UNDERSTANDING THE POLICY AND REGULATORY BARRIERS FOR WATER AND SANITATION RDI IMPLEMENTATION IN SOUTH AFRICA

Report to the
Water Research Commission

by

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EXECUTIVE SUMMARY

"There is no innovation without failure"

In 2020, after five years of implementing Agenda 2030, the World Health Organisation (WHO) and the United Nations International Children's Emergency Fund (UNICEF) took stock of the progress that had been made globally with the two Sustainable Development Goal (SDG) 6 target and indicators for water supply, sanitation and hygiene (WASH). The report indicated that in 2021, only 74% of the global population had access to safely managed drinking water, 64% to safe managed sanitation and 71% to basic hand hygiene services. It is clear from the report that continuing the current global pace and trajectory of provision of universal coverage to WASH services will result in missing the WASH targets and many countries across the globe with not achieve their commitments to ensuring universal and equitable access to WASH. In addition to the slow pace of achieving universal access to safely managed and basic WASH services, the global community will need to attain these human rights WASH commitments within the context of global challenges, such as climate change and the Coronavirus disease 2019 (COVID-19) pandemic.

South Africa is one of many countries that was predicted to be off-track to meet the 2030 WASH targets. If South Africa continued the current pace and type of interventions to addressed SDG6 WASH commitments, universal access to WASH in the country will not be feasible by the 2030 target date. Reaching the SDG6 target using the current services delivery infrastructure types and models, the operation and maintenance models for this infrastructure, and the manner in which these WASH services are governed and managed, will also not achieve the climate-resilient and pandemic-resilient WASH services that are required to mitigate and minimise risks and water scarcity in future. To achieve the SDG WASH targets and goals will require a shift in interventions and actions to a focus on climate, water and health shock resilient WASH services.

Although increasing water scarcity is a stark future reality, South Africa does have the means to mitigate the risks of water scarcity through a number of channels, including innovations in the sector to reduce water demand and thus supply needs, in governance, and in other areas of the WASH services. Apart from water being insecure and the country being water scare and a section of the population not having access to basic WASH services, the existing WASH infrastructure in the country is aging and require intervention, i.e. replacement, rehabilitation, refurbishment, etc. Aging, poor quality and poorly maintained infrastructure in the country has been highlighted as one of the major contributors to high levels of water wastage (i.e. water leakage; non-revenue water) and pollution of rivers and groundwater with sewage.

New innovations can help the nation continue to grow in the face of water scarcity, climate change and the COVID-19 pandemic. WASH innovations are crucial in identifying new avenues for sustainable and inclusive growth in the WASH sector. Innovation in the WASH sector would not only be about generation of new ideas, the traditional focus of science and research policies, but also about trying to diffuse/deploy, socialise and localise such ideas in practice in order to enhance competitiveness and respond to social, economic, environmental and institutional sustainability. Not only could the sustainable, effective and efficient uptake and implementation of WASH innovations in South Africa assist in addressing many of the water services challenges in the country but could contribute to achieving many of the current national imperatives, such as economic transformation and job creation, spatial integrations including services, and education and skills development.

With the global shift to achieving sustainable development through the SDGs and the achievement of sustainable WASH services, it will be necessary in the near future to apply next-generation tools and models that are disruptive to the norm. Disruptive innovations will require the WASH sector of a country to move from the traditional fit-and-conform WASH innovations (based on the broad definition of innovations provided above) to the more demanding stretch-and-transform WASH innovations. These innovations are expected, in the 10 to 15 years, to shift the water services paradigm from reliance on traditional ground- and surface-water resources towards building an environmentally sustainable diversified water portfolio where low-cost, conventional water sources are balanced and augmented with more costly, but also more reliable and sustainable, water supply alternatives, such as water reuse and desalination.

The National Water and Sanitation Master Plan for South Africa does, however, indicate that engaging in different aspects of water research, development and innovation in this sector to faces a range of their own challenges including poor coordination and synergising of activities between institutions; a weak understanding of the role of all water sector organisations in driving innovation; challenges in scaling up of solutions to be ready for the market, and highly limited funding for innovation (particularly in its scale up/ deployment stages). This results in many innovations that emerge from the research and development space not being deployable into the market for localisation and socialisation. Even when these challenges in deployment, localisation and socialisation of innovations are removed/addressed, the difficulties of taking WASH innovations from conceptualisation to market can still face significant barriers. The Water Research Commission (WRC, 2019) concurred, indicating that *some stakeholders have shown that, despite the robust research and development of water innovations in South Africa and very strong legislative framework, has ensured that water is given high research priority, many of these innovations have struggled to move beyond the Research, Development and Innovation (RDI) stage due to various challenges that are encountered by those involved in the innovation ecosystem*". Some of these barriers to deployment, localisation and socialisation of WASH innovations has been noted as policy barriers.

The identification of the potential policy and regulatory barriers to deployment/diffusion, localisation and socialisation of innovations has been a barrier itself, with these processes often conducted in an informal, implicit and unsystematic manner. A more structured gap/barriers analysis approach to determine innovation policy barriers and challenges would ensure that important policy and regulatory barriers to uptake and sustainable implementation of WASH innovations are not overlooked and that unimportant barriers are not given undue attention. This requires the use of a framework to systematically consider potential barriers and the identification and appraisal of evidence of the extent of potentially important barriers. Hence, the WRC issued a call for proposals to provide key insights to policy and regulatory barriers to water sector RDI with a focus on municipal water and sanitation services.

The main aim of the study was to review and quantify the policy and regulatory barriers to sustainable uptake and implementation of water services innovations in the country.

It is important to note that this review was not intended to be a comprehensive after-action review of both successes and failures of municipal water service innovations. Rather, the focus was to identify policy and legal barriers encountered when deploying innovations in the municipal water services sector, with the goal of removing or alleviating them in future.

Several methods were used to identify and clarify the policy/regulatory barriers to innovation in the municipal water services sector, including brainstorming – the bringing together of a group of people with relevant expertise and perspectives to generate ideas about of policy/regulatory barriers to innovation in the municipal water services sector and their likely importance; contacting key informants – discussing potentially important barriers with individuals who understand and have insight into the problem or situation; and searching for published or unpublished studies.

The definition of the Department of Science and Innovation (DSI, previously Department of Science and Technology) was adopted for the term 'innovation' in this study and adapted to include WASH, namely *a WASH innovation is the implementation of a new or significantly improved WASH product (good or service) or process, or a new marketing method for WASH, or a new organisational model in business practice, workplace organisation, or external relations related to WASH*.

Policy that encourages or facilitates growth of innovation in the WASH sector would need to facilitate the development, deployment, localisation and socialisation of new knowledge, of new or adaptation of current sustainable technologies/techniques/processes in the sector and the use, acceptance and normalising of these into society and the economy. Policy barriers to WASH innovation, would also need to be removed or minimised.

While South Africa had considerable sophistication in innovation policy and that the language of innovation systems had taken firm root in the policy, the policies themselves do not always translate to an effective innovation system. A disconnect seemed evident between what researchers and practitioners deem as important gaps in the water and water innovation sector, and what innovation policies and policymakers were seeking to address – namely a policy directionality failure.

The review clearly demonstrates innovations focussed on specific pillars of the value chain, whilst almost ignoring others and a significant amount of research on the piloting and prototyping of innovations with little, to no deployment, localisation and socialisation of many of these innovations. Policy could be a constraint/barrier to addressing the challenges in the innovation sector but may also be an enabler if designed and implemented effectively.

The policy survey by the innovators showed that policy was not deemed to be a barrier/challenge to the Research & Development (R&D) phase of WASH innovation, but that policy was deemed a barrier/challenge in the deployment phase of WASH innovations. Access to finance was a challenge at all stages in the WASH innovation value chain. There seemed to be a general lack of knowledge of how South African innovation and water sector policies and legislation could enable WASH innovation deployment in the country. There was recognition of the helpfulness of the South Africa Water Research, Development & Innovation (RDI) roadmap in the innovation value chain, as well as recognition of the moderate helpfulness of the Technology Innovation Act, South African national standards of the South African Bureau of Standards (SABS), the South African building regulations and the Intellectual Property (IP) R&D Act in the WASH innovation value chain. Policies that were recognised as somewhat helpful (<33% helpful) in the innovation value chain included sector-specific policies, such as the National Sanitation Policy, and the Appropriate Technology Strategy. Accreditation/innovation protection policies, such as the Agrément Act and IP Act, were also deemed somewhat helpful. The general consensus was that a number of local governments, financial and sector-specific policies were currently not helpful to WASH innovations in the country.

Utilising the framework and the inputs from stakeholders, innovations in South Africa were reviewed and categorised into one or more of the circular economy categories for their purpose. Innovations were then prioritised for inclusion in the study and the innovators contacted regarding participation in the survey. The survey/questions of innovators included in the study focussed on capturing policy barriers in the categories. The policy barriers captured in the stakeholder engagement, through the review of the literature and through the review innovations, were categorised into the failure categories.

Emerging from this classification process was that water innovations in the country would fall within two sustainable circular economy categories, namely (1) water innovations that reduce water consumption and losses and (2) innovations to replenish water resources. This was largely due to water supply systems not being able to operate without water and thus water innovations could not fall within the avoid water and the reuse and recycle water, as water in the country can only be reused or recycled in the wastewater (sanitation) pillar of water services in the country. Water innovation (WIs) demonstrated that there was an extensive array of these innovations, particularly related to innovations that target **reduced water in their operations**, or target **reduced water use by the end-user**. There was a dearth of information on innovations for system-wide water reduction, i.e. municipal level water reduction in their networks, as the majority of the water innovations targeted water reduction of the end-user, i.e. households.

Sanitation innovations could be classified across all of the sustainable circular economy categories, from those that avoid water use to those that replenish water resources. South Africa has a large number of sanitation innovations that focussed on **water avoidance** and **water reduction**. The majority of these innovations are adaptations and modifications of dry sanitation systems that avoid water use for the operation and flush sanitation systems that utilise reduced quantities of water to operate. Emerging innovations also focussed on closing the sanitation loop by **treating on-site greywater and wastewater for recycling/reuse** within the sanitation-water cycle or treating **faecal sludge, faeces or urine for recycling/use or reuse** as soil conditions, biochar, etc. on-site or off-site. These recycling and re-use innovations were much fewer in the literature, as compared to the avoidance/reduction sanitation innovations.

Hygiene innovations were largely grouped under those that avoid water use or reduce water use in the operation. Any reuse or recycling of water in hygiene innovations would fall within the sanitation innovations.

The COVID-19 pandemic and disasters, such as were experienced by the Day Zero countdown in Cape Town in 2019, have seen a massive upscaling of innovations in the hygiene arena of WASH services. Many of these innovations focus on practicing good hygiene within the context of little or no water, i.e. **water avoidance or reduction**. The review of such innovation in South Africa did indicate a dearth of such innovations emerging in South Africa (apart from handwashing innovations), with the majority of hygiene innovations emerging from the international hygiene markets, i.e. large multinational organisations such as Johnson & Johnson, Proctor & Gamble, etc.

The review was not a comprehensive review of all WASH innovations in the country, but rather a snapshot of a randomised capturing of innovation based on the WRC, web-based and internet review (i.e. the innovations that were included in the study). The researchers speculated that a key challenge in the WASH value chains of the local government was also the position of many of the innovations in the value chain and the level of 'crowding' in that position.

A large number of the innovations in the database focus purely on addressing a need in the WASH service delivery sector, with these innovations not specifically focussed on addressing a closed-loop approach to delivery of the services. Similarly, the hygiene innovations focussed on addressing hygiene requirements in the WASH sector, namely access to a handwashing facility, to soap and to menstrual products, but not necessarily to ensuring a closed-loop in providing these services. WASH innovations in the dataset that focussed on reusing and recycling resources were limited and should be a key focus of the WASH value chains R&D, deployment, socialisation and demestication in future.

There is a perception in the water sector that the relationship between regulators and innovations is highly hierarchical and as the stakeholder survey and interview showed, restrictive. Regulators often require evidence of short-term return on investments which makes it difficult to implement truly transformational innovation projects.

The water innovation sector of the country also still viewed the innovation value chain as a linear system, relying upon incremental improvement in inputs to ensure the generation and use of societally relevant knowledge and technology (Rose and Winter, 2015a). There seemed to be a disconnect between what researchers and practitioners deem as important gaps in the water and water innovation sector, and what innovation policies and policymakers were seeking to address – namely a policy directionality failure.

WASH and innovation policy and regulations can pose a major barrier to innovation in South Africa. The instruments are sometimes dated (i.e. water acts) or were developed with a focus on specific and already utilised technologies (i.e. standardised WASH value chains of extract-use-discharge/dispose). Policy and regulations can also be fragmented geographically and vertically, with local government regulation sometimes blocking technologies that are permitted or even encouraged by national government or preventing the deployment of innovations for other issues such, as for example, health, safety, etc. and by issue (with health and safety regulations sometimes conflicting with WASH goals).

To address the above challenge and South Africa's own WASH infrastructure and value chain challenges, the country will need a WASH sector that is based on robust, sustainable, effective and efficient WASH value chains. This will require significant innovation and forward thinking. It will also require policy in the country, all forms of policy, to support, guide and regulate the value chains as well as the innovations and forward thinking in the sector. "More of the same" in policy, WASH value chains and WASH innovations will not be enough.

There are also huge opportunities for water innovation related to inputs such as green materials, green chemicals, energy efficiency, etc. in material inputs and design, in materials manufacturing, in data science, etc. Cross-sector collaboration to address some of these opportunities will create substantial benefits, result in cost savings and secure more sustainable WASH value chains.

The study clearly showed that the solution to a number of South Africa's growing water challenges lie, in part, with the development, deployment, localisation and socialisation of WASH innovations. It was clear that based on categorisation of WASH innovations in South Africa and from the Case Study interviews that many of the

WASH innovations in the country, while innovative and new to the WASH sector and providing crucial innovations to address fundamental gaps and challenges in the sector, are innovations that follow the traditional fit-and-conform WASH innovations. The policy barriers and challenges experienced in the deployment of these innovations would potentially be vastly different to those that will be experienced by next-generation, disruptive innovation that are based on premise of stretch-and-transform of the WASH sector of the country. Noting however that this is a broad, generalisation of current WASH innovations included in the study, many of the current WASH innovations are expected to experience challenges, including policy challenges that are common to any water or wastewater/sanitation system that is introduced in the country. Challenges would relate for example, and based on discussions with innovators, to national and local government procurement policy and processes, risk aversion of adopters and implementers of innovations and accreditations and IP challenges.

These next-generation, disruptive innovation that are based on premise of stretching-and-transforming the WASH sector of the country could, experience significantly great challenges to deployment. Since these innovations are expected to shift the fundamental structure and function of the WASH sector (i.e. a shift to hand sanitisers in the handwashing section), there will be greater potential for barriers and challenges to their deployment. For example, environmental policy and legislation in the country may become a significant barrier to the rapid deployment of disruptive innovations, as has been demonstrated in the green energy sector of the country. Disruption of the traditional WASH sector through new, next generation innovations, could fundamentally change the manner in which basic water services are provided in the country in that in-situ treatment, reuse and recycling innovations could shift the role of local government in provision of water services and impact on their regulatory role and financial status. This has already been demonstrated, for example, in the energy sector of the country. A shift to off-grid energy system has impacted on the income of the power utility in the country, as well as reduced the role of utility as a regulator of energy within these household and industries.

What was very clear from the research was that not only policy was a barrier to the sector. Many of the barriers related to the position in the value chain, the risk aversion of the sector to test and pilot innovations, the crowding of innovation in specific sectors of the value chain, serious gaps in innovation in other areas of the value chain, and ‘tunnel vision’ in financing and support innovations. All of these will need to be addressed to accelerate the country into a new paradigm of WASH service delivery that meets the current needs of the country, while also addressing the future needs and challenges that are expected.

More of the same, at the same pace, is definitely not going to allow the country to achieve SDG6, WASH human rights commitments or a sustainable WASH future.

Innovative policy in South Africa would include the development of new regulations that will create the space for WASH innovation, the creation of new finance models and new financial mechanisms and business models, as well as innovation in terms of how the value of WASH and WASH services are communicated to the public. History has shown how regulatory gaps and misdirected policies can slow down the adoption of innovative technologies, therefore, new approaches to WASH innovation policy provide exciting, yet challenging, opportunities to question traditional policy approaches to innovation and how policy can facilitate the combining of new and old technologies that are emerging on to the market.

Government has an important role to play in creating the right policy frameworks, infrastructure, and data to stimulate, facilitate and support the WASH innovation in the country. The typically long-life expectancy, size, and complexity of water and sanitation systems, risk-aversion to WASH innovations, and a conservative business climate help explain the lack of innovation in the WASH sector but are not readily addressed by policy reforms.

South Africa could develop a WASH Innovation Strategy, underpinned with many of the lessons learned in deploying, socialising and localisation of WASH innovations during the COVID-19 pandemic. Policy should facilitate companies, supply chains, stakeholders, regulators, SMEs, start-ups, academia, the public and other innovators to co-create and co-deliver innovation initiatives. Policy should encourage the sector to adopt a transparent approach that leverages the full potential of the WASH community rather than leverage from and by individual organisations.

Developing and clearly articulating the appropriate roles that private sector can play in the WASH innovation sector, and within the WASH value chains, is crucial to leveraging financial resources devoted to these WASH innovation efforts by the private sector. Government should conduct a review of policy and regulation to restructure incentives to transform the WASH innovation sector, as well as establish a strong regulatory framework to monitor performance of WASH innovations (incl. finance and funding) and enforce guidelines for tariff setting to enable financial stability in WASH value chains. Apart from improving the framework for managing WASH innovations, the availability of risk capital and support to WASH innovation investors should be explored. Capital funding for WASH innovations (grants, equity, loans, bonds, and crowdfunding) and operating funding for WASH innovations (grants, memberships fees, return from innovation, billing, advertising, and revenues from services) could be made available. Procurement policy should adopt partner integrity pacts, e-procurement; open contracting data standards, and red flag monitoring. Procurement policy should advocate transparency and integrity in procurement practices related to WASH innovation infusion into municipal WASH value chains.

Policy should be reviewed for WASH service governance improvements, paired with other public financial management (PFM) and financial market development. A high-quality regulatory framework can facilitate market entry and growth for businesses. Various tools and incentives can be utilised to stimulate WASH innovation and to encourage collaboration and partnerships for the successful and sustainable transfer of these technologies, for example tax incentives, and policy development.

The pursuit of active state industry policy to diffuse the latest WASH innovations, needs, and skills in the workforce is critical in sustaining the WASH sector. Public policy can promote the development of WASH innovation firms and their workforce through a variety of mechanisms, such as innovations diffusion programmes (agricultural extensions services as an example in the agriculture sector) that not only expose 'frontier firms' to leading edge innovations but also seek to grow the skills and capability of small and medium-sized enterprises (SMMEs) within the WASH innovation value chains. Services designed to lift the productivity and innovation performance of SME manufacturers in particular; and knowledge sharing platforms and mechanism should be adopted – sharing of innovations on a common website could elevate the status of WASH innovations and allow for sharing of innovations across the value chains.

Although water innovation is one area where South Africa can deliver value to the WASH value chains in the country, there is equally a need for innovation in the environmental policies that guide innovations in this sector. The need for innovative environmental policies, particularly innovative policy that enables deployment, localisation and socialisation of WASH innovations.

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ACRONYMS & ABBREVIATIONS

AMD	acid mine drainage
AMI	Advanced Metering Infrastructure
AnMBR	Anaerobic Membrane Bioreactor
AWSS	Atlantis Water Supply Scheme
BDAT	Blue Diversion Autarky Toilet
BMGF	Belinda and Bill Gates Foundation
CDI	Capacitive Deionization
COVID-19	Coronavirus disease 2019
DBE	Department of Education
DoH	Department of Health
DST	Department of Science and Technology
DST & DSI	Department of Science And Technology (now Department of Science and Innovation)
DTIC	Department of Trade, Industry and Competition
DWA	Department of Water Affairs (now DWS)
DWAF	Department of Water Affairs and Forestry (now DWS)
DWS	Department of Water and Sanitation (previously Department of Water Affairs or Department of Water and Forestry)
ESARO	East and Southern Africa Regional Office
FAO	Food and Agricultural Organisation
FO	Forward Osmosis
FS	Faecal sludge
HDPe	High-Density Polyethylene
HEI	Higher Education Institution
IP	Intellectual Property
IRCWD	International Reference Centre for Waste Disposal
LDCs	Least Development Countries
LSHTM	London School of Hygiene and Tropical Medicine
MD	Membrane Distillation
MH	Menstrual health and hygiene
MH	Menstrual health
MHM	Menstrual hygiene management
NWRS	National Water Resources Strategy
RDI	Research, development and innovation
RO	Reverse Osmosis
RTTC	Reinvent the Toilet Challenge
RWH	Rainwater harvesting
SABS	South African Bureau of Standards
SDG	Sustainable Development Goal
SMME	Small, medium and micro-enterprise
SWH	Stormwater harvesting
TIA	Technology Innovation Agency
UCT	University of Cape Town
UDDT	Urine-diverting Dry Toilet
UNDESA	United Nations Department of Economic and Social Affairs
UNEP	United Nations Environmental Program
UNICEF	United Nations Children's Emergency Fund
VIP	Ventilated Improved Pit Toilet

WASH	Water supply, sanitation and hygiene
WHO	World Health Organisation
WI	Water innovation
WRC	Water Research Commission
WSA	Water Services Authority
WTW	Water Treatment Works
WWTW	Wastewater Treatment Works

GLOSSARY

Circular economy: Looking beyond the current "take, make and dispose" extractive industrial model, the circular economy is designed to restore and regenerate. Underpinned by a transition to renewable energy sources and system-wide innovation, it aims to redefine products and services to reduce waste and negative impacts (DST, 2019).

Innovation: An innovation is the implementation of a new or significantly improved product (good or service) or process, or a new marketing method, or a new organisational model in business practice, workplace organisation or external relations (DST, 2019).

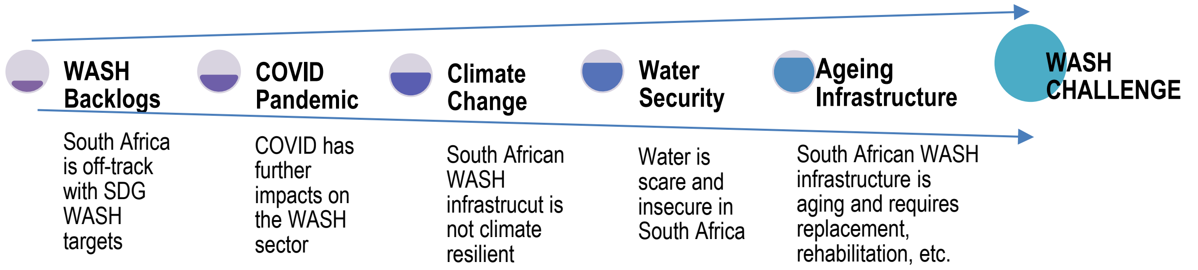
Research and development: R&D comprise creative and systematic work undertaken to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge.

R&D tax incentive: The South African government offers the R&D tax incentive under section 11D of the Income Tax Act, 1962 (Act No. 58 of 1962) in order to promote private sector R&D investment in the country. The incentive allows any company undertaking scientific and/or technological R&D in the country to deduct 150% of its R&D spending when determining the taxable income. The incentive is available to businesses of all sizes and in all sectors of the economy. The Department of Science and Technology (DST) shares responsibility for the delivery of the incentive with the South African Revenue Service and National Treasury. The incentive is part of a package of policy instruments to promote R&D and innovation in the country.

CHAPTER 1: INTRODUCTION

1.1 WHY IS INNOVATION IMPORTANT – THE WASH CHALLENGE

Summary of the Water Supply, Sanitation and Hygiene (WASH) Challenge



In 2015, the world committed to *Transforming our world: The 2030 Agenda for Sustainable Development,* with this 2030 Agenda providing a global plan of action for people, planet and prosperity (WHO and UNICEF, 2021). Signatory countries to the 2030 Agenda committed to ensuring universal coverage to water supply, sanitation and hygiene (WASH), articulating these WASH commitments in Sustainable Development Goal (SDG) 6 that aims to '*ensure availability and sustainable management of water and sanitation for all*'. Progress towards achieving SDG 6 is tracked against eight targets for (1) drinking water, (2) sanitation and hygiene services, (3) wastewater treatment and water quality, (4) water use, (6) water management, transboundary cooperation, water-related ecosystems, official development assistance and participation of local communities (WHO and UNICEF, 2021). The specific WASH targets of SDG6 included:

Target 6.1: By 2030, achieve universal and equitable access to safe and affordable ***drinking water*** *for all;* and

Target 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*.

In 2020, after five years of implementing Agenda 2030, the WHO and UNICEF took stock of the progress that had been made globally with the two SDG 6 WASH target and indicators (WHO and UNICEF, 2021). The report provided the surprising and rather disturbing global conclusion that "*five years into the SDGs, the world is not on track to achieve SDG targets 6.1 and 6.2*" (WHO and UNICEF, 2021). Currently, Figure 1 showed that only 74% of the global population had access to safely managed drinking water, 64% to safe managed sanitation and 71% to basic hand hygiene services. Figure 1 also shows that global actions required to achieve the 2030 WASH targets include (WHO and UNICEF, 2021):

- **Overall WASH:** a quadrupling of the current rates of progress is required to ensure universal access to safely managed drinking water services, safely managed sanitation services, and basic hygiene services (WHO and UNICEF, 2021).
- **Safely managed drinking water supply**: a four-fold increase in current rates of progress, a ten-fold increase in progress in the case of Least Development Countries (LDCs) and a twenty-three-fold increase of progress in fragile contexts is required to achieve universal coverage to safely managed drinking water services (WHO and UNICEF, 2021).

- **Safely managed sanitation:** a <u>four-fold increase</u> in current rates of progress, a <u>fifteen-fold increase</u> in the case of progress in Least Development Countries (LDCs) and a <u>nine-fold</u> increase in progress in the fragile contexts is required to achieve universal coverage to safely managed sanitation (WHO and UNICEF, 2021).
- **Basic hygiene:** a <u>four-fold increase</u> in current rates of progress, a <u>seven-fold increase</u> case of progress in Least Development Countries (LDCs) and a <u>five-fold</u> increase in progress in the fragile contexts is required to achieve universal coverage to a basic hygiene service (WHO and UNICEF, 2021).

Figure 1: Global coverage of WASH services, 2015-2020 (%), and acceleration required to meet SDG6 targets by 2030 (taken from WHO and UNICEF (2021))

The report predicts that if the globe continues at its current pace of delivering access to safely manged drinking water and sanitation services and access to basic hygiene, only 81% of the global population will have access to safely managed drinking water, 67% to safely managed sanitation and 78% to a basic hygiene service by the SDG target year of 2030 (WHO and UNICEF, 2021). It is clear from the report that continuing the current global pace and trajectory of provision of universal coverage to WASH services will result in the missing of the WASH targets and many countries across the globe will not achieve their commitments to ensuring universal and equitable access to WASH.

South Africa is one of many countries that were predicted to be off track to meet the 2030 WASH targets. A recent publication by UNICEF indicated, in Figure 2, that if South Africa continued the current pace and type of interventions to addressed SDG6 WASH commitments, universal access to WASH in the country will not be feasible by the 2030 target date (UNICEF ESARO, 2021).

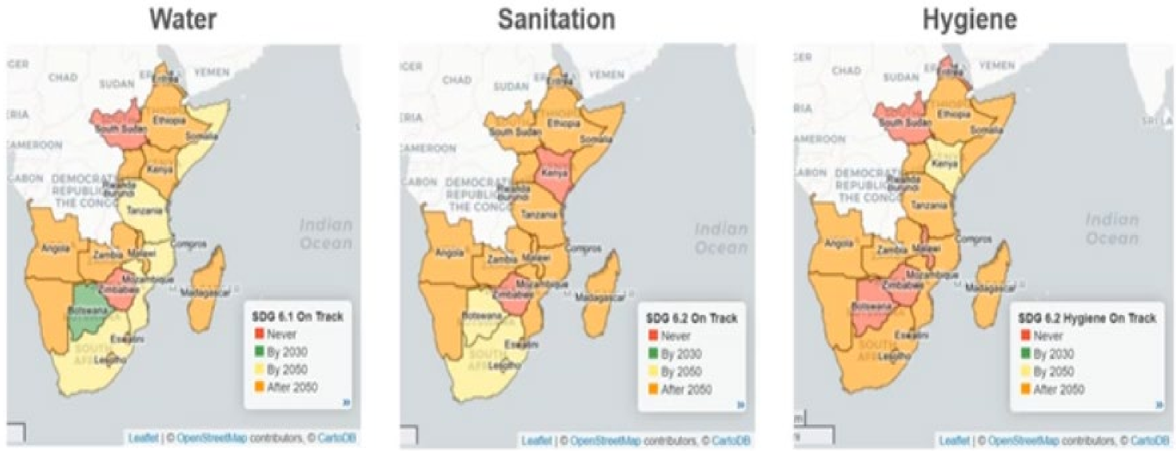


Figure 2: Predication of achieving universal coverage of WASH services at the current rate of progress within the ESAR (taken from UNICEF ESARO (2021))

With an estimated 3 million people in the country still requiring access to a basic water supply service and 14.1 million people needing access to safe sanitation (DWS, 2018), the UNICEF ESARO (2021) predicted, in Figure 2, that at the current pace of progress South Africa would only achieve universal access to a safely managed drinking water and sanitation service after 2030 (sometime before 2050) and access to basic hygiene services sometime after 2050. It is clear from this WASH data that South Africa cannot continue on the current path and pace of WASH service delivery and expect to meet national basic human right WASH commitments. More of the same, at the same pace, is not going to achieve SDG6 WASH and WASH human rights commitments in the country by 2030.

In additional to the slow pace of achieving universal access to safely managed and basic WASH services, the global community will need to attain these human rights WASH commitments within the context of global challenges such as climate change and the COVID pandemic.

The WHO and UNICEF (2021) highlighted that the *COVID-19 pandemic has plunged the global economy into recession, with an additional 119 to 124 million people pushed into extreme poverty during 2020*. Although the COVID pandemic elevated the importance of WASH to protect the health of individuals across the globe and many countries introduced a wide range of WASH interventions, particularly hygiene interventions, to support COVID response actions, the WHO and UNICEF (2021) report indicated that it was too early to assess the medium and long-term impact of COVID on progress towards the SDG WASH targets. The COVID pandemic and its resulting impacts on WASH service delivery, combined with the limitation on movement of populations and on the need for new technology to provide barriers to COVID transmission (i.e. hand hygiene innovations), had however, not only led to innovative technologies in the WASH services, but also a rethink of service delivery models and the manner in which progress and implementation of WASH are monitored and reported. This paradigm shift is expected to continue as the globe persists with efforts to minimise COVID risks.

The impact of climate change on global WASH SDG6 targets and goals has also emerged as a growing and looming challenge. Climate change, according to the IPCC, is expected to (UNEP, 2015):

- significantly reduce surface water and groundwater resources in most dry subtropical regions;
- increase the frequency of droughts in presently dry areas;
- result in variations in the timing, magnitude, and type of precipitation;
- result in temperature increases; and
- result in sea level rise.

All these impacts can have a negative effect on progress with achieving the WASH targets of SDG6 and thus the globally recognised right to water and sanitation.

Reaching an SDG6 target using the current services delivery infrastructure types and models, the operation and maintenance models for this infrastructure and the manner in which these WASH services are governed and managed will also not achieve the climate resilient WASH services that are required to mitigate and minimise climate change risks in future. To achieve the SDG WASH targets and goal within the growing climate change crisis will require a shift in interventions and actions to one of a focus on climate resilient WASH services.

South Africa, in addition to WASH, climate change and COVID challenges, is a water scarce country and has limitations in the quantities and quality of water that is available to allocate for water services now and in the future. The National Water Resources Strategy (NWRS) (2013) of the DWS indicated that South Africa was fast approaching full utilisation of available surface water yields and was running out of suitable sites for new dams, with the NWRS indicated that, *based on water Reconciliation Strategy studies, surface water availability and its remaining development potential will not be sufficient to support the growing economy and associated needs in full. To meet growing demands, South Africa will need to exploit alternative resources* (DWA, 2013). Water security now and in the future, remains a real threat to WASH in the country.

Molden (2007) attributes water security challenges to two dimensions (Figure 3), first is physical (or absolute) water scarcity which results from inadequate natural water resources to supply. The Falkenmark indicator, defined as the fraction of the total annual runoff available for human use, is possibly the most widely used measure of water absolute water scarcity (Brown and Matlock, 2011). With the per capita water available in South Africa at 966 m^3/capita, the country can be classified as "*water scarce*" on the Falkenmark index. In addition to per capita water scarcity in the country, water availability is also unpredictable, as a result of varying annual rainfall across the country and declining water quality (Hanjra and Qureshi, 2010).

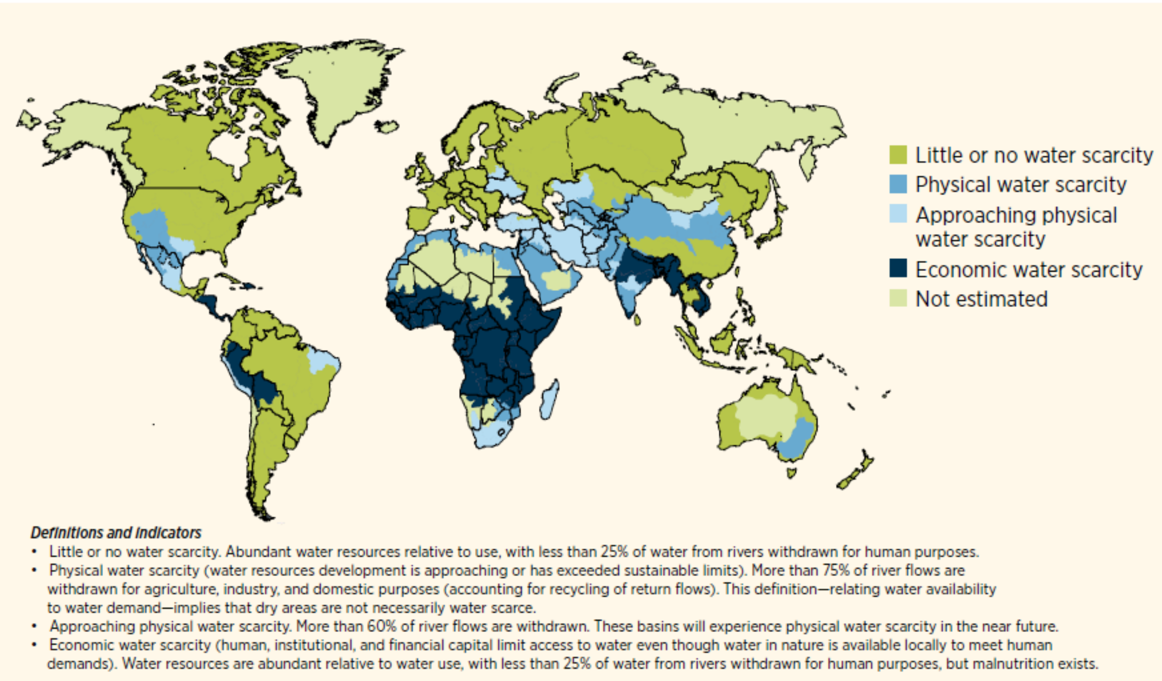


Figure 3: Map of global physical and economic water scarcity (taken from (WWAP, 2012).

The second dimension of water security, according to Molden (2007), is economic water scarcity that results from inadequate administration and/or management of water resources and water supply infrastructure (Figure 3). The FAO (2008) further expanded the definition of economic water scarcity to include the lack of infrastructure development that controls storage, distribution and access and into institutional capacity to provide the necessary water services.

Figure 3 showed that South Africa suffers, and will in future continue to be challenged by, physical water scarcity, with the National Water and Sanitation Master Plan indicating *that R33 billion more will be needed each year for the next 10 years to achieve water security* in the country (DWS, 2018). Although increasing water scarcity is a stark future reality, South Africa does have the means to mitigate the risks of water scarcity, through a number of channels, including innovations in the sector to reduce water demand and thus supply needs, in governance and in other areas of the WASH services innovations. New innovations can help the nation continue to grow in the face of water scarcity.

Apart from water being insecure and the country being water scare and a section of the population not having access to basic WASH services, the existing WASH infrastructure in the country is aging and require intervention, i.e. replacement, rehabilitation, refurbishment, etc. Aging, poor quality, and poorly maintained infrastructure in the country has been highlighted as one of the major contributors to high levels of water wastage (i.e. water leakage; non-revenue water) and to the pollution of rivers and groundwater with sewage (DWS, 2018). The *South African National Water and Sanitation Master Plan* of 2018 indicated that *approximately 56% of the over 1 150 municipal wastewater treatment works (WWTWs) and approximately 44% of the 962 water treatment works (WTWs) in the country are in a poor or critical condition and in need of urgent rehabilitation and skilled operators. Some 11% of this infrastructure is completely dysfunctional* (DWS, 2018). Noting that the Master Plan indicated that *municipal water reticulation infrastructure includes more than 290 000 km of pipelines, an estimated 7,7 million house connections, over 5 million yard taps and more than 2,1 million street taps*, sustainable operation, maintenance and replacement/ rehabilitation/ refurbishment of WASH infrastructure in the country is an enormous challenge (DWS, 2018). In addition, the national grant funding mechanisms for infrastructure tend to incentivise the building of new infrastructure, rather than the maintenance of existing infrastructure (DWS, 2018). The capacity of the Water Service Authorities and Water Service Providers (i.e. local government) to meet these challenges is also limited and requires urgent attention (DWS, 2018).

The National Master Plan indicated that *the South African water sector is in decline with highly vulnerable municipalities characterised by declining levels of service, a continued increase in customer dissatisfaction, rising levels of unpaid bills and aging infrastructure* (DWS, 2018). The capital required for replacement of the existing water and sanitation infrastructure in the country was estimated at R 1,362 billion in 2017, while accumulated backlog in refurbishment were estimated to be R59 billion (DWS, 2018). To address the WASH infrastructure challenges in the country, a capital investment over the next 10 years of at least R90 billion per annum is required to address the following priority needs (DWS, 2018):

1. Clearing the remaining backlog in basic water and sanitation services (at current street tap service levels).
2. Addressing the critical refurbishment backlogs (caused by poor maintenance).
3. Addressing the critical renewals of aged infrastructure.
4. Provision for water resource developments identified in DWS planning studies.
5. Provision of new bulk, connector and reticulation infrastructure to meet the demands of population growth and agreed water use extensions aimed at promoting economic growth.

The reality of the WASH sector is also limited in the manner in which the funds can be generated to pay for the capital inputs and operational requirements of WASH infrastructure, namely either taxes (national) and/or tariffs (users) (DWS, 2018). Fiscal budgets are thus constrained, even more so as a result of the COVID-19 pandemic and its impact on the country’s fiscus.

The above estimates of fiscal requirements and capital inputs were, however, based on utilising ‘more of the same’ WASH service infrastructure, practices and processes. WASH innovation can be a game changer in this process, with the potential to provide similar or better inputs into the WASH value chain, which are more efficient and effective in meeting the country’s WASH infrastructure requirements while addressing a growing population, a need for a circular water economy and green economy, and the need for the provision of sustainable, safely managed WASH services to all.

It is widely recognised that there is an urgent need for innovation to address the multifaceted and intertwined water-related challenges across the globe, but particularly in South Africa (Wehn and Montalvo, 2018). Water scarcity in the country, coupled with competing water demands from the agricultural and industrial sectors (the biggest consumers of water in South Africa) and limitations associated with conventional water treatment process have led to a substantial number of communities in the country not having an adequate and reliable WASH service (Swana et al., 2020). These complex and often interrelated water services challenges in the country provide an opportunity for the development of a wide range of innovations that are crucial for sustainable water management and socio-economic development (WRC, 2019).

WASH innovation are also fundamental to the survival and growth of many organisations in a country (Robbins and O’Gorman, 2016). Small, medium and micro-enterprises (SMMEs), which are the engine of many developed and particularly developing economies, are crucial in identifying new avenues for sustainable and inclusive growth by creating and diffusing innovation and providing employment (Robbins and O’Gorman, 2016). SMMEs and other organisations adopting a ‘problem-solving’ approach to addressing the challenges and barriers in the water services sector have the potential for water innovation to become a force for dealing with important social and economic issues in a country and can contribute to changing the trajectory of progress with the WASH indicators in SDG6, the impacts of climate change on the rights to water and sanitation, and addressing the gaps in service delivery during global emergencies, such as experienced by the COVID-19 pandemic (Edler and Fagerberg, 2017). Innovation in the water services sector would not only be about generation of new ideas, which is the traditional focus of science and research policies, but also about trying to diffuse/deploy, socialise and domesticate such ideas and innovations in practice in order to enhance competitiveness and respond to sustainability (i.e. social, economic, environmental and institutional) (Edler and Fagerberg, 2017). Not only could the sustainable, effective and efficient uptake and implementation of WASH innovations in South Africa assist in addressing many of the water services challenges in the country, but it could contribute to achieving many of the current national imperatives of, amongst others:

- economic transformation and job creation;
- spatial integrations including services; and
- education and skills development – new skills revolution.

The question remains – will the deployment, socialising and localisation of innovations in the water sector be sufficient to address the current challenges and crisis in the sectors? Quoting a water service expert in South Africa, “*we do not want to take existing WASH problems and modify them and expect a different outcome to the challenges experiences in the sector*”. The historical approach to innovation in the WASH sector has largely been ‘reinvented’ many times over human history. The magnitude of the challenges such as climate change, water security, SDG targets and the COVID-19 pandemic requires radical and disruptive changes in the current WASH sociotechnical systems (Kivimaa et al., 2021) Although WASH innovations have quickly and inevitably changed the way that infrastructure services are provided, infrastructure and interventions that transform the boundaries across and within the WASH and other sectors and that disrupt the WASH norm, will be needed to significantly alter and advance the WASH services sector.

The question is: How can WASH innovations, and specifically disruptive innovations, be facilitated to maximise their impact on the South African water sector by 2030?

1.2 BACKGROUND TO INNOVATION IN THE WASH SERVICES SECTOR

In the current economic climate in South Africa of slow economic growth, high unemployment, particularly for the youth, and limited funding, the limited sustainable uptake and implementation of innovations in the water sector is problematic. Despite many years of research, development and innovation (RDI) in the water sectors across the globe, Wehn and Montalvo (2018) highlights that *there is a striking absence of academic studies on the dynamics of water innovation, i.e. examining how relevant actors (fail to) interact to generate, finance, diffuse and apply water innovations and how these processes can be fostered, guided and steered; yet such insights are crucially needed in the face of urgent water-related challenges in developed and developing countries alike that require various types of innovation, both technological and non-technological: incremental improvements, adapted approaches as well as entirely new ways of interacting across stakeholders, basins, regions and related sectors*. This RDI challenges also exist in the water sector of South Africa.

Although the country has been ranked 19th in the world for its contribution to published research related to water and wastewater, translating this research into sustainable, effective and efficient WASH innovations that address the current and future socioeconomic and environmental challenges in the country remains a barrier to sustainable water use and management (Rose and Winter, 2015a, Amis and Lugogo, 2018, Pouris, 2013). The country was also ranked 60th on the 2020 Global Innovation Index (GII), an improvement from 63rd (National Advisory Council on Innovation, 2021). The South African Science, Technology and Innovation Indicators Report of 2021 indicate that the *Innovation Inputs pillar remains a strong area for South Africa in 2019* (National Advisory Council on Innovation, 2021). Research has however, shown that the sector has barely tapped the potential that WASH innovations can offer to economic and social development in the country (Ajami et al., 2014).

The National Water and Sanitation Master Plan for South Africa, indicated that although there were an array of institutions, such as the WRC, the DST, research councils, higher education institutions, private sector, etc. engaging in different aspects of water research, development and innovation (RDI), this sector continues to face a range of challenges including (DWS, 2018):

a) poor coordination and synergising of activities between institutions;
b) a weak understanding of the role of all water sector organisations in driving innovation;
c) challenges in scaling up of solutions to be ready for the market; and
d) limited funding for innovation (particularly in its scale up/ deployment stages).

Ajami et al. (2014) also indicated that various hurdles have been shown to inhibit the development, testing, adoption and diffusion of new water technologies and innovations. This was echoed in a recent report by the 2018 Federation for a Sustainable Environment report on the Water Related Challenges in South Africa, that indicated that the key strategic research, development and innovation (RDI) challenges in the water sector of the country were (Liefferink, 2018):

a) lack of alignment of water research objectives, thrusts and programmes with the broader national policies and strategies relating to water resources management and water use;
b) limited participation of sector-wide stakeholders in the setting and execution of the water-related research and innovation agenda for the country;
c) lack of availability of skills and expertise in water research; and
d) insufficient allocation of financial resources for water sector research and innovation.

The National Water and Sanitation Master Plan indicated that (DWS, 2018):

For South Africa to be ready for the future we must be able to address the innovation chasm where emerging solutions fail to be tested at scale or developed into viable business that are able to engage with different public and private sector role players.

Even when these challenges are removed/addressed, the difficulties of taking water innovations from conceptualisation to market (i.e. deployment, localisation and socialisation) can still be a significant barrier. The WRC (2019) concurred, indicating that *some stakeholders have shown that, despite the robust research and development of water innovations in South Africa and very strong legislative framework has ensured that water is given high research priority, many of these innovations have struggled to move beyond the Research, Development and Innovation (RDI) stage due to various challenges that are encountered by those involved in the innovation ecosystem*". Some of these barriers to deployment, localisation and socialisation of WASH innovations has been noted as policy barriers. Ajami et al. (2014), for example, indicated that the primary management and policy barriers to innovation in the water sector were:

- unrealistically low water pricing rates;
- unnecessary **regulatory restrictions**;
- the **absence of regulatory incentives**;
- lack of access to capital and funding;
- concerns about public health and possible risks associated with adopting new technologies with limited records;
- the geographical and functional fragmentation of the industry; and
- the long-life expectancy, size and complexity of most water systems.

The view that policy may have a role in supporting or enabling innovation has also become widespread, with a need for "innovation policy" commonly used in this context (Edler and Fagerberg, 2017).

Research indicates that an effective WASH innovation policy, one that provides direction to the South African water services innovation efforts, can make a significant contribution to addressing many of the challenges and barriers in the WASH innovation sector of the country (Edler and Fagerberg, 2017). However, it is also noted, that to realise the contributions that WASH innovation policy could make to the deployment, localisation and socialisation of WASH innovations in the country, it is necessary to remove or ameliorate the current innovation policy/regulatory barriers that are being experienced by innovators and their innovations.

The identification of the potential policy and regulatory barriers to deployment/diffusion, localisation and socialisation of innovations has been a barrier itself, with these processes often conducted in an informal, implicit and unsystematic manner. A more structured gap/barriers analysis approach to determine innovation policy barriers and challenges would ensure that important policy and regulatory barriers to uptake and sustainable implementation of WASH innovations are not overlooked and that unimportant barriers are not given undue attention. This requires the use of a framework to systematically consider potential barriers and the identification and appraisal of evidence of the extent of potentially important barriers. Hence, the WRC has issued a call for proposals to provide key insights to policy and regulatory barriers to water sector RDI with a focus on municipal water and sanitation services.

1.3 AIMS AND OBJECTIVES OF THE STUDY

The main aim of the study was to review and quantify the policy and regulatory barriers to sustainable uptake and implementation of water services innovations in the country. The review focused on determining these barriers, and thus enablers, from the perspective of sustainable development (circular water economy), highlighting the benefits and disbenefits of poor implementation/uptake of innovation on individuals, households, business and the national economy. The review thus contributes to a better understanding of the relationship between water policy and regulation and the social, economic, biophysical, technical and institutional barriers and benefits which innovations in the municipal water service sector can provide.

The outcome of the study provides insight into how policy and regulations currently hamper/enable uptake and implementation of RDI that could contribute to sustainability in development, poverty alleviate and contribution to imperatives such as the Green Economy, Sustainable Development Goals, and National Development Plan, etc.

The key aims of the study were the following:

- To explore issues of governance and culture and policy and regulatory environment to facilitate water sector RDI uptake.
- To provide case studies about innovations that have failed to reach the deployment and /or scalable stage. The WRC's "The South Africa Water Innovation Story" (Report SP 126/18) can be used as source of some case studies.
- To develop dissemination material based on case studies to provide opportunities for other innovators.

It is important to note that this review was not intended to be a comprehensive after-action review of both successes and failures of municipal water service innovations. Rather, the focus was to identify policy and legal barriers encountered when deploying innovations in the municipal water services sector, with the goal of removing or alleviating them in future.

1.4 METHODOLOGY OF THE STUDY

Several methods were used to identify and clarify the policy/regulatory barriers to innovation in the municipal water services sector, including:

- brainstorming – the bringing together of a group of people with relevant expertise and perspectives to generate ideas about of policy/regulatory barriers to innovation in the municipal water services sector and their likely importance;
- contacting key informants – discussing potentially important barriers with individuals who understand and have insight into the problem or situation; and
- searching for published or unpublished studies.

The review of policy/regulatory barriers to innovation thus use a range of techniques to capture information. Applying these methods and approach, the following steps were included in the study:

- Step 1: Review of policy/regulatory barriers to innovation in the municipal water services sector.
- Step 2: Stakeholder engagement.
- Step 3: Develop dissemination material based on case studies to provide opportunities for other innovators.

1.5 STRUCTURE OF THE REPORT

This report is structured as follows:

- Chapter 1 provides the introduction, background, aims, objectives and methodology for the study.
- Chapter 2 outlines the definition of innovations in the WASH sector and states the definition of WASH innovation adopted for this study.
- Chapter 3 provides a review of the state of the WASH services and innovation in the country.
- Chapter 4 summarises the review of the national Acts, policies and strategies that impact on innovations in the water sector.
- Chapter 5 outlines the method applied in the review of policy barriers to WASH innovations.
- Chapter 6 shows the results of the review of policy barriers to WASH innovation.
- Chapter 7 explores the patterns of WASH innovations.
- Chapter 8 discusses the enablers and barriers to the infusion of WASH innovations in the country.
- Chapter 9 provides the conclusions drawn from the study and the recommendations for infusing WASH innovations in the WASH sector of the country.

CHAPTER 2: DEFINING INNOVATION IN THE WASH SECTOR

2.1 WHAT IS WASH INNOVATION?

The definition for what constitutes an 'innovation' is important to the review as it determines which policies and regulatory instruments may be enablers or barriers to deployment, localisation and socialisation of innovations in South Africa and thus, which policies and regulations should be included in the study.

Rose and Winter (2015b) defined innovation as *the creation or adaptation of new or existing knowledge, technologies and techniques to solve social or economic problems or bring about economic growth*. In this definition, Rose and Winter (2015b) indicated that innovation includes:

- science (ordered, systematic intellectual knowledge generation);
- technology (the application of this knowledge in physical artefacts and processes); and
- the supporting processes of commercialisation, marketing, administration and management that result in the diffusion of knowledge into society.

An innovation can thus be defined as a new product, but it may also be (Kline and Rosenberg, 1986):

- *a new process of production;*
- *the substitution of a cheaper material, newly developed for a given task, in an essentially unaltered product;*
- *the reorganisation of production, internal functions, or distribution arrangements leading to increased efficiency, better support for a given product, or lower costs; or*
- *an improvement in instruments or methods of doing innovation*.

Chandler et al. (1998) concurred with this definition, defining innovation as *not just a novel idea, but rather a process of developing the idea into product or service to gain a competitive advantage in the marketplace*.

Innovation itself, as described above, is however, not sufficient to ensure that the innovations are accepted, used and dispersed, namely the innovation is diffused by *putting innovations to use* into the public domain. The definition of innovation from Robbins and O'Gorman (2016), although focussed on 'innovation being a new idea', does indicate that innovation is also the *generation, acceptance and deployment of new ideas, processes, products or services*. Innovation must thus go hand-in-hand with (Skjølsvold 2012):

- socialisation of the innovation: including the activities needed to embed new technology in society, as well as processes affecting the embedding; and
- localisation of the innovation: focusing on the enactment of technologies in specific contexts, with a view to the development of practices and sense-making.

Innovation is thus not only the research and development (R&D) or creation of new knowledge, technology or techniques, but also entails the diffusion and implementation of these (Rose and Winter, 2015b). Innovation is also concerned with deployment, localisation and socialisation of ideas, technologies, processes, products or services.

Innovation in the water sector thus requires the generation of knowledge, the development or adaptation of related technologies and the deployment of these into the economy and society, to address the needs of society and the environment (Rose and Winter, 2015b). Successful innovation, according to Kline and Rosenberg (1986), requires a design that balances the requirements of the existing or new product and its manufacturing processes, the market needs, and the need to maintain an organisation that can continue to support all these activities effectively.

Policy that encourages or facilitates growth of innovation in the water series sector would need to facilitate the development, deployment, localisation and socialisations of new knowledge, of new or adaptation of current sustainable technologies/techniques/processes in the sector and the use, acceptance and normalising of these into society and the economy. Policy barriers to WASH innovation would also need to be removed or minimised.

Any review of innovation policies thus must consider the overlapping concerns of the innovation, its deployment, its localisation and its socialisation.

For the purposes of this report, *a WASH innovation is the implementation of a new or significantly improved WASH product (good or service) or process, or a new marketing method for WASH, or a new organisational model in business practice, workplace organisation, or external relations related to WASH.*

2.2 WASH INNOVATIONS VERSUS DISRUPTIVE WASH INNOVATIONS

With the global shift to achieving sustainable development through the SDGs and the achievement of sustainable water services, it will be necessary in the near future to apply next-generation water services tools and models that are based on a combination of technological and non-technological solutions, such as using alternative water resources, while decreasing energy consumption and closing material cycles where possible by extraction of energy and valuable compounds as much as possible (Daigger et al., 2019). Disruptive WASH innovations will be necessary to provide such next-generation WASH services.

Disruptive innovations will require the WASH sector of a country to move from the traditional fit-and-conform WASH innovations (based on the broad definition of innovations provided above) to the more demanding stretch-and-transform WASH innovative (Kivimaa et al., 2021). These innovations are expected, in the 10 to 15 years, to shift the water services paradigm, for example, from reliance on traditional ground- and surface-water resources towards building an environmentally sustainable diversified water portfolio where low-cost, conventional water sources (e.g. rivers, lakes and dams) are balanced and augmented with more costly but also more reliable and sustainable water supply alternatives such as water reuse and desalination (Daigger et al., 2019). These disruptive innovations would also be those that *have a high-intensity effect in the structure of the sociotechnical system(s), demonstrated as long-term change in more than one dimension or element, unlocking the stability and operation of incumbent technology and infrastructure, markets and business models, regulations and policy, actors, networks and ownership structures, and/or practices, behaviour and cultural models* (Kivimaa et al., 2021).

Kivimaa et al. (2021) note that *an assumption can be made that destabilisation of the regime may follow from disruptive influences, especially if a disruptive niche innovation ends up stretching and transforming the regime. In contrast, disruptive innovation may not destabilise the regime if the resulting transition is more a fit-and-conform type*. The deployment of disruptive innovations in the water sector are expected to result in exponential acceleration of the water services authorities/unitalities transition to sustainability by disrupting the status quo (Daigger et al., 2019).

Table 1 demonstrates some the water innovations that have been classified as disruptive innovations and the next-generation innovations.

Table 1: Categories and examples of next-generation disruptive water technologies (adapted from Daigger et al. (2019))

Categories of disruptive Innovation	Examples of disruptive innovations	Description
DIGITAL WATER – solutions that leverage the power of real-time data collection, cloud computing and big data analytics to minimize water losses in the distribution system and maximize operational efficiency, and asset utilization.	*Advanced Metering Infrastructure (AMI) Systems*	AMI systems are computerized systems, which gather, process and analyse real time data of the water use in a given area serviced by the water utility.
	Satellite Monitoring Systems of Water Distribution Systems and Catchments	Uses satellites to monitor leaks in water distribution systems and environmental health of river catchments.
WATER REUSE – solutions that reclaimed water of a specified quality to fulfil multiple water use objectives. **.**	*Direct Potable Reuse*	Production of drinking water from direct and indirect treated municipal wastewater.
	Advanced Oxidation Processes	Removal of micro-pollutants from wastewater for reuse.
	UV-LED Systems:	Used for disinfection of the effluent water from wastewater plants or drinking water facilities.
	Automated Water Quality Monitoring Systems	Online monitoring instruments and software platforms to identify and control water quality in real-time and to adjust the water treatment processes in response to water quality variations.
RESOURCE RECOVERY AND ENERGY SELF-SUFFICIENCY – solutions that entail extraction of energy, valuable nutrients, minerals and rear earth elements from influent wastewater and sludge and from concentrate (brine) generated by desalination plants.	- *advanced membrane-based treatment technologies,* - *anaerobic digestion of sludge:* - *energy reduction for wastewater treatment:* - *New membranes from biomaterials:*	-
	Phosphorus Recovery from WWTP sludge:	Phosphorous recovery vis technologies such as crystallization reactors that precipitate the phosphorus contained in the liquid sludge as a phosphorous mineral compound – struvite, or in the sludge ash.
DESALINATION –	- *pressure exchanger-based energy recovery systems* - *higher efficiency reverse osmosis (RO) membrane elements,* - *innovative membrane vessel configurations, and* - *high-recovery RO systems,*	-
	- *Nano-structured Membranes*	Provide more efficient water transport as compared to existing conventional thin-film membrane elements.
	Forward Osmosis (FO):	A solution with osmotic pressure higher than that of the high-salinity source water (“draw solution”) is used to separate fresh water from the source water through a membrane.
	Membrane Distillation (MD.	Water vapour is transported between “hot” saline stream and “cool” freshwater stream separated by a hydrophobic membrane.
	Electrochemical Desalination	-

Categories of disruptive Innovation	Examples of disruptive innovations	Description
	Capacitive Deionization (CDI):	Uses ion transport from saline water to electrodes of high ion retention capacity, which transport is driven by a small voltage gradient.
	Biomimetic Membranes	Membranes with structure and function similar to these of the membranes of living organisms.
	Joint Desalination and Water Reuse	-

A systematic review of disruptive literature identified four dimensions of disruption that may take place in transitions beyond technology (Kivimaa et al., 2021), i.e.:

- markets and business models;
- **regulations, policies and formal institutions**;
- actors and networks; and
- behaviour, practices and cultural models.

Of note for this research is the dimension that relates to regulations, policies and formal institutions that are typically described either as drivers of disruptive innovation or as a potential source of disruption by removing barriers or encouraging systemic change (Kivimaa et al., 2021).

In accepting and introducing disruptive innovations to the WASH sector, Kivimaa et al. (2021) noted that it will be *important to be aware and address the potential (positive and negative) consequences of disruption, such as direct and cascading impacts on various and intertwined aspects of social justice, security and safety*. A focus on disruption innovations in the WASH sector should also not blind the sector to other alternative concepts in advancing transitions, such as more subtle and incremental processes of traditional innovations.

CHAPTER 3: REVIEW OF THE STATE OF WATER SUPPLY, SANITATION AND HYGIENE (WASH) SERVICES AND INNOVATION IN SOUTH AFRICA

The United Nations Department of Economic and Social Affairs (UNDESA) divides a water sector into three main functional categories, namely water resources management, water infrastructure, and water services (Wehn and Montalvo, 2018):

- Water resources management is aimed at ensuring the protection, sustainable use and regeneration of water resources by protecting ecosystems, rivers, lakes and wetlands and building the necessary infrastructure (e.g. dams and aqueducts) to store water and regulate its flow.
- Water infrastructure includes the construction, operation and maintenance of water-related infrastructure (natural and man-made) for the management of the resource as well as for the provision of water-related services, including the management of floods and droughts.
- Water services comprises the provision of services such as water supply, sanitation and hygiene, and wastewater management for domestic use, as well as water-related services for economic uses, e.g. in the energy, agriculture and industrial sectors.

The three functional categories are intrinsically linked, with each category requiring the other to ensure sustainable, effective and efficient water management and use within a country.

This innovation policy barriers study does, however, have a strong focus on the third functional category of the water sector, namely water services, with the study focussed on innovations and policy barriers to innovations in the water services sector. The study does recognise that water resource and water infrastructure are also a key component of water services.

With the focus on water services and provision of these services in the country, the key stakeholders and thus policy implementers that are the target of the study is local government, as these stakeholders are constitutionally responsible for ensuring that all citizens in their jurisdiction have access to, at least, a basic water supply, sanitation and hygiene (WASH) service. In the South Africa context, a basic WASH service is defined as follows:

The provision of a **basic water supply facility**, the sustainable operation of the facility (available for at least 350 days per year and not interrupted for more than 48 consecutive hours per incident) and the communication of good water-use, hygiene and related practices (DWAF, 2003). A basic water supply facility was, in the most recent revisions of the water policy in South Africa, defined as *the infrastructure necessary to supply potable water to a formal connection at the boundary of a stand or site of a public institution (school, clinic, hospital, etc.)* (DWA, 2014). The minimum level of a basic service in the country is thus, access to a water facility at the boundary of a stand or site (i.e. yard tap).

The provision of a **basic sanitation facility** is provision of a facility that is environmentally sustainable, easily accessible to a household and a consumer, the sustainable operation and maintenance of the facility, including the safe removal of human waste, grey-water and wastewater from the premises where this is appropriate and necessary, and the communication and local monitoring of good sanitation, hygiene and related practices (DWS, 2016). A basic sanitation facility was, in the most recent revisions of the sanitation policy in South Africa, defined as *the infrastructure which considers natural (water; land; topography) resource protection, is safe (including for children), reliable, private, socially acceptable, skilled and capacity available locally for operation and maintenance, protected from the weather and ventilated, keeps smells to the minimum, is easy to keep clean, minimises the risk of the spread of sanitation-related diseases by facilitating the appropriate control of disease carrying flies and pests, facilitates hand washing and enables safe and appropriate treatment and/or removal of human waste and wastewater in an environmentally sound manner* (DWS, 2016). Although not stipulated in the policy, the minimum level of facility for a basic sanitation service is accepted in the country, to be a Ventilate Improved Pit Toilet, with a handwashing facility.

The ultimate goal of the South Africa WASH sector in achieving the constitutional imperatives of universal access to a basic service, is to provide municipal water users with reliable and safely managed water supply and safe and hygiene sanitation systems, in compliance with water quality and wastewater regulations. Innovations in the WASH sector of South Africa need to ensure that they support local government to meet the above constitutional imperatives, namely that innovation ensure and support the provision of at least the above levels of basic water supply and sanitation services, if not a higher service. Innovations in the water supply sector of the country should thus focus on services that, at a minimum, relate to (1) a water supply within the yard of a site and/or (2) communication of good water use, hygiene and related practices. Similarly, innovations in the sanitation sectors should focus on services that, at a minimum, includes (1) a VIP or higher levels of sanitation facility and/or (2) communication and local monitoring of good sanitation, hygiene and related practices.

In addressing the water services goals in the country, water service authorities (WSAs) in the country have historically, firstly operate from the perspective that the demand for fresh water would increase with population and secondly, that the only way to ensure a balance between supply and demand was to find new sources of supply. The focus of WASH management in the country was therefore, historically focussed on supply enhancement rather than demand management. At the same time, interventions to address WASH needs generally looked to large-scale, centralized infrastructure projects to increase supply, on the assumption that large-scale projects would generate significant economies of scale and provide greater operational flexibility. As the challenges discuss above have shown, WASH innovations in future do, however, need to balance supply and demand drive interventions in the WASH sector of the country. Studies have shown that new WASH demand-management innovations, coupled with incentives and education, have the ability to significantly reduce water use in the WASH sector (Ajami et al., 2014). WSAs and WSPs in South Africa need to rethink their assumptions in WASH management, opening up opportunities for a variety of new innovations in the WASH landscape. Rather than relying only on supply enhancement, increasing emphasis also needs to be placed on WASH demand management. There should be increasing interest by WSAs and WSPs for WASH innovations that are more water efficient, and in WASH innovations that can help encourage greater water conservation among consumers. The WASH value chains in the country need to be reviewed, adjusted and implemented to address innovations and the new waterscape that is emerging across the globe.

3.1 THE STATE OF THE WASH VALUE CHAINS IN SOUTH AFRICA

To clarify the policies that need to be included in the study and that impact on WASH innovation deployment, localisation and socialisation, it was necessary to understand that WASH landscape in which these innovations are deployed. This section of the report thus outlines the WASH landscape in South Africa, providing insight into the value chain that makes up this sector. Despite the WASH policies in the country enabling and facilitating the R&D, deployment, localisation and socialisation of WASH innovations, the water supply, sanitation and hygiene services value chain, in which these innovations are deployed in South Africa, is also defined by, and defines, the country's WASH and innovation policies.

The WASH landscape in South Africa was, for simplistic and systematic review, separated into two broad value chains, namely the Wet WASH and the Dry WASH value chain. The Wet WASH value chain demonstrates the value chain for WASH services in the country that are highly reliant on access to reticulated water supply for operation and maintenance, while the Dry WASH value chain shows the WASH service value chain that is not directly reliant on a water reticulation system to function (note: the dry WASH service does require water supply for certain components in the value chain – i.e. handwashing, cleaning purposes, personal hygiene, etc. – but these can still be available from sources of water that are not in-house). Figure 4 and 18 below shows the Wet WASH and the Dry WASH value chains, with a more detailed description of the value chains and their underlying components and innovations. Examples of WASH innovations within each of the value chain pillars are also provided.

Understanding the Wet and Dry WASH value chains can highlight areas where innovation exists and where innovation opportunities may be available in the WASH sector. The figures also highlight that innovation are not only about technology, but also include processes and practices (i.e. treatment, conveyance systems, distribution systems). Similarly, opportunity for innovation exists at the input to the value chains in, for example, the source of water inputs into the value chain – i.e. fog harvesting, rainwater harvesting, acid mining treated water, etc. It is also important to recognise that the other inputs into the value chains may also include innovations, for example innovation in construction methods and materials, innovation in treatment technologies, innovation in soaps and other materials for basic WASH, and innovation in energy that is used in the sector. There is also extensive opportunity for innovation at the user interface in the value chain, however this is perhaps the most challenging pillar of the value chain, particularly related to the socialising and localising of these new and innovative WASH services.

3.1.1 Innovation in the Wet WASH Value Chain

Figure 4 demonstrates the Wet WASH value chain for water supply, sanitation and hygiene in South Africa. The figure depicts the flow of inputs into the WASH value chain (i.e. water source), through the various pillars of Wet WASH services and finally to the output (use, re-use or discharge) from the value chain. It should be noted that although the value chain in the figure has a strong linear flow, there are significant return loops to various inputs (i.e. materials, water inputs, energy generation) along the value chain.

Each of the pillars and components of the Wet WASH value chain are discussed in the section below. Figure 4 demonstrate that the pillars of the Dry WASH value chain include the following:

- Inputs of water, construction and other materials and hygiene materials.
- The water (untreated) conveyance pillar.
- The water treatment pillar.
- The water (treated) storage and distribution pillar.
- The end-user interface pillar.
- The wastewater conveyance pillar.
- The wastewater treatment pillar.
- The treated resource and wastewater use, re-use and discharge pillar.

Innovations have been deployed, socialised and localised in all these pillars with varying levels of success.

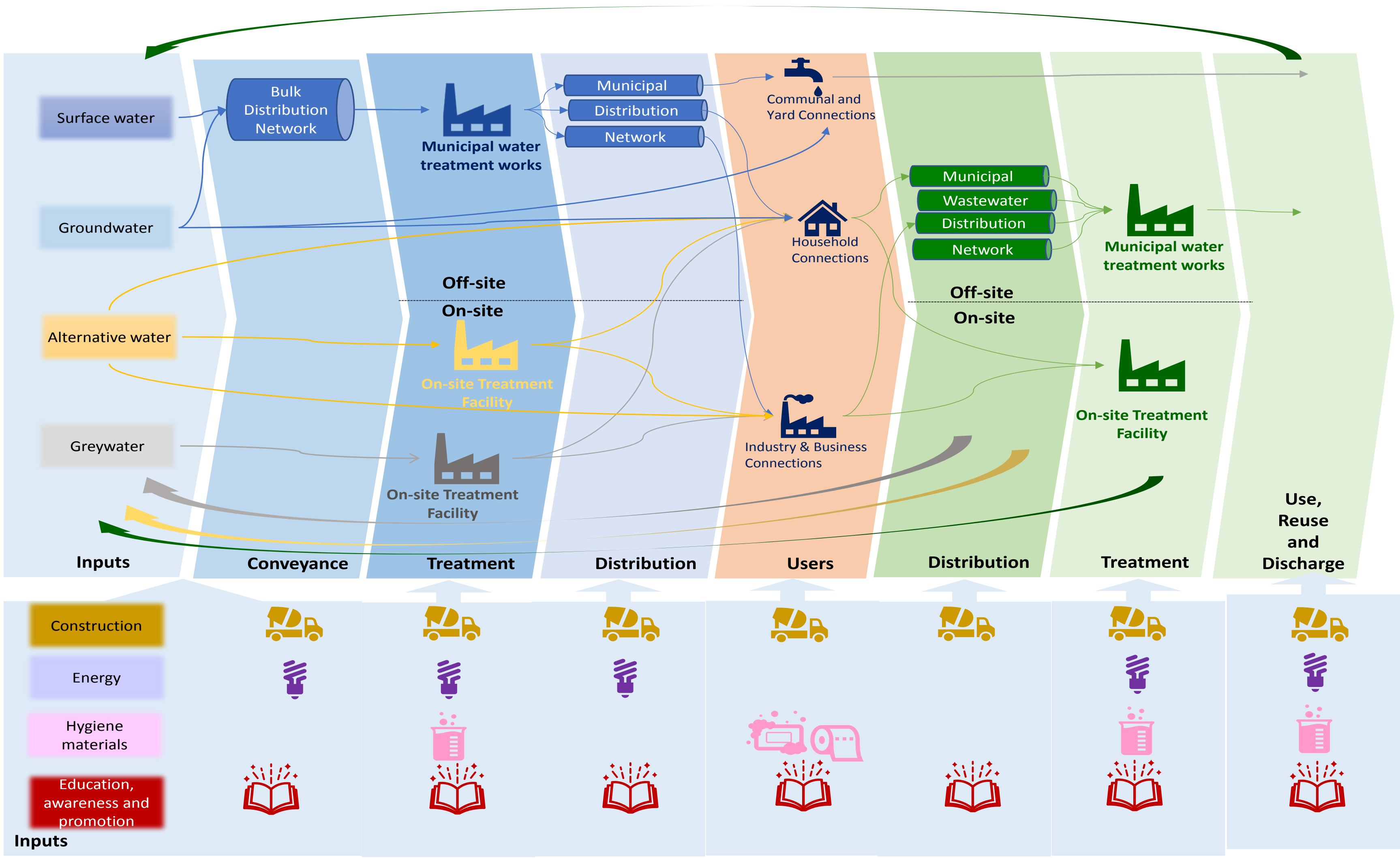
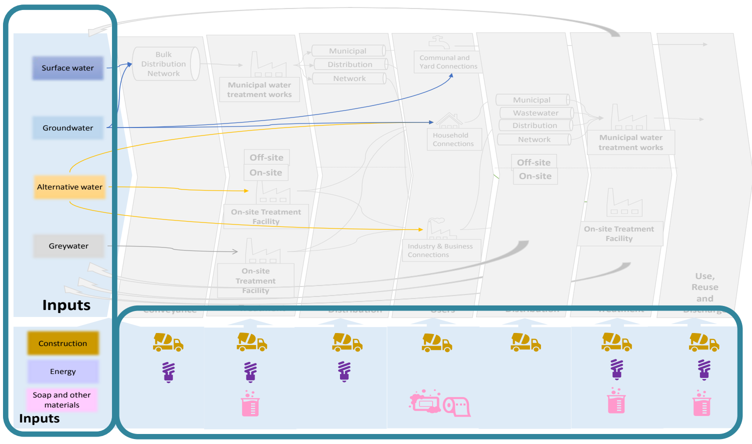


Figure 4: Depiction of the Wet WASH value chain in South Africa

Each pillar of the value chain is discussed in more detail below.

3.1.1.1 Innovation in the Inputs into the Wet WASH Value Chain

This section of the report focusses on the first pillar of the Wet WASH value chain, namely inputs. Inputs are broadly categorised as:



- water resource inputs;
- construction inputs;
- energy inputs (not discussed in this report);
- hygiene inputs; and
- communication, education and awareness inputs.

<u>**Innovation in WASH Water Resources Inputs**</u>

The main input in the Wet WASH value chain is water, that (in broad terms) can be sourced from surface water, groundwater, alternative sources and greywater.

In order to arrest unfavourable trend in water resource utilisation in South Africa, a number of alternative means of managing and using of **conventional water sources such as surface and groundwater sources** (shown by the blue value chain in Figure 4) have been suggested. These include suggestions by Pitman (1995) that the country adopt an alternative, "supply-driven" approach through a "water grid" approach to management of surface water (Smakhtin et al., 2011). An additional alternative option would be to create additional storage in the country through the development of innovative water storage options. For example, Smakhtin et al. (2001) suggests options such as the development of deep storage reservoirs which would address the high evaporation losses from surface storage reservoirs or to trap portions of floodwaters and store this water underground in abandoned mines. All these innovative means of extending and sustainable allocating and utilising the limited water resource inputs into the Wet WASH value chain provide opportunity for innovation in the WASH sector of the country.

Similarly, **groundwater,** shown as the second water source input into the Wet WASH value chain, is the critical underlying resource for human survival and economic development in South Africa, especially in a large number of rural areas of the country and areas prone to drought. A major constraint in the use of groundwater as an alternative water source, is the determining of the rate of replenishment or recharge of these sources (Connelly et al., 1999). The country has opportunity for new and innovative means of recharge of these critical resources, focussing on ground water replenishment through natural processes (i.e. direct recharge by precipitation, surface recharge through rivers and subsurface recharge from adjoining confined aquifers) or through innovation for artificial recharge (see below). One such innovation could be that of water banking, which is storing water in an aquifer for water security purposes.

Alternative water supply, the third water source input shown in the Wet WASH value chain, includes sources such as water from the following:

a) **Treated Acid Mine Drainage** – a recognised alternative water source is the reclamation and use of acid mine drainage (AMD) wastewater (Lottermoser, 2010). Innovations in the treatment of AMD wastewater has led to the development of new treatment processes and technologies in the sector, that today are globally recognised for their innovation (Rose, 2013).

b) **Artificial recharge of groundwater** – innovations in artificial recharge of groundwater, another of the alternative water sources in the Wet WASH value chain, can be achieved by pumping water into the aquifer or by controlled seepage of effluent water and agricultural run-off. Artificial recharge of aquifers has been practised in South Africa since the 1970's, with the town of Atlantis perhaps the most researched example of this process (see Box 1 for example) (Swartz et al., 2014).

c) **Desalination** – the use of seawater as an alternative water source has been a research focus for a long time in South Africa, with the first research products on the WRC database emerging in the early 1990s. Seawater theoretically can provide an unlimited alternative water source to the coastal areas of the country – using desalination technologies (Smakhtin et al., 2001). There is growing interest in utilising desalination technologies to provide alternative water sources. Desalination does, however, still suffer from the perception that the country and region has cheaper, better and complementary ways to supply water that are less risky to the environment (van Vuuren, 2007). A recent WRC report indicated that *desalination is, however, one of the more expensive water supply alternatives. This expense may be justified where the cost of unserved water is greater than the cost of water produced through desalination. What this would mean is that the cost of the desalinated water – which is more expensive than water from traditional bulk water supplies – would be justified by the fact that the economic costs associated with not having access to water are significantly more* ((Punt et al., 2021). See Box 1 for more details and examples

d) **Rainwater harvesting** – in the most basic form, rainwater harvesting involved collecting rainwater in a simple vessel at the edge of the roof. Variations on this approach include collecting rainwater in gutters and draining water through down-pipes to a collection vessel and/or the diversion of the water from the gutters to a container where the particulates are settled before being conveyed to the storage container for the domestic use.

e) **Fog collection/harvesting** – captures water from the air through fog harvesting, providing a simple and low-cost alternative water collection systems for WASH services. Fog harvesting research has been in place in South Africa since 1969 (Schutte, 1971; Olivier et al., 2015).

f) **Stormwater harvesting** (SWH) – another area of alternative water source innovations in South Africa, which could supplement traditional municipal water supplies, while at the same time minimising risk from natural hazards such as flooding. Innovations that focus on direct stormwater use to, for example, water gardens, flush toilet, recharge aquifers, etc. are currently already being implemented (although on a relatively small scale) or being investigated in the country.

The sustainable use of these alternative water source in a Wet WASH value chain to provide WASH services is itself an innovation, often experiencing barriers and challenges to deployment, localisation and socialisation. A number of other alternative water sources innovation exist (i.e. cloud seeding; rainfall or cloud enhancement by intensification, etc.) that have been, and are being, explored to provide water to the WASH services sector. It is, however, not possible to detail all of these in this report. Box 1 below provides some examples of innovations and some of the challenges that may be experienced to socialise and domesticate these alternative water sources as a water supply for WASH services.

The fourth water source input into the wet WASH value chain, is the use of **treated and untreated greywater** (shown as the grey value chain in Figure 4). Greywater, which has been defined as household wastewater from baths, showers, hand-wash basins and laundry (i.e. all non-toilet and kitchen waste water), has been receiving increasing attention and thus innovation as an alternative water source in South Africa (Rodda et al., 2011). Innovations that allow for the safe reuse of greywater for various purposes at an industrial and household level (i.e. irrigation of gardens and crops; manufacturing and other industrial activities, etc.) can alleviate reliance on conventional water supply sources, such as surface and groundwater.

Box 1: Examples of alternative water sources in the Wet WASH value chain

<u>Desalination</u>:

Off-site Sedgefield desalination plant (taken from Turner et al. (2015))**:** an example of a local desalination projects based on membrane technology, implemented in 2009, is the desalination plant in Sedgefield, Western Cape that was constructed due to a severe drought-related water shortage. At the time the Knysna Municipality had to supply water to households via tanker, collecting and transporting water from the nearby town of George. Water sources to the town of Sedgefield were surface water of the Karatara and Hoogekraal Rivers, supplemented by boreholes. The installation of the desalination plan, which utilised reverse osmosis technology, optimised and supplemented these traditional water sources from a 1.5 Mℓ/day containerised seawater desalination plant at Myoli.

On-site Radisson Blu Hotel desalination plant: apart from the water and sanitation interventions, the Radisson Blu Hotel Waterfront in Granger Bay produced 7,000 litres of fresh water an hour from a desalination plant that treated sea water pumped from a 100 m borehole (Relocation Africa Group, 2019). Figure 5 shows a schematic of the system, showing that a borehole under the hotel allows the hotel to pump 11,500 l of seawater an hour into storage tanks (Relocation Africa Group, 2019). Seawater from the storage tanks is treated, by a reverse-osmosis plant treats, after which the treated water is pumped into a 70,000 l fresh- water tank for use in the hotel (Relocation Africa Group, 2019).

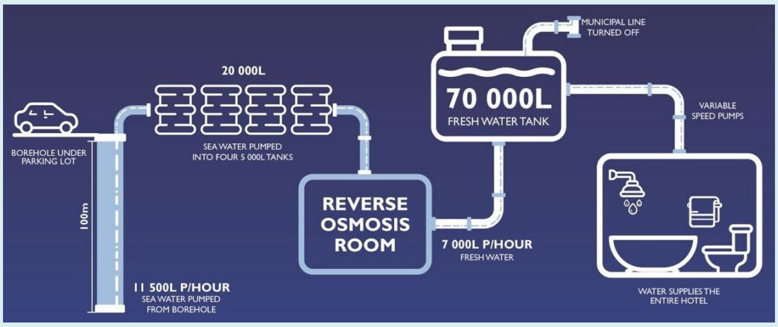


Figure 5: Schematic of the Radisson Blu Hotel Waterfront in Granger Bay desalination system (taken from (Relocation Africa Group, 2019))

Onsite Competitive Small-scale Solar Desalination (taken from WRC (2020))**.** This is a low-cost portable innovation that is a competitive small-scale desalination system using direct solar energy (solar basin still) for water purification and desalination (WRC, 2020). The approach used to develop this innovation entails a transparent cover which allows for solar radiation to enter the still where it is absorbed by an absorber plate beneath the water, consequently causing the water to heat up and evaporate where it can then condense on to the cover (WRC, 2020). Unlike other existing products in the market, the system uses low-cost construction materials which make the solar still cost-effective without significantly reducing the yield (WRC, 2020).

<u>Seawater use</u>: desalination is not the only manner in which seawater could be beneficially utilized. Direct use of seawater, for flushing of toilets and for industrial use, also provide an opportunity as an alternative water source. Despite this, the possibility of direct use of seawater has received little research and development attention in South Africa (Smakhtin et al., 2001). A study by Liu et al. (2016) found that seawater toilet flushing has been practiced in Hong Kong for over 60 years and has been shown as *a promising water supply alternative for modern cities, and particularly for those that are located within 30 km of the seashore and that have an effective population density higher than 3000 persons km^{-2}* (Liu et al., 2016).

Off-site <u>groundwater recharge with stormwater and treated wastewater uses</u> in Atlantis (taken from CSIR, 2009). The Atlantis Water Supply Scheme (AWSS) demonstrates innovations in the use of a portfolio of water sources, including an integrated approach of wastewater treatment, groundwater recharge and water supply. Bugan et al. (2016) indicated that s*ince the late-1970s, the*

AWSS has recycled water, utilizing an artificial groundwater recharge scheme to further purify and store treated domestic wastewater and urban stormwater. Subsequently, the groundwater is abstracted at wellfields and re-used to augment the municipal water supplies to the town of Atlantis (Western Cape, South Africa). The AWSS may be classified as a local application, where the artificial recharge scheme has been incorporated into the overall water management strategy for the town.

Onsite Membrane For Treating Acid Mine Drainage: this innovation is a membrane of polyethersulfone and nano hydroxy-solid particles with hydrophilic functional groups that treats large discharges of acid mine drainage (DST, undated-b). It is suitable for implementation in a filtration cartridge setup that allows for the reclamation of metals which can then be recycled and used for other applications (DST, undated-b).

Greywater Recycling with Dewdrop: a decentralised ecological wastewater treatment system innovation, developed by Isidima, via the WRC Wader initiative (DST and WRC, 2017). The DewDrop is a modular system for harvesting and reuse of domestic greywater, capable of recycling up to 400 L of greywater per day for toilet flushing and garden watering (DST and WRC, 2017)

Innovation in Construction and Installation Material Inputs into the Wet WASH Value Chain

Construction materials, such as bricks, mortar, piping, etc., required to construct a toilet and to pipe and distribute water and wastewater are inputs into the Wet WASH value chain from the point of extraction of the water from the water resource to the discharge or reuse/recycling of the water at the endpoint of the value chain. Construction materials, technology inputs, and in some cases innovation development, the deployment, localisation and socialisation are also key in this input component of the Wet WASH value chain.

Innovation in construction materials is an area of little focus in the Wet WASH value chain in South Africa as these materials are often dictated by the building codes of the country. However, as the country and the Wet WASH value chain moves into a Circular Economy operational approach and shifts to minimising virgin material inputs and to sustainable production and manufacturing of input materials (i.e. focusing on the R's of Reuse, Repair, and Remanufacture), these inputs into the wet WASH value chain should see a shift. For example, currently, piping in the distribution network of the value chain shown in Figure 4 are usually PVC pipes produced from polyvinyl chloride (i.e. raw materials of chlorine and ethylene). In future, a shift may occur to the use of only recycled materials in piping, including recycled, disused PVC pipes and the remanufactured piping for distribution networks. Similarly, brick and mortar construction of homes, business blocks and industry building and sanitation facilities in the Wet WASH may see a shift, where bricks or blocks can be manufactured from waste from the value chain or other waste materials in the municipal area (see Box 2 for some international examples of innovations in bricks for utilisation in the building sector).

Ideally, the innovations of the input materials and technologies for construction and installation of systems in the Wet WASH value chain in future need to focus on (1) reusing wastes from the value chain (i.e. reuse and recycling of PVC pipes, waste such as sludge through creation of biochar brick); (2) minimising the need for natural resource for the manufacture, installation and operation of the materials and (3) minimising energy requirements for the manufacture, installation, operation and reuse/recycling of the materials in the value chain.

Box 2: Examples of innovations in the construction and building materials component of the Wet WASH value chain

Hebel et al. (2014) published a report on building from waste in 2014, with a focus on innovative building and construction materials that had been developed across the globe using various 'waste' materials. The report clearly showed opportunities for utilising of municipal solid waste streams to generate building and construction materials related to the following:

- Load-bearing Products
- Self-supporting Products
- Insulating Products
- Waterproofing Products
- Finishing Products.

Of particular interest to the Wet WASH value chain in South Africa would be such innovative materials from municipal solid 'waste', such as the following (Hebel et al., 2014):

a) ***WaterBrick***: the water brick begins its life as a High-Density Polyethylene (HDPe) water container that once the water has been used, can enter a second life cycle as a basic building block (see Figure 6a below). Their design does not require any mortar, with the bricks combining like toy bricks. Approximately 1000 containers are sufficient to construct a wall with an area of 69 m^2.
b) ***Green Leaf Bricks****:* produced from 30% processed sewage waste and recycled iron oxides, recycled glass, mineral tailings, virgin ceramic scrap – the by-products of open-pit mining operation contents from industrial dust filtration, and a variety of other waste materials. The material is odourless and can be used similar to any other fired brick (see Figure 6b).
c) ***Vbc3000 Bricks and Lightened Granulates****:* manufactured out of partially dried sewage treatment sludge (65% dryness) and clay. Once mixed, the mass is heated to temperatures ranging from 1,000 to 1,200°C, depending on the clay type in use. The products are not only lighter compared to traditional mineral-based building materials but also achieve excellent thermal and soundproofing insulation ratings (Figure 6c).
d) ***Nappy Roofing***: utilizes absorbent hygiene products that contain plastic materials, fibres, and super-absorbent polymers. Sterilized, shredded and separated, these elements are used to create a three-part light weight, easy to install roofing system such as roofing sheets, ridge tiles, and side flashings, that also has good thermal insulation and sound absorption qualities (Figure 6d).
e) ***Natura 2***: a wall covering material made from recovered wasted water hyacinth plants, where the stalk is collected and dried, de-fibered, and glued atop a paperboard for stability. Once trimmed into strips of regular size and properties, the material is connected into standard rolls by manual weaving (see Figure 6(e))

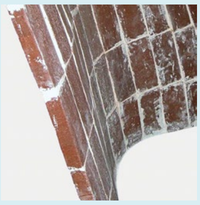
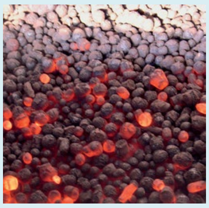
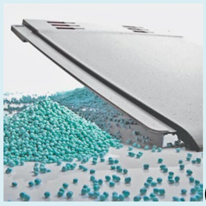
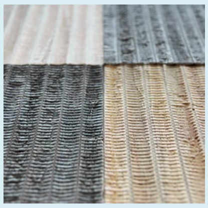
(a)  (b)  (c)  (d)  (e) 

Figure 6: Examples of innovations in the construction and installation materials in the Wet WASH value chain (taken from Hebel et al. (2014)

Biobrick: a South Africa innovation inspired by nature, that involves biocementing a mould containing ordinary masonry sand using feed material derived urine through the action of specific bacteria to form a biobrick (Figure 7) (WRC, 2020). The brick is however still in early commercialisation and has yet to be deployed into the market (WRC, 2020).

Figure 7: The South African Biobrick innovation, produced from use of urine and action of bacteria (taken from WRC (2020))

Wricks – Reinventing Brick Industry – A affordable, lightweight, and waterproof brick, designed by Angirus Ind Pvt. Ltd. in India, as customizable modular bricks made from recycled plastic, construction, and thermal waste (Figure 8a) (EngineeringforChange, 2022).

RePlast – blocks are made from recycled plastics that are heated and compressed using ByFusion systems (Figure 8b). They are designed to be a complementary integration to traditional building materials such as lumber, steel, and cement (EngineeringforChange, 2022).

Watershed Blocks – a building block manufactured by Watershed in the USA, from post-industrial recycled materials using less cement (Figure 8c) (EngineeringforChange, 2022).

-  (b)  (c) 

Figure 8: The Angirus Ind Pvt. Ltd., Wricks brick innovation, (b) the Replast blocks (taken from. EngineeringforChange (2022).

Innovative construction and installation inputs into the Wet WASH value chain are not only related to brick and mortar, but also to the technologies that are installed during the construction process, i.e. toilet pedestals, taps, shower heads, etc. South Africa has demonstrated a range of innovations that have very often been deployed at scale and localised (see Box 3 for examples). Deployment, localisation and socialisation of these innovative end-user technologies are generally driven by the need for water saving in home, business and industries during drought, water scarcity and as a result of WSAs introducing water restrictions to control water usage during these periods.

Box 3: Examples of end user materials and installations innovations in the Wet WASH value chain

Water saving innovations, as inputs into the Wet WASH installation component of the value chain, include, amongst others, the following:

a) Water flow restrictors – can drop water use from as high as 25 litres per minute to 2-6 litres per minute (Figure 9a and 8b).
b) Dual- or low-flush toilet, reducing water from in the region of 9,5 litres per flush to 4-4,5 litres per flush (Figure 9c and 8d).
c) Water flow restrictors on showerhead that can reduce consumption to 7-9 litres per minute (Figure 9e).

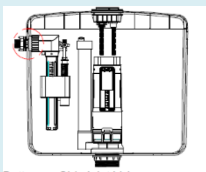
(a)  (b)  (c)  (d)  (e) 

Figure 9: examples of a) aerated flow restrictor for a tap; b) non-aerated flow restrictor for a tap; c) and d) dual flush toilet cistern and e) showerhead flow restrictors (taken from Water Connection (undated)

Pour-Flush Sanitation System: this end-user innovation is similar to the full-flush toilet except that there is no water tank, cistern, flusher or liquefier. Water is poured into the toilet bowl, by the user, for flushing (Figure 10-(a)) (Amis and Lugogo, 2018). The incoming water forms a water seal in the bend portion of the pipe to prevent any odour from the pit backing up into the toilet. Partners in Development (Pty) Ltd (PID), funded by the WRC, has design, develop and tested pour-flush toilets in South Africa, that was followed by support and expertise provided by Envirosan Sanitation Solutions to upscale and commercialize the pour-flush toilet (Amis and Lugogo, 2018). By 2018, over 3000 pour-flush toilets had been installed in the country (Amis and Lugogo, 2018). Considering the massive number of sanitation facilities in South Africa, both flush and dry systems, the pour flush toilet stills has a significant way to go to be deployed at scale. This may be due, in part, to the innovation not yet being socialised and localized as a recognised alternative, an environmentally sound alternative at that, to the traditional waterborne sanitation systems.

The ArumLoo Micro-flush toilet: patented to Isidima Design and Development and developed through funding by the WRC, the ArumLoo Micro Dual-flush toilet was designed to reduce the amount of water required for flushing, using between 1 to 2,5 litres of water per flush (Figure 10b). The final prototype of the innovation was branded as the "Arumloo" as its was designed mimics water movement in nature's Arum Lily plant, namely the system utilizes a vortex and a gush of water ('gush flush") to remove the excreta into the elongated P-Trap.

(a)  (b) 

Figure 10: Example of innovations in end-user installation materials in the Wet WASH value chain showing (a) a Pour Flush Toilet and (b) the Arum Micro-flush toilet (taken from Amis and Lugogo (2018))

<u>Innovation in the Hygiene Inputs into the Wet WASH Value Chain</u>

Hygiene in the WASH sector has many components, including hand hygiene, environmental hygiene, food hygiene, personal hygiene, and menstrual health (MH). All these hygiene components have the opportunities for deployment of innovations and for the uptake of disruptive innovations.

To ensure access to a basic hygiene service in the country, based on the SDG 6 definition, there should be universal and equitable access to **hand hygiene** that includes access to a handwashing facility, with soap and water. The need for water in the handwashing facility thus overlaps the Wet WASH value chain with the Dry WASH value chain, whether the water is piped to the handwashing facilities (i.e. yard or household tap) or whether the water is collected and stored from a water course i.e. stream, river, rainwater tank, etc. (i.e. in the Dry WASH value chain).

A recent market report indicated that the global handwash station market size was $919.4 million in 2019, estimated to grow by 4,4% between 2021 and 2027 to reach $1,482.3 million (Chouhan et al., 2021). Outbreaks of respiratory infection-based pandemic diseases, such as COVID-19, fuelled the demand for hand wash stations among the general public and governments across the globe (Chouhan et al., 2021). These innovations have, due to the COVID-19 pandemic and a gap in the market, been rapidly deployed into the market and became socialised and localised. As a result of this rapid deployment, localisation and socialisation process, the pandemic has given rise to a wide range of emergent handwashing innovation (see Box 4 for some examples). However, the challenge with the innovations is whether they will be sufficiently socialised and localised to be deployed after the pandemic. It should be noted that despite the COVID-19 pandemic driving the mass deployment of handwashing stations across the globe and providing handwashing facilities to individuals in high risk and vulnerable communities, Figure 2 above demonstrated that the country still had a significant backlog in reaching the SDG6 hand hygiene target, with only 43% of households in the country reported to have access to a handwashing facility with both soap and water in 2020.

Box 4 demonstrates innovations in handwashing technologies, largely due to the need to save water or to address hand hygiene COVID needs.

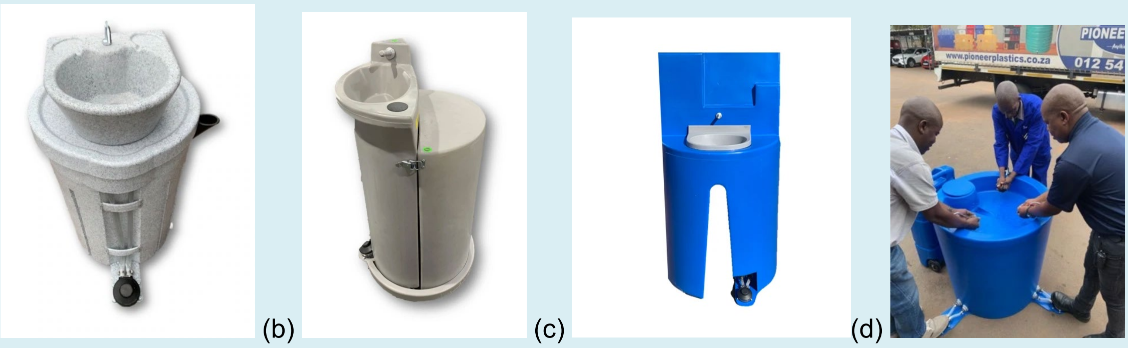
Box 4: Examples of hand hygiene – handwashing innovations

Envirosan EaziWASH handwashing facility: emerging in response to the COVID pandemic and the need to provide handwashing facilities, quickly, to high risk and vulnerable communities such as individuals without on-site water in peri-urban and informal settlements, the EaziWASH comprise a system of four self-closing, low-touch taps attached to a Jojo tank that can be connected to a municipal reticulation system or can be manually filled (i.e. hosepipe connected to a tap) (Figure 11). The system is designed to ensure sufficient social distance between users.

Figure 11: Examples of Envirosan EaziWASH (taken from Envirosan Sanitation Solutions (Undated))

Pioneer 20 litre, 40 litre, 180 litre and 3 station 300 litre foot-pumping handwashing stations: are designed to provide a potable handwashing system, that can dispense water through a foot peddle (Figure 12). The systems have two tanks, one that stores the clean handwashing water and the other that stores the handwashing greywater.

(a) (b) (c) (d)



© Pioneer Plastics

Figure 12: Examples of Pioneer Plastics (a) 20 litre, (b) 40 litre, (c) 180 litre and (d) 3 stations 300 litre Handwashing Stations (taken from Pioneer Plastics (Undated))

Aurum Institute Shesha Geza Handwashing Station: the 600-litre tank features a diluted, chlorine-based sanitizer liquid, which can be used when washing with soap or when using an alcohol-based hand sanitizer is not feasible (Figure 13). The stations are operated by a foot pump to break the chain of transmission through touching taps. The design also allows for hand washing with soap as an alternative to the diluted chlorine-based solution.

Figure 13: Aurum Institute Shesha Geza Handwashing Station (taken from CDC (Undated))

Another component of hand hygiene, which is also crucial for personal and environmental hygiene, is access to soap and cleaning materials (i.e. for cleaning surface and toilet facilities). The soap and cleaning materials value chain is the same for both the Wet and Dry WASH value chain and is thus common to both.

Soaps and detergents for handwashing, personal hygiene and for cleaning of households and materials, requires no introduction and has seen very little change since it was first introduced in the current form of a bar soap in the early 1800s (Draelos, 2018). The first significant disruption to the bar soap value chain did, however, occurred in 1878, when Harley Procter together with his chemist cousin James Gamble, converted the family candle factory into a soap factory (Draelos, 2018). The factory began to produce a creamy white soap, which was able to compete with the soap that was being imported from Europe (Draelos, 2018). The production of “white soap” was discovered quite by accident when the Procter and Gamble team whipped air into the soap solution prior to moulding, resulting in a floating bar (Draelos, 2018).

Another major breakthrough in the soap story, was the prioritisation of soap use in the health sector (Broze, 1999, Ronni Wolf et al., 2001). This prioritisation emanated with the 1861 hypothesis by Ignaz Semmelweis that hand hygiene was the root cause of the higher mortality rate of women from puerperal fever (childbed fever) when the delivery of a baby was attended by a physician or medical student after the handling of corpses during autopsies (Larson, 1999, Best, 2004). Today, the use of soap is an integral part of disease prevention, both at home and within the health sector. The importance of which has been reinforced even more so, with the COVID-19 pandemic.

Recent innovations in the soap and detergent and hand hygiene sector are the following:

1. Liquid detergents, including liquid handwash.
2. Foaming detergents, including foaming handwash.
3. Hand sanitiser liquid, gel, spray and foam.

Although the soap market in South Africa registered a positive compound annual growth rate (CAGR) of 8.76% during the period 2013 to 2018 and demonstrated sales value of ZAR3,743.09 million in 2018, the market is dominated by large international conglomerates and is a massively occupied and crowded market, especially the bar soap market. This limits the opportunities for the deployment, socialising and deployment of any innovations in the bar soap markets or even for disruptive soap and detergent innovations.

The exception in the hand hygiene sector was, however, hand sanitisers. The mass deployment of hand sanitisers is a crucial outcome of the market demand for these products during the COVID-19 pandemic. A vast array of hand sanitisers were rapidly deployed into the market from small, medium, large and international organisations. Market reports indicated that this product market could continue to grow between 3% and 22% between 2021 and 2027, which is significant.

Hand sanitisers are an example of how rapidly an innovated technology can be socialised and localised due to a massive demand, although this demand was pandemic related (see Box 5 for example of hand sanitiser as a rapidly deployed, socialised and localised COVID-19 product in households in South Africa). Sanitisers have become a vital component of many households, with many of these households having more than one sanitiser, placed at a number of strategic points within their households, i.e. entry point at home, in the car, in the bathrooms, in school bags and handbags, etc. These products are more expensive than the soaps that are available in the country, hence poor and rural households that cannot readily replace these sanitisers are still reliant on soaps for the handwashing needs.

Box 5: hand sanitiser as an example of WASH innovations (taken from South African Government (2021) and Phakathi (2021))

The Business Day on 7 December 2020 reported that *SA generated R1.6bn in export revenue for hand sanitiser products over the last six months* (Phakathi, 2021). The basis for this headline was the Department of Trade, Industry and Competition, that indicated that South Africa had, between June and November 2020, issued permits to export hand sanitisers to 30 African countries, with an estimated value of R1,66 billion (South African Government, 2021). These included exports to Nigeria, Ghana, Kenya, Mozambique and Botswana.

South African manufacturers of hand sanitiser had been building significant trading ties with these African countries during the COVID-19 pandemic. The Minister, Ebrahim Patel, is quoted as saying that *at the start of the pandemic, South Africa faced a shortage of hand sanitisers and industry worked with Government to expand local production. Measures were put in place to regulate the export of hand sanitisers to ensure adequate local capacity and to encourage exports to other African countries. As soon as sufficient capacity was built up for local use, the International Trade Administration Commission (ITAC) issued permits to local companies to export product to other African countries* (South African Government, 2021). Significant contribution to the mass deployment, localisation and socialisation of these products, from a South Africa manufacturing perspective, was the pandemic disruption to global hand sanitation supply-chains that encouraged local production and innovation. Since South Africa had a large, diversified industrial base and local know-how, the country was able to roll-out these products at scale. The Minister highlighted that as South Africa builds *a more resilient economy, we will rely more on local innovation and industrial capacity. The legacy of COVID-19 is to underscore the importance of localisation, to create more jobs and enhance economic output* (South African Government, 2021).

The mass deployment of hand sanitiser did not occur without challenges. As COVID-19 began to spread, demand for hand sanitiser quickly outstripped supply. To fill the gap, companies as diverse as distillers, parfumiers, and even automotive industry suppliers, began to make hand sanitiser. At the same time, hard lockdowns disrupted supply chains in many countries and countries had to scramble for standards and regulations to locally produce COVID-19 IPCs, such as hand sanitisers. Many countries adopted temporary policies or regulations, from organisations such as the WHO and EPA in the USA. Countries that had regulations also relaxed these at the start of the pandemic to ensure continued supply. For example, in the USA the EPA eased the reporting requirements on 280 inactive disinfectant ingredients and the FDA relaxed certain restrictions to expedite the release of hand sanitisers onto the market. These allowed for the production of hand sanitiser by entities that weren't registered manufacturers and for alcohol distillers to shift their production to hand sanitisers. South Africa saw a similar surge in manufacturers of hand sanitation, often with these products not meeting international guideline for COVID-19 preventions (i.e. at least 70% alcohol v/v).

As the pandemic developed, regulations and standards were introduced by many countries. South Africa developed and published SANS 490:2020 for alcohol-based hand sanitisers and rubs.

The hand sanitiser case demonstrates, albeit under unusual pandemic conditions, the massive deployment of a hand hygiene innovation to meet market requirements. While the regulations and policies were eased to facilitate the process of deployment of the hand sanitisers to meet this need, this easing also opened the door to abuse and manufacture of substandard products. The case clearly demonstrates the need for policy and regulations, but those that facilitate and ease the deployment, localisation and socialisation of innovation, especially innovations that disrupt traditional WASH markets.

Personal hygiene, another component of the wet WASH hygiene value chain is the availability of cleansing materials at a toilet facility. Perhaps one of the least recognised and acknowledge barriers to faecal-oral transmission of sanitation-related diseases is that of toilet paper used for anal cleansing. Although a massive global market exists for this innovation, the toilet paper market is already well established and has seen little change or demonstrated little innovation for many years. Any innovations that have taken place have focussed on scented paper, paper infused with products (i.e. aloe) and printed/patterned paper. See Box 6 for the toilet paper innovation story.

Box 6: the toilet paper innovation story.

In the centuries before toilet paper, plagues of dysentery, typhoid and cholera were common (Hughes, 1988). The first paper product specifically manufactured as toilet paper was Gayetty's Medicated Paper in 1857, first advertised as "*unbleached pearl-colored pure manila hemp paper, a perfectly pure article for the toilet and the prevention of piles*" (Hughes, 1988). A package of 500 sheets sold for 50 cents, with each sheet of paper watermarked with Gayetty's name (Hughes, 1988).

Despite the patent being awarded in 1871 in the USA for toilet paper in roll form and the establishment of the toilet manufacturing companies such as the Scott Paper Company in the USA and the British Perforated Paper Company, the mass localisation and deployment of toilet paper use remained elusive (Hughes, 1988). It was only with the increase in use of indoor plumbing in these countries, that toilet paper use increased and grew and the use of toilet paper was socialised and localised. By 1919, toilet paper had become an important commodity in the paper market, with the USA reporting in 1879 that 4,063 tons of tissue paper had been produce that year (Hughes, 1988).

Despite a century of use of toilet paper, the widespread acceptance and open discussions of the product is a recent entry to society. For many years the term 'toilet paper' was frowned on and terms such as "bathroom tissue" was used (Hughes, 1988). Although the term 'toilet paper' can now be widely used, advertisements still only refer to the softness or colour of the paper and hardly every market the product based on its intended purpose (Hughes, 1988).

Today however, the toilet paper innovation flourishes, with this product found in almost every toilet facility across the globe. The lack thereof or hint of shortage can lead to panic, as was demonstrated at the start of the COVID-19 pandemic. Wet WASH sanitation systems without the toilet paper innovation would still be plagued by blockages and dysfunction. Similarly, a lack of the toilet paper innovation would remove one of the primary barriers in the faecal-oral routes of sanitary disease transmission. Despite this Wet WASH innovation being socialised and localised across the globe, it does still experience some stigmas, particularly related to research and discussion of its intended purpose, i.e. anal cleansing.

Personal hygiene input in the WASH value chain also includes the materials required to practices safe and hygienic **menstrual health**. These materials are vital to women and girls to be able to practice safe and hygiene menstruation. Menstrual health (MH) have been defined to encompass both menstrual health management (MH) and the broader systemic factors (Tellier and Hyttel, 2017, UNICEF, 2019, WHO/UNICEF, 2012), while the menstrual health management (MH) component of MH has been associated with the management of menstrual process by ensuring that all women and girls have access to (WHO/UNICEF, 2012):

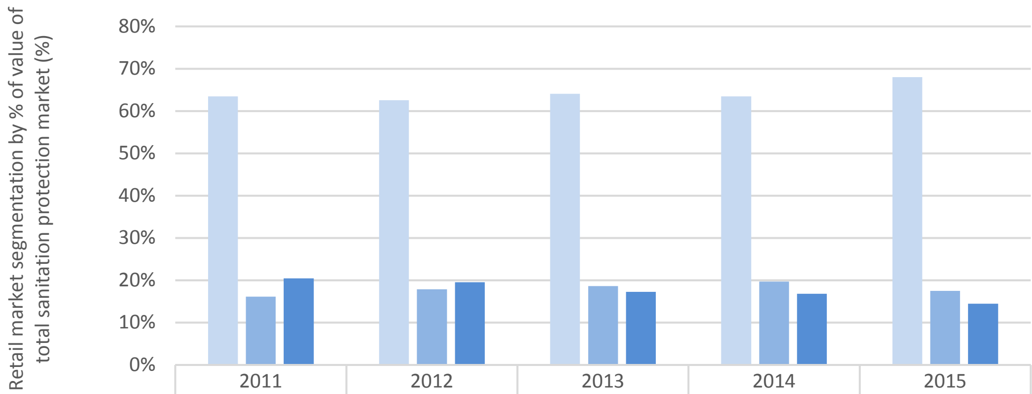
- **menstrual health products** such as sanitary pads, tampons, reusable pads, menstrual cup, etc.;
- **a private place**, such as a toilet facility or washroom, where the materials can be changed in privacy;
- **hygiene materials** such as soap and water;
- **disposal facility** such as bins or incinerators; and
- **knowledge** of the menstrual cycles and how to practice safe and hygienic MHM.

All of the above are inputs required into a sustainable Wet and Dry WASH value chain. Underpinning all these MH requirements is the need for a strong enabling environment (policy, legislation, strategies, standards, etc.) to guide and encourage investment and action to achieve universal and equitable access MH for all in a country. This enabling environment needs to include strong political commitment and will to address MH gaps and challenges, a sound policy and legislative environment to guide and regulate MH actions and enablers such as strategies and budgets.

All the MH inputs to the Wet WASH value chain have scope for innovation and disruption of the personnel hygiene component of the value chain. However, despite menstrual products, such as the sanitary pad innovation that was first introduced into the personal/feminine hygiene market in the 1930s, the sanitary products market has remained relatively consistent over the years, with new innovations and investments being limited chiefly to (Tellier and Hyttel, 2017):

- improving the product range (pads with wings);
- improving quality (changes to the materials used in a pad);
- improving safety (introduction of standards for products); and
- increasing availability (expansion of the reach of these products).

The market did however, see the introduction of the innovation of the tampon to the already existing market of disposal pads (Tellier and Hyttel, 2017). Despite the introduction of the tampon as a new innovation, Figure 14 shows that the market segment of these products still remains small in comparison, at 15% of the market in 2015 (Mintel, 2016).



	2011	2012	2013	2014	2015
Pads/towels	0,63	0,63	0,64	0,64	0,68
Liners	0,16	0,18	0,19	0,20	0,17
Tampons	0,20	0,20	0,17	0,17	0,15

Figure 14: Size of the menstrual product market segment, 2011-2015, in South Africa (taken from Mintel (2016))

More recently, there has been growing innovation and investment in the menstrual cup, the reusable pad, and the biodegradable pad in the menstrual health products markets.

The menstrual cup, typically made of medical-grade silicone, is a non-absorbent bell-shaped device that is inserted into the vagina to collect menstrual flow (UNICEF, 2019). It creates a seal and is held in place by the walls of the vagina (see Figure 15a example) (UNICEF, 2019). This innovation is still challenged related to mass localisation and deployment. Women and girls remain hesitant to utilise the product and require additional knowledge and information to accept and utilise the innovations. Uptake is increasing and more organisations are producing and marketing these products each year.

a)  b)  c) 

Figure 15: Example of the personnel hygiene innovations in the Wet WASH value chain, showing (a) the menstrual cup and (b) reusable pads and (c) banana fibre sanitation pad[1].

The global trend towards environmentally friendly and more sustainable options have created the market for biodegradable menstrual products, with a number of new menstrual pad being introduced to the market that have been manufactured from natural fibres from sources such as banana and sugarcane plants (see Figure 15c for example). The biodegradable/compostable menstrual products market is still an emerging market, particularly in South Africa, with scope for expansion and further research required to grow and expand this market in the MH arena.

The introduction of SANS standards for the reusable pads market (see Figure 15b for example) in the country has been seen as a positive enabler to this component of the value chain and the sector expects that with the standards, product quality will be ensured, and more new entrants will emerge to grow this component of the WASH value chain.

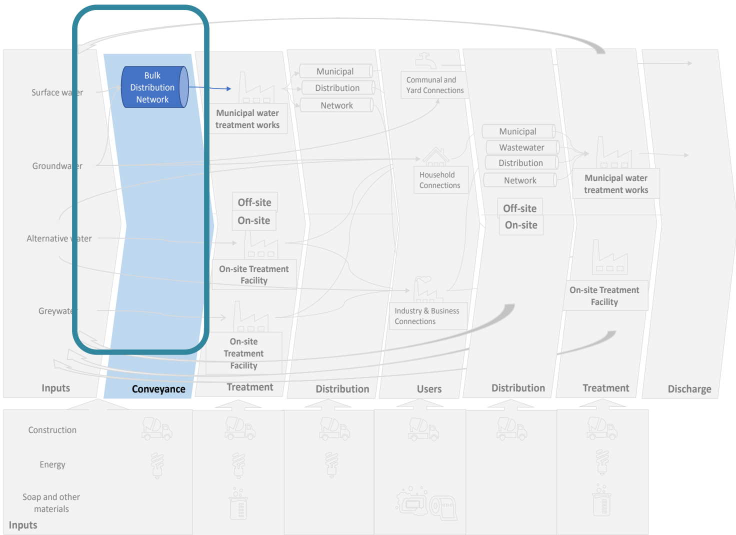
[1] https://www.huffingtonpost.co.uk/2018/03/23/banana-tree-sanitary-pads-are-changing-lives-in-rwanda_a_23393484/

Knowledge technologies innovations, such as menstrual calendar and trackers apps (i.e. Oky), have also been developed (Tellier and Hyttel, 2017).

Similar to the soap market, the menstrual health market is largely dominated by international organisations and is a very crowded market segments, i.e. disposal pads and tampons. Deployment of innovations with a very similar purpose, such as the biodegradable and reusable pad, is impacted by this crowding and domination. It requires a change in preference by end-users and a shift in MHM product norm. This is not an easy shift to the new innovations – the product must often focus on being cheaper, more attractive than the existing product, easier to use, etc. Introducing vastly new (disruptive) innovations, such as the menstrual cup, are even more challenging to disperse, socialise and localise in these crowded markets, especially for the SMMEs that have researched and developed these products.

3.1.1.2 Innovation in Water Conveyance in the Wet WASH Value Chain

The second pillar of the Wet WASH value chain is the conveyance of water from the water source to water treatment facilities, chiefly bulk water systems. This pillar is largely characterised by bulk water transport and storage prior to reaching the water treatment works. Innovations in this Wet WASH pillar focus on innovations related to water extraction, water pumps, bulk water piping and water storage innovations. Leak detection and monitoring processes innovations also form part of this pillar of the value chain.



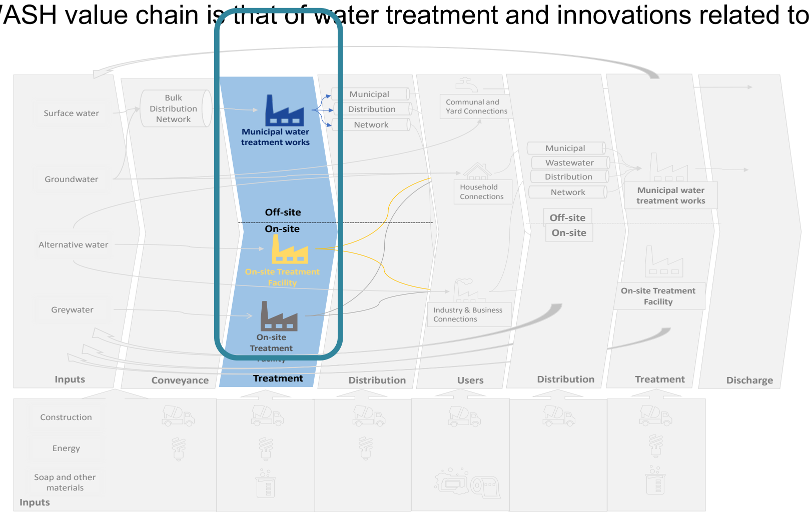
See Box 7 for examples of innovations.

Box 7: Examples of innovations on water conveyance systems

Real-time leak detection: The UCT in partnership with Stellenbosch University have developed a technology, which has undergone field trials, to assess water network condition and assists to detect and isolate water leaks (DST, Undated-a). The technology collects information on multiple relevant parameters such as pressure, leak information, as well as geographical information, inspection information and other associated maintenance information relevant to the management of the piping network (DST, Undated-a). The data is captured in real-time and communication via wirelessly systems to a cloud-based information management system (DST, Undated-a). Municipalities, regional and national water network managers can use the innovation to obtain a daily view of leaks in specific sections of large distribution networks (DST, Undated-a). Data is sent to control rooms and important infrastructure management decisions can be made based on credible data (DST, Undated-a). The system is able to detect very small leaks in an isolated pipe segment – typically leaks as small as 2 L/h where current solutions can only do a minimum of 200 L/h.

3.1.1.3 *Innovation in Water Treatment in the Wet WASH Value Chain*

The third component of the wet WASH value chain is that of water treatment and innovations related to this component.



Gehrke et al. (2015) indicated that *there is a significant need for novel advanced water technologies, in particular to ensure a high quality of drinking water, eliminate micropollutants, and intensify industrial production processes by the use of flexibly adjustable water treatment systems*.

Apart from water treatment chemical innovation as inputs to treatment water sources to potable SANS241 levels in the country, the water treatment pillar of the Wet WASH value chain can and should also demonstrate innovations related to:

- energy efficiency in the treatment of the input water; and
- process efficiency in the treatment of the input water (i.e. chemical minimisation).

The Department of Water and Sanitation indicated that South Africa had over 1,150 drinking water treatment works (WTWs), mostly owned by municipalities, but also by water boards or privately owned, and that water leaving these sites for distribution to end-users needs to meet SANS241 standards in South Africa (DWS, 2020). These standards provide the parameters and limits for drinking water provided by a municipality, with the municipality required to test and report results of water quality testing within their jurisdiction.

The most commonly used water treatment process in South Africa is based on the use of chlorine as the disinfectant, supported by mixing, coagulation and flocculation process. Modern water treatment technologies also include the use of ozone, ultraviolet light and membrane technology.

Innovations in this pillar of the Wet WASH value chain do seem to be limited, with the innovations required to ensure that outputs meet SANS241 specifications, as well as any other standards related to the innovation, i.e. construction standards or materials standards (see Box 8 for water treatment innovation examples).

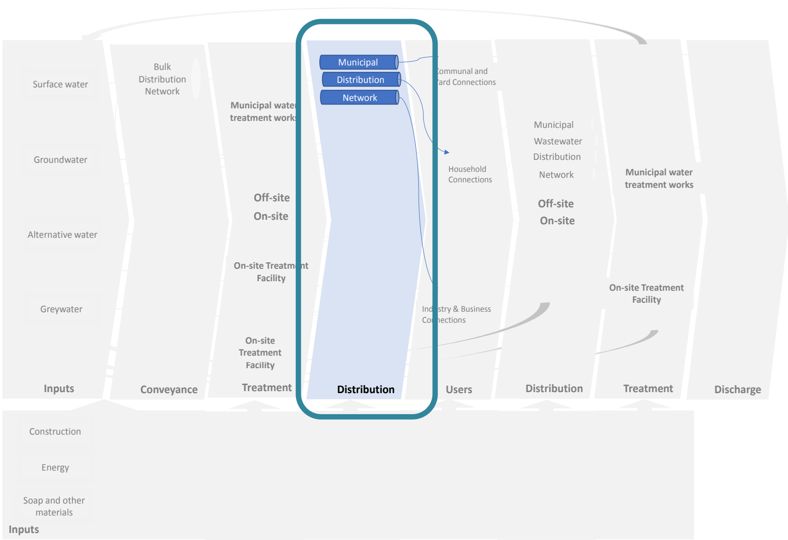
Box 8: Examples on innovations in treatment of water in the Wet WASH value chain

Some of the latest innovation in the water treatment arena include the following:

- **Nanotechnology for water treatment:** the adaptation of highly advanced nanotechnology to traditional process engineering offers new opportunities to advanced water and wastewater technology processes (Gehrke et al., 2015). Nanoengineered materials, such as nano-adsorbents, nanometals, nanomembranes, and photocatalysts, that are compatible to existing water and wastewater treatment technologies offer the potential for novel water technologies that can be easily adapted to customer-specific applications (Gehrke et al., 2015). Nanomaterials has been shown to have higher process efficiency due to their unique characteristics, such as a high reaction rate. South Africa has become a global player in research and development of nanotechnologies for better drinking water quality, including research and development related to metal and bimetallic nanoparticles, nano-sponges and carbon nanostructures (Lukhele et al., 2010). The research is enabled by the National Nanotechnology Strategy of 2006. However, despite millions of dollars spent of research across the globe, many countries have no specific regulation for nanomaterials in the respective laws and many of the technologies have yet to be adapted for upscaling and deployment to be competitive with conventional treatment technologies (Gehrke et al., 2015).
- **Acoustic nanotube technology**
- **Photocatalytic water purification technology**
- **Aquaporin Inside™ technology**
- **Automatic Variable Filtration (AVF) technology**

3.1.1.4 Innovation in Water Distribution in the Wet WASH Value Chain

The fourth pillar of the Wet WASH value chain is that of the distribution of the treated water.



The distribution network is largely the network of piping that connects the water treatment works to the end-user (i.e. yard point of a household, business or industry). Innovations in the water distribution pillar of the value chain are thus focussed on water storage, piping and innovations in ensuring sustainability and ongoing operation of these piping network. Real-time leak detection technologies and monitoring systems are one such innovation (see Box 9).

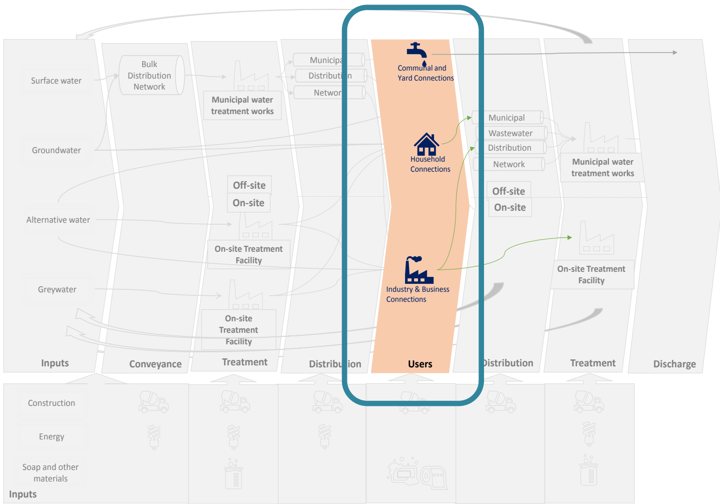
Box 9: Example of innovation in the Wet WASH municipal water storage and distribution network

Advanced Metering Infrastructure (AMI) Systems: as mentioned above, one of the disruptive technologies of the Wet WASH value chain are AMIs that are computerized systems, which gather, process and analyse real time data of the water use in a given area serviced by the water utility. South Africa has a number of these technologies, including:

- OUtility's GaugeIT Smart Water Meter – designed to detect leaks;
- RouteMaster TM and SMART Meter for water meter readings;
- Kamstrup Smart Water Meter;
- XLink/WRP metering system; and
- Water Management Device (WMD), utiliMeter and Aquadata from Utility Systems

These technologies focus on leak detection in the network but also on efficient metering of water use by the end-user.

3.1.1.5 Innovation for Water Users in the Wet WASH Value Chain



End-users of municipal water services are largely households, industries and businesses. The composition of each user group varies by municipality and the percentage use by these groups and the type and quality discharge from these users is thus largely specific to a municipality. By-laws in a municipality are utilised to regulate water users and waste use in a municipality, and thus determine innovations in their jurisdiction. Bylaws need to adhere to national policies and legislation, as well as national standards such as water quality standards SANS 241.

Innovations at the end-use interface are discussed in some detail above, for example under the construction and hygiene inputs sections.

It should be noted that the end-user localisation and deployment of wet WASH input, are the focus of this pillar. This is the pillar in which the end-user experiences the input or innovation and will like/dislike and choose to use the innovation. This end-user interface is in fact the key to mass deployment of any innovation – if the user needs, likes and/or prefers the input/innovation it is likely that they will accept the input/innovation and localise it as part of the wet WASH value chain. Choice drives this pillar and choices often appear to be highly situational or context-dependent, with the way in which a choice is posed, the social context of the decision, the emotional state of the decision-maker, the addition of seemingly extraneous items to the choice set, and a host of other environmental factors appearing to influence choice behaviour (Levin and Milgrom, 2004). At the same time, it should be noted that choice of end-user can often not be considered choices but rather based on intuitive reasoning, heuristics or instinctive visceral desires (Levin and Milgrom, 2004). That people rely on intuition in choice, including choice in inputs into the wet WASH value chain, is not surprising as it is simply not possible to reason through every decision that is made on a daily basis (Levin and Milgrom, 2004). Challenges of choice can thus have a significant impact on whether an innovation disperses into a community and becomes socialised and localised.

Innovations in this pillar are the value chain are discussed in the input section of the Wet WASH value chain.

3.1.1.6 Innovation in Wastewater Conveyance in the Wet WASH Value Chain

The fifth pillar of the Wet WASH value chain is that of the wastewater conveyance network, from the user to the wastewater treatment works. The type and extent of the distribution network from the user would largely be determined by where the wastewater treatment works (WWTW) is situated. WWTW may be municipal systems that are centralised and treat wastewater off-site from the users. These off-site WWTW require extensive networks of pipes to carry the wastewater form the user to the central WWTW.

The second option of distribution networks for wastewater is that for on-site treatment. In this system, the wastewater is distributed through on-site networks of pipes to be treated on-site. The distribution network may have separate pipes for the various type of wastewater or may be a single-pipe systems as utilised in the municipal wastewater networks.

Similar to the water conveyance network, innovations in this pillar would related largely to innovations in piping such as dual piping system, shallow sewer systems, leak detection in sewer networks and ensuring sustainable operation of the network. Hence, innovations in this pillar would need to adhere to SANS and national building standards for piping and piping networks.

Some examples of innovations are provided in Box 10.

Where end-users have on-site treatment of wastewater, the innovative wastewater distribution systems, such as on-site dual systems for sewage and greywater, may return wastewater to the onsite treatment facilities (see next section) for reuse by the household within their water system, i.e. flushing of toilets. Similarly, where industry is able to treat wastewater streams through on-site treatment facilities (see next section for more detail), so this water can be recycled back into the industries water system. Distribution would thus be the dual piping network to convey different used waters from the user and to the user. The distribution network is however, focus on on-site distribution and piping networks.

Box 10: Examples of innovations in wastewater conveyance systems

Simplified/Shallow sewer systems in South Africa: The shallow sewer concept has been successfully implemented in Brazil, Greece, Australia, USA, Bolivia, India and has become the norm in Pakistan (Eslick and Harrison, 2004). It is deployed as a practical, low cost solution for waterborne sewage within highly dense, informal communities (Eslick and Harrison, 2004). A shallow sewer system is constructed using smaller diameter pipes laid at a shallower depth and at a flatter gradient than conventional sewers (CSIR, 2019). Many of the conventional sewer design standards, such as minimum diameter, minimum slopes and minimum depths are relaxed in shallow sewer systems, and community-based construction, operation and maintenance are allowed (CSIR, 2019). A shallow sewer systems was piloted by the eThekwini Water Services (EWS), in a joint venture with Water and Sanitation Services (South Africa) (WSSA) and the Water Research Commission (WRC) in the early

2000s, with the purpose of the pilot to investigate whether Shallow Sewers could provide a viable alternative waterborne sanitation system to the urban poor in dense settlements (Eslick and Harrison, 2004). Eslick and Harrison (2004) concluded, related to the pilot study, that *at this point in South Africa's development, Shallow Sewers in its pure form (i.e. as intended by the La Paz model) are not applicable to the country in general, although there may be instances where it may work to a degree. This is concluded primarily because:*

a) of the mismatches between communities' expectation that the "government will provide" and the self-help tenet of the Shallow Sewers;
b) the governments assuming that rapid infrastructure development and community social upliftment are concordant;
c) the legal conflict between the private land tenure and communal ownership of fixed property on that land; and
d) the institutional arrangements at local government are not structured for interdisciplinary community development (Eslick and Harrison, 2004).

The Kosovo vacuum sewer systems: this system make use of a combination of gravity and differential air pressure as the driving force that propels sewage through the sewer network (CSIR, 2019). Vacuum sewer systems consist of three key components (CSIR, 2019):

- collective chambers;
- vacuum sewers; and
- the vacuum station.

South Africa's first vacuum sewerage system was completed in Kosovo, an informal settlement in Cape Town, in February 2009 (Taing et al., 2011). Although hailed as a good option for sanitation system in the area, the vacuum sewer proved problematic, being continuously blocked by gross solids in its collection chambers (Taing et al., 2011). The disposal of items such as cutlery and bricks into the vacuum system by the residents quickly resulted in some interface valve diaphragms being pierced by sharp objects whilst some sumps were filled with gross solids (Taing et al., 2011). The authors of the pilot of the system concluded that *considered in retrospect, it is evident that Kosovo's vacuum system was bound to fail as implemented because it did not adequately address the technological challenge of managing blockages, it failed to adequately consider the social context, the CoCT lacked O&M knowledge and an enabling environment to effectively plan and manage new technology, and inconsistent project leadership left no one immediately accountable to manage the infrastructure* (Taing et al., 2011).

3.1.1.7 Innovation in Wastewater Treatment in the Wet WASH Value Chain

The seventh pillar in the Wet WASH value chain is that of disinfection and treatment of wastewater. Ensuring the quality of water resources in the Wet WASH value chain depends on the monitoring and control of pollution sources and discharges. Contaminated water bodies pose risks to human health, as well as to the functioning of ecosystems. Uncontrolled discharges of wastewater from the end-users in the Wet WASH value chain can result in contamination of drinking water sources, the overloading of water bodies with organic matter (causing eutrophication), and the accumulation of heavy metals and other pollutants.

Wastewater treatment can be on-site treatment with specialised treatment facilities or can occur off-site at sites such as the municipal wastewater treatment works. Biological techniques are usually used in handling wastewater, with the WWTW commonly comprising aerated lagoons, activated sludge or slow sand filters.

South Africa, in 2018, had over 1,150 municipal wastewater treatment works (WWTW)(DWS, 2018). The Department of Water and Sanitation most recent *National State Of Water Report For South Africa* indicated during the year 2020, 144 Water Services Authorities (WSAs) were monitored for the Green and Blue Drop performances, of which (DWS, 2020):

- only 60% of the WSAs achieved good to excellent wastewater physical compliance;
- only 51% achieved good to excellent wastewater chemical compliance,
- only 45% of the WSAs with available data managed to show a good to excellent wastewater microbial compliance.

The DWS, in the same report, concluded that *the wastewater quality compliance by WSAs throughout the country remains poor as most treatment plants have digressed in terms of operational flows to the facilities, effluent monitoring, quality, and technical skills. Most WSAs are to be put under regulatory surveillance* (DWS, 2020). The report also indicated that *in terms of sanitation infrastructure, 56% of the municipal wastewater treatment plants are in a poor to critical condition and are discharging poorly treated effluent into watercourses (DWS, 2020).* South Africa has a serious challenge related to treatment of the wastewater that is reaching municipal WWTW.

An alternative to the municipal wastewater treatment works is the innovation of on-site treatment of wastewater. A range of innovations exist related to this process, with this pillar of the value chain demonstrating growing research and innovator interest in recent years.

See Box 11 for examples of wastewater treatment innovations.

Box 11: Example of wastewater treatment innovations, internationally and in South Africa

Wastewater Treatment Innovations in the USA: To meet the challenge of keeping progress in wastewater pollution abatement ahead of population growth, changes in industrial processes, and technological developments, the EPA provided in 2013, a document that highlighted the most recent information available on advances and innovative techniques in WWT in the USA (EPA, 2013). The report provided, in Table 2, details of research, emerging and innovative technologies for WWT, categorising these as (EPA, 2013):

- Research (R) – technologies in the development stage and/or have been tested at a laboratory or bench scale only;
- Emerging (EI) – technologies that have been tested at a pilot or demonstration scale or have been implemented at full scale in 3 or fewer installations or for less than 1 year; and
- Innovative (IT) – technologies that have been implemented at full scale for less than five years, or have some degree of initial use (i.e. implemented in more than three but less than 1 percent of US treatment facilities).

Perhaps the most interesting aspect of the document is that, despite the USA having over 14,000 WWTW in 2008, limited research, emerging and innovative technologies were captured in the report (EPA, 2013).

Table 2: Details of research, emerging and innovative technologies for WWT in the USA in 2013 (taken from EPA (2013)).

Type of Process	Type of technology	Technology	Application of the technology						
			C-BOD Removal	Phosphorus Removal	Nitrification-Ammonia Removal	Denitrification – Nitrogen	Solids – Liquid Separation	Targeted Contaminants Removal	Disinfection
Biological Treatment	**Bioaugmentation**								
	IT	**– External Bioaugmentation**	x		x	x			
	IT	– Seeding from Commercial Sources of Nitrifiers	x		x	x			
	IT	o In-Pipe Technology	x		x	x			
	IT	o Trickling Filter and Pushed Activated Sludge (TF/PAS) Process	x		x	x			
	IT	o Seeding from External Dispensed Growth Reactors Treating Reject Waters (Chemostat Type)	x		x	x			
	IT	o In-Nitri® Process	x		x	x			
	IT	o Immobilized Cell-Augmented Activated Sludge (ICASS) Process	x		x	x			
	IT	o Seeding from Parallel Processes	x		x	x			
	IT	o Seeding from Downstream Process	x		x	x			
		– In Situ Bioaugmentation							
	IT	o DE-nitrification and Phosphate accumulation in ANOXic (DEPHANOX) Process	x		x	x			
	IT	o Bio-Augmentation Regeneration/Reaeration (BAR) Process	x		x	x			
	IT	o Bio-Augmentation Batch Enhanced (BABE) Process	x		x	x			
	IT	o Aeration Tank 3 (AT3) Process	x		x	x			
	IT	o Main stream Autotrophic Recycle Enabling Enhanced N-removal (MAUREEN) Process	x		x	x			
	IT	o Regeneration DeNitrification (R-DN) Process	x		x	x			
	IT	o Centrate and RAS Reaeration Basin (CaRRB) Process	x		x	x			

Type of Process	Type of technology	Technology	Application of the technology						
			C-BOD Removal	Phosphorus Removal	Nitrification-Ammonia Removal	Denitrification – Nitrogen	Solids – Liquid Separation	Targeted Contaminants Removal	Disinfection
		Nitrogen Removal							
	IT	Deammonification (Sidestream)	x		x	x			
	IT	Nitritation and Denitritation (Sidestream)	x		x	x			
	ET	OpenCel Focused Pulse			x				
		Nitrogen and Phosphorus Removal							
	ET	Integrated Fixed-film Activated Sludge (IFAS) with Biological Phosphorus Removal	x		x	x			
		Small Site							
	IT	Deep-Shaft Activated Sludge/VERTREAT™	x						
		Solids Minimisation							
	IT	Cyclic Metabolic Environment	x	x	x	x			
	ET	Multi-Stage Activated Biological Process (MSABP™)	x		x	x			
		Solids Settleability							
	IT	Magnetite Ballasted Activated Sludge	x	x	x		x	x	
	ET	Aerobic Granular Sludge Process (AGSP)	x	x	x	x			
		Membrane Processes							
	ET	Membrane Biofilm Reactor (MBfR)	x	x	x	x	x		
	ET	Vacuum Rotation Membrane (VRM®) System	x	x			x		
		Anaerobic Processes							
	R	Anaerobic Migrating Blanket Reactor (AMBR®)	x						
	R	Anaerobic Membrane BioReactor (An-MBR)	x	x					
		Electricity Generation							
	R	Microbial Fuel Cell (MFC) Based Treatment System	x	x					
Physical/Chemical Treatment Processes		**Alternative Disinfectants**							
	ET	– PAA – Peracetic acid							x
	ET	– BCDMH							x
		Nutrient Removal							
	IT	Blue PROTM Reactive Media Filtration		x			x		
	IT	Phosphorus Recovery (Struvite or Calcium Phosphate Precipitation)		x	x		x		
	ET	Ammonia Recovery Analyzer						x	
		Solids Removal							
	IT	Compressible Media Filtration (CMF)	x	x			x		
	IT	Magnetite Ballasted Sedimentation		x			x		
	IT	Multi-stage Filtration		x			x		
	IT	Nanofiltration and Reverse Osmosis		x			x	x	
		Oxidation							

Type of Process	Type of technology	Technology	C-BOD Removal	Phosphorus Removal	Nitrification-Ammonia Removal	Denitrification – Nitrogen	Solids – Liquid Separation	Targeted Contaminants Removal	Disinfection
			Application of the technology						
	ET	Blue CATTM					x	x	x
	Preliminary/Primary Treatment								
	ET	Salsnes Filter							

R = Research – Technologies in the development stage and/or have been tested at a laboratory or bench scale only.
ET= Emerging – Technologies that have been tested at a pilot or demonstration scale or have been implemented at full scale in 3 or fewer installations or for less than 1 year.
IT = Innovative – Technologies that have been implemented at full scale for less than five years, or have some degree of initial use (i.e. implemented in more than three but less than 1 percent [150] of US treatment facilities).

Off-site: Sanitech Portable Modular WWTW. Sanitech has development and marketed a portable modular wastewater treatment plant with a treatment capacities ranging from 50 m³ to 350 m³ per day (Sanitech, undated). Due to their unique composite design, these wastewater treatment plants can withstand environmental conditions both above surface and underground (Sanitech, undated).

Figure 16: Image of the Santech modular, portable WWTW (taken from Sanitech (undated))

Sanitech also supplies Industrial Water Package Plants and Sewage Treatment Package Plants.

On-site: Spier Hotel Wastewater Treatment: Spier Hotel in the Western Cape introduced over the years a wastewater treatment plant, that received effluent from the restaurant, winery, laundry, the Dewcrisp food packaging facility and hotel, houses, staff and public ablution areas (HWT (Pty) Ltd, Undated). The wastewater from these sources was pumped to the treatment plant, where a combination of an activated sludge system and indigenous wetland is utilised to treat the wastewater (HWT (Pty) Ltd, Undated). Hence the wastewater in the Spier facilities is 100% recycle. Installed a decade ago, the plant processed up to one million litres at any given time and produces 50 million litres of clean water annually. The treated water was used on-site for flushing toilets in the estate's busiest washrooms and to irrigate the gardens and lawns (Spier, Undated).

On-site: Hotel Verde Cape Town Airport Wastewater Treatment: Hotel Verde situated at the Cape Town Airport had been specifically designed with environmentally sustainable features, including the following:

- A Reverse Osmosis plant to reduce the hotel's dependency on the municipal water supply.
- An energy-efficient greywater system that helps to recycle 6000 litres of water a day. The dual-flush toilet is supplied with biologically recycled grey water from showers and baths (Verde Hotels Undated);
- An ecopool where the pool water was kept clean by circulating through a living ecosystem of aquatic plants (Verde Hotels Undated). No salt, no chemicals or sterilisation systems are used in the eco-pool. It is a closed system, using a natural water treatment system.
- State of the art cooling/heating system that uses heat pumps coupled to 100 boreholes and 11km of geothermal ground loops.

The hotel uses only 35% of water required by a hotel of the similar size, demonstrating a 65% lower water footprint.

3.1.1.8 Innovation in Use, Reuse and Discharge of Wastewater in the Wet WASH Value Chain

The final pillar in the Wet WASH value chain is that of **use, re-use and/or discharge of treated wastewater** – basically to be used as an input into water value chains lower down the water resource, i.e. river, stream, etc. Although innovations related to discharge are not a key focus of the wet WASH value chain, innovations do exist.

Wastewater can, and should, be a source of water within the Wet WASH value chain, emanating from the return (backwards) flow of the other inputs to the value chain, i.e. once the water sourced from surface, ground, alternative and greywater are utilised by the users (i.e. households, businesses, industry in the municipal area) the wastewater that is discharged for these points-of-use can become a new water source for users (i.e. direct reuse on crops or treated and reused by the users or for other purposes). Water reclamation from wastewater is widely practiced around the globe, contributing to reconciling the gap between available water and water demand.

Around the world, several successful cases for reclaimed water reuse exist, such as (WHO, 2017):

- Goreangab Reclamation Plant in Windhoek, Namibia;
- Groundwater Replenishment System in Orange County in California, USA;
- Upper Occoquan Service Authority Potable Reuse Project in Virginia, USA;
- Water reuse in Singapore—NEWater, Singapore;
- Groundwater Replenishment in Perth (Australia);
- Direct Potable Water Reuse in Texas, USA; and
- The eMalahleni Water Reclamation Plant, South Africa.

Reclaimed water used for city park, golf course and sports ground irrigation are commonly practiced in cities in the United States, Europe, Australia, and in South African cities, such as Cape Town. In Australia, the use of reclaimed and recycled water is highly developed, with entire estates and complexes functioning on dual reticulation systems, using reclaimed water for toilet flushing, garden watering, and other non-potable applications (van Niekerk and Schneider, 2013). Table 3 shows the various uses of reclaimed water from wastewater treatment across the globe.

Table 3: Various uses of water reclaimed for wastewater treatment (taken from Ghernaout (2018))

Categories of use	Uses
Urban uses	Irrigation of public parks, sporting facilities, private gardens, roadsides; Street cleaning; Fire protection systems; Vehicle washing; Toilet flushing; Air conditioners; Dust control.
Agricultural	Food crops not commercially processed; Food crops commercially processed; Pasture for milking animals; Fodder; uses Fibre; Seed crops; Ornamental flowers; Orchards; Hydroponic culture; Aquaculture; Greenhouses; Viticulture.
Industrial uses	Processing water; Cooling water; Recirculating cooling towers; Washdown water; Washing aggregate; Making concrete; Soil compaction; Dust control.
Recreational uses	Golf course irrigation; Recreational impoundments with/without public access (e.g. fishing, boating, bathing); Aesthetic impoundments without public access; Snowmaking.
Environmental uses	Aquifer recharge; Wetlands; Marshes; Stream augmentation; Wildlife habitat; Silviculture.
Potable uses	Aquifer recharge for drinking water use; Augmentation of surface drinking water supplies; Treatment until drinking water quality.

Ally and Campbell (2021) highlighted that in South Africa, *treated sewage effluent which meets the DWS general discharge standard in all instances is potentially suitable for all re-use applications, including, in many cases non-potable domestic use*. Swartz et al. (2014) indicated that considerable work is currently being done in South Africa to promote water reuse in its various forms and the different water cycle sectors. Despite these efforts, wastewater reclamation in South Africa is poorly utilised and is currently estimated to be below 14%.

The main source of reclaimed water in the South African municipal areas is wastewater from municipal treatment works, generally used in a number of ways, including for (Swartz et al., 2014):

- industrial purposes;
- agriculture irrigation purposes;
- dual pipe systems in waterborne systems; and
- direct and indirect potable uses.

Apart from reuse of the water from the sewers in the country, another output of the Wet WASH value chain is the **faecal sludge**. Since sludge from municipal wastewater works comprise large amounts of organic materials, and some plant nutrients, it can be beneficially used as a soil conditioner. An alternative to treatment of faecal sludge for disposal, is the treatment of sludge (largely the biomass) for reuse (Rao et al., 2016). The biomass in faecal sludge can be beneficiated into a useful product through a thermal process, using a range of technologies and treatment temperatures (Novotny et al., 2015). These thermal processes can be roughly classified in three main groups: pyrolysis, gasification and combustion. Figure 17 demonstrates the options offered from faecal sludge reuse, based on various content streams, i.e. water, organic matter and nutrients. The chief reuse beneficiation options are through the production of energy, provision of nutrients for soil conditioning and reuse of the water content. Innovations in this pillar of the Wet WASH value chain would focus on innovations to provide one or more of these products that can be reused in the value chain.

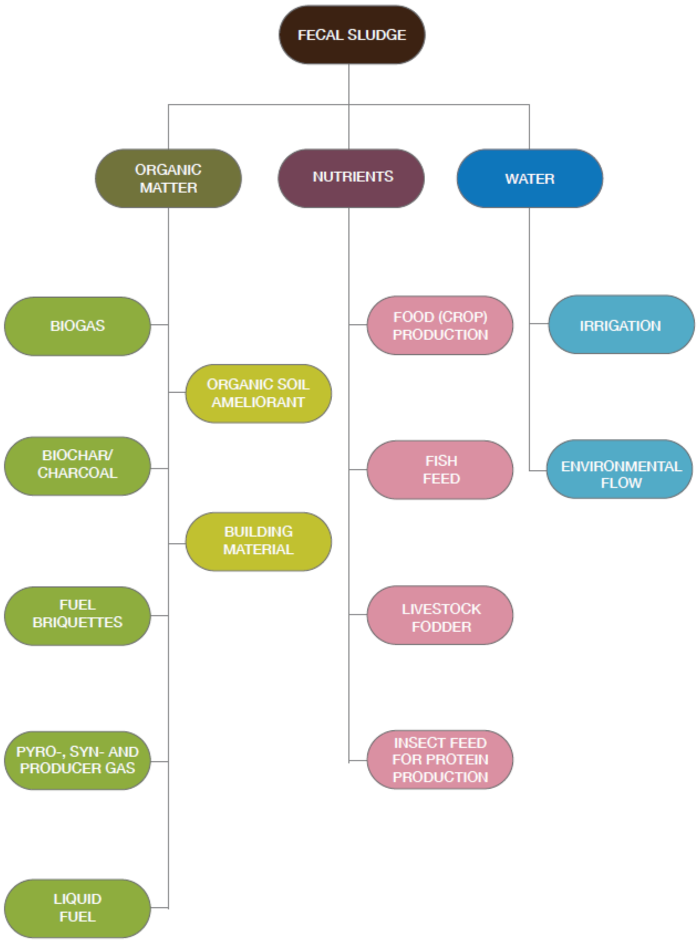


Figure 17: Resource Recovery And Reuse Options For Faecal Sludge (Rao et al., 2016)

Research has shown that sludge has been used not only for the manufacture of products shown in Figure 17, but for making of bricks or tiles, paving, artificial rocks, and used as a raw material for the production of cement, concrete and mortar. Research was also conducted on biotechnology innovations to produce biodegradable plastics from polyhydroxyalkanoates (PHA) in WWTP biomass (Arcos-Hernándeza et al., 2015, Pittmann and Steinmetz, 2017). Noting that many countries are moving to the use of bioplastics and banning the use of plastics made from petroleum materials, this finding is significant and an opportunity for the wastewater reuse sector of the Wet WASH value chain.

See Box 12 for innovations in the reuse or use of wastewater and faecal sludge

Box 12: Examples of treated wastewater and sludge innovations in the Wet WASH value chain

Reuse of treated wastewater: Ally and Campbell (2021) indicated that municipal water reuse projects that are operational in South Africa in 2021 were the following (taken from Ally and Campbell (2021)):

- A direct potable reuse project in Beaufort.
- An indirect potable reuse for surface water recharge in George.
- A project for reuse for industrial purposes in Mossel Bay.
- The reuse for irrigation purposes from the Potsdam WWTP in Cape Town.
- The eMalahleni water reclamation plant (Mpumalanga) that treats mine wastewater for municipal use.
- The Optimum coal water reclamation plant (Mpumalanga) that beneficiates mine wastewater.
- The Outeniqua WWTP where effluent is used to augment surface water resources.

- Direct potable reuse options in Durban (eThekwini Municipality), Port Elizabeth, Cape Town and Hermanus are at advanced planning stages.

The DWS (2020) also indicated that the City of Cape Town is currently implementing a 70 Mℓ/d water reclamation plant at Zandvliet WWTW. The treated water will be pumped to the Faure Water Treatment Works where it will be blended and further treated.

Sludge beneficiation as commercial compost (taken from Ally and Campbell (2021): According to this research report, Sasol was piloting a project to beneficiate sludge from its Sasol's Secunda complex waste streams into compost, to rehabilitate mine dumps, farmlands, and ash heaps (Ally and Campbell, 2021). The project uses specialised microbial populations to target, assimilate and biochemically transform the potentially harmful trace elements found in industrial waste sludges, immobilising them and rendering them environmentally friendly. Sasol intended to have the compost legally classified, as the quality of compost produced from the biosludges tested compared well with that of commercial compost (Ally and Campbell, 2021).

Value-added biopolymers from WWTW sludge: Pilot and prototyping scale investigations have been undertaken in order to evaluate the technical feasibility of producing value-added biopolymers (polyhydroxyalkanoates (PHAs)) as a by-product of wastewater treatment (Arcos-Hernándeza et al., 2015). Bioplastics have in recent year, been used to produce consumer products such as plastic containers, grocery bags and food packaging, with these plastics believed to have a smaller energy footprint and lower impact on the environment. The research on the use of WWTW sludge as PHAs indicated that the piloting process had demonstrated the commercial promise in the polymer quality and that the key challenge going forward was in *social-economic steps that will be necessary to realize first demonstration scale polymer production activities. It is a material supply that will stimulate niche business opportunities that can grow and stimulate technology pull with benefit of real life material product market combinations (Arcos-Hernándeza et al., 2015)*. More recently, research was conducted to the describes the production of polyhydroxyalkanoates (PHA) as a side stream process on a municipal waste water treatment plant (WWTP) and a subsequent analysis of the production potential in Germany and the European Union (EU). This study concluded *that based on the results and detailed data from German waste water treatment plants, showed that the theoretically possible production of biopolymers in Germany amounts to more than 19% of the 2016 worldwide biopolymer production. In addition, a profound estimation regarding the EU showed that in theory about 120% of the worldwide biopolymer production (in 2016) could be produced on European waste water treatment plants (Pittmann and Steinmetz, 2017)*.

3.1.2 Innovations in the Dry WASH Value Chain

The second value chain in the WASH water services sector of South Africa is the Dry WASH value chain (Figure 18). Although the Dry WASH value chain's name implies that no water is utilised in this value chain, this is an incorrect assumption. The Dry WASH value chain does require some level of water supply, particular to meet hygiene imperatives in the value chain. However, the Dry WASH value chain assumes that the input water will be supplied to a yard or communal tap, where the household does not have in-house water and thus does not utilise water for the operation of the components in the pillars of the value chain.

The Dry WASH value overlaps with the Wet WASH value chain in many of the construction inputs and hygiene inputs.

Each of the pillars and components of the Dry WASH value chain are discussed in the section below. Figure 18 demonstrate that the pillars of the Dry WASH value chain include the following:

- Inputs of limited water, construction and other materials and hygiene materials.
- The resource (urine and faeces) containment pillar.
- The user interface pillar.
- The resource emptying/collection pillar.
- The resource transport pillar.
- The resource treatment pillar.
- The resource use, reuse and disposal pillar.

Innovations have been deployed, socialised and localised in all these pillars with varying levels of success.

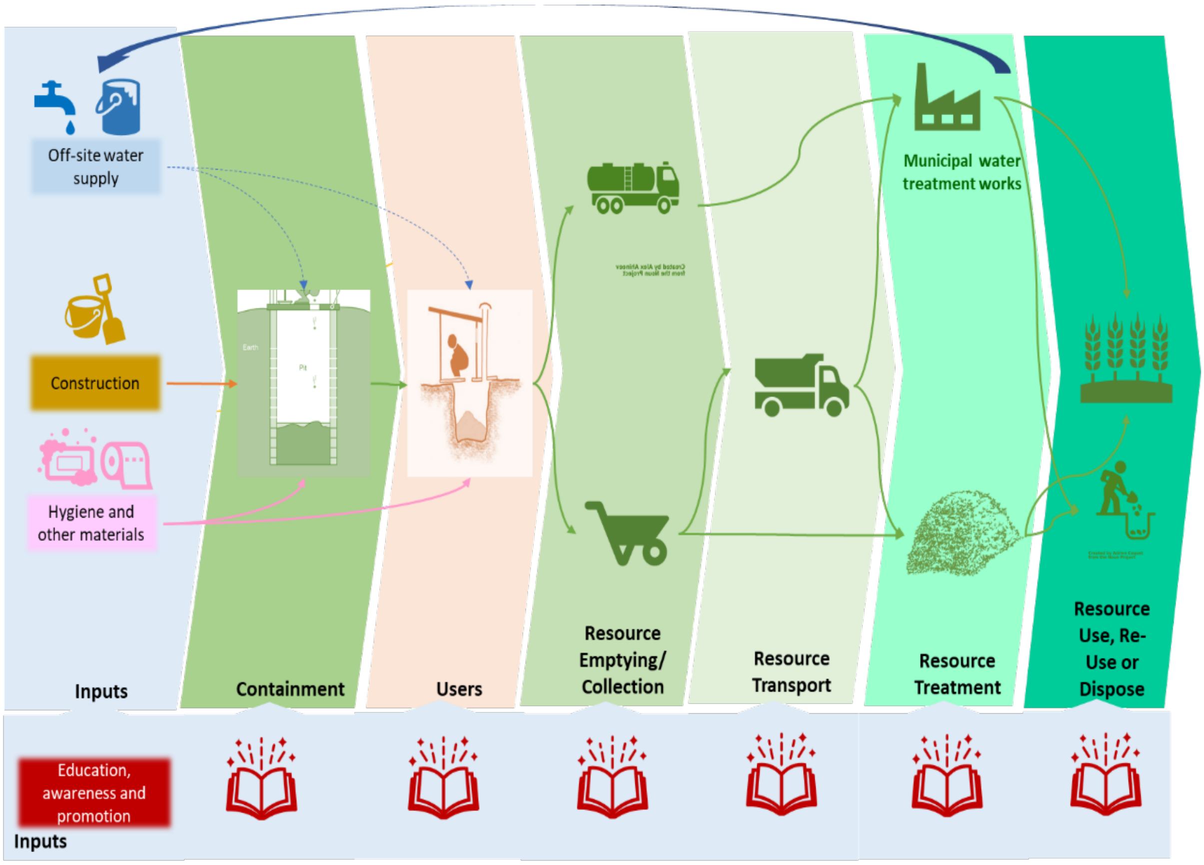


Figure 18: Diagrammatic depiction of the Dry WASH value chain

3.1.2.1 Innovation in the Inputs into the Dry WASH Value Chain

There are significant overlaps in **inputs** into the Dry WASH and the Wet WASH value chains. Many of the inputs in the Wet WASH value related to construction, installation materials hygiene materials, and innovations related to these, are currently inputs into the Dry WASH value chain.

The Dry WASH value chain has a strong additional input of WASH education, awareness, and promotion. Although this input, and its related innovations are discussed in the Dry WASH value chain, it should be noted that WASH education, awareness and promotion inputs should, in fact, be included in the Wet WASH value chain. Currently, this area of inputs and innovation in the Wet WASH value chain is limited, or in many cases, ignored.

Innovative Construction and Installation Materials Inputs

Construction materials such a brick, mortar, piping, etc., required to construct a dry sanitation system are inputs into the Dry WASH value chain. Examples of Dry WASH construction and installation materials innovations are shown in Box 13 below. Innovations have largely focussed on modifications to the Ventilated Improved Pit toilet, Urine-diverting Dry Toilet (UDDT or UD) and the new generation of closed-loop sanitation systems that are water operated but are not connected to the water reticulation or wastewater networks.

Box 13: Examples of Dry WASH materials and construction innovations

Precast Ventilated Pit Toilet: Introduced to the South Africa's sanitation market in the early 1990s, the precast sanitation facilities have become a common site across rural landscapes of the country (see Figure 19a and b for examples). The facilities are assembled from precast slabs, making the installation relative quick when compared to the more traditional brick or block structures. The innovation is not in the type of toilet that is installed but rather in the material that is utilised to install the toilet and the process for installation. The innovation has been adopted and introduced by a number of organisations in the country and has been socialised and localised in the sanitation sector of the country.

(a)  (b) 

Figure 19: Examples of precast VIPs (a) ConcreTex[2] and the Amalooloo[3]1

Urine-diverting Dry Toilet Pedestal: Most UDUT pedestals utilise a partitioned toilet bowl for separation of urine and faeces, however Rieck et al. (2012) indicated that the design of these pedestals in the South Africa UDDT sector is innovative in *that the pedestal is designed so that urine that comes in contact with the wall of the bowl is directed via wall adhesion to a trough at the bottom of the pedestal that leads to the outside*.

Reinvent the Toilet Challenge (RTTC): The Bill & Melinda Gates Foundation has inspired a wave of research on next-generation on-site sanitation technologies, with the specifications that the technology operate off-grid (i.e. without external water supply and sewers), recover resources from toilet waste, and ideally, cost less than USD 0.05 per person per day (Sutherland et al., 2021a). Prototypes of these technologies are being field-tested in peri-urban areas, informal settlements and research institutions in South Africa and India (Sutherland et al., 2021a). In South Africa, an Engineering Field Testing Platform (EFTP), funded by the Gates Foundation, was established in 2017 in the eThekwini Municipal Area (Durban) for testing of these prototypes. Early field-testing of prototypes, from laboratory-based prototype demonstration to prototype demonstration in an operational environment in ‘real world’ settings, are expect to assist in developing a final product that is safe, practical, sustainable, affordable, and acceptable to users (Sindall et al., 2021). Between 2017 and 2020, the EFTP tested 15 prototype sanitation systems across 17 different testing sites including (Sindall et al., 2021):

The Blue Diversion Autarky Toilet (BDAT): Tested in peri-urban areas of eThekwini in South Africa, this technology collects water, urine, and faeces separately and treats them onsite in specific modules (Figure 20) (Sutherland et al., 2021a). The BDAT recycles the reclaimed water for toilet flushing, recovers nutrients for fertilizer production and reliably inactivates pathogens (Sutherland et al., 2021a). Sutherland et al. (2021a) concluded from the piloting of the prototype that *the BDAT functioned well and had a high level of social acceptance. The flushing, cleanliness and odour-free nature of the sanitation technology, its functionality, the household's previous sanitation experience, their experience with and understanding of water scarcity, and the way the testing process connected household members on an ongoing basis to the state, are the main factors underpinning their positive responses.*

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2 Taken from https://www.concretex.co.za/sanitation/

3 https://amalooloo.co.za/

Figure 20: Images of the Blue Diversion Autarky Toilet (BDAT) prototype, tested in eThekwini, South Africa (taken from Sutherland et al. (2021a))

NEWgeneratorTM (NG): through BMGF support, the University of South Florida (USF) has developed a compact wastewater treatment system, called the NEWgeneratorTM (NG), that utilises anaerobic membrane bioreactor (AnMBR) technology as the core treatment process (Shyu et al., 2021). The aim of the NG system is to provide safe sanitation as well as the recovery of nutrients, energy, and water as renewable resources from wastewater (Shyu et al., 2021). The NG system is a fully integrated system housed in a mini-shipping container that operates entirely on photovoltaic power (Shyu et al., 2021). Shyu et al. (2021) concluded that *the field trial of the NG system in the eThekwini Municipality revealed the system's strengths as well as areas requiring additional improvement to consistently meet the entirety of the ISO 30500 standard. Future work will include operating the system in a closed-loop mode to provide recycled water to the CAB for toilet flushing. The potential build-up of constituents over extended periods, and the possible impacts on user experience or treatment processes, will be examined*. The technology is thus still in the prototype phase and requires further inputs and research before deployment into the market.

Innovative Hygiene Inputs

Apart for the hygiene inputs that utilise extensive water for operation, all the inputs that are discussed and are applicable in the Wet WASH value chain can be applied in the Dry WASH value chain. Hence, handwashing facilities connected to in-house water supplies would not apply in this value chain. Handwashing facilities that utilise limited water supplies are applicable (see Box 14 for examples). In these innovations, the facilities need to be filled with water from a water supply such as a yard or communal tap.

Box 14: Example of hygiene innovations in the Dry WASH value chain

Handwashing facilities: A range of handwashing innovation are available for use at sanitation facilities that are not connected to a water reticulation system. All these solutions require manual refilling of a tank with water, and thus require a safe source of water nearby (Sutherland et al., 2021b). Figure 21 shows examples of handwashing facilities, showing facilities that utilise a 2 litre cool drink bottle to store water and dispensing water for handwashing from a specialist tap on the cap of the facility, to a similar system where the water is stored in a sealed section of plastic piping to a system that utilises a washing reservoir for storing 10 litre of water, for handwashing.

-  (b)  (c) 

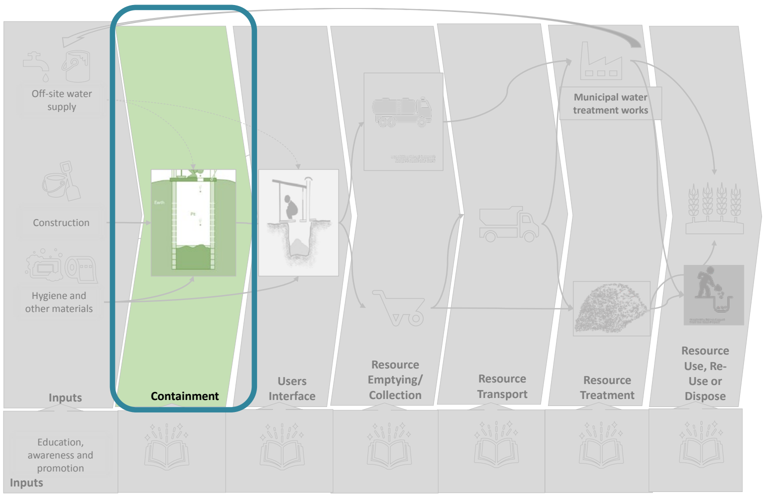
Figure 21: Examples of handwashing innovations that target households with limited access to water for handwashing (taken from Envirosan Sanitation Solutions (Undated))

Autarky (AHWS) handwashing station: Developed by the water research institute Eawag, in collaboration with the design office EOOS and tested in eThekwini South Africa, was shown to be an innovation handwashing technology with potential, as it provides onsite recycling of handwashing water without the need for external water input (Figure 22) (Sutherland et al., 2021b). The technology housed at the back of the AHWS is an on-site water recycling system called the WaterWall, that treats and recycles water for handwashing or toilet flushing without the need for external water input (Sutherland et al., 2021b). Sutherland et al. (2021b) concluded that *the AHWS is a valuable niche intervention for informal settlements and would be appropriate in rural areas and schools in the Global South. The next challenge is to scale up industrial production of this technology and make it commercially viable for implementation both in the Global South and North.*

Figure 22: Example of the Autarky handwashing station tested in eThekwini Metro, South Africa (taken from Sutherland et al. (2021b)

3.1.2.2 Innovations in Containment in the Dry WASH Value Chain

This pillar of the Dry WASH value chain focusses on safe and hygienic containment of human faeces and urine. Since these resources are not combined with water and flushed, as they are in the wet WASH value chain, this pillar of the dry WASH value chain includes innovations for safely 'storing' these resources.



Containment of human faecal and urine matters is largely in two manners, firstly contained together in a pit or vault (i.e. Ventilated Improved Pit toilet) or containment as separate resources (i.e. Urine-diverting Dry Toilet).

The dry sanitation system that is the most utilised in the Dry WASH value chain South Africa is that of the Ventilated Improved Pit toilet (VIP toilet). The VIP toilet is effectively a pit toilet that has a pit that 'stores' human excreta in a safe and hygienic manner and has good ventilation to ensure pests and smell are minimised. The South African VIP is based on the Blair toilet that emerged from the Blair Institution in Zimbabwe in the 1970s. The VIP has seen very little change or innovation since it was first introduced in the country (basically in 1994), with innovations that have taken place focussing on the inputs into the construction of these structures, i.e. pre-caste superstructure, specialist flyscreens, plastic and pre-caste pedestals. Innovations in containment (i.e. pits) have not been a significant area of activity in the dry WASH value chain.

The containment of faeces and urine had however, seen the emergence of innovations to separate resources in a safe and hygienic matter, in the urine diversion toilet. This toilet directs the materials to the different containment compartments of the toilet. The urine-diverting dry toilet (UDDT) emerged as a system that focusses on minimising environmental and health risks related to dry sanitation systems. See Box 15 for the UDDT innovation story. With the vaults largely being above ground in South Africa, these systems have a lower risk of resulting in seepage into water resources, especially in areas with high water tables. The emptying of the UDDT faecal containment vault also has lower risks to human health as the faecal resources, if contained and stored correctly, should be dry when emptied and should thus have low pathogen levels (if any).

Box 15: The Urine-diverting Dry Toilet (UDDT)

The UDDTs with two dehydration vaults, the most common system utilised today, originated as the 'Benjo' toilet in Japan in approximate 1950, further developed into the two vault UDDT system in Vietnam in the 1960s (Winblad et al., 2004). The toilet was developed as a means to safely use human excreta in agriculture, as it was common practice in northern Vietnam, to utilise human excreta to fertilise rice fields (Winblad et al., 2004). With the health risks and concerns association with this practice, the Vietnam health authorities drove the need for finding a solution to this risk and thus the UDDT emerged in the country (Winblad et al., 2004).

The basic, original design of the UDDT has remained the same, with modifications, since 1990, focussing on improving performance of the systems or on streamlining the components of the system, for example by the addition of vent pipes to the vault that stored the faeces and the use of pre-caste ceramic or plastic urine diversion pedestals.

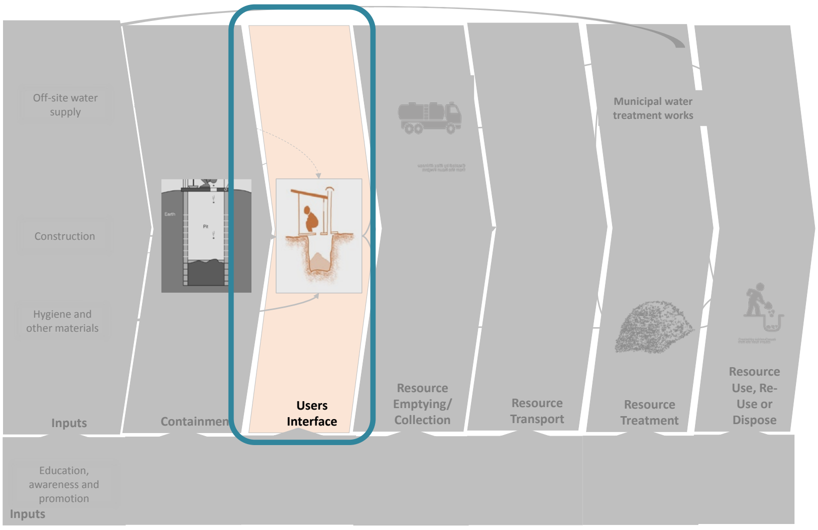
Since the early 2000s, UDDTs have been seen increasingly use as a toilet type that can provide advantages even without any reuse activities attached to it. The innovation has extended to country such as China, Mexico, Norway, Sweden and South Africa, to name a few. In the eThekwini Metro, of South Africa at least 80 000 of these systems have been installed in households outside the waterborne urban edge of the municipality. Another example is Sweden, where a company had sold approximately 200 000 UDDT between 1994 and 2010.

The UDDT has not only reduce the number of households that needed connection to a waterborne sewer system but also made the contents of a dry sanitation system safe and hygienic to utilised as soil conditioner and fertilisers.

Winblad et al. (2004) did however indicate that *in Vietnam the experience of this system is mixed. There is no doubt that it does function well when properly used. A problem in northern Vietnam used to be that some farmers emptied the processing chambers whenever they needed fertilizer, regardless of the retention time. This means that partly processed and even fresh faeces were occasionally spread on the fields. As a result of persistent health education this behaviour is nowadays less common*.

3.1.2.3 Innovation in the User Interface in the Dry WASH Value Chain

Once the materials have been utilised to ensure safe containment of the human excreta, the user interfaces with the innovation and technology. Users of excreta containment facilities in South Africa are individual households, largely in peri-urban and rural settlements.

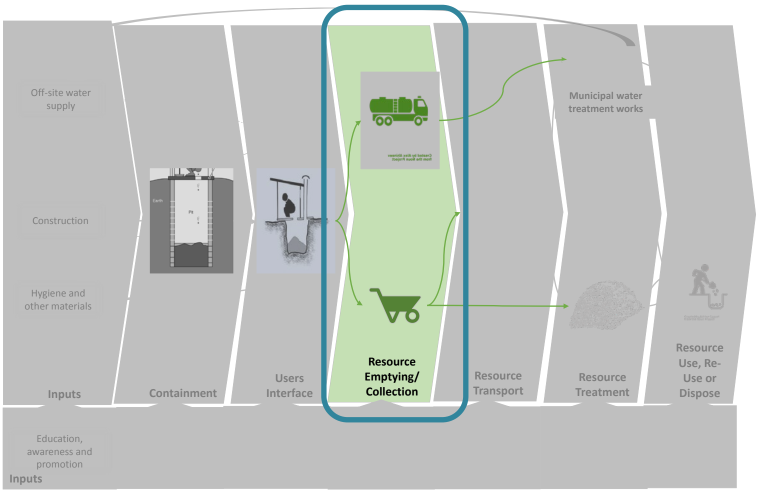


Innovations at the end-use interface are discussed in some detail above in the section on construction and material inputs and in the same sections of the Wet WASH value chain, i.e. related to bricks, etc.

It should be noted that this pillar of the dry WASH value chain would have the same challenges and purposes as the user interface of the wet WASH value chain. Although the innovations or inputs that the end-users are exposed to may be different, the localisation and deployment of dry WASH input would still be the focus of this pillar. This is the pillar in which the end-user also experiences the dry WASH input or innovation and will like/dislike and choose to use the innovation. This end-user interface is in fact the key to mass deployment of any innovation in the dry WASH value chain – if the user needs, likes and/or prefers the input/innovation it is likely that they will accept the input/innovation and normalise it as part of the wet WASH value chain. Choice also drives this pillar and choices challenges will be similarly to those discussed in the wet WASH value chain. Challenges of choice can thus have a significant impact on whether a dry WASH input innovation disperses into a community and becomes socialised and localised.

3.1.2.4 Innovation in Resource Emptying/Removal in the Dry WASH Value Chain

The fourth pillar of the Dry WASH value chain is the emptying of the contents of the vault or pit in which the human excreta has been contained and stored. In the case of pits toilets (i.e. VIPs) or other equivalents, the pit that safely and hygienically contain the human excreta will eventually reach capacity with the accumulated sludge and will require some sort of intervention, with this intervention either being (Still and O'Riordan, 2012):



a) to empty the pit and continue using it; or
b) to dig a new pit and move the superstructure of the facility; or
c) to abandon the facility and revert to using the facilities or environment that was previously utilised.

Ideally, option (a), which requires the pit to be emptied, should be the norm in a country with a large number of VIPs, such as the case in South Africa. A recent DWS report indicated that *approximately 10% of households with onsite sanitation have full pits and are at a risk of defaulting back to open defecation* (DWS, 2020). Noting that StatsSA estimated that there were 3,19 million households utilising improved pit toilets (i.e. VIPs), this would suggest that an estimated 319,000 pit toilets require emptying in South Africa in 2020 (StatsSA, 2020).

Commonly, sludge removal from pit latrines and septic tanks in large developments is done by the vacuum tanker, and often 'fleets' of these machines will service large areas, extracting excreta resources and carting it to treatment sites. The use of vacuum tanks for pit emptying is, however, not feasible in many areas of South Africa, particularly in remote areas with difficult terrain, and in dense settlements with narrow roads and informal settlement patterns. Emptying of full pits in South Africa has thus become a significant area of research and innovation in the country.

The health risks associated with emptying of pits is a key focus of the research and innovation, as well as emptying of the pits in areas and at sites that are often inaccessible to traditional emptying processes, i.e. honeysucker or vacuum tanker trucks. Safe and hygienic emptying of pits in these areas has often required manual emptying or the use of smaller scale mechanical innovations (see Box 16 for examples). Some of these pit emptying innovations rely on semi-mechanised (using manual power transferred through a mechanism) processes and others are fully mechanized systems that employ power from an engine or motor (Still and O'Riordan, 2012). The pit emptying innovations in the country do still need to be upscaled, socialised and localised as part of the suite of machines used by municipalities to provide basic services in their jurisdiction. A number of the technologies have remained at the prototype or pilot phase of the innovation cycle or are being utilised on a small scale, in localised areas.

Box 16: Innovations for emptying of pits in the Dry WASH value chain

Semi-mechanised technologies:

- **The Gulper:** developed in 2007 by the London School of Hygiene and Tropical Medicine (LSHTM), is a low-cost manually driven positive displacement pump that operates along the same principles as that of direct-action water pumps (Strande et al., 2014). Strande et al. (2014) in that the Gulper was the emptying innovation that had reached the widest number of pit emptying service providers in Africa and Asia, of the innovations included in the report.
- **Manually operated diaphragm pumps:** simple low-cost pumps capable of extracting low viscosity pit contents that do not contain large quantities of non-biodegradable materials (Strande et al., 2014). These pumps typically consist of a rigid, disc shaped body clamped to a flexible rubber membrane called a diaphragm (Strande et al., 2014).
- **Bangalore Screwer**: an Indian-designed device which is based on the principle of using an auger screw is hand cranked to lift sludge from the pit (Still and O'Riordan, 2012).
- **Nibbler:** a device designed by Steve Sugden in Tanzania which uses scoops on a chain that are moved by a hand crank to lift pit contents out of the toilet facility pit (Still and O'Riordan, 2012).
- **Pit Screw Auger.** a fully mechanised auger which has proven effective in lifting drier sludge under controlled conditions (Figure 23a) (Still and O'Riordan, 2012, Still et al., 2018)
- **The Gobbler:** a South Africa technology that works on the same design principles as the Nibbler of scoops and a chain(Figure 23b) (Still and O'Riordan, 2012, Still et al., 2018).

Fully Mechanised technologies

a) **Trash pump:** suitable for pumping sludge with high liquid content, the trash pumps work in a similar way to centrifugal impeller water pumps (Strande et al., 2014). However, the impeller of a trash pump typically has fewer solid blades, sometimes with cutting edges that can break up the material being pumped (Strande et al., 2014).

b) **Motorised pit screw auger:** the pit screw augers (SAS), that are based on the Archimedean screw design, were undergoing trials in 2014, with the motorised SAS prototypes mimicking certain aspects of commercial motorised soil augers (Strande et al., 2014).

Vacuum Technologies:

(a) **The Nano Vac:** vacuum technology that uses piston pumps to pump wetter sludge under controlled conditions (Figure 23c) (Still and O'Riordan, 2012).

(b) **The Evac:** vacuum technology using a vane pump to capture wetter sludge under controlled conditions (Figure 23d) (Still and O'Riordan, 2012).

(c) **VacuTug:** originally designed by UN-HABITAT, is a portable machine used to extract faecal sludge from septic tanks and pit latrines in dense informal settlements and peri-urban areas and transport the content to a sewage disposal site (Figure 23e) (Engineering for Change, 2022).

(d) **BREVAC:** the International Reference Centre for Waste Disposal (IRCWD) undertook a series of field tests in Botswana using multiple conventional and specialist vacuum tankers, designed to haul a double-compartmental vessel with the first being a 4.3 m^3 compartment for sludge, and the second a 1 m^3 compartment for service liquid (i.e. water) as well as mechanical collection equipment (Strande et al., 2014).

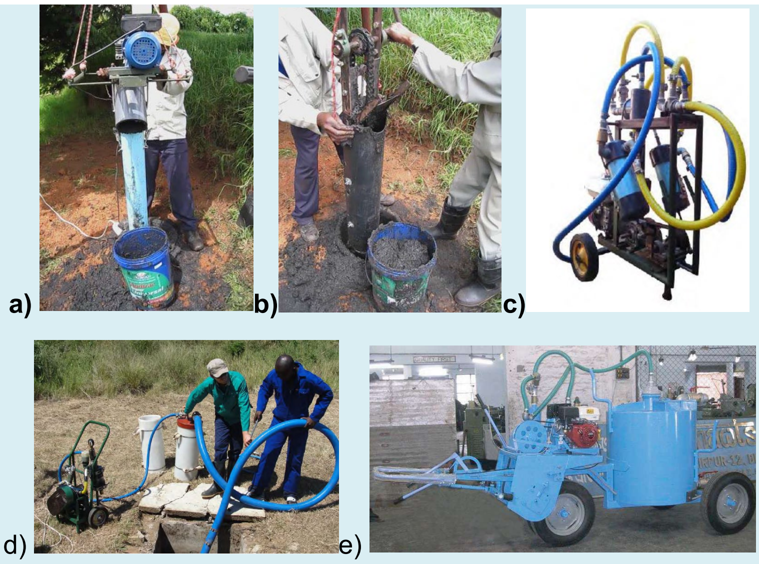


Figure 23: Examples of the (a) pit screw auger; (b) Gobbler prototype (c) the Nanovac prototype (d) the Evac prototype and (e) the VacuTug prototype (images taken from Still and O'Riordan (2012) and Still et al. (2018))

Pit-emptying Guideline: Very recently, a pit-emptying guideline was published by the FSM Alliance, with the publication providing a suite of emptying innovation categories, in Table 4, based on suitability of the technology for pit access, sludge thickness, content, cost and operator preference (Gurski et al., 2022). The table clearly demonstrates that the various innovations and technology have application in specific context and operating environments.

Table 4: Pit-emptying technologies

	PIT ACCESS			SLUDGE THICKNESS				TRASH	VAULT ACCESS	COST		OPERATOR PREFERENCES	
	Use Case Factors												
System	Not truck-accessible	Not tractor-accessible	Long distance to road	Thin or medium-thin sludge	Medium sludge	Medium-thick sludge	Thick sludge	Significant trash	Small aperture	Small purchase budget	Small operating budget	Cleanliness sensitivity	Speed required
Vacuum truck	-	-	-	++	+	-	-	+	++	-	-	++	++
ROM	+	-	-	++	+	-	-	+	++	-	+	++	++
PITVAQ (eVac)	++	++	+	++	++	+	-	+	++	+	+	+	+
Minivac	++	++	+	++	++	+	-	+	++	+	+	+	+
PuPu Pump	++	++	+	++	++	+	-	+	++	+	+	+	+
Supavac/SolidsVac	++	++	++	++	++	+	-	+	++	-	-	+	++
Mobile HoneyWagon*	+	-	-	++	+	-	-	-	++	+	+	++	+
Trailer/pickup pump system*	+	-	-	++	+	-	-	-	++	+	+	++	+
Grinder pump to truck	++	++	++	++	+	-	-	+	-	+	++	+	++
Grinder pump to containers	++	++	+	++	+	-	-	+	-	+	++	+	+
Trash pump to truck	++	++	-	++	-	-	-	+	++	+	++	+	++
Trash pump to containers	++	++	+	++	+	-	-	+	++	+	++	+	+
Progressive cavity pump to truck*	++	++	++	++	++	+	-	-	++	+	+	+	+
Progressive cavity pump to containers*	++	++	+	++	++	+	-	-	++	+	+	+	+
Flexible impeller pump to truck*	++	++	+	++	+	-	-	-	++	+	+	+	+
Flexible impeller pump to containers*	++	++	+	++	+	-	-	-	++	+	+	+	+
Gulper to containers	++	++	+	++	++	+	-	-	++	++	++	+	-
Shovels, buckets to containers	++	++	+	++	++	++	++	++	+	++	++	-	-
Sludge digger to containers	++	++	+	-	++	++	+	+	+	++	++	-	-

Legend	
++	Well suited, operates as intended
+	Operates with reduced performance or additional issues
-	Not suitable

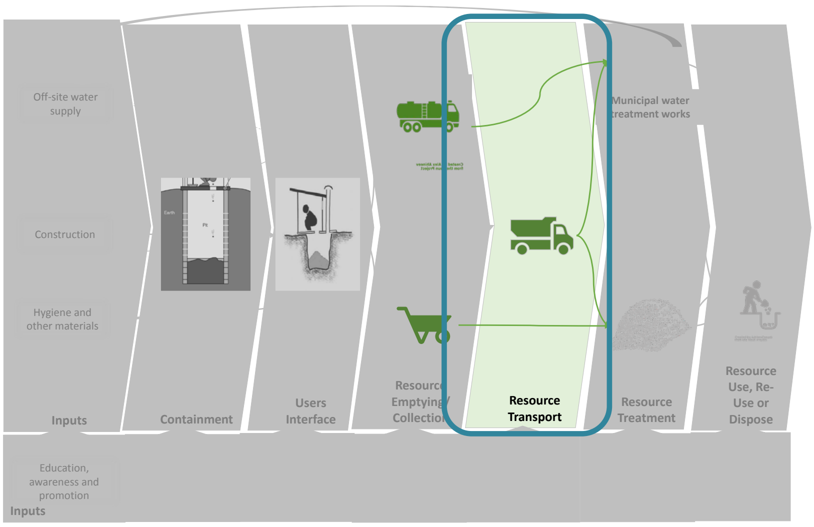
Emptying of the Urine-diverting Dry Toilets (UDDT) in the country are somewhat simpler and should have decreased health and environmental risks. Since South Africa generally installed these facilities with a double vault, the vault with filled content should have been unused for a period of time to allow for the faecal content to dry and for the pathogen contents to reduce. These vaults should therefore be safe for removal of content manually. The use of standard protective gear and instruments such as a rake and spade are sufficient to address the emptying needs.

It should be noted that a number of inputs are commonly utilised by all service providers when emptying the content of facilities in the dry WASH value chain, whether manually, semi-mechanised or mechanised systems are utilised in the emptying process, including (Strande et al., 2014):

- shovels, pry bars and probes to locate tanks and open the honeysucker slabs;
- screwdrivers and other hand tools to open pit covers;
- long handle shovels and buckets which may be necessary to remove solids that cannot otherwise be removed;
- hooks to remove non-biodegradable solids;
- hoses for adding water to the pits for vacuum pumping (if necessary); and
- safety equipment including:
    - wheel chocks to prevent the vehicle from moving when parked;
    - personal protective equipment such as hardhat, face protection, eye protection, boots and gloves; and
    - disinfectants, barriers, sorbents and bags for cleaning up and collecting spilled material.

There may be innovations in these commonly utilised tools, particularly where manual emptying of pits is necessary and related to personal protective equipment and materials for disinfecting of spilled resource during emptying.

3.1.2.5 Innovation in Resource Transport in the Dry WASH Value Chain



After removal of pit and UDDT vault contents from the containment compartment of the facility, the faecal and urine resources need to be transported for safe treatment and disposal or reuse. The machine that collects the resources from the pits and vaults may be the same that transport the materials, i.e. the vacuum tanker or vacutug. However, most of the pit/vault emptying equipment described in the previous section of the dry WASH value chain are not capable of transporting of the content to a site for treatment, use or re-use (Strande et al., 2014). Low-cost transport equipment, standardised or customised, is therefore often used for the transport of sludge to the transfer station or treatment facility. These pit/vault content transport equipment can be categorised into two main types (Strande et al., 2014):

- Those that are manually propelled by human or animal power.

- Those that are motor-propelled using a fuel-powered engine.

Pit/vault content in the dry WASH value chain are manually transported using both standard carts or customised carts designed specifically for transport (Strande et al., 2014). Although designs vary widely, standardised carts typically consist of (Strande et al., 2014):

- a load-bed mounted on a single axle with one or more wheels;
- containers of sludge with capacities of up to 200 litres; and/or
- carts are designed to be manoeuvrable in tight spaces and have an effective range of up to 3 km.

Motorised transport of pit/vault contents typically consist of (Strande et al., 2014):

- the potential for larger load capacities and increased speed;
- reduced travel times and a greater range; and/or
- operation and maintenance of motorised transport is generally more complex.

A number of innovations have emerged across the globe related to transport of human excreta, with many of these technologies linked to removal of the excreta from the facility together with transport (see Box 17 for examples).

Box 17: Innovations for the transportation of pit contents in the Dry WASH value chain

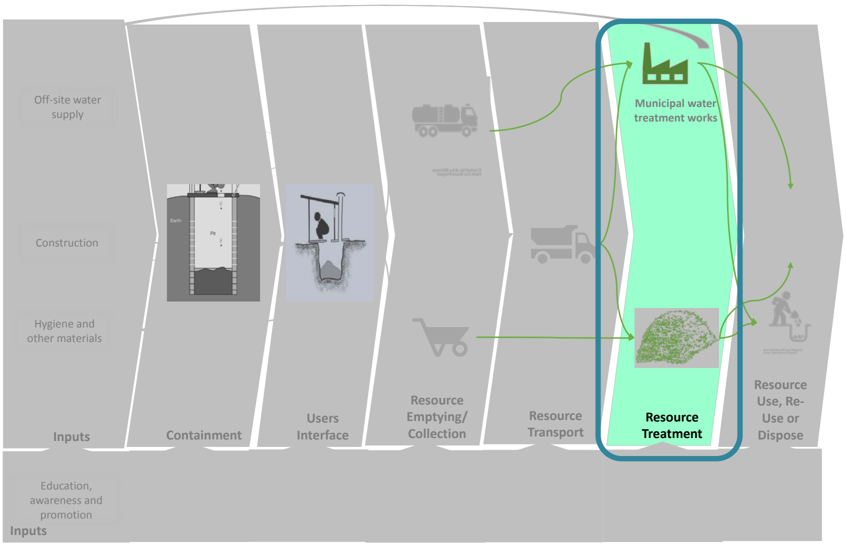
a) **Motorised tricycles**: These small transport vehicles are the smallest type of low-cost motorised transport used to move pit/vault contents (Strande et al., 2014). They vary in size and power and are able to access narrower streets than the larger motorised vehicles. Some models are capable of carrying loads of up to 1,000 kg, in drums on the load bed of a tricycle or in a tank fitted to the back (Strande et al., 2014).
b) **The Microvac:** The Micravac is a micro vacuum tanker developed for use on uneven roads and areas with poor access (Figure 24a) (O'Riordan, 2009).
c) **The Dung Beetle**: The Dung Beetle is a machine developed by a Dutch company J.Hvidtved Larsen and deployed in Ghana (Figure24b). This machine uses a two-wheel tractor-based drive, with the driver sitting on the tank and steering using the long handles on the machine. These machines have been successfully used for many years in Ghana (O'Riordan, 2009).
d) **The Vacutag**: see Box 15 above

a) 

b) 

Figure 24: Examples of innovations to transport human excreta from pit toilets, showing (a) the microvac and (b) the Dung Beetle (taken from O'Riordan (2009))

3.1.2.6 Resource Treatment in the Dry WASH Value Chain



Ideally, the urine and faecal matter collected and transported in the dry WASH value chain should be safely and hygienically treated, either before or after collection and transport, to enable the use and reuse of these resources.

Faecal sludge (FS), the urine and faecal matter from dry, onsite sanitation facilities, is defined by Strande et al. (2014) as *raw or partially digested, a slurry or semisolid, and results from the collection, storage or treatment of combinations of excreta and blackwater, with or without greywater*. FS is highly variable in consistency, quantity, and concentration (Strande et al., 2014). Treatment of FS from VIPs can occur at a municipal WWTW (entering the Wet WASH value chain), on-site through small on-site WWTW or through co-composting on-site. The norm in South Africa is for these resources to be transported to a municipal WWTW where it enters the Wet WASH value chain.

Innovations in treatment of the human excreta resource for VIPs have focussed on a number of components required to ensure safe and hygiene use, reuse or disposal of the contents collected from facilities in the dry WASH value chain, including related to the following:

- **Innovations for dewatering of the faecal sludge**: One of the most important treatment mechanisms of FS is dewatering that is necessary prior to resource recovery from the FS for applications such as creating biochar, composting or combustion as a fuel (Strande et al., 2014). Dewatering is based on physical processes such as evaporation, evapotranspiration, filtration, gravity, surface charge attraction, centrifugal force and pressure (Strande et al., 2014).
- **Innovations in biological treatment of FS:** Biological treatment of the FS is necessary to inactive pathogens and transformation of organic matter and nutrients (Strande et al., 2014). Biological treatment may include co-composting.
- **Innovation in chemical treatment of FS:** Chemical treatment of FS involves the addition of specialised chemicals (Strande et al., 2014). Chemical treatment and innovations could relate to addition of alkaline and ammonia additives (Strande et al., 2014).

Box 18: Examples of Innovation in the Treatment of Faecal Sludge in the Dry WASH value chain

Chemical treatment

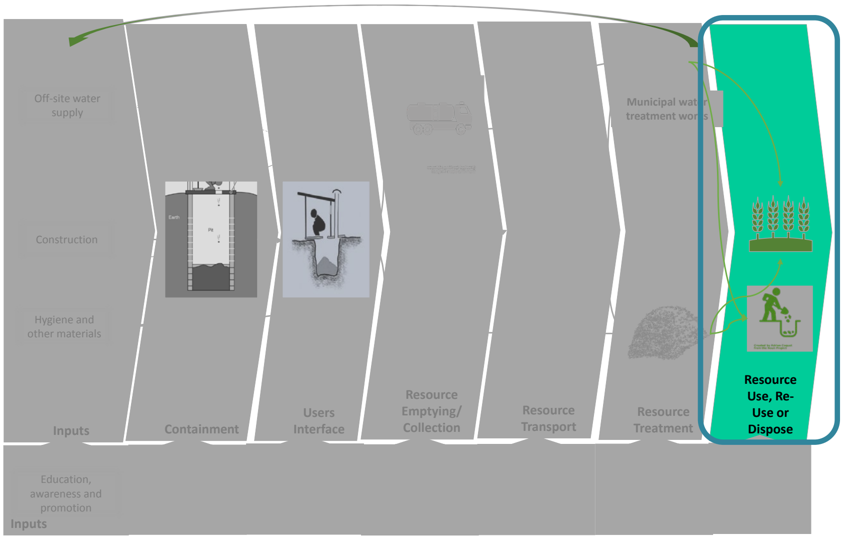
- **Alkaline stabilisation:** focusses on pathogen reduction by using uncharged ammonia (NH3), where ammonia (NH3) enters cells, takes up intracellular protons for the formation of ammonium (NH4). Investigations were underway in 2014 to use the ammonia from excreta (i.e. collected urine) for pathogen reduction in FS (Strande et al., 2014).

Physical process treatment

- **Thermal drying:** allows the removal of all types of liquids from FS, commonly using direct or indirect thermal dryers that are also referred to as convection or contact dryers, respectively (Strande et al., 2014).

The treatment of sludge from pit latrines can apply similar technology and innovations utilised for the treatment of sludge that emerges from the Wet WASH value chain.

3.1.2.7 Resource Use, Reuse and Disposal in the Dry WASH Value Chain



Once FS from VIPS and faecal matter from UDDTs is treated (commonly simply thermal or co-composting), as shown in the previous pillar of the dry WASH value chain, the end-products that result may require further treatment, may be disposed of, or may be harnessed for some type of resource recovery (Strande et al., 2014). End-products, for example dried or partially dried sludge, compost, leachate, and biogas, each have an intrinsic value, which can support resource recovery and value creation (Strande et al., 2014).

Over the last two decades, due to a shift in the focus of the WASH sector to increasingly considering on-site or decentralised technologies as not only long-term viable options, but possibly the more sustainable alternative in many ways when compared to sewer-based systems, innovations have emerged to use, reuse or disposal of the FS from these on-site, dry sanitation facilities. A vast array of end-product options for FS exists, many of which are supported by innovations (see Box 19 for examples), including the following:

- **End-use as a soil conditioner** – The most common resource recovery from sludge has been as a soil conditioner and organic fertiliser, as excreta contain essential plant nutrients and organic matter (Strande et al., 2014). Soil conditioners can be achieved through composting, co-compositing, vermicomposting of treated and untreated FS.
- **End-use in biogas**: Biogas can be produced during anaerobic digestion of FS, with the remaining sludge also being used as a soil conditioner (Strande et al., 2014).
- **endue as biofuel**: According to Strande et al. (2014) novel developments are underway to recover end products as a biofuel, for example pyrolysis, gasification, incineration and co-combustion.
- **end-use as biochar**: FS can undergo pyrolysis to yield carbon-based end products such as (bio)char, oils and gases, the quantity of each depending on the processing temperature and presence of gasifying agents (Strande et al., 2014).
- **End-use as energy:** Incineration of FS involves the burning of sludge at temperatures between 850-900°C, typically for disposal but may also take advantage of the potential for resource recovery, such as to generated energy from the incineration of sludge for, for example cement kilns (Strande et al., 2014)
- **End-use for protein production**: Novel development was also underway for resource recovery of organic matter through the growth of Black Soldier flies for protein production.

- **End-use as building materials**: Dried FS can be used in the manufacturing of cement and bricks, and in the production of clay-based products (see the wet WASH value chain inputs for more examples).
- **End-use as reclaimed water:** Ultimately, the dewatering of the FS and treatment of the water can provide reclaimed water for use in the wet WASH value chain, i.e. discharge into water sources that are inputs into the wet WASH value chain.

Box 19: Examples of Innovation in the End-use of Faecal Sludge in the Dry WASH value chain

Soil conditioning

- **Pelletising**: combines mechanical dewatering and thermal drying technologies, with the resulting dried pellets being used as an energy source or soil conditioner (Strande et al., 2014). An example of combining drying and pelletising is the LaDePa (Latrine Dehydration and Pasteurisation) system developed by eThekwini Water and Sanitation (EWS, Durban, South Africa) in conjunction with their technology partner Particle Separation Systems. The process treats FS from pit latrines over a number of subsequent thermal and mechanical treatment steps, to produce pellets that can be sold and used as a fuel or as a soil amendment (Strande et al., 2014).
- **Deep row entrenchment in Durban, South Africa (taken from Strande et al. (2014):** a technology that can be considered as both a treatment and end-use of the FS (Strande et al., 2014). This end-use of FS involves digging deep trenches, filling them with untreated sludge and covering with soil so that trees can be planted on top to benefit from the organic matter and nutrients that are slowly released from the FS (Strande et al., 2014). Strande et al. (2014) indicated that *the water and sanitation unit (EWS) of the eThekweni municipality in Durban has been pursuing deep row entrenchment for disposal and treatment of both sludge from municipal wastewater treatment and FS derived from ventilated improved pit latrines (VIPs). The EWS project in Umlazi, south of Durban, started operation in 2009. Pit latrine sludge was buried at different loading rates in sandy soils (Still et al., 2012). Positive effects were seen on the trees that were planted, however, there where substantial differences depending on the species and experimental conditions.*
- **Vermicomposting**: with vermicomposting, worm's breakdown larger organic particles, stimulate microbial activity, and increase the rate of mineralisation, thereby converting FS into hemic like substances with a finer structure than normal compost
- **The Black Soldier fly (Hermetia illucens) protein:** Black Soldier fly (BSF) larvae have been investigated for the degradation of organic wastes such as municipal solid wastes, animal manure, and FS (Strande et al., 2014). This process relies on the natural growing cycle of BSF which need to feed only during the larval stage, then migrate for pupation, and do not feed anymore, even during the adult stage. Therefore, the risks of the BSF being a vector for disease transmission is very low (Strande et al., 2014). The FS residue remaining after the BSF larvae feed need to be further composted or anaerobically digested to produce a soil conditioner (Strande et al., 2014).

The content of UDDT toilet can also be utilised for end-products such as soil conditioner and fertiliser. Urine has been shown to have a significant amount of crucial nutrients require for crop production, thus has application as a soil fertiliser. However, use of urine for crop production remains a challenge in many countries due to public aversion and social stigmas to utilising human urine for these purposes (Ally and Campbell, 2021). In South Africa, the contents of vaults in the UDDT are usually buried or transported off-site, with very little use as a soil conditioner or fertiliser.

3.1.3 Summary of Innovations in the WET WASH and DRY WASH Value Chains

The review of innovations in the WET WASH value chain indicated that the innovations dominate the inputs pillar of the chain and the discharge, reuse and use pillar. Interestingly, the review showed that WET WASH innovations in South Africa are focussed on the inputs, user interface and outputs of the WET WASH value chain. The intermediate pillar, such as conveyance, water treatment, distribution to the user, distribution from the user and wastewater treatment do not seem to be significant areas of innovation in the country. Within each of the pillars of the value chain, the conclusion could be drawn as shown in Table 5.

Table 5: Summary for innovations in the Wet WASH value chain

Pillar	Conclusions drawn
Inputs	***Water inputs*** *into the value chain* a) innovations in this component of the value chain demonstrated a focus largely on two areas - innovations for using and managing traditional water sources (i.e. surface and groundwater) in a more sustainable, effective and efficient manner and innovations related to alternative water sources. b) There is growth in disruptive innovations that utilise alternative water sources such as reclaimed greywater, return water flows (treated and untreated) from end-users, groundwater recharge and other alternative water sources. Alternative water sources are innovations themselves. ***Materials inputs*** *into the value chain* c) Materials innovations as inputs into the wet WASH value chain are largely focus on materials/construction inputs at the end-user interface, i.e. taps, toilets, showerheads, etc. d) Construction material innovations are a component of the wet WASH value chain that has not seen large scale innovation, but offer opportunity for innovation deployment, localisation and deployment in future, particularly disruptive innovation that focus on new materials such as bricks from waste (i.e. closing the sanitation loop by utilising outputs of the wet WASH value chain as material inputs into the value chain). For example, sanitation facilities constructed from brick made from sewage sludge solids. e) There is growth in innovations in materials at the end-user interface, with innovations focussed on system that reduce water use. It should be noted that many of these innovations largely focus on modification or adjustments to existing technologies and process in the value chain, i.e. low flush- and low-water use technologies that are not necessarily disruptive innovations. Hence, these innovations have been socialised and localised – particularly in water scare areas of the country where there are water shortage or water has become expensive due to the water restriction tariffs. ***Hygiene input*** *innovations in the value chain* f) This component of the inputs into the Wet WASH value chain has seen the most significant rapid deployment, localisation and socialisation of innovations in the last two year. The COVID-19 pandemic fast-tracked many new hygiene innovations into households, particularly those that provided primary barriers to COVID spread such as handwashing facilities, soaps and sanitisers. Whether the current spread of deployment can and will be sustained in future to achieve hand hygiene SDG6 targets remains to be seen. g) The hand sanitiser innovation demonstrated, abet under unusual pandemic conditions, the rapid and massive deployment of a hand hygiene innovation to meet localisation and deployment requirements. While the regulations and policies were eased to facilitate the process of deployment of the hand sanitisers to meet this need, this easy also opened the door to abuse and manufacture of substandard products. The case clearly demonstrates the need for policy and regulations, but those that facilitate and ease the deployment,

Pillar	Conclusions drawn
	localisation and socialisation of innovation, especially innovations that disrupt traditional WASH markets. h) Toilet paper is a WET WASH innovation that has widely and globally been socialised and localised. The innovation was, however, slow to deploy and in fact, only saw wide uptake and acceptance as the Wet WASH value chain (i.e. flush toilet) took hold in countries and became the mainstream sanitation system. The toilet paper is however, still shrouded in some stigmas, with the purpose of the product hardly every utilised in the marketing of the product or often utilised as the “butt” of jokes in the sector. i) Menstrual health input innovations have followed international trends of focussing on environmental products that can be reused and recycled. These innovations however, have to be deployed into a very challenging market with a vast array of stigmas, taboos and misinformation. This makes deployment of the innovation at scale difficult and the localisation and deployment of these innovation an enormous challenge. The market has seen little change since the deployment, localisation and socialisation of the disposable pads. These innovations remain to today, the most socially accept menstrual products.
Water conveyance	Innovations in this WET WASH pillar have a focus on innovations related to water extraction and pumps, bulk water piping and water storage innovations. Leak detection and monitoring processes innovations are also part of this pillar of the value chain. A limited number of innovations were highlighted in this pillar of the value chain.
Water treatment	Innovations in this pillar can focus on the chemical inputs for treatment of water or on the technology and process of treatment. However, innovations in South Africa are limited, with treatment process focussed on traditional methods, with the addition of some of the more modern water treatment technologies such as ozone, ultraviolet light and membrane technology. Chemical treatment is focussed largely on the continued use of chlorine and standard flocculants, etc.
Water distribution	Where water is transported from the treatment works to the end-uses is largely focussed on the piping networks and monitoring of leaks. Innovations have emerged largely related to real-time and electronic means of leak detection and water use metering in the piping networks. South Africa has seen a significant number of electronic metering innovations in recent years.
End-user	Focussing on the interface of the user with the water supply and sanitation services. This pillar is largely address in the inputs pillar of the WET WASH value chain. Innovations focus on innovations in taps, shower heads and toilet facilities that reduce water use or recycle water. Innovations to facilitate and encourage uptake, acceptance, localisation and socialisation of new WET WASH innovations are however, limited. These innovations would relate largely to social tools, methods, processes to aspects such as choice, acceptance, preference, etc. to facilitate the upscale, localisation and socialisation of WASH innovations at the end-user interface.
Conveyance of wastewater	Where wastewater is transported from the end-user to the wastewater treatment works, would focus largely on innovations in piping such as dual piping system, shallow sewer systems, to leak detection in sewer networks and to ensuring sustainable operation of the network. However, these seem to be few large-scale deployment, localisation and socialisation of new innovations in this pillar in the WET WASH value chain.
Treatment of wastewater	Focusses on the process and chemicals required to treat these resources. Again, the wet WASH value chain in the country seems to focus on traditional wastewater treatment methods and process, with no noteworthy large-scale deployment, localisation and socialisation of new innovations.
Use, reuse and discharge of wastewater	Seems to be an emerging area of innovation in the wet WASH value chain. This pillar of the value chain is seeing increasing interest and emergence of innovations, with a particular focus on innovations related to reuse of reclaimed water and use of sludge for various products. Large-scale deployment of the innovations into the

Pillar	Conclusions drawn
	market has not yet been realised and localisation and deployment of in innovation and the products is limited.

The DRY WASH value chain is dominated by innovations to reduce, reuse, reclaim and recycle urine and faeces and other resource input into the value chain. Within each of the pillars of the value chain, the conclusion could be drawn as shown in Table 6.

Table 6: Summary for innovations in the DRY WASH value chain

Pillar	Conclusions drawn
Inputs	*Water inputs into the value chain* a) Limited to water collect from yard and communal taps. *Materials inputs into the value chain* b) Materials innovations as inputs into the DRY WASH value chain are the same as the Wet WASH value chain, focus on materials/construction inputs at the end-user interface, i.e. toilets facilities. c) Construction material innovations are a component of the DRY WASH value has great innovation focus, with a specific focus on materials for the construction of on-site superstructure, pedestals and pits. The innovations have however, focussed on deployment, socialising and deployments of innovations related specifically to the VIP and UD toilet – little new innovations are available related to on-site dry sanitation systems themselves. d) There is growing materials and facilities innovation related to technologies that close-the-loop in operations. In these on-site systems, although not necessarily dry system, the innovation does not require direct connection to the water and wastewater network to operate, i.e. the water circulates in a looped system. These innovations however have yet to see deployment into the market and mass localisation and deployment. *Hygiene input innovations in the value chain* • Hygiene inputs into the DRY WASH value chain are often the same as in the WET WASH value chain and thus have seen the same innovation in this value chain. • Like the WET WASH value chain, this component of the inputs into the DRY WASH value chain has seen the most significant rapid deployment, localisation and socialisation of innovations in the last two years. The COVID-19 pandemic fast-tracked many new hygiene innovations into households, particularly those that provided primary barriers to COVID-19 spread such as handwashing facilities and hand soaps. Whether the current spread of deployment can and will be sustained in future to achieve hand hygiene SDG 6 targets remains to be seen.
Containment	Innovations in this DRY WASH pillar have a focus on innovations related to safe and hygienic containment of the contents of the sanitation facility. This pillar of the value chain has seen little innovation in recent times, with the introduction of the UDDT being the most recent introduction. Innovations

Pillar	Conclusions drawn
	have focussed on streaming current containment system, i.e. streamlining and increasing performance of UDDT vaults.
End-user	Innovations at the end-use interface are discussed in some detail above in the section on construction and material inputs and in the same sections of the WET WASH value chain, i.e. related to bricks, etc.
Resource emptying/collection	Innovations in this pillar have seen significant research and growth in recent years driven largely by the funding provided by the WRC and the Bill and Melinda Gates Foundation to conduct this research. Innovation is still largely focussed on the prototype stage, with deployment, localisation and socialisation still to be achieved.
Resource transportation	Innovation in this pillar is largely linked to the manner in which the excreta and urine/faeces are collected form the VIPs and UDs. Hence, these are also still largely in the prototype state, with deployment, localisation and socialisation still to be achieved.
Treatment	Treatment of the faecal sludge from pits toilet generally occurs at a municipal WWTW as these resources are commonly transported to these sites in South Africa. Where the contents are not taken to the WWTW, they may be thermal treated or co-composted for other uses. Contents may also be buried, i.e. deep row entrenchment. Innovations in this pillar are thus linked to the innovation in the Wet WASH treatment pillar.
Use, reuse and disposal	A vast array of end-use options exists for FS, many of which are supported by innovations. Again, these innovations still lack deployment, localisation and socialisation.

From the above review, the innovations in the DRY WASH value chain in South Africa have focus on deployment, socialising and deployment of innovations in three pillars, namely input materials (including user interface), resource emptying/collection and FS and urine/faeces use and reuse. It is clear that a number of the pillars in the value chain do not experience significant innovation focus or R&D inputs.

3.2 ENABLERS OF THE WET AND DRY WASH VALUE CHAIN

The WASH value chain in South Africa does not operate in a vacuum and require a sound, structured and coordinated enabling environment to ensure the sustainability of the value chain. The deployment, localisation and socialisation of WASH innovations within the value chain are themselves enablers, as these innovations can improve, streamline and re-position the current value chain to meet both current and future needs of the WASH sector in the country. At the same time, the deployment, localisation and socialisation of WASH innovations requires an enabling environment to support and faculty the process. Enablers of the WET and DRY WASH value chain include the following:

a) Policy, legislation and strategies (see Section 3 for a review of South Africa's policy, legislative and strategic enablers of the value chains and innovations in these value chains).
b) Finance and funding.
c) Management instruments and tools, i.e. processes, procedures, tools methods, etc.
d) Knowledge, skills and information.
e) Partnerships and colorations.

Box 20: Examples of innovation in the WASH enabling environment

Tool for evaluating public water literacy: A structured questionnaire, developed by Chris Swartz Eng. with funding from the WRC, to evaluate public water literacy. The questionnaire was for use by water services authority/provider (or delegated authority) as part of planning for water activities, informing their communication strategies for disseminating knowledge associated with water-saving behaviours (WRC, 2020). In addition, the questionnaire guided the identification of potential subgroups who may require additional targeting to build knowledge and support for water management initiatives (WRC, 2020).

CHAPTER 4: REVIEW OF SOUTH AFRICA WASH INNOVATION POLICIES

South African policy on innovation is still fragmented across government. South Africa's science and innovation policy dates back to September 1996, when the White Paper on Science and Technology (1996), which identified the need for a more inclusive science, technology and innovation system, was published. Various developments and key milestones, championed by the Department of Science and Innovation (DSI), have influenced South Africa's innovation landscape. The growing recognition of the importance of innovation, and its cross-cutting nature, more national government departments, such as in particular, the Department of Trade, Industry and Competition (DTIC), the Department of Economic Development, the Department of Health, the Department of Small Businesses, the Department of Public Service and Administration and others, have become involved in innovation related discourse (Sibanda, 2018).

4.1 NATIONAL ACTS, POLICIES, STRATEGIES THAT ENABLE INNOVATION

This section of the report summarises the national Acts, policies, strategies and standards impacting on innovation in the Dry and Wet WASH value chain.

According to recent reviews, the main factors constraining innovation are:

a) inadequate and non-collaborative means of setting the agenda for innovation in the country;
b) insufficient policy coherence and coordination;
c) weak partnerships between actors (particularly the inadequate involvement of business and civil society);
d) inadequate monitoring and evaluation (M&E);
e) inadequate high-level science, engineering and technology (SET) and technical skills for the economy;
f) an undersized research system;
g) a poor environment for innovation; and
h) significant levels of underfunding (DSI, 2019).

From the review of the value chains in Section 3 above, a number of the above challenges in innovation do seem to resonate. The review clearly demonstrates that innovations focussed on specific pillars of the value chain, whilst almost ignoring others and a significant amount of research on the piloting and prototyping of innovations with little, to no deployment, localisation and socialisation of many of these innovations. Policy could be a constraint/barrier to addressing the challenges in the innovation sector but may also be an enabler if designed and implemented effectively. Table 7 shows the main Acts, policy, strategies and standards that can be barriers or enablers to the innovation value chain in South Africa. The figure positions the document within this value chain to demonstrate the point or area on the value chain that should be enabled by the regulatory instruments.

4.1.1 Review of National Acts as Enablers of WASH Innovation

National acts and legislation have the tendency to encourage bureaucracy to minimise risk. Bureaucratic government structures aim for precision, reliability and efficiency, therefore pressing for officials to be methodical, prudent and disciplined to attain conformity. Innovation is often the opposite of conformity.

A suite of national legislation is publicised as having objectives that enable innovation, across the entire Wet and Dry WASH value chain. This legislation includes:

- innovation legislation such as the Technology Innovation Agency Act, the Agrément South Africa Act, the Intellectual Property Act and the Intellectual Property Rights from Publicly Financed Research and Development Act;
- WASH legislation, such as the National Water and National Water Services Acts and the Municipal Systems Act; and
- Public Finance such as the Public Finance Management Act, Local Government: Municipal Finance Management Act Preferential Procurement Regulations (PPR) Act and the Preferential Procurement Policy Framework Act.

This legislation is reviewed below, with a specific focus on how they enable innovation in the WET WASH and DRY WASH value chains.

Table 7: Review of national legislation related to WASH Innovations

Legislation	Description
Innovation Legislation	
Technology Innovation Agency Act No. 26 of 2008 (RSA, 2008)	This Act provides for the promotion, development and exploitation of discoveries, inventions, innovations and improvements that are in the public interest and also provides for the establishment of the Technology Innovation Agency (TIA). The TIA is a national public entity that serves as the key institutional intervention to bridge the innovation chasm between research and development from higher education institutions, science councils, public entities, and private sector, and commercialisation. An example is the collaboration between the Water Research Commission (WRC) and the Technology Innovation Agency (TIA) in launching the Water Seed Fund of up to R200,000 per project for innovation-oriented projects conducted by Higher Education Institutions (HEIs) and Small and Medium Enterprises (SMEs) in the water sector. The Technology Innovation Agency, established in compliance with this Act, implements its mandate to provide financial and non-financial support to innovators and inventors through (taken from (https://www.tia.org.za/) • providing funding to innovations in specific section, one of which is the natural resources that is focused on water resources management, waste management, and mining. Funding support in this sector seeks to support technologies that solve: o the water crisis, improve water security and support sanitation programs. o the waste management sector supports technologies that address waste management challenges and climate and environment issues within South Africa. o technologies in mining to sustainably improve process efficiencies in the extraction and exploitation of natural resources safely. • through providing support through a suite of programmes that include: 1) Technology stations programme: The goal of this programme is to contribute towards improving the competitiveness of industry through the application of specialised knowledge and technology, facilitating the interaction between industry and academia, in order to enable innovation. 2) Innovation for Inclusive Development (IID) Project Management Unit (PMU): a ring-fenced pilot programme of DSI. The PMU represents TIA's efforts to fully deploy the TIA mandate and temper with the notion of innovation as limited only to research output that produces intellectual property. 3) Youth Technology Innovation Programme (YTIP): drives the participation of young people in the economy by providing funding for development of

Legislation	Description
	techno-enterprises. The Programme is targeted at funding and supporting youth, between the ages of 18-30, who have innovative ideas that has potential to establish new businesses. 4) Global Cleantech Innovation Programme (GCIP): part of a global initiative aimed at promoting clean technology innovation and supporting entrepreneurs in growing their Small, Medium and Micro Enterprises (SMMEs) and start-ups into viable, investment-ready businesses. 5) Innovation Skills Programme: to stimulate and strengthen critical thinking capabilities to support and enable innovation to occur and support the progression of technologies from proof-of-concept stage through to pre-commercialisation (from TRL level 3-8) The Act and the TIA that was established based on the Act is targeted to enable innovations in the country, through both financial and non-financial support of innovations and through various programmes that provide support to specific sectors and innovation types.
Intellectual Property Rights from Publicly Financed Research and Development Act (IPR Act) No. 51 of 2008	South Africa has a number of intellectual property (IP) legislations and provisions incorporated into other legislations. The IP regulatory framework is important for creating an enabling environment for innovation to thrive. South African intellectual property (IP) law encompasses all legislation which concerns patents, designs, trademarks and copyright protection. IP law is taken seriously in South Africa and across the world due to its power in protecting intangible intellectual property that can hold immense value. It is crucial for intellectual property to be protected legally in order to restrict the usage of what is rightfully that of the inventor or creator (South Africa, 2013a). The relationship between IP and innovation policies is critical for those institutions that generate, diffuse and adapt new technological knowledge. The specific objective of the Intellectual Property Rights from Publicly Financed Research and Development Act (IPR Act) is that IP emanating from publicly financed research and development should be commercialised for the benefit of all South Africans and protected from appropriation. The IPR Act further provides for an enabling environment for intellectual property creation, protection, management, commercialisation and utilisation. Mangena (2015) captures this imperative in stating that: “The significant weakness of the South African IP law presently is that it does not sufficiently cover research, development and innovation in the private sector space. This is a serious shortcoming, considering the fact that it is the private sector that should be powering us into the knowledge-based economy, not the public sector.” Kaplan (2009) concurs with the challenges in the IP sector concluding that *South Africa’s innovation system is at a critical stage. System performance has not been strong, particularly relative to the increases in resources committed. There has been considerable policy experimentation and innovation in many areas, but with regard to intellectual property, policy changes have been piecemeal and largely reactive to changing circumstances, particularly international obligations. There is a need for a comprehensive review of the IP regime. Such a review should rest on a consideration of the role that it has played and could play in enhancing innovation, investment (particularly FDI) and growth. This, in turn, requires considerable research on the economic impact of intellectual property – an area that has attracted very little attention in the past. The purpose of this publication is to provide some initial research, but also to initiate and stimulate further research. Such research has the potential to enhance understanding, and also make an invaluable contribution to ensuring that future policy changes in South Africa rest on firm empirical foundations (Kaplan, 2009).*
WASH Legislation – this legislation should enable innovation across the entire WET WASH and DRY WASH value chains.	

Legislation	Description
National Water and National Water Services Acts (RSA, 1997b, RSA, 1996)	South African water services are regulated through two acts, the National Water Act (Act 36 of 1998) and National Water Services Act (Act 108 of 1997) (RSA, 1996, RSA, 1997b). The review of these acts clearly demonstrated that innovation is not a priority for these acts. Neither the NWA nor the NWSA contain any policy positions related to innovation, or research and development of water resources and water services. However, provisions in the acts could impact on water innovations and the water innovation value chain in South Africa. Some stipulations in the NWA and the NWSA strangle innovation because of the restrictions placed on the use of water and the manner in which water services. This can breed a culture that is averse to trying new and relatively untried ideas.
Local Government: Municipal Systems Act, No. 32 of 2000	The Municipal Systems Act defines the legal nature of municipalities as part of a system of cooperative government. It clarifies the rights and duties of the municipal council, local communities, and the municipal administration. The Municipal Systems Act also sets out strict rules and parameters that need to be adhered to for all matters concerning, inter alia, water and sanitation services, including innovations in the water sector.
Public Finance Legislation – since the provision of WASH services is a responsibility of public institutions in South Africa, specifically local government, public finance legislation is the key instrument that can enable the deployment, localisation and socialisation of WASH innovations at scale. Uptake of innovation through local government financial process can enable this process of mass deployment of innovations.	
Public Finance Management Act (PFMA) No. 1 of 1999	The Public Finance Management Act regulate financial management in the national government and provincial governments; to ensure that all revenue, expenditure, assets and liabilities of those governments are managed efficiently and effectively; to provide for the responsibilities of persons entrusted with financial management in those governments; and to provide for matters connected therewith. The objective of this Act is to secure transparency, accountability, and sound management of the revenue, expenditure, assets and liabilities of the institutions to which this Act applies. This Act sets put strict rules and parameters that need to be adhered to for all matters concerning, inter alia, water and sanitation services, including innovations in the water sector.
Local Government: Municipal Finance Management Act	The objective of this Act is to secure sound and sustainable management of the fiscal and financial affairs of municipalities and municipal entities by establishing norms and standards and other requirements for ensuring transparency, accountability and appropriate lines of responsibility in the fiscal and financial affairs of municipalities and municipal entities. This Act prescribes all actions and activities related to expenditure in municipalities and does not leave much room for expenditure on innovations.
Preferential Procurement Regulations (PPR) Act No. 5 of 2000	The PPR stipulate the identification of preference point system, designated sector, pre-qualification criteria, objective criteria, and subcontracting for services providers, contractors, and tenderers.
Preferential Procurement Policy Framework Act No. 5 of 2000	Preferential Procurement Policy Framework Act is to enhance the participation of Historically Disadvantaged Individuals (HDIs) and the small, medium and micro enterprises (SMMEs) in the public sector procurement system. It was envisaged that the implementation of these regulations would enhance the involvement of black businesses in the public tendering system and would contribute to the upliftment of disadvantaged communities. It would further assist in the inclusion of the informal business sector into the main stream of the economy.

4.1.2 WASH Innovation Enabling Policies and Strategies

Even more so than the legislation of the country enabling WASH innovation, is the need for the policies and strategies to enable this products and services. National policies and strategies provide the vision and aspirations of the various sector of the country and provide the road maps to reaching these, within the constraints of legislation. The policy and strategies that should enable WASH innovation in the country are shown in Table 8.

Table 8: National policies and strategies that should enable WASH innovations.

Policy of Strategy	Description
Development policy	
National Development Plan (National Planning Commission, 2012)	The NDP indicates that *South Africa's global competitiveness needs to be improved, and the system of innovation has a key role to play. It is the principal tool for creating new knowledge, applying knowledge in production processes, and disseminating knowledge through teaching and research collaboration (National Planning Commission, 2012)*. The NDP indicated that South Africa's competitiveness will rely on national systems of innovation, permeating the culture of business and society. Innovation and learning will need to become integral part of this process. The NPD indicated that public policy could focus on research and development in existing areas of competitive advantage, where global markets are set to grow. The NDP acknowledges that economic development takes time, and that innovation should grow in importance in years to come. It indicated that: • in the first phase of implementation of the NDP (2012-2017), the focus would be on "intensifying research and development (R&D) spending, emphasising opportunities linked to existing industries". • in the second phase (2018-2023), the country is expected to "lay the foundations for more intensive improvements in productivity" and "innovation across state, business and social sectors should start to become pervasive". • as 2030 approaches, "the emphasis should be on consolidating the gains of the second phase, with greater emphasis on innovation, improved productivity, more intensive pursuit of a knowledge economy, and better utilisation of comparative and competitive advantages in an integrated continent" (DSI, 2019).
SALGA 2017-2022 Strategic Agenda (SALGA, 2017)	The South African Local Government Association developed a strategy for 2017-2022 called the SALGA 2017-2022 Strategic Agenda: Inspiring Spatial Justice and Social Cohesion through the Integrated Management of Space, Economies and People. Innovation is identified as one of the key enablers that must be prioritised in order to enhance performance of SALGA and Local Government. The strategy focuses on three areas for innovation, i.e. adaptation, transferrable projects, and policymaking. The intent is that innovations in service delivery can help municipalities to serve more people, with less money, less time, and better quality (SALGA, 2017).
Integrated Development Plans (IDPs)	An Integrated Development Plan is a super plan for an area that gives an overall framework for development. It aims to coordinate the work of local and other spheres of government in a coherent plan to improve the quality of life for all the people living in an area. It is used by municipalities as a tool to plan short- and long-term future development. An IDP has a lifespan of 5 years that is linked directly to the term of office for local councillors. The council can adopt the existing IDP or develop a new IDP that takes into consideration existing plans. The IDPs could be a barrier for innovations that are developed after the IDPs were approved and budgets were set for its 5-year term. It could be possible to include an innovation during the annual review of an IDP. The elected council makes all the final decisions on the IDP.

Policy of Strategy	Description
Municipal Bylaws	Municipal by-laws set strict rules to adhere to in terms of roles and responsibilities; agreements and conditions for rendering services; the installation, operation and maintenance of infrastructure and equipment; applications and approvals; compliance with SABS codes and standards; use of water, wastewater and sanitation; metering and tariffing; supply chain management; credit control; etc. Municipalities have a direct impact on innovation through their policies on property valuation, user charge collection, levies collection, procurement practices, licensing, etc. Innovators and businesses have to bear the payments to municipalities for services, as well as pay for the time and effort required for tax administration, thus the red tape increases the cost of innovation and conducting business. In addition to policies on the revenue side, municipalities also affect businesses through their expenditure-related policies. Municipal structure and processes are meant to be built for reliability and repeatability, which can breed a culture averse to trying new and relatively untried ideas. Reliability is built on repeatable processes, which are supported by standard workflows and budgeted investments, which are tracked by standard measures. In general, municipal by-laws are responsible for services delivery that enhances human health and well-being, which, compounded by consumer and social acceptability issues, encourages the use of tried and tested technologies, leaving little room for innovation.
Innovation Policy	
White Paper on Science, Technology and Innovation (DST, 2019)	In terms of innovation, the policy is focussing on: • Enhancing the innovation culture in society and government (adopting a whole-of-society approach to innovation). • Involving business and other NSI partners in government STI planning. • Using local procurement to support South African innovators, especially SMEs. • Developing local and provincial innovation ecosystems. • Supporting social and grassroots innovation. • Encouraging entrepreneurship. • Using STI to modernise existing industries and to respond to the Fourth Industrial Revolution. • Supporting the greening of the economy via STI.
Intellectual Property Policy (DTI, 2018)	Intellectual Property (IP) is an important policy instrument in promoting innovation, technology transfer, research and development (R&D), creative expression, consumer protection, industrial development and more broadly, economic growth (dti, 2018). The policy indicated that *South Africa requires a coordinated and balanced approach to IP that provides effective protection of IPR and responds to South Africa's unique innovation and development dynamics* (dti, 2018). The goals of the South African IP Policy are (dti, 2018): • To consider the development dynamics of South Africa and improve how IP supports small institutions and vulnerable individuals in society, including in the domain of public health • To nurture and promote a culture of innovation, by enabling creators and inventors to reach their full potential and contribute towards improving the competitiveness of our industries • To promote South African arts and culture • To solidify South Africa's various international obligations, such as the Convention on Biological Diversity (CBD) and the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilisation (Nagoya Protocol on ABS), in the service of our genetic resources and traditional knowledge associated with genetic resources.

Policy of Strategy	Description
	The policy seeks to address challenges relating to the need for a coordinated South African approach to IP informed by South Africa's development imperatives is sorely missing, and urgently necessary.
Water Research, Development and Innovation Roadmap (2015)	The Water RDI Roadmap has three pillars: research, human capacity development, and deployment of innovation, and includes development, testing, demonstration, positioning, and deployment of new solutions, know-how, and technologies. The Water RDI Roadmap is a high-level planning tool that facilitates and guides refocusing of research, reprioritisation of funds, synergising of existing initiatives, and ring-fencing of new resources in order to facilitate a more effective water innovation system. To support the RDI and to create economic, health, social and environmental benefit for the country, the National Water Research, Development and Deployment (RDD) of innovations programme focus on delivery of at least one breakthrough technology every five years; increasing the number of small- and medium-sized enterprises operating in the water sector; and increasing access to water for rural communities, including provision of sanitation for all, in a sustainable manner (WIN-SA, 2016). WADER is one of the instruments of the Roadmap and focuses on the demonstration of promising technologies emerging from the innovation pipeline in the water sector.
WASH Policy	
The Second National Water Resources Strategy (NWRS2) (2013)	The purpose of the NWRS2 (DWA, 2013) is to ensure that national water resources are protected, used, developed, conserved, managed and controlled in an efficient and sustainable manner towards achieving South Africa's development priorities in an equitable manner. In the context of the need for growth, equity and protection of water resources, this Strategy identifies three broad objectives: water supports development and the elimination of poverty and inequality; water contributes to the economy and job creation; and water is protected, used, developed, conserved, managed and controlled in an equitable and sustainable manner. In addressing these objectives, the Strategy emphasised that the country would consider other potential sources of water, such as water reuse, desalination, groundwater utilisation, water conservation and water demand management measures, rainwater harvesting, recovering water from acid mine drainage, and the import of water intensive goods. This indicates ample opportunities and scope for innovation. However, the stipulations in the NWA stifle attempts at innovation because of the many restrictions placed on water users.
National Water and Sanitation Master Plan (2019)(DWS, 2018)	The NWSMP seeks a resilient and fit-for-use water supply; universal water and sanitation provision; equitable sharing and allocation of water resources; effective infrastructure management, operation and maintenance; and reduction of future water demand. The NWSMP also addresses the enabling requirements of the sector, such as the institutional and legal arrangements for implementation, funding requirements and models, monitoring and evaluation models, the creation of effective water sector institutions, managing data and information, building capacity, ensuring financial sustainability, amending legislation where required, and enhancing research, development and innovation. The NWSMP reiterates that ongoing research, development and innovation, and the harnessing of international developments, is a critical element of translating research and innovation into implementation at scale. Innovation actions in the NWSMP: 1) Implement and regularly review/revise Research, Development and Innovation Policies, Plans and Roadmaps across the sector 2) Scan and sort the innovation sector for solutions that are ready for application and invest in their implementation 3) Continue to develop high end skills (post graduate) to ensure a future science, technology and innovation capability in South Africa

Policy of Strategy	Description
	4) Continue to support programmes that enable development of critical skills and exposure to emerging innovations (e.g. Young Engineers Programme).
Strategic Framework for Water Services (2003)	The Strategic Framework on Water Services (SFWS) (DWAF, 2003) sets out a strategic framework for the implementation of water policies and legislation, ranging from small community water supply and sanitation schemes in remote rural areas to large regional schemes supplying water and wastewater services to people and industries in our largest urban areas. It makes no reference to innovation or R&D in setting out its principles and goals. Its main focus is that water services authorities and providers must provide water services sustainably in an effective and efficient manner – "Protecting consumer interests must be the key consideration when water services authorities consider how water and sanitation services should be provided" (DWAF, 2003:16) – thus striving to meet and exceed recognised best-practice benchmarks. Therefore, the conventional, and tried and tested ways of servicing the country is advocated with little space for innovation. The SFWS does support the use of appropriate technologies: "National government will support the development and dissemination of appropriate and environmentally friendly technology to support the provision of affordable and reliable water and sanitation services to all South Africans. This will assist water services authorities to examine the full suite of options available before deciding on a particular technology for delivery of water and sanitation" (DWAF, 2003:47).
National Sanitation Policy (2016)	The National Sanitation Policy (DWS, 2016) emphasises that research and innovation in the sanitation sector is crucial to achieving both national and international imperatives of water conservation and demand management, water security and the public health benefits of sanitation. The policy states that the focus should be on developing the skills and capacity to conduct research and innovation required to address current and future sanitation sector needs; that R&I capacity should focus on minimising resource use and impacts and maximise reduce, reuse, recycling and reclamation; and that R&I of appropriate sanitation service technology should be strengthened. This policy promotes innovation in that it supports the use of appropriate and sustainable technologies for sanitation based on a bottom-up approach emphasising the use of local knowledge, resources and labour in reduction, re-use, recycling and recovery efforts.
Appropriate Technology Strategy (2009)	An Appropriate Technology (AT) Strategy was developed in 2009 for the then Department of Water Affairs, which described appropriate technologies as "technologies with a human face", in that they fit the socio-cultural, geographical, economic and environmental context of the community in which it is being applied. Although the AT strategy did not place emphasis on innovation in itself, its approach of appropriateness of water and sanitation technologies infers innovation, even though it does not exclude the conventional tried and tested technologies.
Financial Policy	
R&D Tax Incentives	The R&D Tax Incentive is part of a package of measures that the government has introduced to support R&D led innovation, industrial development and competitiveness. This incentive, in wanting to boost "… *innovation by improving the capability for developing new products and processes and improving existing ones*", provides tax deduction for expenditure of approved projects in South Africa aimed at systematic investigative, or systematic experimental, activities. This tax incentive can boost innovation, but the bureaucracy and time it takes to apply and obtain approval for innovative projects may be too onerous for innovators.

Policy of Strategy	Description
Supply chain management (SCM)	Supply Chain Management is an integrated part of financial management, intended to introduce international best practices. SCM is a collaborative strategy to integrate procurement and provisioning processes so as to eliminate non-value-added cost, infrastructure, time and activities in a way that will serve end users better and more competitively. The purpose of Supply Chain Management (SCM) is to give effect to the five pillars of procurement – fair, equitable, transparent, competitive and cost effective. The onerous and time-consuming processes do not assist in innovations being scaled up.

4.1.3 National Legislation that Enables Innovation in the Inputs to the WET and DRY WASH Value Chains

Inputs into the WET and DRY WASH value chains are regulated through a number of Acts, specifically acts related to:

a) the Agrément South Africa Act;
b) the building and construction Acts in the country;
c) the environmental Acts related to wastes, i.e. menstrual product inputs; and
d) the health Acts related to hygiene products/

Legislation	Description
The Agrément South Africa Act No. 11 of 2015	The Agrément South Africa Act supports and promotes the process of integrated socio-economic development in South Africa, as it relates to the construction industry, by facilitating the introduction, application and utilisation of satisfactory innovation and technology development. Agrément South Africa (ASA) is an independent public entity for the technical assessment and certification of fitness-for-purpose of innovative building and construction products or systems. The ASA's mission is to promote government's objectives of economic development, good governance and raising living standards and prosperity in South Africa by encouraging and facilitating the use of innovative and non-standard construction products through its certification scheme.
National water and sanitation norms and standards (2017)	Water conservation, recycling and environmental protection measures required for integrated water management reflected in the norms and standards create ample space for innovation. However, seeking to attain reliable and repeatable services result in a reluctance to try new and relatively untried ideas, thus a lack of innovation.
Building regulations and codes	The National Building Regulations and Building Standards Act No. 103 of 1977, as amended in 2008, forms the basis of how buildings in South Africa should be constructed and developed to suit human habitation (RSA, 1997a). The legislation became enforceable as law in September 1985, and two years later were published by the SABS as part of the original Code of Practice for the application of the National Building Regulations, SABS 0400-1987. Its intention is to provide for the promotion of uniformity in the law relating to the erection of buildings in the areas of jurisdiction of local authorities and for the prescribing of building standards. Innovation and uniformity do not necessarily go together.
South African National Standards (SANS)	Several national standards, which need to be adhered to, are prescribed by the SABS for water and sanitation facilities, the most recent, the SANS 30500. These national standards are aimed at providing effective and efficient products and services, promoting the conventional tried and tested, and do not leave much room for innovation or the adoption and use of innovative technologies.

4.2 SUMMARY OF THE SOUTH AFRICA WASH INNOVATION POLICY

Although water innovations is one area where South Africa can deliver value to the WASH value chains in the country, there is equally a need for innovation in the water and environmental policies that guide innovations in this sector (O'Callaghan et al., 2020). The need for innovative water and environmental policies, in concurred by the outcomes of the stakeholder engagement process in Section 6.2 and Section 6.3, particularly innovative policy that enables deployment, localisation and socialisation of innovations.

Innovative policy in South Africa would include the development of new regulations that will create the space for water innovation, the creation of new finance models, and new financial mechanisms and business models, as well as innovation in terms of how the value of water is communicated to the public (O'Callaghan et al., 2020). Countries have experience on how regulatory gaps and misdirected policies can slow down the adoption of innovative technologies, thus new approaches to water innovation policy provide an exciting, yet challenging, opportunities to question traditional water policy approaches to innovation and how policy can facilitate the combining of new and old technologies that are emerging on to the market (O'Callaghan et al., 2020).

Rose and Winter (2015a) noted that, while South Africa had considerable sophistication in innovation policy and that the language of innovation systems had taken firm root in the policy, the policies themselves do not always translate to an effective innovation system. R&D statistics on their own also do not provide a true picture of innovations in the country. The same study indicated that the gaps and challenges identified in the innovation sector of the country and in policy for water innovation was largely due to challenges in optimising innovations from R&D to deployment (and ultimately localisation and deployment) (Rose and Winter, 2015a).

The water innovation sector of the country still viewed the innovation value chain as a linear system, relying upon incremental improvement in inputs to ensure the generation and use of societally relevant knowledge and technology (Rose and Winter, 2015a). There seemed to be a disconnect between what researchers and practitioners deem as important gaps in the water and water innovation sector, and what innovation policies and policymakers were seeking to address – namely a policy directionality failure. This lead Rose and Winter (2015a) to conclude that *the gap between the intentions of forward-thinking innovation policy and the realities confronting research and researchers is wide, and remains a significant challenge. Efforts to build a system of innovation are clear, but actual policy action does little to encourage innovation systems thinking, but rather relies on traditional, R&D-based action in practice. Local government and other state players fail to create an enabling environment to test, pilot and diffuse new water-related solutions. In response, a new level of stimulation is required from the major players in the innovation system – the NRF, TIA, WRC and DST – that need to stimulate the coordination and alignment of their actions within an acceptable and appropriate innovation systems framework.*

Rose and Winter (2015a) suggested that to address gaps in the water innovation sector, innovation policy needs to be focussed on strengthening the entire innovation chain from conceptual stage to market, while at the same time meeting social development needs. Innovation policy also needed to (Rose and Winter, 2015a) :

- be supported by a strong leadership and enabling (i.e. policy) environment;
- be supported by risk-taking in water science and technology;
- promote knowledge-related infrastructure and data sharing;
- reorganise the research environment within universities;
- strengthen funding for entrepreneurship and support for infant enterprises;

- create centres of competency with strong industrial-design and economic- and market analysis capabilities; and
- retain post-doctoral students through improved and longer-term funding to sustain longer-term research activities.

Diercks (2019) suggested the developing and implementing transformative innovation policy in a country necessitates a focus on two core parameters: (1) the policy agenda being pursued, and (2) the understanding of the innovation process used in the articulation of innovation policy. From the perspective of the first parameter, namely the water innovation policy agenda in South Africa, a transformative innovation water policy would need to rest on a societal policy agenda with three elements:

1) Targeting water innovation policy domains beyond economic and industrial policy.
2) Including water innovation policy objectives dealing with a broad range of societal challenges.
3) A water innovation policy logic that challenges a strong pro-innovation bias.

From the perspective of the second transformative innovation parameter, namely the understanding of the innovation process, the water innovation policy would need to recognise the heterogeneous and contested elements in the country regarding water innovations:

a) Actors.
b) Activities.
c) Modes of innovation.
d) Even though South Africa has a number of good legislation and policies in place to support and enhance innovation, the onerous compliance requirements may have prevented countless potential entrepreneurs and innovators from succeeding, or even starting the process. Aspects of the implementation of the South African regulatory requirements has for a long time hindered rather than helped innovation. Systemic institutional fragmentation due to a lack of coherence and coordination across government departments and institutions, poses a challenge. According to Sibanda (2018), a Ministerial Review (2012) found that the concept of the national system of innovation has failed due to poor coordination across government departments and agencies.
e) The policy lag between the enactment of laws and the drafting of municipal policies and the implementation lag between approval of policies and their effective implementation pose a major challenge.
f) The current legislation in the water and sanitation sectors appears to bureaucratise rather than incentivise innovation. This may lead to unintended consequences, resulting in a decline in the volume of research conducted for innovation, or a decline in the volume of research made available for public benefit, or a decline in the search for innovative technologies to address the water and sanitation challenges.
g) South Africa has adequate intellectual property rights and policies to promote innovations, research and development and technology transfer to support a growing, sustainable economy. However, there is a lack of understanding and awareness around intellectual property policies in South Africa, which has had significant negative impacts on the transfer of innovation (Amis & Lugogo, 2018).

CHAPTER 5: METHOD FOR THE REVIEW OF POLICY BARRIERS TO WASH INNOVATION IN SOUTH AFRICA

5.1 FRAMEWORK FOR THE REVIEW OF POLICY BARRIERS TO WASH INNOVATION

The globe has in the past 5 years shifted developmental focus onto achieving the Sustainable Development Goals (SDGs). Key to achieving the SDGs are economies and economic growth that minimise/reduce negative impacts on natural resources and focus on the reuse, recycling and replenishing of resource to minimise waste from economic and other activities. Hence, the emergence of the circular economy discussions in many sectors across the globe.

A circular economy and value chains in this economy, according to the Circular Economy Action Plan of the European Union, is one where "the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised" (European Commission, 2015). A key vehicle for systemic change to a circular economy, according to the action plan, is innovation in "new technologies, processes, services and business models that will shape the future of our economy and society" (European Commission, 2015).

Similar to other resource use sectors, water is traditionally viewed in a linear fashion, from the perspective of a liner process of Take-Use-Discharge that is commonly adopted in the sector. The Wet and Dry WASH value chains shown above are largely linear value chains in South Africa, with new inputs being fed into the value chain and outputs from the value chain, including solid waste outputs such as discarded construction and installation materials and hygiene inputs, entering the waste streams in the country. Although there has been innovation and a shift in focus to changing this linear norm, these innovations and practices are localised and have yet to reach mass scale localisation and deployment to transform the value chains to a circular value chain, with little leakage from the value chain into the waste streams of the country (both liquid and solid waste streams).

Water in a circular economy in South Africa, would focus on a water system guided by 3 core principles (Tahir et al., 2018):

1) Principle 1: Design out waste externalities
2) Principle 2: Keep Resources in Use
3) Principle 3: Regenerate natural capital.

Applying these principles to the water system, Tahir et al. (2018) provided an adapted version of Circular Economy Systems Diagram specific to Water System, shown in Figure 25 below. The right-hand side of the water circular economy diagram focuses on human managed water systems, specifically those areas in the water sector related to provision of water and sanitation services to water users. The opportunity of the human managed water systems side of the water circular economic is in the deployment, localisation and socialisation of water services innovation that closely mimic water use and behaviours in the natural water cycle. All innovations, whether communal, public or market driven innovations, can be inspired by or supported by nature, and can be developed, deployed, socialised and localised to closely align to these natural systems (Ziegler, 2017). This especially pertains to innovation for a circular economy that focusses on regenerative processes (Ziegler, 2017). Indeed, nature-based solutions in the nature managed circular water economy, promote "greater resource productivity aiming to reduce waste and avoid pollution, including through reuse and recycling" (WWAP, 2018). Water services innovation for a circular economy in the water sector would thus need to focus on mimicking the natural water cycle to (taken from Tahir et al. (2018):

- avoid water use – through rethinking products and services and eliminating ineffective actions;
- reduce water use – driving continuous improvements through water use efficiency and better resource allocation and management;
- reuse wastewater, urine and faeces – pursuing any and all opportunities to reuse WASH resources (water, urine and faeces) within an operation (closed loop) and for external applications within the surrounding vicinity or community;
- recycle wastewater, urine and faeces – within internal operations and / or for external applications; and
- replenish water, urine and faeces – efficiently and effectively returning water to the basin and nutrients in urine and faeces to the soil.

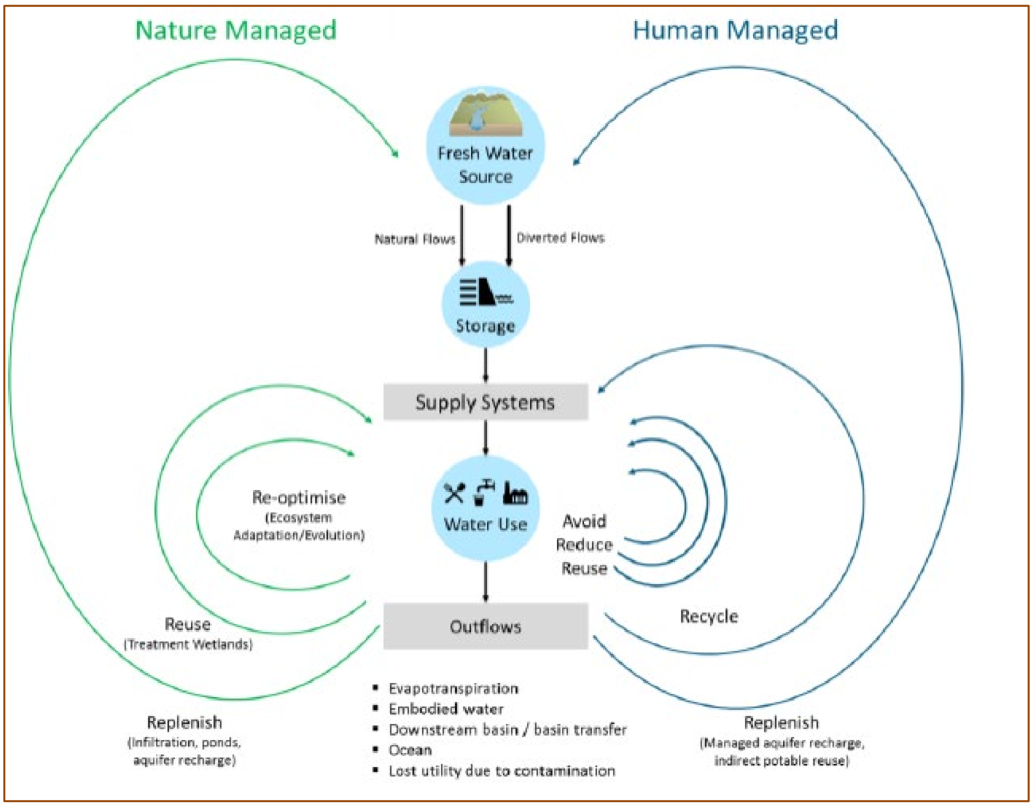


Figure 25: Circular Economy Systems Diagram specific to Water System (taken from Tahir et al. (2018))

Innovation thus, has a central role to play in the human managed water system, specifically in water use avoidance, reduction, reuse, recycling and replenishment.

To shift the linear framing of the water system in South Africa will require transformative change. Transformative change within the water services sector of the country may require change of life-style, and thus daily mobility, water, energy, food and other resource use practices of individual water users (or consumers), as well as by industrial and professional water users (Schot and Steinmueller, 2018).

The approach recommended to reviewing water innovation policy in South Africa was that of a transformative innovations policy model. Since transformation innovative policy is the newly adopted approached to formulation of innovation policies, the assumption is made that the South African water innovation sector would opt to follow a similar approach in their innovation policy/policy positions for the future. Similarly, the transformative innovation policy model has a strong focus on innovations for addressing issues of sustainability and poverty or inequitable income distribution (Schot and Steinmueller, 2018). Since these are national imperatives of the country, one could assume that the model for innovation policy would best suite the current needs for water services innovation policy in the country.

Evaluation of transformative innovative policy in the water sector would begin with the recognition of four types of failures that can occur in the transformative innovation value chain, namely (Schot and Steinmueller, 2018):

a) Directionality failure.
b) Policy coordination failure.
c) Demand-articulation failures.
d) Reflexivity failure.

Utilising the above and key innovation assessment methodological documents, such as the Oslo Manual of 2018 and EUs Innovation Union Competitiveness Report of 2013, a framework and assessment tools were developed to assess, using case studies, the policy barriers/challenges and enablers to innovation in the municipal water services sector of South Africa. Combining the complex, transformation innovation value chain adopted by the study, shown in the middle diagram of Figure 26, and the key components of a human managed circular water economy from Figure 25, a framework of interactions begins to emerge (Figure 26).

Figure 26 demonstrates an innovation value chain that has research and knowledge at the core, informing and being informed by the innovation value chain. The framework also demonstrates the need for feedback mechanisms between all the components of the innovation value chain. Applying this innovation value chain to the water services value chains in the country, should support and guide the emergencies of a human managed circular water economy, based on the principles of water avoidance, reduction, reuse, recycling and replenishment.

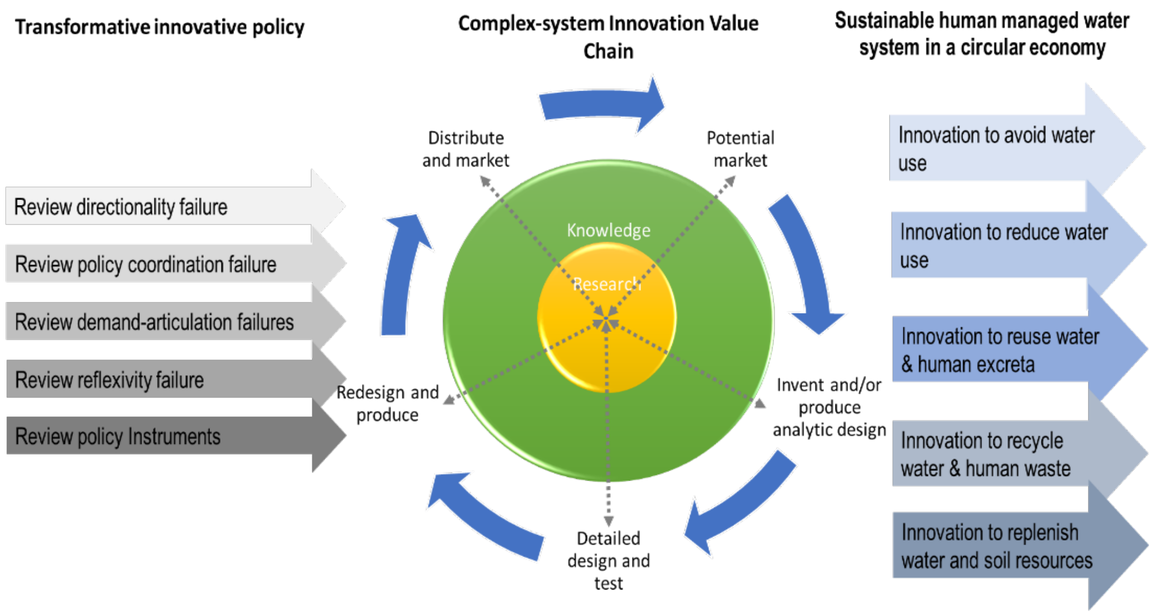


Figure 26: Framework for review of transformative innovation policy in the water services sector.

Initialising the framework outlined in Figure 26, innovations in South Africa were reviewed and categorised into one or more of the circular economy categories shown in the right-hand arrows of

Figure 26, i.e. categorised for their purpose – water avoidance, water reduction, etc. The innovations were subsequently prioritised for inclusion in the study and innovators contacted to participate in the survey. The survey/questions of innovators included in the study focussed on capturing policy barriers in the categories shown in the left of Figure 26, namely the barrier in a transformative innovation policy. The policy barriers captured in the stakeholder engagement, through the review of the literature and through the review of innovations were categorised into the failure categories shown on the left of Figure 26. These categories included the following:

- **Policy directionality challenges**: These policy failures are due to countries' WASH sector and WASH innovation value chains lacking the means for making social choices over alternative pathways of water development, i.e. barrier to adopting transformative WASH innovations. To address directionality failures in the water services value chain in South Africa, transforming the water services innovation policy would require consideration of innovation options beyond the narrow boundaries set by incumbents, and the nurturing of the opportunity for various groups to challenge dominant views embedded in the current socio-technical systems.
- **Policy coordination challenges**: These policy failures are due to policy coordination failures, namely the lack of ability of innovation policy to coordinate horizontal policies from various domains. To address coordination failure in an innovation value chain, transformative innovation policy would need to ensure coordination with other cross-cutting policies, including tax policy, economic policy, social policy, as well as ensuring coordination multiple-levels between local, regional, national and international policy. A whole-of-government approach would be required for the disruptive WASH innovative value chain.
- **Policy demand-articulation challenges:** These policy failures are due to policy that does not sustain an innovation demand articulation culture in a sector, namely policies that require not only exchange of information on qualities and costs of innovations, but also of information on the (technological and user-related) contents of these innovations. The policy would need to recognise and stimulate the major role of knowledge in user-producer interactions, placing an emphasis on interactive learning. To innovate successfully, policy needs to encourage constant sector learning. These interactive learning processes in which demands for (characteristics of) innovations are increasingly better understood can be regarded as demand articulation.
- **Policy reflexivity challenges**: These policy failures are due to failures in current thinking, of problem solving, of managing resources and people, and of planning. Policy that alters the modes of knowledge generation and use can be seen as reflexive modernisation.
- **Policy instrument challenges**: These policy failures are due to failures in policy instruments to realise the intent of the instruments.

5.2 METHOD FOR PRIORITISING INNOVATIONS

Together with the survey of the perceptions and experiences of the innovators with policies within the WASH sector, the study utilised case studies to highlight WASH innovation policy barriers and enablers. To determine these case studies, as well as to determine the innovations/innovators that could be included in the survey, a criteria-based assessment of WASH innovations in South Africa was utilised.

The prioritisation of innovations firstly, applied the review framework shown in Figure 26 above. Thus, innovations had to focus on mimicking the natural water cycle (taken from Tahir et al. (2018) by assisting the sector and users to either:

a) avoid water use in their operation;
b) reduce water use in their operations,
c) reuse water in their operation (closed loop) or reuse of wastewater/faeces'/urine resources;
d) recycle water, faeces, urine or wastewater; and/or

e) replenish water resources.

Thus, the first criteria applied to the innovations was that the innovation had to fall within one or more of these sustainable human water systems.

The assessment of innovations, using the criteria-based approach, was largely based on innovations listed in the WRC literatures, as well as innovations found in research literature and from an internet search. The criteria that were applied to prioritise and selected these WASH innovations largely related to South Africa's definitions for innovations that would address a circular economy in the country, namely innovations that avoid, reduce, reuse, recycle and replenish water resources or that meet basic human rights need. Thus, innovations were prioritised if they met the South African (DWS, 2013 NWRSII) definition for reusing or recycling resources and met the research study definition for water avoidance, recycling and replenishment (see Box 21 for these definitions). The definition for water recycling and reuse innovations had to be adapted slightly to address the reuse and recycling of faeces and urine, largely from dry sanitation system.

A definition was also utilised for categories human rights water innovations, which were deemed to be innovations that may not necessarily meet the innovation criteria required for a circular water economy but address a gap in the water value chain in the country that address a need to ensure universal rights to basic water and sanitation services.

Box 21: Key definitions applied to prioritise WASH innovations

Human rights water innovations: these are innovation that have the purpose of addressing the **universal right to basic water and sanitation** services.

Water avoidance innovations: water is not required to operate the innovations

Water reduction innovation: innovations that save water through reduce water consumption in their operation or reduced water losses in the system

Recycling innovations: these are defined as innovation that facilitate the utilization of **treated or untreated wastewater, faeces and urine for the same process that generated it**, i.e. it does not involve a change of user (DWS, 2013 NWRSII). For instance, recycling the effluents in a pulp and paper mill.

Re-use innovations: these are defined as innovation that facilitate the utilization of **treated or untreated wastewater, faeces and urine for a process other than the one that generated it**, i.e. it involves a change of user (DWS, 2013 NWRSII). For instance, the re-use of municipal wastewater for agricultural irrigation.

Direct re-use: Re-use of treated or untreated wastewater by directly transferring it from the site where it is produced to a different/separate facility for the next use (DWS, 2013 NWRSII).

Indirect re-use: Re-use of treated or untreated wastewater after it has been discharged into a natural surface water or groundwater body, from which water is taken for further use (DWS, 2013 NWRSII).

Intentional or planned re-use: Use of treated or untreated wastewater as part of a planned project. It is always performed intentionally, consciously and using reclaimed water for a specific user (DWS, 2013 NWRSII).

Unplanned or incidental re-use: Subsequent use of treated or untreated wastewater after it has been discharged into a surface water or groundwater body from which water is taken for drinking purposes or another use. Initially, it always occurs as a subconscious activity; with time it might occur consciously but not as part of a planned project in which wastewater is properly treated and water quality monitored for the specific water use purpose (DWS, 2013 NWRSII).

Reclaim Innovations: these are defined as innovation that facilitate the utilization of wastewater that has been treated to a level that is suitable for sustainable and safe re-use (DWS, 2013 NWRSII).

Utilising the criteria for categorising innovations, namely the definition for the sustainable human management systems in the circular economy, WASH innovations in South Africa were classified into the sub-groups of innovations shown in Figure 27.

Emerging from this classification process was that water innovations in the country would fall within two sustainable circular economy categories, namely (1) water innovations that reduce water consumption and losses and (2) innovations to replenish water resources. This was largely due to water supply systems not being able to operate without water and thus water innovations could not fall within the avoid water and the reuse and recycle water, as water in the country can only be reused or recycled in the wastewater (sanitation) pillar of water services in the country.

Sanitation innovations could be classified across all of the sustainable circular economy categories, from those that avoid water use to those that replenish water resources. Hygiene innovations were largely groups under those that avoid water use or reduce water use in the operation. Any reuse or recycling of water in hygiene innovations would fall within the sanitation innovations.

Innovations through this process of categories, were therefore, largely categories based on the key purpose of the innovation, i.e. reduce, reuse, etc. This provided insight in the levels of innovations that targeted circular water economy imperatives in the country.

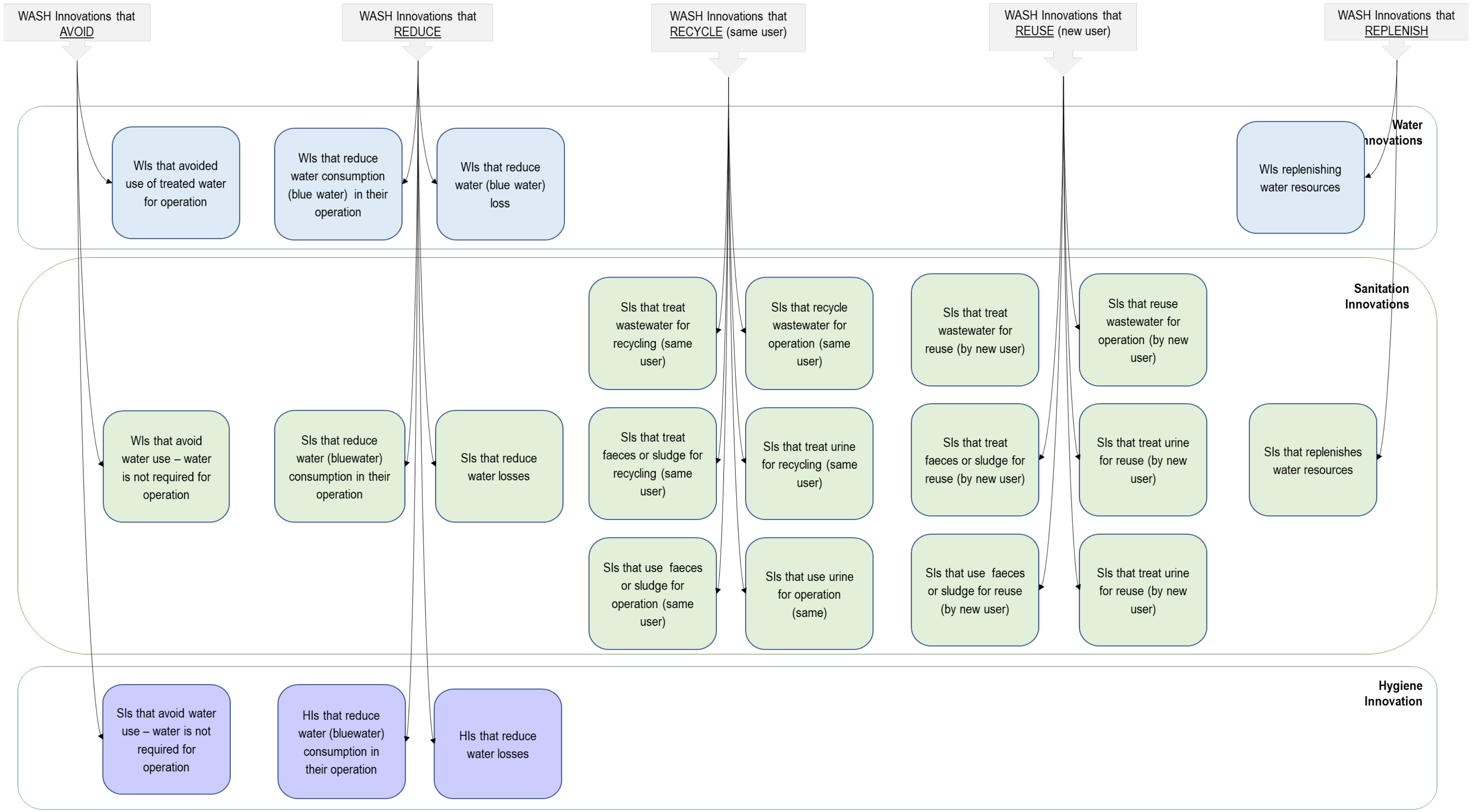


Figure 27: Classification utilised for the prioritisation of WASH innovations.

5.3 METHOD OF STAKEHOLDER ENGAGEMENT ON WASH INNOVATIONS POLICY BARRIERS

The review of policy barriers adopted a stakeholder engagement process. Noting the need to understand stakeholders' perceptions and experience with national and local policies when developing and deploying their innovations, a structured interview survey was developed for this study (see Appendix 1 for the questionnaire). The questionnaire was focussed on capturing policy challenges and enablers experienced by innovators in the WASH sector of the country.

The survey was loaded onto the SoGoSurvey App to garner inputs from innovators in the WASH sector. The innovators had to be 18 years and older and had to agree to participate in the survey.

The questions covered the following:

- Demographic information (gender, age).
- The category of WASH innovation (water, wastewater, on-site sanitation, sewered sanitation, hygiene).
- Name of WASH innovation.
- Trigger for the WASH innovation (what gap/challenge/need does your innovation address).
- Stage in the RDI value chain of the WASH innovation.
- The main (top 5) obstacles experienced regarding the research and development of the WASH innovation.
- The main (top 5) obstacles experienced regarding the deployment of the WASH innovation into the market or society.
- Awareness of policies that support to research, development and deployment of WASH innovations
- List of policies that helped/hindered research, development and deployment of WASH innovations into the market and society.
- Innovators' opinions regarding policy support in the South African water sector for WASH innovation research, development and deployment.
- Innovators' advice to new innovators/entry innovations regarding policy support for WASH innovation research, development and deployment in the South Africa.

The survey and link to the SoGo site was emailed to 54 innovators in the WASH sector who were identified through the innovation prioritisation process above.

The questionnaire for the survey also formed the basis for virtual interviews with key stakeholders.

CHAPTER 6: RESULTS OF THE REVIEW OF INNOVATIONS AND INNOVATORS SURVEY

6.1 RESULTS FROM THE CRITERIA-BASED CATEGORISATION OF WASH INNOVATIONS

Applying the prioritisation method outlined in Section 5.2 above, a review of South Africa WASH innovations was conducted and these innovations categorised into one or more of the systems shown in Figure 27 above. It should be noted that only WASH innovations that have application in the municipal water and wastewater management systems were captured. Innovations related to management of water resources were not captured, as was the case for innovations that focussed on ecological systems.

6.1.1 Water innovations

Water innovation (WIs) demonstrated, in Table 9, that there was an extensive array (not all could be included in the table) of these innovations, particularly related to innovations the target **reduced water in their operations** or target **reduced water use by the end-user**. There was a dearth of information on innovations for system wide water reduction, i.e. municipal level water reduction in their networks, as the majority of the water innovations targeted water reduction of the end-user, i.e. households.

Table 9: Water innovation that avoid or reduce water use in the operations or by the end-user.

Category	Innovation	Non-optimal criteria	Optimal criteria	Innovation	Innovation Examples
Water innovations with Avoid Treated Water Use in their Operation	WIs that avoid the use of treated bluewater for their operation	Supply systems that require treated water	Water supply system with mixed use of water	Utilisation of alternative water sources	• Rainwater harvesting • See Section 3.1.1.1 for more examples
Water innovations with reduce water consumption	WIs that <u>reduce</u> consumption (blue water) in their operation	Shower head Minimum flow rate of 15 L/min	maximum flow rate of 7 L/min or less	low flow showerheads	• Ecoflow Tri-Flow 2 – 6LPM Adjustable Shower Head • Ecoflow 5.7LPM Luxury Spa Shower Head • Ecoflow 6.7LPM Prestige Handheld Showerhead
		Tap flow rate of 12 L/min or more	Tap flow rate of 4 L/min and less	Flow limiters on taps-for example spray taps	• Neoperl M22 Directional Swivel Regulating 6L/min Aerator • Oxygenics Water Saving Shower Head SkinCare with Flow Control
	WIs that <u>reduce</u> water (blue water) loss	Leakage of water from distribution systems	Reduces leakages from the water system		• Econoleak • Benchleak Model

6.1.2 Sanitation Innovations

The review of sanitation innovations highlighted, in Table 10, that South Africa has a large number of sanitation innovations that focussed on **water avoidance** and **water reduction**. The majority of these innovations are adaptations and modifications of dry sanitation systems that avoid water use for the operation, and flush sanitation systems that utilise reduced quantities of water to operate.

There were also emerging innovations that were focussing on closing the sanitation loop by **treating on-site greywater and wastewater for recycling/reuse** within the sanitation-water cycle or treating **faecal sludge, faeces or urine for recycling/use or reuse** as soil conditions, biochar, etc. on-site or off-site.

These recycling and reuse innovation were much fewer in the literature compared to the sanitation innovations in avoidance/reduction.

Table 10: Water innovation that avoid, reduce, reuse and recycle resources (i.e. water, faeces, urine) in their operation or by the end-user.

Category	Innovation	Non-optimal criteria	Optimal criteria	Innovation	Innovation Examples
Water avoidance sanitation innovations	Innovations that avoid water use – water is not required for operation	Sanitation innovation that requires water to operate	0% water to operate	Dry sanitation systems	• African Sanitation (desiccation toilet) • AndyLoo • Auger toilet with liquid/solid separation (Desiccation) • Composting Solar Powered Toilet (desiccation toilet) • Dehydration Conveyance Toilets • Eco Mite • ECOSAN waterless toilet system • Enviro Loo • Fossa Alterna • Gran Taldoro de la tierra • LaDePa Sludge Pelletiser • Loowatt – seals faeces in a biodegradable film • Peepoo – biodegradable bag used for excreta collection where no toilet is available • Solar San • Urine Diversion Toilet • Waterless Sanitation • ZerH2O Waterless Toilet
Sanitation innovations with reduce water use or losses	SIs that <u>reduces</u> water (bluewater) consumption in their operation	9.5 L/min flush older models	An effective volume of 4.5 L for dual -flush or 3-6 L flushing toilets	Waterborne sanitation systems that reduce water use	• Arum toilet • DSA toilet • EziFlush • HS toilet • Low-flush – Calcamite • Low-flush – DSA • Mtee Designs Low Flush • Pour flush toilet • Smartsan – New World Sanitation • The Bubbler • Vacuum toilet (Low Flush)
	SIs that <u>reduces</u> water losses				• Sanflow

Category	Innovation	Non-optimal criteria	Optimal criteria	Innovation	Innovation Examples
Sanitation innovations (SI) that recycle water, faeces or urine, i.e. same user	SIs that uses treated or untreated wastewater for operation	Utilise potable/fresh water (bluewater) for operation	Utilisation of greywater for operation	Greywater from kitchen, bathroom and laundry directly or indirectly reused	• Grey water systems for flushing toilets • Greywater bucketing • Greywater diversion device • Greywater treatment system
			Utilisation of wastewater for operation	Closed-loop household sanitation systems	• Portable SMARTSAN Recycle Toilet • SMARTSAN Recycle • Bio-Mite Recycling System (BRS)
	SIs that treats wastewater for recycling	Discharge wastewater into sewer system	Treats wastewater for recycling on-site	Closed-loop wastewater treatment plant or household sanitation systems	• Portable SMARTSAN Recycle Toilet • SMARTSAN Recycle • Bio-Mite Recycling System (BRS)
			Treats greywater for recycling on-site	Closed-loop household sanitation systems	• Ozone Greywater System • Ecogator • EzGrey
	SIs that treats faeces, for recycling	Faeces flushed and enter the bluewater system	Utilisation of faeces for soil conditioner (household level)	Desiccation and compositing sanitation systems	• AndyLoo • Biofil Wastewater Treatment Technology • Compost Biofil Technologies • Composting Solar Powered Toilet (desiccation toilet) • Fossa Alterna • Humanure (composting) Toilet • LaDePa Sludge Pelletiser – a dehydration and pasteurisation system designed to produce organic fertiliser from pit latrine sludge. • NWS Bacterial Toilet • Urine Diversion Toilet
	SIs that contain or treat urine for recycling	Innovations where urine enter the bluewater system	Utilisation of urine for soil conditioner (household level)	Dry sanitation systems	• Urine Diversion Toilet
Sanitation innovations	SIs that treat wastewater for reuse				• Biofil Wastewater Treatment Technology •

Category	Innovation	Non-optimal criteria	Optimal criteria	Innovation	Innovation Examples
that reuse water, faeces or urine, i.e. different user	SIs that reuse treated or untreated wastewater for operation	Utilisation of potable water (bluewater) for operation	Utilisation of greywater for operation	Greywater from kitchen, bathroom and laundry directly or indirectly reused	• Advanced Baffled Reactors (ABR) • Anaerobic Filter Biodigestors • Horizontal Constructed Wetlands • Vertical Constructed Wetlands • Ecological Wastewater Treatment Systems
	SIs that treat faeces or sludge for reuse directly or indirectly	Flushing of faeces and sludge into water systems	Treatment of faeces or sludge for use by other users		• Black Soldier Fly Lavae (BSF) •
	SIs that treat urine for reuse directly or indirectly	Flushing of urine into water systems	Sanitising of urine for use by other users	Innovations that sanitise urine for reuse	• Urine Diversion Toilet
	SIs that uses treated or untreated urine	Flushing of urine into water systems	Utilisation of sanitation urine for other purposes	Innovations that utilise urine to operate	• Urine Diversion Toilet

6.1.3 Hygiene Innovations

The COVID-19 pandemic and other disasters, such as were experienced by the Day Zero countdown in Cape Town in 2019, has prompted a massive upscaling of innovations in the hygiene arena of WASH services. Many of these innovations focus on practicing good hygiene within the context of little or no water, i.e. **water avoidance or reduction**. The review of such innovation in South Africa did indicate a dearth of such innovations emerging in South Africa (apart from handwashing innovations), with the major of hygiene innovations emerging from the international hygiene market, i.e. large multinational organisations such as Johnson&Johnson; Proctor&Gamble, etc.

Table 11: Hygiene innovation that avoid, reduce, reuse and recycle resources (i.e. water and greywater) in their operation or by the end-user.

Category	Innovation	Non-optimal criteria	Optimal criteria	Innovation	Innovation Examples
Water avoidance hygiene innovations (His)	HIs that avoid water use in their operation – water is not required by innovation	HIs that require blue water to operate	0% water to operate	Dry shampoo	• Waterless Haircare (P&G) • Schwarzkopf Got2b Fresh It Up Dry Shampoo • Shelly – Dry Shampoo • Marc Anthony Grow Long Dry Shampoo Foam • Chi Luxury Dry Shampoo
				Dry shower	• DryBath • Pump it Up Dry Shower

Category	Innovation	Non-optimal criteria	Optimal criteria	Innovation	Innovation Examples
				Dry soap	•
				Hand sanitizer	
Hygiene innovations (His) with reduce water consumption or reduced water losses	HIs that reduce water consumption in their operation			Hygiene systems that reduce water use	• See water technologies that reduce water consumption
	HIs that reduce water losses in their operation				
Hygiene innovations that recycle water, i.e. same user	To use treated wastewater, directly or indirectly for hygiene innovations	Hygiene innovation that utilises potable/fresh water (bluewater) for operation	Utilisation of greywater for operation	Greywater from kitchen, bathroom and laundry directly or indirectly reused	
Hygiene innovations that reuse water	To reuse water – treated wastewater for potable or non-potable reuse	Utilisation of potable water (bluewater) for operation	Utilisation of greywater for operation	Greywater from kitchen, bathroom and laundry directly or indirectly reused	

The above listed innovations were utilised to conduct the survey of innovators in the country.

6.2 RESULTS OF THE SOGO SURVEY

Despite emailing the survey to a wide range of WASH innovators in South Africa, and after following up with the recipients of the survey, only 5 innovators completed the survey. The main findings from these 5 respondents are provided in this section of the report.

The respondents answer to the question of what trigger their development of the WASH innovation was:

1) the need for water efficient toilets that enable equal access and equal quality across society;
2) the water scarcity and ineffective water processing infrastructure in South Africa demonstrated the need for in-house off-grid sanitation which is also sludge-free;
3) the need for low-cost materials to improve wastewater quality;
4) to address a specific need in the sector such as treatment of acid mining waste water; and
5) to provide a viable and attractive upgrade alternative to VIP technology.

Figure 28 shows that respondents indicated that the main obstacles to WASH innovation research and development in South Africa was a lack of finance or the inability to raise the finance, as well as the challenging accreditation environment.

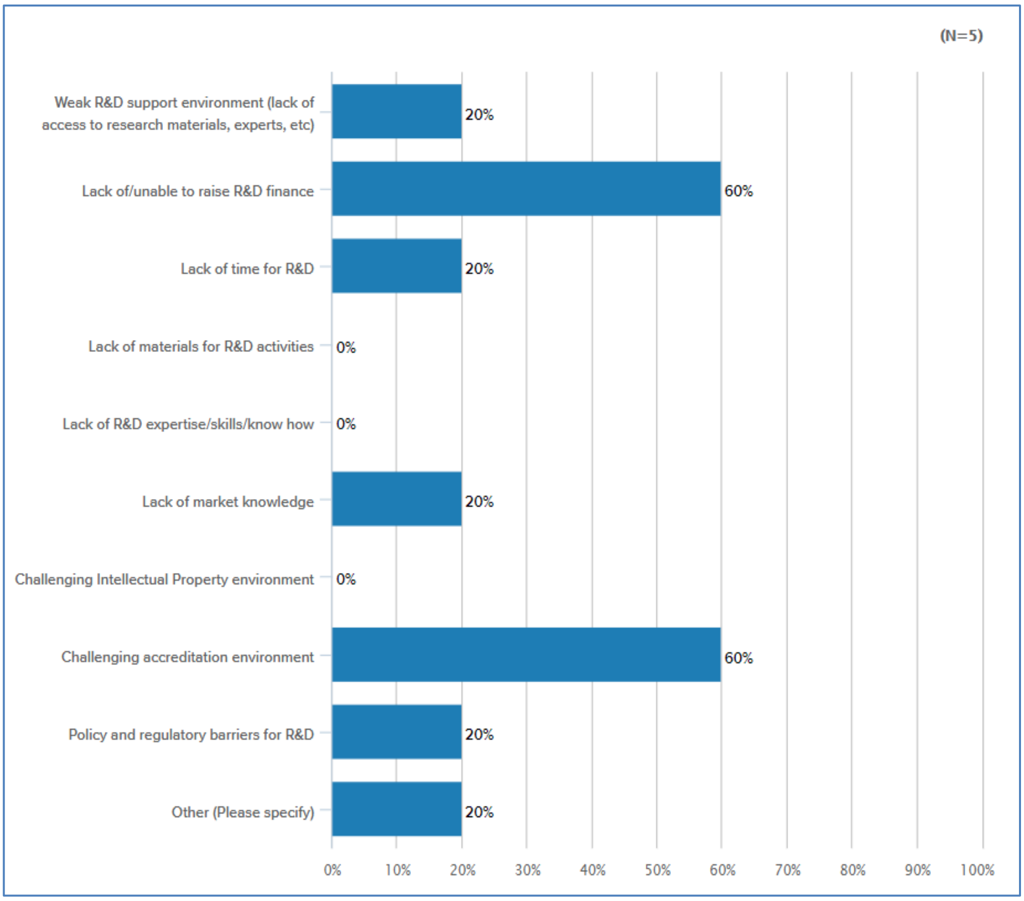


Figure 28: Main obstacles for R&D in the WASH sector

The respondents listed the following as policy barriers to research and development of WASH innovation:

i) “MFMA policies for capital equipment”.
ii) “Lack of knowledge from Municipalities and reluctance to adapt”.
iii) “BEE rules in general; no matter the innovation”.
iv) “SABS standard lag behind innovation”.
v) “The major barrier to new innovations in South Africa is that of the mining”.
vi) “MOA and MOU agreement authorization from highest levels such as manager director level”.
vii) “Community ‘protocols’ in general; notwithstanding allowance and respect for these”.
viii) "’Protocols’ are often used to solicit actions not supported by good business practice”.
ix) “Management have little interest in applying any new technology until they are forced by law to do so”.
x) The above indicates that some policies are useful and assist WASH innovation, especially in the R%D phase, but that many policies form barriers in the deployment phase of WASH innovation.

The main obstacles for <u>deployment</u> of WASH innovations mentioned by the respondents, shown in Figure 29, were the lack of, or inability to raise financing for deployment, and **regulation and policy barriers for deployment**. It is interesting that for the respondents who are in the R&D phase of innovations, their challenges were the financial and the accreditation environment, while the deployment phase of innovations was challenged by financial constraints, while regulation and policy were also barriers.

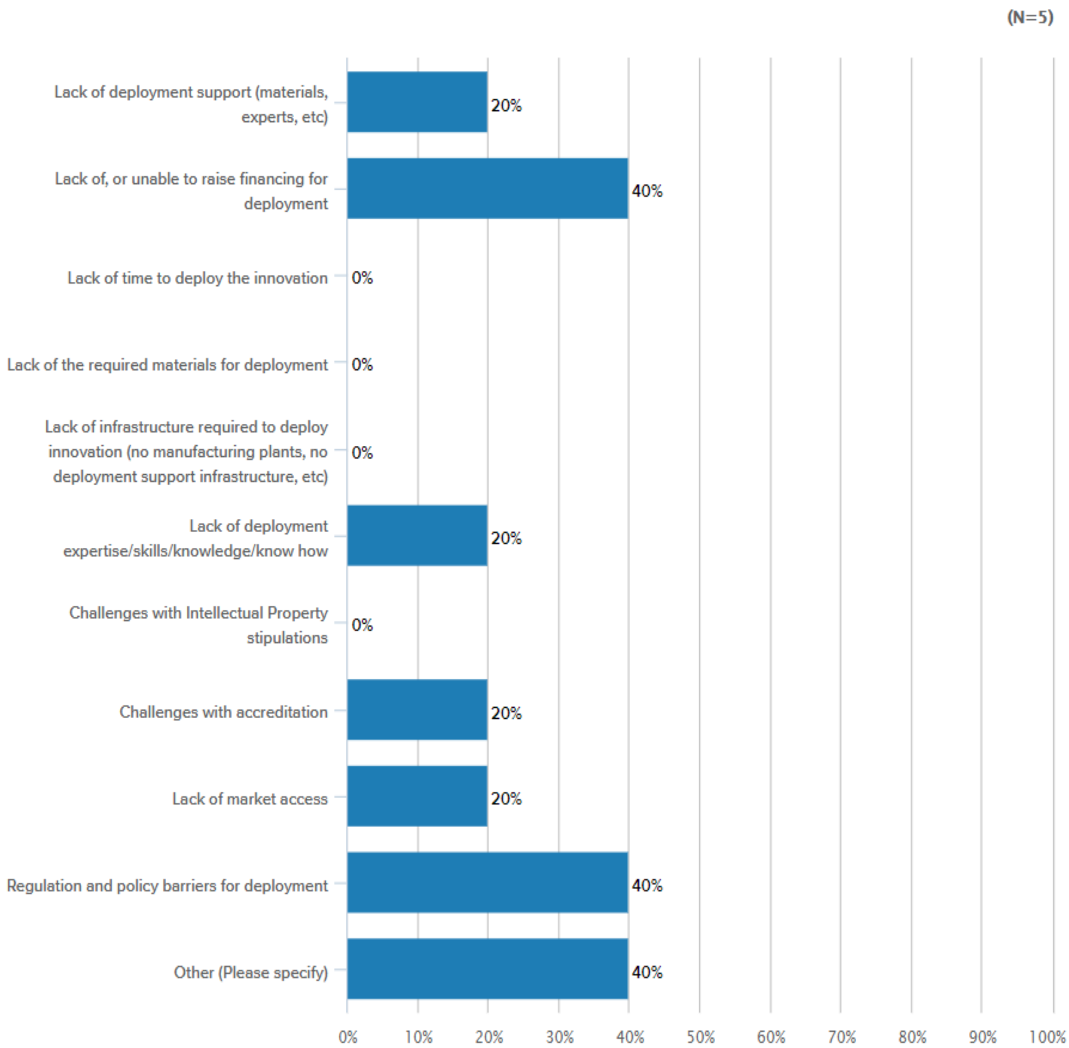


Figure 29: Main obstacles for deployment of WASH innovations

Focussing on the policy barriers noted by respondents, they indicated the following related to policies that support WASH innovation:

i) “I don't know of any 'policies' that support anything meaningful right now”.
ii) “None”.
iii) “Some support from the WRC”.
iv) “The Innovation Agency (TIA) – they worked very well to get our project to the marketable point”.

For the question about the usefulness and effectiveness of policies for WASH innovations, Figure 30 shows the respondents categorisation of the various policies for their ‘helpfulness” in assisting to get their innovations to deployment. The figure showed high recognition of the helpfulness of the South Africa Water RDI roadmap and moderate helpfulness of the Technology Innovation Act, South Africa national standards of the SABS, the South African building regulations and the IP R&D Act. Policies that were somewhat helpful (<33% helpful) were the National Sanitation Policy, Appropriate Technology Strategy, Agrement Act and IP Act. The policies that were perceived to be “not helpful at all were the STI White Paper, NWRSII, Finance Policies, Local Government policies and R&D Tax incentives. One could speculate that these policies and Acts could also be perceived to be barriers or provide challenges to innovation deployment of the country.

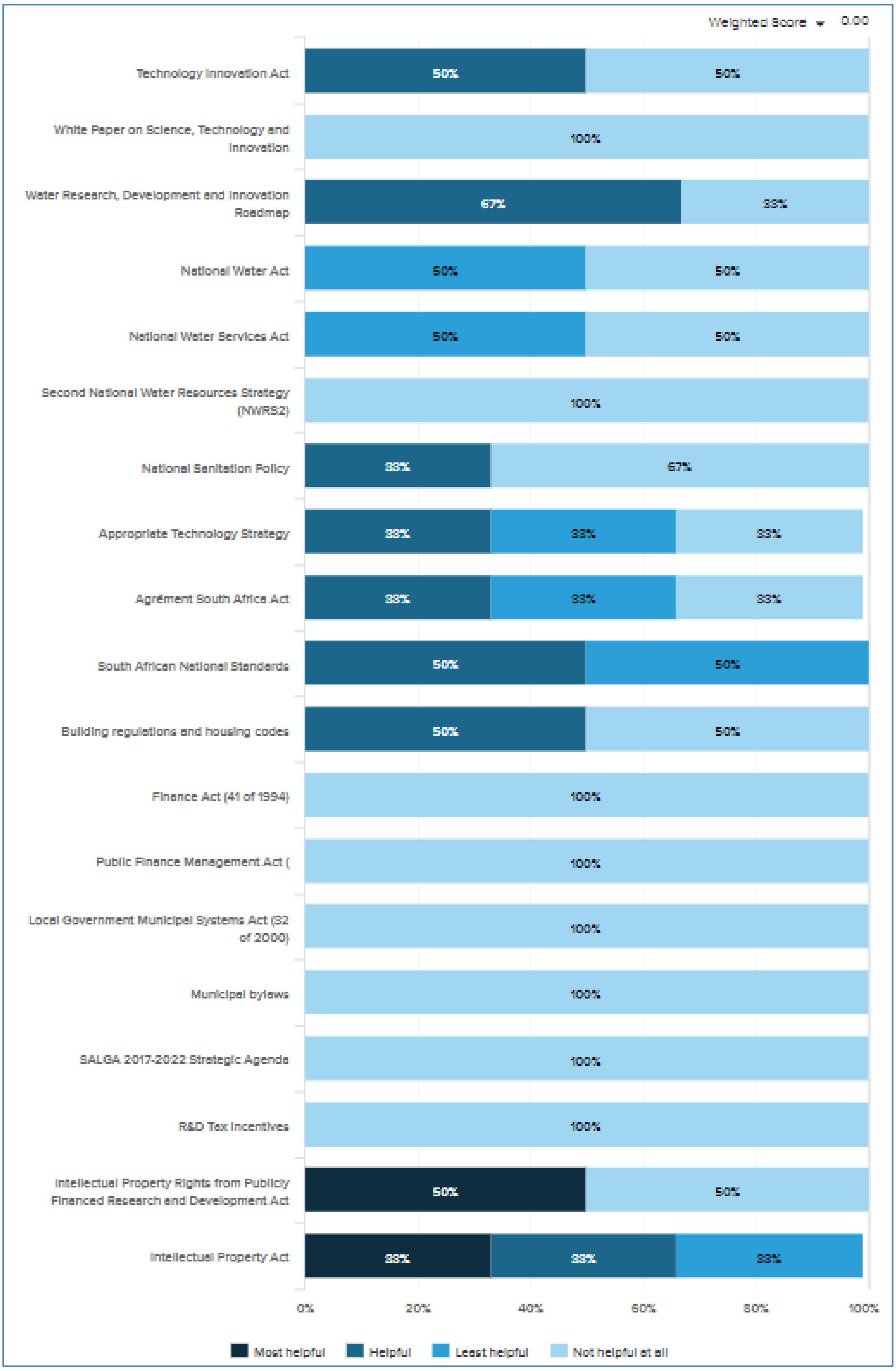


Figure 30: Respondents rating of usefulness of various policies related to WASH innovations

The respondents provided the following opinions on policy support to their WASH innovations:

i) “Successful demonstration needs to lead to accreditation and policy adoption”.
ii) “It exists in a bubble and Municipalities are unaware or could not care”.

iii) “It could be improved and all the signs and new drives that are emerging points towards improve support”.
iv) “Feeble”.
v) “The industry is practically in huge disarray; and WASH activities are lower in SA than in neighbouring countries. Why would that be? Lack of urgency from the 'top'; or lack of collaboration on the ground? Or both? ‘Policy’ has very high impact or weight when the main stakeholders do not connect to do what is necessary”.

The respondents’ advice to other innovators in the WASH sector are quoted as follows:

i) “Municipalities offer little support and universities would be better to support this drive with additional student and knowledge support”.
ii) “Do not rush to secure patenting, keep ideas secret until you have a good trajectory for commercialisation. Ensure that the technology complies with the required standards, or where there is a deviation that this can be justified as not compromising health or performance”.
iii) “Ensure your product follows market trends, patent what you can, take out design rights where applicable. Don’t re-invent the wheel but improve on it”.
iv) “If you believe in your product hard enough, you'll make it – simply because you're not willing to give up”.
v) “Hope that someone gets some teeth to bite the mining industry”.

In summary the survey results indicated the following:

- There seems to be serious interview/survey fatigue in the WASH innovation sector of the country – this fatigue was in fact voiced in some of the interviews that were conducted in the next step of the study.
- Policy was not deemed to be a barrier/challenge to the R&D phase of WASH innovation.
- Policy was deemed to be a barrier/challenge in the deployment phase of WASH innovation.
- Access to finance was a challenge at all stages in the WASH innovation value chain.
- A general lack of knowledge is evident of how South African innovation and water sector polices and legislation could enable WASH innovation deployment in the country.
- Recognition was evident of the helpfulness of the South Africa Water RDI roadmap in the innovation value chain.
- Recognition was evident of the moderate helpfulness of the Technology Innovation Act, South Africa national standards of the SABS, the South African building regulations and the IP R&D Act in the WASH innovation value chain.
- Recognition was evident that policies that were somewhat helpful (<33% helpful) in the innovation value chain included to sector specific policy such as the National Sanitation Policy and Appropriate Technology Strategy and accreditation/innovation protections policies such as the Agrément Act and IP Act.
- There was general consensus by survey respondents that a number of local governments, financial and sector specific policies were currently not helpful to WASH innovations in the country.

The survey results do seem to concur with a recent research study by Habiyaremye (2020) that indicated, based on data collected from key informant interview analysis as well as available secondary sources, the key constraints to deployment/diffusion of innovations to scale in the water sector of South Africa were in fact:

- financing constraints;
- technical validation difficulties;
- adoption costs; and
- lack of municipal support budget.

The study recommended that policy measures to support diffusion strategies should be introduced to ensure that innovators have the means to overcome the multiple diffusion obstacles that they are confronted with.

6.3 RESULTS FROM THE INTERVIEWS WITH INNOVATORS

Due to the low response to the survey of WASH innovators in South Africa, a number of virtual interviews were conducted with innovators that have deployed WASH innovations into the WASH value chains in the country. The Reference Group for this study also provided invaluable insight into the barriers and challenges in the WASH innovation value chain.

The following challenges and barriers to deployment of the innovations shown in the case studies were highlighted by the interviewees (Table 12).

Table 12: Policy barriers impacting on innovation in the water sector according to the interviewees.

Barriers	Description
External barriers	The COVID-19 pandemic has and will continue to affect the deployment of WASH innovations in the country.
Procurement and financial barriers	Slow and non-payment by government for WASH innovations, when installed or procurement by these institutions, can severely impact on deployment and on the manner in which WASH innovations are deployed to the market, i.e. innovators shift the market focus and thus limit deployment to private sector funding streams.
	Taking the deployment of WASH innovations to scale can be extremely costly, especially when specialised moulds or manufacture processes are required. The cost of upscale can sometime out way the benefits of deploying the WASH innovation on a large scale. The innovators suggest that in some cases "staying small is better" for some WASH innovations.
Knowledge and sharing barriers	There were barriers in the sector in share and networking of WASH innovation information. The sector is disjointed, with innovators operating in isolation without having a centralise platform/repository of information to share knowledge, build a community of practices, to source crucial information and data and to share experience, markets and insights related to deployment of WASH innovations.
Institutional barriers	Current WASH institutional and service delivery models may not be equipped to upscale and deploy disruptive innovations.
Market barriers	Knowledge and access to market are not always available for innovators, particularly innovators that are entering the WASH sector for the first time.
	The assumption is made that the person that develops and design the innovation, should be able to deploy the innovation into the market. However, experience has shown that very different skill sets are required for each stage in the WASH innovation value chain. This should be recognised by the WASH sector, as well as the WASH policy sector.
	The market may not be ready, may be unwilling or may be risk adverse to adopting innovations, particularly disruptive innovations, which require capture, treatment, recycling and reuse of wastewater, faecal sludge, faeces or urine. The aversion to change may be linked to the "yuck" factor attached to recycling and reuse of these resources.

Barriers	Description
	The manufacture industry or process may not be equipped to produce, at scale, disruptive innovation or even traditional innovations. This is a barrier to market entry for these innovations.
Policy barriers	There are gaps in standards for accreditation of some of the WASH innovations, even more so for disruptive, stretch-and-transform WASH innovations.
	There are gaps in government procurement policy and processes that is a barrier to uptake and deployment of WASH innovations.
	Innovation policies and innovation deployment needs to focus on national strategic needs as outlined in the Water and Sanitation Master Plan and National Development Plan. This can ensure that disruptive WASH innovations are targeting niche needs in the sector, while address Master Plan and national development imperatives.
	Policy currently does not drive demand for innovations, especially disruptive WASH innovations. Policy enablers in future need to focus on how to drive this demand for innovations.
	Local government by-laws may be a barrier to deployment and even the testing stage of disruptive WASH innovations.

Focussing on the above needs for a transformative WASH innovation policy in the country (Section 5.2, Table 13 shows the policy barriers that emerged as barriers to WASH innovation deployment localisation and deployment in the country. The deployment barriers in Table 11, which were highlighted by the stakeholders, are categorised within the various policy failures that could be employed to address, remove or mitigate the barriers to deployment of WASH innovations. The policy change categories include the following:

- Policy directionality challenges.
- Policy coordination challenges.
- Policy demand-articulation challenges.
- Policy reflexivity challenges.
- Policy instrument challenges.

Table 13: Application of the Framework for Policy Review to the Barriers to Deployment of WASH Innovations Highlighted by Stakeholders in the Country.

	Barriers and Challenges in the WASH Innovation Value Chain	Category of Policy Failure that could be Addressed to Remove or Mitigate the WASH Innovation Challenge/Barrier				
		Policy directionality changes	Policy coordination changes	Policy demand-articulation changes	Policy reflexivity changes	Policy instrument changes
External barriers						
	COVID-19 pandemic	√		√		√
Procurement and financial barriers	Slow and non-payment by government for WASH innovations	√				√
	High cost of upscale					√
Knowledge and sharing barriers	Barrier in the sector in sharing and networking of WASH innovation information			√	√	
	WASH innovations do not always understand the enabling role of policy and legislation			√	√	
Institutional barriers	Current WASH institutional and service delivery models may not be equipped to upscale and deploy disruptive innovations	√	√	√	√	√
Market barriers	Knowledge and access to market are not always available for innovators			√		
	Different skill sets are required for each stage in the WASH innovation value chain			√		
	The market may not be ready, may be unwilling or may be risk adverse to adopting innovations			√	√	√
	The manufacture industry or process may not be equipped to produce, at scale, disruptive innovation or even traditional innovations			√	√	√
Policy barriers	There are gaps in standards for accreditation of some of the WASH innovations			√	√	√
	There are gaps in government procurement policy and processes		√			√
	Innovation policies and innovation deployment needs to focus on national strategic needs as outlined in the Water and Sanitation Master Plan and National Development Plan	√	√			
	Policy current does not drive demand for innovations, specifically disruptive WASH innovations	√	√			
	Local government by-laws may be a barrier to deployment and even the testing stage of disruptive WASH innovations					

It should be noted that WASH innovation policy changes may not directly act on the barriers and challenges highlighted by stakeholders but will provide an enabling environment to facilitate the change that may need to take place to address, remove or mitigate the barriers to deployment of WASH innovations.

CHAPTER 7: EXPLORING THE PATTERNS OF WASH INNOVATIONS

Reaching this stage in the review of policy barriers to WASH innovation in the country, and despite sector stakeholders attributing challenges in deployment, localisation and socialisation of innovations to financial and policy/regulatory barrier, the researchers were interested to note whether one of the key challenges in deployment, localising and socialising WASH innovations may also be the position of many of the innovations in the value chain and the level of 'crowding' in that position. To better understand this issue, the researchers cross-tabulated the innovations that were captured in the review of the Dry WASH and Wet WASH value chains in Section 3.1 of the report, with the innovations reviewed as part of the prioritisation process in Section 5.2.

A database of 314 innovations were compiled, with the database utilised to conduct the analysis in this section of the report. The database categorised innovations in the follow manner:

a) WASH Value Chain; categories the innovation into the value chain in which it operates, namely Wet WASH, Dry WASH or both'.
b) WASH Sector – categorise the innovation as to which WASH sector that it operates in – water supply, sanitation or hygiene.
c) South African – categories those innovations that were developed in South Africa or had/will be deployed in South Africa.
d) Value Chain Pillar – categorised innovation into their positions in the value chain, i.e. the pillar in which the innovation would operate such as inputs, distribution/conveyance, treatment, user interface, etc.
e) Circular Water Economy Purpose (closed-loop purpose) – categorises the innovation based on its purpose in the circular economy, i.e. reuse, recycling, avoiding.

It was not a comprehensive review of all WASH innovations in the country, but rather a snapshot of a randomised capturing of innovation based on the WRC, web-based and internet review (i.e. the innovations that were included in the study).

Table 14 shows that of the 314 innovations captured in the database, the innovations were almost evenly categorised in the wet WASH (46,2%) and the Dry WASH (41,4%) value chains. A suite (12,4%) of innovations fell within both value chains, with these largely being hygiene and materials inputs into the value chains.

Table 14 demonstrates that the South African WASH innovations landscape in the database was very different, with the country's WASH innovations predominantly (62%) categorised as requiring water to operate and thus falling within the Wet WASH value chain. A higher percentage (20,2%) of the South African innovations also fell within both value chains, largely hygiene related, when compared to the 12,4% of these innovations making up the full dataset.

Table 14 also shows that, despite this study focussing on capturing innovations that had been developed and deployed in South Africa, only just over a quarter (25,2%) of the innovations that were captured in the database had either been developed or already been deployed into the WET WASH and DRY WASH value chains in the country. This is despite all the innovations in the value chain having the potential to contribute positively to the South Africa value chains.

Table 14: Categories of the innovations, all in databases and South Africa, by value chain

WASH VALUE CHAIN	ALL INNOVATIONS IN THE DATABASE		SOUTH AFRICAN INNOVATIONS IN THE DATABASE		
	# of Innovation in the Database	% of Innovations	# of RSA Innovation in Database	%t of RSA Innovations	% of All Innovations in the Database
Dry WASH	130	41,4%	14	17,7%	4,5%
Wet WASH	145	46,2%	49	62,0%	15,6 5
Wet WASH & Dry WASH	39	12,4%	16	20,2%	5,1%
TOTAL	**314**		**79**		**25,2%**

Table 15 shows the categorisation of innovations within the various value chains by the pillar in which the innovations was deemed to operate, i.e. input, water conveyance, WWTW/WTW, etc. From a value chain perspective, Table 15 shows the following:

1. **Innovations in the Pillars of the WET WASH Value Chain:** The full innovation database captured and categorised innovations across all the WET WASH pillars. However, there were limited innovations categorised in the pillar of inputs- hygiene (1,3%) (note that many of the hygiene inputs were captured in the combined value chains in table 15), input – metering (1,9%), distribution (including monitoring) (2,8%) and reuse, recycling and discharge (1,6%). This could suggest that innovations were limited related to water supply hygiene, water metering and leak detection in water supply networks and related to the reuse, recycling and discharge of wastewater. Since this value chain is the largest focus on municipal activities in South Africa, these gaps would be worrying if they are reflected in the South Africa data.
   Table 15 does show a similar pattern for the South Africa innovations, but also reflected limited innovations captured for all pillars from conveyance innovations to the reuse, recycle and discharge pillars. South Africa innovations in the database do seem to have been focussed in four pillars, namely input – alternative water (7,5%); inputs – materials (12,5%); inputs- metering (7,5%) and wastewater treatment (18%) of innovations.
   At the same time, the innovations in the database reveal crowding in the inputs-materials (12,5%) and the wastewater treatment (18%) pillars. This could perhaps be attributed to the significant number of water saving/reduction innovations that have been deployed, socialised and localised in the country, such as low-flow taps and shower heads and the innovations in low-flush sanitation, i.e. pour flush/low flush sanitation facilities (although these still need to be deployed at scale). All of these innovations were categorised as input materials in the value chains. Although this focus of the innovations on input materials may reflect the need for these innovations in the country, the crowding of innovations in the value chain pillar could make it more challenging and difficult for innovations to stand-out and thus be deployed, socialised and localised.

   The limited innovations that were captured for the post-input pillar of the WET WASH value chain to the output pillar of reuse, recycling and discharge (excluding the wastewater treatment pillar) could reflect a gap in the targeting of innovation R&D and deployment in the country. The WET WASH value chain could benefit from innovations, for example, related to the following:
   1. Innovative municipal water conveyance and distribution systems, i.e. green pumping and piping systems.
   2. Innovative municipal water distribution monitoring systems, i.e. real-time leak detection, metering, etc.
   3. Innovative green and sustainable water treatment at WTW (i.e. low energy, natural chemicals, etc.).
   4. Innovative reuse and recycling of treated faecal sludge and wastewater from municipal WWTW.

Deployment of new innovations within this largely overlooked WET WASH pillars could (1) focus on deployment, localisation and socialisation of existing international innovations or (2) targeting R&D for new South African innovations to address market gaps in these pillars. Note should however be taken of the level of 'crowding' of the pillar in the international value chain.

Table 15: Categorise of the innovations, all in database and South Africa, by value chain and pillar in the value chain

WASH Value Chain and Pillar	ALL INNOVATIONS IN THE DATABASE		SOUTH AFRICAN INNOVATIONS IN THE DATABASE		
	# of Innovation in the Database	% of Innovations	# of RSA Innovation in Database	%t of RSA Innovations	% of All Innovations in the Database
Wet WASH					
Inputs - alternative water	18	5,7%	6	7,5%	1,9%
Inputs - hygiene	4	1,3%	1	1,3%	0,3%
Inputs - materials	23	7,3%	10	12,5%	3,2%
Inputs - metering	6	1,9%	6	7,5%	1,9%
Water Conveyance	20	6,4%	3	3,8%	1,0%
Water Treatment	31	9,9%	2	2,5%	0,6%
Water Distribution	7	2,2%	2	2,5%	0,6%
Water Distribution - Monitoring	2	0,6%	2	2,5%	0,6%
Wastewater Treatment	28	8,9%	15	18,8%	4,8%
Reuse, recycling and discharge	5	1,6%	1	1,3%	0,3%
TOTAL	145	46,2%	48	60,0%	15,3%
Dry WASH					
Inputs - chemicals	3	1,0%			0,0%
Inputs - hygiene	9	2,9%	4	5,0%	1,3%
Inputs - materials	34	10,8%	6	7,5%	1,9%
Resource emptying	15	4,8%	2	2,5%	0,6%
Resource transport	3	1,0%			0,0%
Wastewater Treatment	1	0,3%			0,0%
Reuse, Recycling and Disposal	6	1,9%	2	2,5%	0,6%
Water distribution	2	0,6%	2	2,5%	0,6%
Water Treatment	58	18,5%			0,0%
TOTAL	**130**	**41,4%**	**16**	**20,0%**	**5,1%**
Wet WASH & Dry WASH					
Inputs - hygiene	25	8,0%	11	13,8%	3,5%
Inputs - materials	14	4,5%	5	6,3%	1,6%
TOTAL	**39**	**12,4%**	**16**	**20,0%**	**5,1%**
Grand Total	**314**		**79**		**25,2%**

- **Innovations in the Pillars of the Dry WASH Value Chain:** In the DRY WASH value chain, Table 15 demonstrated limited innovation in the full dataset categories in all the DRY WASH pillar barring the innovations in the input-materials (10%) and water treatment (18,5%) pillars. This does suggest that innovations that were captured in the innovation database had a bias towards inputs of materials into the value chain (i.e. sanitation technologies such as UD systems, handwashing facilities, etc.) and innovations related to water treatment. Since households in this value chain do not have in-house water supply, it is necessary to store water, which has resulted in a large body of innovations emerging across the globe that focus specifically on treatment of water supplies at point-of-use. Hence the larger body of innovations categorised as water treatment innovations in the DRY WASH value chain. This provides some indication of a pillar where some crowding of the international market may be occurring.

The South Africa innovation dataset, shown in Table 15, demonstrated that there were at least three pillars in the DRY WASH value chain that did not have any innovations captured within them, namely inputs (chemicals, resource transport and water treatment). The lack of innovations of input chemical could potentially be attributed to the use of UD and VIP toilets in the DRY WASH value chain that should not require input chemicals for operation. Hence, there has potentially not been the need for a significant focus on these innovations in recent years. The resource transport pillar also has a dearth of South African innovations, as pit emptying and transport of contents are dominated by the municipal honeysucker/tanker programme (where it is operational). The lack of innovations categorised as resource transportation could potentially be attributed to this being a relatively new area of research with the focus largely on the emptying technologies, with the use of standard transport vehicles once systems are emptied, i.e. small trucks, wheelbarrows, etc. The lack of water chemicals in the South Africa DRY WASH value chain may be due to, limited point-of-use treatment innovations being deployed in the country. Addressing these pillar gaps in the value chain could (1) focus on socialising and deployment existing appropriate international innovations in the pillars or (2) R&D and deployment of South Africa point-of-use innovations in the pillar. It should be noted however, when considering deploying these innovations in South Africa, that they would need to be deployed within an existing international market. Innovations would need to keep this ‘norm’ in mind.

Innovators in the South African DRY WASH pillars of the value chain need to also note that the database showed that international materials input pillar was a ‘crowded’ pillar in the database, largely due to the large number of UD and composting toilet that are on the global market. Since UD and VIP toilets are the norm in South Africa, deployment of new innovations in this pillar will be impacted by the ‘crowded’ international market and the ‘norm’ market in the country. The innovations would need to be able to demonstrate significant difference/improvement/acceptance, etc., compared to these.

Generally, the South African DRY WASH innovations in the value chain pillars were extremely limited.

- **Innovations in the Pillars of the Combined Dry and Wet WASH Value Chains:** the hygiene – inputs markets, as mentioned previously in this report, is in many cases dominated by large international conglomerates. The inputs to the two value chains from these conglomerates are the deployed, socialised and localised ‘norm’ innovations internationally and in South Africa. To enter this pillar of the value chains will be significantly impacted by this norm and dominance. The South African hygiene-inputs was also shown as crowded in the dataset, with many of these innovations focussed on handwashing technologies, reusable pads and the menstrual cup. Deployment of these innovations would need to consider this crowded space and ensure that the innovations stand-out form the ‘norms’, by for example demonstrating the innovation being more cost effective, easier to use, work better, more appealing, etc.

Finally, in understanding the WASH innovations within the value chains, each innovation was categorised based on the benefits it would contribute to the circular water economy in the country, i.e. reducing water use, avoiding water in operations, etc. Figure 31 demonstrates the categorisation of the innovations in each of the value chains. The table shows that a large number of the innovations in the dataset focus purely on addressing a need in the WASH service delivery sector, with these innovations not specifically focussed on addressing a closed-loop approach to delivery of the services. Figure 31 also demonstrates that many of these service delivery innovations in the database were categorised as having a water and wastewater treatment purpose. This is to be expected as these are crucial pillars in the value chains and in the delivery of sustainable services that address national and international quality standards, i.e. SANS 241, in South Africa.

The resource collection in the DRY WASH value chain, of which 15 innovations were captured in the dataset, and the transport innovation in both WET and DRY WASH value chains, of which 23 innovations were categorised in the WET WASH value chain and 9 in the DRY WASH value chain, demonstrated innovations that had emerged to remove urine, faeces and FS from sanitation systems and transport these to WWTW in the case of UD and VIP contents or to a disposal site in the case of FW from WWTW. These innovations do not necessarily focus on the reuse and recycling of the resources that are removed. Similarly, the hygiene innovations in the dataset focussed on addressing hygiene requirements in the sector, namely access to a handwashing facility, to soap and to menstrual product, but not necessarily to ensuring a closed-loop in providing these services. The figure does demonstrate some crowding, particularly in the dataset, in innovations that target water and wastewater treatment, menstrual health products and resource transport (distribution and pumping of water in the wet WASH value chain).

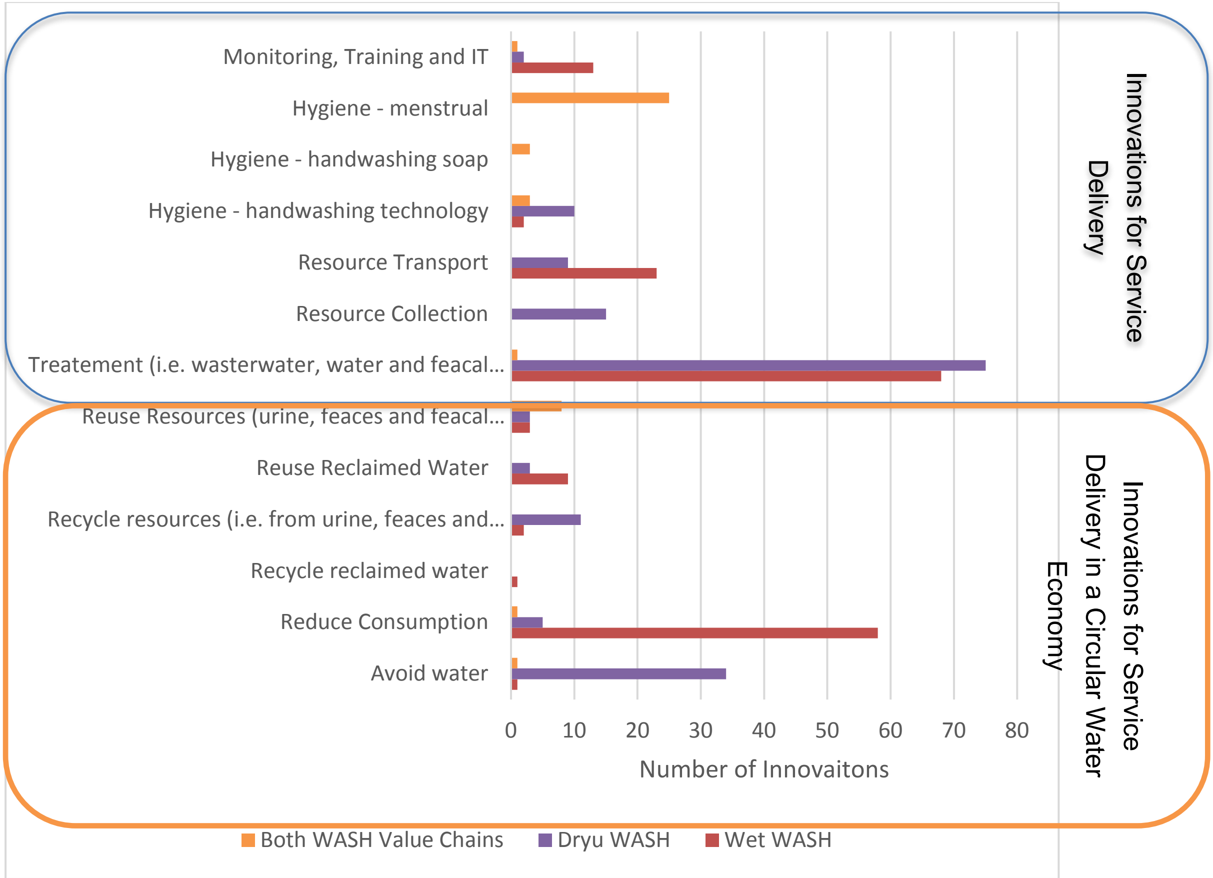


Figure 31: Number of WASH innovations in the dataset, categorised by purpose of the innovation.

Figure 31 shows that closed-loop targeting innovations in the dataset were captured as those that reduced water consumption by the user or municipality in the WET WASH (n=58) value chain and those that avoided water use in the DRY WASH value chain (n=34). The dataset may thus demonstrate greater crowding in these target areas of the value chains, as compared to innovations that target other aspects of the closed-loop, i.e. reuse and recycling of water and resources. The WASH innovations in the dataset that focussed on reusing and recycling resources were limited and should be a key focus of the WASH value chains R&D, deployment, localisation and localisation in future.

Figure 32 provides the same categorisation of innovations in the database but filtered for South African innovations. Figure 32 clearly demonstrates a strong focus on the service delivery innovations in South Africa on (1) treatment innovation, following the same trend as the international dataset, (2) on menstural health products, and on (3) monitoring, training and IT. The last category has emerged as a result of the WET WASH sector introducing innovations related to real-time monitoring of water leaks and metering. The menstural health innovations have a focus on reusable pads and the introduction of these products to the hygiene WASH value chains in the country.

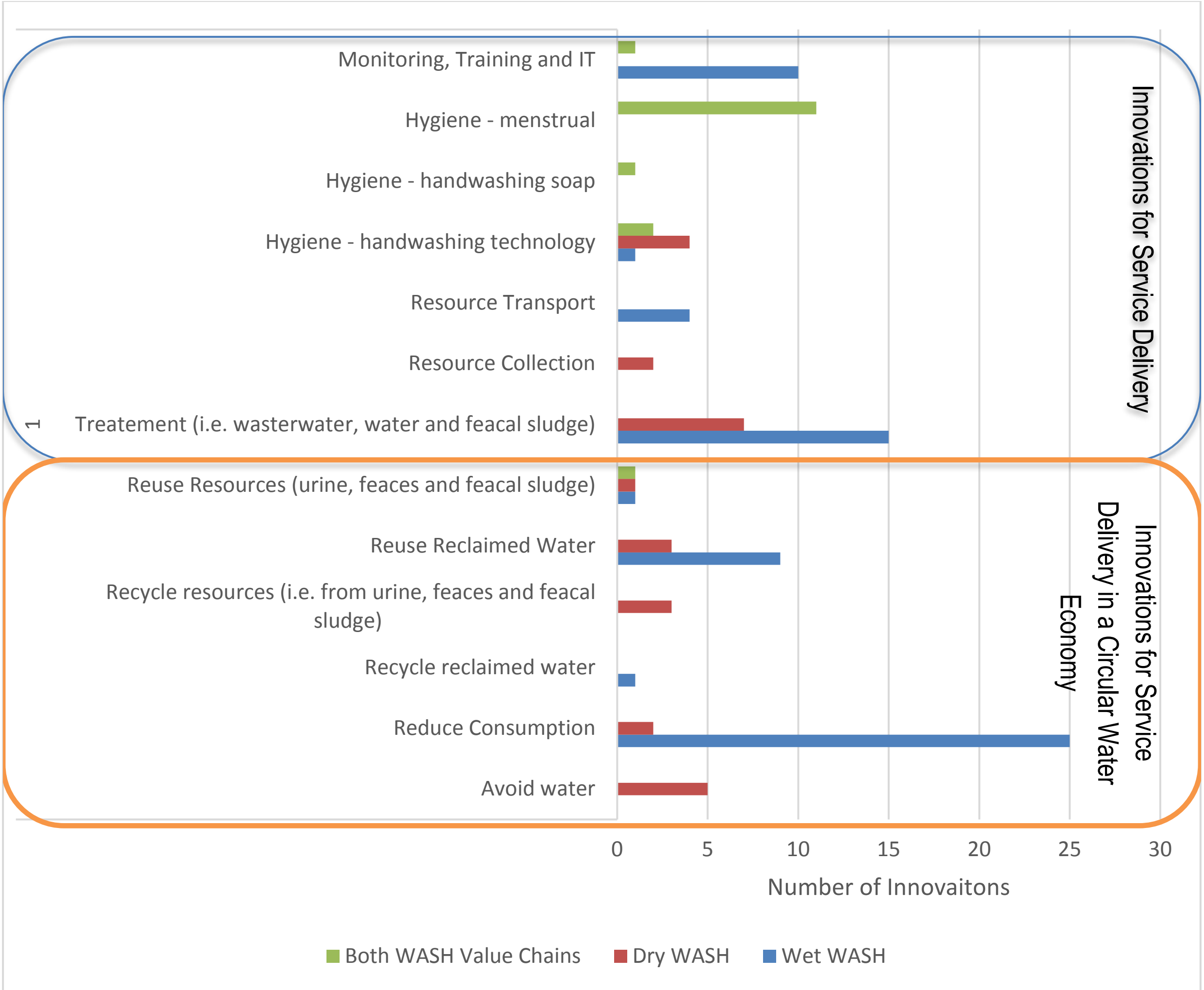


Figure 32: Number of South African WASH innovations in the dataset, categorised by purpose of the innovation.

The closed-loop WASH innovations in the database demonstrated a strong focus on reducing water consumption in the WET WASH value chain (i.e. low flow taps and shower heads, low flush toilets, etc.). As mentioned previously, this is a relatively crowded area of the value chain, providing additional challenges of entry to innovators.The South African WET WASH value chain has also demonstrated innovations that reuse/reclaim water.

It should be noted that the number of innovaitons in each of the closed-loop target areas is extremely low, particularly in the areas of innovations that reuse and recycle resources, such as urine, feaces and feacal sludge.

CHAPTER 8: ENABLERS AND BARRIERS TO INFUSING INNOVATIONS INTO THE WASH VALUE CHAINS

Innovation is essential to global, country and company recovery from economic downturns and to thrive in today's highly competitive and connected economies (OECD, 2010). Innovation in the WASH sector can be a powerful engine for development and for addressing social and national challenges. Through knowledge creation, WASH innovations can hold the key to employment generation and enhanced productivity growth in the country (OECD, 2010).

"Global Water Intelligence estimates that meeting the UN Sustainable Development Goals for water and sanitation between 2018 and 2030 will cost $1,785 billion for rehabilitation and $4,056 billion for new infrastructure. Activity on this scale will require significant innovation and forward thinking"

(UK Water Companies, 2020).

South Africa's WASH sector needs to be underpinned by robust, sustainable, effective and efficient WASH value chains. This will require significant innovation and forward thinking. It will also require policy in the country, all forms of policy, to support, guide and regulate the value chains, as well as the innovations and forward thinking in the sector. "More of the same" in policy, WASH value chains and WASH innovations will not be enough.

There are significant opportunities for water innovation related to inputs, such as green materials, green chemicals, energy efficiency, etc.; in material inputs and design; in materials manufacturing; in data science; etc. Cross-sector collaboration to take advantage of some of these opportunities will create substantial benefits, resulting in cost savings and secure, sustainable WASH value chains.

Currently, innovation in the water sector in South Africa, as shown in the review of innovation and case studies in the previous section of the report, are housed and deployed by individuals, SMMEs and larger companies, each of which adopts their own approaches to innovation development, deployment, localisation and socialisation. Some collaboration networks are present, driven and support largely by institutions, such as the DST and WRC, that support collaboration between innovators. However, there is significant opportunities to create a sector-wide shared WASH innovation culture in the country.

Government has an important role to play in creating the right policy frameworks, infrastructure, and data to stimulate, facilitate, and support the WASH innovation and value chains in the country.

8.1 Non-Policy Enablers to Infusing Innovations into the WASH Sector

Some WASH innovation deployment, localisation and socialisation challenges cannot be directly addressed by new government policies alone. As examples:

- **Following traditional WASH management approaches:** The WASH infrastructure that has been installed in South Africa was planned to last for decades or longer. The WASH value chains are generally complex engineered systems, consisting of large-scale infrastructure with long life spans. Hence, the nature and life span of WASH infrastructure are biased toward the adoption of incremental upgrades rather than toward innovative and ground-breaking innovations.
- **Management for sustainability:** There is an innate need for water services authorities (WSAs) and water service providers (WSPs) to manage the WASH value chains from a demand management, resource conservation, and sustainable WASH service perspective. This may, however, often not be the norm in local government.

- **Aversion to adopting innovation:** The innate conservatism in the uptake, localisation and deployment of WASH innovations is another hindrance to deployment of innovations in the country. Innovation conservatism is also the norm in WSAs in the country.
- **Focus on public health concerns:** The innate aversion of deploying, localisation and domesticating WASH innovations without ALL the public health concerns being completely clear remains a challenge. The norm of the WASH sector to focus on the public health concerns of poor water quality and sanitation services can result in these concerns overriding any other considerations in deployment, localisation and socialisation of innovations and their benefits in the WASH value chains. WSAs may be reticent to use new innovations that have not been scientifically tested at multiple scales and found to present absolutely no risk to the safety of water resources and humans.

These factors — a typically long-life expectancy planning and management approach, the size, and complexity of water systems in the country, and the operation and maintenance (O&M) provisions linked to these, the risk-aversion to WASH innovations and the conservative business climate in the water sector of the country, help explain the lack of innovation in the WASH value chains. However, these challenges will not necessarily be addressed by policy reforms alone. This report thus focusses on three additional (chiefly non-policy) barriers/enablers of WASH innovation:

a) WASH innovations for disaster management, i.e. COVID-19, drought, etc.;
b) procurement and financial enablers for WASH innovation; and
c) market enablers for WASH innovation.

8.1.1 Pandemic Enablers for WASH Innovation

Changes in the WASH value chains may, in many cases, be reactive. For example, shifting and adjusting to operational necessity, natural disasters, such as drought (i.e. Day Zero in Cape Town and Gqeberha), economic realities (i.e. fiscus and budget constraints), technology advancements (i.e. introduction of UD toilets), and health pandemics and epidemics (i.e. COVID-19 and cholera outbreaks). This practice of reactive changes can often lead to adoption of less-innovative, mostly off-the-shelf and established solutions to the challenge being experienced. However, it can also result in the rapid development, deployment, localisation and socialisation of innovations if the value chain and enabling environment allows for this process.

There is no doubt that the COVID-19 pandemic has had a significant and lasting impact on the WASH sector across the globe, from the manner in which the sector manages these resources, the manner in which users use and need these resources, to the manner in which the wastewater systems are treated, monitored and managed. The pandemic has impacted on all the stakeholders in the WASH value chain. Consumers have seen their daily lives and thus their daily WASH needs focussed on domiciles. Organisation and businesses have seen their work forces no longer commuting to office buildings or operating with a skeleton staff on-site on a daily, rotational basis. Even public institutions, such as schools, have seen changes in the WASH needs on a daily basis, with the focus on being able to ensure sufficient, sustainable WASH supplies and facilities to meet COVID-19 regulatory requirements. Where these facilities and sustainable supply are not available, these institutions have had to remain closed.

The changes in the manner in which stakeholder engage and are actively involved in the WASH value chain on a daily basis is not expected to significantly change or revert to old way in the near future. This means that the WASH value chains will need to adapt to the 'new' normal WASH behaviours, needs and activities in the country. While the current WASH value chains and services can still meet these new needs, they will need to adapt and change in some areas in future. For example, with the changes to home-based working, the manner in which WASH infrastructure is managed and monitored may need to adapt to more real-time and online monitoring systems. Billing systems have to become electronic, where possible, and innovative solutions for billing of consumers that are not online need to be sought (i.e. SMART-phone billing).

8.1.2 Procurement and Financial Enablers/Barriers to WASH Innovation

Stakeholder in the study highlighted the significant challenges with municipal procurement processes when deploying innovation in the WASH value chains in South Africa.

The South African WASH sector continues to be challenged on how best to utilise an extremely limited fiscus to address the challenges in the water sector and within the WASH value chains in the country. Given the limited room for fiscal manoeuvring in South Africa, it is more crucial than ever that responses to the WASH challenges in the country are innovative, context-appropriate, and the product of collaboration with multiple stakeholders in the domestic private sector, public sector and international community.

Since South Africa democratisation in 1994, public procurement processes have been decentralised from the Central National Tender Board to individual ministries, departments and local government (OECD, 2021). Over the years, the centralised oversight of public procurement processes has been weakened while procurement rules for decentralised procurement processes have hardened. Box 22 demonstrates a case study, from the City of Cape Town, outlining the procurement procedure that needed to be followed in this Metro (which is similar in many of the municipalities across the country).

WSA and WSP procurement processes, although having some flexibility, can still be laborious and take a significant amount of time in many municipalities, impacting on the speed of deployment of innovations, and on the payment to innovators in the long-term. Partnerships in the WASH sector and in the WASH innovation sub-sector are highly contractual, linked to Service Agreements, Memoranda of Understanding, etc. These contractual instruments constrain the speed and flexibility of procurement systems, particularly at a local government level where the innovations need to be deployed for localisation and socialisation. These inflexible procurement processes can include long payment periods or approval process that can hamper collaboration with small and medium enterprises who need to manage their cash flows and rapidly deploy new innovations.

Box 22: Case study from OECD (2021) on public procurement procedures in Cape Town, South Africa

Municipal procurement is regulated by the Municipal Finance Management Act No. 56 of 2003 (MFMA) and its regulations, including the Municipal Supply Chain Management Regulations (2005). These regulations specify the minimum requirements, but municipalities are allowed to apply stricter standards. The National Treasury also sets further requirements. The MFMA outlines the competitive procurement processes and unsolicited bids are not encouraged. As stipulated by the National Treasury, for projects worth more than ZAR30,000 (USD2 056) but less than ZAR50 million (including value-added tax), the price contributes 80 points of the total score and the Broad-based Black Economic Empowerment (B-BBEE) status contributes 20 points. For projects above ZAR50 million (USD3.4 million), the price contributes 90 points and the B-BBEE status. Municipalities can also specify prequalification criteria to limit the competition to certain groups. These groups include companies with higher B-BBEE scores, exempted micro-enterprises (EMEs) and qualifying small enterprises (QSEs).

Companies wishing to do business with the City of Cape Town must first register with city's supplier database and the national Central Supplier Database (CSD). For goods and services less than ZAR200,000 (USD 13,700), Cape Town publishes Requests for Quotations (RFQs) on its procurement portal. Companies must first register as a supplier and then register on the portal. For *goods and services exceeding ZAR200,000 (including value-added tax), a formal bidding (tender) process is required. Companies must be registered as a supplier and registered on the tender portal where tenders are advertised. Tenders are also advertised in local newspapers. For tenders valued at more than ZAR10 million (USD0.7 million), there is a more extensive process, including additional documentation requirements.*

Stakeholder in the study highlighted the significant capital required to upscale and deploy innovation in South Africa. This is not a country-specific challenge, with many WASH innovations across the globe experiencing this challenge.

The existing WASH value chains in South Africa and across the globe has resulted in financial instability in the sector, with this instability stemming for the:

a) growing operation and maintenance costs required for existing infrastructure;
b) decreasing revenue due to declining household incomes and business closures from a stagnant or slow growing economy;
c) declining revenue in areas where water demand decreased due to conservation efforts (i.e. reduce household water consumption in Cape Town due to Day Zero interventions); and
d) loss of revenue due to inefficiencies in the WASH system (i.e. water loss and leakages).

A 2019 UNICEF reported indicated that in four countries reviewed as part of the report, none of the urban water and sanitation systems in the countries were achieving full cost recovery, which has also been shown for the continent itself (Jones et al., 2019). Where WASH tariffs were not achieving full cost recovery, contractual agreements had been put in place between the private or semi-autonomous service providers and the government to subsidise the cost difference between the production of water and a price that is affordable and acceptable to users (Jones et al., 2019). As a result, urban water tariffs vary considerably across the Eastern and Southern African region, as shown in Figure 33.

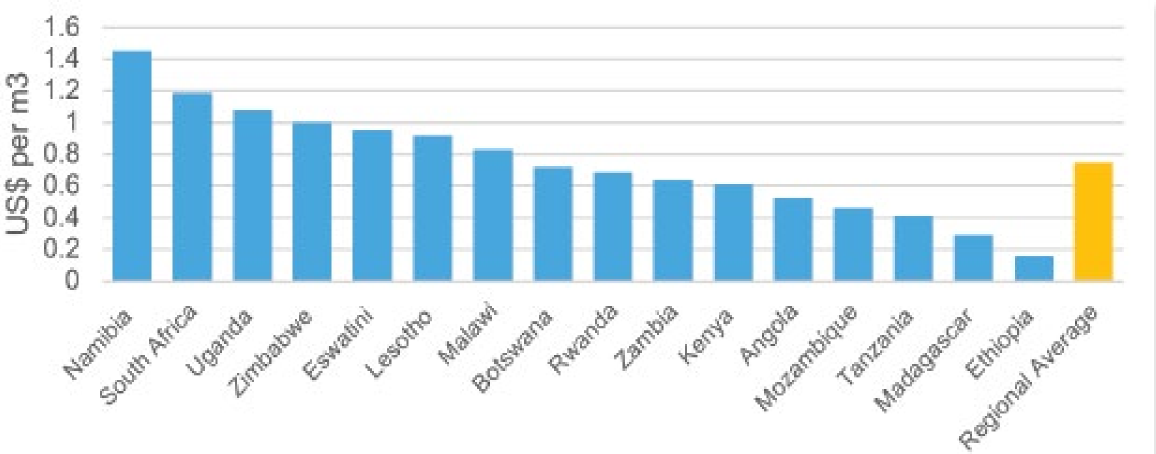


Figure 33: Water tariff estimates for a selection of African countries (taken from Jones et al. (2019))

In addition to the poor pricing of water services, water users in many countries, including South Africa, are not paying for services (Jones et al., 2019). The willingness to pay, or unwillingness to pay, for WASH services has been attributed to consumer issues related to inability to pay and perception of poor service levels, as well as the water service providers challenges with billing (Jones et al., 2019). Figure 33 shows that in a UNICEF review of metering in selected African countries, a fundamental requirement for good management and financing of the WASH value chain and thus WASH innovations, that South Africa had the lowest coverage of water metering in urban setting (Jones et al., 2019).

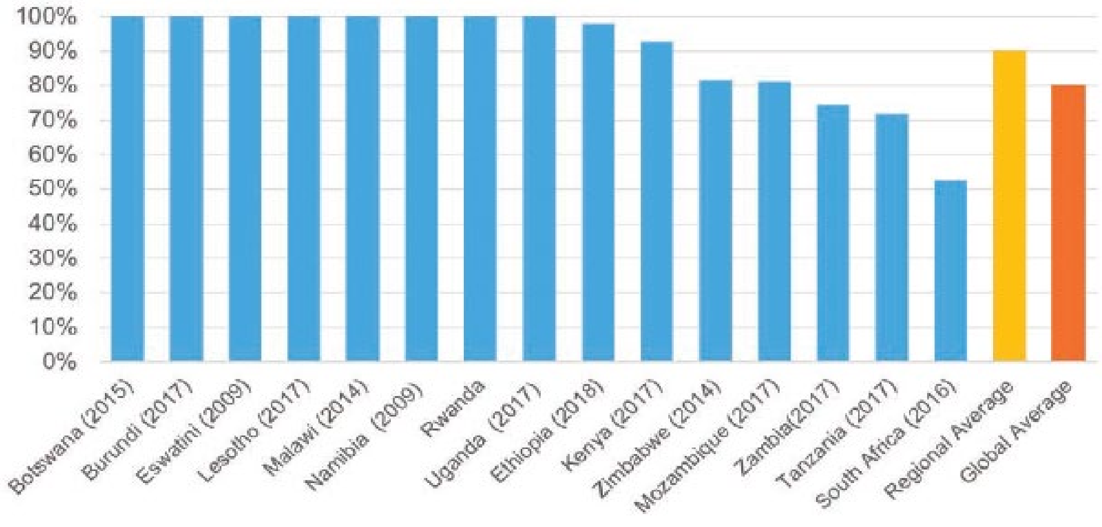


Figure 34: Percentage of urban WASH consumers with meters (taken from Jones et al. (2019)

The factors of poor pricing, poor billing, and poor payment by consumers together with the increasing cost for the operation and maintenance of WASH infrastructure and increasing inefficiencies in the system (i.e. water losses and leakages) have led to financial instability in WASH value chains in South Africa. This financial instability, particularly financial instability of WSAs and WSPs in South Africa, have a significant impact on the ability and willingness of these stakeholders to infuse new and unknown innovations into their WASH value chains.

The lack of access to capital introduces another barrier to seeking and embracing innovation in the WASH value chains. The large role that the public sector, in South Africa's case the municipal level WSAs and WSPs, plays in the provision of WASH services can inhibit the raising of capital for WASH innovations. Like many public sector water services providers across globe, these local WSAs and WSPs may rely on high-quality, low-yield bond funding (Ajami et al., 2014). Paying back these bonds is often highly reliant on revenue generated by the municipality, which is impacted by the rising costs of WASH service delivery and declining revenue (Ajami et al., 2014). Hence, these institutions may be risk-adverse to large investments for deployment of new innovations.

Ajami et al. (2014) also indicated *that bond pricing and rating depend on the risks associated with a project. As a result, public entities often are unable to finance technologies that promise higher but riskier rates of return. For example, where the profitability of desalination technology depends on future water supply limitations and on future increases in the cost of other water supply options, governmental entities may find it difficult to raise needed funding to build the desalination plant today*. This may impact on WSAs' and WSPs' appetite for the uptake, deployment, localisation and socialisation of WASH innovations, particularly disruptive WASH innovations.

8.1.3 Market Enablers and Barriers to WASH Innovations

The stakeholders participating in the study indicated a number of market-related challenges in the WASH innovation sector, including the following:

- Knowledge and access to market are not always available for innovators.
- Different skill sets are required for each stage in the WASH innovation value chain.
- The market may not be ready, may be unwilling, or may be risk-adverse to adopting innovations.
- The manufacturing industry or process may not be equipped to produce, at scale, disruptive innovation or even traditional innovations.

A large section of the report provides an overview of the WASH value chains in South Africa, indicative of the WASH market in the country, and the innovations within the pillars of this value chain. Hence, a status quo of the market will be limited in this section of the report. The focus is specifically on innovation in the private sector, as lack of market knowledge and access can often be one of the root causes of the challenges experienced by innovators in the deployment, localisation and socialisation of WASH innovations. Crowding of innovations in specific areas/pillars of the value chains are compounded by the other challenges, such as lack of finance, skills gaps and WSA/WPA innovation risk aversion, to scaling up of innovations in the value chains.

Knowledge and access to the market in the country are not always available for WASH innovations. As one of the stakeholders indicated in the engagement process, that it was "*very lonely being a sanitation entrepreneur in South Africa*". Weak sharing of information and knowledge, but also weak best practice experience, can lead to the WASH sector and innovators operating in isolation and sometimes in silos in one of the pillars within the WASH value chain. This may also lead to innovators becoming focussed in a specific pillar or WASH value chain, making it even more challenging to deploy, domesticate and socialise innovations.

Stakeholders within the study also recognised that different skill sets are required for each stage in the WASH innovation value chain and within the development of innovations. As demonstrated previously, the WASH innovations sector in South Africa is populated by a wide range of stakeholders, leading to marked variations in the propensity and intensity of innovation that are developed, deployed, socialised and localised. A wide range of activities are undertaken when firms conduct the WASH innovation in the country, indicating that the demand for skills for innovation is not uniform across the WASH value chains and sector and, by implication, that there is enormous variation in the type of skills required for innovation across the sector, firm size and ownership structure. It has been observed that there is a systematic relation between product and innovation cycles and the demand for skills, namely the development of innovations may require new job tasks within a firm and research institution (Toner, 2011). A survey by Toner (2011) of innovating businesses demonstrated that just 2,2% of innovating firms recruited scientific personnel for innovation. The same study found that the *skills recruited by the highest proportion of innovating firms were general business (22,6%), information technology (18,2%) and marketing (16,7%). There are large differences in the type of skills sought across industries. For example, 43% of electricity, gas and water firms sought general business skills compared to just 14,9% in property and business services. Nearly a quarter of innovating electricity, gas and water firms sought marketing skills, which was nearly double the proportion of firms in transport and storage* (Toner, 2011). Noting this need for a range of skills to deploy, socialise and domesticate an innovation, the lack of access to this range of skills in SMMEs may have a significant impact on their ability to enter and flourish in the WASH sector and value chains in the country.

8.2 POLICY BARRIERS TO WASH INNOVATION

A perception exists in the water sector that the relationship between regulators and innovations is highly hierarchical and, as the stakeholder survey and interview showed, restrictive. Regulators may require evidence of short-term return on investments of deployment of a WASH innovation, which can make it difficult to implement truly transformational innovation projects. Many in the water sector would welcome more open two-way dialogue between regulators and water companies.

Although water innovations is one area where South Africa can deliver value to the WASH value chains in the country, there is equally a need for innovation in the water and environmental policies that guide innovations in this sector (O'Callaghan et al., 2020). The need for innovative water and environmental policies is agreed by the outcomes of the stakeholder engagement process in Section 6.2 and Section 6.3, particularly innovative policy that enables deployment, localisation and socialisation of innovations.

Innovative policy in South Africa would include the development of new regulations that, to name a few (O'Callaghan et al., 2020), will:

- create the space for water innovation;
- facilitate the creation of new finance models and new financial mechanisms;
- facilitate the creation of new business models; and
- provide innovative means of communication of the value of water to the public.

New approaches to water innovation policy provide an exciting, yet challenging, opportunity to question traditional water policy approaches to innovation and how this policy can facilitate the combining of new and old technologies that are emerging on to the market (O'Callaghan et al., 2020).

Rose and Winter (2015a) noted that, while South Africa had considerable sophistication in innovation policy, and that the language of innovation systems had taken firm root in the policy, the policies themselves do not always translate to an effective innovation system. The water innovation sector of the country still view the innovation value chain as a linear system, relying upon incremental improvement in inputs to ensure the generation and use of societally relevant knowledge and technology (Rose and Winter, 2015a). A disconnect seems to exist between what researchers and practitioners deem as important gaps in the water and water innovation sector, and what innovation policies and policymakers were seeking to address – namely a policy directionality failure. This led Rose and Winter (2015a) to conclude that *the gap between the intentions of forward-thinking innovation policy and the realities confronting research and researchers is wide, and remains a significant challenge. Efforts to build a system of innovation are clear, but actual policy action does little to encourage innovation systems thinking, but rather relies on traditional, R&D-based action in practice. Local government and other state players fail to create an enabling environment to test, pilot and diffuse new water-related solutions. In response, a new level of stimulation is required from the major players in the innovation system – the NRF, TIA, WRC and DST – that need to stimulate the coordination and alignment of their actions within an acceptable and appropriate innovation systems framework.*

Rose and Winter (2015a) suggested that, to address gaps in the water innovation sector, innovation policy needs to be focussed on strengthening the entire innovation chain from conceptual stage to market, while at the same time meeting social development needs. Innovation policy also needed to (Rose and Winter, 2015a):

- be supported by a strong leadership and enabling (i.e. policy) environment;
- be supported by risk-taking in water science and technology;
- promote knowledge-related infrastructure and data sharing;
- reorganise the research environment within universities;
- strengthen funding for entrepreneurship and support for infant enterprises;
- create centres of competency with strong industrial-design and economic- and market analysis capabilities; and
- retain post-doctoral students through improved and longer-term funding to sustain longer-term research activities.

Diercks (2019) suggested the developing and implementing transformative innovation policy in a country necessitates a focus on two core parameters: (1) the policy agenda being pursued, and (2) the understanding of the innovation process used in the articulation of innovation policy. From the perspective of the first parameter, namely the water innovation policy agenda in South Africa, a transformative innovation water policy would need to rest on a societal policy agenda with three elements:

1) Targeting water innovation policy domains beyond economic and industrial policy.
2) Including water innovation policy objectives dealing with a broad range of societal challenges.
3) A water innovation policy logic that challenges a strong pro-innovation bias.

From the perspective of the second transformative innovation parameter, namely the understanding of the innovation process, the water innovation policy would need to recognise the heterogeneous and contested elements in the country regarding water innovations:

- Actors.
- Activities.
- Modes of innovation.

8.2.1 National Policy Barriers

The WASH and innovation policy and regulations can pose a major barrier to innovation in South Africa. The instruments are sometimes dated (i.e. water Acts) or were developed with a focus on specific and already utilised technologies (i.e. standardised WASH value chains of extract-use-discharge/dispose). Policy and regulations can also be fragmented geographically and vertically, with local government regulation sometimes blocking technologies that are permitted, or even encouraged, by national government, or preventing the deployment of innovations for other issues, such as for example, health, safety, etc., and by issue (with health and safety regulations sometimes conflicting with WASH goals). Some of the other policy barriers highlighted by the respondents in the study were the following:

- There are gaps in standards for accreditation of some of the WASH innovations, particularly disruptive innovations.
- There are gaps in government procurement policy and processes for enabling of deployment, localisation and socialisation of WASH innovations and disruptive innovations.
- Innovation policies and innovation deployment need to focus on national strategic needs as outlined in the Water and Sanitation Master Plan and National Development Plan.
- Policy currently does not drive demand for innovations, specifically disruptive WASH innovations.

As highlighted by the above review of innovations and by the stakeholders that participated in the review, regulation in the WASH sector can both promote and be a barrier to innovation. The WASH and innovation policy, legislation and regulations can encourage innovation through different mechanisms, including the following:

(a) **Policy to directly encourage R&D, deployment, localisation and socialisation** through the introduction of new policy and regulatory requirements.
(b) **Policy to ban technologies**: WASH innovation R&D, deployment, localisation and socialisation can be facilitated by introducing policy that bans or discourages the use of existing 'dirty' WASH technologies (i.e. technologies that use significant water or energy to operate, etc.).
(c) **Technology focusing regulation**: The sector can introduce new WASH performance standards (i.e. in policy, legislation, regulations, SABS standards) that would require new innovations in the WASH value chains to achieve the standards (called technology forcing regulations). Technology-forcing regulations have the ability to help drive down the cost of innovation through shared experience and economies of scale (Ajami et al., 2014). They are also most effective when enacted in conjunction with other enabling actions, such as research support and information sharing (Ajami et al., 2014).
(d) **Policy to incentives innovation**: A mechanism for dealing with the opposition of industries to WASH innovation policy and to shifts in the WASH value chain are to introduce incentives, such as

innovation incentives in the policy (waivers, in which the government waives technological standards in return for a company's commitment to develop and test new technological options).

8.2.2 Local Government Policy Barriers

One of the barriers highlighted by stakeholders to WASH innovation deployment, localisation and socialisation was municipal local government by-laws. A report by Steytler (2008a) had highlighted the challenges of regulation at a local government levels, indicated that there was a plethora of policies and legislation that had the intent to structure the institutions and processes of local government, including the Municipal Structures Act, the Municipal Electoral Act, the Municipal Systems Act, Municipal Finance Management Act, the Municipal Fiscal Powers and Functions Act; and legislation emanating from sector departments that is directed at managing the functional areas of schedules 4B and 5B of the Constitution, such as the Water Services Act and the National Water Act. Steytler (2008a) indicated that together this plethora of policy and legislation could be suffocating or overregulating local government, preventing it from executing its constitutional mandate and stifling the infusing of innovation into municipal actions and activities. The bylaws of local government are the instruments that are meant to localise this plethora of policies and legislation to the specific municipal context, thus can also over-regulatory and stifling to the deployment, localisation and socialisation of innovations, including WASH innovations.

Steytler (2008b) identified a range of features of the legislative framework that could be problematic at a local government and by-law level of regulation (Steytler, 2008b):

- The long-windedness and minute detail contained in a number of pieces of legislation leave little room for innovation, experimentation, local responsiveness and discretion.
- The 'one-size fits all' approach, which underlies all local government legislation, means that the same set of rules regarding institutional structures, administrative and financial duties and processes apply, irrespective of the resources (human, financial, etc.) available within the municipality.
- The presumption that laws can solve mismanagement problems – namely, solving mismanagement require additional legislation.
- The lack of integration of local government policy and legislation, leading to the need for a wide range of by-laws at a local level to regulation implementation of the policy and legislation.

Steytler (2008a) indicated that an example of over-regulations that pose a challenge, can be costly and difficult to implemented to local government included provision in sections 76-84 of the Municipal Systems Act, related to Part 2: provision of services (provision 76-82) and Part 3: service delivery agreements involving competitive bidding (provision 82-83), that are compounded by section 120 of the Municipal Finance Management Act; and the Municipal Public-Private Partnership Regulations (PPP Regulations) issued in terms of the latter Act. Outsourcing of the provision of basic service, as provided in Section 76-82 of the Municipal Systems Act, may be too complex and costly for many of the ailing municipalities in the country (Steytler, 2008b).

According to Steytler (2008b), (Steytler, 2008a), overregulation of local government could lead to the following situations:

1) **Costly and complex compliance:** Processes prescribed by legislation could prove too costly or difficult to undertake, requiring costly legal practitioners to guide them in their effort to comply with an elaborate legal framework.
2) **Opting out of governing:** A municipality may choose to outsource to the private sector key processes that are difficult for it to carry out itself. This takes place where the complexities and

demands of the legal requirements overwhelm administrators that they inevitably haul in the consultants to ensure compliance.

3) **Stifling of innovation – overregulation stifles innovation, experimentation and local initiative, the lifeblood of decentralisation of governance and service delivery, including WASH service delivery, in the country** (see Box 24 for an energy example of overregulation stifling innovation).
4) **Self-strangulation due to overregulation:** In many cases local government focusses on ensuring compliance with the rules, promulgating and implementing by-laws to ensuring this compliance with sector specific legislation. This fixation with compliance can become more important than achieving the objective behind the rules and result in stifling innovation, experimentation and local initiative.
5) **Opting for lawlessness:** The most excessive consequence of overregulation can be that local government opt to ignore the over regulatory environment and act outside the legal framework.

Box 23: Steytler (2008a) provides the Sustainable Energy Africa case as an illustration of, in his words, "outsourcing of municipal services that have been regulated out of existence".

Sustainable Energy Africa (SEA) is a section 21 company working in the field of sustainable energy development with a particular focus on city energy planning. In exploring the use of alternate sources of energy, municipalities, they contend, will bump their heads against Act 56 of 2003. Act 56 of 2003, they argue, places the emphasis on reducing short-term financial risk. Exploring alternative forms of sustainable energy sources requires more long-term sustainability and risk. The crux of the problem is that alternative sources of renewable energy may be more costly at the outset and only become cost effective in the future (also given other environmental advantages of a non-carbon energy generation for climate change). Sustainable Energy Africa thus argues as follows: prevailing interpretation of "wasteful expenditure" prohibits medium- to longer-term efficiency within local government. Many energy efficiency measures, such as efficient lighting, efficient water pumps, etc., may require an initial upfront cost higher than other existing technologies, but are proven to be more cost effective over 5-20 years. It would appear that financial decision making in local government does not feel able to take this kind of "value for money" into account. Retrofitting buildings or functions for energy efficiency is typically undertaken by energy services specialist companies, who operate by taking on the upfront capital cost which they then offset by being paid out a percentage of the savings achieved through the energy efficiency interventions (a win-win framework). Local government bumps up against the interpretation of Act 56 of 2003 that argues that private companies may not benefit from municipal assets. Many energy efficiency interventions may require fairly long-term contracts due to payback timeframes. Act 56 of 2003 makes this difficult.

Their plea is thus that local government should be allowed a greater degree of flexibility to be able to fulfil the sustainability aspects of its service delivery functions.

It should be noted that efforts to address overregulation of local government should not adopt the simplistic approach of recommending less laws or advocating that current policies and legislation should allow sufficient scope for municipalities to fulfil their constitutional mandate. According to Steyler (2008a and b), to address the overregulation and thus challenges with bylaws, the following should be considered (Steytler, 2008b, Steytler, 2008a):

- **Policy and legislative innovation, experimentation and context-specific application (regulation asymmetry)**: Policy and legislation should be reviewed and amended to enable infusing of innovations into the WASH value chains, while also ascertaining whether municipalities have the maturity to cope with greater freedom. (Steytler, 2008a) has argued that: *'While the laws remain uniformly applicable, the differences between municipalities could be recognised in the regulations implementing the laws. In the Systems Act, for example, the minister for local government in issuing regulations or guidelines may differentiate between "different kinds of municipalities which may, for the purpose of the regulations, be defined in the regulation either in* *relation to categories or types or municipalities or in any other way". This provision, while leaving the principal legal framework intact, may accommodate the diversity of capacity found in municipalities by issuing asymmetrical regulations. It would appear, however, that the minister has not yet made use of this power.'*

- **Recognising that legislation and policy has limitation**: Policy and legislation may have limited ability to direct and influence human and organisational behaviour – additional policy and legislation does not necessarily translate to a change in social or organisational behaviours and challenges.
- **Consider outcomes-based regulations**: Policy and legislation (including by-laws) could be designed for outcomes, rather than regulating processes and procedures.
- **Recognise that the solution may be political**: Recognising that in certain instances a political solution to the challenge is required.
- **Restraint in implementation of policy and legislation**: Policy and legislation should be used in a restrained manner in order to allow the appropriate scope for local discretion. This should, however, not be equated with a minimalist approach: a clear distinction should be made between areas requiring detailed regulations and other areas where greater flexibility would be beneficial.
- **Integration of policy and legislation at a local level**: There is a need for ensuring integration of sector policy and legislations at a local government regulatory level.
- **Support and training for administrators**: Support and training for administrators should be available in the application of new law; increase the practice of accountability of the administration to the council; and sanctions for failure to comply with compliance regulation should lie within the system itself.
- **Enable a regulatory framework to create an open and flexible WASH governance environment** that is innovation-friendly and encourages valuable innovations, including disruptive innovations.

Steytler (2008b) concludes that there is *a balance to be struck between letting the flowers of local initiative and innovation bloom, and preventing the weeks of mismanagement, incompetence and corruption from taking over the flower beds.*

CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

9.1 CONCLUSION

The study clearly showed that the solution to a number of South Africa's growing water challenges lie, in part, with the development, deployment, localisation and socialisation of WASH innovations. It was clear that based on categorisation of WASH innovations in South Africa and from the case study interviews that many of the WASH innovations in the country, while innovative and new to the WASH sector and providing crucial innovations to address fundamental gaps and challenges in the sector, are innovations that follow the traditional fit-and-conform WASH services. The policy barriers and challenges experienced in the deployment of these innovations would potentially be vastly different to those that will be experienced by next-generation, disruptive innovation that are based on the premise of stretch-and-transform of the WASH sector of the country. Noting, however, that this is a broad, generalisation of current WASH innovations included in the study, many of the current WASH innovations are expected to experience challenges, including policy challenges that are common to any water or wastewater/sanitation system that is introduced in the country. Challenges would relate, for example and based on discussions with innovators, to national and local government procurement policy and processes, risk aversion of adopters and implementers of innovations, and accreditations and IP challenges.

The next-generation, disruptive innovation that are based on the premise of stretching-and-transforming the WASH sector of the country, are expected to experience significantly greater challenges to deployment. Since these innovations are expected to shift the fundamental structure and function of the WASH sector (i.e. a shift to hand sanitisers in the handwashing section), there will be greater potential for barriers and challenges to their deployment. For example, environmental policy and legislation in the country may become a significant barrier to the rapid deployment of disruptive innovations, as has been demonstrated in the green energy sector of the country. Disruption of the traditional WASH sector through new, next generation innovations could fundamentally change the manner in which basic water services are provided in the country in that in-situ treatment, reuse and recycling innovations could shift the role of local government in provision of water services and impact on their regulatory role and financial status.

The research showed that the WASH innovation sector's main challenges to deployment of their products and services were:

- the lack of, or inability to raise financing for deployment; and
- regulation and policy barriers for deployment.

These challenges could be intensified by additional management and policy barriers to deployment, localisation and socialisation of WASH innovations in the country, such as:

- unrealistically low water pricing rates;
- unnecessary regulatory restrictions;
- the absence of regulatory incentives;
- lack of access to capital and funding;
- concerns about public health and possible risks associated with adopting new technologies with limited track records;
- the geographical and functional fragmentation of the industry; and
- the long-life expectancy, size, and complexity of most water systems.

Although the last three factors are inherent to the water sector and tough to change, substantial policy reforms are feasible that could alter pricing, regulation, and finance in the WASH innovation sector.

What was very clear from the research was that not only policy was a barrier to the sector. Many of the barriers related to the position in the value chain, the risk aversion of the sector to test and pilot innovations, the crowding of innovation in specific sectors of the value chain, serious gaps in innovation in other areas of the value chain, and 'tunnel vision' in financing and supporting innovations. All of these will need to be addressed to accelerate the country into a new paradigm of WASH service delivery that meets the current needs of the country, while also addressing the future needs and challenges that are expected.

More of the same, at the same pace, is definitely not going to allow the country to achieve SDG6, WASH human rights commitments or a sustainable WASH future.

9.2 Recommendations

9.2.1 Recommendations related to policy adjustments and changes at a national level

Changes in the innovation policy process present a challenge to existing national policy frameworks. While innovation policy may focus on strengthening public research and on providing incentives for firms to invest in research and development, this is not enough to address the innovation needs of the WASH sector in the country. A more strategic approach to fostering innovation is needed, one which considers the full spectrum of policies to create, diffuse and apply knowledge.

9.2.1.1 Create an enabling environment

To minimise the barriers and negative impacts of WASH regulations, a two-pronged approach to regulatory reform is recommended:

- Firstly, conduct a review of innovation and WASH policy and practices at a national and local government level utilising several key criteria. The goal of the strategic review would be the development of recommendations for needed regulatory changes, whether new WASH innovation policy/regulations or the elimination or modification of existing policy/regulations
- Secondly, national and provinces/district government should create offices of water innovation to better coordinate innovation efforts and recommend and oversee regulatory reforms to the WASH sector.

The policy/regulations review should be conducted along the following parameters:

1. **Ensuring synergies** between national, provincial and local government innovation regulations and policy. National should provide the national WASH innovation regulatory framework, with provincial and local government aligning to these.
2. WASH innovation regulation should provide for **cross-sectoral consistency**. Legislators and regulators of WASH innovations should consider the cross-sector impacts when adopting new regulations, i.e. energy-WASH impacts. Wherever possible, new regulatory instruments should coordinate across sectors (e.g. water and wastewater, or water and energy) to ensure consistent treatment of new and disruptive innovation and reduce unnecessary obstacles.
3. Innovation regulations should provide **sufficient flexibility** to avoid blocking the timely adoption of new and disruptive WASH innovations.
4. Innovation legislators and regulators should consider the **appropriateness** of prescripts that encourage the adoption of new WASH technologies. Provisions should be appropriate to the current status and needs of the WASH sector but should also be appropriate for future needs, i.e. encouraging water avoidance, reuse, recycling, etc.

Before adopting new policy/regulations, key decision makers should investigate **which WASH innovations and value chains might be affected and whether any resulting deterrence is justified**. Once existing regulations have been reviewed and revised, WASH innovation legislators, regulatory departments, and local government should **ensure that future regulatory actions are consistent with WASH innovation instruments**.

A second prong of regulatory reform would necessitate a commitment by national and/or province/district government to WASH innovation within the WASH value chains through the establishment of an office of WASH innovation and development (i.e. WASH innovation office), tasked both with developing a vision for the role of innovation in driving sustainable WASH management and WASH value chains, and with promoting policies to implement that vision. A major area of focus would be WASH innovation regulatory support. The WASH innovation office could assume responsibility for drafting a WASH innovation vision and plan and determining and applying means to overcome institutional, sectoral, and financial fragmentation in the WASH innovation value chain. The office could also promote systematic within-sector and cross-sector coordination on WASH innovation advances. More generally, the innovation office, working closely with WASH regulatory institutions at various governmental levels, could be responsible for:

- examining the role of innovation in promoting sustainable WASH management and value chains;
- coordinating and streamlining policy, legislative and regulatory frameworks in order to promote and not hinder WASH innovation;
- identifying and promoting best management practices, including appropriate pricing policies, for promoting WASH innovation;
- collecting and publishing relevant WASH data, which are essential to effective evaluation of new and disrupted innovations;
- acting as a clearinghouse for all funding sources and identifying and enabling access to non-governmental funding sources;
- encouraging and facilitating cooperative funding and development of new WASH innovations among multiple water entities, by, in-part, expanding public-private partnerships; and
- promoting coordination of new WASH innovations among and within sectors (e.g. between water and wastewater, and between water and energy sectors), as well as across all relevant jurisdictional levels (local to provincial to national government).

The innovation office could also be given the authority to promote the development, testing, and adoption of new WASH innovations. The innovation office could also have responsibility to disseminate information about the performance and costs of new WASH innovations to other water service authorities and providers in order to encourage appropriate deployment of effective WASH innovations into the WASH value chains.

The adoption of WASH innovation offices should take an incremental, cascading approach. Since the national government (i.e. DWS, DST, DTIC, DoH, DBE) collectively are well positioned to take the lead in a national WASH innovation office, this should be established first. Provincial/district offices could be established in future, based on areas of greatest need for WASH innovations and disruptions to WASH value chains.

9.2.1.2 Recommendations for WASH Innovation in National Policy

Returning to Figure 35 below from Chapter 1, which outlines the major challenges in the South African WASH sector of the country, recommendations for changes to policy to facilitate, enable, infuse and expand innovations, including disruptive innovation, in the WASH sector are categorised within these challenges to ensure that the policies that regulate and enable innovative solutions to these challenges also facilitate and enable WASH innovation deployment, localisation and socialisation.

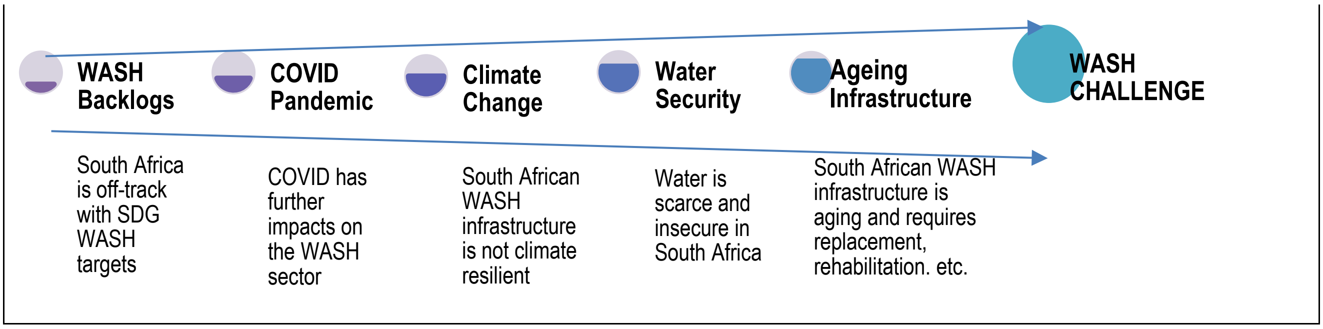


Figure 35: Summary of the Water Supply, Sanitation and Hygiene (WASH) Challenge

<u>Overarching Policy for Innovation in WASH</u>

ALL policies should be reviewed to facilitate growth in the R&D, deployment, localisation and socialisation of WASH innovations.

- South Africa should develop a WASH Innovation Policy, underpinned with many of the lessons learned in deploying, socialising and localisation of WASH innovations during the COVID-19 pandemic, as well as the policy intents outlined in the White Paper on Science, Technology and Innovation (ST&I).
- Many of the policy positions in the ST&I White Paper already provide the framework of innovation in the WASH sector, it is important to contextual and adapt these to address the specific needs of the entire WASH innovation and value chain in the country.
- The WASH Innovation Policy should have a strong focus on:
  - creating an open and flexible governance regulatory framework that is innovation-friendly and encourages valuable new technologies;
  - facilitating companies, supply chains, stakeholders, regulators, SMEs, start-ups, academia, the public, and other innovators to co-create and co-deliver innovation initiatives (Competition Commission provisions need to be noted);
  - encouraging and facilitating collaboration as a central approach and common purpose of WASH innovation, with all stakeholders playing an active role to achieve transformational innovation;
  - encouraging the sector to adopt a transparent approach that leverages the full potential of the WASH value chain community rather than leverage from and by individual organisations; and
  - encouraging and supporting inclusive participation and an inclusive focus of the innovation value chain on addressing the needs of vulnerable groups (i.e. design by women for women, or design by children for children, or design by people with disabilities for people with disabilities, etc.)
- The WASH Innovation Policy should be aligned with the new Intellectual Property (IP) Policy of 2018.
- The WASH Innovation Policy should encourage relinquishment/waiving of IP rights for public good/basic services/human right-based WASH innovations.
- The WASH Innovation Policy should be aligned with the RDI Roadmap of 2015 published by the Water Research Commission.
- Lessons learnt from the implementation of the RDI Roadmap should inform the WASH Innovation Policy.

<u>Policy for Innovation in WASH to Address Backlogs</u>

All water and sanitation policies should be reviewed, and possibly new policies be issued to facilitate growth in the R&D, deployment, localisation and socialisation of WASH innovations in addressing the WASH backlogs in the country. Inclusion to be considered in the water and sanitation policy could be:

- Review of the Water and Sanitation White Paper: The Water and Sanitation White Paper needs to be reviewed and refined to strengthen and expand the policy positions related to WASH innovation. The Water and Sanitation White Paper currently has significant gaps related to innovation. In reviewing the policy, the following should be considered for basic services:
  - Ensure that the WASH Innovation Policy has policy positions for all sanitation systems and provides clear definitions of these sanitation systems.
  - The WASH Innovation Policy should outline positions on how to facilitate and support (i.e. funding, capacity, etc.) developers/innovators (both public and private sector) with testing of innovations in a field situation.
  - The WASH Innovation Policy needs to provide policy positions that facilitate collaboration, partnership and coordination of WASH innovation efforts.
  - The WASH Innovation Policy should provide policy positions related to basic services along the entire WASH value chain and positioning of innovation in the enabling environment (i.e. innovative management, funding, operating and maintenance for basic services).
  - It is crucial to develop and clearly articulate the appropriate roles that private sector can play in the WASH innovation sector and within the WASH value chains to leverage financial resources devoted to these WASH innovation efforts by the private sector.
- Policy to encourage public investment in WASH innovation: WASH and financial policy should allow for inter-governmental support to basic WASH services provision, as well as encourage innovative delivery that targets impoverished communities and other vulnerable groups. Grants and targeted credit mechanisms could be used to support innovation toward broadly accepted, policy-supported WASH targets.
- Policy to reward WASH innovation: WASH and financial policy should promote efficiency and reliability of WASH services, while rewarding transparent and accountable innovations in WASH service provision. Pairing this focus on recognition with enhanced public investment to deploy, socialise and domesticate WASH innovations is the next logical step for success.
- Policy to encourage new and innovative financing mechanisms and investment strategies: In parallel with pricing and regulation reform to meet necessary WASH needs in the country, improved finance is needed for both investment in the core WASH value chains and for the WASH innovations themselves. The former requires aligning the incentives for investors, while the latter requires addressing, head on, the reality that many of the benefits of fundamental WASH innovation are a public good.
- Policy for government to play a supportive role in diversified financing and funding of innovative solutions: In particular, WASH innovation and financial policy prescripts need to be able to be a catalyst and to leverage funding for R&D and facilitate provision of low-interest loans and grants to pilot and implement WASH innovations. Private, off-fiscus finance for WASH services can also be encouraged by governance policy. These policy reforms would require improvement in management systems, targeting efficiency, reductions in cost, and cost-recovery measures by WSAs and WSPs. Such national policy efforts in conjunction with other local public and private financing mechanisms could facilitate a faster rate of WASH innovation deployment, localisation and socialisation. Policy coherence should be ensured by treating innovation as a central component of government policy, with strong leadership at the highest political levels. Regional and local actors should be enabled to foster innovation, while ensuring coordination across regions and with national efforts. Evidence-based decision making, and policy accountability should be fostered by recognising measurement as central to the WASH innovation agenda.
- Improve water pricing policy: Water pricing policy in South Africa, as is the case across the globe, needs to ensure that the full cost of delivering water is captured for the financial health of WSAs and WSPs in the country. Water pricing policy reform in the WASH sector can play an important role in promoting WASH

innovation as a stable financial WASH institution allows from flexibility and scope to explore and fund innovations. The poor financial status of WSAs and WSPs decrease the funding that water utilities have available to invest in innovation. Ensuring water pricing captures the full cost of water supply may also encourage conservation behaviours by end-users and thus quick and easier localisation and deployment of new innovations (specifically those that reduce end-use water use).

- Review water supply policies: A review is required of all water supply policies to inform, update and expand innovation policy positions in the WASH Innovation Policy.
- Policy for WASH transformation: Since policy failures may be due to country's WASH sector and WASH innovation value chains lacking the means for making social choices over alternative pathways of WASH development, i.e. barrier to adopting transformative WASH innovations, transformation of the water services innovation policy may require consideration of innovation options beyond the narrow boundaries set by officials, and the nurturing of the opportunity for various groups to challenge dominant policy-driven WASH views embedded in the current systems.
- Policy for a focus on green technology and processes: The WASH innovation capacity should focus on minimising resource use and impacts, and maximise reduce, reuse, recycling and reclamation.
- Policy for appropriate technology: innovation of appropriate WASH technology should be strengthened to ensure that the WASH innovations are relevant for the context they would be deployed in.

Policy for Innovation for Management of COVID-19 and Other Disasters

All policies should be reviewed to prepare for, mitigate, and manage pandemics and other man-made or natural disasters in the country. Disaster policy should focus on WASH innovation positions related:

- innovative means of keeping WASH services operational during a pandemic or disaster situation (i.e. sustainability of services).
- innovative means of evaluating, monitoring and reporting on WASH needs and access to WASH services during a pandemic or disaster situation.
- innovative means to stimulate and support hygiene innovation deployment, localisation and socialisation, i.e. soaps, sanitisers, handwashing facilities, etc., during a pandemic or disaster situation.

Policy for Innovation for Climate Resilient WASH

All policies should be reviewed to prepare for, mitigate, and manage climate change in the WASH sector of the country. Policies for innovations for climate resilient WASH should focus on

- reviewing and redirecting WASH, Climate Change and Health policy to enhance focus on the design and development of climate resilient WASH technologies and processes, including WASH innovations.
- advocating and supporting climate resilient WASH innovation in WASH, Climate Change and Health policy, along the entire WASH value chain.

<u>Recommendations related to “SABS standards lag behind innovation”</u>

This challenge relates to the SABS standards not yet being available for new and disruptive innovations. The SANS 30500 is a step in the right direction but still do not fully assist with designing and developing disruptive WASH innovations. Similar to the hand sanitiser localisation process, it is recommended that a system be developed to allow for some flexibility in deployment and localisation of the WASH innovations, while at the same time providing a systematic approach that would allow government stakeholders to explore and support these innovations with comfort. The relevant SANS can then be compiled and published concurrent to innovation piloting and processes.

9.3 Recommendations Related To Municipal Policies

The respondents included in the research highlighted several policy challenges to the uptake of WASH innovations in the country. The challenges related to existing ‘policies’ were largely in the municipal sector, covering not only legislative policy but also operational policies at municipal levels. Apart from the national regulatory policy reviews and adjustments recommended in the previous section, recommendations related to municipalities and WASH innovation could address the innovation barriers mentioned by the innovators, specifically the following:

9.3.1.1 Recommendations related to “MFMA policies for capital equipment”

Municipalities generally have a focussed manner in which they view funding for any innovation. Basically, if it cannot strictly adhere to common MFMA procedures the innovation is not considered. Funding of an innovation is viewed only from the budget available from the fiscus. However, a range of funding options are available to municipalities that could facilitate the piloting, localisation and socialisation of WASH innovations, while at the same time remaining within the MFMA provisions. The SALGA 2018 Conference report on *Municipal Innovative Infrastructure Financing* provides for such a suite of funding options to unlock innovation opportunities in a municipality, including for WASH innovations (SALGA, 2018) (see Box below). As indicated in the report in a *context where resources are scarce and over reliance on the fiscus is futile option, the local government sector has to explore new avenues, tools and instruments for infrastructure* [including innovation] *financing. This is very important for continued sustainable service delivery, meeting infrastructure needs of a growing population, stimulating economic growth and job creation. Understanding the various infrastructure financing options and tools is the first step toward tacking these challenges head-on (SALGA, 2018).* Municipalities should consider these funding options to pilot, scale up and localise WASH innovation that will address the current and future challenges that the WASH sector will face, and to ‘disrupt’ the tradition and norm by moving service delivery into a new era of effective, efficient and sustainable WASH services. In agreement with the report, the following are recommended for municipalities to adopt the basic approaches to cope with WASH services challenges (SALGA, 2018):

- Expand the funding of WASH innovation, including innovative infrastructure funding.
- Develop a new instrument to fund special local WASH innovations investments, especially local innovation investments.
- Coordinate and integrate WASH innovation funding.
- Foster capacity development to take up WASH innovations, manage WASH innovations and finance WASH innovations.
- Develop a national-municipal WASH innovation project pipeline.
- Match-make between WASH innovators, planners, project preparators, funders and executors.

Funding options that can be considered for WASH innovations, in line with the SALGA recommendations for municipal infrastructure financing options (SALGA, 2018):

- **Own public budget: savings, internal cross-financing**
- **Other public budget: grants**
- **Advance payment of citizens: Tax Increment Financing (TIF)**
- **Borrowing from 3rd parties**:

1) Bank loan;
2) Municipal Bonds (MB);
3) Municipal Pooled Financing (MPF);

- **Partnership: Pay for Success in Social Public Private Partnership (PSSPPP)**

The municipal sector should explore the availability of risk capital and support engagement with WASH innovation investors, who can also provide mentoring and advice, as well as finance, to entrepreneurs. The following additional types of funding could be made available

(1) capital funding for WASH innovations: crowdfunding; and

(2) operating funding for WASH innovations: memberships fees, return from innovation, billing, advertising, and revenues from services.

Apart from explore funding sources, it is recommended that, at a municipal level:

- Government should conduct a review of policy and regulation to restructure incentives to transform the WASH innovation sector at a municipal level.
- Financial targets for WASH innovations should be clearly articulated and adhered to, with clear roles and responsibilities related to these.
- Provide training to staff so they better understand sustainable finance models for WASH innovations and to understand that enabling finance of WASH innovations can improve efficiency and mobilise additional resources for WASH value chain activities.
- Improve the policy framework to manage WASH value chain and WASH innovation risks under various financial scenarios.
- Develop policies to enhance access to international credit for WASH value chains and WASH innovations.
- Establish a strong regulatory framework to monitor the performance of WASH innovations (incl. finance and funding) and enforce guidelines for tariff setting to enable financial stability in WASH value chains.

The municipality should also ensure that the financial capacity is available to explore and support WASH innovations, including the following:

- Municipal human resources (HR) practices and procedures should ensure that financial appointees are capacitated to support and explore WASH innovations within the MFMA and municipal procurement procedures.
- Procurement policy should adopt partner integrity pacts, e-procurement; open contracting data standards, and red flag monitoring.
- Procurement policy must advocate transparency and integrity in procurement practices related to WASH innovation infusion into municipal WASH value chains.

9.3.1.2 Recommendations related to "Lack of knowledge from Municipalities and reluctance to adapt" and "Management have little interest in applying any new technology until they are forced by law to do so"

Some policy and actions that can create an enabling environment for WASH innovations at municipal level include the following:

- Policy should be reviewed for WASH service governance improvements — paired with other public financial management (PFM) and financial market development. A high-quality regulatory framework can facilitate market entry and growth for businesses.
- Various tools and incentives can be utilised to stimulate WASH innovation and to encourage collaboration and partnerships for the successful and sustainable transfer of these technologies, for example tax incentives, policy development, etc. The manner in which effective and efficient WASH services are measured needs to be review, and aligned to sustainability principles such low water use, dry systems, reuse and recycling, use of green chemicals, etc. Municipal systems that focus on these principles should be rewarded to encourage innovation by municipalities and uptake to scale of innovations.
- Knowledge sharing platforms and mechanism should be adopted. For example, sharing of innovations on a shared website could elevate the status of WASH innovations and allow for sharing of innovations across the value chains. This platform could be expanded to include to provide supporting policy information, funding source details, etc. A UNESCO (2015) report indicated that one of the drivers of locally developed innovations and applications in African countries were the technology hubs springing up across the continent. Hubs allow for sharing, collaboration and support to SMMEs in the WASH innovation value chains, providing key skills that may be lacking in these organisations and facilitating entry and understanding of the WASH market.
- International collaborative partnerships, between a range of partners, government, education institutions, Non-governmental Organisations (NGOs) and Non-profit Organisations (NPOs), private institutions, communities, or a combination of these, should be encouraged to transfer WASH innovations within South Africa, but also across the globe (Merle and Dellas, 2011). Collaborative partnerships for transfer should be developed at various stages of the technology life cycle.

9.3.1.3 Recommendations related to "BBBEE rules in general; no matter the innovation" and "MOA and MOU agreement authorization from highest levels such as manager director level"

In the pursuit of active national policy to diffuse the latest WASH innovations, skills in the workforce are critical for sustaining the WASH sector and its value chain. Public and local policy can promote the development of WASH innovation firms and their workforce through a variety of mechanisms, including:

- innovation diffusion programmes (agricultural extension services as an example in the agriculture sector) that not only expose 'frontier firms' to leading edge innovations, but also seek to increase the skills and capability of SMMEs within the WASH innovation value chains; and
- services designed to boost the productivity and innovation performance of SME manufacturers in particular.

9.3.1.4 Recommendations related to "Community 'protocols' in general; notwithstanding allowance and respect for these".

Localisation of WASH innovation is inherently linked to communities – protocol have to be followed and respected to ensure the sustainable uptake and localisation of any innovation. It is recommended that a guidance protocol or practical guideline for WASH innovations be developed to support entry and engagement with the communities that would benefit from the WASH innovations.

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