CLEANER TECHNOLOGY OPTIONS FOR IMPROVEMENT OF WATER QUALITY IN SOUTH AFRICA

AN OVERVIEW

FRESHWATER ECOSYSTEM NETWORK (FEN) ANNUAL MEETING

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WATER IS LIFE - SANITATION IS DIGNITY

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

2030 NDP

BACKGROUND INFORMATION

- Project coordinated by the Directorate: Sources Directed Studies (SDS) of the Department of Water and Sanitation (DWS) since 2023/24.
- Aligned to key sector policies and strategies (*i.e.,* NWRS, NW&SMP, and IWQM) recommending to:
  - Apply smart and **water-efficient technology** systems and continue developing high-end skills to ensure future science, **technology**, and **innovation** capability in South Africa.
- 2025 Water and Sanitation Indaba Declaration and Resolutions:
  - Increase investment in water **research** and **development,** and **technological** transfer.

PROJECT AIM AND OBJECTIVES

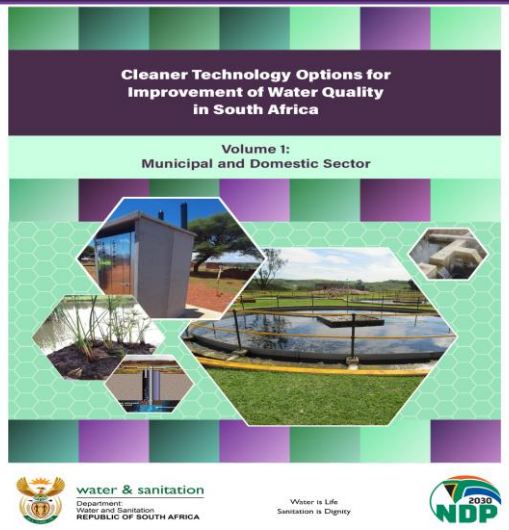
- The project aims to provide guidance on the Cleaner Technology Options (CTOs) for the Improvement of Water Quality in the water sector and other affected sectors.

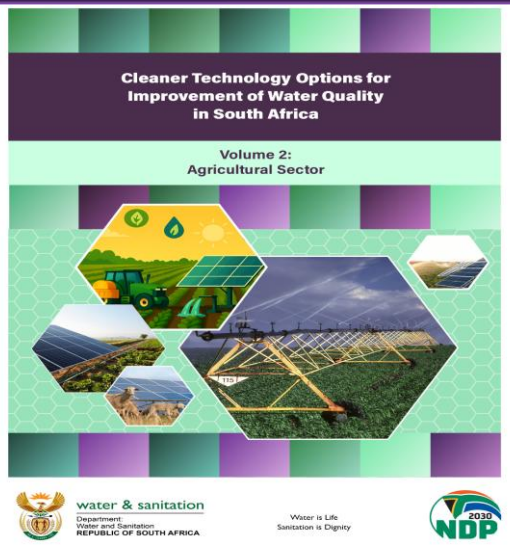
- Objectives:
  - ✓ To establish the status quo on various CTO;
  - ✓ To map the legislative framework supporting the CTOs for water resource management; and
  - ✓ To integrate effective CTOs for long-term water quality solutions.

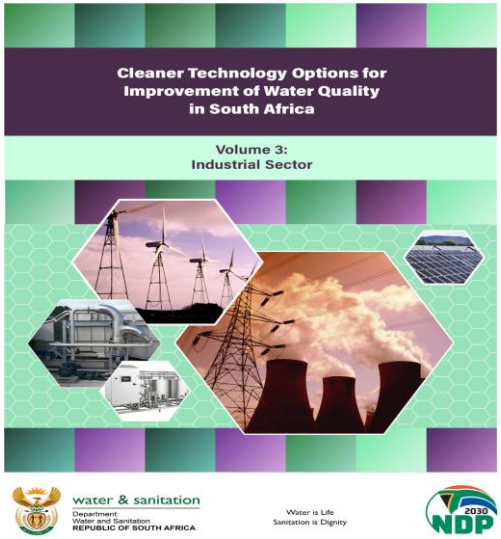
Disclaimer:

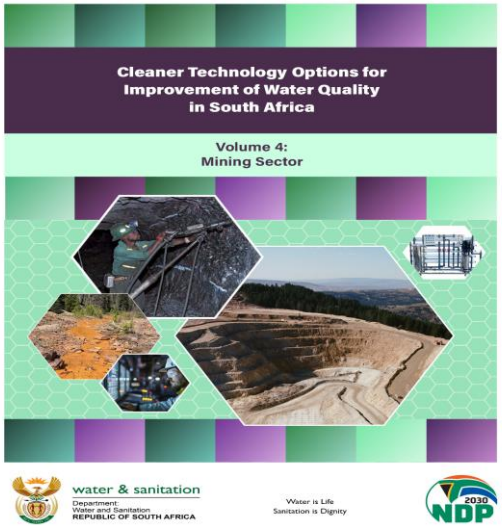
It is not the intention of the Department to be prescriptive in terms of recommending specific technologies, but rather to encourage the achievement of efficiency through innovation and to ensure water use efficiency as well as resource protection.

KEY SECTOR THEMES

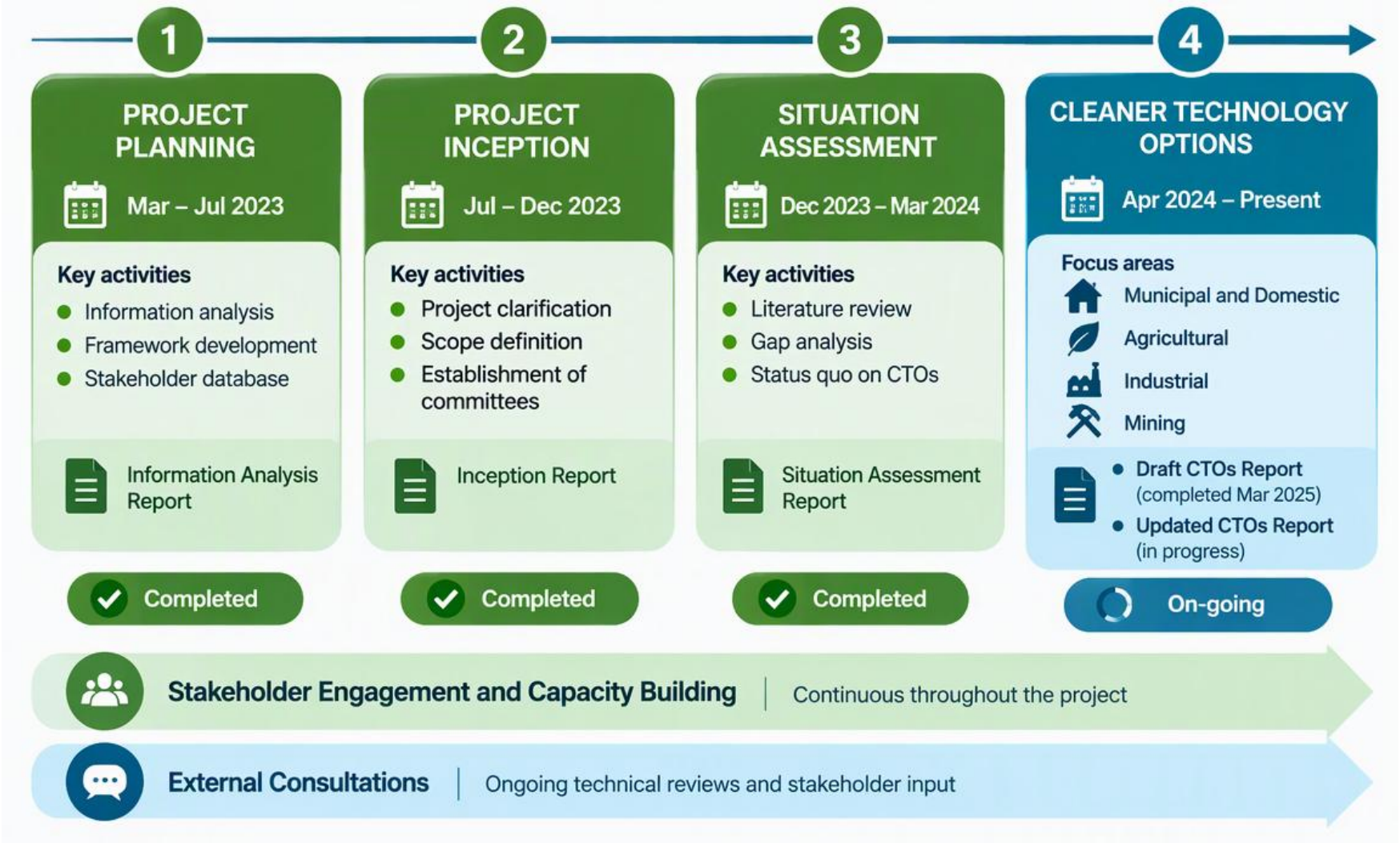








PROJECT MILESTONES



STAKEHOLDER ENGAGEMENTS

Stakeholder Engagements to date

North-West Integrated Provincial Water Monitoring Committee (NW-IPWMC)
Umgeni-uThukela Water (UUW)
Gamtoos Water User Association
South African Pork Producers' Organisation (SAPPO)
Northern-Cape Integrated Provincial Water Monitoring Committee (NC-IPWMC)
Department of Environmental Affairs and Development Planning, Western Cape Government (DEADP)
JB Marks Municipality
Fruit Industry Value Chain Round Table (FIVCRT)
University of KwaZulu-Natal (UKZN)
Department of Economic Development, Tourism and Environmental Affairs (KZN-EDTEA)
West Coast District Municipality - Municipal Coastal Committee (MCC)
Freshwater Ecosystems Network*

Planned Stakeholder Engagements

Minerals Council South Africa
National Water Quality Management Forum (NWQMF)
Catchment Management Forum (CMFs)
Western-Cape Integrated Provincial Water Monitoring Committee (WC-IPWMC)

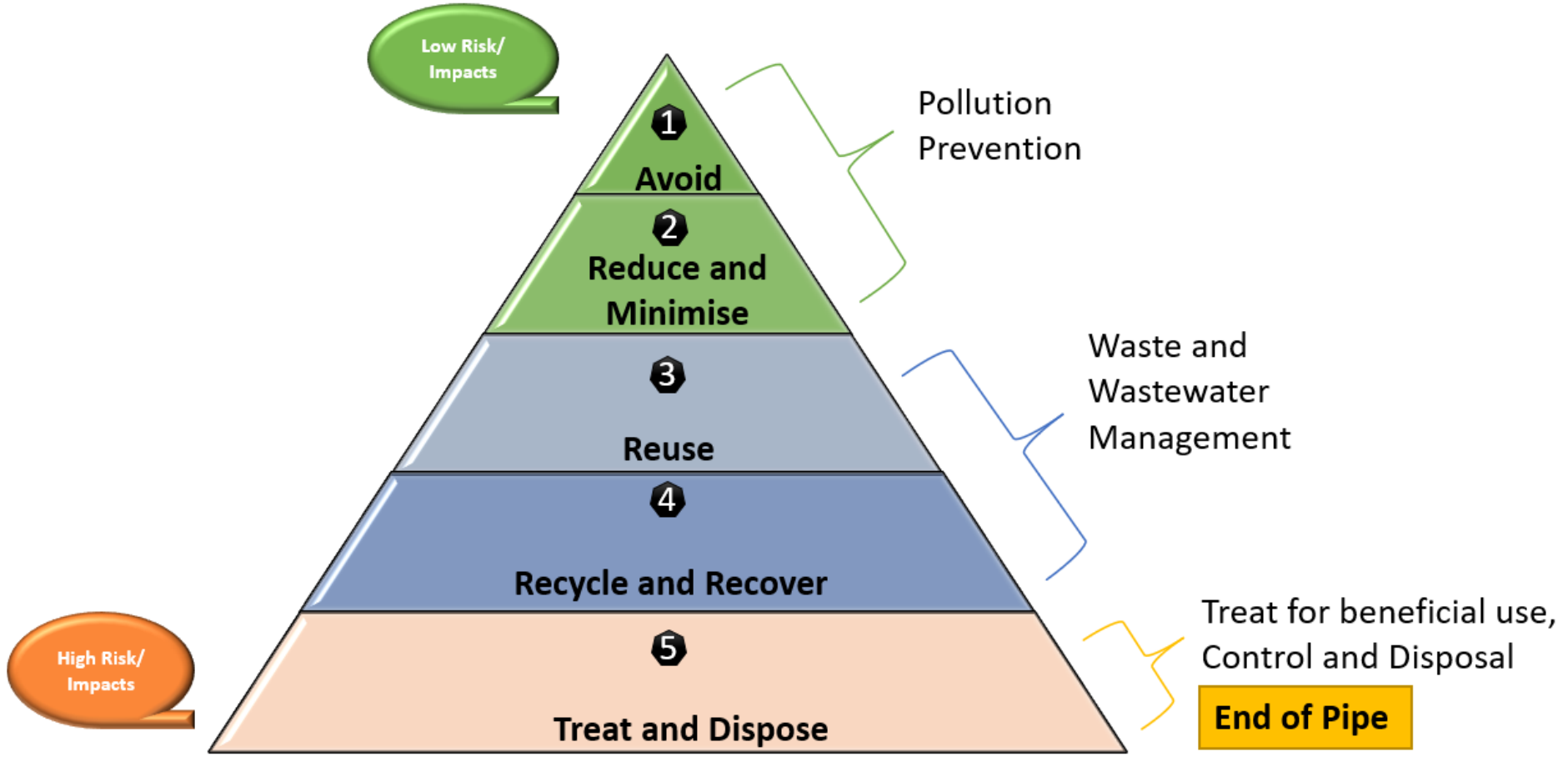
DEFINITION

Cleaner Technology (CT) refers to:

…environmentally sustainable technologies and practices that are aimed at avoiding, minimising or reducing, mitigating the generation of pollution at source, while also treating existing pollution problems including symptoms thereof, and reusing or disposing of treated effluent for the protection of water resources to promote resource efficiency.

Adapted from OECD, 1989; WRC, 2011

WATER MANAGEMENT MITIGATION HIERARCHY FOR CTOs

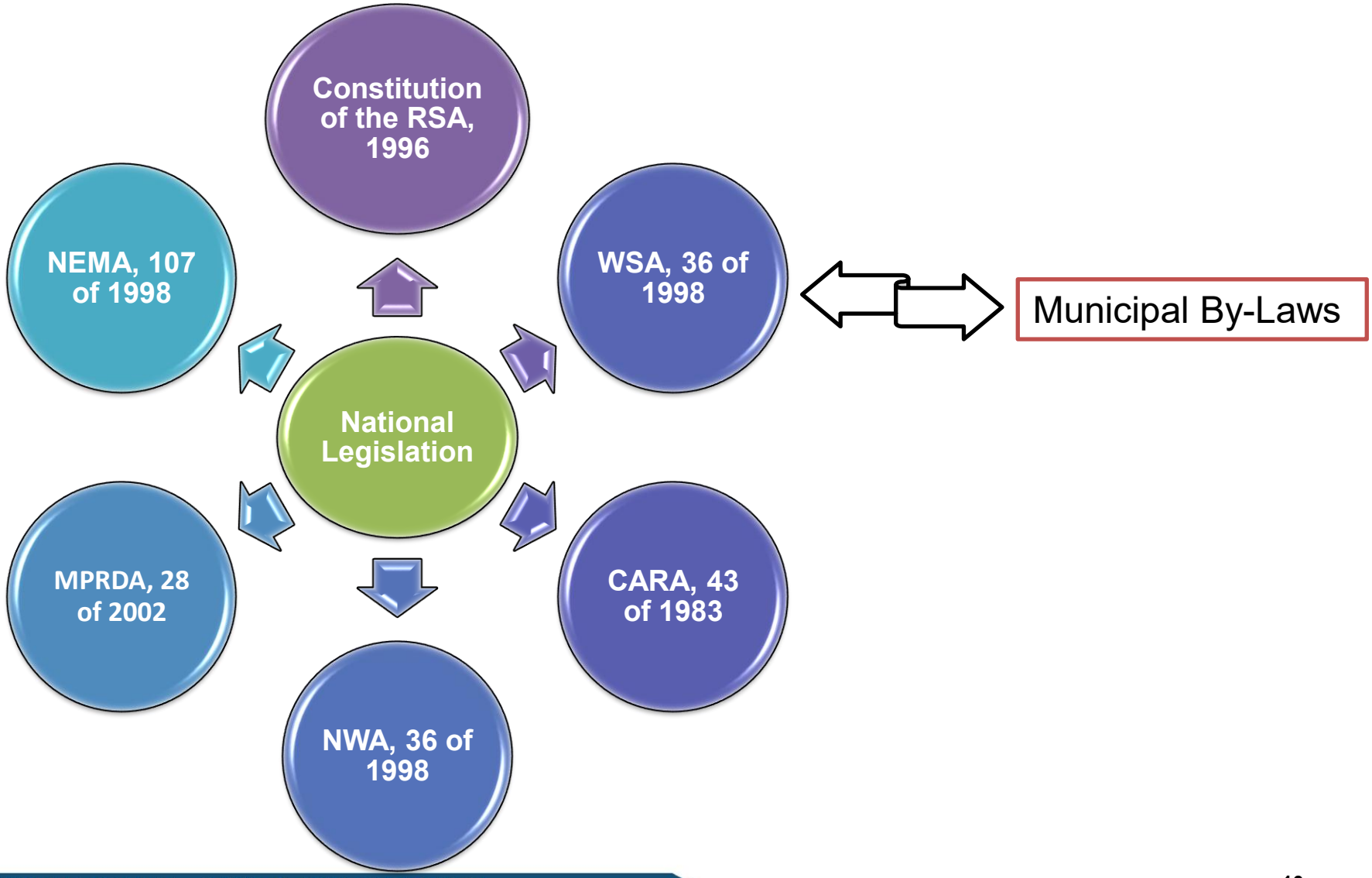


(Source: modified from DEAT, 2004).

LEGISLATIVE FRAMEWORK (1)

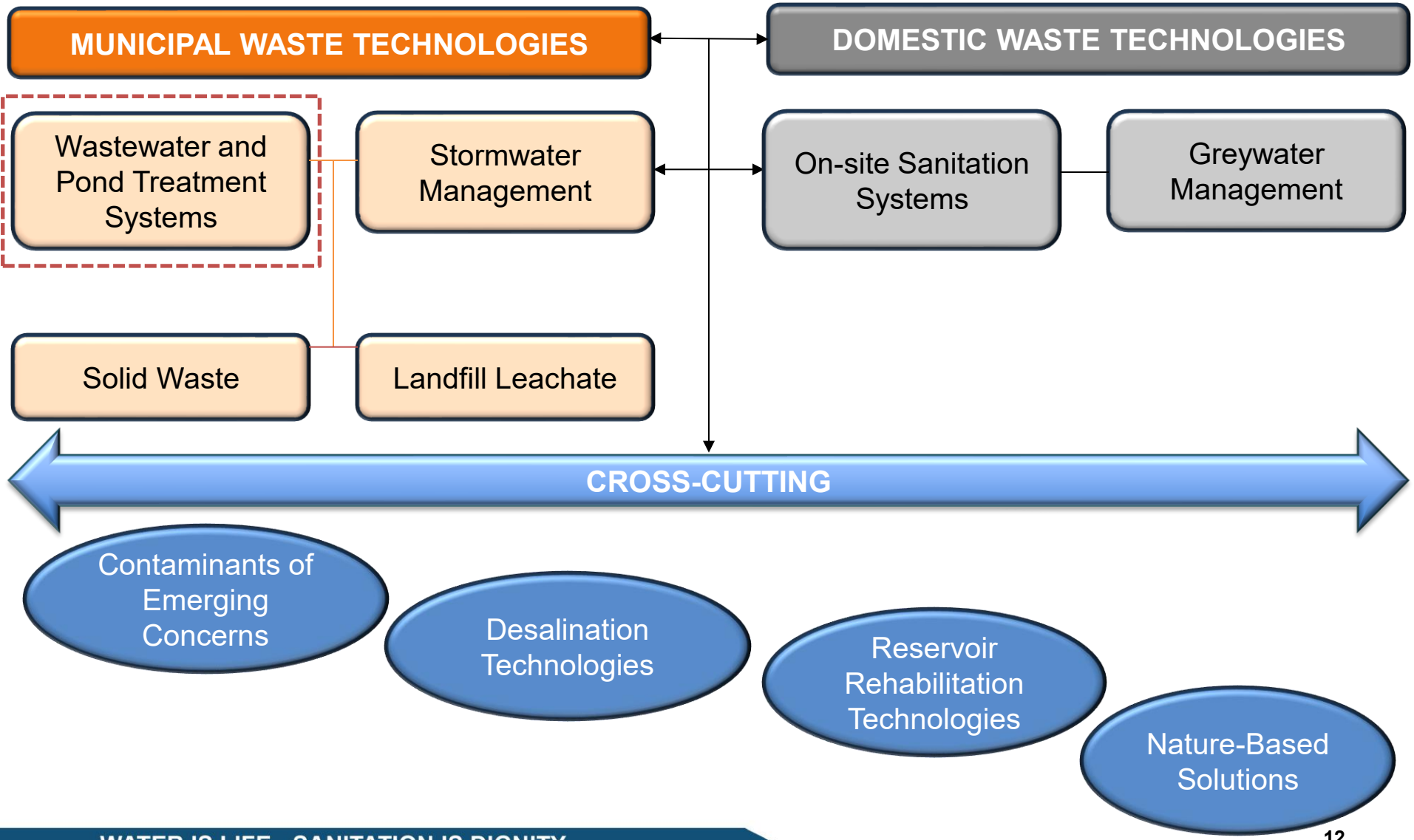


LEGISLATIVE FRAMEWORK (2)



MUNICIPAL AND DOMESTIC SECTORS

MUNICIPAL AND DOMESTIC SECTORS CLEANER TECHNOLOGY OPTIONS



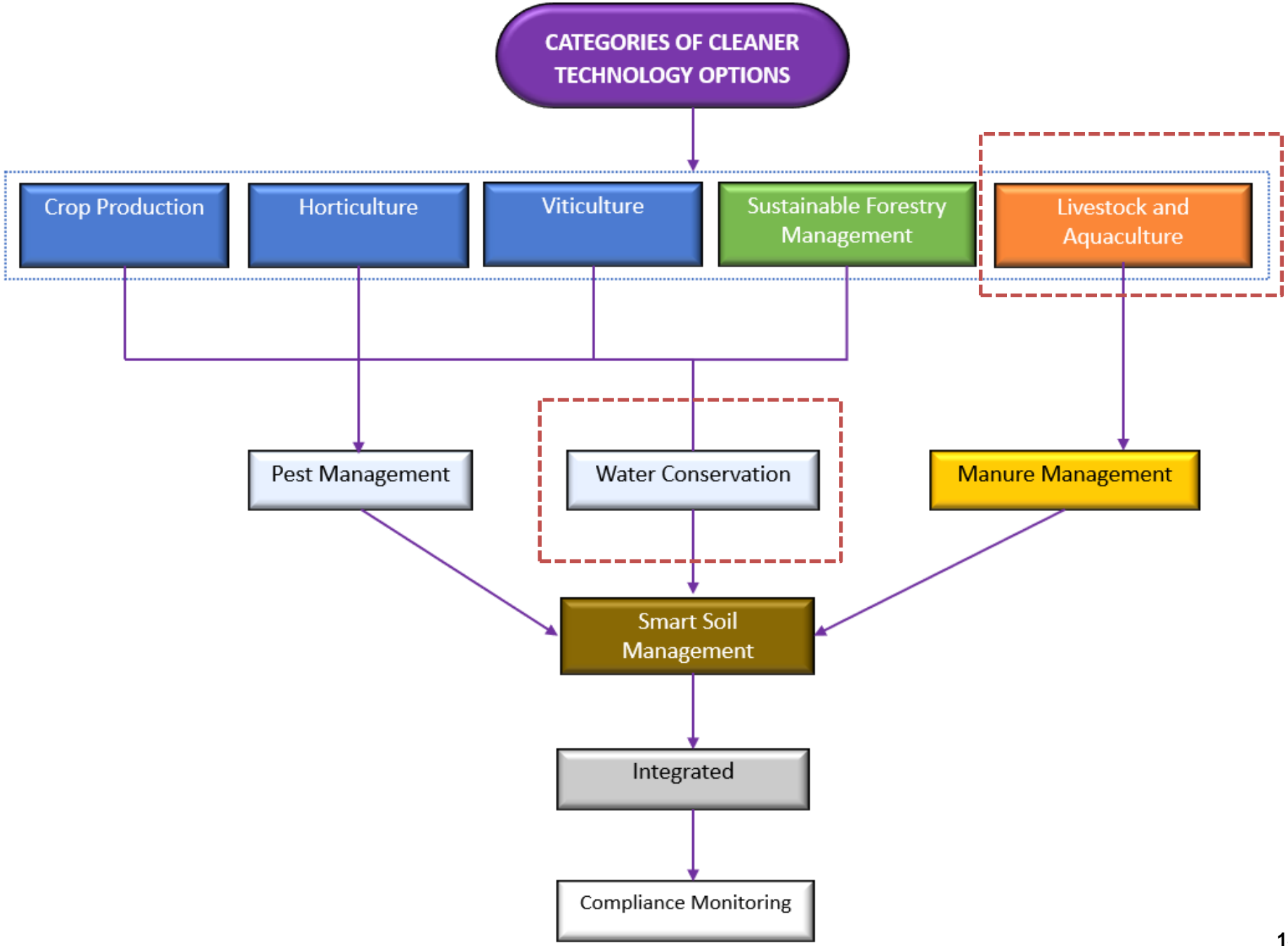
DECENTRALISED WASTEWATER TREATMENT SYSTEM



ABR = anaerobic baffled reactor; AF = anaerobic filter; HFCW = horizontal flow constructed wetland; SC = siphon chamber; SDB = sludge drying bed; SS1 = vertical flow constructed wetland sampling sump; SS2 = horizontal flow constructed wetland sampling sump; VFCW = vertical flow constructed wetland

Fig. Newlands Mashu DEWATS (Arumugam *et al., 2023*)

AGRICULTURAL SECTOR


CATEGORIES OF CLEANER TECHNOLOGY OPTIONS
Crop Production
Horticulture
Viticulture
Sustainable Forestry Management
Livestock and Aquaculture
Pest Management
Water Conservation
Manure Management
Smart Soil Management
Integrated
Compliance Monitoring

AQUACULTURE TECHNOLOGIES

- Constructed wetland for a reticulation system:
  - ✓ Effective at treating nitrogen-containing wastewater.
  - ✓ Realistic and cost-effective solution for treating wastewater.

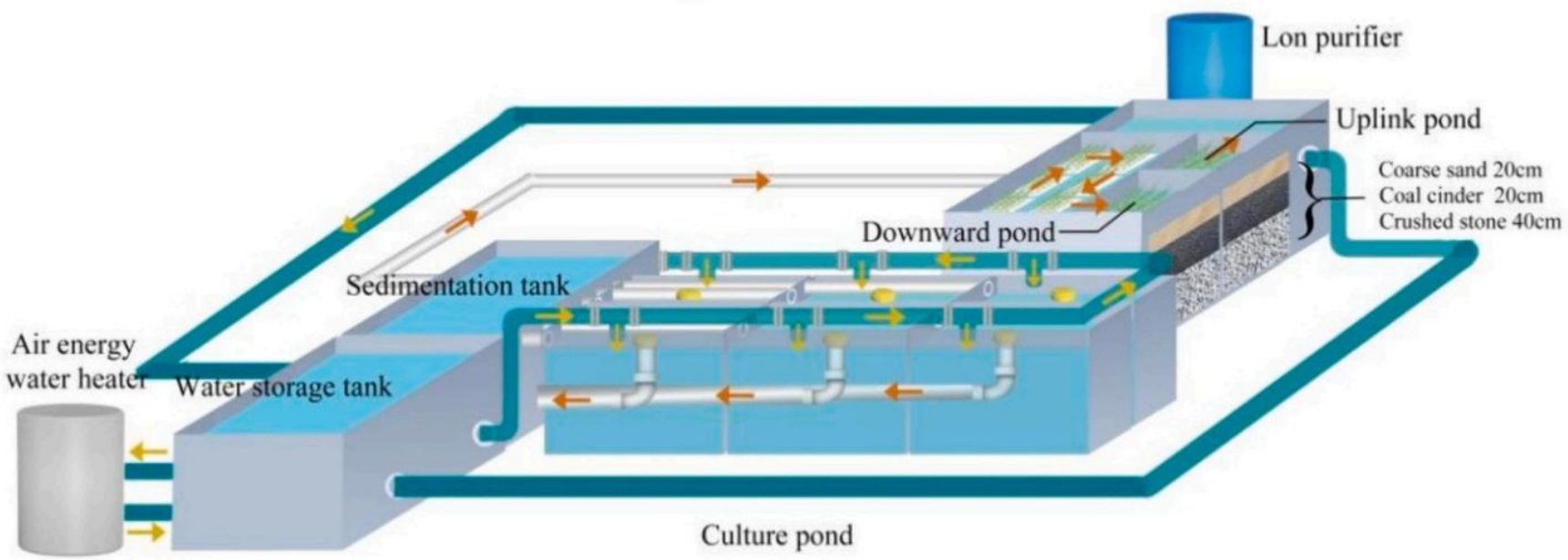
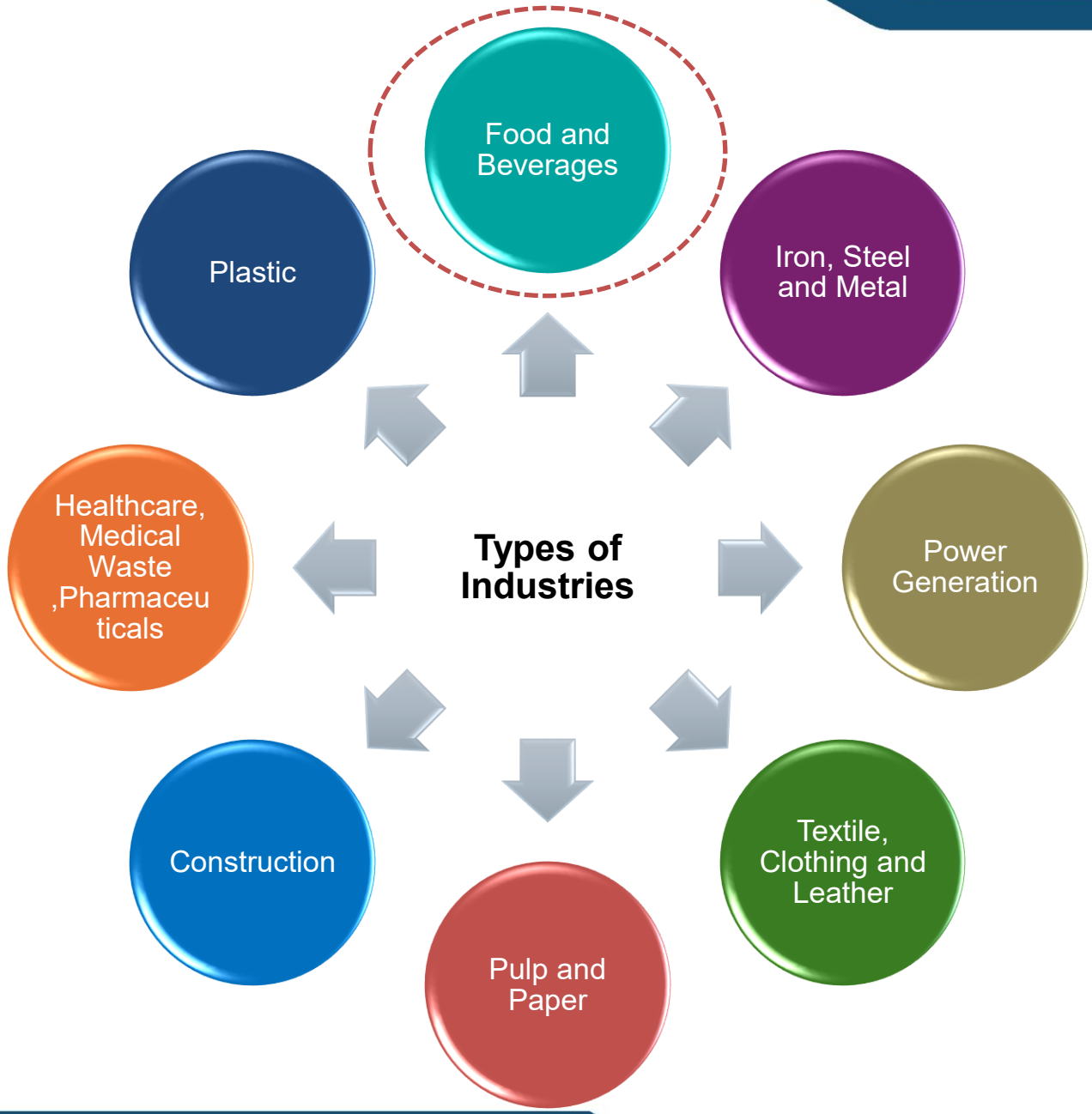


Fig. Constructed Wetlands in Recirculation Aquaculture System (Wang et al., 2024).

INDUSTRIAL SECTOR


Food and Beverages
Iron, Steel and Metal
Power Generation
Textile, Clothing and Leather
Pulp and Paper
Construction
Healthcare, Medical Waste ,Pharmaceuticals
Plastic
Types of Industries

EDIBLE OILS

Physico-chemical Treatment

Gravity settling or fat traps	Prevents oil from entering the wash-down water
pH Correction	It allows dissolved waste to be separated from water during the treatment process
Acidification	Involves adding acid to the oil or using acid media to treat soap stock
Enhanced Dissolved Air Floatation	Removes emulsified oils from wastewater by introducing fine gas bubbles into the liquid phase

Ozonation Application

- **Direct oxidation of ozone** occurs at low pH and is slow and very selective
- **Indirect oxidation of ozone** occurs at high pH values and is fast and non-selective
- **Ozonolysis** process is significant in organic chemistry for transforming unsaturated compounds into valuable functional groups

Biological Treatment

Anaerobic Biological Treatment

Biological treatment of soluble and colloidal wastewater in the absence of oxygen, at a low redox potential

Bench-scale Aerobic Biological Nutrient Removal

Wastewater treatment process that uses microorganisms to remove nutrients from wastewater in an aerobic environment

MINING SECTOR

MINING COMMODITY CATEGORIES

COMMODITY CATEGORY	INCLUDED COMMODITIES	TYPICAL MINING ACTIVITY / DESCRIPTION	
Precious Metals and Minerals	Diamonds, Gold, PGM (Platinum-Group Metals), Semi-precious Stones	Mines focused on high-value gemstones and precious metals.	
Energy Commodities	Coal, Natural Gas, Petroleum, Uranium	Extraction sites for fuel and energy resources.	
Ferrous Metals	Chrome, Iron Ore, Manganese	Mines extracting iron-based and other ferrous minerals.	
Non-Ferrous Metals	Copper, Lead, Lithium, Nickel, Rare Earth Metals, Titanium, Zinc, Zircon	Mines producing metals other than iron or iron alloys.	
Industrial Minerals	Andalusite, Attapulgite, Bentonite, Brick-making shale/clay, Corundum, Feldspar, Gypsum, Kaolin, Limestone, Mica, Phosphate, Silica, Talc, and others (24 mineral groups).	Quarry and mining operations for minerals used in industrial processes, manufacturing, and construction.	
Aggregates and Sand	Aggregates, Sand	Sites producing construction-grade aggregates and sands for building materials.	

HEALTHY FRESHWATERS | THRIVING ECOSYSTEMS | SUSTAINABLE FUTURES

Science • Collaboration • Impact

AMD TECHNOLOGIES

TECHNOLOGY	COUNTRY	ADVANTAGES	DISADVANTAGES	TECHNOLOGY READINESS LEVEL (TRL)
Alkali-based-calcium (ABC)*	South Africa	Treats water to the required discharge limit; recovery of sulphate	Hazardous, heterogeneous, and highly mineralised sludge generation; Requires precise barium dose to balance the stoichiometry and residual barium	4-6
Adapted SAVMIN process	South Africa	Treat water to the required discharge limit; Feasibility of recovering valuable minerals; The process is mature; Therefore, scaling up will be straightforward	Hazardous sludge generation; Generation of toxic sludge due to mixture of heavy metals; complex process	2-3
Basic oxygen furnace soda ash and reverse osmosis (BOF SRO)	South Africa	Reclaim drinking water; Recover gypsum	Voluminous sludge rich in Iron; requires a high dosage of basic oxygen furnace slag; Generation of brine, which is difficult to dispose of	2-3
Magnesite softening reverse osmosis and eutectic freeze [MASRO(E)]*	South Africa	Treat water to the required drinking limit; Recovery of Fe-based minerals; Recovery of gypsum and lime	Cost-intensive brine generation; Heterogeneous Fe-sludge with unviable recovery feasibility	4-6
DESALX	Australia	High (> 90%) water reclamation potential; Water quality is fit for aquifer re-injection	As- and Sb-rich sludge is produced; Gypsum-based sludge is produced	9
Environmental and remedial technology holdings (EARTH)	South Africa	Uses ion exchange to recover uranium and sulfate; The sulfate can be used to produce ammonium sulfate; Water quality for discharge or re-use (wash water)	Cost-intensive; Generation of toxicants from ion exchange regenerants; Requires acid for operation	6-7
High Recovery Precipitating Reverse Osmosis (HiPRO)*	South Africa	Drinking water is reclaimed; Gypsum is synthesized and recovered; Brine-free and zero-liquid-discharge process	Cost-intensive; Hazardous sludge from the ozonation process	9
ROC	South Africa	Drinking water reclamation through filtration; Minerals recovery from brine using freeze technique; Recover Fe-based minerals for the synthesis of goethite, hematite and magnetite	Cost-intensive; Still at pilot scale; Complex process that requires intense training; Challenges with the synthesis of Fe-based minerals	4-5
Tshwane University of Technology Magnesium Barium Alkali (TUT MBA)	South Africa	Recovery of valuable minerals such as barium sulfate; Reclamation of product water that can meet the discharge limits and minimize ecological contamination; Recover barium using GYP-SLIM	Generation of hazardous, heterogeneous and highly mineralised sludge in magnesium stage; Requires a precise barium dose to balance the stoichiometry and residual barium	4-5

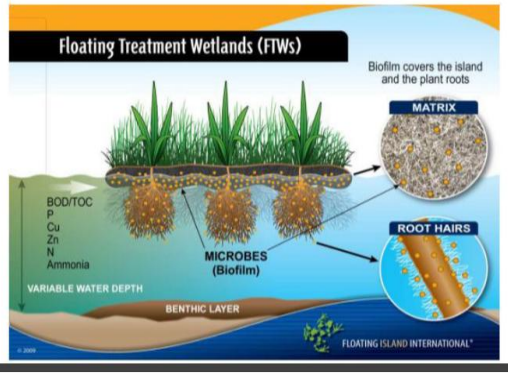
CROSS-CUTTING TECHNOLOGIES

Constructed Wetlands

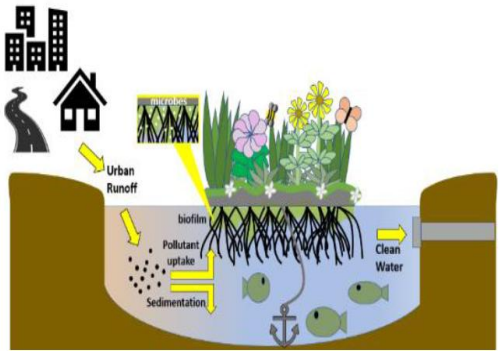
- The main functions of constructed wetlands include:
  - ✓ **Water purification:** filter pollutants, sediments and nutrients.
  - ✓ **Habitat creation:** provide habitats for various plants.
  - ✓ **Flood control**: absorb excess water.
  - ✓ **Erosion control:** vegetation stabilises soil
  - ✓ **Carbon sequestration:** capture and store carbon.

- The following plant/vegetation selection criterion are recommended by DWS (2025):
  - ✓ **Treatment capability**: Select plants based on their ability to absorb or degrade specific pollutants.
  - ✓ **Growth habits**: Consider the growth rate and mature size of plants.
  - ✓ **Climate adaptation**: Choose species that are well-adapted to the local climate.

a)



b)

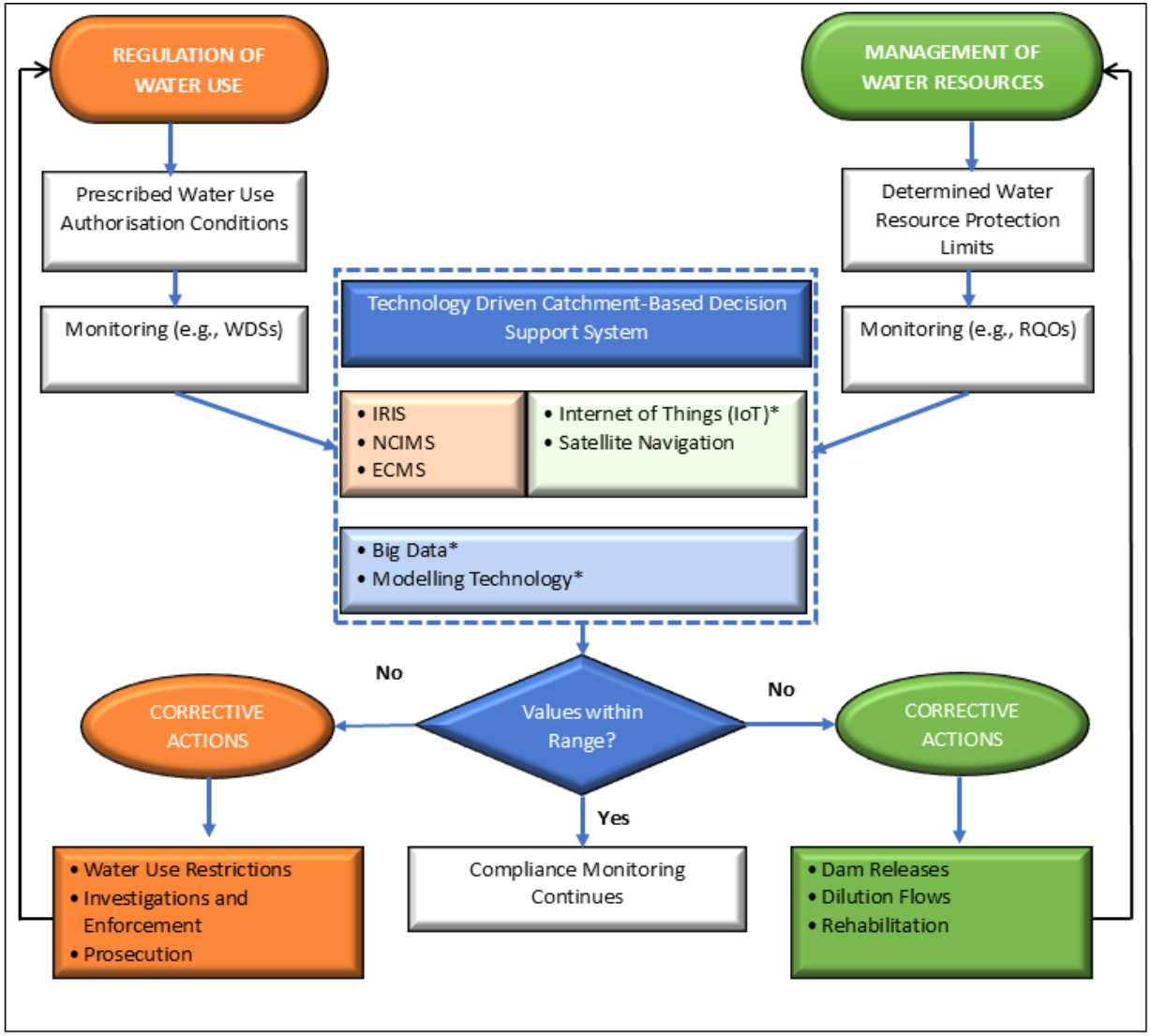


c)



(Source: DWS, 2025)

REGULATORY CONSIDERATIONS



Key:

- **WDSs** – Waste Discharge Standards
- **RQOs** – Resource Quality Objectives
- **IRIS** - Integrated Regulatory Information System
- **NCIMS** – National Compliance Information Management System
- **ECMS** – Enforcement Case Management System

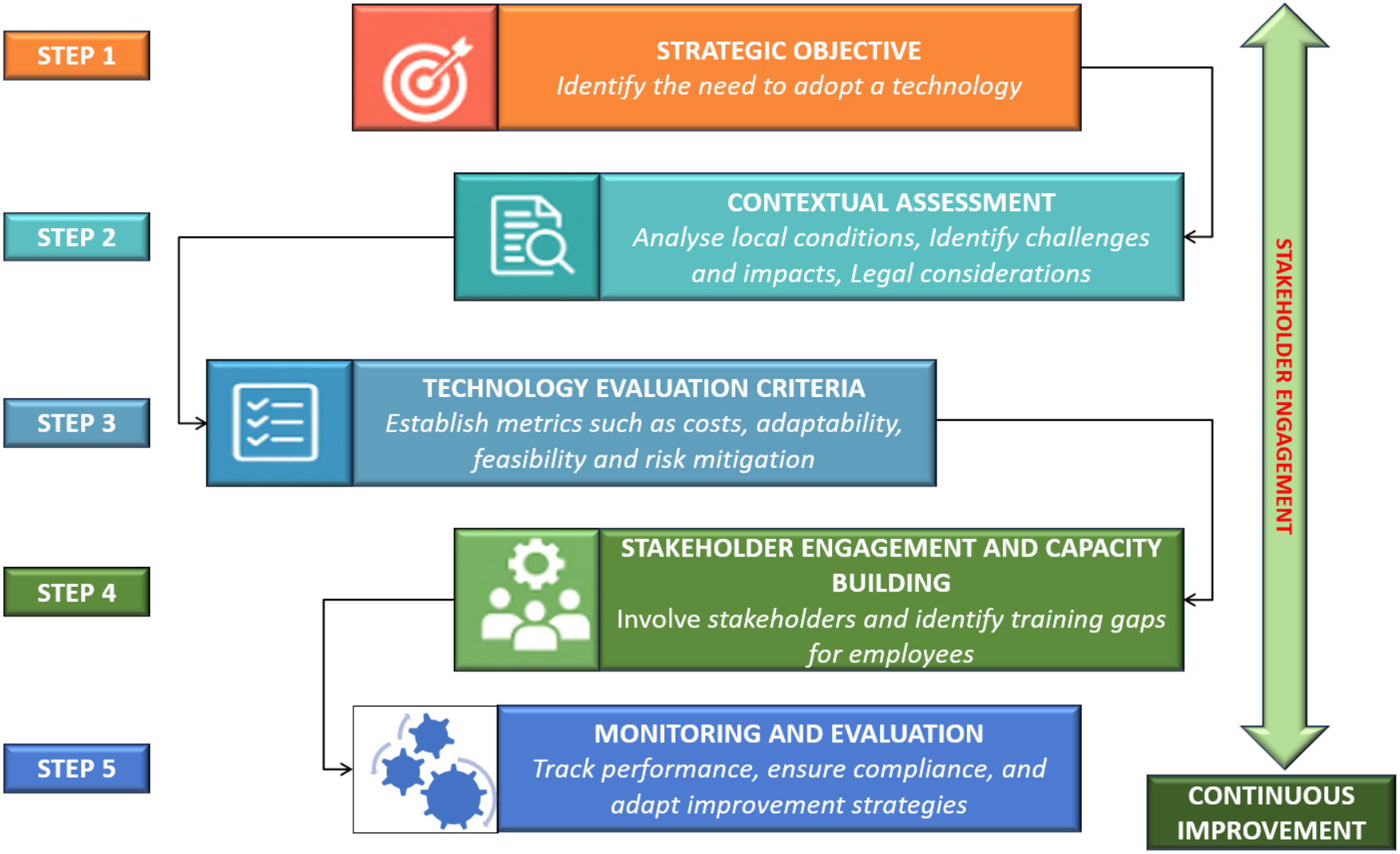
*Not yet used by the DWS

FINANCIAL CONSIDERATIONS

- Adoption of CTOs requires a collaborative financial strategy with shared responsibilities across all stakeholders

- **Cost factors are case-specific**
  - ✓ Land cost
  - ✓ Capital cost
  - ✓ Operational and Maintenance cost
  - ✓ Monitoring cost
  - ✓ Waste management/disposal cost for treatment residues
  - ✓ Legal cost
  - ✓ Discharge cost

CLEANER TECHNOLOGY SELECTION FRAMEWORK



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Technical Review	Project Steering Committee
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THANK YOU

More information on the:
Cleaner Technology Options Project
can be accessed on DWS Website: https://www.dws.gov.za/WEM/SDCCOactive.aspx

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