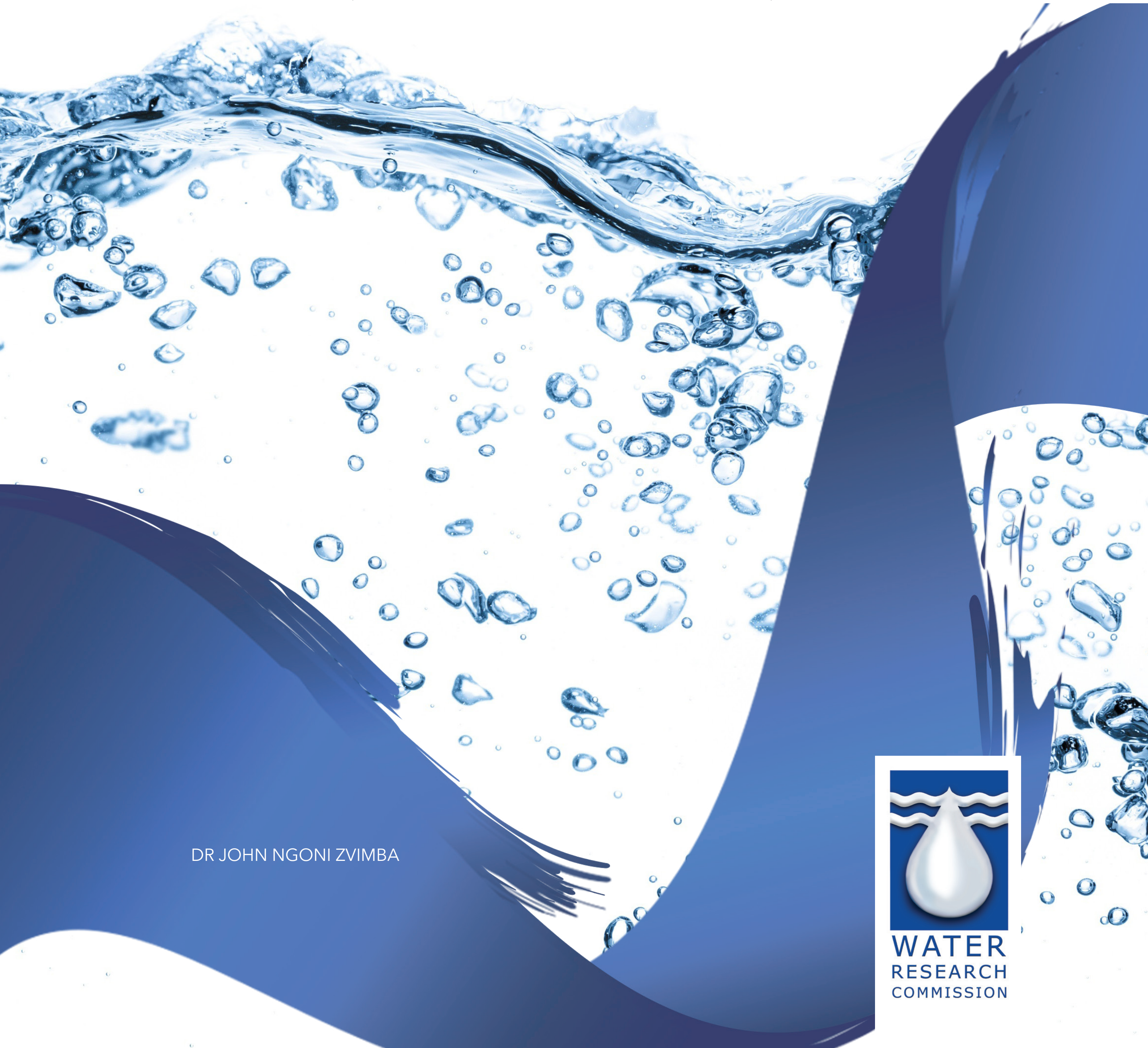
WATER USE, WASTEWATER RESOURCES AND SANITATION FUTURES

SUSTAINABLE INTEGRATED WASTEWATER RESOURCES FUTURES RESEARCH STRATEGY

2020/21 – 2025/26



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EXECUTIVE SUMMARY

The view regarding wastewater as a 'nuisance' has been gradually changing to one of a 'resource'. This has globally resulted in a significant shift from end-of-pipe treatment to reuse and resource recovery. In this regard, the sustainable integrated wastewater resources futures research portfolio strategy seeks to explore reuse and resource recovery opportunities available from integrated municipal, industrial and mine-impacted wastewater(s), and drive maximum benefits from utilisation of such resources through development of sustainable wastewater management practices and innovations in support of environmental protection and human health.

The sustainable integrated wastewater resources futures research portfolio strategy is therefore premised on three critical focus aspects, namely:

- Paradigm shift from current wastewater management practices underpinned by 4IR
- Wastewater as a resource catalysing achievement of sustainable development goals (SDGs)
- Transitioning the water sector to a circular economy

This strategy has been designed to provide the required research, development and innovation (RDI) focus that drives integration of municipal, industrial and mine-impacted wastewater(s) resource opportunities in support of sustainable future wastewater management. The scope of this portfolio is to address wastewater as a resource by promoting and encouraging reuse and volarisation/beneficiation across the domestic, industrial and mining sectors. In this regard, the strategy makes use of five key programmes to drive development of novel and innovative knowledge solutions that promote a shift from current wastewater management practices, use wastewater as a resource to catalyse SDGs achievement and support transition of the water sector to a circular economy. To achieve the strategic goals, the following five broad key thematic areas will be prioritised over the next 5 years:

- Regulations, best practices, approaches and tools promoting pollution prevention at source
- New and emerging low energy or energy efficient treatment options for sustainable wastewater management
- Approaches, tools and innovations for maximum resource recovery from wastewater
- Nature-inspired innovations and solutions for sustainable wastewater management
- Approaches, tools, innovations and practices for sustainable mine closure

By focusing on the above thematic areas, this strategy will use RDI within the next five years to provide some of the key solutions that would address sustainable integrated wastewater management in support of improved service delivery. Ultimately it is believed that the strategy will further strengthen the sector's ability to tap the strength of wastewater(s) and restore environmental health, sector competitiveness, stimulate enterprise development, and contribute towards economic growth and prosperity.

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LIST OF ACRONYMS

CE	Circular Economy
DSI	Department of Science and Innovation
DMRE	Department of Minerals Resources and Energy
DWS	Department of Water and Sanitation
4IR	Fourth Industrial Revolution
IWA	International Water Association
MWCB	Mine Water Coordinating Body
RDI	Research, Development and Innovation
SALGA	South African Local Government Association
SDGs	Sustainable Development Goals
WRRF	Water Resources Recovery Facilities
WWTW	Wastewater Treatment Works

1.0 INTRODUCTION

Currently, approximately 4 billion people live in water-scarce and water-stressed regions, with nearly 1 billion people without access to safe drinking water and almost 1 million deaths per year from waterborne diseases. The World Economic Forum projects that under business-as-usual policy and technology practices, the world faces a 40 percent gap between water supply and demand by 2030. In addition to water scarcity impacts, the world also faces negative effects from flooding and poor water quality to economic growth, business continuity, ecosystem health and social well-being. In particular, cities are vulnerable to the impacts of water scarcity and extreme weather events. These impacts are currently being realised in many cities and, as a result, various cities are looking to increase their resiliency to changing hydrologic conditions.

Current research indicates that cities most concerned about their water supply are in Asia and Oceania, Africa and Latin America, with 196 cities reporting risks of water stress and scarcity, 132 a risk of declining water quality, and 103 a risk of flooding. Furthermore, impacts from water scarcity on a regional and national scale as previously presented by the World Bank has indicated that water scarcity, exacerbated by climate change, could cost some regions up to 6 percent of their GDP, spur migration, and spark conflict. The combined effects of growing populations, rising incomes, and expanding cities will see demand for water rising exponentially, while supply becomes more erratic and uncertain.

As the global water security challenges continue to present themselves before the global community, South Africa remains a water scarce country, with 98% of its water resources already allocated, about 41% non-revenue water and a projected 17-20% supply deficit by 2030. From the total amount of water withdrawn in South Africa per annum 62% is used by the agricultural sector, 27% by the municipal sector and 11% by the industrial sector (Figure 1). However, 89% and 86% is attributed to greywater of the water footprint in industry and in domestic supply respectively, while in agricultural production, this figure is only 6% (Table 1). In this regard, any strategy for mitigating the water footprint of industrial (including mining) and municipal sectors should focus on the polluting effect of effluent rather than the supply of freshwater. However, sole focus on polluting effect of effluent is not attractive for both industry and municipalities. Therefore, consideration for other beneficial aspects such as volarisation and beneficiation of wastewater(s) in support of offsetting treatment costs is required as part of the strategy.

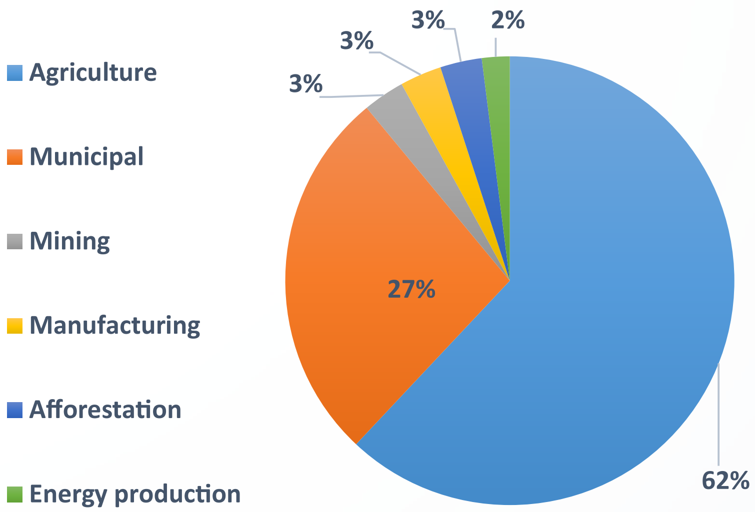


Figure 1: National water footprint for different sectors in South Africa

Table 1: Greywater footprint for industry, domestic supply and agriculture

Water Footprints (million m^3)						
Agricultural Production			Industry		Domestic Supply	
Green	Blue	Grey	Blue	Grey	Blue	Grey
45 928	6694	3126	38	309	390	2368
55 748			347		2758	

It is on this basis that wastewater resource management of the future will entail practising a more sustainable way of managing wastewater resources that will prioritise aspects such as reuse and resource recovery. Additionally, future wastewater management approaches should be designed to go beyond addressing sustainability issues and begin to address restoration and regeneration of the planet (Jazbec et *el*., 2020).

In this regard, designing for sustainability refers to design for human and planetary health; to maintain the planet in a condition where life as a whole can flourish. Sustainable actions are generally at the energy neutral point of not doing any further damage, and are considered as resource efficiency initiatives that can be implemented within the control of the water sector business. However, as we push the planet beyond the planetary boundaries, sustaining is no longer enough, as we need to consider restoring the material balance and then to actively go further with restorative actions that will ensure the planet's health, resilience and ability to adapt.

Therefore, restorative solutions focus more on resource recovery with a broader material flow influence which may require new business models. Moving towards the regenerative state where actions are designed in line with nature, solutions seek to integrate a wider influence on social and environmental systems, with the aim of doing more rather than just doing less harm. However, for this to be successful, it requires thinking, designing and doing things differently, including disruptive technologies and governance approaches that enhance our natural, urban and social environments. This might mean considering the problem from an entirely different perspective, such as considering waste products (including wastewaters) as resources, moving away from end-of-pipe solutions, or starting with the outcome in mind and planning services around those.

For the South African context, wastewater resource management of the future should broadly aspire to address current water sector challenges in support of achieving sustainability, restoration and regeneration of the planet. This will entail a significant consideration of the following three critical aspects by the water sector as pillars for achieving sustainable wastewater resource management of the future:

- Paradigm shift from current wastewater management practices
- Wastewater as a resource catalysing sustainable development goals (SDGs) achievement
- Transitioning the water sector to a circular economy

2.0 STRATEGIC OVERVIEW

2.1 PARADIGM SHIFT FROM CURRENT WASTEWATER MANAGEMENT

According to the World Bank, across the globe, about 1.3 billion metric tons of waste is generated every year and is expected to continue increasing in future because of rapid urbanisation and industrialisation across regions. Furthermore, the smart waste management market has been valued at USD 1.77 billion in 2020 and is expected to reach USD 6.52 billion by 2026, registering a compound annual growth rate of 25.7%, during the forecast period of 2021 – 2026.

Currently, almost 90% of waste generated in South Africa continues to be sent to landfill for disposal, with waste management facilities in South Africa generally structured as follows:

- 82% Landfills
- 11% Wastewater treatment plants
- 7% Recovery centres

Despite the challenges associated with waste management in South Africa, the waste economy currently has a financial potential of R15 billion and provides 29 833 jobs, with implementation of 100% recycling able to unlock R17 billion worth of resources/ products. In this regard, more opportunities are available within the South African industrial operations (including mining) and wastewater services. For instance, wastewater services currently host more than 1 000 municipal wastewater treatment works (WWTW), treating about 7 500 ML/d at an operational cost of about R4.5 billion/year. On the other hand, the abandoned gold mines within the Witwatersrand have the potential to supply 145 – 240 ML/day of mine-impacted water, with opportunities for valuable recovery existing from the implemented three neutralisation plants. Currently the neutralised mine-impacted water is discharged into the Vaal Barrage where the water is diluted with freshwater from the Vaal Dam to ensure compliance before discharge into the Vaal River. With Lesotho highlands water projects phase 2 scheduled to be commissioned by 2025, until then, the water availability in the Vaal River System (VRS) will remain at risk, with dam levels in the VRS declining. Th DWS should therefore implement various initiatives to mitigate against future water security risks in the integrated VRS.

Other water resource recovery and reuse opportunities exist within current coal mining locations, particularly in Mpumalanga where most mines are due for closure within the next 10 – 20 years. As an example, the eMalahleni water reclamation plant currently purifies 30 Ml/d of mine-impacted water to potable quality and covers almost 20% of the total potable water demand in eMalahleni. The capacity distribution of municipal treatment works and schematic for the mine-impacted water treatment works within the Witwatersrand basin is given in Figure 2 below.

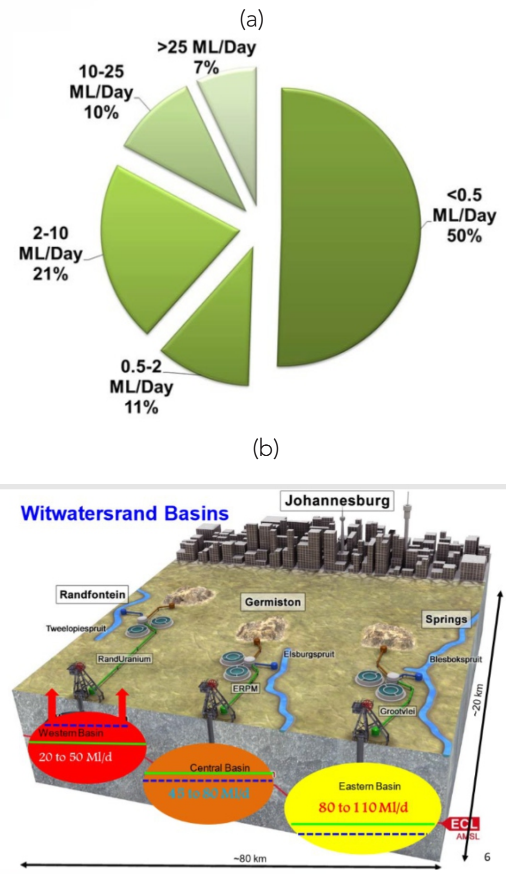


Figure 2: Distribution of the (a) WWTW capacity within the South African wastewater sector and (b) schematic for the mine -impacted water treatment works within the Witwatersrand basin

Furthermore, the 18 major industrial operations in South Africa currently documented as part of the national survey are well known to use significant quantities of water and energy while generating huge amounts of wastewater that poses challenges for the water sector. The currently available updated national survey documents providing a a snapshot of current water use and wastewater generation and management within the specific industries are given in table 2:

Table 2: The national survey reports presently available

No.	Title	Year	Report no.
1	Water and wastewater management in the malt brewing industry	2016	TT 676/16
2	… metal finishing…..	2016	TT 644/15
3	… soft drink……	2016	TT 640/15
4	… dairy…..	2015	TBC
5	… sorghum malt & beer industry	2016	TT 692/16
6	… edible oil	2016	TT 702/16
7	… red meat abattoir	2016	TT 701/16
8	… laundry	2016	TT 703/16
9	… poultry abattoir	2017	TT730/17
10	… tanning and leather finishing	2017	TT 713/17
11	… sugar	2017	TT 721/17
12	… paper and pulp	2016	TT 704/16
13	… textile	2017	TT 724/17
14	… fruit and vegetable processing	2021	TBC
15	…oil refining and re-refining industry	Outstanding	
16	….power generating	2021	TBC
17	… iron and steel	2017	TT 705/16
18	… pelagic fish	2021	TT 839/20

Despite the challenges associated with poor wastewater management in the sector, there exists opportunities to address these challenges and improve current wastewater management practices, thereby creating an opportunity to shift from current wastewater management practices to sustainable future wastewater management. For instance, the majority of municipal treatment systems have serious overload challenges resulting in poor operations and maintenance and non-compliance. On the other hand, industry's continuous failure to comply with municipal bylaws places a huge burden on municipal treatment systems, while treatment systems for mine-impacted water face serious ingress challenges, thereby making general wastewater management in the sector too costly.

In this regard, a shift from the current less cost-effective, end-of-pipe treatment and disposal is required, and this can be achieved by catalysing conversion of current treatment systems into future water resource recovery facilities (WRRFs) across industrial (including mining) and municipal operations. Figure 3 shows an envisaged mapping of such WRRFs, whereby such a facility would use energy-efficient operations, supported by smart systems to recover water, energy and materials such as nutrients, as well as produce clean water and other valuable products for industry and agriculture in an integrated manner.

The efficient operation of such WRRFs will be further supported by well engaged and informed communities. On this basis, officials, industry and the public will manage the demand and waste better, support resource recovery goals, and contribute to integrated solutions for water, energy and food supply.

The envisaged benefits and outcomes of transitioning current treatment systems to future WRRFs within the water sector include the following:

- Health environment
- Renewable energy supply
- Reduced carbon emissions
- Economic growth and
- Vibrant and green communities

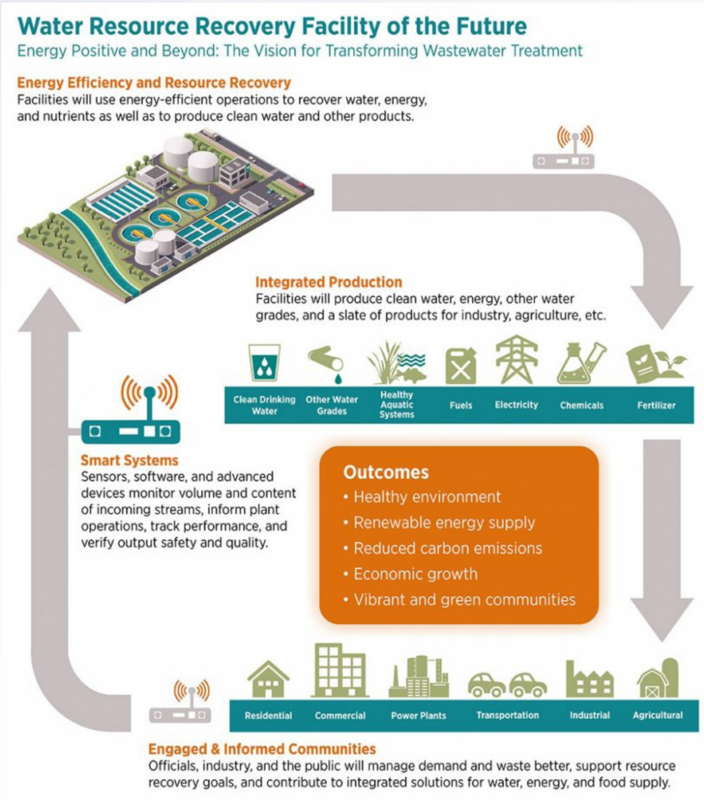


Figure 3: Water Resources Recovery Facilities of the future (Courtesy of The Bioenergy Technologies Office: Advancing a Thriving and Sustainable Bioeconomy Fueled by Innovative Technologies, November 3, 2015)

2.1.1 The role of the Fourth Industrial Revolution

Our relationship with water is undergoing a transformation in response to increased demand for water, the impacts of climate change and poor water quality.

Digital technologies such as information communication technologies or ICT are leading this transformation through the emergence of technologies such as remote sensing, inexpensive sensors, smart devices, machine learning, artificial intelligence, virtual reality, augmented reality and blockchain. This digital transformation of water is currently enabling real-time water quantity and quality monitoring, vastly improved management of infrastructure assets, direct consumer engagement and facilitating the adoption of off-grid and localised infrastructure technologies. Not only will water utilities be transformed by digital technologies, but the public sector will benefit through improved knowledge of water supply, demand and quality to better inform public policy and investments. The private sector will also be positioned to ensure the efficient and effective use of water in their supply chains and operations.

Several organisations have already acknowledged the potential of digital water technologies. The World Economic Forum frames the adoption of digital technologies in all industrial sectors as the Fourth Industrial Revolution or 4IR. In this regard, digital technologies have the potential to democratise access to water data, actionable information and, in turn, to safe drinking water. Achieving SDG 6 may be within reach through digital technologies and their ability to facilitate the adoption of other innovative water technologies. By 2030 we will therefore see digital water technologies as commonplace just as we have seen digital technologies become integrated into the energy and transportation sectors. Moreover, digital technologies will enable leapfrogging of traditional infrastructure such as centralised systems to hybrid and new systems by providing real time access to water/wastewater quantity and quality data for consumers, technology providers and regulators.

Therefore, digital technologies will be transformational in positioning the water industry, other commercial sectors and governments for expanded resilience from increased demand for water and the impacts of climate change. The water/wastewater industry has therefore the opportunity to take the lead in addressing 21st century water risks through the adoption of digital water technologies.

2.2 WASTEWATER AS A RESOURCE CATALYSING SDGs ACHIEVEMENT

Agricultural production requires huge inputs of nutrients for optimal production. Solid stream wastewater can be utilised as a source of nutrients, restoration of degraded land and as carbon sink in support of climate change mitigation. The liquid stream wastewater is also useful as source of water and nutrients, referred to as fertigation. In this regard, the use of solid stream wastewater as a source of nutrients contributes to increased food production in support of zero hunger (SDG 1). This further contributes to good health and wellbeing (SDG 3) as solid stream wastewater is a good source of micronutrients, thus fortifying the nutrient composition in support of food production and security. On the other hand, the use of liquid stream wastewater as a source of water contributes to SDG 6 as this reduces possible contamination of water resources through irresponsible discharge and disposal. Similarly, use of both solid and liquid stream wastewaters in support of food production contributes to responsible consumption and production (SDG 12) as well as supporting life on land (SDG 15). Furthermore, the use of both solid and liquid stream wastewaters in agricultural facilitate sequestration of carbon in support of climate change mitigation (SDG 13). Figure 4 shows the role of wastewater generated from integrated municipal, industrial and mine-impacted water as a resource catalysing SDGs achievement.

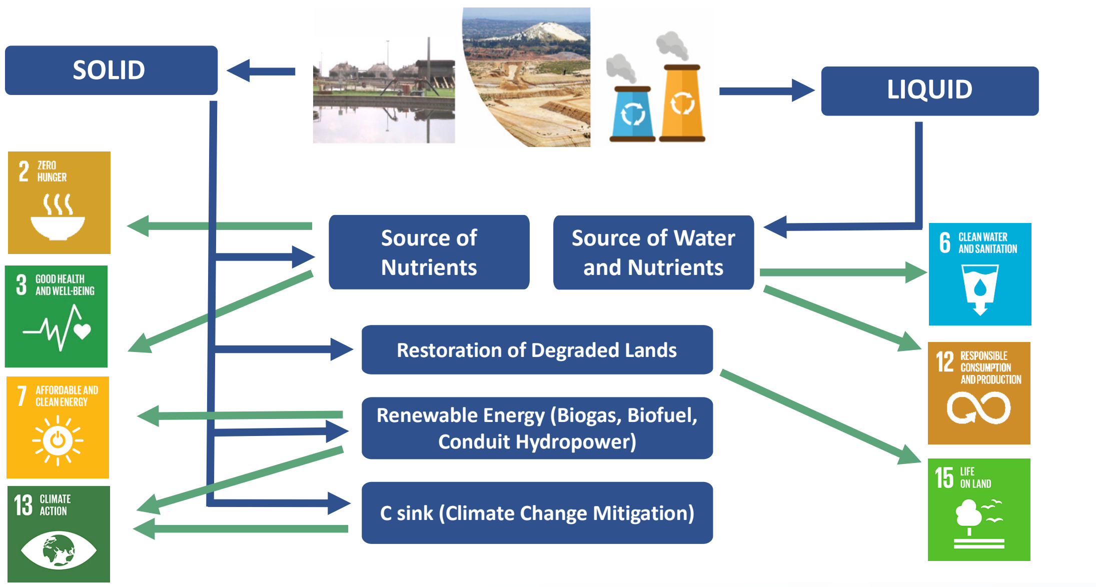


Figure 4: Wastewater as a resource catalyzing SDGs achievement

2.3 TRANSITIONING THE WATER SECTOR TO A CIRCULAR ECONOMY

A circular economy (Figure 5a) is an alternative to a traditional linear economy (Figure 5b; make, use, dispose) in which resources are kept in use for as long as possible, extracting the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life. Figure 5 shows the conceptual framework of both circular and linear economy for the water sector.

Currently, many utilities globally are considering the benefits of unlocking the circular economy to better manage water and wastewater resources, make and use products to regenerate natural systems. To define a clear role for water utilities in transitioning to a circular economy, the International Water Association (IWA) developed framework has identified three key interrelated pathways to achieving circular economy principles in the water sector as water, material and energy pathways. The water pathway needs to be developed as a closed loop, with diversified resource options, efficient conveyance systems and optimal reuse as three key factors. Under the materials pathway resource recovery from wastewater operations must be able to compete with other products on the market for successful incorporation into the circular economy. On the other hand, the objective of the energy pathway includes reduction of carbon-based energy consumption and increased renewable energy production and consumption, thereby contributing to the zero-carbon emissions initiative.

The transitioning to a circular economy within the South African water sector is in line with the United Nations SDGs.

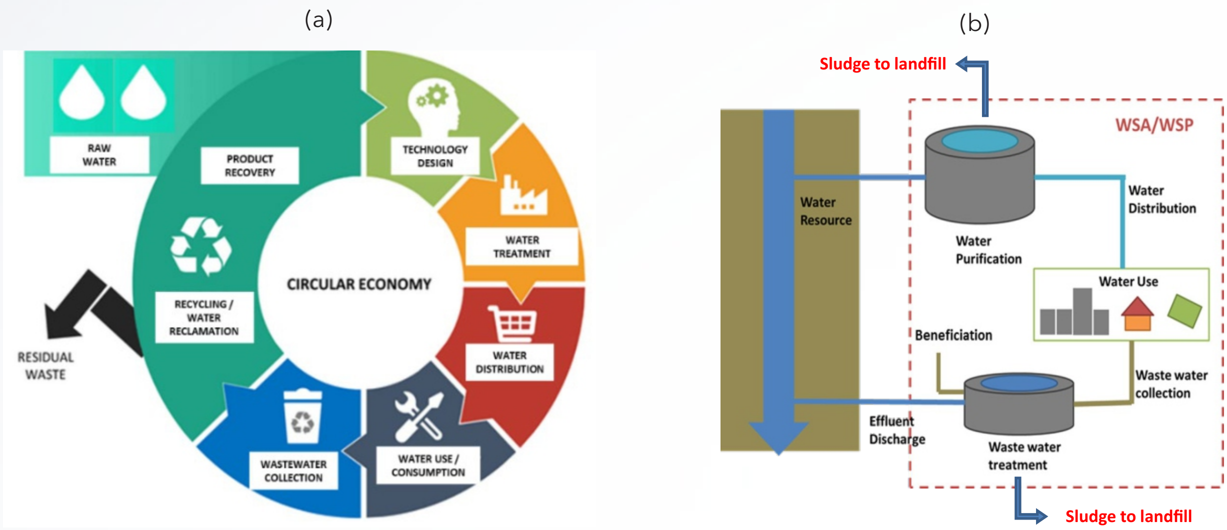


Figure 5: Conceptual framework of (a) circular economy and (b) linear economy for the water sector

Water has a dedicated goal in SDG 6 (ensure availability and sustainable management of water and sanitation for all) and its attainment will be reliant upon contributing to and benefiting from the attainment of other SDGs, most notably in the context of the circular economy, SDG 12 (ensure sustainable consumption and production patterns). This interdependence across goals manifests at a national level in highlighting the need for greater cooperation amongst sectors, incentivised innovation and enabling meaningful engagement with citizens. Moreover, the shift from a linear to a circular economy has multiple economic, social and environmental benefits. It allows the sector to create more value while reducing their dependence on scarce and costly resources. Furthermore, a circular industrial system that is regenerative by design, which restores material, energy, and labour inputs, can only be good for both society and business.

3.0 SUSTAINABLE INTEGRATED WASTEWATER RESOURCES FUTURES

Although wastewater effluents from municipal, industrial and mining operations are a critical component of the water management cycle, they are generally considered a burden to be disposed of. However, in the face of ever-growing demand, wastewater is gaining momentum as a reliable alternative source of water, shifting the paradigm of wastewater management from treatment and disposal to reuse, recycle and resource recovery.

The scope of this research portfolio is to address wastewater as a resource, encourage the valorisation and reuse of wastewater effluents and promote sustainable wastewater management through reducing pollution, removing pollutants, reusing/recycling reclaimed water and recovering useful resources. The need for a paradigm shift from current wastewater management practices, use wastewater to catalyse SDGs achievement and transition to a circular economy will be key pillars for a successful sustainable integrated wastewater resources management of the future. Therefore, to address the challenges associated with the integrated wastewater sector in a sustainable manner, the research portfolio will prioritise research, development and innovation that will deliver the required solutions, innovations, processes and interventions at scale.

3.1 INTEGRATING MUNICIPAL, INDUSTRIAL AND MINE-IMPACTED WASTEWATERS

The newly conceptualised sustainable integrated wastewater resources futures research portfolio (Figure 6) has been designed to provide the required research, development and innovation (RDI) focus integrating municipal, industrial and mine-impacted wastewater(s) as a resources in support of future wastewater management. The scope of this portfolio is to address wastewater as a resource and encourage the volarisation/beneficiation across the domestic, industrial and mining sectors. In this regard, the research portfolio seeks to tap the power of wastewater(s) using innovative solutions, approaches and interventions to promote a paradigm shift from current wastewater practices, catalysing SDGs achievement and transitioning to a circular economy.

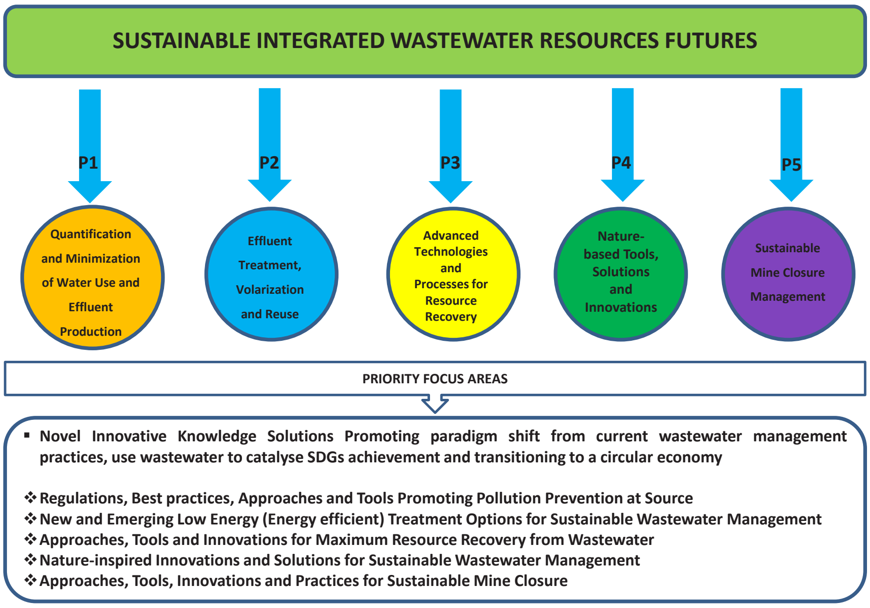


Figure 6: Sustainable integrated wastewater resources futures research portfolio

3.1.1 Objectives

In order to strategically address challenges associated with sustainable integrated wastewater resources management, interventions would therefore target five interconnected thematic areas within the integrated wastewater management cycle, as outlined in the following strategic objectives:

- To promote prevention and reduction of pollution generation at the source
- To promote reuse of treated effluent through fit for purpose treatment and volarisation in support of alternative sources of water
- To develop advanced technologies, processes, tools and approaches for sustainable recovery of resources from wastewater(s) in support of conversion of current treatment systems into future WRRFs
- To harness nature-inspired solutions and processes in support of sustainable, restorative and regenerative wastewater management
- To address mine closure environmental, social and economic challenges in a sustainable, restorative and regenerative manner

Overall, the five thematic areas are derived from the portfolio programmes as key priority research focus areas. The portfolio programme details are given below.

3.2 PROGRAMMES

3.2.1 Quantification and minimisation of water use and effluent production

Approaches on water use efficiency promoting the concept of doing more with less, water pollution control and wastewater prevention and minimisation should be given priority over traditional end-of-pipe treatment whenever possible. These approaches include adoption of best practice cleaner production processes, prohibiting or controlling the use of certain contaminants to eliminate or limit their entry into wastewater streams through regulatory, technical and/or other means. Remedial actions to clean up polluted sites and water bodies are generally much more expensive than measures to prevent pollution from occurring. Furthermore, monitoring and reporting of pollutant discharges from municipal, industrial and mine wastewater(s) to the environment need to be strengthened in support of water quality.

The objective of reducing pollution at source will therefore entail, (i) better understanding of the water footprint of industries, (ii) promotion of water use efficiency with reduced effluent production and (iii) establishing capabilities for preventing and reducing pollutants from entering the environment. In this regard, new tools, methodologies and models, etc. that aid with prediction, quantification, minimisation of water use and effluent production will be prioritised.

3.2.2 Effluent treatment, volarisation and reuse

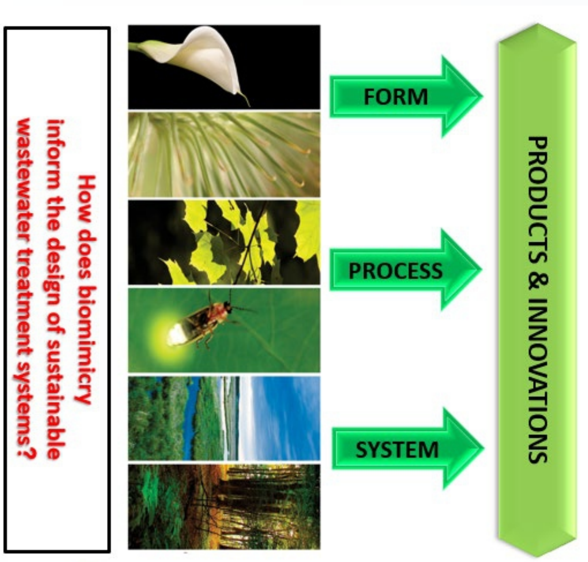
Reclaimed water offers opportunities for a sustainable and reliable water supply for industries and municipalities as an alternative source to meet increasing demand. Therefore, the treatment of wastewater effluents and volarisation to a quality standard acceptable by users (i.e. 'fit-for-purpose' treatment) need to be prioritised to supplement the ever-growing demand of water supply in support of sustainable reuse.

The objective of effluent reuse and volarisation will entail, (i) tapping into reclaimed water opportunities as alternative source and (ii) treatment of effluents and volarisation to quality standard acceptable by users. Further, 'fit-for-purpose' treatment to supplement the ever-growing demand of water supply needs to be prioritised.

3.2.3 Advanced technologies and processes for resource recovery

Innovative technologies, processes and solutions for resource recovery from wastewater effluents need to be developed and used to demonstrate recovery of high-value products that can be used as feedstocks for secondary industrial processes, with special focus on scaling up recovery of water, material and energy-based resources. Therefore, technologies and processes driving the three key interrelated pathways (water, materials and energy) need to be developed, tested and applied in support of the circular economy.

Generally, the objective of resource recovery will entail, (i) development of innovative technologies, processes and solutions for resource recovery from wastewater(s) (ii) demonstrating recovery of high value products that can be used as feedstocks for secondary industrial processes and (iii) scaling up recovery of water, material and energy-based resources.



3.2.4 Nature-based tools, solutions and innovations

The use of many years of nature inspired solutions, seeking to learn, emulate and use natural forms, processes and systems can contribute to the improved management of integrated wastewater(s).

The objective of nature-based solutions entail emulating, mimicking and using nature inspired forms, processes and systems to address challenges associated with sustainable integrated wastewater resources management. Generally, the focus will be on (i) capacity building and providing awareness, (ii) supporting the community of practice and (iii) strengthening nature inspired research, development and innovation traction targeting products and innovations.

3.2.5 Sustainable mine closure management

To address the environmental, social and economic challenges arising from mine closure, including long-term mine water management post closure, innovative approaches to mine rehabilitation and land management yielding sustainable solutions as part of economic sustainability, community upliftment and local economic development and entrepreneurship need to be prioritised in support of the green economy.

The objectives of sustainable mine closure will entails supporting (i) mine-impacted water management, (ii) mine rehabilitation and land management, (iii) community upliftment through local economic development (iv) entrepreneurship and economic sustainability.

4.0 THE STRATEGIC IMPLEMENTATION FRAMEWORK

4.1 Introduction

The strategic implementation framework given in Figure 7 focuses on developing innovative knowledge solutions that allows the sector to tap the power of wastewater(s) using innovative solutions, approaches and interventions to promote a paradigm shift from current wastewater practices, catalyse SDGs achievement and transition to a circular economy. In this regard, the five priority focus or thematic areas outlined in Figure 6 will be used as drivers to achieve this broad goal.

The implementation framework outlines key priority areas of focus (thematic areas) designed to deal with delivery of the required innovative knowledge solutions, the key objectives, required actions, partners and envisaged outcomes. Sustainable integrated wastewater resources futures will need to promote, *inter alia*, a paradigm shift from end-of-pipe treatment and disposal to more attractive approaches such as (i) reduction of waste at source, (ii) fit-for-purpose reuse/ recycle and (iii) recovery of valuables. In this regard, wastewater resource management of the future need to focus and prioritise tapping the power of wastewater(s) so as to deliver at scale solutions, innovations, processes and interventions that address current sector challenges in support of sustainability and the circular economy.

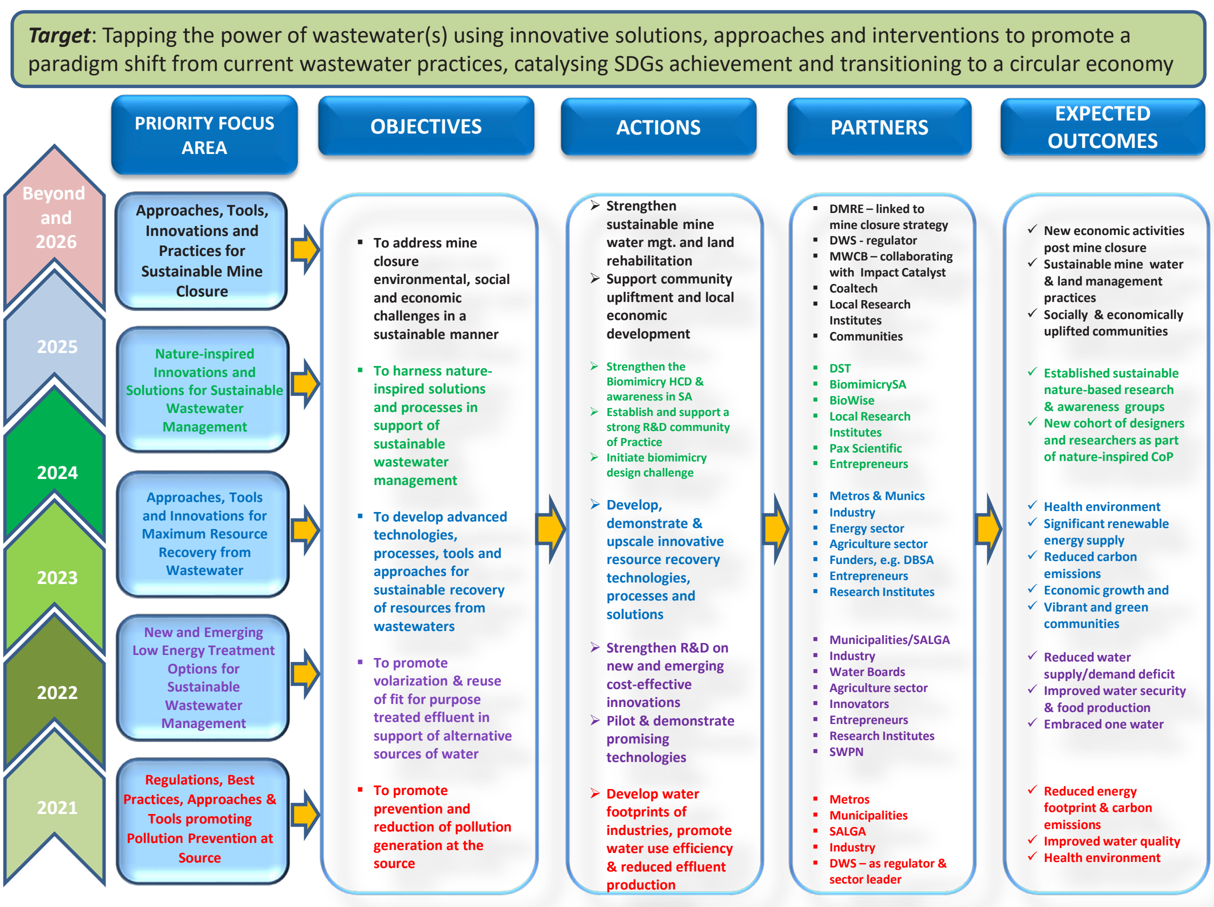


Figure 7: Sustainable integrated wastewater resources futures strategic implementation framework

4.2 THE BIG TICKETS

The big tickets are research focus areas that are potential game changers for the sectors, and can be used as accelerators for implementation of developed solutions. These big tickets are given high priority to ensure that implementation of the strategy is designed for impact and for the sector to derive significant benefits. Table 3 shows the three big ticket topics to be prioritised under this strategy.

Table 3: The big ticket focus areas

Topic	Objectives	Strategic Intent	Implementation Approach	Time Frame
Reuse of treated effluent and sludge repurposing	'Fit-for-purpose' reuse and sludge repurposing in support of water and food security	Catalysing conversion of treatment systems into active water reclamation facilities in support of water security and relevant SDGs	Pilot and demonstration scale studies on fertilizer value of wastewater (including sludge) and irrigation using poor quality mine-impacted and municipal wastewater(s)	2021 - 2024
Advanced technologies, tools and processes for resource recovery	Development of tools, technologies and processes for sustainable resource recovery in support of circular economy and relevant SDGs	Conversion of treatment systems into future water resource recovery facilities in support of economic development and relevant SDGs	Laboratory, pilot and field-scale studies on resource recovery innovations, modelling resource recovery and utilisation, including adoption of 4IR technologies, and field testing of the recovery processes	2021 - 2026
Sustainable Mine closure management	Addressing mine closure environmental, social and economic challenges	Local economic development for community upliftment and empowerment post mine closure	Field demonstration of innovative approaches/ practices yielding sustainable solutions for community upliftment and local economic development post mine	2021 - 2026

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