common in the WASH sector as a way to address the lack of sustainability of interventions, and by governments and development agencies calling for national leadership to achieve SDG6. We posit that WASH services can be more sustainably planned and provided within a country when they are treated as public services delivered by national systems, and when the subsystems required to ensure universal coverage are clearly defined. Our objective was to introduce a practical framework for understanding the essential components and functions of the WASH system, reducing the complexity to make it more manageable for stakeholders, in turn increasing their coordination and potential for impact by aligning them toward a common understanding and vision.

In the past five years, our framework of windows, or building blocks, has been taken up by other actors as a useful simple framework for describing and studying WASH systems. The framework has been used as an analytical tool for multi-stakeholder assessment in six countries and 10 districts by IRC, and has emerged as mental model and heuristic for other global actors in pursuit of SDG6. It is a tool to structure discussions and investment strategies, and helps to align discrete interventions with longer term pursuit of a goal to achieve universal services through government led public systems.

Facilitated analysis using the framework in a specific context helps stakeholders to appreciate the complexity and multi-level nature of WASH systems, while remaining simple enough to apply through participatory methods led by practitioners. The definition of service delivery models was an essential first step to defining the WASH system and its boundaries. Gaps and ambiguities in service delivery models remain in many countries and identifying these as part of the WASH assessment is an important part of reducing the complexity.

The framework has noted limitations, in particular its minimal consideration of social and power dynamics, and a gap in addressing demand-side factors. These can be addressed through an additional window on user demand and behaviour, and the use of complementary analytical tools. Inclusive facilitation and modification framework to fit context specific needs and objectives is encouraged to ensure its relevance to local actors and its suitability to application in different contexts.

We continue to test the conceptual framework as tool for communicating the importance of supporting public systems in their entirety and investing in government leadership as the most effective way to achieve universal and sustainable water and sanitation services.

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Logical bridge 2 (connecting material)

Chapter 5 developed a conceptual and analytical framework for water, sanitation, and hygiene (WASH) as public system. It identified nine essential subsystems and tested their relevance through their application in six countries (see six-country results summary in Chapter 8, Figure 31). In Chapter 6, the framework is applied to an in-depth case study on drinking water services in Kabarole District in Uganda. This further tests the use of the framework for measuring the performance of the WASH system and studies its use in a participatory process.

Kabarole has characteristics common in rural and peri-urban contexts in sub-Saharan Africa, making it a useful test case. Often unreliable water services are provided using a mix of informal and *ad hoc* approaches. Uganda's water sector is dynamic, with strong national leadership committed to improving sector performance. The many decentralised actors involved in service delivery must understand and embrace national directives to implement them. Regulation is limited and adaptive behaviour is common.

Chapter 6 is implemented working closely with stakeholders in Kabarole in an action-research methodology. The Kabarole District Local Government aims to achieve universal drinking water services by 2030. A learning alliance of stakeholders is in place, acting as a 'think and do tank' to support district WASH strategy and planning. The nine drinking water subsystems (building blocks/windows) are analysed for each service delivery model in Kabarole. The quality and type of services provided by each model are assessed quantitatively with infrastructure and household surveys. Collaborative analysis with the learning alliance ensures contextual knowledge and multiple perspectives are incorporated. It also enables me to test the relevance of the framework to local actors, and to analyse its useability and impact on social learning.

The research presented in Chapter 6 focuses on the results from Kabarole and the drinking water transition in place in Uganda. The critical discussion of work with the learning alliance is presented in Chapter 7.

Chapter 6: (Paper 3) More Sustainable Systems Through Consolidation? The Changing Landscape of Rural Drinking Water Service Delivery in Uganda

Journal article published in Water Alternatives.

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Published as: Huston, A., Gaskin, S., Moriarty, P., & Watsisi, M. (2021). More Sustainable Systems Through Consolidation? The Changing Landscape of Rural Drinking Water Service Delivery in Uganda. *Water Alternatives*, *14*(1), 248-270.

Abstract:

The drinking water services sector in Uganda is in the early stages of a nationally planned transition; it aims to move from a paradigm based on community managed point sources towards one of professional utilities of piped networks. The implementation of this transition was studied in Western Uganda's Kabarole District between 2017 and 2019; a systems approach (building blocks) was used to assess the sustainability of the different service models. The level of services was assessed using household and infrastructure surveys; these were supplemented by a management assessment, key informant interviews and stakeholder workshops. The two utility models present in Kabarole outperformed the community management model, with the existing national utility demonstrating greater maturity and performance than the newer Umbrella utility. The community management model, while relatively well defined in policy and planning

frameworks, was poorly implemented, with less than 20% of community management structures operational at water points. The water sector is undergoing a process of consolidation of service delivery under a smaller number of larger providers, a trend that has been observed in other countries as they progress towards universal supply. In this paper, the prospects and risks of the current sector trajectory are discussed, as are the implications for monitoring, regulation and planning systems across the urban–rural spectrum.

6.1 Introduction

Drinking water services in much of sub-Saharan Africa are characterised by low reliability, poor water quality, and frequent breakdown and/or abandonment of facilities (Chowns, 2015; Liddle and Fenner, 2017; WHO and UNICEF, 2017). Decades of investments have not achieved the anticipated outcomes; this is attributed by some to a sector that is too heavily driven by outsiders and international organisations which have inadequately developed local and national systems for service delivery (Huston and Moriarty, 2018). Many African nations face the additional challenges of a high rate of population growth, low tax revenue, weak governance and regulatory systems, all of which hinder progress (Chitonge et al., 2020; Pories et al., 2019).

Increasingly, investments in improving drinking water supply in Africa have focused on strengthening national institutions under government leadership (Huston et al., 2019; SWA, 2010). The Sustainable Development Goal (SDG) agenda, which was set in 2016, embraces national systems building through its 169 targets for 2030; national systems building is seen as the foundation for progress, as demonstrated by the emphasis on economic and institutional development as being core to social and technological progress (WHO and UNICEF, 2017). Sustainable Development Goal 6 sets 2030 as the target for achieving safely managed water and sanitation services for all.

The metrics for evaluating drinking water services delivery are largely agreed as being quality, quantity and availability; however, the means of achieving these targets and the models for planning, provision and maintenance often remain unclear (Moriarty et al., 2013). In theory, drinking water service delivery models in a country are each supported by a legal and regulatory framework and a clear set of roles and responsibilities for actors throughout the service delivery lifecycle (Bey et al., 2014; Huston and Moriarty, 2018); in practice, the range of the various service delivery models remains poorly defined, unregulated and ad hoc (World Bank, 2017).

Community management is the predominant service delivery model for water supply in rural sub-Saharan Africa while in cities a utility model mainly prevails (Adams et al., 2019; Chowns, 2015). As demographics, livelihoods and environmental conditions shift, this bifurcated approach is thrown into question, particularly with regard to rural water supply (Hope et al., 2020; Whaley and Cleaver, 2017). Population densification is making the boundary between urban and rural increasingly ambiguous and is causing a shift in the range of applicability of different models. International actors such as external support agencies or international charities often introduce new models that may not have legal grounding in the country or fit the social context (Whaley and Cleaver, 2017). The implemented services can become a patchwork of overlapping systems, contested mandates, and competing models of service delivery, with starkly different levels of service being delivered within a single geographic area; furthermore, there is a risk that marginalised populations will be neglected if they do not fit any of the models.

We hypothesise that in order to achieve universal access to services, as is called for in SDG 6, there is a requirement for a clear understanding of the range, scope and appropriateness of existing and potential service delivery models in a given context. The vision must detail how the models fit together and must ensure that they collectively provide appropriate services to all. This vision and understanding will allow the sector to progressively improve performance through the modification of existing models or, as required, the introduction of new ones.

This research focuses on Uganda – using Kabarole as a case district – to study the changing landscape of service delivery and assess the ability of the current service models to meet the changing needs of the population. Since the 1990s, with its progressive decentralisation and institutional restructuring, Uganda has been a notable example of a systematic government-driven approach to potable water service delivery (Sinclair, 2004; WHO and UNICEF, 2008). Its population, however, has doubled since then and, as of 2017, more than half of its 43 million people still do not have access to basic drinking water services (WHO and UNICEF, 2017; World Bank, 2019).

In Kabarole, with national-level planning, the regional and national utilities are expanding into rural areas in which community managed facilities are the status quo. Our objective was to assess the implications of this transition for the achievement of universal drinking water services. We analysed the performance and likelihood of sustainability of each service delivery model and assessed the implications of the availability of a mix of models in a single geographic area. We aimed to improve understanding of the situation in Kabarole in order to support district-level planning, provide insights on the decentralised implementation of national policies in Uganda, and inform wider debates about how water services could be more effectively provided in low-income countries.

6.2 The Ugandan context

Uganda's growing population is young, with 47% under 14 years; it is rapidly densifying and urbanising, though it is still 76% rural. Its overall 3.3% growth rate (5.7% in urban areas) means that its current population of 42.7 million is expected to reach 100 million by 2050. It is in this context that the country's water service delivery needs are evolving (CIA, 2017; World Bank, 2019). While the percentage of the population living in poverty has decreased to 21.4%, per capita gross domestic product (GDP) has also declined since 2015 to its current level of US$1,807 (in purchasing power parity) (World Bank, 2019), with an estimated 72% of the population relying on subsistence agriculture (FAO, 2018). Urbanisation and modernisation in cities and small towns, in parallel with the persistence of rural subsistence livelihoods, suggests the need for a diversity of models for public services within the boundaries of a single district.

The Government of Uganda and the Ministry of Water and Environment (MWE) maintain an ambitious set of objectives which includes dynamic sector learning platforms and an annual joint sector review (Eyatu, 2019). The Government of Uganda's Third National Development Plan (2020/21-2024/25) sets targets[7] for increasing access to water supply from 75% to 85% in rural areas and from 74% to 100% in urban areas (National Planning Authority, 2020), with a 2040

[7] Government of Uganda targets are based on increasing access to an improved water source, which is defined as one that is physically protected from contamination.

vision to achieve 100% access to piped water supply (compared to a baseline of 21% in 2017) (National Planning Authority, 2013). Following the definitions of the WHO's Joint Monitoring Programme (JMP)[8], approximately 81% of the population has access to an improved water source, with 42% meeting the standard for 'basic access', 32% having 'limited access', and a further 7% having 'safely managed' water access (WHO and UNICEF, 2017).

The sector is strongly influenced by international actors and external aid; these have financed sector strengthening and have influenced the choice of service delivery models and the setting of priorities (Danida, 2019). The presence of external NGOs, particularly in the rural sphere, means that a significant portion of the investment in the sector is done 'off budget' and does not go through Ministry of Water and Environment (MWE) or Government of Uganda planning and budgeting systems; these external NGOs thus contribute to service delivery outcomes but do not contribute to maintenance and development in the same way as do nationally budgeted investments.

6.2.1 Drinking water systems in Uganda

The MWE regularly reviews and adapts sector guidelines, policy, and monitoring frameworks in an effort to overcome the challenges in service quality and reach; in doing so, it shows both leadership and responsiveness to the influence of the external actors who provide financial support to the sector (Danida, 2019). A Community Based Management System (CBMS) model has been institutionalised since 1986, whereby the District Local Government is the authority for planning and implementation of new supplies and is responsible for providing backup support to communities (Kiwanuka and Sentumbwe, 2015). Despite its ubiquitousness, the model is poorly implemented throughout most of the country and has been called a "blueprint for breakdown" for its poor performance in operations and maintenance services (van den Broek and Brown, 2015). In 2019, a new framework for rural water supply operations and maintenance was

[8] The Joint Monitoring Programme of the WHO distinguishes three levels of service possible from an improved (uncontaminated) water source: 'limited access' when water is available at more than 30 minutes round trip from the home, 'basic access' when available at less than 30 minutes, and 'safely managed access' when water is available as needed on the user's premises (WHO and UNICEF, 2017).

developed, which outlined reforms to community management; it is being rolled out in 2020/21 (MWE, 2019a).

There are two main utility service providers in Uganda: the National Water and Sewerage Corporation ('National Water'), and six regional utilities called Umbrella Authorities for Water and Sanitation ('Umbrellas') that were formed in 2016. The Umbrellas were created from existing Umbrella Organisations, which played a support role to larger community managed schemes (MWE, 2017). The establishment of the Umbrellas as utilities and an expanded mandate for National Water to serve small towns and rural growth centres (Amayo, 2018) have led to an intensified pursuit of piped water coverage by utilities in rural areas. Many of the small schemes that were previously managed using CBMS have been gazetted (legally transferred) to the Umbrellas, leading to a consolidation of service provision under a smaller number of larger operators. In addition, private sector participation in small town water supply has been encouraged, though this is mostly limited to small-scale contracting for operations and maintenance tasks (Hirn, 2013; Magara et al., 2018).

An estimated 19% of the Ugandan population does not access an improved water source; instead they access surface or ground water directly or purchase water from a local vendor or neighbour (WHO and UNICEF, 2017). Some households and small groups take steps to provide water for themselves in what is known as self-supply (Sutton and Butterworth, 2021; in Uganda, self-supply ranges from very basic (fetching surface water with a bucket) to fairly sophisticated (hand-dug protected wells or rainwater harvesting), the latter being classified as an improved source (Carter et al., 2005). The Government of Uganda does not actively support self-supply, but it is recognised as an option (MWE, 2013).

6.2.2 Key roles in service provision

In Uganda, the MWE (Figure 18) is responsible for setting national policies, standards and priorities, and for monitoring and regulation of the drinking water and sanitation sector (Eyatu, 2019). It is designated as the owner of all public water supply assets in the country, though this is at times still debated for schemes that are constructed without ministry financing, such as community point sources developed by international actors, independent politicians, or by the communities themselves (MWE, 2013).

Under decentralisation, the District Local Government (the 'District') is the delegated service authority responsible for planning and coordination, and for ensuring that drinking water services meet standards within its boundary (Government of Uganda, 1997a; Government of Uganda, 1997b; MWE, 2013). The exception to this is in cities and towns, where drinking water services are gazetted to the authority of the utilities by the MWE. In areas not covered by utilities, Districts delegate most functions of service provision to community management structures, although these structures are given little or no resources, back-up or training to perform this role.

To date, there is no independent regulator in Uganda; this has been recognised as an impediment to improving sector performance (MWE and WURD, 2018). The regulatory function is currently fulfilled by the Urban Water Department within the MWE, with a vision to build capacity and eventually establish an independent body. A new department and interim strategy for water utility regulation was established in 2018 and is due for updating in 2021 (Kabirizi, 2018; MWE, 2018). At the district level and for rural services, District Water and Sanitation Coordination Committees are multi-stakeholder platforms in which civil society organisations and/or subdistrict and district officials can register complaints and hold service providers accountable for performance (Magara et al., 2018).

Ten deconcentrated arms of the MWE, called Technical Support Units (TSUs), provide technical support to communities, to all 134 districts in Uganda, and to utilities (Figure 18). Initially set up as temporary structures to support decentralisation, TSUs play a key role in supporting sector actors and as liaisons with the MWE (Quin et al., 2011; MWE, 2019a). In addition to TSUs, water basin authorities typically span several districts (Water Management Zones) and are responsible for overall coordination and control of water resources management.

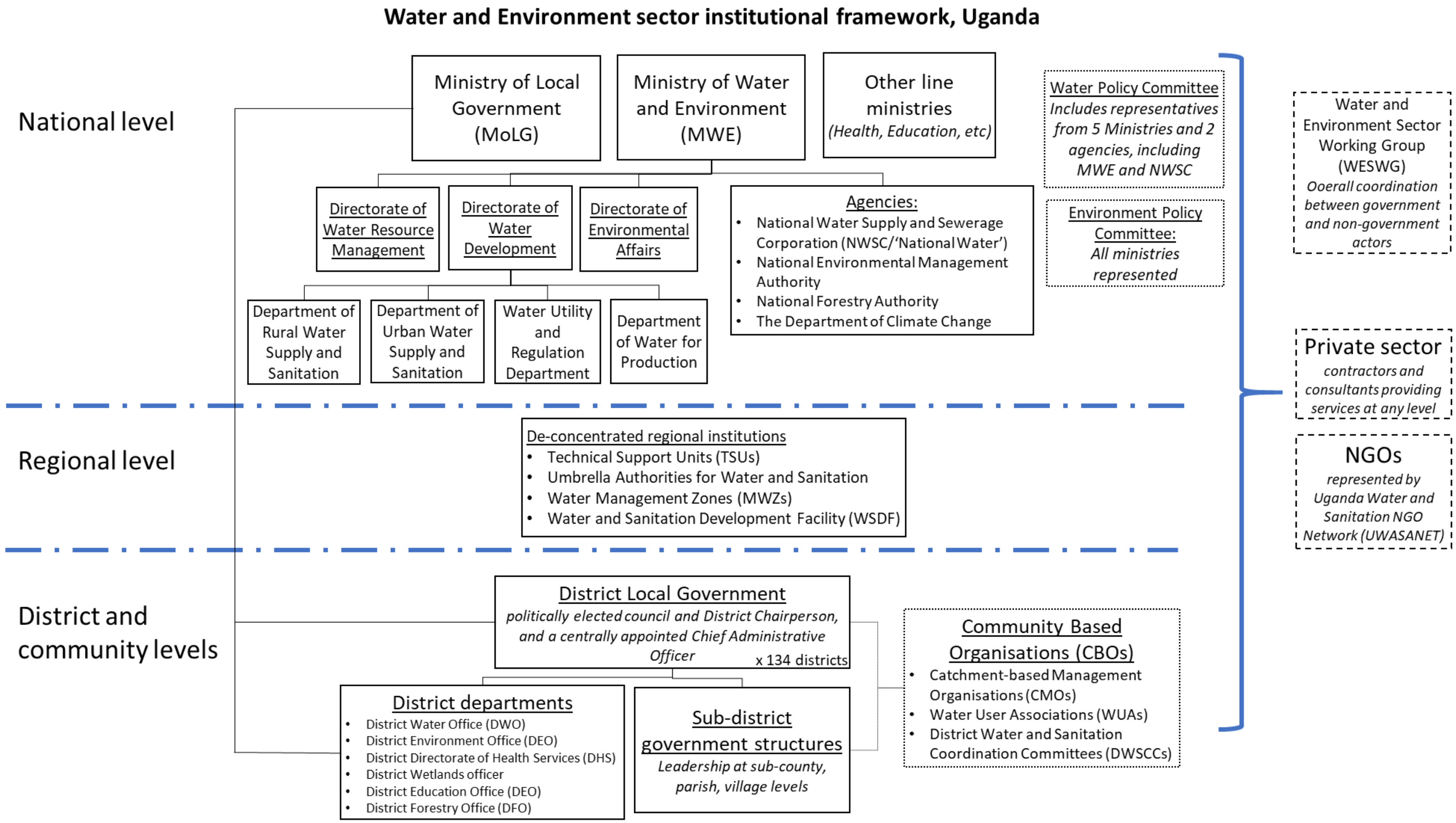

Figure 18: Uganda water and environment sector institutional framework. Adapted from Lockwood et al. (2018).

6.2.3 Case study context: Kabarole District

Kabarole is a mountainous district in western Uganda with naturally abundant fresh surface and ground water; it has a land area of 1,814 km^2 and, in 2019, it had an estimated population of 341,000 (World Bank, 2019). It experiences two annual rainfall periods, and many climate change projections for East Africa anticipate an increase in precipitation and rainfall and a decrease in severity of drought in the coming decades (Kisakye et al., 2018).

Kabarole has one urban municipality (Fort Portal Town, with a population of 61,000), four urban town councils (total population 46,000) and 11 rural sub-counties (total population 233,000) (Figure 19); Fort Portal Municipality and town councils are zoned as urban, while sub-counties are zoned as rural. Kabarole District Council is primarily responsible for town councils and sub-counties, while Fort Portal Municipality has an independent governance structure.

National data show that the rate of access to improved water sources for residents of Kabarole is above the national average (80% in Kabarole compared to 68% nationally), and the functionality of water schemes is reported as approximately average (82% in Kabarole compared to 85% nationally) (MWE, 2019c); the national data base, however, may overestimate coverage and functionality due to the low frequency of updating and the inclusion of decommissioned water points as active. The main drinking water sources are gravity flow schemes, shallow wells, protected springs and unprotected surface water sources.

The diversity of the landscape and the service delivery approaches in Kabarole District make it well suited for studying the service delivery landscape in Uganda; a strong network of stakeholders – connected in a learning alliance – also makes it a good environment in which to develop improved planning approaches. District stakeholders have developed the Kabarole WASH Masterplan 2018-2030 (Kabarole District Council, 2018), which sets out a vision and framework for the universal provision of Water, Sanitation and Hygiene (WASH) services within the district by 2030.

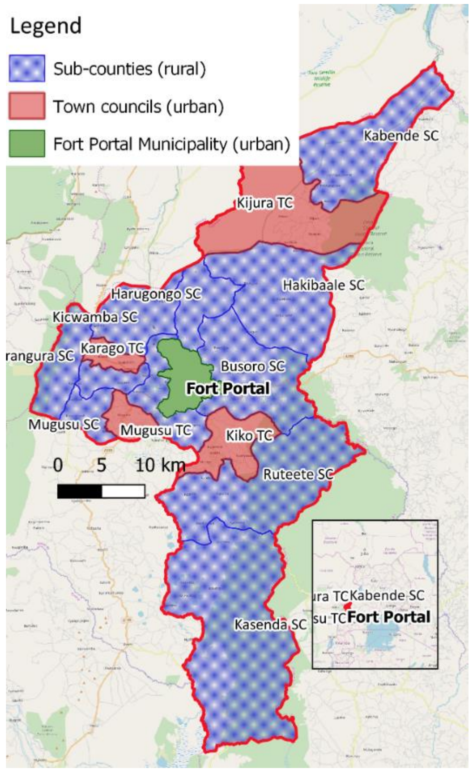

Figure 19: Kabarole District sub-counties and town councils and the Fort Portal Municipality. Source: Author.

6.3 Methodology

This research was implemented using mixed methods, in a participatory action-research methodology (Feilzer, 2010) that worked closely with a learning alliance (Bogdan and Biklen, 1997; Darteh et al., 2019) composed of 26 district-level WASH stakeholders[9]. The authors are part of IRC (an international and Ugandan NGO) and McGill University, Canada. This research is part of IRC's wider efforts to improve WASH systems in Kabarole and Uganda.

The service delivery system in Kabarole was assessed through an analysis of the services provided (infrastructure study), the level of services received (household and user surveys), and

[9] The learning alliance included technical and political leaders, NGOs, health extension workers, handpump mechanics, and representatives from the water, health and education offices in Kabarole, some of whom were also interviewed as key informants.

performance of the service delivery models (mixed methods). As some factors affecting service delivery exist beyond the district's boundary, the national-level governance and sector framework in Uganda were also considered using policy and document review, interviews, and multi-stakeholder workshops.

As facilitators of the learning alliance, IRC maintained a dual role as researcher and change agent, focusing on the systematic analysis and use of information to promote *social learning* (Waterson, 2000), improved coordination, and joint planning among stakeholders. Research was collaborative and learning alliance members including the district engineer, handpump mechanics, and public health workers contributed to the design of interviews, surveys and workshops, and to the overall research strategy and analytical approach.

6.3.1 Methods

In 2017 and 2019, service level and asset assessments were undertaken. Research methods were chosen to enable the identification of the service delivery models and the analysis of their performance according to criteria for functionality, reliability, accessibility, affordability, and level of satisfaction of users.

The type and quality of services provided was analysed through an infrastructure survey conducted in 2017 and 2019. Information on the construction, age and condition of infrastructure and on its operation, payment and management was obtained through a census of improved water point facilities (tap stands, deep boreholes, shallow wells, protected springs, rainwater harvesting tanks). A total of 1,077 improved water points were mapped in the 2017 census and 1118 in the 2019 census. In 2019, the main components of all 12 piped schemes in the district were also mapped (sources/catchments, reservoirs, pumping stations, treatment infrastructure, break-pressure tanks). The study focused on the performance and supply outside of Fort Portal Municipality, since our aim was to analyse the changing rural landscape in which multiple models (National Water, the Umbrella, and community management) coincide. A Geographical Information System was used to map facility infrastructure and study changing service delivery patterns.

In 2017 and 2019, the overall level of services received was assessed using a household survey that was based on the SDG definitions and methodology (Adank et al., 2018; WHO and

UNICEF, 2017). Three-stage stratified random sampling (proportional to the population) was applied at the urban/rural sub-county, parish, and village levels; 2,289 households were sampled in 2017 and 756 households in 2019 (for a 95% confidence interval of 2% and 3.5%, respectively). In order to be assured that both methods produced the same results within the margin of error, the household survey results for service levels were triangulated with the infrastructure data by calculating access rates based on a standard number of users per facility.

To complement the quantitative study, we used a review of national sector documents (N = 27), grey and academic literature from Uganda and Kabarole District (N = 61), participant observation, and direct facilitation of district stakeholder workshops (N = 13), national stakeholder meetings (N = 2), and structured and semi-structured key informant interviews (N = 18). Data were coded according to the nine building blocks for drinking water systems in the framework of Huston and Moriarty, 2018: policy and legislation, institutions, infrastructure development and maintenance, planning, monitoring, regulation and accountability, finance, water resource management, and learning and adaptation (Figure 20).

Each service delivery model was assessed against an analytical framework of normative benchmarks for each of the nine building blocks. The framework, presented in Huston and Moriarty (2018) and in Huston et al. (forthcoming) (Chapter 7), is based on evidence about the factors influencing rural water sustainability and on a previous study of rural water service delivery models in 16 countries (Smits and Lockwood, 2011; World Bank, 2017). The benchmarks were assessed on a Likert Scale (Table 10) and the scores were added to produce a heat map (Figure 25).

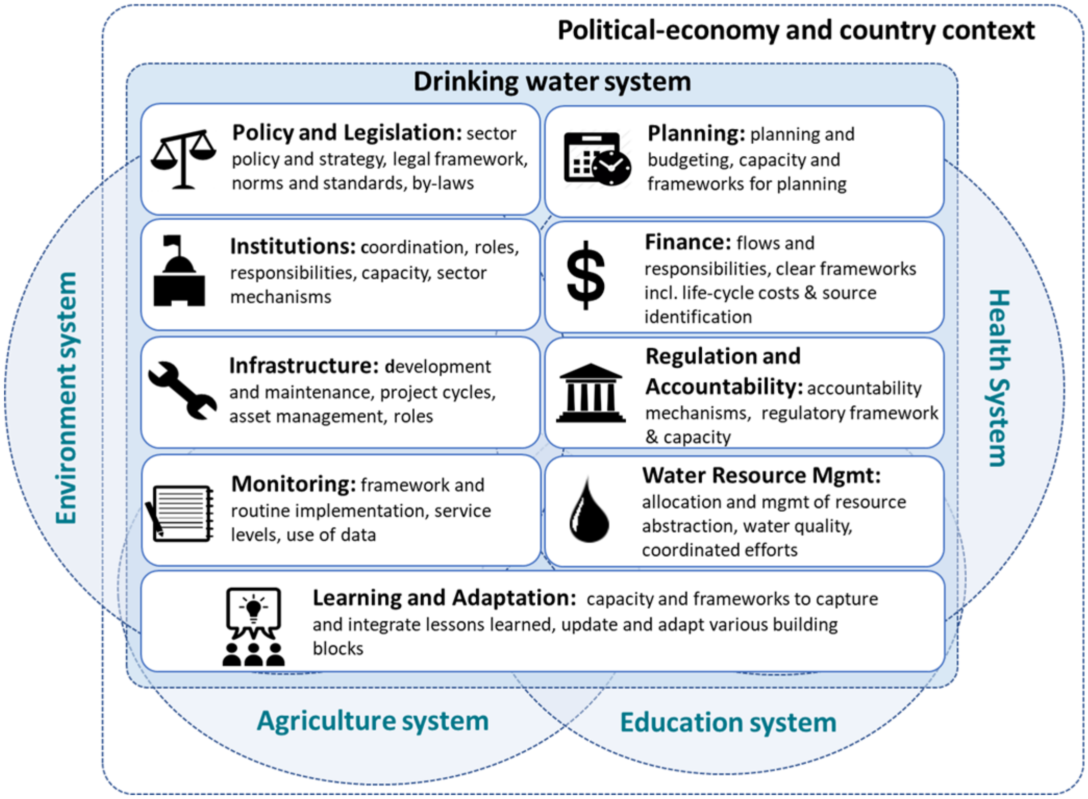

Figure 20: A conceptual framework for the drinking water system. Adapted from Huston and Moriarty (2018)

Table 10: An example of building block scoring statements from the 'regulation and accountability' building block.

Building block	**Main subcomponents**	**Example criteria for benchmarks (each statement scored on a scale of 1 to 5)**
Regulation and accountability	Accountability mechanisms, regulatory framework, and capacity	• A regulator for services exists or regulatory functions are delegated to subnational institutions (e.g. through contracts). It is defined who is responsible for paying capital expenditure (CapEx) and capital maintenance expenditure (CapManEx). • The entity equipped with regulatory functions sets 1) tariff regulations and tariff calculation guidelines; 2) service level requirements; and, 3) rules that protect consumers. • The entity equipped with regulatory functions uses monitoring data to guide performance management and apply effective enforcement (incentives, penalties) in the three areas of regulation. • A mechanism is in place for citizens (civil service organisations) to hold service providers to account.

The analysis was iterative and participatory; both raw and analysed data from the household and infrastructure surveys were presented for discussion with learning alliance members including representatives from the District Water Office and the MWE Technical Support Unit, and service providers. The initial results from the benchmark assessment and service level assessments were used to compare the models, to stimulate critical feedback, and to draw out further insight on stakeholder perceptions and on experiences with the models in Kabarole.

6.4 **Results**

We first present the key findings from the national-level assessment in order to frame the detailed analysis of Kabarole District; we then present a summary of results from the service delivery assessment in Kabarole District, followed by an analysis of the service delivery models.

6.4.1 Consolidation of service providers and expansion of utility provision

Traditionally, Uganda saw a clear demarcation between rural and urban areas, with urban areas served by utilities and rural areas by various forms of community management. In rural Uganda, however, there has recently been a clear national trend towards the expansion of utilities and consolidation of service providers. This process of consolidation began in the early 2000s when the previously uncoordinated network of community management groups and small providers were federated through membership in Umbrella Organisations, which offered structured support. A second phase began in 2016 when the Umbrella Organisations were granted service authority status and began taking over direct management of existing piped schemes; the aim was to eventually consolidate all schemes in small towns and rural growth centres under the six Umbrella Authorities for Water and Sanitation (Umbrellas) (MWE, 2017). As of August 2018, a total of 434 piped schemes in Uganda, previously under community management, have been gazetted to the Umbrellas. The aim of this consolidation is to improve financial and service delivery performance – and thus sustainability – through improved cost recovery (improved tariff collection) and more professional management.

The National Water and Sewerage Corporation (National Water) is also undertaking rapid expansion through extending its piped networks and taking over management of existing schemes. National Water, a public parastatal, has been providing domestic water in large cities in Uganda since 1972 and has embraced reforms to progressively improve performance over the past two decades (Schwartz, 2008; Muhairwe, 2009; Amayo, 2018). In 2016, National Water received a mandate to provide services to small towns and rural growth centres (NWSC, 2019); as a result, it has gone from serving 23 towns in 2013 to serving 253 towns in 2019 (MWE and NWSC, 2017; NWSC, 2019). This rapid growth has in part been fuelled by the 100% Service Coverage Acceleration Project (SCAP100), which, between 2017 and 2020, provided financing for

140,000 new household water connections and 20,000 public standpipes (PSPs) in over 12,000 Ugandan villages (21% of the total villages).

The centrally led shift towards utilities and their expansion into rural areas means it is increasingly common to have multiple service delivery models present in a single administrative area. In a series of national dialogues between 2017 and 2019, stakeholders discussed if and how the new Umbrellas, the expanding National Water, and the District Local Governments (and their delegated community management structures) could co-exist and cooperate to achieve the National Vision 2040 goal of piped water supply to all households (National Planning Authority, 2013; MWE, 2017). In 2018, a new department was formed and an interim strategy for water utility regulation was released to help direct utility cooperation (Kabirizi, 2018; MWE, 2018); in 2019, a new National Framework for Operation and Maintenance of Rural Water Infrastructure in Uganda was launched, which aims to improve community management while introducing a more consolidated approach to operation and maintenance (MWE, 2019b).

6.4.2 Water service delivery in Kabarole

Both national-level changes and persistent sector challenges can be observed in Kabarole District. Figure 21 shows the relative proportion of the population accessing limited, basic, and safely managed services (as per JMP definitions), based on household surveys in Kabarole in 2017 and 2019. The situation has improved slightly since 2019 due to an increase in household connections to piped networks, shown in Figure 21 as 'safely managed services'. An improved community water point was reported by 55% of sampled households as being their primary source of water, but only 31% of these could fetch water within a 30-minute round trip (the minimum benchmark for basic access). A total of 33% of households reported using unimproved sources as their primary drinking water source, and about half of these households reported boiling the water prior to consumption.

Services in Kabarole are delivered by five different models, each having several variants (Figure 22); these models are classified in terms of their procurement process, technology type, intended service level, payment mechanisms, and maintenance model (maintenance model definitions are from Lockwood, 2019). There are two versions of utility management, National Water and the Umbrellas, with the Mid-Western Umbrella of Water and Sanitation as the

Umbrella present; there are also two versions of community management, Water Source Committees (WSCs) and Water Supply and Sanitation Boards (WSSBs); and there are several variants of self-supply.

Figure 21 uses modified indicators that are based on the JMP definitions for the SDGs. Piped water services in households were assumed to be safely managed; notably, only National Water provides disinfection in the form of chlorination, while the Umbrella and CBMS piped networks provide only primary treatment in the form of a settling tank.

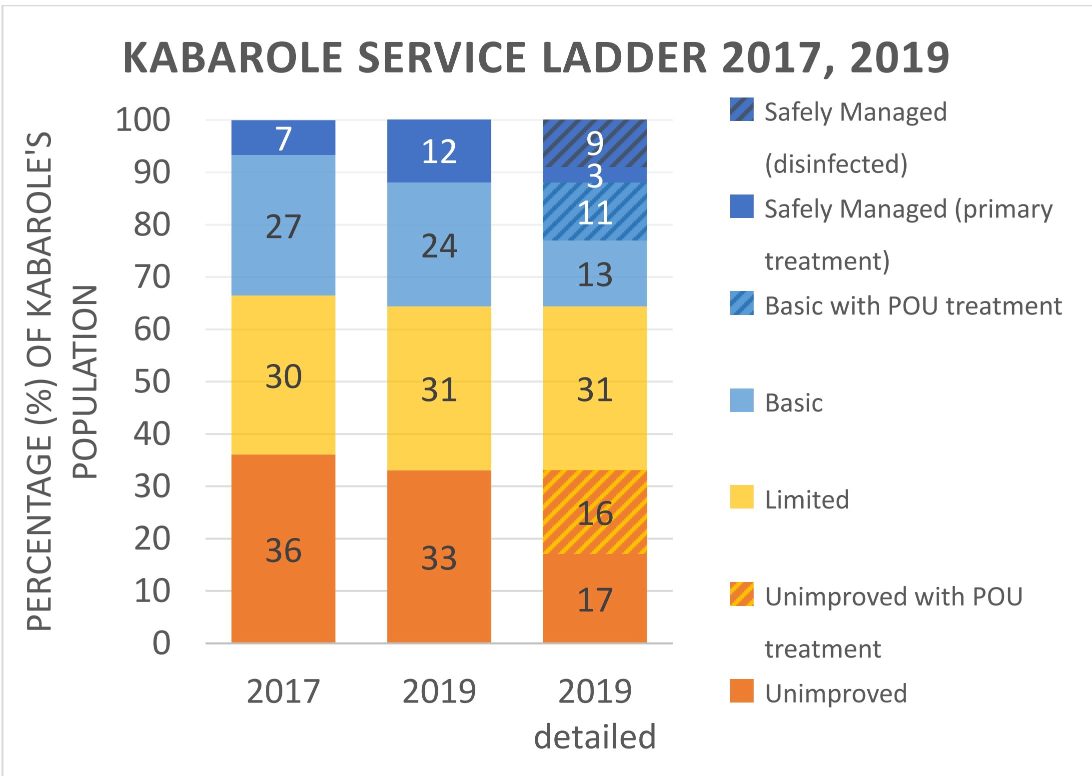

Figure 21: Service levels in Kabarole in 2017 and 2019. Note: POU = Point-of-use, that is, treatment at the household level (assessed through self-reporting).

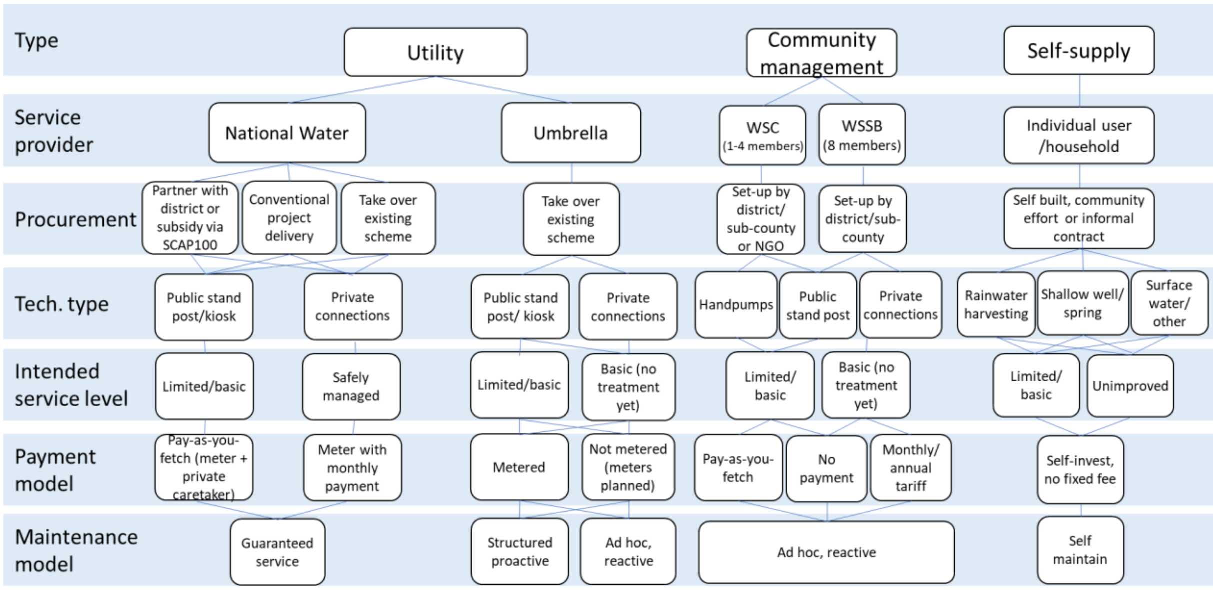

Figure 22: Domestic water service delivery models in Kabarole, with blue lines showing all possible variants. Note: Intended service levels are according to JMP definitions for limited, basic, and safely managed water access (WHO and UNICEF, 2017); private connections on premises are only considered safely managed when water is guaranteed to be treated and free from microbiological and priority chemical contamination; maintenance model definitions are from Lockwood, 2019.

6.4.3 Utility models

National Water is the sole provider for the 61,000 residents of Fort Portal Municipality and for an estimated 31,700 people (11%) in the sub-counties and town councils of the greater Kabarole District; water is provided through a combination of private connections and public standpipes (PSPs). The Umbrella utility manages three schemes, all originally developed under community management; they serve an estimated 14,000 people (4%) through a combination of PSPs, private connections and institutional connections. Two large gravity flow schemes were constructed before 2001 and a third solar-powered scheme was constructed in 2018.

The maps in Figure 23 are from 2017 and 2019; they show the significant expansion of the National Water municipal network and the new presence of the Umbrella. Of the 112 National Water PSPs ('taps') outside the municipality, 89 (44%) have been constructed since 2015. Under the MWE’s SCAP100 project (2017-2020), 294 villages in greater Kabarole District (of a total of 510) were targeted for National Water service by 2020. Under SCAP100, a village receives two subsidised PSPs (aimed at vulnerable populations), and interested households or businesses nearby can purchase private connections.

Overall, taps managed by National Water had the highest functionality and reliability, showing 75% functionality compared to 49% and 38% for Umbrella and community managed taps; 85% of taps had not broken down in the past year, compared to 21% of Umbrella taps and 31% of community managed taps. On the day of the survey, 61% of National Water taps were functioning at 100% with no detectable issues, whereas only 31% of other taps were functioning to the same degree.

The performance of schemes under the Umbrella model varied significantly; their performance was highly influenced by the schemes' management legacies prior to being gazetted to the Umbrella. The condition of the schemes at the time of transfer to the Umbrella in 2018 ranged from fair to very poor. The schemes were each managed by a branch unit of the Umbrella that worked towards monthly performance targets for functionality, non-revenue water, and bill collection. Umbrella scheme managers all reported that resource limitations required them to take a modest and gradual approach to improving scheme performance despite documented knowledge of continuity problems.

6.4.4 Community managed water supply

In 2019, there were 771 water point sources and 135 standpipes under community management, serving an estimated 198,000 people (58% of the total population). Historically, these facilities received all their capital investments from the District's annual budget and constituted the sole means of supply in rural areas. They are a mix of small gravity flow schemes, protected springs, shallow wells (hand dug, less than 15 metres deep) and deep boreholes (drilled, deeper than 15 metres); shallow wells dominated until 2018, when the MWE stopped funding their construction due to concerns about safety and seasonality. The type and functionality of community managed water sources in Kabarole is shown in Figure 24. Many households reported using multiple sources, including a mix of PSPs, community supplies, and unimproved sources.

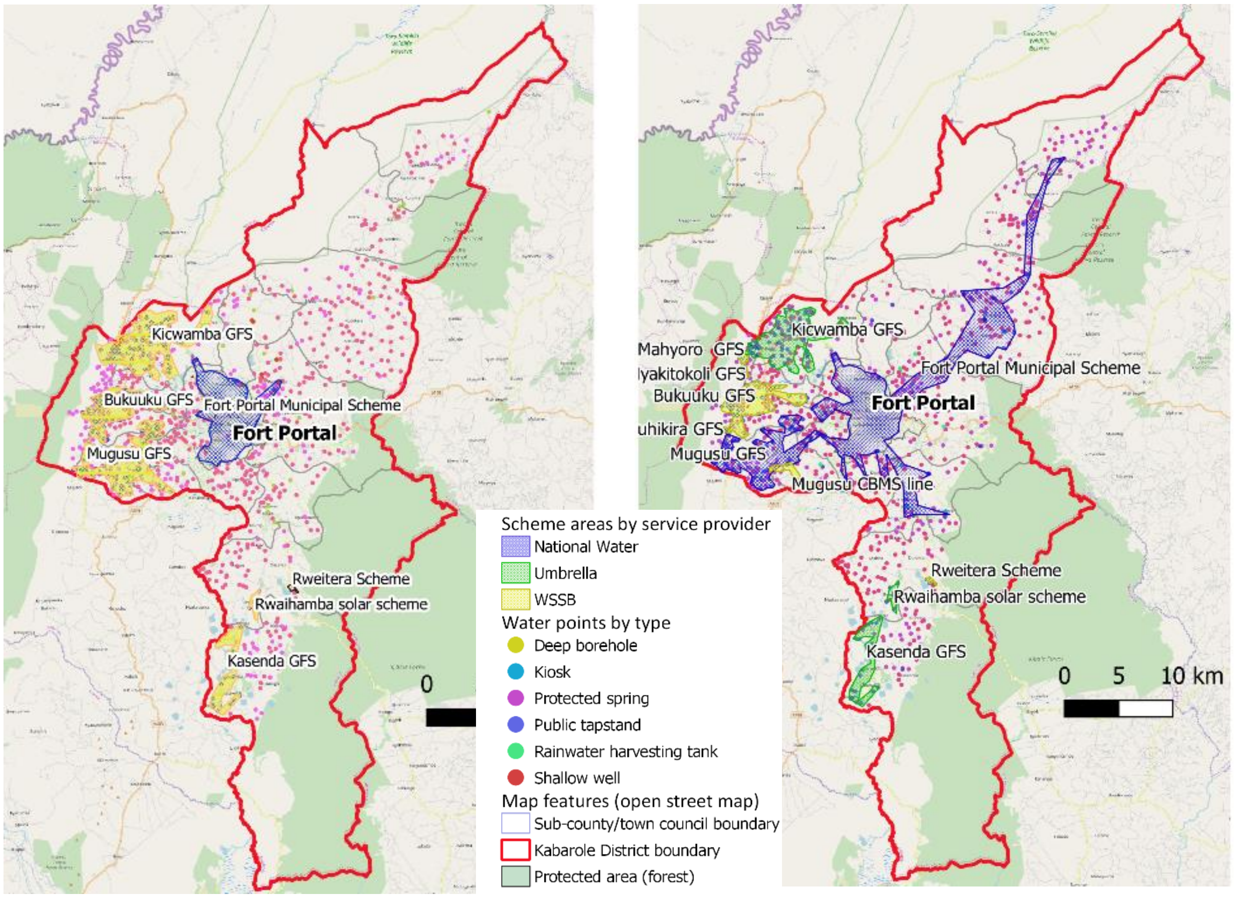

Figure 23: Maps of Kabarole in 2017 (left) and 2019 (right) showing water points by type and piped schemes according to their management bodies. Note the expansion of the National Water and Umbrella service areas. Note: WSSB = Water Supply and Sanitation Board.

All water points developed by the District are gazetted for management by Water Source Committees (WSCs); in practice, however, WSCs are not in place for most water points. Of the 771 surveyed water points in 2019, only 210 (27%) had active WSCs and only 92 (12%) had WSCs that had organised maintenance in the past 12 months. Only 39 WSCs (5%) reported having a bank account, despite this being listed in the MWE's District Implementation Manual as a requirement for WSCs (MWE, 2013). Only 38 out of the existing 210 WSCs in Kabarole reported receiving support, training, or advice from the government in the past 12 months; even so, 547 of the 771 water point operators (76%) reported that a WSC "had been established" and 301 reported having "received training" at some point.

Water Supply and Sanitation Boards (WSSBs) are community structures for managing piped schemes; they have a total of eight members, typically including active and retired public servants who have been selected based on their perceived capacity for management. In Kabarole, seven schemes had been constructed by the District and were intended for management by WSSBs, however our survey found only one WSSB actively managing a scheme. During the two years of this study, the active WSSB was being supported by IRC (independent of this research) as part of a pilot to improve management. Of three schemes constructed by the District between 2017 and 2019, none had an established WSSB; the schemes were also largely non-operational due to disagreements or problems between the District and lower local governments related to design specifications. A fourth scheme, a gravity flow scheme constructed by an NGO in 2017, was being managed by the community in an ad hoc manner, in the absence of a formalised WSSB. Three other schemes did have operational WSSBs but had been gazetted for utility management, leaving the former WSSB with a limited role.

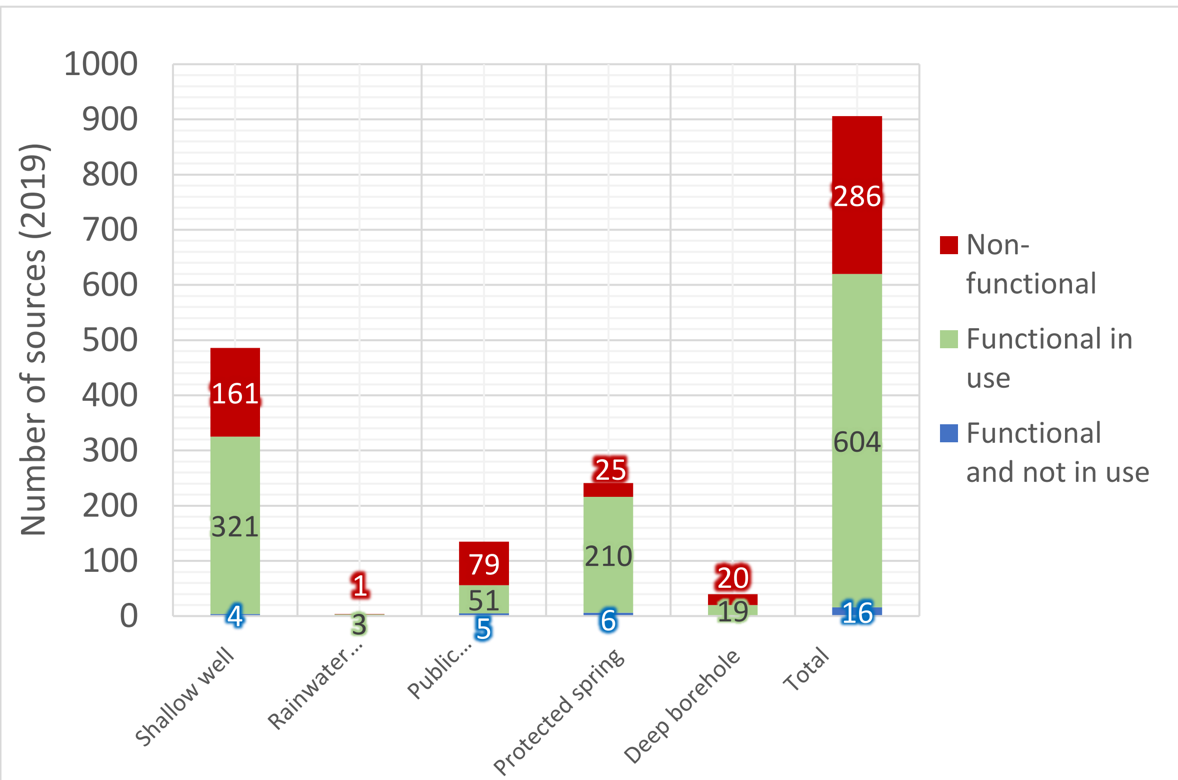

Figure 24: The type and functionality of community managed sources in Kabarole (2019). Note: CBMS = Community Based Management System.

6.4.5 Self-supply and unserved households

An unimproved water source was reported by 31% of households to be their primary drinking water option, with the majority reporting that they had no secondary source or alternative options; these households were clustered in specific villages or parishes having a low number of improved supply options. Compared to other households in the district, households using unimproved water were significantly less satisfied with their drinking water situation in terms of distance to source, quality of water, quantity of supply, and overall management.

The term self-supply, as it is used in the literature (for example, Sutton and Butterworth, 2021), normally applies when households make some sort of investment in improving the convenience or safety of their water source. In Kabarole, nearly half of the households using unimproved sources (48%) reported always treating the water prior to consumption, suggesting that many households may be willing or able to invest in improved and safer self-supply options. To date, Kabarole District has not systematically supported or invested in improving self-supply. There may be some households using improved self-supply options, however our household survey results suggest that the majority were using unprotected shallow or surface water sources.

6.4.6 Service delivery systems analysis

When analysed against the nine building blocks for service delivery systems, the National Water model performed the highest, followed by the Umbrella model, with community management and self-supply coming last. The summary results are shown in the heat map in Figure 25 where green indicates that the corresponding building block is well developed and in place, yellow indicates that it is developed but not well applied, and red indicates that the building block is not clearly defined or is non-existent.

The National Water model scored high or very high against 67% of the benchmarks; the indicators that scored low were those for monitoring, data management, and regulation. The policies, roles and practices for National Water are clearly defined and adhered to, however its recent expansion into rural areas that are under the jurisdiction of District Local Governments brings uncertainty with regard to regulation. National Water technically remains accountable to the MWE at the national level but has no legal or regulatory relationship with District Local

Governments (MWE and WURD, 2018); this has the potential to create confusion or even conflict with the local officials who are generally responsible for ensuring access within the District's boundaries.

In terms of benchmarks, the Umbrella model scored high or very high for 26%, medium for 41%, and low for 31%. The low and high scores were distributed across the different categories, demonstrating both positive attributes and shortcomings in many categories. Several of the problems with the model were associated with the service authority roles, suggesting that the system for supervision, support and regulation of the Umbrella utility is underdeveloped. Given that the model in its current form is less than five years old, the Umbrella model has had less time to develop and adapt than the National Water model; this may help to explain the poorer development of key building blocks.

Despite over 30 years of iterations for improvement of the community management model in Uganda, both the WSC and the WSSB models received medium or lower scores for over 74% of the benchmarks and scored either low or very low for 33% and 60% of benchmarks, respectively. The highest-scoring categories were legislation and planning, both of which reflect national frameworks more than the decentralised implementation of the model. Monitoring, finance and regulation were weak, as were benchmarks for service provider performance and capacity.

Self-supply scored lowest overall as a service delivery model in Kabarole, as it has not been supported by the District nor promoted by the Central Government. The relative prevalence of self-supply in Kabarole, in part due to the availability of shallow and surface water sources, suggests that the model should be either invested in to improve its safety and regulation, or structurally phased out if it is deemed unfit.

Figure 25 (Next page): The results of the service delivery assessment for each service delivery model in Kabarole; the bottom row shows the overall score for each building block.

Service delivery model	Variant	Institutional							Legislation			Finance									Planning					Infrastructure development and maintenance											Monitoring							Regulation				Learning and adaptation					Water resource management							
Utility-managed	National Water	5	5	5	5	4	4	4	4	4	3	5	5	5	5	5	4	4	4	5	5	4	4	4	4	4	4	3	3	2	2	4	5	5	4	5	3	3	4	2	5	5	4	5	4	2	3	4	3	3	3	3	4	4	4	3	3	5	5	5
	Umbrella	3	3	3	4	4	3	2	3	2	3	4	2	3	2	5	2	2	2	3	3	3	2	2	3	4	2	2	3	2	1	2	5	5	3	4	4	3	3	2	4	5	4	2	2	2	2	4	3	3	3	3	3	3	3	3	3	4	4	4
Community-managed	WSSBs	3	2	2	2	4	1	1	2	2	2	5	2	3	3	4	2	2	2	4	4	5	3	3	3	3	2	2	3	1	2	2	3	2	2	3	2	3	1	2	1	2	3	1	3	2	2	2	3	3	3	3	2	2	3	2	2	2	1	1
	WSCs	5	2	1	2	2	1	1	3	4	2	4	2	4	3	4	2	2	2	4	4	4	3	3	3	3	3	3	3	2	2	2	4	3	3	3	2	3	1	2	1	1	2	1	3	2	2	2	3	3	3	3	2	2	2	2	2	1	1	1
Self supply		3	2	1	1	1	1	1	2	1	2	2	1	2	3	2	1	2	1	2	0	0	0	0	1	2	1	1	3	1	1	2	5	0	0	0	2	3	1	2	0	1	0	1	1	2	2	0	3	3	2	1	3	0	0	0	0	0	0	0
Sector overall		5	1	2	1	2	2	2	2	2	3	4	4	4	4	4	0	0	0	0	4	4	2	5	5	3	2	2	3	2	1	2					3	3	3	3				4	5	1	2	4	3	3	3	2	3	3	3	2	2			

Figure 3: The results of the service delivery assessment for each service delivery model in Kabarole; the bottom row shows the overall score for each building block. Note: Dark green (a score of 5) indicates that the building block component is in place and is functioning as intended; light green (a score of 4) indicates that a building block is in place and usually functioning as intended; orange (a score of 3) indicates that a building block is in place but not functioning as intended; yellow (a score of 2) indicates that a building block is not in place or is poorly developed; and red (a score of 1) indicates that a building block is not at all developed; white indicates no data or that the building block criterion is not applicable. WSSB = Water Supply and Sewerage Board; WSC = Water Source Committee.

6.5 Discussion

The mixing of service delivery models across the urban – rural spectrum in Kabarole make it a good case for studying the wider changes taking place in Uganda. Rising service levels with an increasing number of private utility connections were observed while, at the same time, a large portion of the population is still unreached by any level of improved community facility or relies on a community managed source with ad hoc management and poor reliability.

6.5.1 Towards better performance with consolidation of service providers

The gazetting of community managed piped schemes to the Umbrella and the expansion of National Water to cover small towns and villages reflects a trend of consolidation and professionalization of service providers. Consolidation in potable water supply has been documented as an important phase of sector maturation in the Netherlands (Zetland and Colenbrander, 2018), the United States (Goodwin and Doeksen, 1984; US Water Alliance and UNC, 2019), France (Franceys, 2019), and India (Hutchings et al., 2017). Proponents suggest it can help access economies of scale and reduce human capacity requirements for water management at local levels (Franceys, 2019; Hope et al., 2020; McNicholl et al., 2019). The Umbrella, while only four years into its role as a utility, has the mandate to take over all piped schemes outside of those gazetted to National Water. It is too soon to tell whether it will have the capacity to deliver this mandate and whether it will result in a significant improvement to the performance of those schemes as compared to performance under community management.

A form of consolidation has recently been planned for point-source management in Uganda. The new National Framework for Operation and Maintenance of Rural Water Infrastructure in Uganda, launched in late 2019, followed upon a series of dialogues about the challenges under the country's current model. The proposed new model, called Community Based Management System Plus (CBMS+), aims to reduce the burden on community volunteers and to professionalise maintenance by transferring responsibility from Water Source Committees to a smaller number of contracted Area Service Providers; under this model, each Area Service Provider would provide maintenance services to all water points within a given geographic area (MWE, 2019b). This transfer of responsibility away from the unsupported community appears appropriate to address the persistent challenges of community management that are documented in this research and elsewhere (van den Broek and Brown, 2015; Chowns, 2015; Hope, 2015).

The proposed CBMS+ model builds on a proof of concept that has been developed in other parts of Uganda (Harvey, 2017) and in Kenya (Goodall and Katilu, 2016). The approach can incentivise rapid and preventative maintenance while increasing access to economies of scale by having a single provider with a performance contract for an entire area (MWE, 2019b; McNicholl et al., 2020). A subsidy mechanism can be built in to the contract between the Area Service Provider and local government in order to ensure services for those who cannot afford the tariff. While such approaches have thus far been primarily promoted by internationally affiliated actors at the scale of up to only a few districts, the move towards a nationwide rural utility service approach in Uganda demonstrates a unique promise to implement the approach at scale.

A transition to higher service levels using piped networks requires increased capacity for service providers – for example utilities – but the costs of maintaining this capacity (and staffing) may be met by economic gains within the model (McNicholl et al., 2019). A 2018 study of 14 operational areas in sub-Saharan Africa found that although piped schemes required higher capital costs for initial construction, they were more likely to operate at a positive working ratio (percent of costs recovered through user payments) than point sources, which failed to achieve cost recovery in all cases even when managed under an area service provision model (ibid). Utilities that cover larger areas, either through large piped networks or multiple schemes, are also able to do direct cross-subsidisation from profitable customers in denser easy-to-reach areas to more costly or difficult-to-reach rural customers (Lockwood et al., 2018; Franceys, 2019); still, a mix of both incentives and enforceable policies will be needed to ensure that an expansion of utilities does not leave vulnerable communities and people behind. All main models in Uganda receive public finance, which offers the potential to develop a joined-up multi-institutional public financing strategy.

6.5.2 Generating effective demand

Even if generous public finance can be secured to cover some of the costs, the ability of National Water and the Umbrella to survive in rural areas will depend on their ability to attract and secure paying customers. In line with other findings from Uganda (Bey et al., 2014; Marshall, 2019; Tsimpo and Wodon, 2018), our household survey found that the majority of residents were willing and able to pay for safe, reliable and formalised (albeit subsidised) services. Residents expressed dissatisfaction at paying for low levels of service that are informally managed, as is the case for most community managed services in which no regular meetings or financial records are kept. This matches 2018 findings from Uganda which found supply-side constraints to outweigh demand constraints as a limitation on installing new household connections (Tsimpo and Wodon, 2018). All four National Water managers interviewed for this research indicated that they experienced high effective demand for new (paid) connections, including in rural areas which previously had free water provided at a lower service level.

The presence of multiple service providers with different policies in a single geographic area can lead to frustration when both free-of-charge and paid services are offered in the same community and when there are conflicting messages about the tariff requirements for households. The price per 20 litres of water varies for each provider: 83 UGX (US$0.022) for National Water domestic connections; 25 UGX (US$0.006) for National Water's subsidised public standposts; 94 UGX (US$0.025) for Umbrella domestic connections; and 50-100 UGX (US$0.013-0.027) for community managed water points that charge collection fees. Only the utilities consistently enforce tariff payment, however, and most community sources only collect money when repairs are needed. In 2019, an estimated 38% of households reported paying for water regularly (about half of these being within the municipality of Fort Portal, served by National Water) and another 28% reported making contributions after breakdowns (the mode of reported contributions is 200 UGX (US$0.054)).

Utility managers emphasised the importance of professionalism, customer service and enforcement capacity in distinguishing themselves from community managed services for which many customers are unwilling to pay. National Water is a known institution with an established brand and has built a reputation with customers by demonstrating the reliability of its services and by taking a customer-centric approach. It uses internal incentive mechanisms to boost branch performance (Mugisha et al., 2007) and, in Kabarole, offers same-day response to complaints, which is made possible by having adequate capital to stock spare parts. National

Water also has the technical capacity to enforce payment by cutting off supply in response to non-payment, which forces out non-paying customers and commands respect for bills.

In contrast, the regional Umbrella utilities are low-maturity institutions established in 2016, which have yet to prove themselves as professional utilities that can provide high levels of service. In Kabarole, they have not yet installed meters on all scheme connections. According to interviews with customers and managers in Kabarole, the Umbrellas are not perceived to have the authority or technical capacity to enforce their own policies or cut off supply to noncompliant customers; community managers also reported challenges in routine tariff collection and community members indicated a lack of trust in community managers being able to responsibly handle collected funds (Marshall, 2019).

6.5.3 Implications of overlapping models

The MWE strategy of coordinating the complementarity of the Umbrellas, National Water, and the proposed area service provision approach (CBMS+) is unclear, as can be expected at this early stage of consolidation. Several interviewees in Kabarole, including District Local Government and utility managers, did not have a complete understanding of the centrally led changes taking place in the sector nor the implications of these changes for district-level planning. Both District Local Governments and the utilities carry service authority roles, and the hierarchy among them is still unclear. The MWE and the deconcentrated arms of the MWE – the Technical Support Units – play a critical role in supporting these entities in better understanding and negotiating centrally led changes, but TSUs support multiple districts and helping actors to adjust will take time.

In other contexts, collaborations between public agencies – sometimes referred to as public – public partnerships – have proven effective as a way to increase water supply efficiency, while avoiding some of the known challenges of public – private partnerships (Silvestre et al., 2018). Accountability to both the public and each other is critical for the success of public – public arrangements, whether they are established centrally or at the municipal level; the presence of two public utilities and the District Local Governments as rural authorities in Uganda presents an opportunity for establishing such an arrangement. Districts, which have a broad mandate to ensure service delivery to all rural citizens unserved by utilities, can form attractive partnerships with utilities which include incentives for the utilities to expand their service areas.

The SCAP100 programme of the MWE and National Water has given National Water a role in extending subsidised first-time access to unserved villages. This builds in the institutional capacity to support underserved areas and builds National Water's public image as a utility offering services even in low-resource areas. In one case in Kabarole, the District and National Water collaborated on a 9.6 km extension to reach a previously unserved village; the District provided the capital expenditure while giving National Water a contract to build, operate and manage the scheme. The legal and technical strategies for joint planning between agencies, however, remain weak, as does the legality of, and ability to enforce, new types of public – public partnership contracts.

Uganda lacks a single authority for regulating all of the country's service providers; because accountability is not clearly held by any individual provider or authority, there is a risk that some users will be left out. While the District is, by default, the rural authority, responsibility at the perimeter of utility piped scheme service areas is blurred. The Umbrella mandate is limited to the service area of gazetted schemes, as is that of National Water (except when an entire city or town is gazetted). In the current framework, utilities are seemingly able to cherry pick the best schemes and customers, leaving the District responsible for those who are unreached (or unreachable) by piped schemes or those in areas that could easily be reached by extending existing schemes but are not financially viable; this is not inherently problematic but has cost implications for the District. More support for service providers and clarification of their expectations and roles is needed from the MWE and the Ministry of Local Government. Together they are asset owners and duty bearers for ensuring water service delivery to everyone; they are both responsible for ensuring coordinated planning and the prioritisation of reaching underserved groups.

With population densification in Uganda and the expansion of utilities into rural areas, the traditional divide between urban and rural water services planning and models may be reaching its limit. Both National Water and the Umbrella are overseen by the urban department of the Directorate of Water Development; the District's water development efforts are primarily guided by its rural department. To begin to address the challenge of merging urban and rural service provision, the Water Utility Regulation Department was established; its interim strategy

(2018-2021) is aimed at improving coordination between service providers and ensuring that customers and vulnerable groups are protected (Kabirizi, 2018; MWE, 2018; MWE, 2019a). The strategy does not, however, cover the entire rural – urban spectrum; it covers only the service areas of piped schemes in small towns and rural growth centres. The next phase of the Water Utility Regulation Department (due in 2021/22) may benefit from the direct involvement of the rural-oriented Technical Support Units and collaboration with Districts, in order to ensure that no areas are left out between urban and rural policy frameworks.

In 2020 and 2021, the MWE District Implementation Manual is set for updating (the current edition is from 2013); this is expected to provide clarification on the role of the Districts in coordinating and planning both community managed rural point sources and utility services. This manual will provide the practical guidelines for implementation at the district level of the new National Framework for Operation and Maintenance of Rural Water Infrastructure in Uganda. It is not clear who will take the role of Area Service Provider; it could be taken on by one of the utilities, by a local association of mechanics, or by a new private sector actor. This choice will have major implications for the ability to cross-subsidise services at the scale of a single service provider.

In a round table discussion held as part of this research, managers for National Water, the Umbrella, and Kabarole District Local Government all expressed a desire to collaborate on the goal of universal access. "We are all working toward the same goals, and we know there is no one at this table who can do it alone. We have to work together", said one utility manager. Efforts have been made by the MWE to promote shared asset-monitoring systems in the form of the Uganda Water Supply Atlas and Utility Performance Monitoring and Information System. Both of these provide online databases that, theoretically, are up to date with information about water supply from utilities and districts across Uganda; in our research, however, some stakeholders were aware of these data sources but none were using it to inform their planning or decision-making.

6.5.4 Study limitations and future work

The research framework included qualitative methods that are subject to research bias; this potential bias was mitigated by including many stakeholders, triangulating findings through use of multiple methods, and by being engaged actors throughout the research process. Overall, we view our largest contribution to be the synthesis and framing of several occasionally conflicting findings and viewpoints within the sector.

The study was limited in its consideration of water quality, water resource management, seasonality, and in its assessment of the details of self-supply. Future work could include more narrowly defined quantitative analyses of certain results, for example cost modelling, assessments of appropriate technology, and willingness to pay. More financial modelling would be required to determine the optimal blend of models, tariff levels, and public subsidies to optimise investment.

6.6 Conclusion

A large amount of data and information from different sources and stakeholders was synthesised, enabling a comprehensive analysis of the emerging approach to mixed-model service delivery in Uganda. The increasingly blurred urban – rural boundary and the growing role of utility provision of piped water within the rural landscape in Kabarole shows a slow but accelerating departure from the status quo. In the case of Kabarole, however, a majority of the population outside the municipality still relies on community managed point sources and 31% of households still do not have access to an improved water source.

The drive towards consolidation and professionalization in Uganda reflects a stage of sector maturation that can also be observed in other countries as part of the transition towards higher performing and more universal service delivery systems. The creation of new management models and consolidation under a smaller number of public providers offers an opportunity to close gaps in service delivery (and improve service levels), but the wider financial, regulatory and planning systems that are needed to manage this transition are still under development. The implications of centrally led changes are yet to be fully understood at the local level, and more support will be needed to enable decentralised actors to understand and play their roles in the new landscape.

The performance of each service provider is affected by demographic factors, by its relationship and interaction with other service providers, by the decisions of authorities and regulators, and by customer demand. Central Government policy and the relative allocations of public finance to each utility and to District Local Governments will have a decisive role in the progressive improvement – or decline – of each service delivery model and its supporting systems.

The progressive reforms in the Ugandan drinking water services sector make it a good case for exploring the practicalities of service delivery model innovation and implementation of change at scale. Documentation and integration of applied research results in Kabarole, and in Uganda overall, may help the sector to adapt more rapidly, while also providing insight and solutions relevant to other countries who may be facing similar challenges. Despite the urgency of the water supply crisis, an iterative process of strategy adjustment, implementation and monitoring is likely to continue for years to come. The good news is that this process seems to be one that the majority of stakeholders in Uganda are prepared to engage with and support.

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Logical bridge 3 (connecting material)

In Chapter 6, the drinking water system in Uganda was found to be in a period of transition. The landscape of community managed point sources is being consolidated under a new operation and maintenance framework, and utility models with piped networks are extending into rural areas. Chapter 7 builds on these findings and presents the second part of the participatory action-research carried out with the learning alliance in Kabarole. It includes an analysis of the demand aspect of improving water supply, an aspect noted as missing from the nine subsystems in Chapter 5. The work presented in Chapter 7 is guided by two research questions:

First, 'Is systems assessment (through its sub-systems) an effective approach to identify pathways to change, and to support a network of stakeholders to use systems thinking to plan, innovate, and promote public system transformation for WASH?'. Answering this question requires a future-oriented approach. Members of the learning alliance in Kabarole, including stakeholders representing regional and national levels, are engaged in a scenario development process. Starting with an extensive list of factors derived from the systems analysis in Chapter 6, the most important and influential factors are identified. These are used to define possible future scenarios and to co-create strategies to achieve the Kabarole's service delivery targets under a range of possible conditions. The scenario techniques within a learning alliance, as part of the systems approach, are used to increase social learning and support adaptive management. The effectiveness of this process is discussed.

Second, 'How can a national WASH system transition from a paradigm of low quality unreliable services toward one that delivers universal access to safe water?'. Theory from the field of transition management is used to analyze how change takes place in public service sectors. The transition in Uganda is studied from this perspective, with a focus on understanding what will be required to achieve the higher standards and universality of services targeted in SDG6 and Uganda's National Vision. The role of a learning alliance and a knowledgeable network of stakeholders in stimulating constructive change in the WASH system is discussed.

Chapter 7: (Paper 4) Scenarios for public systems transition using learning alliances: the case of water supply in Uganda

Journal article accepted for publication by the International Journal of Water Resources Development

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Published as : Huston, A., Gaskin, S., Nabunnya, J., Moriarty, P., Watsisi, M. (in press). Scenarios for public systems transition using learning alliances: the case of water supply in Uganda. *International Journal of Water Resources Development.*

Abstract

Uganda's Vision 2040 aims to modernize rural water supply through a transition from community managed point sources to professionally managed piped water services. at the start of the transition period, a learning alliance established in Kabarole District participated in action-research to develop scenarios predicting possible future development trajectories. The diversity of its membership, whose formal institutional roles spanned national, district and niche levels, increased the robustness of strategies proposed for the adaptively managed transition of the

public water service. The learning alliance has been facilitated by an NGO providing funding and expert advice; the effectiveness of this approach is demonstrated.

7.1 Introduction

The Sustainable Development Goals (SDGs) are a global agenda for poverty reduction, elimination of inequalities, environmental protection, peace and justice with 17 goals to be achieved by 2030. SDG 6 sets the target for universal access to basic drinking water and an increase in the quality and safety of services. For countries, achieving this goal is complex due to population growth, limited financial resources, urbanization, climate change, and water resource degradation (WHO & UNICEF, 2017). Universal public drinking water services require adequate water resources and service delivery models to reach all of the population; these depend on effective public administration and finance to implement the policy of universal provision. All components of the system need to work together and must adapt to the continually evolving social, technical, and environmental context. Where the system is weak, adaptive management is difficult to achieve solely through directives form central government (Geels, 2005).

In sub-Saharan African countries, such as Uganda, there is a general transition toward new drinking water service delivery methods, particularly outside major urban centres in informal settlements, in small towns and in rural settings (Huston et al., 2021 (Chapter 6)). After decades of service delivery using community-based and at times charity-driven systems, many countries are adopting professional approaches to piped water delivery (WHO & UNICEF, 2019; National Planning Authority, 2020). In urban areas, there is widespread attention to utility reform (Eberhard, 2018). Expectations of water service standards are also rising, pressuring providers to professionalise their services. Public sector leadership is tasked with the challenge of accelerating service delivery improvements, while ensuring that the still unserved and marginalised populations are not left behind.

National level stakeholders in Uganda have a vision to achieve SDG 6 by 2030 and universal access to safe piped water by 2040. The targets for 2025 are to achieve 100% access in urban areas and 85% access in rural areas, using a combination of public stand posts and household connections (National Planning Authority, 2013). To meet the targets, Uganda plans to transition from rural water services delivered by community managed facilities based on manually operated point sources (boreholes and wells) to piped services provided by public utilities and professional private operators.

In Kabarole District, as representative of Uganda, an established learning alliance had developed the Kabarole District WASH Masterplan 2018-2030 (‘Masterplan’). The Masterplan describes a high-level strategy for the progressive realisation of universal water, sanitation, and hygiene (WASH) services by 2030 (Kabarole District Council, 2018). Scenario development and action-research were used to develop specific implementation strategies for achieving the goal and to support social learning, with a focus on drinking water. The strategies developed by the learning alliance and the observed changes underway are analysed using the multi-level perspective for socio-technical transitions, as developed by Geels (2005).

7.2 **Literature review and background**

Scenario development by a learning alliance is a multi-level technique for managing a socio-technical transition, which can be used in public water service provision. The Ugandan context in which this is implemented is described.

7.2.1 Learning alliances and the use of scenario development

Learning alliances are a structured process for facilitating social learning, which is used to support the re-orientation of a social-technical system to deliver improved outcomes (Moriarty, et al., 2005). Similarly to ‘transition management’ and ‘strategic niche-management’ (Geels, 2005), group experimental learning is used to identify possible solutions and improve system outcomes. In the learning process, a facilitator supports the development of a shared vision of the future and stimulates innovation by members through critical dialogue and problem solving and/or action research. An enabling environment for the implementation of the vision is built through the formal institutional roles of the members at different levels in the system, which helps identify 'windows of opportunity' for change (Geels, 2005). Learning alliances are based on the understanding that social learning and interaction across all levels of the system, both at conceptual levels (niche, regime, landscape) and administrative/political levels (e.g. district, national), are necessary for evolutionary socio-technical change (Moriarty, et al., 2005).

Scenario development is an approach to study structural system change and explore long term development trajectories, while building collective capacity for adaptation (Sondeijker et al., 2006). For scenario development within a learning alliance, stakeholders first agree on key details of the shared problem and construct a shared vision for the future. Subsequent scenario development iteratively explores possible futures and strategies to achieve the vision, which improves the strategies' resilience. The discussions may lead to a modification of the original vision, while fostering social learning and building capacity (Batchelor, et al., 2005).

7.2.2 A multi-level perspective of public systems for drinking water services

Public drinking water systems are developed and improved progressively through a process of socio-technical co-evolution, over decades to centuries (Geels, 2005). When describing transitions in socio-technical systems, a multi-level perspective can help conceptualise how the dominant meso-system 'regimes' shift over time as the result of macro level (context, landscape) and micro level (niche) influences (Geels, 2005). The socio-technical sub-systems for water services include institutional capacity, finance, demand for and use of services, and sustainability in terms of water resource availability and long-term functionality of facilities.

The perspective has been applied to study transitions in water supply in the Netherlands and waste management in East Africa (Geels, 2005; Oyake-Ombis et al., 2015). In the Netherlands, the transition has been described as a continuous cycle of problem definition, solution development, observation of new problems, and adaptation. These iterations brought the country from a pay-per-bucket system with high rates of contamination in 1850 to today's system of nearly universal access to affordable piped safe water at the household level (Colenbrander and Zetland, 2018). Niche technical innovations, such as household plumbing or new water treatment options, only led to transitions when they were accompanied by social and cultural (landscape) changes such as widespread adoption of new personal hygiene practices and changing attitudes about payment for services. Landscape changes were then codified through regime-level instruments like new policies and the introduction of new service delivery institutions (Geels, 2005).

Currently, in many low- and middle-income countries, this process of public service evolution is occurring at an accelerated pace and with different dynamics. The differences are due, in part, to widespread knowledge of the importance of safe water for health and development, the development of government policies aligned to achieving time-bound national and global targets such as the SDGs (WHO & UNICEF, 2017). There is also increasing government commitment and spending (Hujo & Bangura, 2020). It has also been argued that externally driven initiatives have short-cut the natural co-evolution of demand and supply by providing improved water supplies at artificially low cost (Franceys, 2019).

7.2.3 Decentralized service delivery in Uganda

Uganda's Vision 2040, championed by strong national leadership, calls for the transformation of the country ''from a peasant to a modern and prosperous society" in 30 years. It plans for a transition from traditional use of surface water and springs toward higher levels of service offering greater reliability, safety, and equity for the population (Huston et al, 2021). The National Development Plan III (2020/2021 - 2024/25) introduces a high-level strategy to professionalise services and achieve cross-cutting SDG targets. The aim is, first, to provide at least basic water services to every village, and by 2040, to have upgraded the two thirds of the country currently served by community managed single point sources to piped water supply services (National Planning Authority, 2020).

In Uganda, public water service delivery is directed by the central (national) government through the Ministry of Water and Environment (MWE) that sets sector policies and legislation, and through the Ministry for Local Government (MoLG), which defines the framework for decentralised service delivery. The District Local Government ('District'), by the Water Act of 1997, is the service authority (i.e. responsible) for planning, managing and overseeing public service delivery, except when the authority is gazetted (legally assigned) to other providers. External actors are playing a reducing role, although an estimated 27% of water points in Uganda were constructed with NGO funding (MWE, 2020).

The District administrative structure includes political and technical units, which are regulated by the policies of the MoLG and the MWE (MWE, 2013). The District works with lower administrative structures (Sub-County/Town Council) to procure and construct drinking water schemes and to gazette them to service providers for operation and maintenance. Rural point sources and smaller schemes are gazetted to community management by water source committees or community water supply and sanitation boards. Piped schemes in urban areas, and increasingly in rural areas (due to the Vision 2040 transition), are gazetted to Regional and National public utilities for management, operation and maintenance. As the utilities grow, they are also undertaking capital projects to expand existing piped networks independent of, but in coordination with local governments.

Decentralized regional bodies of the Rural Water and Sanitation Division of the MWE are called Technical Support Units (TSUs), but recently renamed Rural Water and Sanitation Regional Centres (RWSRC). These were created in 2001 to support decentralization by working with districts, utilities, water management authorities, NGOs and development partners. They are critical as a liaison between central MWE planning and the District implementation of WASH policies and activities, in addition to supporting niche level innovation.

The 134 District Local Governments are thus the central pillar of the public service delivery regime. Primarily funded by government transfers, they must follow central government policy and financial frameworks, although individually a district or actors within a district can participate in niche-level innovation and incubation of new ideas. However, many districts face resource and capacity limitations (in both staff and resources) that hinder their performance, while unspent annual budgets are returned to the central government (MWE, 2019a).

In Kabarole, to assist the District to achieve SDG 6, a District WASH Task Team (Task Team) was established in 2016 to drive innovation and provide guidance. The Task Team developed the Kabarole District WASH Masterplan 2018-2030, which describes a high-level strategy for the progressive realisation of universal water, sanitation, and hygiene services (Kabarole District Council, 2018). The Task Team was supported by the international NGO IRC and the Sustainable WASH Systems Learning Partnership to become an active learning alliance with 26 members.

7.3 Methods

The research (2016 – 2019) used a participatory action-research methodology based on the Participatory Transformative Advocacy Research (PTAR) approach developed by Folifac (2012). The action-research was undertaken by the learning alliance together with IRC, an international non-governmental organisation working at the interface of policy and multi-stakeholder capacity-building in pursuit of SDG 6 (authors of this paper). The current research builds on existing networks from IRC's joint projects in Uganda since 2010.

The learning alliance was supported by IRC to undertake a comprehensive mixed-methods review of their water supply, sanitation, and hygiene systems, linked to a 2030 visioning and Masterplanning process. The type and quality of services in Kabarole were assessed in 2017 and 2019. The water service delivery system was analysed using a framework comprised of nine sub-systems (see Huston and Moriarty, 2018), each of which was assessed at national and district levels, and for each service delivery model in Kabarole (e.g. National Water, Umbrella, community management, self-supply) using a total of 392 Likert indicators. The assessment results are detailed in a separate publication: Huston et al., 2021 (Chapter 6).

The comprehensive review became the foundation for the Kabarole District WASH Masterplan 2018-2030 ('Masterplan'), which was the first of its kind in Uganda. It describes a high-level strategy including targets, a costed work plan and a financing strategy, for the progressive realisation of universal water, sanitation, and hygiene services (Kabarole District Council, 2018). Scenario development was initiated, as part of a larger action-research agenda, to support its implementation with a focus on drinking water.

Scenarios were developed over a two-year period using a combined approach based on methods from Moriarty et al (2005), Bishop et al (2007), and Wright et al (2013) to identify implementation strategies for a transition to improved water service delivery. An initial list of factors influencing service delivery, or expected to influence progress toward the 2030 vision as articulated in the Masterplan, was developed based on the mixed-methods assessment from the learning alliance and a review of literature and policy documents from Uganda. The list was expanded and refined through discussion of factors in sector meetings and workshops, and through dedicated reflection and analysis with learning alliance members. IRC facilitated dialogue with all 26 members during meetings, and also met with subgroups of 2-5 members with IRC transferring ideas between members and subgroups. Informal and semi-formal stakeholder interviews with national stakeholders were used to obtain perspectives on the relative importance and uncertainty of identified factors. A social network analysis and factor-mapping exercise with the learning alliance also provided insight on the scenarios (McNicholl, 2018; Valcourt et al., 2019). More details on the methods and numbers of stakeholders involved is provided in supplementary materials Table A4.1 (Appendix 4).

Using these methods, factors were grouped into common themes and those with high interconnection / dependency were combined. The factors were plotted according to their importance (greater/lesser) for achieving universal services by 2030 in Kabarole as specified in the Masterplan, and the level of uncertainty of them occurring (greater/lesser) as shown in Figure 1. The clustering of factors, through identification of leading factors and root causes, and the importance/uncertainty plotting was repeated three times incorporating feedback from key stakeholders, and the review of reports and proceedings of government meetings. The positive and negative extremes (predicted for 2030) of the three leading factors from the most important/most uncertain quadrant were used to identify eight scenarios, while the most-important/least-uncertain were included as trends expected in all scenarios (e.g. population growth). Similar scenarios were combined resulting in five final scenarios.

Strategies to achieve the vision under these different scenarios were developed starting with the identification of the basic strategy elements, which are the possible interventions (mechanisms and available technology) for water service delivery (e.g. extend piped networks, drill new bore holes, etc.).

Through group meetings facilitated by IRC, and individual discussions between sub-groups of members (e.g. planners and engineers, hand pump mechanics), learning alliance members considered ways to create incentives and enabling conditions for the interventions to be successful, both for the status quo and for the five identified scenarios. IRC, as facilitators, encouraged the consideration of district (regime) level as well as landscape and niche level initiatives.

To spur creative thinking, IRC organised learning visits for the members to travel to other districts in Uganda; a sub-group of members went on aa field trip to Ethiopia. IRC convened a national dialogue, on behalf of the MWE, that invited speakers from Kenya to present innovations in rural service delivery approaches (MWE,2019b). Some members were given financial and presentation support to attend and present at Uganda Water and Environment Week and one member attended an international WASH conference. While seeking ideas and inspiration from outside, the strategies were generally constrained by Uganda’s constitutional and legal frameworks, prompting learning alliance members to consider how to adapt ideas from other context to fit local needs.

Discussions were supported by the depictions of the positive and negative extremes of the leading factors in a QGIS map of Kabarole District with layers for population density, poverty, roads, water infrastructure and water resource availability. The 'most likely' scenario from the five was selected to further refine the strategies, while those 'less likely' were revisited periodically to increase the robustness of the strategies within different possible futures. In the final step (ongoing), the learning from these discussions is being used to further refine the strategic priorities for the implementation of Kabarole District's Masterplan.

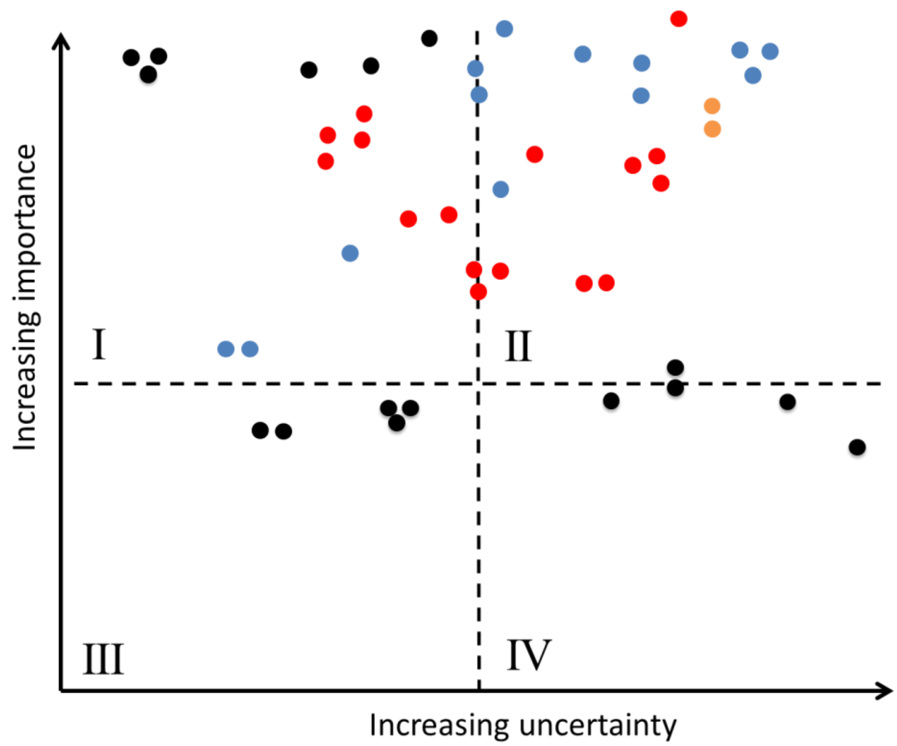


Figure 26: Ranking Factors for narrative scenarios according to importance and uncertainty. Factors were clustered into themes where blue= district mandate and capacity, red=demand for services, orange=water resource quality and black=other. The complete list of factors and their corresponding codes are presented in the supplementary materials Table A4.2 (Appendix 4).

7.4 Results

The meta-goals and strategy from the Kabarole District Masterplan 2030 are presented (Figure 27), followed by the empirical results from the scenario building work by the learning alliance in Kabarole district.

7.4.1 Sector ambition and the Kabarole District WASH Masterplan 2018-2030

The Masterplan was an initiative of The District WASH Task Team ('Task Team'). It was developed as both a technical and as a political tool to increase investment in WASH and accelerate progress toward universal and sustainable services. (Though not an official government structure, the Task Team has two members from the District Executive Committee, a small group of elected officials headed by the District Councilperson V (equivalent to a Mayor) that plans and develops programmes to bring to the District Council for debate and decision. Its members also include the TSU/RWSRC, representing regional and national interests.

IRC supported the Task Team to achieve its declared vision as a 'think and do tank', in the form of additional resources to conduct action-research studies, learning exchanges, and technical support and capacity building including facilitation of meetings. Though all activities in the methods section were jointly planned with members (e.g. learning visits to Ethiopia), IRC provided resources, ideas, and coordination to carry out these ideas.

The 26 learning alliance members are government staff (political and technical) from the water, education, and health sectors; members of the professional association of hand pump mechanics, religious leaders, journalists, CSOs/NGOs employees and representatives from sub-county government. The alliance is recognised by the District Council and makes recommendations to both the District WASH Coordination Committee and the District Council.

The learning alliance is a niche-level platform, whose members are embedded in the main service delivery regimes at district level. Some remain active in multi-stakeholder networks at regional and national levels, such as formal working groups and informal learning exchanges. The

Masterplan and its targets (Figure 27) were adopted by the District Council. Although it was launched by the State Minister of Local Government, it remains a niche tool that will require more follow-up support to be fully recognised by the MoLG. Progress toward the 2021 targets of the Kabarole Master Plan appear to be on track despite COVID-19, but a review planned for 2021 will provide a complete assessment.

The Masterplan was developed during a period in which the MWE had initiated a series of progressive regime level changes to improve water supply: an expanded mandate for the National Utility (2016), the conversion of existing support organisations for community management into six new regional rural utilities (2017), a new Regulatory strategy for water service regulation, and a revised operation and maintenance framework for rural water (2019). From 2017-2020, linked to the National Development Plan II, the 100% Water Service Coverage Acceleration Project (SCAP100) financed 140,000 new water connections and 20,000 Public Stand Pipes (PSPs) in over 12,000 villages (21% of all villages) across Uganda. Each year, sector guidelines are produced by the MWE to help actors adapt to new policies based on feedback from the previous year. However, the direct implications of central changes are not always clear for local government (Huston et al, 2021 (Chapter 6)).

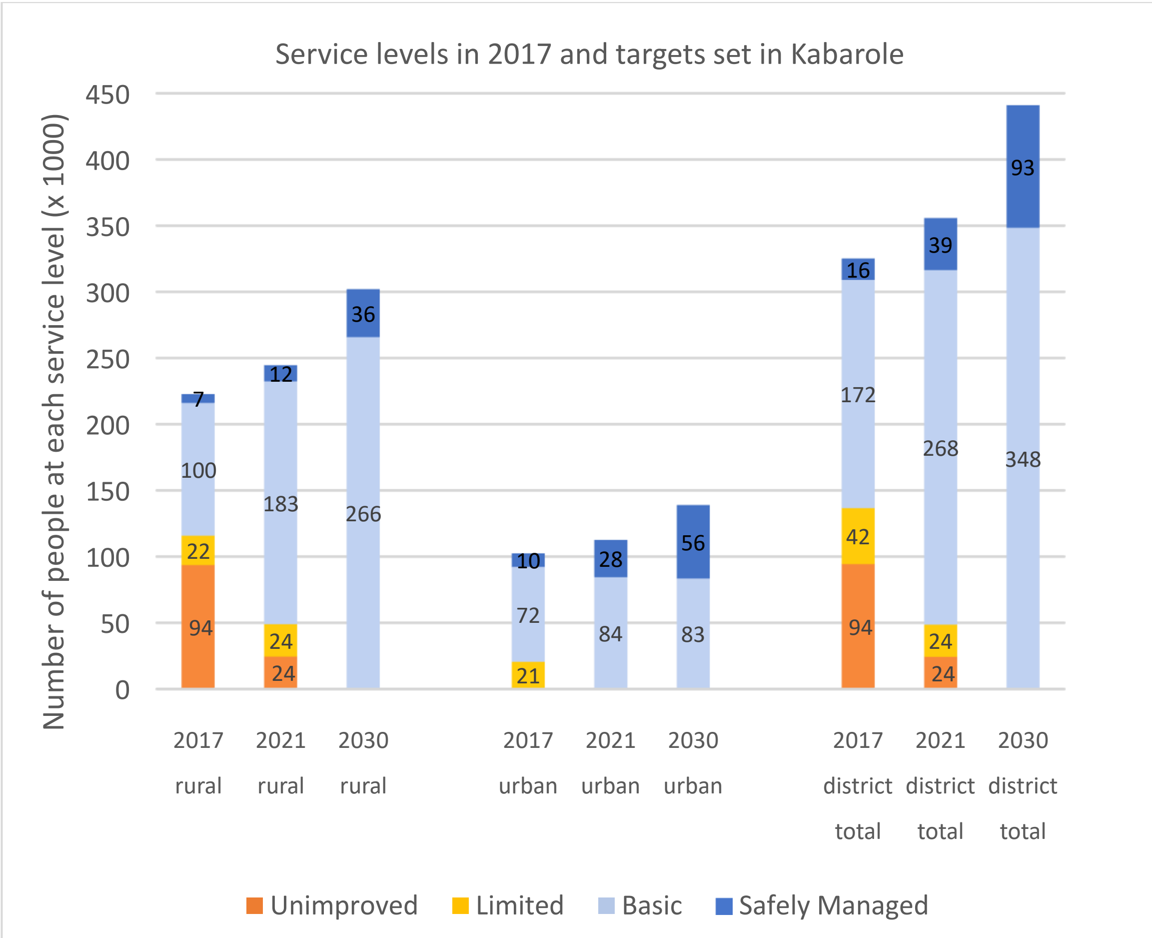


Figure 27: Service levels in 2017 and agreed targets for 2021, and 2030 set by Kabarole District Stakeholders in Masterplan, accounting for the projected population growth (Kabarole District Council, 2018).

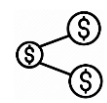
7.4.2 Scenario development results

The scenario development supported the first phase of the Masterplan, 2017-2021. Forty-seven factors were identified that would influence the District's ability to achieve the Masterplan targets and foster a systems transition. The factors were used to develop potential future scenarios and the strategies required to foster the transition to full service provision.

Factors in service delivery

The three most important and most uncertain factors (quadrant II in Figure 1) affecting the District's ability to achieve the Masterplan targets were identified, based on 20 clustered factors, as the District's capacity to fulfil service authority responsibilities (financial and human resources), the effective demand for professional water services, and water resource quality and degradation. Hypothetical positive and negative extremes for each factor were defined (Table 1) and used to develop the scenarios. The complete list of factors and their clustering into the 3 main factors is in the supplementary materials in Table A4.2 (Appendix 4).

Table 11: The three priority factors chosen for scenario development.

Main Factor	Negative extreme	Positive extreme	Icon for scenario descriptions (Table 12)
District mandate and capacity to serve as service authority (financial and human resources)	District resources decrease and they are left powerless; no alternative service authority steps in leaving service provision uncoordinated; the poor and hardest to reach are left behind	Districts have discretional funding to fulfil the vision and service authority mandate. Service standards improve, appropriate infrastructure investments are made. The District's power is validated at the national level, they are able to collaborate with and hold utilities and other service providers to account.	
Effective demand for professional	People use unimproved water sources, drink contaminated water (inadequate demand for professional/improved water)	95-100% population demand and are willing and able to pay for water.	

water services			
Water resource quality and degradation	Extreme degradation, reduction in quality and quantity. Shallow wells and protected springs dry up, people use unimproved (or poorly protected) sources and are increasingly ill. Utility water requires sophisticated treatment and becomes prohibitively expensive to provide.	Water sources are protected, quality improves, quantity remains the same. Shallow wells continue to be used as a part of supported self-supply for those unable to be reached with more sophisticated infrastructure.	

Factor 1: District mandate and capacity as service authority (financial and human resources)

The District Local Government is the service authority for all water services except those gazetted to utilities, and is responsible for planning, coordination of service providers, oversight of services and support to service providers. When the number of schemes gazetted for utility management increases, the District will be responsible only for point sources and areas unreached by utilities (more difficult/less efficient services), as well as for coordination with utilities and other WASH stakeholders operating in the district.

Kabarole District Local Government has demonstrated leadership and soft power by performing as a competent and ambitious service authority, exemplified by the development of and commitment to the Masterplan, but also has capacity limitations (financial and staffing) that affected its ability to fulfil its mandate (Huston et al, in press). The District's mandate and its resources are key factors that will influence 2030 outcomes.

Factor 2: Effective Demand for professional water services

Achieving the professionally delivered safe water services of SDG6 will require citizens' to demand, use, and pay for a substantial part of the total cost, even if subsidies will still be required for expanding and delivering services (Fonseca & Pories, 2017).

Many users appear to be unwilling to pay for the low levels of service offered by community managed water points, but express willingness and ability to pay for the newly available utility services and household connections that are more reliable, safer (treated), and more convenient (Marshall, 2019). The 2030 outcomes will depend on whether effective demand for services can be developed and matched by the provision of services of the expected quality.

Factor 3. Water resource quality and degradation

An estimated 70% of the population in Kabarole rely on untreated, improved point sources drawing on (shallow and deep) groundwater, while 20% rely on the National Water and Sewerage Corporation (NWSC) municipal network, which is supplied by treated and disinfected water from the River Mpanga. Both are subject to seasonal variation, are directly impacted by land use changes, and are extremely vulnerable to contamination (Kabarole District Council, 2018). The likely climate change impacts in western Uganda are expected to influence the period and duration of the two annual rainy seasons (Kisakye et al., 2018). It is possible to adapt to these changes by using either deeper groundwater sources (which are more resilient and protected from contamination), and or building additional storage capacity and water treatment and disinfection facilities. This factor has significant implications for the cost and the technology required to meet the 2030 targets.

Possible scenarios for Kabarole in 2030

Summary descriptions of the five scenarios developed are presented in Table 12. These include the most likely scenario, an optimistic scenario, a pessimistic scenario, and two alternative possible scenarios. The most likely scenario resulted from a declining capacity of the district to be the service authority, a rising effective demand, and the degradation of water resources such that low-cost shallow water sources become highly unsafe. The discontinuation of the use of shallow wells began formally in 2019 with an MWE ban on their construction due to their seasonal unreliability and contamination.

The most likely scenario was depicted using GIS map simulations for two aspects: i) the drying up or irreversible contamination of wells, simulated as the removal of all shallow wells (< 15 m) and ii) expansion of professional piped schemes continuing at the same rate as observed between 2016-2019 during the SCAP100 initiative. These changes, compared to the 2019 water supply situation maps, are presented in Figure 3. These maps were a critical tool for supporting visualisation of future scenarios and future-oriented thinking of stakeholders during the strategy development process.

Table 12: Five scenarios for WASH service delivery in Kabarole.

Possible Scenarios	**Main factors used to develop scenario**
Most likely scenario: The rise of paid professional services with limited local regulation	
Budget constraints have increased, and public finance is directed toward utilities, making less available for Districts. More utility networks means a smaller area of responsibility under the District, focused on the 'most rural'. People are willing and able to pay for utility services but not for point sources under community management which remain at status quo, with lower water quality.	
Optimistic scenario: a resilient landscape of professional services	
The District is a responsible and capable service authority, with more resources to support coordination with utilities. It has increased capacity to spend its funds efficiently for service provision in rural dispersed areas not reached by utilities. People are willing to pay for improved point and utility services. Relative stability	

of water resources prevents the need for expensive infrastructure for storage and advanced treatment; primary treatment options are extended.	
Pessimistic scenario: Inadequate resources and open consumption of poor-quality water	
The district struggles to get adequate resources to deliver its mandate and is perceived by other actors as powerless. People refuse to pay for services and the growth of utilities slows down after the 2017-2020 SCAP100 project (which is currently financing major National utility expansion) ends. The business case for utilities struggles as people fail to increase consumption and pay bills. Water resource quality degrades making supply costs higher, and untreated and unimproved supplies become increasingly risky.	
Alternative scenario 1: District leads in collaboration with utilities to address degrading water resources	
Resources for the District increase and it can deliver its mandate to strengthen performance of community management (in line with MWE's vision for 'community management plus') and effectively coordinates with utilities, who have a growing role. Water resource quality in surface and shallow groundwater sources degrades, so more expensive technologies and treatment are required, and those who can pay are willing to invest in safer water.	
Alternate scenario 2: District leadership improves services but struggles for professionalization	
Resources for the District increase, including more discretionary funding, however user contribution for services is low. Rural service delivery is through subsidized community management as utilities retreat from areas where customer payments are unreliable. Water resources remain at status quo, with deeper point sources reducing seasonality concerns. Many people continue using unimproved or basic sources that can be accessed for free or very cheaply.	

Figure 28 (next pages): From left: (a) Water points in Kabarole in 2019; (b) 2030 scenario with shallow wells and protected springs removed simulating dying up or contamination; (c) piped schemes mapped in 2017; (d) 2030 scenario with piped schemes extended at similar rates to those observed between 2017-2019. Note that the administrative boundaries of the municipality of Fort Portal are expected to change following the formation and expansion of Fort Portal City.

Figure 28 (a): 2019 mapped water points

Figure 28 (b): 2030 scenario: groundwater degradation

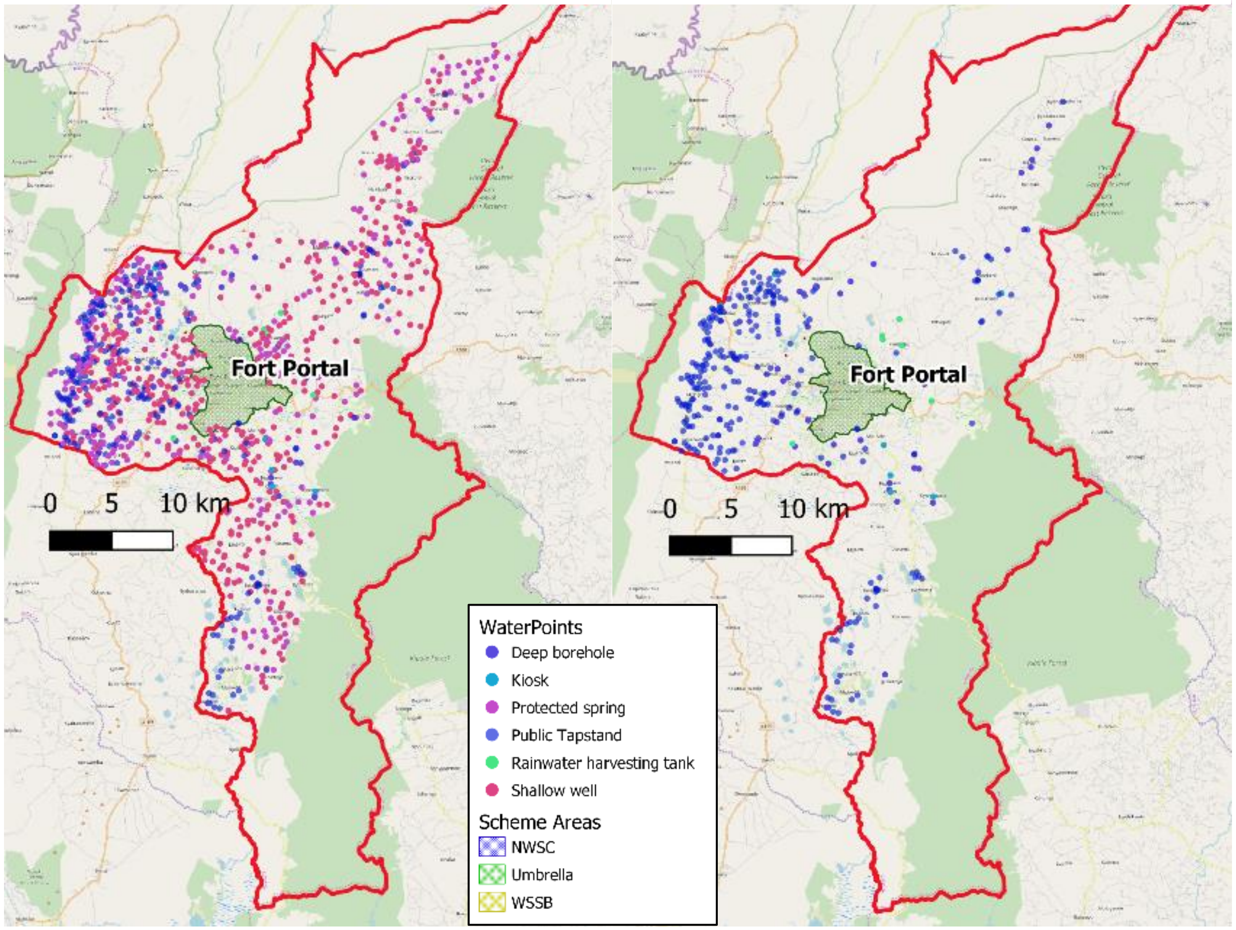


Figure 28 (c): 2019 mapped schemes

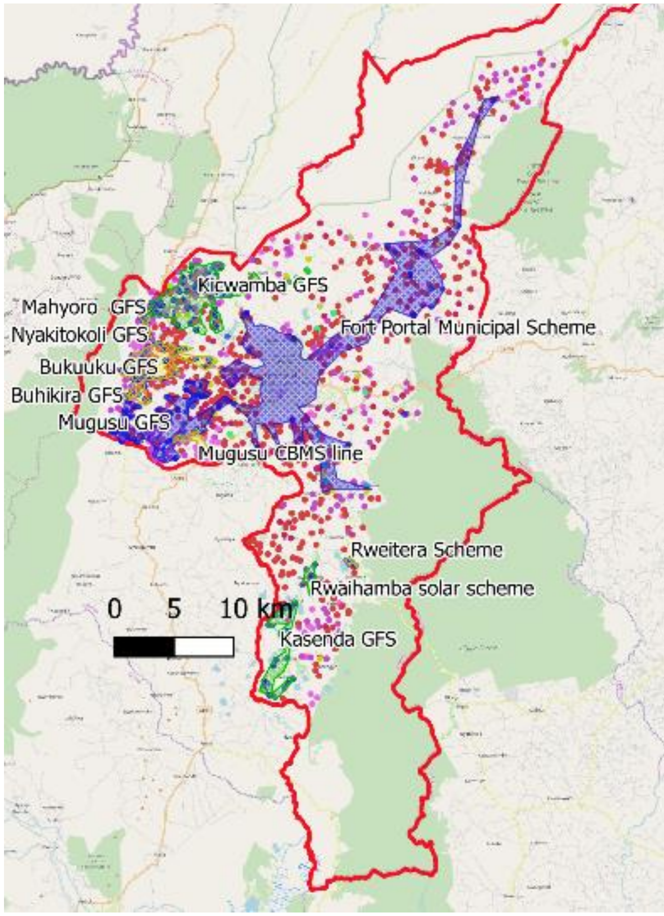
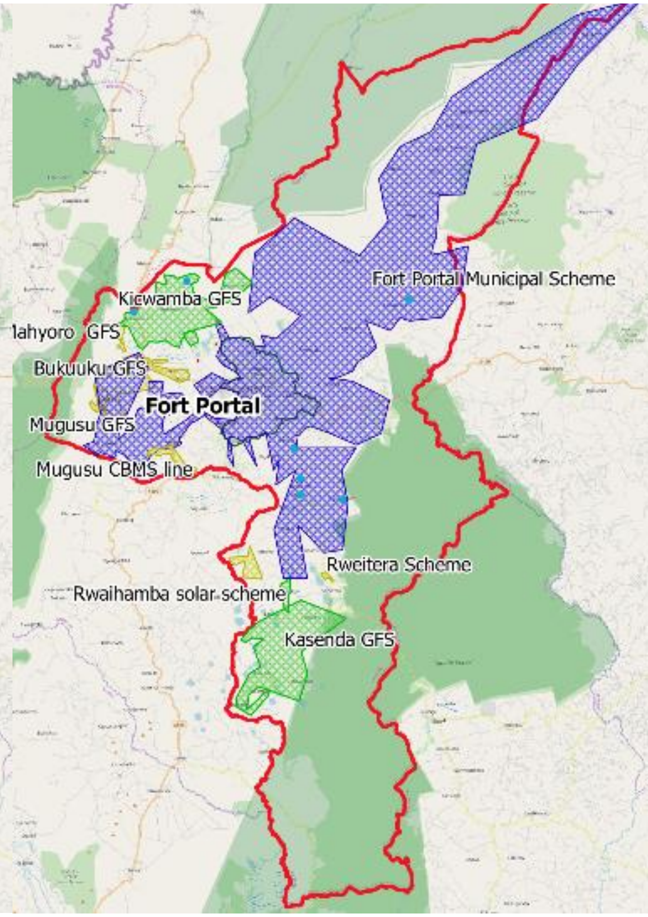


Figure 28 (d): 2030 scenario: utility growth



7.4.3 Strategies to achieve universal water supply services in Kabarole by 2030

The basis for different strategies , for example installing new household connections or improving water treatment options, were discussed with learning alliance members individually and as a group, and with utility managers to assess their potential for reaching the Masterplan targets. Strategies were developed to incorporate these ideas. Five strategies were judged to have the strongest potential of achieving the desired transition, or of fostering the conditions for achieving 100% access to basic services by 2030 under a range of possible future scenarios. These are summarised below (details are in supplementary materials Table A4.3 and Table A4.4) (Appendix 4).

Table 13: The five leading strategies developed to support implementation of the Kabarole District Masterplan 2030

Strategy 1: District pursues partnership with National Water and other utilities to establish a public-public partnership model to accelerate service provision: Use government-utility partnerships to prioritise extension and performance improvement of piped networks to achieve economies of scale, while remaining accountable to the national vision of universality as public entities.
Strategy 2: Professional area-wide management arrangement for non-gazetted rural areas: An area-based service provider (ASP) is given a performance-based contract for managing operations and maintenance for all point water sources in a defined area. This provider could be part of an existing utility, a hand-pump mechanics association, a Sub-County Water Supply and Sanitation Board, or a new entity altogether.
Strategy 3: Sub-County Water Supply and Sanitation Boards to support community management: The gap between district structures and community level service provision is large. To fill this gap, a formal sub-county level structure could receive and manage public funds, and support and hold community service providers to account for performance.

Strategy 4: Turn effective demand into user payment through customer care and customer satisfaction as a regulatory feedback mechanism: The service authority requires service providers (community management and utilities) to focus on developing the value proposition for improved water services: demonstrating the quality of the service (and the water), informing users of the actual costs of service delivery, and reinforcing the role of the water user as a customer (not a beneficiary) through improved billing and clear customer feedback mechanisms.

Strategy 5: Systematic support to self-supply: Support for self-supply through a community oriented approach incentivising rainwater harvesting, supporting households to upgrade supplies, and undertaking information campaigns and incentivising the use of point-of-use water treatment technologies (boiling, filtration, chlorination).

These strategies can be implemented (one or more) and can also be used to make recommendations in the review of existing policies. Strategy 2 and 3 were proposed from the review of the Operation and Maintenance Framework (guidelines and manuals for Water Supply and Sanitation Boards and Area Service Providers) for rural water supply by the Technical Expert Committee on Infrastructure Operation and Maintenance of the MWE. Members of the learning alliance, including IRC, are also members of this committee ensuring the sharing of knowledge between these groups. In Kabarole District, the strategies will continue to be refined by the members of the learning alliance, and will be presented in a report supporting a 2020/2021 review of the Kabarole WASH Masterplan 2030.

7.5 Discussion

7.5.1 The learning alliance in the context of national landscape change

The learning alliance was active during a time of national change. As the third phase of the National Development Planning framework toward Uganda's Vision 2040 began, the MWE adopted a new framework for the operation and maintenance of rural water supply infrastructure and formed a new department for water utility regulation to oversee a multi-year transition strategy for the sector, while national and regional utilities grew significantly. The rationale for these changes was an improvement of sector performance responding to weaknesses in the current systems. The MWE identified many similar challenges and factors as identified by the Kabarole learning alliance (MWE, 2019a, 2019c). MWE was transparent and inclusive in developing the proposed changes, using multi-stakeholder platforms to consult with a range of stakeholders and used the feedback to refine the changes. Participation of District staff in the national process was variable, but the deconcentrated arms of the MWE (the TSUs) are considered to represent decentralised needs and interests. In 2020, the TSUs were renamed to RWSRCs and their number was reduced to six (one for each of the six regions of Uganda) to align with the changing sector structure. The new rural operation and maintenance framework was disseminated over several months to ensure staff in all 134 districts were informed of the implications.

In addition to centrally-led changes, the landscape factors of shifting livelihoods and changing cultural attitudes associated with urbanisation and increasing global connectivity are exerting pressure (National Planning Authority, 2020). In the water sector, user expectations are rising and there is a greater willingness to pay for more convenient or safer services (Huston et al, in press), even with 70% of the population practicing subsistence agriculture. People from all socio-economic backgrounds already pay for health, education, energy and communications services, and for bottled water for special events - even in remote rural villages. This cash economy is at odds with the regime of community managed services, with its roots in an earlier pre-cash economy, its reliance on volunteers for operation and maintenance, and its provision of a low level of 'basic' service. This landscape shift has also been observed in Kenya, where community managed services were the least preferred by rural residents (Hope, 2015).

Another significant landscape factor is the 3% population growth rate (5% in urban areas) and the age structure, which will put enormous pressure on public services in the next 20 years. An estimated 36 million people will be added to the current population of 45 million (UNDESA, 2017). In Kabarole, to account for a projected population increase of 24% (86,000 people) by 2030 (9 years) approximately 460 additional public stand posts and 4,900 household connections will be required (Figure 2). If the rapid rate of infrastructure expansion (as in the SCAP 100 project) cannot be sustained, it will lead to lowering of the level of services received. At the same time, increasing population density – if managed well – will reduce the per-capita costs of providing services.

A gradual and transformative approach to change within socio-technical regimes requires that regime level actors are able to perceive and act on landscape pressures. While population growth rates were rarely mentioned during scenario development in Kabarole (it was listed as a landscape factor, and built into Masterplan targets and costing, but not prioritised by learning alliance members in the scenarios), the Third National Development Plan 2020/2021-2024/2025 refers frequently to both the challenges and opportunities provided by Uganda's demographics. In Uganda, population increase is being considered by policy makers in the water sector, but its pressure on services could outpace improvements unless policy is developed to rapidly expand services, and/or population growth rates start to decrease.

7.5.2 Transition management of the Ugandan drinking water sector

Public sector transition management is a deliberate attempt to bring about long-term change at a systems level for collective benefit, by fostering change using instruments of governance (Rotmans et al., 2001). The Ugandan water and environment sector leadership is managing a transition from community managed point sources under District authority to professionally managed piped water services under the authority of national (NWSC) and regional (umbrella utilities) public utilities. At both district and national levels, public authorities are steering the transition using long-term planning based on multi-actor, multi-level thinking.

Uganda's Vision 2040 is being implemented through a series of National Development Plans and progressive reforms, which reflect learning-by-doing, continuous innovation and systems improvement. Within the centrally led change process, the MWE is providing a policy framework in which space for innovation is retained. The sector (led by the MWE) has several institutionalised processes for multi-stakeholder sector learning and it encourages interaction between stakeholders from niche, regime, and landscape levels. Joint sector review mechanisms, a network of technical working groups, and specific deconcentrated units (TSUs/ RWSRCs) are dedicated to supporting actors at decentralised levels to improve performance and implement national policies.

The MWE embraces a culture of sector learning and seeks genuine feedback through these processes; in a series of national dialogues on maintenance of water supply infrastructure (MWE, 2019b), a representative of the MWE made the message clear, *"Learn along with us, please bring your experiences and your ideas because from where we sit we cannot yet see the whole picture."* The annual Uganda Water and Environment Week, hosted by the MWE's Water Resources Institute (WRI) since 2018, is another strong example.

An important caveat for learning and adaptive management is the importance of regulation and of keeping complexity to a manageable level while supporting innovation. One of MWE's objectives in the new Operations and Maintenance Framework is to reduce the number of non-standard service delivery models and direct the sector toward a more harmonised and uniform service delivery regime. As stated by a high-level technocrat in the MWE, "*We want to end the situation in which every district or organisation is doing things in their way.*" This regime level effort to reform operations and maintenance processes could be interpreted as curbing innovation, however it will support the stabilisation and consolidation of service delivery, and promote a more consistent approach that embraces and systematises use of best practices. An example of the balance between control of and support to innovation is the legislative structure and performance standards provided by MWE for the six regional utilities (established in 2016), which allowed each regional utility to experiment with management frameworks and strategies. After three to four years of experience, the MWE promoted a learning exchange between them and is expected to adopt successful innovations and approaches as requirements and standards to implement across all six utilities.

An adaptive approach is also embraced at decentralised levels. In the Rwenzori Region (in which Kabarole sits), there is an annual learning forum focused on water, sanitation, hygiene and water resources management. The forum was initially funded by an IRC project (2009-2015) but is now institutionalised as a government-funded event. It, convenes stakeholders from 13 districts to share insights and concerns, promote best practices, and discuss implementation of national policies. In Kabarole, an adaptive approach is evident in an inclusive annual planning and budget conference, in the data-driven approach to developing the Masterplan, and in the responsiveness of district level decisions makers to emerging ideas from action-research activities of the learning alliance. While Kabarole has extra support from IRC in the form of financing and support of the learning alliance activities, other Districts, such as Kamwenge and Kamuli, demonstrate similarly inclusive approaches.

The District has the challenge to innovate and optimize its performance within the framework provided nationally by the MWE, and while this framework evolves under the MWE's adaptive planning approach. The MWE is expanding professional provision in rural areas through its SCAP 100 programme in which new piped village systems are built and operated by the National Water and Sewerage Corporation (NWSC) utility. It is also gazetting existing piped systems (formerly community managed) to rural umbrella utilities. While the District Local Government and/or sub-county governments are consulted on the gazetting of schemes, the District's authority and role is changing as the MWE is more involved in planning decisions at decentralised levels. The utility service providers in a district are first accountable to the MWE as the regulator, and the mechanism for accountability toward or joint planning responsibility with the District is unclear. During the transition to a professionally managed service delivery regime, both the community management and utility frameworks will coexist. The overlapping of responsibility during the transition is a necessary, but time limited stage within a regime transition, particularly for a sector engaged in a “learning-by-doing” process. There are numerous pathways to all socio-technical transitions, depending on many factors at all levels, which lead to different possible future scenarios. Competition between these regimes is already emerging as both regimes depend on public finance, so budget allocations and priorities will influence the trajectory of change.

Despite growing institutional and technical capacity, the District faces resource constraints in its current role that are likely to continue. For example, 2 out of 5 staff positions in the District Water Office were empty at some point during this study, and the District Headquarters does not have a reliable internet connection. The greatest percentage of the District’s revenue comes from the central government, but has declined gradually since 2012. However, there is room to generate more revenue locally, such as by raising taxes or tariffs. Both the District Council and the Task Team have established resource mobilisation teams to explore ways to increase funding from local, national, or international sources.

7.5.3 The role of a learning alliance and participatory scenario development

The Kabarole District learning alliance (based on the District WASH Task Team) is a niche level platform with actors from all levels, including several who are influential at the regime level. Its placement at the District level, where the regime, landscape, and niche levels interact, means that its 26 members representing diverse perspectives could collectively identify a complete list of factors for scenario development. Representatives of sub-district structures, civil society, and religious groups in the learning alliance enable it to develop solutions that are appropriate for the local context. Participation of the TSUs/RWSRCs (the deconcentrated structures of the MWE) brings feedback and information from the national level and from other districts. Learning alliance members are also active in other learning platforms such as the Rwenzori Regional Learning Forum and Uganda Water and Environment Week, which enhances social learning and offers pathways to scale up ideas generated within the learning alliance, for example district Masterplans.

The scenario development with the learning alliance complemented larger ongoing action-research initiatives, such as testing of new service delivery models and monitoring tools. It was integrated within ongoing activities in the learning alliance workplan. Brainstorming and critique of emerging results was done within regular (approximately quarterly) learning alliance meetings and through routine dialogue with smaller groups of members or individuals, rather than as a series of workshops dedicated to scenario development only. While intended to reduce the burden on the already very busy members, the absence of a focused group dedicated entirely to the scenario development limited the mastery of the methodology obtained by stakeholders and the ownership of results. IRC synthesized the many discussions to produce results, which were iteratively improved through inclusive dialogue with individuals and the group. Certain strategy elements and concepts, such as exploring the potential for the Hand Pump Mechanics Association to become an area-wide service provider— are being taken forward by the alliance. The full scenario and strategy results are scheduled for reflection with the learning alliance as part of a Masterplan review scheduled for 2021. To ensure the learning alliance offers support to, rather than duplication of, other structures and that its ideas will be taken up, regular communication and feedback with formal structures is important. The District Water and Sanitation Coordination Committee is a separate multi-stakeholder body that convenes stakeholders quarterly to share plans and updates and to inform the District Council. The learning alliance provides an update at these quarterly meetings as well as any recommendations it has developed, while the District Council or other stakeholders may suggest topics for the learning alliance to address. The connection to national sector planning and reviews is important to ensure that action-research priorities align with emerging trends at the regime level. The TSUs/RWSRCs in particular have an important liaison role in bringing ideas and insights from the learning alliance upward to the MWE and horizontally to other districts as well as for bringing outside expertise to the learning alliance.

The learning alliance has no decision making power (or public budget). It is through its members' roles in, or engagement with, government departments or implementing bodies that the ideas generated from scenario development can influence and inform decisions made by members in their formal institutional roles. The participation of learning alliance members is not as representatives of their institutions, which removes the constraints imposed by their formal institutional role. The non-binding nature of proposals they develop gives the group members more freedom to use their expertise to collaboratively develop new strategies or solutions. A 'talking shop' among stakeholders, who do not normally interact, such as a hand pump mechanic and a district politician, can help actors to understand challenges from different perspectives to better identify collective solutions, while avoiding missteps or unrealistic planning. More than only talking, their planning and piloting of interventions to improve service delivery (through action-research) ensures ideas can be tested prior to promoting them at a larger scale and keeps members motivated and interested.

Hypothetical creative thinking can be challenging for those faced with daily constraints to problem-solving in their formal roles. In this context, scenario development (as a method) provides a structure and process to give 'license' to creative thought (Nieto-Romero et al., 2016). It stimulates creative problem solving in a similar manner to "serious games" (Hummel et al., 2011). This process also revealed differences in stakeholder attitudes about how much the learning alliance should seek to influence or advocate for change on issues beyond its direct sphere of influence in the District, such as Ministry decisions or public attitudes. The use of GIS maps to illustrate possible future scenarios aided the process of developing strategies beyond current constraints.

The fact that the learning alliance is a niche structure without a legal mandate also poses limitations, particularly in terms of sustainability, replicability and ending of reliance on NGO support. Athough the learning alliance role in Kabarole is recognised and its elected chair is a District Councilperson, IRC provides funding, facilitation, coordination, and structuring of its action-research agenda. While the learning alliance would likely continue to meet in the absence of IRC support, resources that promote learning and innovation, such as piloting new ideas and participating in learning exchange visits would not likely continue at the same intensity in Kabarole. Nationally, the pro-active sector knowledge exchange promoted by MWE and described in the previous section would ensure that some of the key horizontal and vertical channels persist, yet no other platforms focus specifically on social learning within districts.

Replication of learning alliances in every district in Uganda is clearly not feasible, yet the representation, innovation, and feedback from districts into national level processes is important. District Local Governments are central to the regime as service authorities, and, at this level, actors and factors from all levels intersect. A learning alliance offers a way to gather the collective expertise held at district level, and leverage it to influence national strategies. Since many (if not most) districts are likely to face similar challenges as Uganda's change process rolls out, the presence of learning alliances and/or other platforms in at least some representative districts across Uganda could be useful to support the identification, incubation, and promotion of promising ideas, and to provide feedback into national processes. While NGO support to the learning alliance may not be sustainable for the platform in the long-term, the use of external resources to empower local actors to drive innovation is argued as a sustainable way to address root causes and support national systems development (Banks and Hulme, 2012).

The NGO in a facilitation role can also introduce bias and steer the platform's agenda toward NGO priorities. While the members jointly establish the learning alliance agenda and workplan, IRC ultimately chooses which ones are followed up on or given most resources. IRC's priorities are influenced by its own organisational vision, as well as project funding, commitments and requirements from national government. Individual IRC experts may also convey their perspectives on how universal services can best be achieved. Thus external expertise can both empower stakeholders through capacity building and undermine local ownership (Mussa et al., 2019). IRC clearly acknowledges its dual role as a facilitator and a stakeholder, and aims to be open and honest with learning alliance members about IRC's priorities and constraints. The presence of local long-term staff, who have built up relationships with stakeholders over a decade, builds trust and accountability. On some occasions or for sensitive topics, IRC has hired a third-party facilitator (local consultant) to step in so IRC staff could focus on IRC's role as a learning alliance member. Critical reflection within IRC's facilitation team and with staff and partners from outside the district also helps it to remain reflexive, and to identify potential bias so it can be mitigated.

When the COVID-19 pandemic struck in Kabarole, the Learning Alliance was quick to take action, scaling up one of their action-research initiatives— the onsite production of alcohol-based hand sanitiser for health care facilities. The presence of a pro-active and connected group of stakeholders aided the District response, even as the group was unable to meet in-person for several months. During this time, efforts to support masterplan implementation continued through virtual communications but were slowed due to the immediate pandemic-response priorities.

7.5.4 Study Limitations

Authors (IRC employees) as embedded actors risk bias such as overstatement of results or confirmation of pre-existing beliefs (Mackenzie et al., 2012). As an NGO, IRC's bias stems from its need to deliver project outputs to funders. Bias was mitigated by 1) working as a facilitation team of several members of IRC staff and several local stakeholders, with IRC employees recusing themselves from facilitation when there was a potential conflict of interest, 2) employing critical inquiry to eliminate potential biases 3) applying 'inclusive rigour' by selecting methods stakeholders can understand, by including diverse stakeholders at each stage of the research (Chambers, 2015) and triangulating, using mixed methods, between literature and field findings.

7.6 **Conclusion:**

Uganda's Vision 2040 aims to meet the SDG6 targets for rural water supply through a transition from services mainly supplied by community managed point sources to publicly funded professionally managed piped water services. The MWE at the national level is actively and adaptively planning and managing this transition through regime level changes including a new O & M framework for rural utilities, establishment of rural umbrella utilities and expansion of the National Utility. For each of these, the MWE seeks feedback from the regional and district levels through multi-stakeholder platforms and deconcentrated technical units. The transition towards piped water utilities responds to the landscape pressures of changing livelihoods, population growth, and both a demand and willingness to pay for higher levels of service.

In Kabarole District, action-research with the learning alliance supported this transition using scenario development as a tool to envisage possible development trajectories and propose robust strategies to meet the Masterplan goals. The alliance membership, and the members' participation in national, district and sub-district level networks, , provided a multi-level perspective, an understanding of the task and a means to disseminate the resulting knowledge .

The effectiveness of the learning alliance depends on its placement at the correct administrative and geographic levels. The district level platform is effective for enabling communication and a membership spanning the formal institutional roles is representative of all the key perspectives within the public service system. The purely advisory nature of the recommendations made by the alliance encourages creativity and collaboration in the assessment of the water services and in the development of strategies for its transition. While the institutional roles of the members facilitate dissemination of its learning. Robustness of its advice stems partly from the habitual exchange of information between levels represented by its diverse membership, and the semi-structured assessment of the present and future development trajectories as achieved with scenario development.

The facilitation of the learning alliance by an NGO has the advantage of incorporating expert advice and an outsider's perspective, but with the risk of influencing the agenda and compromising the sustainability of its activities. A more formalised platform for district-level insight within national sector working groups or learning mechanisms may be advantageous, for example to help identify groups excluded from service delivery or to address practical ambiguities resulting from new policies, and to co-develop strategies to mitigate them.

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Logical bridge 4 (connecting material)

In Chapters 6 and 7, the WASH systems framework from Chapter 5 was applied in Kabarole, Uganda. In contrast to the case studies on sanitation in Chapter 4, the overall sector and its overlapping service delivery systems were analysed together, instead of focusing on a single intervention or service delivery model. The complexity was managed using the nine subsystems (building blocks/windows) and the concept of service delivery models. With the learning alliance, the systems assessment was a foundation for developing strategies to improve water systems performance. Adaptive management and social learning in the Ugandan sector were analysed. The discussion in Chapter 7 explored how and if the increased systems thinking and social learning contribute to the drinking water system transition.

In Chapter 8, the discussion section of my thesis, I perform a critical reflection on the use of the systems framework in Uganda and globally, and the extent to which my research aims have been met. By including data and experiences from the application of the WASH systems framework in six countries over three years, expert consultation with practitioners, as well as the in-depth experience from Uganda, the relevance of the framework to the WASH sector overall is considered. The focus remains on the rural and peri-urban parts of the sector where established frameworks are lacking and complexity is highest. First, the extent to which the framework from Chapter 5 has increased systems thinking and social learning among actors is evaluated. Secondly, its use of the framework as a measurement and monitoring tool is assessed through presentation of summarised data and a critical reflection. Perspectives from other sector actors who have applied this or similar frameworks and recommendations for future work are also included in the discussion.

Chapter 8: (Paper 5) Water and sanitation as public service systems: a critical reflection on the experiences applying the WASH systems framework

The discussion of the thesis is written as a paper to be submitted for publication in Water, Sanitation and Hygiene for Development

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Abstract

This paper is a critical discussion on recent work to define water, sanitation, and hygiene (WASH) services as products of a complex system. A WASH systems framework was introduced with the aim to encourage its users to think about WASH as a system, and to support comprehensive assessment of WASH systems in specific contexts. Following three years of application of the framework in Burkina Faso, Ethiopia, Ghana, Honduras, India, and Uganda, and in international stakeholder fora, we discuss feedback from stakeholders in these contexts and review the assessment results to date. The framework is found to be effective as a shared mental model for how WASH services can be sustainably provided by national and local systems. It may be a step toward a benchmarking framework for WASH, particularly in contexts with multiple overlapping service delivery models (i.e. outside the service area of large utilities). Visible trends are seen between drinking water services and the scores earned using the WASH systems assessment framework, but a longer sampling frame will be needed for quantitative analysis of change in national systems.

8.1 Introduction

Water and sanitation are public services and human rights, however 1.5 billion people do not have access to a protected water source when needed and 2.4 billion do not have a basic toilet. Most of these are in low- and middle-income countries where existing services may be often unreliable or unsafe. Outside the coverage areas of urban utilities, the water, sanitation, and hygiene (WASH) sector in many countries is loosely structured, with uncoordinated actors implementing fragmented approaches. WASH is not observable as a single system with a single responsible 'owner', but many overlapping and often inefficient systems. Particularly in peri-urban and rural areas, complexity is increased due to the absence of clear frameworks, service delivery models, and strategies for achieving agreed service delivery goals.

In the last ten years, there has been a shift toward 'systems approaches' that recognise this complexity and promote strengthening of a government-led national system for WASH service delivery (see for example, the Agenda for Change, UN-Water & WHO, 2019; Liddle & Fenner, 2017; Neely, 2019; Valcourt et al., 2020). To support this, we introduced a conceptual framework for WASH as a system comprised of smaller subsystems that can be evaluated and strengthened to improve overall performance (Huston and Moriarty, 2018). This framework has been embraced by many in the sector, and other similar frameworks have come into use (Fogelberg & Lockwood, 2020; Tillet, Huston, et al., 2020). The conceptual and analytic framework for WASH as a system has been applied in international networks and at national and district levels.

This paper is a critical reflection on this work by IRC, a Netherlands-based international NGO. It draws on work by others using similar frameworks, and experiences from using systems approaches in health and other public sectors. The objective of the WASH systems framework and approach as applied by IRC was to 1) increase systems thinking and social learning for more effective collective action and 2) measure and study systems to provide enough insight to be able to intervene effectively. We evaluate the extent to which these objectives have been achieved and propose the next steps for a WASH systems praxis.

8.2 Methods: A subsystems framework

In Huston and Moriarty (2018) and Huston et al. (in prep) (Chapter 5), we characterised WASH as a complex adaptive system, conceptualised as nine interacting subsystems. We initially referred to these as 'building blocks', and later as 'windows' to draw attention to their use as different perspectives from which to study the interconnected whole. We use the term 'window' throughout this paper. The nine windows are shown in Figure 29, where the WASH system clearly sits within the political economy of the country and overlaps with other systems and sectors.

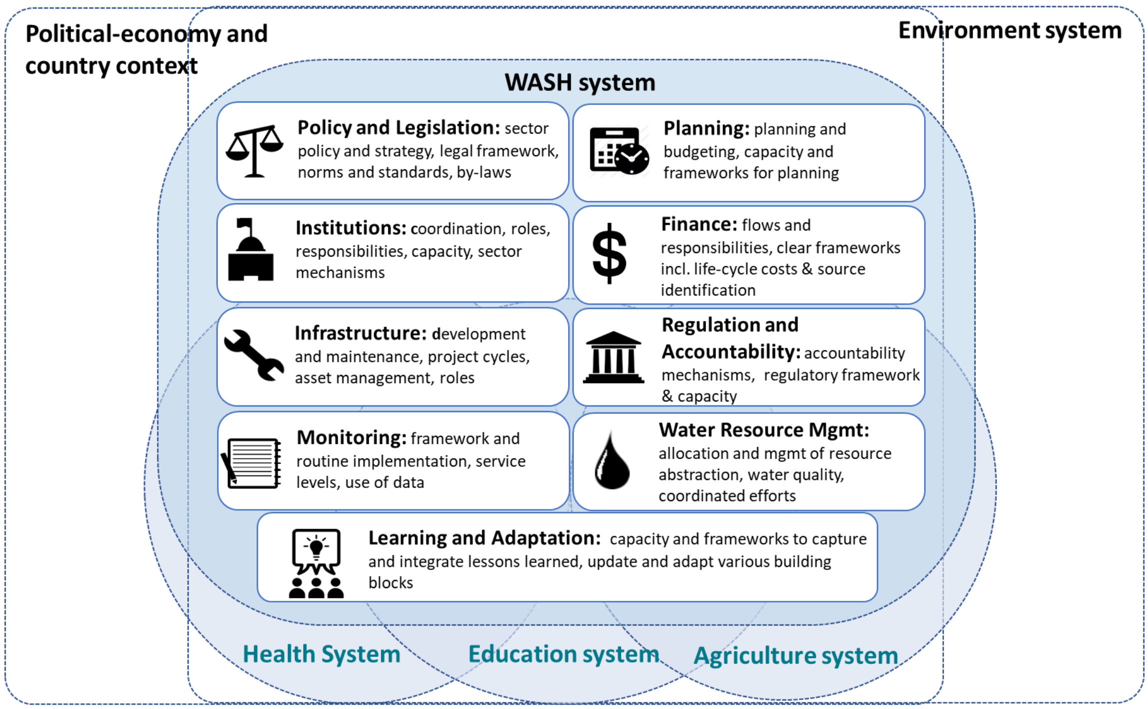

Figure 29: The WASH system and nine windows for viewing it (also referred to as building blocks)

We posit that the functions in these windows must be present at both national and district levels, and for each service delivery model in the country (e.g. utilities, community managed water supply, on-site household sanitation, etc) in order to have a performing sector. The term 'district' is used to refer to the main decentralised level of government with responsibility for public services, though the administrative units and distribution of roles and responsibilities varies between countries. A service delivery model is defined as the legal and institutional framework for the provision of WASH services, including all links in the value chain, the method of provision, the end use of services and the level of service delivered (Huston & Moriarty, 2018).

Building on earlier work (Smits & Lockwood, 2011; The World Bank, 2017), an analytical tool was developed for assessing the 'strength' of the system. System *strength* is an aggregated assessment of each subsystem using 3 to 5 Likert indicators for each, that were averaged to produce the score for that subsystem. System *performance* was assessed by the quality and quantity of WASH services provided, using standard indicators from national frameworks and the UN-Water/WHO Joint Monitoring Programme (WHO & UNICEF, 2017).

There were a total of 102 Likert indicators for the national level, 99 for the district level, and 40 for each service delivery model level. These were organised by the nine windows: each indicator was assessed on a 5 point scale, where 1=false/undeveloped or undefined; 2=poorly developed/defined or not in place; 3=developed/defined but poorly applied or not functioning as intended (i.e. it exists only 'on paper'); 4=in place and usually functioning as intended and 5=in place and functioning. A narrative and references were provided to justify the scores. Examples are provided in Table 14. These were assessed using mixed sources of secondary data and through a stakeholder workshop facilitated by IRC staff.

Both the conceptual and analytical frameworks have been refined through pragmatic participatory action-research (Feilzer, 2010; Lewin, 1946; McTaggart, 1991). An initial concept was developed based on literature review and practical experience, then the concept was applied in several contexts and revised again. An open research design allowed for flexible application of the method and these experiences were documented and used in a continuous cycle of reflection and adjustment leading to the framework presented here. It will continue to evolve. Figure 30 depicts our model for praxis development through experiential learning.

Table 14: Examples of Likert scoring and narratives for countries performing at different levels for one indicator from the infrastructure development window (national level). Each window has 3-5 indicators that are averaged to produce the overall score for the subsystem, as shown in the heatmap in Figure 31.

Indicator prompt: The project delivery models and procurement procedures for capital investments projects (drinking water infrastructure) are clearly articulated in government-sanctioned implementation manuals.		
Score	**Narrative response**	**Reference provided**
5	There are well documented guidelines and procedures for public procurement stipulated in the Public Procurement and Disposal of Assets act established in 2003 by the Act of parliament to regulate public procurement processes in Uganda. The PPDA Amendment Act was passed by Parliament on May 10, 2011 and the amended regulations on May 9, 2013.These are understood and used for all sanctioned capital investment projects.	PPDA Amendment Act 2011
4	The regulatory framework for procurement is clearly established and provides very specific guidance on the execution of investments in the country. Technical standards are also defined according to zones, with standard tender documents available that set out technical specifications. There are also mayor's guides. However, these tools are not updated to take account of sectoral developments (such as new focus of the SDG targets) and they are not accessible to all stakeholders.	Public procurement code, mayor's guide, tender documents for the development of hand pumps
3	The rules and guidelines are clearly articulated in the Ministry's Programme Operational Manual but only used for projects funded by the consolidated WASH account.	Ministry Programme operational Manual, 2015
2	There are general recommendations for who should be involved in project delivery but these are only loosely described in the national water policy. There is no guideline for implementing this policy and thus the recommendations are only sometimes followed and there is no clear way to identify or resolve issues that emerge. Some NGOs have agreed on best practices but these are not sanctioned by government and cannot be enforced.	National water policy, and Interview with District Engineer July 2017.
1	None of the participating stakeholders are aware of any guidelines for project procurement and implementation. There is no registry of projects implemented and no manuals or guides for how this should be done.	National water policy, stakeholder meeting on May 2017.

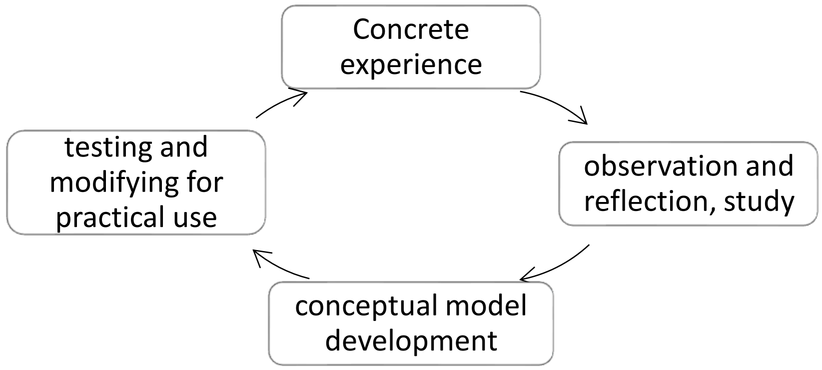

Figure 30: Praxis: Iteration between theory and practice.

8.3 Application of the framework in different contexts

A discussion paper on viewing WASH as a system was published by IRC to consolidate the emerging framework and generate expert feedback and critique (Huston & Moriarty, 2018). In 2019, an international symposium dedicated to consolidating 'the state of the art' of WASH systems thinking and practice was held in the Hague, the Netherlands (IRC, 2019). The event convened over 350 professionals from around the world in 62 technical sessions. Thirty technical papers were written on the topic of WASH systems; this forum for discussion was particularly important to ensure insight, critique, and responses from practitioners.

Since 2017, the analytical framework has been applied by IRC using participatory methods in 7 countries and 10 partner districts: Burkina Faso and its commune of Banfora (Nansi et al., 2018), Ethiopia and the woredas of South Ari and Mile (Adank et al., 2019), Ghana and its Asutifi North District (IRC Ghana, 2018), Honduras and 15 focal municipalidades (Smits & Rodriguez, 2018), India and its Chatrapur block in Ganjam district (Shiva & Krukkert, 2018), Niger at national level only (Boukari, in prep), and Uganda and its Kabarole District (Magara et al., 2018). In Uganda, the framework was applied as part of the lead author's doctoral research on characterising service delivery models and evaluating potential scenarios for achieving universal services by 2030 (see Huston et al, 2021; Huston et al, in prep). In both Uganda and Ethiopia, it has been used with a suite of other systems analysis tools including systems dynamic mapping and network analysis as part of the Sustainable WASH Systems Learning Partnership (Hollander et al., 2020).

The conceptual framework has been employed as a communication and advocacy tool for national and international actors, governments, and funding agencies. It has been used to structure proposals, and is used to promote greater investment in the systems needed to make infrastructure function in the long term. WASH systems thinking and building blocks terminology has become mainstream at IRC and with others, particularly in international organisations and agencies and in academic research (see for example (Agenda for Change, 2021; Liddle & Fenner, 2017; Neely, 2019; UN-Water & WHO, 2019; Valcourt, Javernick-Will, et al., 2020). Several frameworks or modified versions are in use (Casey & Crichton-Smith, 2020; Drabble et al., 2018; Tillet, Huston, et al., 2020; Gensch & Tillett, 2019; Hollander et al., 2020). The reflections in this paper are based on the framework from IRC, but most comments are also relevant to other WASH systems frameworks based on interacting subsystems (e.g. windows or building blocks). An overview of the scope of application of related frameworks is shown in Table 15.

Table 15: Number of applications of our WASH systems tool at each level, and a summary of known applications of some similar frameworks.

Assessment type	**National**	**Districts**	**Include service delivery method assessment?**
IRC tool	7	10	Yes
Similar tools (Agenda for Change members) (Fogelberg & Lockwood, 2020)	14	44	Yes and No
Earlier iteration of tool (2017 World Bank 16 country study) (The World Bank, 2017)	16	--	Yes
UNICEF WASHBAT (UNICEF, 2020)	36	11	No

8.4 **Critical reflection**

The WASH systems framework is reviewed as a tool for social learning and collection action; following this, its use as a monitoring tool is discussed

8.5 **Increasing systems thinking**

We aim to popularise thinking about WASH as a system and help overcome ‘systems blindness’ in the sector (Moriarty, 2017). Consistent with a review of WASH systems approaches by Liddle and Fenner (2017), a 'systems mindset' helps stakeholders understand their role and influence in the system (Liddle & Fenner, 2017; Stroh, 2015). In our experience, participatory analysis of WASH through these windows is effective in cultivating a systems mindset for stakeholders in Africa, Asia, and Latin America, Europe and America. Looking 'upstream' from infrastructure functionality, it provides a wider consideration of the systemic issues influencing service delivery outcomes. The perspective obtained through these windows, when combined with a quantitative understanding of the type and level of WASH services in a given area, adds richness to the collective understanding of the problem. The windows are used to identify gaps in current systems and set priorities and targets for change. A representative of Uganda Ministry of Water and Environment said that "the WASH systems approach shows us how to operationalise sustainable service delivery."

8.5.1 Managing WASH systems complexity

Fostering deliberative change in complex environments requires an understanding of how change happens (Wiek et al., 2012). Complex adaptive system theory, and concepts such as boundaries, leverage points, and feedback loops provide helpful imagery for system evolution and emergence (Huston & Moriarty, 2018). When defined as a complex adaptive system, WASH is conceptualised as network of interacting actors that adapt continuously and in response to discrete disruptions (Casella et al., 2015). This understanding implies that a flexible and adaptive approach to WASH planning is essential, described by Donella Meadows as 'dancing with the system' (Meadows, 2008).

In early cycles of action-research with the WASH systems framework, we found that theory from complex adaptive systems was very compelling for some actors and off-putting for others. A focus on the complexity itself could lead to 'paralysis by analysis' and risks overuse of resources to study the system as compared to taking action to change it (IRC, 2019; Schreiner, 2019). The focus on unpredictable adaptive change risked neglect for the essential role of government as an authority and regulator of public processes.

In response, we moderated the outward use of technical concepts from complex adaptive systems in sector documents and field tools, but retained it as an underlying philosophy. We realised that our goal to popularise systems thinking would be better achieved through use of simple professional language and familiar concepts to describe WASH systems features and dynamics. The nine windows helped to recognize and reduce complexity by organising the complex web of factors into manageable subsystems that could be individually addressed.

In more recent work, we focus on the public nature of WASH (Huston et al, forthcoming). Defining WASH systems as a public services further clarifies the end goal (universality and equity) and helps to align the objectives of different actors. It emphasises the role of the state in bringing order to the system to deliver higher quality outcomes with more certainty, and to that ensuring services supplied meet standards. This does not exclude a role for private actors, but highlights the importance of a strong public system to keep market forces in balance with the need to ensure universal and equitable services.

Literature on public sector transitions describes the role of governance: to create rules, incentives, disincentives, and boundaries to guide the behaviour and adaptation of other actors (Geels, 2005). With a public sector perspective, abstract concepts from complex adaptive systems such as leverage points, feedback loops, and emergence, become concrete in the form of policy priorities, information exchange and accountability mechanisms, and adaptive management. These concepts are embedded in the definitions of the windows, making complexity thinking more concrete and accessible.

It is important to note that defining WASH services as public does not exclude a role for private actors. The extent to which private sector is involved is typically determined nationally; our framework is agnostic with regards to the degree of private sector participation in WASH. In every case, well developed public systems are needed to keep profit-making interests in check and incentivise and ensure equitable service delivery.

8.5.2 Use of WASH subsystems as a measurement or evaluation tool

The second objective of the framework is to support WASH systems assessment — measurement and evaluation— in different contexts. The assessment is used by IRC as a metric for *WASH systems strength*, defined as a key intermediate outcome in its theory of change. The framework is also used to facilitate multi-stakeholder assessment in the wider sector, as part of IRC's approach to fostering more effective collective action. Aside from the Likert indicator framework, it has been used qualitatively as a guide for thematic content analysis.

An assessment of the WASH system with stakeholders aims to fill a known gap in joint monitoring and sector review processes in some countries, but an essential condition is that it does not undermine or duplicate national monitoring systems (SWA, 2016). For this reason, the level and type of stakeholder participation is adjusted in each context to suit local needs, for example using a larger high-profile workshop in countries with no similar national process, or a smaller meeting and assessment relying more on secondary data if there is already a joint sector review process in place.

The recommended approach is for the IRC team to gather and review key sector documents and data sets (as well as global data sets like GLAAS and JMP), then to convene a group of knowledgeable sector stakeholders (including relevant government agencies) to jointly discuss and score the indicators for each window. In practice, this approach is easier for the district level assessments than those at the national level due to the smaller number and closer proximity of stakeholders. Some teams expedite the assessment process by doing a preliminary scoring internally or with a smaller group of stakeholders, before conducting a validation workshop to discuss and finalise the scoring. The multi-stakeholder process also focused on the follow-up actions: selecting priorities and target areas for systems strengthening.

The emphasis on WASH as both public and complex kept the government at the centre of the process while recognising that the public officials cannot command immediate change. Politicians rely on recommendations from technical staff and respond to priorities presented by civil society. Both must use policy, regulation, and incentives to foster desired behaviour from other actors. The framework made clear that responsibility for improving services was multi-level and did not lie only with service providers—utilities or community operators who are often the face of failed infrastructure.

The results from each country assessment are available in reports for each country as referenced above, and the consolidated three-year time series for national level are shown in Figure 31, and is available with more detail in IRC (2020).

Defining WASH systems by the service delivery models

Using these windows to assess the WASH system is generally appreciated by stakeholders as an opportunity for constructive joint reflection. The windows and indicators provide a systematic way to analyse problems and discuss potential solutions. Use of a shared vocabulary helps stakeholders to increase precision in dialogue and pinpoint discrepancies in stakeholders' understanding of WASH issues. It also makes it easier for technical staff to discuss with policy makers and non-state actors with whom they do not normally engage. The specificity of the benchmarks helps to focus on single issues and avoid placing blame on individuals.

The assessment is conducted for national and district WASH systems, and also separately for each service delivery model in the country. Prior to the assessment according to each window, each of the service delivery models in use in the country is defined and described, to establish the boundary of the WASH systems in that context. Without these, a generic analysis of sector systems lacks critical detail, constraining the ability to investigate root causes and identify potential solutions. For example, a generic discussion of ''tariff models'' is less insightful than separate analysis of tariff models of community managed water supplies; services provided by small private operators; and communal latrines.

This preliminary step had turned out to be critical and more challenging than anticipated. In some countries, the service delivery models are poorly defined in sector documents and only marginally understood by stakeholders. A mix of informal and ad hoc approaches to planning, operating, and managing services are in use and the legal grounds and roles and responsibilities for each are unclear. This poses a fundamental challenge to defining WASH as a system, and to planning for systematic improvements to each window.

The definition of the service delivery models, even if it can not be finalised or fully described and validated according to national policies, has in some cases been one of the most informative parts of the analysis. Once the models are defined, the assessment of WASH through windows at both national and district levels helps to differentiate between gaps in national frameworks versus problems with their implementation at the district level. This in turn helps identify the appropriate level for action.

Analysing change over time

Following a comprehensive baseline study, each IRC country programme identified the priority windows or subsectors (i.e. water, sanitation, hygiene, WASH in schools and healthcare facilities) for investment over the coming 2 to 3 years. These windows and the corresponding indicators are then monitored annually by updating the Likert scoring. To date, three years of data have been reported from the six countries. The national level scores for water and sanitation are summarised in Figure 31.

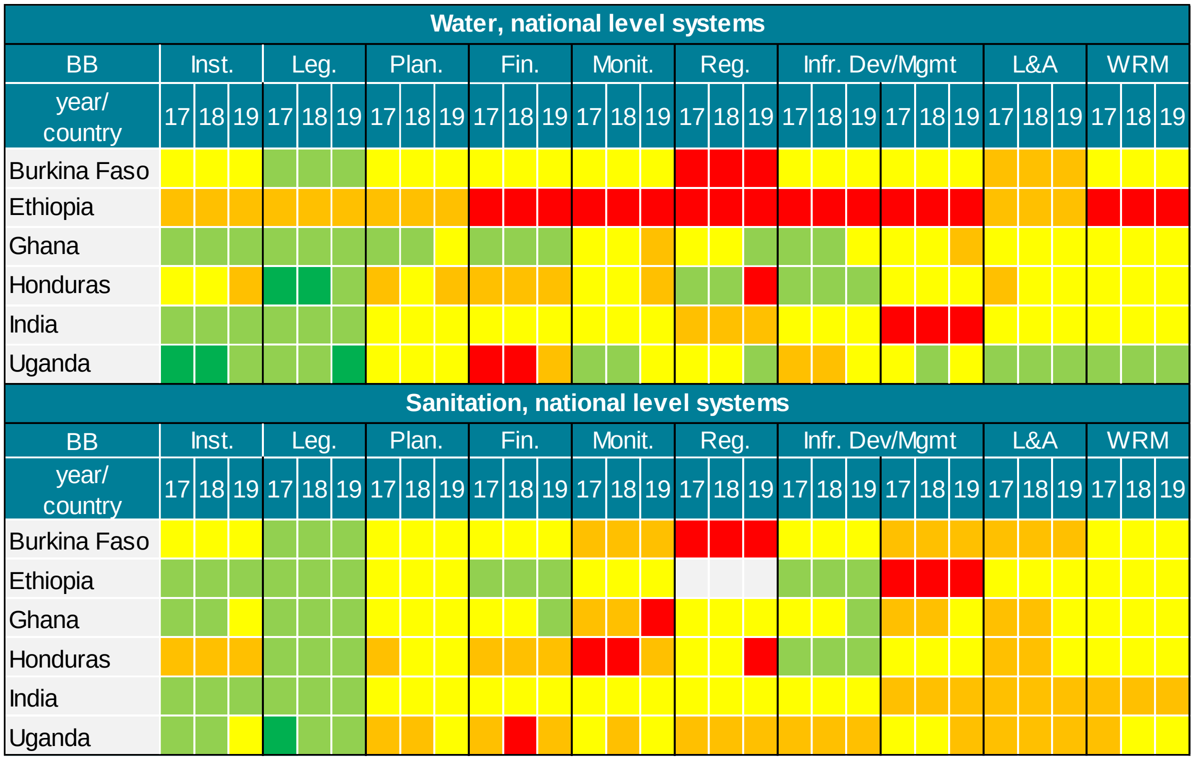

Figure 31: A summary of Likert data for national level water and sanitation for the years 2017, 2018, and 2019. Narratives and numerical scores, as well as data for hygiene, WASH at the district level including healthcare facilities and schools are available in IRC (2020).

The change against the benchmarks was slow in the three years, consistent with our expectation that significant changes in WASH systems would take five to fifteen years. Some significant change in national systems has been documented during this period and can be observed in the narratives provided for each score (see supplementary materials), but have limited visibility in the summarised, consolidated data. For example, the establishment of a new Regulatory Department in Uganda is a significant step in systems strengthening, but this shift is only reflected in a single indicator in the 'regulation and accountability' window (a third party regulator exists to oversee tariff-setting). Since 3 to 5 indicators are aggregated to produce each subsystem score (each cell in Figure 31), it is only once additional changes to other indicators follow (e.g. the regulatory entity uses data to guide performance management) that the colour of that subsystem in the heatmap actually changes. The breadth of the framework has consequences on the degree of granularity, so complementary tools, such as outcome harvesting or most significant change, were needed to document progress in the short term (GOPC et al., 2016).

Does WASH systems strength equate to better WASH services?

To date, there is insufficient data for statistical correlation testing of the link between WASH systems strength and their performance in terms of service outcomes. A longer time series, or WASH systems scoring data from more countries would be needed.

To explore emerging trends in our six country data set, consolidated Likert scores for systems strength for each country are plotted against the percentage of the population in that country using 'at least basic' water and sanitation services according to the Joint Monitoring Programme (Figure 32 and Figure 33) (WHO & UNICEF, 2017). For the water systems benchmarks, there is a visible correlation that countries with higher scores are the wealthier countries with higher levels of access to at least basic services (Figure 32). For sanitation, the trend is less apparent. This could indicate that achieving a basic level of sanitation is less dependant on national systems as compared to other factors (such as culture, environment, or social factors), or, that the indicators in our framework do not focus on the most important parts of the system. We also compared the results to other proxy indicators for public systems such as national GDP per capita and UNDP Human Development Index (HDI) rankings obtaining the same trend.

These findings match observations by Smits (2018) that few countries have achieved greater than 80% access to basic services with a GDP per capita of less than 2000 USD (ppp, constant 2011 USD). Countries with middle levels of wealth (2000-4000 USD per capita) vary significantly in their service levels, while almost all countries with a GDP per capita of greater than 8000 USD have greater than 90% access to basic services (Smits, 2018). Systems development is essential to improve services, and systems require a certain degree of national wealth, but these correlations are non-linear and are dependant on many other contextual factors (Meier et al., 2017).

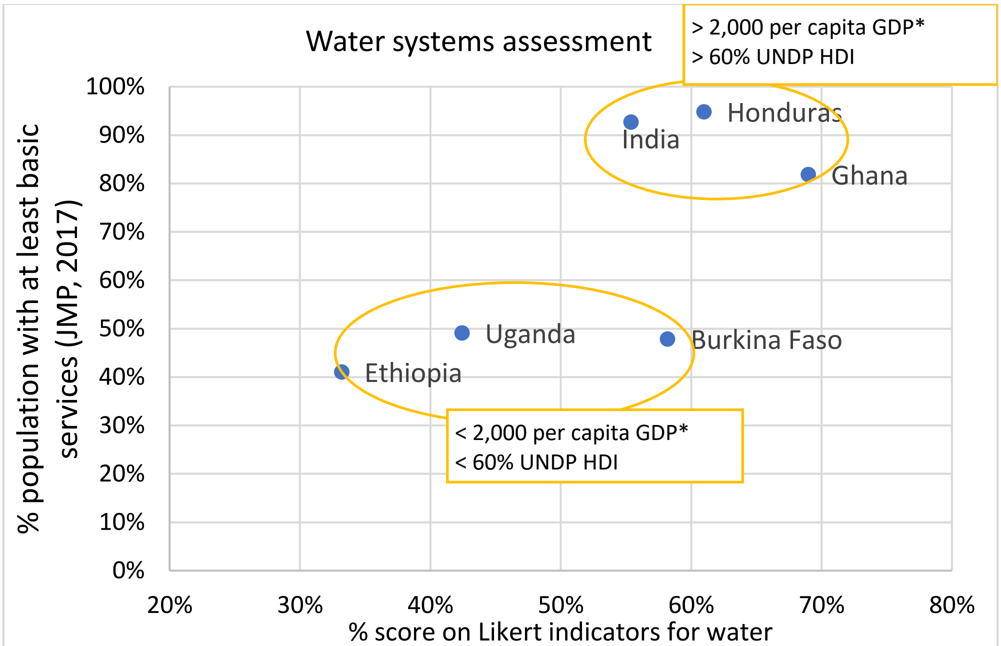

Figure 32: Aggregated results of Likert indicators for the Water windows against JMP data for 'at least basic' services.

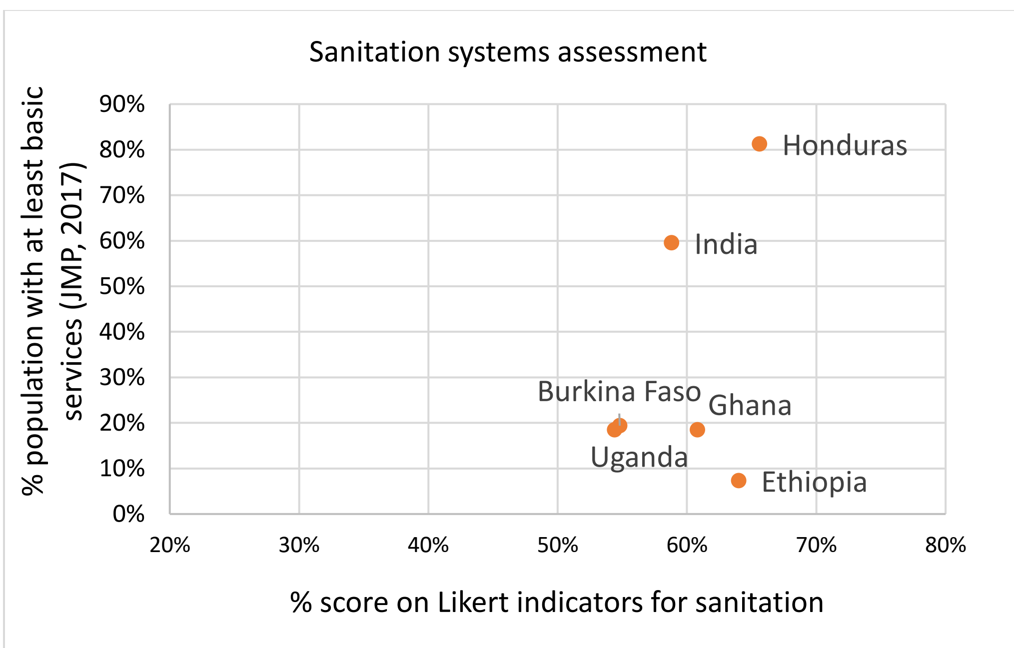

Figure 33: Aggregated results of Likert indicators for the sanitation windows against JMP data for 'at least basic' services.

Robustness of results

The scoring of Likert indicators is based on the analysis of secondary data and sector documents, and a perception-based assessment of the degree to which formal mechanisms are applied and functioning. The inclusion of expert analysis and multi-stakeholder perspectives on for each window increases the richness of the results and mitigates the risk of inflated scores for systems that 'exist on paper' but not in practice. It also introduces an element of subjectivity. Narrative justifications of scores, and reference documents for supporting information are required to encourage critical objectivity. Narrative justifications also enable the use of a consistent scoring logic for repeated assessments over several years, even if the facilitator or participants change.

The quality and robustness of the results depend on the quality of the facilitation, and the availability of information and local expertise. Robustness is highest when the scoring is completed after a rigorous analysis of national data and policy documents (and global data sets like JMP), and when an inclusive and iterative scoring workshop is held to interrogate the scores. As with all research, the methodology used to obtain results must be clearly documented and acknowledged when using and communicating the results. We did not identify any cases of staff, stakeholders, or government, intentionally creating bias in results, but efforts to avoid and mitigate bias—intentional or unintentional— should be included in facilitator training.

Inclusive facilitation is possible when the framework is implemented by IRC, where staff are trusted long-term local partners. However, the ability to achieve 'rigour by inclusion' may be limited depending on how and by whom it is facilitated (Chambers, 2015). Depending on the objective for doing the assessment, it can alternatively be conducted an individual researcher. This requires that adequate sector documentation is available, and it would likely require interviews or spot checks with key informants to fill in gaps.

Feasibility and level of effort

A comprehensive assessment for each window in each WASH subsector is a considerable undertaking. As for any monitoring tool, it is critical that the benefits of data collection outweigh the costs, and that the objectives and eventual use of data are clearly defined (Gugerty & Karlan, 2018). In the case of the six country assessment, there are several objectives: increase systems thinking capacity; increase attention to and investment in the WASH systems that support services; provide a baseline against which to monitor systems change; and report on the status of WASH systems to current or potential investors. Monitoring experts at the WASH systems symposium emphasized that the 'process is as important as the result', something that should also be considered in planning assessments are less efficient for the sake of greater participation and inclusion (IRC, 2019).

The complete assessment tool, including Likert indicators for each service delivery model, and at the national level, for water, sanitation, hygiene, and WASH in schools and healthcare facilities, includes 241 indicators. These are organised in an Excel tool according to subsector (water, sanitation, hygiene, WASH in healthcare facilities and schools), and level (national, district service delivery model). This enables the selection and use of a subset of indicators if appropriate, however, cross-cutting analysis using data from different levels and subsectors provides greater insight into the dynamics and potential leverage points. IRC staff leading the assessments report spending about 15 days annually to complete the assessment at the national level and for one district. Writing detailed narratives to justify the scores, which is perhaps the most valuable and immediately useable output from the scoring, takes time. The 15 days reported include gathering supporting documents, hosting workshops to discuss with stakeholders, and internal discussions with colleagues to finalise the analysis and reporting. In our case, it also includes reviewing and providing feedback on the tools as part of our praxis development, observation and reflection for this research.

During early iterations of the framework, we consolidated and reduced the indicators as much as possible. For example, at the district level, the water, sanitation and hygiene analyses were combined, since the responsible stakeholders are generally the same for each of these subsectors. However, each time granularity is reduced it has implications for the depth of analysis and useability of the results. Ultimately, there are too many indicators for the assessment to be simple or rapid, but not always enough to offer the depth of analysis needed to get specific insights into bottlenecks or root causes of the problems observed. One team member described it as "ranking the issues'' in terms of importance, in collaboration with stakeholders.

Given our objective, the middle ground is adequate to achieve a holistic and comprehensive understanding of the system without arriving at 'paralysis by analysis'. Following the WASH systems assessment, complementary tools can be applied to address specific topics that emerge as priorities after reflecting on the overall system.

Since the assessment of the windows separately for each service delivery model is in many cases the most insightful, one option to reduce the weight of the assessment would be to apply it only at this level and remove the district and national level scoring. For the purpose of aggregation, national and district scores could be computed by averaging the scores for each of the service delivery models, weighted according to the estimated portion of the population using each service delivery model as their primary means of WASH access.

Since the indicators for each window are better suited to measuring medium and long term change, depending on the objective it may be possible to reduce the frequency of updating to every 2 or 3 years, for example, to have 4 data points over 10 years. To track changes over a shorter time frame or during a project cycle, more narrowly defined context or outcome specific indicators can be defined to assess progress and detect change.

8.5.3 Proposed addition to the windows

The framework describes public systems for service *provision* but does not directly address demand-side aspects of service delivery. We agree with Gensch and Tillet, who have proposed adding a building block (window, subsystem) to the WASH systems framework for citizen demand and behaviour, particularly to ensure it reflects experiences from the sanitation and hygiene subsectors (Gensch & Tillett, 2019). The need to keep end users at the centre also emerged as a focus during the WASH systems symposium (IRC, 2019). It is important to ensure that users are central to public service planning. Pro-active marketing of services and trust-building with consumers is already a fundamental part of promoting the long term viability of public service organisations in other sectors like education, health care, and transportation (McLaughlin et al., 2009). It is important in WASH where a significant portion of financing already comes from household investments and therefore citizen priorities ultimately drive change (Sutton & Butterworth, 2020). Furthermore, in a service delivery model and scenario planning exercise in Uganda, our research identified ‘demand for higher levels of services’ as a determinate factor for achieving universal WASH services by 2030 (Huston et al, in review).

8.5.4 Limitations

The WASH systems assessment only provides part of the picture. It should not be mistaken for a silver bullet or an exhaustive monitoring tool for the sector or an organisation. We discuss key considerations and limitations for applying the assessment framework, based on our experience in six countries, recent research in Uganda (Huston et al., 2021 (Chapter 6)), and from consultation with others who have adapted and applied this approach. For additional considerations see Mason et al (2019).

The structured nature of the framework, when taken too literally, can be perceived as static or prescriptive. The approach has been said to give inadequate consideration to the interactions between subsystems (Mason et al., 2019; Valcourt, Walters, et al., 2020). This was one of our motivations to begin referring to the subsystems as 'windows' rather than 'building blocks,' in order to emphasise that the boundaries between subsystems are illustrative and conceptual in nature. Interaction between the subsystems is embedded in the descriptions of the subsystems (for example the use of monitoring information in regulation and budgeting), however these dynamics are easily overlooked if the framework is interpreted as a checklist rather than an integrated assessment.

Similarly, the framework does not include an analysis of power dynamics among actors; a WASH assessment against the subsystems is unlikely to reveal hidden or counter-intuitive dynamics. Social dimensions like trust, willingness to collaborate, or cultural and political dynamics are likely to influence change trajectories and have implications on what types of strategies will be successful. Corruption, for example, was pointed out by one expert as a 'shadow system' that can render well-defined building blocks useless if sector decisions are based on an ulterior agenda (Schreiner, 2019).

Other system dynamics tools may be insightful for interrogating specific dynamics and feedback loops within a project or research context (see for example Valcourt et al., 2020b). Tools such as political economy assessment, power mapping, or network analysis have also been used in WASH (Neely, 2019). However, more complex and quantitative tools also require more analytical support from (usually external) experts, which can reduce local ownership of results (Liddle & Fenner, 2017). These tools bring their own terminology and mental models, and their technically demanding methodologies do not easily lend themselves to national level scaling or application within a wider community of practice. To maximize the level of participation from stakeholders, the use of universally recognisable language and simple methodologies offer a notable advantage (Chambers, 2015).

Another risk pointed out by Mason et al (2019) is that the normative nature of the building blocks may encourage 'isomorphic mimicry'. This term is used to describe copying the form and structure of functional systems without adequately achieving the intended function. The risk of 'looking like a public service system without acting like one' is valid (Andrews et al., 2017), however we have not yet seen this risk materialise as a result of WASH systems thinking. Our understanding of this risk is part of the motivation for using five point Likert scale indicators that enable an assessment of desirable characteristics that existed both 'on paper' (which could earn a 2 or 3), and in practice (earning a 4 or 5). The indicators are intended to focus on functions and general concepts (e.g. norms and standards exist) rather than specific qualities or institutional structures that would invariably depend on context.

It should be noted that this framework is developed for application in countries with some degree of stability in sector governance and democratic process. The approach itself, and the emphasis on government leadership assumes a basic level of political will, and capacity, for improving public services. It has been used in Uganda, Burkina Faso, and Ethiopia which are classified as 'least developed countries' and are far from exempt from political uncertainty (UNCTAD, 2020). A critical analysis by Tillet et al (2020) examined WASH systems thinking from the perspective of fragility, and concluded that a systems approach offered a much-needed new lens to humanitarian work aimed at reducing WASH vulnerability (Tillet et al., 2020). In any case, viewing WASH as a public system calls for a careful review of context and political dynamics prior to beginning any sort of stakeholder engagement or intervention.

We note an additional concern emerging from our observation of WASH systems thinking uptake in the wider sector. There is a risk that shifting the focus too far 'upstream' from service delivery — to WASH systems— can result in overlooking the quantity, quality, and equity of WASH services produced by that system. Accountability for WASH investments must ultimately lie in measurable improvements in service levels. WASH systems are an intermediate outcome, and an essential means to the end of better services. Indicators for systems *strength*, or proxies for sustainability, do not replace robust data on the quality and quantity of services provided and used. WASH systems *performance* is defined by the services provided. We remain confident in our thesis that WASH services can only be sustainably provided by strong national systems, but the ultimate performance of these systems requires reliable and deliberate study of the quality and equity of services delivered.

8.5.5 The importance of complementary tools

To address these limitations, complementary tools are usually needed when applying the WASH systems framework. For IRC, a theory of change is used to define additional intermediate outcomes and support a comprehensive strategy for how to strengthen systems (see Figure 34). In addition, service level assessments are used to study the actual level of water or sanitation services received. Defining the WASH system as a key intermediate outcome is a particularly helpful way to incorporate WASH systems thinking into a logical framework.

At the district level, Masterplans for achieving 2030 targets and strengthening the WASH system were developed with local government and partners. These area-wide strategies set targets for WASH service levels, and intermediate outcomes for better functioning WASH systems, that can be tracked annually (IRC, 2020). In Uganda, participatory scenario development was used to model potential future contexts, and to develop strategies to foster progress toward 2030 goals (Huston et al, in prep). There are a number of additional tools like political economy analysis and power-mapping that could be used to complement WASH systems assessment (Kooy & Harris, 2012). The WASH systems benchmark indicators could also be modified or used to set specific targets that are achievable within a one- or two-year time frame.

Adaptive management and collective action also require self-reflection on one’s contribution to observed change. The WASH systems framework does not measure the contribution of different actors or the reasons for the changes observed. When used with a group of stakeholders, it supports collective accountability, but not the individual accountability that is also often necessary. At IRC, several complementary tools are used to track IRC’s own inputs, activities, and outputs, and their contributions to change. Using IRC’s theory of change (Figure 34), each activity and output (the orange boxes in Figure 34) is linked to one or more outcomes (the blue boxes), and sometimes even linked to specific windows or targets within the WASH system. Outcome harvesting is used to analyse the effectiveness of IRC's contribution to changes and capture unplanned change (positive or negative) (Wilson-Grau & Britt, 2012). Using a theory of change further encourages thinking about WASH as a system, and helps to reflect on one's own role within a larger systemic change process.

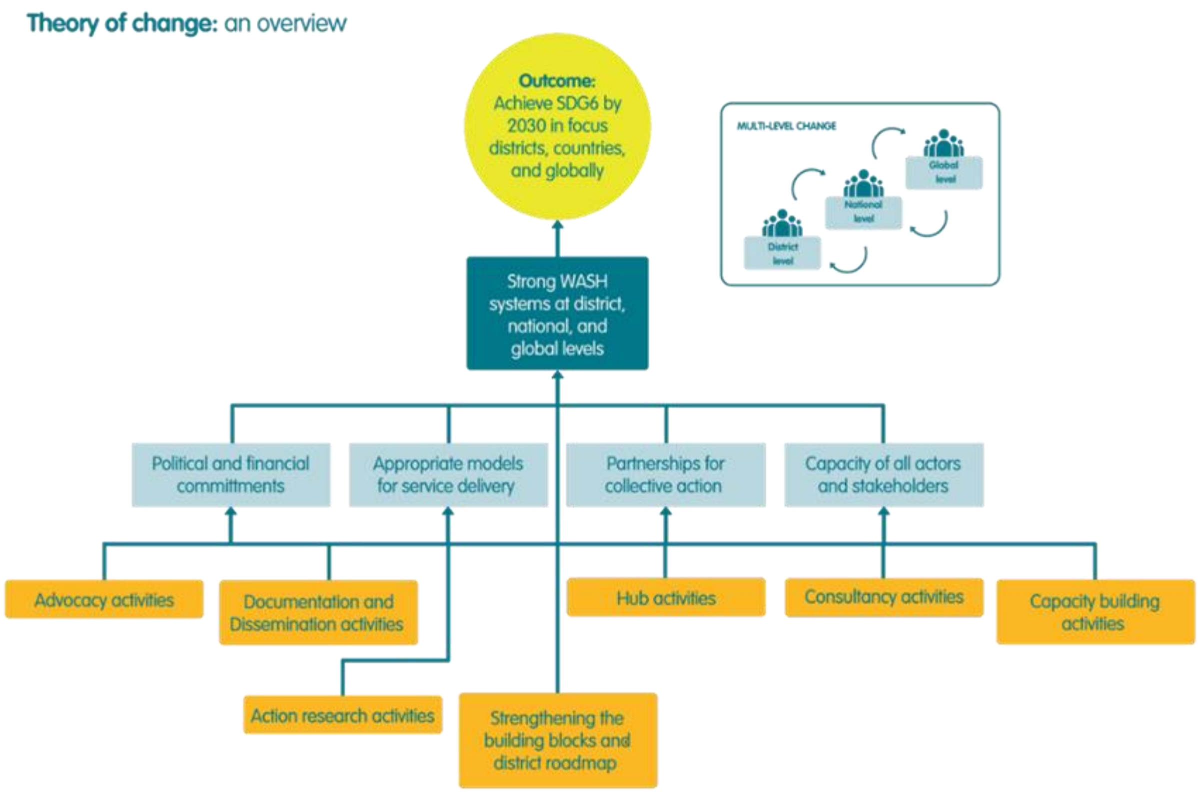

Figure 34: A simplified version of IRC's theory of change 2017-2030. Activities are in orange, intermediate outcomes are in light and dark blue, the chief outcome in yellow. The arrows represent a highly simplified flow of cause and effect. For the complete map of logic pathways for district, national, and global levels, see (Moriarty, 2017).

8.5.6 A note on the WHO health systems building blocks

A conceptual framework using building blocks has been used in the global health sector for over a decade. Developed by the World Health Organisation (WHO) in 2007, it has become nearly ubiquitous among international actors for programme planning, evaluation, and applied research (WHO, 2007). The framework is credited with aligning diverse global actors toward a better understanding of how health systems function, in turn helping to better structure and plan investment decisions (Mounier-Jack et al., 2014). It has been critiqued and modified over the years, but remains the most commonly used framework for global health systems thinking.

While not as developed as the health systems framework, the uptake of WASH systems thinking over the past four years is a promising step toward greater alignment, even as actors continue to use several similar, but not identical, frameworks. Many WASH actors continue to critique, adapt, and improve on existing frameworks rather than to replicate them. This may change if an authority like the WHO were to promote a single framework, however earlier WASH frameworks promoted by Sanitation and Water for All and UNICEF, both of whom have significant influence, have been met with attempts to change and improve them (such as ours) rather than with widespread adoption. The variation in the frameworks raises mainly practical issues for comparing results across contexts; and is a missed opportunity to reduce duplication and fragmentation. On the other hand, the different frameworks may help to overcome a noted critique of the health systems framework: a common framework results in common blind spots (Mounier-Jack et al., 2014).

8.6 Discussion

WASH systems thinking has helped to positively reframe sustainability challenges. This work was intended to help foster a paradigm change in WASH; from a sector rife with piecemeal and patchwork projects toward a future in which an adequately resourced public service system makes universal and safe services the norm. The WASH systems framework is a step in guiding the sector in this direction. Where applied, it has effectively reversed the narrative from 'trying to prevent breakdowns' toward a forward-looking strategy: build strong public systems. When the desirable characteristics of the WASH system are defined and the frameworks for service delivery are in place, previously misaligned actors can more effectively coordinate their inputs and roles. The positive framing and shared mental model encourage collective efforts toward a nationally owned goal.

In work on health systems, Chee et al (2013) made a distinction between 'systems support' and 'systems strengthening.' Systems support consists of efforts to improve acute service delivery results: direct service provision, infrastructure construction, or emergency relief. Systems strengthening described efforts to permanently make the system function better, in ways that offered the possibility of achieving leverage and scale. Systems strengthening interventions required an understanding of how the system works to enable the planning of interventions that can have cross-cutting impact on services of different types and at different levels (Chee et al., 2013). Our aim with the WASH systems framework was to empower more actors to understand the WASH system well enough to plan and implement interventions to strengthen it.

Analysing the system from multiple perspectives (windows, institutional levels, service delivery models) provided more insight than an analysis at any single level, since public service functions and responsibilities are found at all levels and across sectors. We found that the separate analysis of the nine windows for each service delivery model was particularly insightful for the purposes of problem diagnosis and planning. While increasing the broad understanding of WASH as a system is important, it is critical to maintain a clear understanding of the precise service delivery models in use since it is these models that ultimately provide the connection between institutional and administrative aspects of WASH systems and the end result of service delivery.

Final reflections

Our analysis suggests a need to re-examine the complexity thinking promoted in WASH literature. The complexity within the WASH system must be acknowledged, but it should not be upheld as a fundamental characteristic. Experiences from both WASH and other public services sectors around the world suggest that a greater degree of clarity and organisation are necessary to achieve consistent outcomes (Hall & Lobina, 2006). Public health standards can be more reliably met if the system providing these services is bound by rules and regulations and hence made less complex.

In many cases the complexity in WASH is simply a result of poorly defined mandates, unclear legislation, or a lack of reliable data to inform decisions. Adaptative behaviour and innovation, while perhaps commendable from a human geography perspective, emerge out of necessity. Ultimately, these are social responses to meeting an unfilled need due to poorly developed or absent public service systems. A structured system with government leadership and the supporting subsystems in place need not preclude the opportunity for innovation, and increases efficiency. This increases the potential for an efficiently managed transition to better system performance.

Defining the WASH system, its subsystems, and their characteristics is a critical step in reducing the complexity. Our relatively simple, yet comprehensive, framework has helped to align the mandates and behaviour of public, private, and civil society actors toward a shared goal. The definition of service delivery models is an important preparatory step since these determine the requirements and boundaries of the WASH system in a given context. Analysing the WASH system in a participatory manner is helpful because it increases stakeholder awareness and understanding of sector policies, which in turn deepens dialogue while unlocking new perspectives through social learning.

Future work

The WASH systems assessment framework is a step toward a more universal set of benchmarks for service delivery in the rural and peri-urban sphere. The International Benchmarking Network for Water and Sanitation (IBNET) has promoted best practices and improved performance in the utility sector globally (IBNET, 2020), but no such framework exists for use outside the formal sphere of large scale WASH utilities. The WASH subsystems indicators, when applied to specific service delivery models and frameworks, could provide a basis for a more universal set of standards for smaller scale and decentralised water and sanitation services.

More work is needed to combine experience from a range of benchmarking and systems monitoring initiatives, in collaboration with governments and service providers, to better understand the needs and potential benefits of a more harmonised regional or global system. Starting in Latin America, the Rural Water and Sanitation Information Systems (SIASAR) has harmonized the monitoring indicators and approaches across 14 countries and includes indicators for both infrastructure performance and aspects of the WASH system such as institutional and operational capacity. SIASAR is intended for use in countries with similar characteristics to the six countries of IRC research, and has been used in Honduras and Uganda. Future work on the WASH system framework could benefit from a study of the experiences from SIASAR, IBNET, and other public sector benchmarking systems from countries with already high standards of services.

Using the WASH systems framework as an assessment structure is only one way of turning a conceptual understanding of these windows into a useable tool. There is scope for further development and modification into a forward looking planning tool. We have tested use of these windows for the identification of factors in scenario building where it was helpful to ensure a comprehensive consideration of the complex dynamics involved (Huston et al, in review). The definitions of the windows could be contextualised or adapted to a particular sector strategy or framework, or used to define more context-specific targets and goals. Some countries already have clear targets and measurement frameworks, but others are still in the early stages of developing national monitoring and planning frameworks. In such countries, sector planners and technocrats may benefit from taking a forward looking approach to studying and planning to ensure that each of these subsystems is systematically developed and improved.

8.7 Conclusion

The WASH systems framework has been used to increase systems thinking and social learning for more effective collective action, and to measure and study systems to provide enough insight to be able to intervene effectively. It has been applied by local, national, and international actors in Africa, Asia, and Latin America, and there is now a wide variety of actors now using this or other WASH systems approaches.

A framework that divides the system into subsystems (building blocks or windows) helps its users to see through the complexity to understand what the essential elements are and what desirable characteristics may be. Analyses of using these windows at the country level supports social learning and can provide a foundation for planning and more informed decision making. In particular, defining each service delivery model and studying it through the nine windows was constructive.

Reducing the complexity of water, sanitation, and hygiene service provision to nine universally relevant subsystems and their benchmarks required compromises. Simplification and generalisation limits the depth of analysis provided for any one aspect of the system. In most cases, the analysis has met our objective of ‘’knowing enough to intervene effectively’’, but complementary tools and analyses may be required depending on who is using the framework and for what objective.

As a monitoring tool, the broad scope of the framework means that some significant real world changes may not be detected, or can be hidden by the large number of other indicators and windows that remain unchanged. The Likert indicators offers limited insight into changes within a typical project cycle, but behind each benchmark there is a story to tell that can captured in the narrative or using complementary methods. Significant change across each of the subsystems is more likely to occur on the timescale of decades rather than years.

The traction gained in WASH systems thinking in recent years builds on successes from GLAAS, IBNET, and SIASAR, and other efforts to measure and benchmark systems and support their development. It is important to find synergies between these approaches and the lessons learned from them. Ultimately, we should strive to more harmonized support of national actors, who have the authority to make change, so we can write less about frameworks and more about success cases from WASH systems around the world.

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Chapter 9: Policy implications and future work

Several practical recommendations for water and sanitation service systems development emerged from the research. First, to bring order to these systems and increase efficiency, the responsibility for service management may need to be consolidated under a smaller number of providers and authorities. Consolidation offers an opportunity to improve coverage of service delivery (and improve service levels) and increase efficiency. The wider financial, regulatory and planning systems required to manage the WASH transition to utility services are still in development in most low- and middle-income countries. Consolidation of WASH services was observed in Uganda, and it has been documented in the water sector in North America, Europe, and China, often as part of a larger process of municipalisation of essential services. The transition process can be chaotic and multi-phase. In Uganda, the temporary stage of overlap between old and new regimes resulted in a lack of clarity and caused some confusion at local levels, for example with regards to asset ownership and monitoring responsibilities. This intermediary stage of transition has been referred to as ''information chaos'' in the case of the solid waste management transition in the Netherlands, resulting from simultaneous innovations and divergent plans and ideas among sector stakeholders (Geels and Kemp, 2007). Care is needed to ensure that consolidation and 'utilitisation' are not interpreted as singular solutions to rural services, as was done with privatisation of utilities throughout the 1990s. All nine subsystems will require investment and strengthening in order for the potential of the WASH systems to be sustainably realised.

For the WASH sector, achieving the 2030 targets, will require skilful navigation of this transition. If universal services are to be realised in Uganda in the next ten years, the process will require a significant acceleration of service level improvements, as compared to rates of change observed over the previous two decades. Implications of the process of consolidation and of 're-centralisation' of planning or service authority functions at regional and national levels are yet to be fully understood and conceptualised. A combination of centrally-directed change and bottom-up collective action will be needed to foster accelerated progress while avoiding the gross inequalities that could emerge if efficiency is prioritised over equity and quality of services.

Decentralised actors, including water users and civil society, will be able to better understand and play their roles in the new landscape if they are included in the visioning phase and are knowledgeable about the intended strategy and desired future systems. Government planning processes can be more adaptive and responsive to concerns of equity if they include multi-stakeholder fora, such as learning alliances, that can improve information exchange and foster social learning and innovation.

The push for professionalization and rapid utility growth against a backdrop of persistent inequalities and underserved populations suggests that a hybrid approach to WASH systems development will be necessary. There is a need to prioritize both an increase in overall efficiency and also mechanisms to reach the members of society, who cost more to serve and may be unable to pay for services. Authorities have a role to play in creating the incentives and conditions for service providers to meet the public needs and fulfill Human Rights obligations. Universality of public services will also require pressure from civil society, both on politicians to demand affordability, higher quality of services, and to demonstrate citizens' commitment to paying affordable prices as higher levels of service become available, and on service providers to ensure they meet the proscribed service levels and have adequate consumer relations.

Public systems take time and resources to mature. Few countries have surpassed 80% access to basic water and sanitation services while operating on a GDP per capita of less than 2000 USD (ppp, in constant 2011) (Smits, 2018). Authorities in Uganda, similarly to other sub-Saharan African countries, faces issues of both long-term solvency and service-level solvency in public service planning. While there are promising concepts emerging for pooling risk and increasing operational efficiency, no level of efficiency will replace the need for more funds to invest in infrastructure and the systems that support them. Technical innovation, social movements, and market acceleration each have a role to play, but a complete transition to universal services will only be possible when it is part of a larger societal and economic landscape change. Increased national wealth, effective taxation and public spending will be required to achieve 2030 WASH targets. This will likely require a combination of nationally directed spending and voluntary and investment in WASH upgrades by individuals at the household level. A rise in WASH service levels improves public health, frees up time, and contributes to a virtuous cycle of development.

A stronger 'enabling environment' and WASH system is presumed to be a necessary precursor to unlocking more financial resources, however the system itself needs investment in order to mature. There is a requirement to build institutional capacity and increase access to finance at the same time, despite evidence that many public service institutions in rural areas, only become financially viable after decades of operation, if ever. They require major periodic public investment in new capital or capital maintenance to meet new population needs or raise the quality of services. The Umbrella utilities in Uganda demonstrate how professionalisation under resource constraints is possible, but slow. The Umbrella utilities had greater management efficiency and capacity than community providers, but lacked the resources needed to respond rapidly to the problems identified in their systems, such as installing meters for tariff regulation. This hindered their ability to translate the improved operational capacity into higher quality services and greater financial performance. It also slowed efforts to build public trust and increase demand (and investment) for their services. Temporarily, it may be possible to buffer the competing need to increase performance and investment simultaneously by using transparent communication of challenges and multi-stakeholder forums to foster greater understanding. Continued progress in developing demand for safe water and public trust in authorities to provide it is likely to be an essential part of the water and sanitation systems transition. While banks and private investors are not yet willing to risk loans to new and still-unproven institutions, early-stage utilities and service authorities would be a beneficial place to direct development and aid funds.

Slow, continuous progress in strengthening each of the WASH subsystems remains an essential part of the solution to achieving long term service sustainability goals. This work shows that change is slow, is difficult to measure, and will often be unrecognized or even unseen. Gradual institutional development, and phased investment in the other essential subsystems for services, will take time before it is observable in the form of improved service quality, reach, and sustainability. The increased understanding of the importance of these systems, and of public finance and national leadership demonstrate an important shift in the WASH sector. In Uganda and other African countries, strong national commitment to these services, paired with progressive technical and institutional developments, are promising. The sector remains complex, but a stronger presence of national authorities and stricter definition of service delivery models reduces some of the complexity. The understanding of WASH as a public system provides a structured process for analysing, investing in, and ultimately transforming how services are delivered and used.

Future academic research

Several recommendations for future academic research emerge from the thesis (Table 16). These are primarily in four categories: additional research through application of the framework on a larger sample size, modification of the framework for use in other applied methodologies, further exploration of the scope of the framework as a monitoring tool, and targeted research on specific conclusions from the thesis.

The scope of the study could be expanded from the six countries and three years to cover a representative sample of countries within a region or globally, and to enable statistical analysis of trends in results. A longer study period would enable analysis of the correlation between change in the WASH sub-systems and changes in demography or political economy (e.g. GDP per capita or public budgets). Alternatively, correlations between changes in WASH sub-systems and changes in service delivery outcomes could be tested. Sensitivity analysis to test these relationships may produce greater insights into priorities and minimal conditions for improving WASH service delivery performance through systems strengthening.

A modified framework could be developed to focus on the dynamic aspects of the system. In particular, incentives and disincentives to improving WASH systems performance among actors could be studied using the building blocks. Similarly, a modified framework could be developed to focus on WASH system equity or inclusivity/exclusivity of service delivery, drawing on these six countries or other contexts.

More work is needed to combine the results obtained from existing benchmarking and systems monitoring initiatives such as The International Benchmarking Network for Water and Sanitation (IBNET), the Rural Water and Sanitation Information Systems (SIASAR), and this and other WASH systems frameworks. If done in collaboration with governments and service providers, such research could help to better understand the demands for and potential benefits of a more harmonised regional or global monitoring system. There is scope to study experiences of rural utility benchmarking and standardisation from North America and Europe where higher standards of decentralised service delivery have been achieved.

Finally, further studies could probe at the specific findings from Uganda. In particular, cost-modelling of different service delivery models to explore optimal utility service area size and how a mix of models can use competition to drive performance while optimizing use of public (or private) finance to incentivise achievement of universal coverage. A study of appropriate technology and the service criteria that increase willingness to pay could be used to identify strategies to increase household contributions to drinking water and sanitation service expansion.

Table 16: Research question answered in the thesis and recommended topics for future work.

Research questions addressed in thesis	**Future work**
1. What are the main "building blocks" of a healthy WASH system, and are they the same/similar in all contexts? a. Why do many solutions fail, and what is needed for success?	Study framework in larger number of country and over longer period to observe macro-trends
2. What does a resilient WASH system look like, what are the main sub-systems or 'building blocks'?	Map and analyse systemic tools (for service providers and authorities) to incentivise inclusion while pursuing greater solvency and financial performance, scale Study of WASH systems from high-performing contexts

	Financial modeling of tariff structures and business model performance for different service delivery models
3. How can each sub-system be objectively measured or assessed?	Develop benchmarking system for 'informal' WASH sector and test building blocks indicator framework in more countries and over a longer time scale
4. Is systems assessment (through its sub-systems) an effective approach to identify pathways to change, and to support a network of stakeholders to use systems thinking to plan, innovate, and promote public system transformation for WASH?	Develop minimized indicator set to optimize the framework for use as a routine monitoring tool Test acceptability of qualitative benchmarks for different stakeholders (e.g. service providers, authorities, funders, planners, technicians).
5. How can a national WASH system transition from a paradigm of low quality unreliable services toward one that delivers universal access to safe water?	Study scaling models and WASH systems forms/functions conducive to expanding rural utilities, and to providing services through a mix of service delivery models

Chapter 10: Conclusions

Globally, 2.2 billion people lack access to domestic piped potable water and 2.4 billion do not have basic sanitation (WHO & UNICEF, 2017). In low- and middle-income countries there is a shortage of facilities; existing facilities often fail prematurely or provide low levels of service. Efforts to improve service coverage or service levels are often narrowly-defined or focus on only one aspect of the service delivery system, such as the infrastructure or service provider capacity. Improvements frequently fail to be sustained over the long term due to the absence of permanent local systems to operate, maintain, and support service improvements. The enabling environment or wider systems required to support service delivery are unrecognized and not improved. A lack of metrics to define and understand these systems has been cited as a reason for the lack of (effective) investment.

In this research, I developed and tested a conceptual framework to assess potable water supply and sanitation as public services provided by a complex system. The objective was to improve planning, implementation, and monitoring of water, sanitation, and hygiene (WASH) services and thereby increase their sustainability. In collaboration with the non-governmental organisation (NGO) IRC, the framework was tested in six countries: Burkina Faso, Ethiopia, Ghana, Honduras, India, and Uganda. My research focused on sub–Saharan Africa and the case of Uganda. I adopted a pragmatic action-research methodology with the aim to improve service delivery outcomes while pursuing the answers to my research questions.

I started with a critical analysis of the patterns of poor performance in the WASH sector, with a focus on sanitation in East Africa (Chapter 4). Factors associated with failure and success were identified through exploratory case studies in rural and urban environments in Kenya, Uganda, and Tanzania. A lack of systems-based thinking and weak consideration of governance and long-term financing were associated with failed cases. Solutions developed by actors, who were from outside the context of implementation and that lacked adequate involvement of local stakeholders, tended to fail.

In contrast, location-based solutions that were embedded in existing systems were able to secure more resources and generate continuous demand from citizens. Promising interventions found ways to add value through the identification of co-benefits such as resource recovery or livelihood improvements. Engaging and empowering stakeholders across the system achieved more than just a solution to the initial problem, by unlocking innovation potential and stimulating collective action to continuously improve it while adapting to future conditions. Success often came through the iteration of ideas; once a promising solution was identified, it was tested, refined, and improved in a continuous cycle. Eventually, promising ideas were scaled up and made sustainable by establishing systems with incentives or feedback mechanisms to promote desirable behaviour among the actors invovled.

The research findings from East Africa reflect the recent discourse in the WASH sector across Africa, Asia, and Latin America. An increasing number of actors cite the complexity of WASH, and a failure to understand it as an interconnected system, as a reason that investments fail to deliver scalable impact. The complexity of the WASH system is often unmanaged and poorly understood by stakeholders at all levels.

In response, in my work I conceptualised WASH services as being provided by local and national public service systems, using a framework comprised of nine interacting subsystems (building blocks/windows) (Chapter 5). Theory from systems science and public sector management were used to build on existing models for WASH sector sustainability. Each of the nine subsystems in the framework describes a set of key functions in a public system: institutions and coordination, policy and legislation, planning, infrastructure development and maintenance, finance, monitoring, regulation, water resource management, and learning and adaptation. An additional window for demand and user behaviour was recommended. These subsystems are found in most countries with robust and universal services, but tend to be absent or poorly developed in countries with inadequate services. I hypothesized that defining, investing in, and strengthening the WASH system using these subsystems would support sector maturation and improve service delivery.

The framework was applied to the water sector using mixed methods in Uganda and specifically in the district of Kabarole (Chapters 6 and 7). Using participatory action-research, rural water service delivery systems were studied from a national and district perspective. The situation in Kabarole demonstrates the complexity characteristic of WASH systems around the world, with a mix of community and utility models were present across the urban-rural transition zone. Since 2016, the national urban utility has been expanding its schemes to rural growth centres, and new regional utilities have been established to take on management of existing community managed piped networks in rural areas. Significant extensions to the piped networks in Kabarole were observed between 2017 and 2019, but the majority of the population outside the municipality still rely on community managed point sources. Thirty-one percent (31%) of households did not used an improved water source at all.

Each service delivery model in Kabarole was analysed using the WASH systems framework; service delivery performance was assessed through a household survey and an infrastructure asset evaluation. The utilities had more clearly defined and developed systems than the community management model; self-supply was the least developed. The national utility performed best in the service delivery assessment; the regional utility performance was variable corresponding to the range in age and condition of their facilities.

The *multi-level perspective* for socio-technical systems change was used to study the public sector transition occurring in Uganda (Chapter 7). The three conceptual levels of landscape, regime, and niche were applied to study how transitions can be intentionally guided through formal (regime) leadership and managed innovation. I defined the intended transition in rural Uganda as one from an *ad hoc* landscape of unreliable, substandard, often unpaid services toward a paradigm of professional, paid, and regulated services that consistently meet standards. In Kabarole both regimes presently exist: the established regime of community management and an emerging regime of professionally managed piped services. The co-existence of established and emerging regimes is seen as a necessary part of a transition process, but it is unclear how long this transition will take and what the final system will be.

A scenario development process was used to explore the factors likely to influence the transition, and to identify strategies to achieve the goal of achieving universal access to WASH services in Kabarole by 2030. The three most influential and uncertain factors were the district's mandate and capacity as a service authority, the degree of citizen demand for higher levels of service, and water resource degradation. Five strategies were developed to account for the uncertainty and increase the likelihood of meeting the goal. The strategy development was carried out with a learning alliance established to help Kabarole District Local Government with innovative strategies to achieve its WASH goals. The learning alliance is also connected to regional and national levels through its network and the inclusion of actors representing these levels. It is a niche platform but its members are part of the established regime in their formal institutional roles outside of the learning alliance. This creates the opportunity for niche ideas from the learning alliance to influence regime level decisions and wider sector decisions.

In Uganda, structural changes to the WASH system are directed by the central government, but are often implemented at decentralised levels. My analysis found the sector leadership to be practicing adaptive management approaches. There are frequent opportunities for inclusive multi-stakeholder dialogue and extensive efforts to support decentralised uptake of policy change. Still, the learning alliance members in Kabarole were only beginning to understand the implications of national changes. As of late 2019, the notion of utilities as a permanent actor in the rural landscape had not yet been integrated into district planning and monitoring. The WASH systems assessment helped to identify and address ambiguities in the sector strategy, or in its interpretations by decentralised actors. This supports my hypothesis that participatory analysis using the WASH framework can improve the understanding of stakeholders and influence their adaptive response.

Kabarole is one of 134 districts in Uganda; the presence of multiple service delivery models and an established learning alliance made it a good case to study the changing national context. Conducting the research with IRC helped to ensure my research built on the expertise of local and international professionals involved in service planning and delivery.

The goal of applying the WASH systems framework was to increase systems thinking and social learning by providing a conceptual model and replicable analytical tool (Chapter 8). The WASH systems framework helped to navigate the complexity of a dynamic public sector and provided a mental model of how services can be sustainably provided. The relative simplicity of the framework, as compared to other tools using systems theory, promoted inclusion and replicability, since it could be led by facilitators without special training. The use of Likert indicators with established terminology made it feasible for a group of stakeholders to jointly conduct an assessment using semi-objective criteria. It was applied over three years in six countries with few adaptions needed. After initial publication of the concept in 2018, it was used by international actors as a common framework for discussions of WASH complexity. The analytical framework may be a step toward a more universal benchmarking system for the WASH sector, in particular in contexts where a mix of service delivery models are present and such a benchmarking system is absent.

During the three-year study period, the framework did not reveal significant trends or change trajectories in the six countries. Significant changes in Uganda and other countries were documented in qualitative data, but these were obscured when looking at the aggregated data from Likert scoring. To compensate, rigorous analysis of the qualitative narratives and the identification of priority indicators from within the overall framework are recommended. If applying this framework as a monitoring tool, it is necessary to use complementary monitoring methods that can track progress at shorter intervals. When looking at the entire system and what is required for it to deliver sustainable services, change is slow. A larger sample size and longer sampling frame will be needed to study the correlation between systems change and WASH service levels.

My research is progress toward a greater understanding of what the WASH system is and how it can be systematically strengthened. By defining WASH as a public service system, the responsibility of government to oversee the transition from the current mix of *ad hoc*, overlapping and often contradictory approaches to a more coherent set of models is made clear. In the absence of fully developed government frameworks, a clear definition of the WASH system and intended service delivery models was shown to reduce uncertainty and help stakeholders align to shared goals. The overall conclusion of my work is that it is only by reducing the perceived and absolute complexity of the WASH system – by settling on an agreed set of models for service delivery within a country – that lasting progress can be made in the quality, reliability, and equity of services.

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Appendix 1: WASH subsystems benchmarking tool

Table A1.1 The benchmarks (scored as Likert indicators) for national and district levels, water system.

Subsystem	Benchmarks for national/sector level (Water)	Benchmarks for the district level (Water)
Institutions	Responsibilities of the national and decentralized level bodies are clearly defined, and there are no gaps or overlaps between them.	All the required staff positions of the service authority are filled.
	Staffing requirements at national level (ministries, departments except the service authority) and decentralized bodies are clearly defined and the positions at national level are filled.	Service authorities and service providers have a formalised relationship for addressing accountability (contract, performance agreement and authorization).
	Staffing requirements for the service authorities for the different SDMs are clearly defined, e.g. in terms of no. FTE, or specific job profiles.	The required institutional set-up for the different Service Delivery Models (in particular for the service authority and service provider roles) does exist and is in place.
	The responsibilities and institutional set-up for service authorities for the different SDMs are clearly defined and understood.	The service authority receives regular back-up or support from higher levels of government.
Policy and Legislation	Legal framework for the sector is in place.	By-laws and ordinances for service delivery arrangements are in place.
	National guidelines for development and management of services are in place.	By-laws for hygiene and environmental protection are in place.
	National Sector Policy and Strategy is in place.	National sector legislation is known by local stakeholders.
	Norms and standards for quality of works and service delivery are in place.	
Planning	National planning mechanisms exist and they are based on a vision for reaching the WASH targets.	A consultation process with key stakeholders for making the plan is in place.

	Planning and budgeting is coordinated with donors (aid effectiveness).	There are district level WASH targets that link to national targets (multi-annual).
	The national plan reflects and takes into consideration the planning done at decentralised level and vice versa.	These plans are costed with reasonable indication of source of financing.
	The national plans take into account both capital investment (CapEx) needs and the needs to ensure sustainable service delivery (direct support (ExpDS) and capital maintenance (CapManEx)).	These plans take into account both capital investment needs and needs to ensure sustainable service delivery (direct support and capital maintenance).
	The national plans take into account in-country differences (geography; demography; water resources), recognizing the different SDMs.	These plans take into account equity (access) issues.
Finance	All the cost components are covered/taken into account in the sector budget (no gaps).	The nationally defined mechanisms for capital maintenance expenditure and direct support are being applied.
	Funding mechanisms and flows can be identified for the cost components CapEx, CapManEx, ExpDS, ExpIDS (see glossary). There are no unhelpful duplications.	The nationally defined mechanisms for financing capital expenditure are in place.
	It is defined who is responsible for paying CapEx and CapManEx.	The nationally defined subsidy mechanisms (block tariffs, cross subsidies between providers or other) are applied.
	Sector budgets and expenditures are justified in parliament with sector performance data.	There are measures to prioritise WASH in local level planning (earmarked budget).
	There are subsidies/subsidy mechanisms to address equity: e.g. cross subsidy, targeted subsidy for latrines.	There is sufficient absorption capacity for and a manageable gap between budget and disbursements to follow planning of service development.
Infrastructure	An inventory exists of all (or most) infrastructure assets (including public latrines), including age and current physical state of assets.	An inventory exists of all (or most) water infrastructure assets, including age and current physical state of assets for the focus district.

	Asset management is operationalized through standard tools, guidelines, trainings, etc.	Asset ownership is defined in detail between service authority and service provider(s) following the national legal framework.
	Asset ownership is clearly defined in laws and regulation.	Sufficient capacity for carrying out due diligence and regulation and following procurement and implementation manuals is in place.
	The manuals for project delivery are followed by the different national-level stakeholders.	The mechanisms for carrying out due diligence, regulation and procurement are in place.
	The project delivery models and procedures are sufficiently differentiated for different segments of the population and articulated with the service delivery models.	The project delivery models and procurement and implementation manuals and procedures for capital investments projects (drinking water infrastructure) are followed.
	The project delivery models and procurement procedures for capital investments projects (subsidies for onsite sanitation infrastructure, public latrines, treatment facilities, sewers) are clearly articulated in government-sanctioned implementation manuals.	The service authorities provide support to service providers to do operation and maintenance.
	The project delivery models ensure good quality of works and of the institutional development process.	The service authority is fulfilling its role with respect to asset management.
	The roles and responsibilities for asset management are clearly defined and separated between service providers and authorities, including differentiation between minor and major maintenance (not including households).	
	There are mechanisms and capacity in place to ensure due diligence, regulation and control over procurement.	
Monitoring	The data from the monitoring system are analyzed and used at sector level, e.g. for macro-level planning, trends analysis, policy making.	Service provider performance data are available

	The data in the national monitoring system are regularly updated.	The agreed national monitoring system(s) for the specific Service Delivery Models are in use in the district.
	The monitoring systems actively cover the entire country (all districts, all communities, all service providers).	The data in the monitoring system used at district level are regularly updated.
	The monitoring systems include service delivery indicators (Service level, Service provider performance, Service authority performance) and is covering the whole sanitation supply chain (include FSM)	The total of monitoring systems in use cover the entire district (all communities, all service providers).
	There is a national monitoring framework (the different sectoral monitoring systems speak to each other, in particular with the National Bureau of Statistics).	
Regulation	The entity equipped with regulatory functions sets (1) tariffs for sewerage connections and/or emptying fees; (2) rules for private emptying and for private sector players on-site: emptying techniques, transport and disposal	A mechanism for citizens (Civil Society Organisations) to hold service providers to account is in place.
	The entity equipped with regulatory functions uses data (monitoring data, audits, score cards) to guide performance management, and apply effective enforcement (incentives, penalties) in the three areas of regulation mentioned in the previous statement.	Platform(s) for citizens (Civil Society Organisations) to be informed and to be consulted on service delivery issues are in place.
	There is a regulator for the services or are regulatory functions delegated to sub-national institutions (e.g. through contracts).	The entity equipped with regulatory functions sets (1) tariff regulations and provides tariff calculation guidelines, (2) service level requirements and (3) rules that protect consumers.
		The entity equipped with regulatory functions uses monitoring data to guide performance management, and applies effective enforcement (incentives, penalties) in the three areas of regulation.

Learning and Adaptation	The national platforms are linked to the decentralized level.	The deliberations of the learning platforms are regularly documented and made available for interested stakeholders.
	The platforms are sufficiently representative of the different sector stakeholders.	The learning platforms are sufficiently representative of the different sector stakeholders.
	The reflections from these platforms are systematically taken up in policies, strategies etc., e.g. through "undertakings" (targeted actions).	The reflections from these platforms are taken up in local policies, strategies through 'undertakings' (targeted actions).
	There are institutionalized learning platforms and/or mechanisms at sector level, e.g.: Joint sector reviews, donor platforms, donor-government platforms, national learning alliance, thematic working groups, resource centres, sector web sites, etc.	There are institutionalised learning platforms at district level (district stakeholder platform, thematic working groups, resource centres and integrated with coordination platform).
		These district learning mechanisms are linked to the national level.
Water Resource Management	There are mechanisms or platforms in place to allow representation of service authorities and/or service providers for WASH (sanitation) services in WRM bodies.	Service providers and/or authorities develop and expand the water supply infrastructure, taking into account water resource availability and variability, including vulnerability to extreme events, as well as impact on receiving water bodies.
	There are national and sub-national water resource management institutions in place and able to undertake their mandated functions in the area of sanitation for water resource management (e.g. catchment authorities, river basin authorities).	Service providers and/or the service authority are able to engage with water resource management decision making at catchment or basin level.
	There is legislation and/or policy in place that clearly defines priorities and processes related to interference with water bodies and aquifers, regulation and water uses.	Service providers in the district plan for and carry out source protection and preservation activities such as water safety and water security plans.

	There are mechanisms in place for managing any conflicts or rather synergies between users of water for drinking and other uses (such as agriculture and livestock) that minimise the effect of the performance of schemes (such as Multiple Use Systems).
	Water Resource Management instruments such as abstraction permits, abstraction fees and disposal license are applied.

Table A1.2 The benchmarks (scored as Likert Indicators) for national and district level, sanitation

Subsystem	Benchmarks for national/sector level (Sanitation)	Benchmarks for district level (Sanitation)
Institutions	Responsibilities of the national and decentralised level bodies are clearly defined, and there are no gaps or overlaps between them.	All the required staff positions of the service authority are filled.
	Staffing requirements at national level (ministries, departments except the service authority) and decentralised bodies are clearly defined and the positions at national level are filled.	Service authorities and service providers have a formalised relationship for addressing accountability (contract, performance agreement, authorization).
	Staffing requirements for the service authorities for the different Service Delivery Models are clearly defined in terms of number of fulltime-equivalent (FTE), or specific job profiles.	The required institutional set-up for the different Service Delivery Models (in particular for the service authority and service provider roles) does exist and is in place.
	The responsibilities and institutional set-up for service authorities for the different Service Delivery Models are clearly defined and understood.	The service authority receives regular back-up or support from higher levels of government.
Policy and Legislation	Legal framework for the sector is in place.	By-laws and ordinances for service delivery arrangements are in place.

	National guidelines for development and management of services are in place.	By-laws for hygiene and environmental protection are in place. National sector legislation is known by local stakeholders.
	National Sector Policy and Strategy is in place.	
	Norms and standards for quality of works and service delivery are in place.	
Planning	National planning mechanisms exist and they are based on a vision for reaching the WASH targets.	A consultation process with key stakeholders for making the plan is in place.
	Planning and budgeting is coordinated with donors.	There are district level WASH targets that link to national targets (multi-annual).
	The national plan reflects and takes into consideration the planning done at decentralised level and vice versa.	These plans are costed with reasonable indication of source of financing.
	The national plans take into account both capital investment needs and the needs to ensure sustainable service delivery direct support and capital maintenance.	These plans take into account both capital investment needs and needs to ensure sustainable service delivery (direct support and capital maintenance).
	The national plans take into account in-country differences (in terms of geography, demography and water resources), recognising the different Service Delivery Models.	These plans take into account equity (access) issues.
Finance	All the cost components are covered/taken into account in the sector budget. There are no budget gaps.	The nationally defined mechanisms for capital maintenance expenditure and direct support are applied.
	Funding mechanisms and flows can be identified for the cost components of capital expenditure, capital maintenance, direct support and indirect support. There are no redundancies.	The nationally defined mechanisms for financing capital expenditure are in place.
	It is defined who is responsible for paying capital expenditure and capital maintenance.	The nationally defined subsidy mechanisms (pro-poor, cross subsidies, sewer/on-site or other) are applied.
	Sector budgets and expenditures are justified in parliament with sector performance data.	There are measures to prioritise WASH in local level planning (earmarked budget).

	There are subsidies/subsidy mechanisms to address equity; cross subsidy and targeted subsidy for latrines.	There is sufficient absorption capacity for and a manageable gap between budget and disbursements to follow planning of service development.
Infrastructure	An inventory exists of all (or most) infrastructure assets (including public latrines), including age and current physical state of assets.	An inventory exists of all (or most) sanitation infrastructure assets, including age and current physical state of assets for the focus district.
	Asset management is operationalised through standard tools, guidelines and trainings.	Asset ownership is defined in detail between service authority and service provider(s) following the national legal framework.
	Asset ownership is clearly defined in laws and regulation.	Sufficient capacity for carrying out due diligence, regulation, and following procurement and implementation manuals, is in place.
	The manuals for project delivery are followed by the different national-level stakeholders.	The mechanisms for carrying out due diligence, regulation and procurement are in place.
	The project delivery models and procedures are sufficiently differentiated for different segments of the population and articulated with the service delivery models.	The project delivery models, procurement and implementation manuals, and procedures for capital investments projects (including public latrines) are followed.
	The project delivery models and procurement procedures for capital expenditure projects (subsidies for onsite sanitation infrastructure, public latrines, treatment facilities, sewers) are clearly articulated in government-sanctioned implementation manuals.	The service authorities provide support to service providers to do operation and maintenance.
	The project delivery models ensure good quality of works and of the institutional development process.	The service authority is fulfilling its role with respect to asset management.
	The roles and responsibilities for asset management are clearly defined and separated between service providers and authorities, including differentiation between minor and major maintenance (not including households).	

	There are mechanisms and capacity in place to ensure due diligence, regulation and control over procurement.	
Monitoring	The data from the monitoring system are analysed and used at sector level for macro-level planning, trends analysis and policy making.	Service provider (pit emptying) performance data are available.
	The data in the national monitoring system are regularly updated.	The agreed national monitoring system(s) for the specific Service Delivery Models are in use in the district.
	The monitoring systems actively cover the entire country (all districts, all communities, all service providers).	The data in the monitoring system used at district level are regularly updated.
	The monitoring systems include service delivery indicators (service level, service provider performance, service authority performance) and is covering the whole sanitation supply chain (include faecal sludge management).	The total of monitoring systems in use cover the entire district (all communities and all service providers).
	There is a national monitoring framework. The different sectoral monitoring systems speak to each other, in particular to the National Bureau of Statistics.	
Regulation	The entity equipped with regulatory functions sets tariffs for sewerage connections and/or emptying fees, rules for private emptying and for private sector players on-site (emptying techniques, transport and disposal).	A mechanism for citizens (Civil Society Organisations) to hold service providers to account is in place.
	The entity equipped with regulatory functions uses data (monitoring data, audits, score cards) to guide performance management, and apply effective enforcement (incentives, penalties) in the three areas of regulation mentioned in the previous statement.	Platform(s) for citizens (Civil Society Organisations) to be informed and to be consulted on service delivery issues are in place.
	There is a regulator for the services or regulatory functions are delegated to sub-national institutions (through contracts).	The entity equipped with regulatory functions sets (1) tariff regulations and provide tariff calculation guidelines, (2) service level requirements and (3) rules that protect consumers.

		The entity equipped with regulatory functions uses monitoring data to guide performance management, and apply effective enforcement (incentives, penalties) in the three areas of regulation.
Learning and Adaptation	The national platforms are linked to the decentralised level.	The deliberations of the learning platforms are regularly documented and made available for interested stakeholders.
	The platforms are sufficiently representative of the different sector stakeholders.	The learning platforms are sufficiently representative of the different sector stakeholders.
	The reflections from these platforms are systematically taken up in policies and strategies through "undertakings" (targeted actions).	The reflections from these platforms are taken up in local policies, strategies through ‘undertakings’ (targeted actions).
	There are institutionalised learning platforms and/or mechanisms at sector level (joint sector reviews, donor platforms, donor-government platforms, national learning alliance, thematic working groups, resource centres, sector web sites).	There are institutionalised learning platforms at district level; district stakeholder platforms, thematic working groups, resource centres and integrated with coordination platform.
		These district learning mechanisms are linked to the national level.
Water Resource Management	There are mechanisms or platforms in place to allow representation of service authorities and/or service providers for WASH services in Water Resource Managment bodies.	Service providers and/or authorities develop and expand the sanitation infrastructure, taking into account water resource availability and variability, including vulnerability to extreme events, as well as impact on receiving water bodies.
	There are national and sub-national water resource management institutions in place and able to undertake their mandated functions in the area of sanitation for water resource management (catchment authorities, river basin authorities).	Service providers and/or the service authority are able to engage with water resource management decision making at catchment or basin level.

There is legislation and/or policy in place that clearly defines priorities and processes related to interference with water bodies and aquifers, regulation and water uses.	Service providers/Service authorities in the district plan for and carry out source protection and preservation activities.
	There are mechanisms in place for managing any conflicts or rather synergies between sanitation service users and/ or between users and service providers.
	Water Resource Management instruments such as abstraction permits, abstraction fees, disposal license are applied.

Subsystem	Benchmark for service delivery model
Institutional	Programs and initiatives of technical assistance to train and support service providers on business development and technical capacity are in place.
	Service providers receive external support and backstopping on a regular basis.
	Service providers have the technical and managerial capacity to provide services effectively.
Finance	Tariffs provide cost recovery for Opex and CapManEx
	Service providers have access to a source of financing to cover capital maintenance/depreciation costs (e.g. public funding, repayable finance or other).
	Subsidy mechanisms are in place to remove affordability constraints (e.g. tariff cross-subsidies).
Infrastructure	The ownership of the assets is clearly understood by service providers.
	The responsibilities for asset management tasks (if any) are clearly defined in performance contracts or lease agreements of service providers.
	Asset replacement is planned and budgeted for based on understanding of life cycle of the assets (and main components).

Monitoring	Service delivery levels and/or operational performamce are monitored by service providers.
	Service providers regularly report monitoring data to service authorities or other entities.
	Consumers have (reasonable) access to information about services and performance.
Regulation	Economic regulation (balance between service level and pricing) is in place (by agency or by contract).
Water Resource Management	Service providers plan for and carry out water protection and preservation activities, such as water safety/water security plans.
	Service providers are able to engage with water resource management decision-making at catchment or basin level.
	Service providers and or authorities manage and expand the service infrastructure, taking into account water resource availability, variability and vulnerability for extreme events, as well as impact on receiving water bodies due to disposal of faecal sludge and wastewater.
	Conflicts between water for household use and other uses (agriculture/livestock) that affect the performance of schemes are minimized or managed well.

Appendix 2: Survey instruments for household questionnaires

Table A2.1: Household survey from used in Kabarole district in 2019.

Form 3 - Household Survey (v. 5.0)	
Question	**Response**
General Information	
1. Title of data collector	
	Hand pump mechanic______
	Extension worker______
	Research assistant______
2. Select Sub County (S.C.) or Town Council (T.C.)	__________________________
3. GPS location of Household	__________________________
Household Details	
4. Name of survey respondent	__________________________
5. Gender of survey respondent	
	Female______
	Male______
6. Telephone number of survey respondent	__________________________
7. Is the survey respondent the head of household?	
	Yes______
	No______
Only answer if you responded No to Q7	
8. Gender of head of household	
	Female______
	Male______
9. How many people live in the household the majority of the year?	
	less than 5______
	5-10______
	more than 10______
Household access to water	
10. What is the primary source of DRINKING water for your household?	
	Improved water source - private in house or yard______
	Improved water source - shared communal source______
	Rainwater harvesting______
	Unimproved water source or surface water______

	Purchase from vendor______
Only answer if you responded Improved water source - shared communal source to Q10	
11. What is the type of improved source that you use?	
	Handpump - shallow well or borehole______
	Protected Spring______
	Public Tapstand______
	Fetch from neighbour's piped connection______
	Mechanized borehole______
Only answer if you responded Improved water source - private in house or yard to Q10	
12. To which scheme is your private tap connected?	
	Kicwamba GFS______
	Rwaihamba Scheme______
	Kasenda Scheme______
	Bukuku GFS______
	Mugusu NWSC______
	Mugusu GFS______
	NWSC - Fort Portal Town______
	Nyakariba GFS______
	Rweitera Scheme______
	Nyakitokoli Scheme______
	Buhikira GFS______
	Bitabu GFS______
Only answer if you responded Public Tapstand to Q11	
13. To which scheme is your Public Tapstand connected?	
	Unknown______
	Kicwamba GFS______
	Rwaihamba Scheme______
	Kasenda Scheme______
	Bukuku GFS______
	Mugusu NWSC______
	Mugusu GFS______
	NWSC - Fort Portal Town______
	Nyakariba GFS______
	Rweitera Scheme______
	Nyakitokoli Scheme______
	Buhikira GFS______
	Bitabu GFS______
Only answer if you responded Public Tapstand to Q11	

14. On average, how much time round trip do you spend collecting water from this source, including walking and queuing ?	
	Less than 30 minutes per trip______
	More than 30 minutes per trip______
15. How satisfied are you with your water service in terms of distance to water source?	
	Satisfied______
	Partly Satisfied______
	Not satisfied______
Only answer if you responded Improved water source - private in house or yard to Q10	
16. In the past month, how many days was your home connection delivering water?	
	Always when opening the tap______
	More than 15 days out of the past month (more than 50% of the days)______
	Less than 15 days in the past month (less than 50% of the days)______
	Never______
Only answer if you responded Improved water source - private in house or yard|Improved water source - shared communal source to Q10	
17. When it is functioning, how many hours per day is it possible to fetch water from this source?	
	less than 8______
	8-16______
	more than 16 hours per day______
18. How satisfied are you about the number of hours per day that water is available?	
	Satisfied______
	Somewhat Satisfied - partly satisfied______
	Not Satisfied______
19. What is the secondary source of DRINKING water for your household?	
	NO secondary source______
	Improved source - private connection household or yard______
	Improved source- community source______
	Improved source - from a neighbour's connection______
	Unimproved water source______
	Rainwater harvesting______
	Purchase from vendor______
	Improved water source______
	Unimproved water source______

20. What is the primary source of DRINKING water for your household in the DRY season?	Rainwater harvesting______
	Purchase from vendor______
	Purchase bottled water______
21. What type of water source do you use for NON-DRINKING (domestic) purposes?	
	Improved source______
	Unimproved source - hand dug well______
	Unimproved source - Surface water______
	Rain Water Harvesting Tank______
Only answer if you responded Unimproved source - hand dug well|Unimproved source - Surface water|Rain Water Harvesting Tank to Q21	
22. Do you ever drink water from the well or surface water?	
	Yes______
	No______
23. Do you do anything to make your water more safe to drink?	
	Yes - always______
	Sometimes______
	Rarely______
	Never______
Only answer if you responded Yes - always|Sometimes|Rarely to Q23	
24. What method do you use use to make your water safe to drink?	
	Boil______
	Add bleach/Chlorine (Waterguard)______
	Strain through a cloth______
	Use a filter (e.g. ceramic or composite)______
	Solar disinfection______
	Let is stand and settle______
25. How satisfied are you with your service in terms of quality of the water?	
	Satisfied______
	Somewhat satisfied (partly satisfied)______
	Not Satisfied______
Only answer if you responded Improved water source - private in house or yard|Improved water source - shared communal source|Rainwater harvesting|Purchase from vendor to Q10	
26. Does your household Pay (or contribute money) to collect water from your primary source of water?	
	Always______
	Sometimes______
	Only after breakdown______
	Never______
	Unknown______

Only answer if you responded Always|Sometimes to Q26	
27. What type of tariff system?	
	fixed tariff per month______
	fixed tariff per year______
	pay per 20 L jerry can______
	pay per cubic meter (m3) - billed based on consumption______
Only answer if you responded Only after breakdown to Q26	
28. ON AVERAGE- How often do you contribute for repairs?	
	More than one time per month______
	About once in a month - or every 4-6 weeks______
	5 to 10 times per year______
	1 to 5 times per year______
	Less than once per year______
	Unknown______
Only answer if you responded Only after breakdown to Q26	
29. How much do you usually contribute when there is a repair?	___________________________
Only answer if you responded fixed tariff per month to Q27	
30. What is the monthly tariff?	___________________________
Only answer if you responded fixed tariff per year to Q27	
31. What is the annual tariff?	___________________________
Only answer if you responded pay per 20 L jerry can to Q27	
32. What is the cost per 20L jerry can?	___________________________
Only answer if you responded pay per cubic meter (m3) - billed based on consumption to Q27	
33. What is the tariff per cubic meter (m3) ?	___________________________
Only answer if you responded Sometimes|Never to Q26	
34. What is the MAIN reason that your household does NOT pay for water from your primary drinking source?	
	No one ever asked us to pay______
	Do not trust those collecting money______
	The service is bad/ unreliable______
	Was told not to pay by a leader______
	Can't afford to pay______
	Elderly / ill (Exempt)______
	Don't know why / can't answer______
Only answer if you responded Yes|Only for contribution to repairs to Q26	

35. How satisfied are you with your water service in terms of cost?	
	Satisfied______
	Somewhat Satisfied (partially satisfied)______
	Not satisfied______
36. How satisfied are you about the total amount (quantity) of water that you are able to use each day?	
	Satisfied______
	Somewhat satisfied - partly satisfied______
	Not satisfied______
Only answer if you responded Improved water source - private in house or yard to Q10	
37. Who is the service provider/manager for the tap?	
	WUC/WSC or Community Management Board______
	NWSC______
	Midwestern Umbrella Utility______
38. How satisfied are you with the management of your water source? (Does the manager do a good job?)	
	Satisfied______
	Somewhat Satisfied (partially satisfied)______
	Not Satisfied______
Household sanitation and hygiene	
39. Does the household have access to a sanitation facility?	
	Yes______
	No______
Only answer if you responded Yes to Q39	
40. Is the sanitation facility private or shared?	
	Privately owned by the household______
	Shared by multiple households______
	Public facility______
	Belongs to an institution______
Only answer if you responded Yes to Q39	
41. What type of sanitation facility does the family have access to?	
	Traditional pit latrine______
	VIP latrine______
	Pour flush toilet______
	Flush toilet______
	Ecosan toilet (UDDT)______
	Composting pit latrine______
Only answer if you responded Pour flush toilet|Flush toilet to Q41	

42. Where does the flush/pour flush toilet connect to?	
	septic tank or cesspool______
	sewer______
	open field / drainage field______
Only answer if you responded Privately owned by the household|Shared by multiple households to Q40	
43. Take a photo of the sanitation facility	__________________________
Only answer if you responded Privately owned by the household to Q40	
44. Does the sanitation facility have the essentials of a super structure?	
	Roofing______
	Door______
	Raised walls______
Only answer if you responded Privately owned by the household to Q40	
45. Is the floor platform/ slab of the sanitation facility washable?	
	Yes______
	No______
Only answer if you responded Privately owned by the household to Q40	
46. When the cesspool or pit gets full, what do you do?	
	Cover it and construct a new one (no emptying)______
	Empty it - household members empty it______
	Empty it - pay someone to empty it (emptying service)______
	Unknow / it has never filled up yet______
Only answer if you responded Empty it - household members empty it|Empty it - pay someone to empty it (emptying service) to Q46	
47. What happens with the waste when it is emptied?	
	It is disposed of onsite or nearby______
	It is buried______
	It is collected and removed from the premises (taken off-site)______
Only answer if you responded Empty it - pay someone to empty it (emptying service) to Q46	
48. Is it emptied manually or with a cesspool emptying truck?	
	Manual Emptying______
	Cesspool emptying truck______
	Unknown______

Only answer if you responded Empty it - pay someone to empty it (emptying service) to Q46	
49. How much do you pay for emptying one time?	
	Less than 100,000 UGX______
	100,000 - 300,000 UGX______
	More than 300,000 UGX______
50. How satisfied are you with the sanitation facility that you use?	
	Satisfied______
	Somewhat Satisfied (partially satisfied)______
	Not Satisfied______
51. Observe around the sanitation facility and compound. Is there any evidence of open defecation?	
	Yes, there is evidence of OD______
	No, there is not evidence of OD______
Only answer if you responded Privately owned by the household to Q40	
52. Is there a handwashing station or place to wash near the sanitation facility?	
	Yes______
	No______
Only answer if you responded Yes to Q52	
53. Observe : Is there evidence of use of the hand-washing facility?	
	Yes - it has been used recently______
	No - no evidence of use______
	Unsure - it looks like it may be used sometimes but not recently______
Only answer if you responded Yes to Q52	
54. Observe: Is there soap at the hand-washing facility?	
	Yes______
	No______
Only answer if you responded Shared by multiple households|Public facility|Belongs to an institution to Q40	
55. Do you have a handwashing facility at or in your home?	
	Yes______
	No______
Only answer if you responded Yes to Q55	
56. Observe : Is there evidence of use hand-washing sanitation facility?	
	Yes - it has been used recently______
	No - no evidence of use______

	Unsure - it looks like it may be used sometimes but not recently______
Only answer if you responded Yes to Q55	
57. Observe: Is there soap at the hand-washing facility?	
	Yes______
	No______

Appendix 3: Survey instruments for asset registry

The asset registry in 2019 was completed using a total of 6 different forms in AkvoFlow. The forms used for the point source/stand post survey are shown in Figure A2.1. The forms used in the piped scheme survey (management and major component, excluding stand posts) are shown in Figure A2.2. Each of the forms and response options are included below.

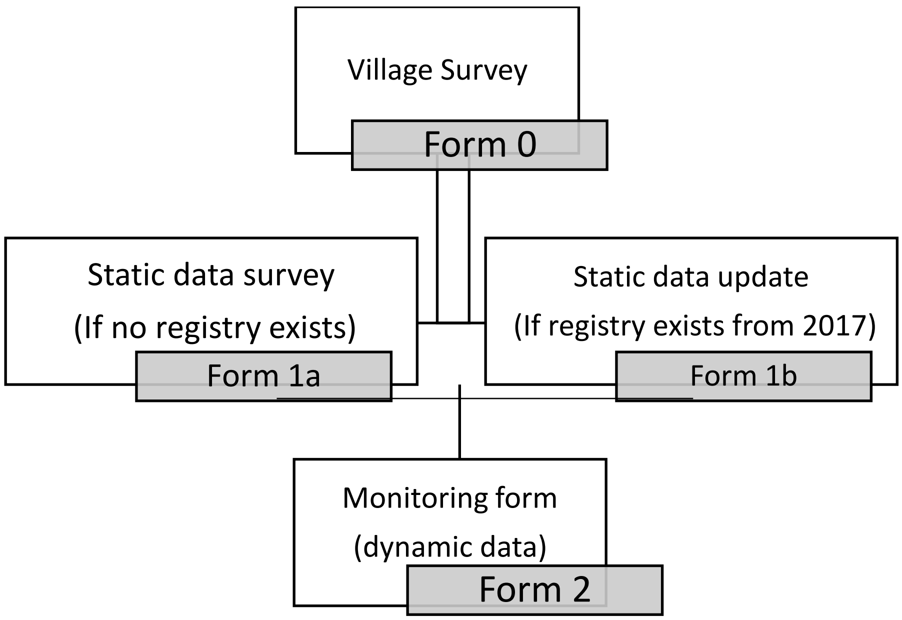

Figure A3.1: Hierarchy of monitoring question forms for asset inventory of point sources.

The village survey was conducted upon starting a new village, then all water points in that village were registered using Form 1 for static data (location, type, etc.). If the water point was not in the existing database from 2017, from 1a was used. If the water point ha already registered in the database in the 2017 survey, form 1b was used to update the register. Form 2 was used for all water points for dynamic data (functionality, condition, management practices, etc.)

Table A3.1: Village survey form used upon arrival in each village; used to map villages and ensure all water points and stand posts in each village were registered.

Form 0 - Village survey (v. 4.0)	
Question	**Response**
General Information	
1. Select Sub County (S.C.) or Town Council (T.C.)	___________________________
2. GPS location of the village	___________________________
3. Describe where the GPS recording was taken	___________________________
4. Number of households?	___________________________
Contact Details	
5. Name of Interviewee #1	___________________________
6. Gender of interviewee #1	
	Female______
	Male______
7. Position of interviewee #1	
	Water User Committee member______
	LC1 Executive______
	Religious or opinion leader______
8. Telephone contact of interviewee #1	___________________________
Access to water	
9. Is there an improved drinking water source in this village?	
	Yes______
	No______
Only answer if you responded Yes to Q9	
10. How many improved drinking water sources are in the village?	___________________________
Only answer if you responded Yes to Q9	
11. Of those, how many are shallow wells?	___________________________
Only answer if you responded Yes to Q9	
12. Of those, how many are deep boreholes?	___________________________
Only answer if you responded Yes to Q9	
13. Of those, how many protected springs?	___________________________
Only answer if you responded Yes to Q9	
14. Of those, how many are Public Tapstands?	___________________________
15. How many are rainwater harvesting systems?	___________________________
Only answer if you responded No to Q9	
16. What is the primary source of drinking water in the village?	
	Scoop hole______

	Unprotected spring______
	River or stream______
	Lake______
	Purchased from vendor______
Only answer if you responded No to Q9	
17. Is there a secondary source of drinking water in the village?	
	Yes______
	No______
Only answer if you responded Yes to Q17	
18. What is the secondary source of drinking water in the village?	
	Scoop hole______
	Unprotected spring______
	River or stream______
	Lake______
	Purchased from vendor______
19. What is the primary source of DRINKING water in the village in the DRY season?	
	Unimproved Source______
	Improved Source in the village______
	Use source from a nearby village______

Table A3.2 Water point and stand post register form (static data)

Form 1a - Water Point and stand post Register (v. 7.0)

Question	Response
General information	
1. Water point Name	__________________________
2. Location of water point	__________________________
Water point details	
3. Type of water source	
	Protected spring______
	Shallow well______
	Deep borehole______
	Public Tapstand______
	Kiosk______
	Rain water harvesting tank______
Only answer if you responded Public Tapstand|Kiosk to Q3	
4. Name of the water scheme connected to the tapstand or kiosk	
	Kicwamba GFS______
	Rwaihamba Scheme______
	Kasenda Scheme______
	Bukuku GFS______

	Mugusu GFS______
	Mugusu NWSC______
	NWSC- Fort Portal town______
	Nyakiriba GFS______
	Rweitera Scheme______
	Nyakitokoli GFS______
	Buhikira GFS______
	Bitabu GFS______
Only answer if you responded Protected spring|Shallow well|Deep borehole to Q3	
5. DWD number of water point	___________________________
6. GPS location of water point	___________________________
7. Take photograph of water point	___________________________
8. Year of water point construction	___________________________
9. Who funded the construction of this water point	
	Government______
	NGO______
	Community______
	Private______
	Religious institutions______
	Politician______
10. Has this water point had a major rehabilitation since the initial construction?	
	Yes______
	No______
Only answer if you responded Yes to Q10	
11. What year was the major rehabilitation?	___________________________
Only answer if you responded Yes to Q10	
12. Who funded the recent major rehabilitation of this water point?	
	Government______
	NGO______
	Community______
	Private______
	Religious institutions______
	Politician______
Only answer if you responded Rain water harvesting tank to Q3	
13. Volume of the tank (litres)	___________________________
Only answer if you responded Protected spring to Q3	
14. What type of protected spring is it?	
	improved______
	ordinary______
Only answer if you responded ordinary to Q14	
15. How many spouts does it have?	
	one______
	more than one______
Only answer if you responded improved to Q14	
16. How many taps does it have?	
	One______
	more than one______
Only answer if you responded Shallow well|Deep borehole to Q3	
17. Borehole or well depth (meters)	___________________________
Only answer if you responded Shallow well|Deep borehole to Q3	
18. Borehole or well diameter (inches)	___________________________

Only answer if you responded Shallow well|Deep borehole to Q3	
19. Type of lifting device?	
	Handpump______
	Rope pump______
	motorized pump______
	manual lifting with a rope______
20. Are their livestock drinking facilities at the water point?	
	Yes______
	No______
Only answer if you responded Yes to Q20	
21. Take a photograph of the livestock drinking facilities	________________________

Table A3.3: Monitoring form for dynamic data at water points and stand posts

Form 2- Monitoring Form (water points and stand posts) (v. 4.0)	
Question	**Response**
Contact details	
1. Name of interviewee	________________________
2. Gender of Interviewee	
	Male______
	Female______
3. Position of interviewee	
	Caretaker/operator______
	Member of WUC/WSC______
	Member of LC1______
	Water User______
4. Telephone contact of interviewee	________________________
Water point details	
5. Take a photo of the water point	________________________
6. Is the water point currently functional?	
	Functional in use______
	Functional and not in use______
	Non-Functional______
	Decommissioned______
Only answer if you responded Functional in use|Functional and not in use|Non-Functional to Q6	
7. Type of water point	
	Deep borehole______
	Shallow well______
	Protected spring______
	Public Tapstand______
	Kiosk______
	Rainwater Harvesting Tank______

Only answer if you responded Deep borehole|Shallow well to Q7	
8. Type of lifting device	
	Handpump______
	Rope pump______
	Motorised pump______
	Manual lifting with ropes______
Only answer if you responded Handpump|Rope pump|Motorised pump to Q8	
9. What is the make of the pump?	
	AfriDev______
	India Mark______
	Nira Pump______
	Otara______
Only answer if you responded Handpump to Q8	
10. What is the type of pump?	
	U2______
	U3______
	U3Modified______
	U3 GS______
Only answer if you responded Deep borehole|Shallow well|Protected spring to Q7	
11. What is the pipe material?	
	GI______
	PVC______
	Stainless Steel______
	HDP______
	Unknown______
Functionality	
Only answer if you responded Non-Functional to Q6	
12. Main cause of non-functionality	
	Dry or low yielding source______
	Technical failure - breakdown of handpump______
	Technical failure - Taps broken______
	Technical failure - other______
	Unknown______
Only answer if you responded Functional and not in use to Q6	
13. Reasons why the functional water point is not in use	
	poor water quality______
	technical problem______
	poorly located or inaccessable______
	better alternative sources are nearby______
	difficult to use______
Only answer if you responded Functional in use|Functional and not in use to Q6	
14. Please rate the level of functionality	
	Fully functioning at 100%______
	Partially functioning - works with some issues/difficulties______
	Barely functioning______
Only answer if you responded Non-Functional to Q6	

15. Can the water point be brought back into service WITHOUT major overhaul or construction?	
	Yes______
	No______
	Unknown______
Only answer if you responded No to Q15	
16. Can the water point be rehabilitated to bring it back to service WITH A MAJOR overhaul or construction project?	
	Yes______
	No______
	Unknown______
Only answer if you responded Non-Functional to Q6	
17. Specify the nature of the technical breakdowns	______________________________
Only answer if you responded Non Functional to Q6	
18. Duration of the current non-functionality (how long has it has been out of service)	
	1 to 5 days______
	6-10 days______
	11-20 days______
	more than 20 days but less than one year______
	more than one year______
Only answer if you responded Functional in use|Functional and not in use|Non-Functional to Q6	
19. Is this a seasonal water point that commonly fails in the dry season?	
	Yes______
	No______
Only answer if you responded Functional|Partially Functional to Q6	
20. Does the colour of the water change depending on the season or time of the day?	
	Yes______
	No______
	Unknown______
Only answer if you responded Functional in use|Functional and not in use|Non-Functional to Q6	
21. How many days in total was the water facility out of service during the past one year?	
	It was never broken down______
	About 1 week in total______
	About 1 - 3 weeks in total______
	More than 3 weeks total______
Only answer if you responded Functional in use|Functional and not in use to Q6	
22. How many hours per day is it possible to collect water from this source?	
	more than 8______
	8-16 hours______
	more than 16 hours______
Only answer if you responded Functional in use|Functional and not in use to Q6	

23. How many minutes does it take to fill a 20 Liter jerry can?	
	less than 1 minutes______
	1-3 minutes______
	more than 3 minutes______
Only answer if you responded Public Tapstand to Q7	
24. Is there a water meter at the water point / Tapstand?	
	Yes______
	No______
Only answer if you responded Yes to Q24	
25. Is the water meter functioning?	
	Yes______
	No______
Condition and use of assets	
Only answer if you responded Deep borehole|Shallow well|Public Tapstand to Q7	
26. Physical state of the Apron	
	Excellent______
	Good______
	Fair (moderate)______
	Poor______
	Very poor______
Only answer if you responded Deep borehole|Shallow well to Q7	
27. Physical state of the pedestal	
	Excellent______
	Good______
	Fair (moderate)______
	Poor______
	Very Poor______
Only answer if you responded Protected spring|Public Tapstand|Kiosk to Q7	
28. Physical state of Tap/spouts	
	Excellent______
	Good______
	Fair (moderate)______
	Poor______
	Very poor______
Only answer if you responded Excellent|Good|Fair (moderate)|Poor|Very poor to Q28	
29. Status of how the tap/spout is currently being used	
	Active - all are in use______
	At least one tap/spout not in use - repair needed______
	At least one tap/spout not in use - abandonded or never used______
Only answer if you responded Deep borehole|Shallow well|Protected spring|Public Tapstand|Kiosk|Rainwater Harvesting Tank to Q7	
30. Physical state of drainage channel and soakpit	
	Excellent______

	Good______
	Fair (moderate)______
	Poor______
	Very poor______
Only answer if you responded Deep borehole|Shallow well to Q7	
31. Physical state of the Pumphead	
	Excellent______
	Good______
	Fair (moderate)______
	Poor______
	Very poor______
Only answer if you responded Deep borehole|Shallow well to Q7	
32. Physical state of the handle	
	Excellent______
	Good______
	Fair (moderate)______
	Poor______
	Very poor______
Only answer if you responded Protected spring to Q7	
33. Physical state of the retention wall	
	Excellent______
	Good______
	Fair (moderate)______
	Poor______
	Very poor______
Only answer if you responded Kiosk to Q7	
34. Physical state of the superstructure (building and door)	
	Excellent______
	Good______
	Fair (moderate)______
	Poor______
	Very poor______
Only answer if you responded Kiosk to Q7	
35. Physical state of the plumbing works in the kiosk	
	Excellent______
	Good______
	Fair (moderate)______
	Poor______
	Very poor______
Only answer if you responded Rainwater Harvesting Tank to Q7	
36. How many rainwater harvesting tanks are present?	______________________________
Only answer if you responded Rainwater Harvesting Tank to Q7	
37. What is the total storage capacity of the tanks?	______________________________
Only answer if you responded Rainwater Harvesting Tank to Q7	

38. How many rainwater harvesting tanks are in USE?	___________________________
Only answer if you responded Rainwater Harvesting Tank to Q7	
39. What is the total storage volume of the tanks IN USE?	___________________________
Only answer if you responded Rainwater Harvesting Tank to Q7	
40. Physical state of the gutters	
	Excellent______
	Good______
	Fair (moderate)______
	Poor______
	Very poor______
Only answer if you responded Rainwater Harvesting Tank to Q7	
41. What is the status of the filtration system?	
	No filtration system exists______
	Present and in use______
	Present - not in use, repair needed______
	Present - not in use, not connected______
Only answer if you responded Present and in use|Present - not in use, repair needed|Present - not in use, not connected to Q41	
42. Physical state of the filtration system	
	Excellent______
	Good______
	Fair (moderate)______
	Poor______
	Very poor______
Only answer if you responded Rainwater Harvesting Tank to Q7	
43. Physical state of the MAIN tank	
	Excellent______
	Good______
	Fair (moderate)______
	Poor______
	Very poor______
Only answer if you responded Functional in use|Functional and not in use|Non-Functional to Q6	
44. Please explain any other observable technical problems that require repairs	___________________________
Only answer if you responded Deep borehole|Shallow well to Q7	
45. Are there any components of the well/borehole that require total replacement?	
	Apron______
	Drainage channel______
	Handle______
	Pumphead______
	Spout______
	Pedestal______
	Rope pump______
	NONE______
Only answer if you responded Protected spring to Q7	

46. Are there any components of the protected spring that require total replacement?	
	Retention wall______
	Landing and steps______
	Spouts/taps______
	Catchment protection or fence______
	NONE______
Only answer if you responded Public Tapstand to Q7	
47. Are there any components of the public tapstand that require total replacement?	
	Apron______
	Drainage channel______
	Tap______
	Meters______
	NONE______
Only answer if you responded Kiosk to Q7	
48. Are there any components of the kiosk that require total replacement?	
	Superstructure (building and doors)______
	Plumbing works______
	Taps______
	Drainage channel______
	NONE______
Only answer if you responded Rainwater Harvesting Tank to Q7	
49. Are there any components of the rainwater harvesting system that require total replacement?	
	Gutters______
	Filtration system______
	Tank______
	Taps______
	Drainage channel______
	NONE______
Only answer if you responded Deep borehole|Shallow well|Public Tapstand|Kiosk to Q7	
50. Are there any potential sources of contamination within 10 meters of the water point?	
	Latrine nearby______
	Animal excreta nearby______
	Livelihood activity nearby (e.g. brickmaking)______
	Rubbish nearby______
	NONE - No contamination risk observed______
Only answer if you responded Protected spring to Q7	
51. Is the catchment protected and are there any potential sources of contamination nearby?	
	No fence______
	Animals at the catchment______
	Agriculture/cultivation at the catchment______
	Latrines nearby______

	Livelihood activities at the catchment (e.g. brickmaking)______
	Clothes washing in the catchment______
	Children playing______
	NONE - No contamination risk observed______
Only answer if you responded Rainwater Harvesting Tank to Q7	
52. Are there any potential sources of contamination to the rainwater system?	
	Visible contamination on roof catchment area (plants, dirt, excreta)______
	gutter channels are collecting dirty water______
	entry points or openings to the tank are not properly covered______
	NONE - no contamination risks observed______
Management survey	
Only answer if you responded Functional in use|Functional and not in use|Non-Functional to Q6	
53. Who is responsible for daily operation of the water point?	
	Caretaker______
	Private operator______
Only answer if you responded Caretaker to Q53	
54. Is the caretaker paid or unpaid?	
	paid______
	unpaid______
Only answer if you responded Functional in use|Functional and not in use|Non-Functional to Q6	
55. Is there a WUC/WSC for this water point?	
	Yes______
	No______
Only answer if you responded Functional in use|Functional and not in use|Non-Functional to Q6	
56. Who is responsible for the overall management of this water point?	
	WUC/WSC______
	Midwestern Umbrella______
	NWSC______
	NGO______
	Private operator______
	Unknown______
	No management______
Only answer if you responded Yes to Q55	
57. Is the WUC/WSC currently active?	
	Yes______
	No______
Only answer if you responded WUC/WSC|Midwestern Umbrella|NWSC|NGO|Private operator|Unknown to Q56	
58. In the last year, has the WUC/WSC/management body organised any maintenance activities or repairs?	
	Yes______
	No______
	Unknown______

Only answer if you responded Yes to Q55	
59. In the last year, has the WUC/WSC received any support or guidance from the sub-county or district government?	
	yes______
	no______
	Unknown______
Only answer if you responded Yes to Q55	
60. Number of members of the WUC/WSC	___________________________
Only answer if you responded Yes to Q55	
61. Number of Active members on the WUC/WSC	___________________________
Only answer if you responded Yes to Q55	
62. Number of women on the WUC/WSC	___________________________
Only answer if you responded Yes to Q55	
63. Number of women in key positions on the WUC/WSC (chair, secretary of finance)	___________________________
Only answer if you responded Yes to Q55	
64. Is the WUC/WSC a member of the Sub County Water Supply and Sanitation Board?	
	Yes______
	No______
	Unknown______
Only answer if you responded Functional in use to Q6	
65. Estimate the number of households who use this water point as their source of water	
	less than 25______
	25-50______
	50-100______
	more than 100______
Only answer if you responded Functional in use|Functional and not in use to Q6	
66. What is the main purpose for which people use water from this water point?	
	Drinking water______
	water for other household and domestic use______
	washing cars / motorcycles______
	Agriculture (crops or animals)______
	Institutional use (school or healthcare facility)______
Only answer if you responded Functional in use|Functional and not in use|Non-Functional to Q6	
67. Is water used by vendors/collected to sell other places?	
	Never______
	Rarely______
	Sometimes______
	Often______
Only answer if you responded Functional in use|Functional and not in use to Q6	
68. Do users pay for water?	
	Yes______
	No______

	users contribute fees only when repair is needed______
Only answer if you responded users contribute fees only when repair is needed to Q68	
69. How much is typically collected from each user when there is a breakdown or repair?	___________________________
Only answer if you responded Yes to Q68	
70. Type of tariff system	
	fixed tariff per month______
	fixed tariff per year______
	Tariff per 20 L jerry can______
	Tariff per institution (schools, health centres, etc)______
Only answer if you responded fixed tariff per month to Q70	
71. What is the monthly tariff?	___________________________
Only answer if you responded fixed tariff per year to Q70	
72. What is the annual tariff?	___________________________
Only answer if you responded Tariff per 20 L jerry can to Q70	
73. What is the tariff per 20L jerry can?	___________________________
Only answer if you responded Yes|Sometimes or only for repairs to Q68	
74. Percentage of community members who COMPLY with the payment?	___________________________
Only answer if you responded Yes|Sometimes or only for repairs to Q68	
75. Are there any families or people in the village exempted from payment due to inability to pay?	
	Yes______
	No______
Only answer if you responded Tariff per institution (schools, health centres, etc) to Q70	
76. What is the institutional tariff?	___________________________
Only answer if you responded Tariff per institution (schools, health centres, etc) to Q70	
77. Number of institutions using the water source that pay a monthly institutional tariff?	___________________________
Only answer if you responded Tariff per institution (schools, health centres, etc) to Q70	
78. Number of institutions using the water source that do not comply with tariff	___________________________
Only answer if you responded Yes|Sometimes to Q68	
79. Does the WUC/WSC/operator keep records of the water meter readings or amount of water collected?	
	Yes______
	No______
	Unknown______
Only answer if you responded Yes|Sometimes to Q68	
80. Does the WUC/WSC/operator keep financial records on income collected?	
	Yes______
	No______
Only answer if you responded Yes to Q55	

81. Does the WUC/WSC keep financial records on expenditure and/or a record of repairs?	
	Yes______
	No______
Only answer if you responded Yes to Q55	
82. Does the WUC/WSC have a bank account?	
	Yes______
	No______
	Unknown______
Only answer if you responded Functional in use|Functional and not in use to Q6	
83. When were the last water quality tests done?	
	During construction of the water source______
	Less than 3 months ago______
	3 months to 1 year ago______
	1 to 5 years ago______
	Never______
	Unknown______
Only answer if you responded Midwestern Umbrella|NWSC|NGO|Private operator to Q56	
84. Does the operator keep financial records on expenditure and/or a record of repairs?	
	Yes______
	No______
Only answer if you responded Yes to Q55	
85. Has the WUC/WSC received any support or training from the Sub county or the district in the past year?	
	Yes______
	No______
	Unknown______
Only answer if you responded Functional in use|Functional and not in use to Q6	
86. Is there concern about potential contamination of the water quality?	
	Contamination from animals or human feces (e.g. latrines or OD)______
	Contamination from pesticides or herbicides (agriculture)______
	Contamination from soil or metals______
	Contamination from industry or chemicals______
	No concern- water is clean______
Only answer if you responded Functional in use|Functional and not in use to Q6	
87. Are there any concerns about the COLOUR of the water?	
	Always - problems with colour______
	Sometimes______
	Never______
Only answer if you responded Functional in use|Functional and not in use to Q6	

88. Are there any concerns about the ODOUR/SMELL of the water?	
	Always - problems with odour______
	Sometimes______
	Never______
Only answer if you responded Functional in use|Functional and not in use to Q6	
89. Are there any concerns about the TASTE of the water?	
	Always - Problems with Taste______
	Sometimes______
	Rarely______
Only answer if you responded Functional in use|Functional and not in use to Q6	
90. Please any other concern about water quality	_________________________

Table A3.4: Piped schemes register (static data)

Form 10- Register for piped schemes (v. 3.0)	
Question	**Response**
General Scheme Info	
1. Name of water supply scheme	
	Kicwamba GFS______
	Rwaihamba Scheme______
	Kasenda Scheme______
	Bukuku GFS______
	Mugusu GFS______
	Mugusu NWSC______
	NWSC-Fort Portal Town______
	Nyakiriba GFS______
	Buhikira GFS______
	Bitabu GFS______
	Rweitera scheme______
2. Additional scheme identification details?	_________________________
3. Select Sub County or Town Council where the Source is located	_________________________
4. Current GPS location	_________________________
5. Describe where GPS location is recorded	_________________________
6. Year of initial construction and commissioning of the distribution system	_________________________
7. Year the scheme first started delivering water to consumers	_________________________
8. Who primarily funded the construction of the scheme?	
	District Local Government______
	NWSC______

	Umbrella Utility/Association______
	NGO______
	Community or church______
	Private______
	Politician______
9. Who was responsible for operation of the scheme immediately after it was first constructed?	
	WSSB______
	Community - no board was set up______
	Government______
	Private Operator______
	NWSC______
	MWUWS______
10. What type of scheme is this?	
	Gravity Flow Scheme______
	Pumped Pipe______
	Hybrid______

Table A3.5: Register and monitoring form for new assets on piped schemes (static and dynamic data). Form 11 was used for major components, excluding stand posts as they are registered with Form 1.

Form 11 - New asset register (v. 7.0)	
Question	**Response**
Contact Details	
1. Name of interviewee #1	___________________________
2. Position of interviewee #1	
	Water User Association Chairperson or member______
	Scheme operator______
	Caretaker of scheme______
	Scheme manager______
	Plumber for the scheme______
3. Telephone contact interviewee #1	___________________________
4. Is there a second interviewee present?	
	Yes______
	No______
Only answer if you responded Yes to Q4	
5. Name of interviewee #2	___________________________
Only answer if you responded Yes to Q4	
6. Position of interviewee #2	
	Water User Association Chairperson or member______
	Scheme operator______
	Caretaker of scheme______

	Scheme manager______
	Plumber for the scheme______
Only answer if you responded Yes to Q4	
7. Telephone contact interviewee #2	__________________________
Overall Scheme Details	
8. Name of Water Supply Scheme	
	Kicwamba GFS______
	Rwaihamba Scheme______
	Kasenda Scheme______
	Bukuku GFS______
	Mugusu GFS______
	Mugusu NWSC______
	NWSC- Fort Portal town______
	Nyakiriba GFS______
	Buhikira GFS______
	Bitabu GFS______
	Rweitera Scheme______
9. Additional scheme identification details?	__________________________
Asset Register	
10. GPS location of asset to be registered	__________________________
11. What type of asset do you want to register at this location?	
	Source / intake______
	sedimentation tank______
	storage/reservoir______
	break pressure tank______
	bulk meter______
	Control valve______
	Power station/generator______
	Booster pump______
	Treatment plant______
12. What is the name of the asset? If it is source, what is the name of the source?	__________________________
13. Photograph of the asset	__________________________
14. What year was the asset constructed? Or if recent major rehabilitation, what year was it?	__________________________
15. Is this asset currently in use?	
	Functional and in use______
	Functional and not in use______
	Non functional - needs repair______
	Non functional - was never in use (not yet functioning)______
	Non functional - abandoned or decomissioned______
Only answer if you responded Functional and not in use|Non functional - needs repair|Non functional - was never in use (not yet functioning)|Non functional - abandoned or decomissioned to Q15	
16. Main case for non-functionality or reason it is not in use?	
	Distribution pipeline failure______
	Insufficient water at source______

	water quality concern______
	Switchboard failure______
	Submersible pump failure______
	power- Generator failure______
	Unknown______
Only answer if you responded Functional and not in use|Non-functional|Non functional - abandoned or decomissioned to Q15	
17. Describe the non-functionality or non-use	___________________________
Only answer if you responded Functional and not in use|Non functional - needs repair|Non functional - was never in use (not yet functioning)|Non functional - abandoned or decomissioned to Q15	
18. Number of months since non-functional or not in use?	___________________________
Only answer if you responded Functional and in use to Q15	
19. Is there emerging problem that might lead to non-functionality in the near future?	
	Yes______
	No______
	Unknown______
Only answer if you responded Yes to Q19	
20. Please describe the threat or emerging problem	___________________________
Only answer if you responded Source / intake to Q11	
21. What type of source is it?	
	Protected spring______
	Protected shallow well______
	Protected deep borehole______
	Rain water harvesting tank______
	Surface water or unprotected spring______
Only answer if you responded Source / intake to Q11	
22. Photo of primary water source	___________________________
Only answer if you responded Source / intake to Q11	
23. Does the source have an intake structure?	
	Yes______
	No______
Only answer if you responded Yes to Q23	
24. Please take a photograph of the intake	___________________________
Only answer if you responded Yes to Q23	
25. Physical state of intake	
	Excellent______
	Good______
	Fair (moderate)______
	Poor______
	Very poor______
Only answer if you responded Yes to Q23	
26. How many collection chambers?	___________________________
Only answer if you responded Yes to Q23	
27. How many Dams or retention walls?	___________________________
Only answer if you responded Source / intake|Power station/generator|Booster pump|Treatment plant to Q11	
28. How many hours per day is this asset productive?	___________________________

Only answer if you responded Source / intake to Q11	
29. What is the listed (registered) production rate for this source? (include units)	________________________
Only answer if you responded Source / intake to Q11	
30. What is the average production rate for this source over the past 12 months? (include units, or % of design production rate)	________________________
Only answer if you responded Source / intake to Q11	
31. What is the lowest production rate during dry season or on a dry day during the past 12 months? (include units, or % of optimum production rate)	________________________
Only answer if you responded Source / intake to Q11	
32. Is this a seasonal water source that commonly fails or reduces in the dry season?	
	Yes______
	No______
	Unknown______
Only answer if you responded Source / intake to Q11	
33. How many days was this source out of service in the last month?	________________________
Only answer if you responded Protected shallow well|Protected deep borehole to Q21	
34. Please take a photograph of the borehole/well	________________________
Only answer if you responded Protected shallow well|Protected deep borehole to Q21	
35. What is the borehole/well depth?	________________________
Only answer if you responded Protected shallow well|Protected deep borehole to Q21	
36. What is the borehole/well diameter?	________________________
Only answer if you responded Protected shallow well|Protected deep borehole to Q21	
37. What is the pipe material of the borehole/well?	
	GI______
	PVC______
	Stainless steel______
	Unknown______
Only answer if you responded Protected shallow well|Protected deep borehole to Q21	
38. What is the riser pipe depth/pump position?	________________________
Only answer if you responded Protected deep borehole to Q21	
39. What is the riser pipe diameter/pump diameter?	________________________
Only answer if you responded Protected shallow well|Protected deep borehole to Q21	
40. Physical state of borehole/well itself	
	Can't inspect______
	Excellent______
	Good______
	Fair (moderate)______
	Poor______
	Very Poor______
Only answer if you responded Protected shallow well|Protected deep borehole to Q21	
41. Is there an apron or seal on the protected deep borehole?	
	Yes______
	No______

Only answer if you responded Yes to Q41	
42. What year was the apron or seal constructed, or what is the year of the most recent major rehabilitation?	____________________________
Only answer if you responded Yes to Q41	
43. Take a photo of the apron or seal on the protected deep borehole	____________________________
Only answer if you responded Yes to Q41	
44. Physical state of apron or seal	
	Excellent______
	Good______
	Fair (moderate)______
	Poor______
	Very Poor______
Only answer if you responded Protected shallow well|Protected deep borehole to Q21	
45. Are there pump test records for this well/borehole?	
	Yes______
	No______
Only answer if you responded Protected spring to Q21	
46. Take a photograph of the protected spring	____________________________
Only answer if you responded Protected spring to Q21	
47. How many "springboxes" - intake structures at the source?	____________________________
Only answer if you responded Protected spring to Q21	
48. Physical state of protected spring	
	Excellent______
	Good______
	Fair (moderate)______
	Poor______
	Very poor______
Only answer if you responded Source / intake to Q11	
49. Is the catchment area around this source protected from contamination ?	
	Yes______
	No______
	Partially______
Only answer if you responded Source / intake to Q11	
50. Is there a fence blocking access to the area around the source ?	
	Yes______
	Yes but partially broken/ not obeyed______
	No______
Only answer if you responded No|Partially to Q49	
51. What are the threats to contamination at the source?	
	Animals______
	People fetching water______
	Farming or agriculture______
	Fecal contamination- latrines or OD______

	Clothes washing or other livelihood activities______
	Industry or factories______
	Overgrowth of plants______
	Sedimentation/erosion______
Only answer if you responded Source / intake|sedimentation tank|storage/reservoir|break pressure tank|Power station/generator|Booster pump|Treatment plant to Q11	
52. Type of lifting device (power) present at the asset	
	No pump / not applicable______
	Motorised pump (fuel)______
	Motorised pump (grid)______
	Solar powered pump______
	Hydroelectric powered pumping______
Only answer if you responded Motorised pump (fuel)|Motorised pump (grid)|Solar powered pump|Hydroelectric powered pumping to Qnull	
53. Photo of pump	__________________________
Only answer if you responded Motorised pump (fuel)|Motorised pump (grid)|Solar powered pump|Hydroelectric powered pumping to Qnull	
54. Type of pump	
	Submersible______
	Surface______
	Unknown______
Only answer if you responded Motorised pump (fuel)|Motorised pump (grid)|Solar powered pump|Hydroelectric powered pumping to Q52	
55. Year of pump installation (or last major replacement)	__________________________
Only answer if you responded Motorised pump (fuel)|Motorised pump (grid)|Solar powered pump|Hydroelectric powered pumping to Q52	
56. What is the brand (make) of the pump?	__________________________
Only answer if you responded Motorised pump (fuel)|Motorised pump (grid)|Solar powered pump|Hydroelectric powered pumping to Q52	
57. Date of last repair / servicing of the pump?	__________________________
Only answer if you responded Motorised pump (fuel)|Motorised pump (grid)|Solar powered pump|Hydroelectric powered pumping to Q52	
58. Physical state of pump	
	Excellent______
	Good______
	Fair (moderate) - functions with occasional breakdowns that can be repaired______
	Poor - does not function well or breaks down frequently______
	Very Poor - constant problems or issues, non functional______
	Unknown______
Only answer if you responded Motorised pump (fuel)|Motorised pump (grid)|Solar powered pump|Hydroelectric powered pumping to Q52	
59. Pump capacity (KW)	__________________________
Only answer if you responded Motorised pump (fuel) to Q52	
60. GENERATOR: what year was the generator installed (or year of re-installation) ?	__________________________
Only answer if you responded Motorised pump (fuel) to Qnull	

61. Photo of the generator	___________________________
Only answer if you responded Motorised pump (fuel) to Q52	
62. Generator brand	
	Perkins______
	Lister Petter______
	Cummins______
	Caterpillar______
	Coelmo______
	Green Power______
	Iveco______
	Lovol______
	Stamford______
Only answer if you responded Motorised pump (fuel) to Q52	
63. Generator capacity (KVA)	___________________________
Only answer if you responded Motorised pump (fuel) to Q52	
64. Physical state of generator	
	Excellent______
	Good______
	Fair (moderate) - functions with occasional issues that can be repaired______
	Poor - functions with difficulty and frequent breakdowns______
	Very Poor - Doesn't function or constantly breaksdown______
Only answer if you responded Hydroelectric powered pumping to Qnull	
65. Photo of solar or hydroelectric installation	___________________________
Only answer if you responded Solar powered pump to Q52	
66. Year of Solar installation	___________________________
Only answer if you responded Motorised pump (fuel)|Motorised pump (grid)|Solar powered pump|Hydroelectric powered pumping to Q52	
67. In the last three months, how many times has the power source failed?	
	0______
	1______
	2-3______
	4-6______
	6+______
Only answer if you responded Motorised pump (fuel)|Motorised pump (grid)|Solar powered pump|Hydroelectric powered pumping to Q52	
68. How long did the last power failure last?	
	less than 12 hours______
	12-24 hours______
	1-3 days______
	4-7 days______
	more than one week______
Only answer if you responded 1|2-3|4-6|6+ to Q67	
69. Please describe the reason for power failure	___________________________
Only answer if you responded Motorised pump (fuel)|Motorised pump (grid)|Solar powered pump|Hydroelectric powered pumping to Q52	

70. Switchboard type	
	Direct Online______
	Star/Delta starter______
	Soft starter______
	Impedance______
	Unknown______
Only answer if you responded Motorised pump (fuel)|Motorised pump (grid)|Solar powered pump|Hydroelectric powered pumping to Q52	
71. Switchboard capacity (kW)	__________________________
Only answer if you responded Motorised pump (fuel)|Motorised pump (grid)|Solar powered pump|Hydroelectric powered pumping to Q52	
72. Physical state of switchboard	
	Excellent______
	Good______
	Fair (moderate)______
	Poor______
	Very Poor______
Only answer if you responded Motorised pump (fuel)|Motorised pump (grid)|Solar powered pump|Hydroelectric powered pumping to Qnull	
73. Take a photograph of the switchboard	__________________________
Only answer if you responded Source / intake|sedimentation tank|storage/reservoir|break pressure tank|Power station/generator|Booster pump|Treatment plant to Q11	
74. Are there bulk meters at this source or asset?	
	Yes- functioning and in use______
	Yes- Functioning and not in use______
	yes- but not functioning______
	No bulk meter for this source______
Only answer if you responded Yes- functioning and in use|Yes- Functioning and not in use|yes- but not functioning to Q74	
75. How many bulk meters at this asset?	__________________________
Only answer if you responded Yes- functioning and in use|Yes- Functioning and not in use|yes- but not functioning to Qnull	
76. Photo of the bulk meters	__________________________
Only answer if you responded Yes- functioning and in use|Yes- Functioning and not in use|yes- but not functioning to Q74	
77. Are the readings from the bulk meters written down or recorded anywhere?	
	Yes______
	No______
Only answer if you responded Yes- functioning and in use|Yes- Functioning and not in use|yes- but not functioning to Q74	
78. Take a photo of the log book or most recent reading if possible	__________________________
Only answer if you responded Source / intake|storage/reservoir|bulk meter to Q11	
79. Any other info on bulk meters?	__________________________
Only answer if you responded Source / intake to Q11	
80. Is there sedimentation or treatment at this site	
	Yes- at the source______
	No - there is treatment later in the system______

	No - no treatment in this scheme______
	Unknown______
Only answer if you responded Source / intake to Q11	
81. Does this source go to a transmission line, if so, how many? (Do not count direct distribution lines)	
	No______
	Yes- 1 transmission line______
	Yes - 2 transmission lines______
	Yes - 3 transmission lines______
	Yes - 4 or more______
82. To which reservoir or storage tank does transmission line 1 go?	________________________
Only answer if you responded Yes- 1 transmission line|Yes - 2 transmission lines|Yes - 3 transmission lines|Yes - 4 or more to Q81	
83. How long is transmission line 1? (in meters)	________________________
Only answer if you responded Yes- 1 transmission line|Yes - 2 transmission lines|Yes - 3 transmission lines|Yes - 4 or more to Q81	
84. What is the pipe material of transmission line 1?	
	HDPE______
	Steel______
	PVC______
Only answer if you responded Yes- 1 transmission line|Yes - 2 transmission lines|Yes - 3 transmission lines|Yes - 4 or more to Q81	
85. What is the pipe diameter of transmission line 1? (in mm)	________________________
Only answer if you responded Yes- 1 transmission line|Yes - 2 transmission lines|Yes - 3 transmission lines|Yes - 4 or more to Q81	
86. In which year was the transmission line 1 constructed?	________________________
Only answer if you responded Yes- 1 transmission line|Yes - 2 transmission lines|Yes - 3 transmission lines|Yes - 4 or more to Q81	
87. What is the the state of the transmission line 1?	
	Functional- in use______
	Function - not in use______
	Non - functional - needs repair______
	Non - functional - not yet functioning (has never been in use)______
	Non - functional - abandoned______
Only answer if you responded Yes - 2 transmission lines|Yes - 3 transmission lines|Yes - 4 or more to Q81	
88. To which reservoir or storage tank does transmission line 2 go?	________________________
Only answer if you responded Yes - 2 transmission lines|Yes - 3 transmission lines|Yes - 4 or more to Q81	
89. How long is transmission line 2? (in meters)	________________________
Only answer if you responded Yes - 2 transmission lines|Yes - 3 transmission lines|Yes - 4 or more to Q81	
90. What is the pipe material of transmission line 2?	
	HDPE______
	Steel______
	PVC______

Only answer if you responded Yes - 2 transmission lines|Yes - 3 transmission lines|Yes - 4 or more to Q81	
91. What is the pipe diameter of transmission line 2? (in mm)	________________________
Only answer if you responded Yes - 2 transmission lines|Yes - 3 transmission lines|Yes - 4 or more to Q81	
92. In which year was the transmission line 2 constructed?	________________________
Only answer if you responded Yes - 2 transmission lines|Yes - 3 transmission lines|Yes - 4 or more to Q81	
93. What is the the state of the transmission line 2?	
	Functional- in use______
	Function - not in use______
	Non - functional - needs repair______
	Non - functional - not yet functioning (has never been in use)______
	Non - functional - abandoned______
Only answer if you responded Yes - 3 transmission lines|Yes - 4 or more to Q81	
94. To which reservoir or storage tank does transmission line 3 go?	________________________
Only answer if you responded Yes - 3 transmission lines|Yes - 4 or more to Q81	
95. How long is transmission line 3? (in meters)	________________________
Only answer if you responded Yes - 3 transmission lines|Yes - 4 or more to Q81	
96. What is the pipe material of transmission line 3?	
	HDPE______
	Steel______
	PVC______
Only answer if you responded Yes - 3 transmission lines|Yes - 4 or more to Q81	
97. What is the pipe diameter of transmission line 3? (in mm)	________________________
Only answer if you responded Yes - 3 transmission lines|Yes - 4 or more to Q81	
98. In which year was the transmission line 3 constructed?	________________________
Only answer if you responded Yes - 3 transmission lines|Yes - 4 or more to Q81	
99. What is the the state of the transmission line 3?	
	Functional- in use______
	Function - not in use______
	Non - functional - needs repair______
	Non - functional - not yet functioning (has never been in use)______
	Non - functional - abandoned______
Only answer if you responded Source / intake|sedimentation tank|storage/reservoir|break pressure tank|Treatment plant to Q11	
100. How many Distribution lines go out directly from this asset?	
	0______
	1______
	2______
	3+______
Only answer if you responded 1|2|3+ to Q100	

101. What is the name or destination of Distribution line 1?	___________________________
Only answer if you responded 1|2|3+ to Q100	
102. What is the pipe material of distribution line 1?	
	HDPE______
	PVC______
	Steel______
Only answer if you responded 1|2|3+ to Q100	
103. What is the diameter of distribution line 1 ? (in mm)	___________________________
Only answer if you responded 1|2|3+ to Q100	
104. In which year was distribution line 1 constructed?	___________________________
Only answer if you responded 1|2|3+ to Q100	
105. What is the state of distribution line 1?	
	Functional - in use______
	Functional - not in use______
	Non -functional - needs repair______
	Non-functional - not yet in use (has never functioned)______
	Non-functional - abandoned______
Only answer if you responded 2|3+ to Q100	
106. What is the name or destination of Distribution line 2?	___________________________
Only answer if you responded 2|3+ to Q100	
107. What is the pipe material of distribution line 2?	
	HDPE______
	PVC______
	Steel______
Only answer if you responded 2|3+ to Q100	
108. What is the diameter of distribution line 2 ? (in mm)	___________________________
Only answer if you responded 2|3+ to Q100	
109. In which year was distribution line 2 constructed?	___________________________
Only answer if you responded 2|3+ to Q100	
110. What is the state of distribution line 2?	
	Functional - in use______
	Functional - not in use______
	Non -functional - needs repair______
	Non-functional - not yet in use (has never functioned)______
	Non-functional - abandoned______
Only answer if you responded 3+ to Q100	
111. What is the name or destination of Distribution line 3?	___________________________
Only answer if you responded 3+ to Q100	
112. What is the pipe material of distribution line 3?	
	HDPE______
	PVC______
	Steel______
Only answer if you responded 3+ to Q100	
113. What is the diameter of distribution line 3? (in mm)	___________________________

Only answer if you responded sedimentation tank|storage/reservoir|break pressure tank to Q11	
114. What type of reservoir or tank is it?	
	In ground (open) reservoir______
	Underground storage (holding tank)______
	Tank - concrete______
	Tank - masonry______
	Tank - metal______
	Tank - plastic______
	Tank - fiberglass______
Only answer if you responded sedimentation tank|storage/reservoir|break pressure tank to Q11	
115. What is the volume/capacity of the reservoir or tank? (in cubic meters)	__________________________
Only answer if you responded sedimentation tank|storage/reservoir|break pressure tank|Treatment plant to Q11	
116. How often does this tank get washed out (emptied and cleaned) on average?	
	Weekly______
	Every two weeks to one month______
	Quarterly______
	1-2 times per year______
	Never______
	Unknown______
Only answer if you responded sedimentation tank|storage/reservoir|Treatment plant to Q11	
117. Is chlorination practiced in this tank?	
	Yes- for cleaning only (less than 2 times per year)______
	Yes- quarterly or monthly______
	Yes- weekly______
	Yes- daily______
	Never or very rarely______
Only answer if you responded Power station/generator|Booster pump to Q11	
118. Type of lifting device (power)	
	No pump / not applicable______
	Motorised pump (fuel)______
	Motorised pump (grid)______
	Solar powered pump______
	Hydroelectric powered pumping______

Table A3.6: Survey form for desk interviews with piped scheme managers (dynamic data)

Form 12 - Desk Survey (v. 4.0)	
Question	**Response**
Contact Details	
1. Name of interviewee #1	__________________________
2. Gender of interviewee #1	

	Male______
	Female______
3. Position of interviewee #1	
	WSSB chairperson______
	WSSB member- treasurer______
	WSSB member- other______
	Operator/caretaker______
	scheme manager______
	Engineer responsible for the scheme______
4. Telephone contact interviewee #1	___________________________
5. Is there a second interviewee	
	Yes______
	No______
Only answer if you responded Yes to Q5	
6. Name of interviewee #2	___________________________
Only answer if you responded Yes to Q5	
7. Gender of interviewee #2	
	Male______
	Female______
Only answer if you responded Yes to Q5	
8. Position of interviewee #2	
	WSSB chairperson______
	WSSB member- treasurer______
	WSSB member- other______
	Operator/caretaker______
	scheme manager______
	Engineer responsible for the scheme______
Only answer if you responded Yes to Q5	
9. Telephone contact interviewee #2	___________________________
Only answer if you responded Yes to Q5	
10. Is there a third interviewee?	
	Yes______
	No______
Only answer if you responded Yes to Q10	
11. Name of interviewee #3	___________________________
Only answer if you responded Yes to Q10	
12. Gender of interviewee #3	
	Male______
	Famale______
Only answer if you responded Yes to Q10	
13. Position of interviewee #3	
	WSSB chairperson______
	WSSB member- treasurer______
	WSSB member- other______
	Operator/caretaker______
	scheme manager______
	Engineer responsible for the scheme______
Only answer if you responded Yes to Q10	

14. Telephone contact interviewee #3	___________________________
Overall Scheme Details	
15. Name of Water Supply Scheme	
	Kicwamba GFS______
	Rwaihamba Scheme______
	Kasenda Scheme______
	Bukuku GFS______
	Mugusu GFS______
	Mugusu NWSC______
	NWSC- Fort Portal town______
	Nyakiriba GFS______
	Buhikira GFS______
	Bitabu GFS______
16. Additional scheme identification details?	___________________________
17. Which Sub Counties and/or Town Councils are served by this scheme?	
	Bukuuku SC______
	Busoro SC______
	Hakibaale SC______
	Harugongo SC______
	Karambi SC______
	Kabende SC______
	Kasenda SC______
	Karangura SC______
	Kicwamba SC______
	Ruteete SC______
	Karago TC______
	Kijura TC______
	Kiko TC______
	Mugusu TC______
	Municipality______
18. What type of scheme is this?	
	Gravity Flow Scheme______
	Pumped Piped______
	Hybrid______
19. Has the scheme undergone major rehabilitation/transformation since its construction?	
	Yes______
	No______
	Unknown______
20. Has the scheme undergone major rehabilitation/transformation since its construction, if so which year?	___________________________
Only answer if you responded Yes to Q19	
21. In which year was the most recent major rehabilitation?	___________________________
Only answer if you responded Yes to Q19	
22. Who funded the most recent major rehabilitation of the scheme?	
	District Local Government______
	MWUWS - Umbrella______

	NWSC______
	WSSB______
	Community or church______
	Private______
23. Have any new distribution lines been laid in the past 12 months?	
	Yes______
	No______
Only answer if you responded Yes to Q23	
24. Estimate the length in meters of new distribution lines in the past 12 months	________________________
25. How many new connections (of any type) have been installed in the past 12 months?	________________________
Only answer if you responded Yes to Q23	
26. Has additional water supply volume (sources or intakes) been added to accommodate scheme expansion?	
	Yes______
	No______
Sources	
27. How many water sources are serving this scheme? (including functional and non-functional)?	
	1______
	2______
	3______
28. What is the primary water source for this scheme?	
	Projected spring______
	Protect shallow well______
	Protected deep borehole______
	Rain water harvesting tank______
	Surface water or unprotected spring______
29. Is this primary source currently in use?	
	Functional and in use______
	Functional and not in use______
	Non-functional______
	non-functional- abandoned or decomissioned______
Only answer if you responded 2|3 to Q27	
30. What is the second water source for this scheme?	
	Projected spring______
	Protect shallow well______
	Protected deep borehole______
	Rain water harvesting tank______
	Surface water or unprotected spring______
Only answer if you responded 2 to Q27	
31. Is this second source currently in use?	
	Functional and in use______
	Functactional and not in use______
	Non-functional______
	Non-functional - abandoned or decomissioned______

Only answer if you responded 3 to Q27	
32. What is the third water source for this scheme?	
	Projected spring______
	Protect shallow well______
	Protected deep borehole______
	Rain water harvesting tank______
	Surface water or unprotected spring______
Only answer if you responded 3 to Q27	
33. Is this third source currently in use?	
	Functional and in use______
	Functional and not in use______
	Non-functional______
	Non-functional - abandoned or decomissioned______
Additional assets	
34. How many Break Pressure tanks on this scheme?	__________________________
35. How many reservoir/storage tanks in total?	__________________________
36. Is there treatment in this scheme?	
	No treatment______
	Yes - sedimentation tank only______
	Yes - filtration______
	Yes- chlorination______
37. How many bulk meters?	__________________________
38. How many control valve?	__________________________
39. How many main distribution lines?	__________________________
Management survey	
40. Who is the overall service provider, manager, for this scheme?	
	WSSB______
	MWUWS - Umbrella______
	NWSC______
	Community - no board______
	private operator______
Only answer if you responded MWUWS|NWSC to Q40	
41. Which branch or area office?	__________________________
Only answer if you responded MWUWS - Umbrella|NWSC to Q40	
42. When did this scheme get gazetted to the utility for management?	__________________________
43. Is the WSSB currently active?	
	Yes______
	No______
Only answer if you responded WSSB to Q40	
44. Number of members on the WSSB	__________________________
Only answer if you responded WSSB to Q40	
45. Number of Active members on the WSSB?	__________________________
Only answer if you responded WSSB to Q40	
46. Number of women on the WSSB?	__________________________
Only answer if you responded WSSB to Q40	

47. Number of women in key positions on the WSSB? (chair, secretary of finance/treasurer)	___________________________
Only answer if you responded WSSB|Community - no board|private operator to Q40	
48. Dos the WSSB/private operator have a bank account?	
	Yes______
	No______
	Mobile Money account but no bank account______
49. In the last year, has the management body organised any maintenance activities or repairs?	
	Yes______
	No______
Only answer if you responded Yes to Q49	
50. In the last three months, has the management body organised any maintenance activities or repairs?	
	Yes______
	No______
51. In the last year, has the management body received any support or guidance from the Sub-County/ Town-Council, or District Local Government?	
	Yes______
	No______
	Unknown______
52. What type of support or guidance?	___________________________
53. Do you have to report to any service authority or regulatory body?	
	Yes______
	No______
	Unknown______
Only answer if you responded Yes to Q53	
54. To whom do you report ?	
	MWE______
	District Local Government______
	Umbrella Authority______
	NWSC head office______
	NWSC regional/area office______
Only answer if you responded Yes to Q53	
55. What are you required to provide?	
	Verbal reports only______
	records on expenditure/income______
	performance data (management/revenue collection/Non Revenue water)______
	Water Quality/Quantity (production) data______
56. Who is responsible for daily operation of the scheme?	
	Caretaker______
	Operator______
	Scheme manager______
57. Is the caretaker paid or unpaid?	
	Paid______
	Unpaid______

58. Are the operators of this scheme also responsible for any public sanitation facilities ?	Yes______
	No______
	Unknown______
Only answer if you responded Yes to Q58	
59. Please specify the sanitation facilities and responsibility	__________________________
Only answer if you responded Yes to Q58	
60. Do you regularly perform maintenance or supervisory activities for these facilities?	
	Yes- annual mainteance______
	Yes- quarterly______
	Yes- monthly______
	Yes- weekly______
	Yes- daily______
	Yes - only when called to repair a problem______
	No______
Connections	
61. Type of connections	
	Distributed supply to one or more public tap stands______
	Distributed supply to household(s)______
	Distributed supply to school facilities______
	Distributed supply to health facilities______
	Distributed supply to water kiosks______
	Distributed for irrigation purposes______
	Distributed for industrial purposes______
Only answer if you responded Distributed supply to one or more public tap stands to Q61	
62. Total number of public tap stand connections on the system	__________________________
Only answer if you responded Distributed supply to one or more public tap stands to Q61	
63. How many of the Public Tap Stands are metered?	__________________________
Only answer if you responded Distributed supply to one or more public tap stands to Q61	
64. How many Public Tap Stands are currently functional?	__________________________
Only answer if you responded Distributed supply to water kiosks to Q61	
65. Total number of water kiosks on the system?	__________________________
Only answer if you responded Distributed supply to water kiosks to Q61	
66. How many of the kiosks are metered?	__________________________
Only answer if you responded Distributed supply to water kiosks to Q61	
67. How many of the kiosks are currently functional?	__________________________
Only answer if you responded Distributed supply to household(s) to Q61	
68. Total number of household connections on the system?	__________________________
Only answer if you responded Distributed supply to household(s) to Q61	
69. How many of the household connections are metered?	__________________________
Only answer if you responded Distributed supply to household(s) to Q61	
70. How many of the household connections are currently functional?	__________________________

Only answer if you responded Distributed supply to school facilities to Q61	
71. Total number of school connections on the system	___________________________
Only answer if you responded Distributed supply to school facilities to Q61	
72. How many of the school connections are metered?	___________________________
Only answer if you responded Distributed supply to school facilities to Q61	
73. How many of the school connections are currently functional?	___________________________
Only answer if you responded Distributed supply to health facilities to Q61	
74. Total number of health facility connections on the system	___________________________
Only answer if you responded Distributed supply to health facilities to Q61	
75. How many of the health facility connections are metered?	___________________________
Only answer if you responded Distributed supply to health facilities to Q61	
76. How many of the health facility connections are currently functional?	___________________________
Only answer if you responded Distributed for irrigation purposes to Q61	
77. Please provide additional details about the irrigation use?	___________________________
Only answer if you responded Distributed for industrial purposes to Q61	
78. Please provide additional detail about the industrial use	___________________________
Only answer if you responded Distributed supply to household(s) to Q61	
79. What is the fee for installing a first time household connection (in UGX per connection)?	___________________________
Only answer if you responded Distributed supply to school facilities to Q61	
80. What is the fee for installing a first time school connection (in UGX per connection)?	___________________________
Only answer if you responded Distributed supply to health facilities to Q61	
81. What is the fee for installing a first time health centre connection (in UGX per connection)?	___________________________
Only answer if you responded Distributed supply to one or more public tap stands to Q61	
82. What is the fee for installing a new Public Tap Stand (in UGX per connection)?	___________________________
Only answer if you responded Distributed supply to water kiosks to Q61	
83. What is the fee for installing a new Kiosk (in UGX per connection)?	___________________________
Only answer if you responded Distributed for irrigation purposes|Distributed for industrial purposes to Q61	
84. What is the fee for installing an irrigation or industrial connection (in UGX per connection)?	___________________________
Only answer if you responded Distributed supply to one or more public tap stands to Q61	
85. Who pays the fee to connect the new Public Tap Stand?	___________________________
Only answer if you responded Distributed supply to water kiosks to Q61	
86. Who pays the fee to connect the new Kiosk?	___________________________
Only answer if you responded Distributed supply to school facilities to Q61	
87. Who pays the fee to connect the School connection?	___________________________
Only answer if you responded Distributed supply to health facilities to Q61	
88. Who pays the fee to connect the health facility?	___________________________

89. New question - please change name	___________________________
Tariffs	
90. Type of tariff systems	
	Fixed tariff per month______
	Fixed tariff per week______
	Fixed tariff per half year______
	Fixed tariff per year______
	Tariff per 20L jerry can______
	Tariff per institution (per unit time)______
	Tariff per volume (m^3)______
	No Tariffs- Scheme is used free of charge______
Only answer if you responded Fixed tariff per month to Q90	
91. What is the fixed monthly tariff?	___________________________
Only answer if you responded Fixed tariff per week to Q90	
92. What s the fixed weekly tariff?	___________________________
Only answer if you responded Fixed tariff per half year to Q90	
93. What s the fixed 6 monthly tariff?	___________________________
Only answer if you responded Fixed tariff per year to Q90	
94. What s the fixed annual tariff?	___________________________
Only answer if you responded Tariff per 20L jerry can to Q90	
95. What is the price per 20L jerry can?	___________________________
Only answer if you responded Tariff per institution (per unit time) to Q90	
96. What the fixed price per institution? (indicate UGX and per which unit of time)	___________________________
Only answer if you responded Tariff per volume (m^3) to Q90	
97. What is the price per cubic meter?	___________________________
98. Do you keep records of the billing and tariff collection, or payments for new connections?	
	Yes______
	No______
	Unknown______
99. If possible, ask to see records and photograph them	___________________________
Only answer if you responded Fixed tariff per month|Fixed tariff per week|Fixed tariff per half year|Fixed tariff per year|Tariff per 20L jerry can|Tariff per institution|Tariff per volume (m^3) to Q90	
100. What is the total number of paying customers using the scheme?	___________________________
101. Of the total number of customers who should pay, how many are paying regularly?	___________________________
Only answer if you responded Fixed tariff per month|Fixed tariff per week|Fixed tariff per half year|Fixed tariff per year|Tariff per 20L jerry can|Tariff per institution|Tariff per volume (m^3) to Q90	
102. Are paying customers provided with invoices or bills?	
	Yes______
	No______
	Sometimes______

103. Is this scheme used by bulk water vendors or collected to sell to other places ?	
	Yes______
	No______
	Unknown______
Continuity	
104. How reliable/continuous is the service provided by this scheme?	
	Rotation is practiced at least part of the year______
	No rotation practice but there are unplanned interuptions______
	Water flows at 8 hours per day at every tap______
	Water flows more than 16 hours per day at every tap______
	Water flows uninterrupted throughout the scheme______
105. In the last one year, was the water scheme ever broken down or out of service for more than one day?	
	Yes______
	No______
	Unknown______
106. How many times was the water facility out of service in the past year?	
	1 to 2 times______
	3 to 5 times______
	more than 5 times______
	Unknown______
107. How many days did the last breakdown last?	
	1 to 5 days______
	6 to 10 days______
	11 to 20 days______
	more than 20 days______
	Unknown______
Only answer if you responded Yes to Q105	
108. Why was the water scheme broken down or out of service?	___________________________
109. Is this a seasonal water scheme that commonly fails in the dry season?	
	Yes______
	No______
	Unknown______
110. Do you keep a record of breakdowns and/or repairs?	
	Yes______
	No______
	Sometimes______
Only answer if you responded Yes|Sometimes to Q110	
111. Ask to see the record/ log of breakdowns and repairs and photograph it if possible	___________________________
Water Quality and Quantity	
112. What is the listed production rate of this scheme (indicate units)	___________________________
113. What is the average observed production rate during the past 12 months?	___________________________

114. What is the production rate during the driest / lowest production months of the year?	___________________________
115. Where there water quality tests done prior to (or during) construction of this scheme?	
	Yes______
	No______
	Unknown______
116. Have water quality tests been done in the last 12 months?	
	Yes, in the last one month______
	Yes, in the last three months______
	Yes, in the last 12 months______
	No______
Only answer if you responded Yes, in the last one month|Yes, in the last three months|Yes, in the last 12 months to Q116	
117. What was the result?	
	Water is safe for drinking______
	Water is unsafe for drinking______
	Unknown______
118. Do you keep records of water quality testing and results?	
	Yes______
	No______
119. Does the water quality change depending on the season or the time of the day?	
	Yes______
	No______
	Unknown______
Only answer if you responded Yes, in the last one month|Yes, in the last three months|Yes, in the last 12 months to Q116	
120. Was E.Coli/bacterial contamination tested for?	
	Yes______
	No______
	Unknown______
Only answer if you responded Yes to Q120	
121. What was the result?	___________________________
122. Are there specific contaminants of concern?	
	Bacteria______
	Fluoride______
	Salt / Salinity______
	Nitrate______
	Other______
	No concern______

Appendix 4: Supplementary materials from Chapter 7

This appendix presents the supplementary materials submitted for publication with Chapter 7.

Table A4.1 :Sources and methods used to identify factors, trends, and develop scenarios and strategies.

Data source	Quantity	Method of analysis and purpose
National sector documents	27	Document review of key sections, coding them according to identified themes and adding key points to list of factors
Reports and analysis of Uganda and Kabarole district (grey and academic literature)	23	Quantitative review of findings to identify trends, map key concerns and factors said to influence services, preferences, and user feedback
Household Survey	2 rounds of HH surveys: 2288 (2017) 775 (2019)	Descriptive analysis in SPSS and Excel on service levels, user preferences, choices, concerns
Asset data: Census of improved water supply assets	Registration and geolocation of assets and their functionality (2017) Update functionality and condition of assets and additional indicators (2019)	Descriptive and probabilistic Statistical analysis in SPSS and Excel, trends in service delivery and areas of uncertainty, inequalities and factors influencing functionality, management trends.
Participation and facilitation of district level stakeholder dialogues and workshops	8 events: direct participation (18-38 ppl each) 5 events: Remote participation and review of minutes (18-38 ppl each)	Qualitative review, coding according to themes identify factors, points of concern, points of agreement and divergence of stakeholders

Participation in National WASH stakeholder dialogue and working groups	1 Direct participation 1 Review of meeting minutes (estimated 45 participants each)	Qualitative review, coding using according to conceptual dimensions, identify factors, points of concern, points of agreement and divergence of stakeholders
Key informant Interviews	15 interviews: district engineer, water officer, district sanitation inspector, TSU, district council person, district planning officer, handpump mechanic association chair, other district staff, advisor for iNGOs, etc.	Qualitative Information Systems scoring, Qualitative interpretation, use of prioritisation of factors and development of strategies
Geospatial mapping	2 (2017 and 2019)	Visual analysis of coverage, multi-layer analysis against administrative and population data, modelling of potential scenarios for 2030 and extremes of factors

Table A4.2: Complete list of factors identified, and key to the codes for each factor used in Figure 26 in Chapter 7 of the thesis.

*The rightmost column shows the connection between the factor and the final three factors chosen for scenario development. Main factors used for scenario development: 1= District mandate and capacity to serve as service authority (financial and human resources); 2= Effective demand for professional water services; 3= Water resource quality and degradation

Conceptual dimension of drinking water system (adapted from Huston and Moriarty, 2018)	Factors	code	Link to final priority factors *
Institutional	service authority is maintained as critical role for support to all service providers, the multiple roles of a service authority are clear and accounted for in sector frameworks	I1	1
Institutional	District capacity as service authority	I2	1
Institutional	entrepreneurs find business opportunities in service provision	I3	
Legislation	national service delivery frameworks are revised and updated to respond to emerging challenges	L1	1
Legislation	legal framework for all SDMS exists (including SS)	L2	2
Finance	subsidy/cross subsidy exists for non-viable models/schemes, and pro-poor measures	F1	2
Finance	funding flows for each cost component can be secured (CapEx, CapManEx, OpEx, Direct support, indirect support, etc)	F2	1
Finance	new donors or external funding sources can be attained	F3	1
Finance	tariffs as an allowable proportion of income are enough to cover O&M	F4	

Finance	Districts have financial capacity, and local spending follows national frameworks. Relates to decentralisation of financial power	F5	1
Finance	water is unaffordable due to need for cost recovery	F6	
Finance	National Ministry level financing is inadequate	F7	
Planning and budgeting (P/B)	Donor and Aid money is channelled to support sector vision	G1	
P/B	planning accounts for national diversity and range of different SDMs to meet needs	G2	
P/B	Sub-national planning and insights are appreciated at national level	G3	
P/B	planning is inclusive of key stakeholders	G4	
Infrastructure	models: increasingly community based v increasingly privatized	D1	
Infrastructure	project/time-bound funding can be leveraged toward long-term targets	D2	
Infrastructure	O&M framework and roles are clear	D3	
Infrastructure	service authority and provider coordination are effective	D4	1
Infrastructure	cost of infrastructure increases significantly	D5	
Monitoring	district asset inventory exists and is up to date	M1	
Monitoring	MWE continues to update and use national monitoring system	M2	
Monitoring	service delivery indicators are prioritized	M3	
Regulation	tariffs are regulated	R1	2
Regulation	service levels standards are regulated, manuals and frameworks followed	R4	
Regulation	civil society has space to claim their rights and has a seat at the table; users can hold service providers to account	R2	2
Regulation	national policies are enforced locally (vs. 'free for all' service provision)	R3	
Learning/adaptation (L/A)	JSRs and other national platforms continue to support national strategy improvement and coordinated efforts	A1	1
L/A	Uganda WASH sector has strong national leadership	N4	
L/A	key stakeholders are included in sector reviews/coordination (no groups left out)	A2	

L/A	experiences at the decentralised level feed into national dialogues	A3	
L/A	platforms make space for new and evolving roles of different stakeholders. Sector is willing to adapt	A4	
Water Resource Mgmt (WRM)	water resources are prioritised and considered in resource allocation and regulation	W1	
WRM	service providers perform source protection and preservation	W2	
WRM	water resource degradation (quality and/or quantity)	W3	2,3
WRM	conflicts are handled effectively and systematically	W4	
WRM	WRM institutions have adequate capacity to perform their mandate	W5	
WRM	shift in rainy seasons and temperature. E.g. drought, reduced surface water for drinking	W6	3
Political Landscape	political prioritisation of WASH at local level	P1	1
Political Landscape	the country is politically stable and follows long term vision and plans	P2	
Social Landscape	people are be willing to pay for services of different calibres	B1	
Behavioural	people pay for services (demand)	B2	2
Behavioural	people use unimproved services	B3	2
National Landscape	population growth and urbanisation	N1	
National Landscape	oil or industrial exploitation changes the economy drastically	N2	3
National Landscape	GDP per capita grows	N3	

Table A3: Strategy elements and their potential: The types of interventions that could advance current service levels toward the 2030 targets were identified.

Strategy element	Description	Priority strategy element to achieve safely managed services targets	Priority strategy element to achieve basic services targets
Increase household connections	increase the number of people receiving safely managed services	✓	
Increase performance and continuity	improve existing schemes to make water more available when needed	✓	✓
Increase safety	Increase the safety of existing schemes through additional protection or water quality treatment	✓	✓
Increase improved communal sources	provide new point sources (hand-pumps or public taps) in currently un- or underserved areas		✓
Support self-supply	Increase support of self-supply and strengthen point of use safety		✓

Table A4.3: Detailed strategy descriptions corresponding to Table 13 in Chapter 7 of the thesis.

* Bibliographic information for the references cited in the strategies that are not included in the main article are provided in the final row of the table.

Strategy 1: District pursues partnership with National Water and other utilities to establish a public-public partnership model to accelerate service provision *Supports increasing household connections; increasing performance; increasing scheme safety; and increasing improved sources;* The District pursues partnerships with the existing utilities in an arrangement in which the District constructs infrastructure and the utility is contracted for operation and management . This could be used both for the construction of new schemes and/or extensions of existing utility schemes beyond that possible by the utilities alone. This strategy is available to districts as a result of the national level legal frameworks and institutional mandates developed since 2016 that allow (and encourage) utilities to extend into rural areas. In Kabarole, and other districts in Uganda, strategic partnerships with public utilities can help to leverage the existing economies of scale within the National Utility without a need to replicate capacity. There are several contractual arrangements that support public-public partnerships that could be systematically analysed by the MWE as a next step in its planning for 100% coverage (Mugisha, 2007; Santiago, 2005; Silvestre et al., 2018).
Strategy 2: Professional management arrangement for non-gazetted rural areas *Supports increasing scheme performance and increasing improved schemes* Even if piped supplies and utilities expand significantly in the next ten years, point sources and micro-schemes are likely to remain important for reaching dispersed populations in 2030. A new management strategy is needed to improve the level of service they provide. The District is the responsible service authority (and the asset owner) but it is not able to effectively support and enforce management of the over 1000 separate water facilities. An additional structure with a performance-based contract to manage operation and maintenance could be

established to improve direct support to community service providers or to replace community management structures entirely. This area-based service provider (ASP) could be part of an existing utility, a hand-pump mechanics association, or a new entity all together, but would be contracted to support all the water points within a defined geographical area to ensure universal service improvement.

During 2016-2019, the MWE completed a consultative update of the rural water supply Framework for Operation and Maintenance (MWE, 2019a). The updated framework does not detail the structure for Area Service Provision, which provides opportunities for Kabarole (and other districts) to innovate with clustered models for water point management. To overcome past financial barriers, it is essential that there are clear incentive and payment structures for all actors and structures with a role in service provision.

Strategy 3: Sub-County Water Supply and Sanitation Boards to support community management:

Supports increasing scheme performance and increasing improved schemes

The gap between district structures and community level service provision is large. Kabarole District has a population of 340,000 and the District Water Office retains service authority status for the over 1000 community managed water sources in the district; the District does not have capacity to support and regulate the large number of providers in the District (Mirembe, 2014). A network analysis in Kabarole in 2017 showed that despite capacity and relationships at District level, there was a gap between District actors and the communities that are ultimately involved in service delivery (McNicholl, 2018).

Kabarole is divided into eleven rural sub-counties and five town councils, each of which has a local government structure that replicates the District's; including political and technical officers responsible for local economy, public services, and laws (Commonwealth Local Government Forum, 2018). These local government structures have part-time staff dedicated to drinking water services, but do not have dedicated staff or a formalised structure that is able to administer funds and run a budget for drinking water supply, which limits their commitment and resources to be able to systematically support service providers within their jurisdiction.

The presence of a formal structure at sub-county level that could receive and manage public funds, and support and hold community service providers to account for performance, could be one way to fill this gap and support the district.

The need for dedicated support structures for community management was identified by the MWE as early as 2003 with the establishment of Umbrella Organisations at the regional level to support operators of small piped-schemes in rural growth centres (Twinomucunguzi & Nyakana, 2011). In 2014 IRC worked with local government in Kabarole and Lira Districts to pilot the idea of Sub-County Water Supply and Sanitation Boards as a formalised support structure for community management (Mirembe, 2014). These efforts showed some promising results but were never adequately supported, incentivised, or invested in. A sub-county structure could be established, either community-based or within sub-county government, that could apply for funds directly from the district to invest in systematic support to the community management model.

Strategy 4: Turn effective demand into user payment through customer care and customer satisfaction as a regulatory feedback mechanism

Supports increasing household connections; increasing performance; increasing scheme safety; and increasing improved sources;

In the scenario in which demand is present, it is still necessary to turn effective demand into actual payments by expanding service provision to a greater percentage of the population, and ensuring revenue collection by enforcement. This strategy targets payment for community point sources and for community and domestic connections to a utility scheme. The strategy is multipronged: to demonstrate the quality of the service, to inform users of the actual costs of service delivery, and to reinforce the role of the water user as a customer through improved billing and clear customer feedback mechanisms.

The value proposition for users must be clear, therefore, the quality of the service, including the reliability, convenience, and water quality should be notably better than unimproved sources available free of charge in Kabarole. National Water has already achieved this, so part of this strategy is to take advantage of the normalisation of payment for professional water services that will come with National Water active in the district; this is also associated with rising standards and the professionalisation of water points. The umbrella management can learn from this example (despite its lower resources and the legacy technical problems in its schemes. Specific interventions within this strategy are professionalising billing (with electronic itemised billing), demonstrating the value of safe (protected, treated) water over unimproved or unprotected sources, campaigns about water safety, etc.

To discourage the use of unimproved or unprotected sources, more sensitisation about their health risks is needed – either to discourage their use or to encourage households using these sources to choose the safest option and to invest in treatment options.

Strategy 5: Systematic support to self-supply

Supports increasing self-supply

Approximately one third of the population of Kabarole accesses unimproved sources, surface water, or purchases water from neighbours or vendors (Huston et al, in press). The majority of these households expressed a lack of satisfaction with their water supply situation, and a self-supply study across Uganda found that households already make cash and labour investments to improve the safety or convenience of supply, for example by investing in a hand-dug well close to home or by boiling water before consumption (Carter et al., 2005). Support of self-supply in Kabarole could be through incentivising rainwater harvesting (Kisakye et al., 2018), supporting households to upgrade supplies, and undertaking information campaigns and support for point-of-use water treatment technologies (boiling, filtration, chlorination). Supporting self-supply can be a way to leverage scarce resources by shifting the financial (and oversight) responsibility for water supply to households (Sutton, 2009), who may be willing to invest in a supply option if they believe it to be safer and more reliable and/or convenient than other available options.

Self-supply is acknowledged by the Ugandan government and has been made safer through various pilot programmes (Carter et al., 2005; Kabirizi et al., 2005), but remains largely unsupported (MWE, 2013). Self-supply is not recognized or tracked in the MWE monitoring system or that of the Joint Monitoring Programme (though rainwater harvesting can be classified as an improved drinking water source (WHO & UNICEF, 2017)); currently there is little incentive for districts to focus on improving the safety of supply for households in the 'unimproved' category. Though monitoring the safety of self-supply is difficult, adding an indicator for reporting household water treatment to the Ugandan National Monitoring System, even if it has a wide margin of error, could incentivise districts to adopt measures to make self-supply safer and more openly acknowledge it as a service delivery model.

Additional references for strategies:

Carter, R.; Mpalanyi, J.M. and Ssebalu, J. (2005). Self-help Initiatives to Improve Water Supplies in Eastern and Central Uganda, with an emphasis on shallow groundwater A Case Study of the RWSN Self-Supply Flagship.

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Mugisha, S.; Berg, S.V. and Muhairwe, W.T. (2007). Using internal incentive contracts to improve water utility performance: the case of Uganda's NWSC. *Water Policy* 9(3): 271–284.

Santiago, C. (2005). Public-public partnership: An alternative strategy in water management in Malaysia. *Transnational Institute and Corporate Europe Observatory, Reclaiming Public Water–Achievements, struggles and visions from around the world* 55–61.

Silvestre, H.C.; Marques, R.C. and Gomes, R.C. (2018). Joined-up Government of utilities: a meta-review on a public–public partnership and inter-municipal cooperation in the water and wastewater industries. *Public Management Review* 20(4): 607–631, Sutton, S. and Butterworth, J. (2021). *Self-Supply: Filling the Gaps in Public Water Supply Provision*. Practical Action Publishing, https://books.google.it/books?id=zvgRzgEACAAJ.

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Twinomucunguzi, F. and Nyakana, R. (2011). Regional umbrella organizations for sustainable management of rural piped water supply systems: Uganda's experience and expectations. In *Rural Water Supply in the 21st Century: Myths of the Past, Visions of the Future*, Uganda: RWSN.