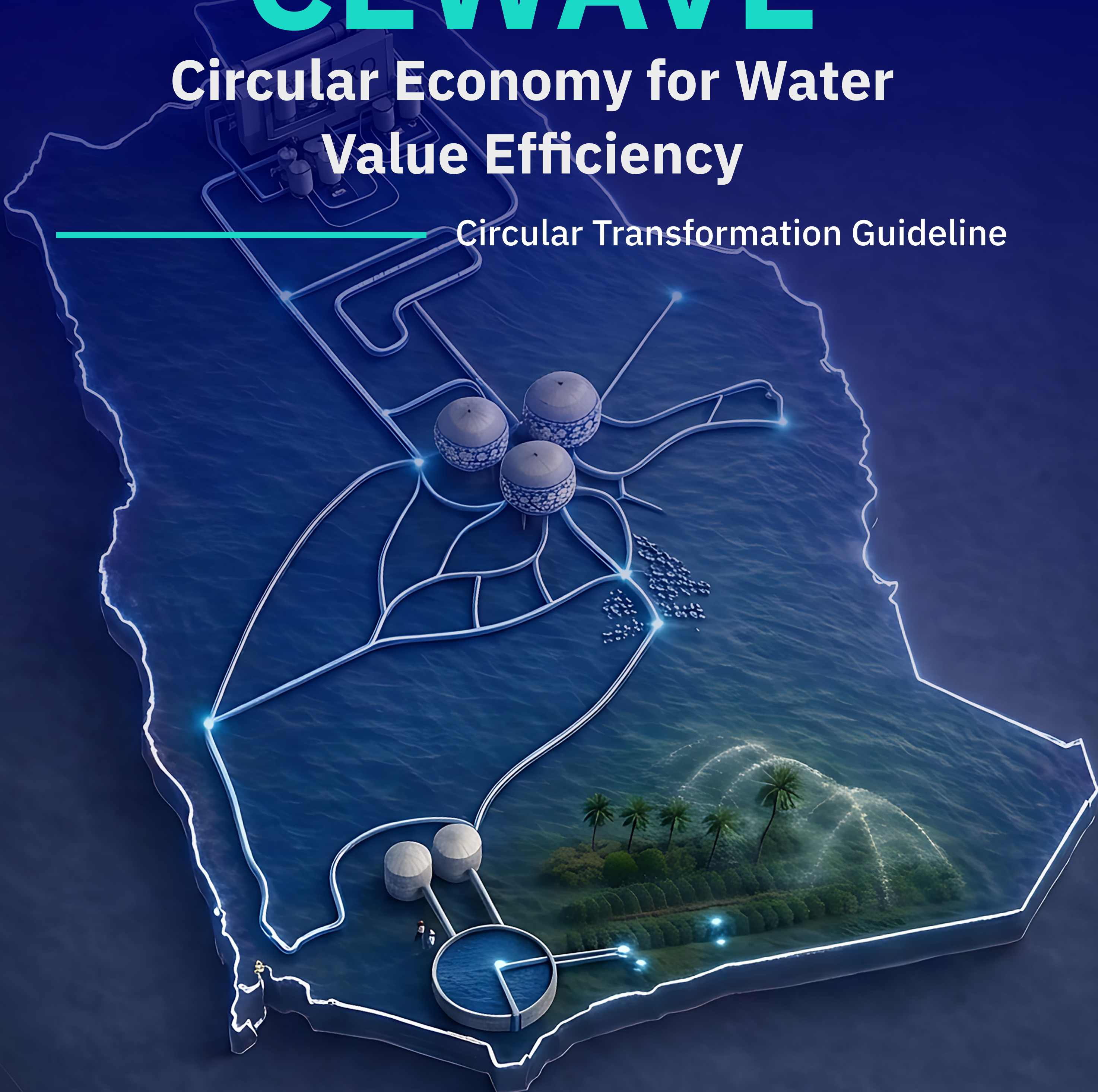
الهيئة السعودية للمياه
Saudi Water Authority

CEWAVE

Circular Economy for Water Value Efficiency

Circular Transformation Guideline



2026

Executive Summary

CEWAVE – Circular Economy for Water Value Efficiency: Implementation Guide for Circular Transformation serves as Saudi Arabia's national guide for embedding circular economy principles across the water sector.

Designed to turn national sustainability goals into practical action, CEWAVE offers a clear and adaptable pathway for organizations to integrate circular approaches into asset management, procurement, and infrastructure operations. It supports the ambitions of Vision 2030, the Saudi Green Initiative (SGI), and the National Water Strategy (NWS), driving progress in resource efficiency, carbon reduction, and long-term water security.

Each chapter is paired with Guidance Notes that translate high-level frameworks into practical, low-cost steps that can be implemented immediately. These notes help stakeholders move from ideas to execution through initiatives such as product life extension, circular procurement, digital integration, and resource recovery.

CEWAVE positions circularity as a national driver of innovation, efficiency, and competitiveness. It shows how circular business models can transform the Saudi water sector into a benchmark for sustainable value creation, helping reduce costs, optimize resources, and directly support the Kingdom's climate and diversification goals.

By adopting CEWAVE, water-sector stakeholders can accelerate the shift from linear operations to a regenerative, high-efficiency system that preserves natural resources, strengthens resilience, and sustains growth in line with the Kingdom's long-term sustainability vision.

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Introduction & Context

Saudi Arabia's water sector is entering a new era of transformation where efficiency, innovation, and sustainability come together under the circular economy framework. The goal is no longer to react to scarcity but to unlock value through smarter resource use, longer asset life, and collaboration across sectors.

The Circular Economy for Water Value Efficiency (CEWAVE) provides a unified implementation guide for this transition. It adapts global circular economy principles into actionable strategies tailored to the Kingdom's policies, infrastructure, and markets.

This guide reframes circularity as a value opportunity, that eliminates waste from systems, recovers resources, lowers lifecycle costs, and enables new performance based service models. With this approach, stakeholders and operators can strengthen financial sustainability, deliver stronger environmental outcomes, and enhance national resilience.

CEWAVE builds on global best practices, including the Ellen MacArthur Foundation's ReSOLVE Framework and Accenture's Circular Advantage Archetypes, while aligning them with Saudi Arabia's regulatory priorities. Each section includes Guidance Notes that set out clear, practical actions stakeholders can take immediately, ensuring that the principles of reuse, regeneration, and efficiency are embedded in daily operations.

Circular transformation in the Saudi water sector is not a distant goal. It is a real, measurable opportunity to advance economic efficiency, technological leadership, and environmental stewardship, fully aligned with Vision 2030, SGI, and NWS.

Strategic Value and Impact of the CEWAVE Guideline

1. National Alignment and Policy Integration

Show how CEWAVE operationalizes Vision 2030, SGI, and NWS objectives:

- Enables resource efficiency and cost optimization (Vision 2030 Objective 4).
- Supports decarbonization and resilience targets under the SGI.
- Delivers measurable outcomes for NWS Objectives 4, 5, 7, and 8, linking circularity directly to water security.

2. Sector-Wide Economic Impact

Quantify or describe macro-level value creation:

- Expected reduction in capital and operational costs through reuse and refurbishment.
- Localization of manufacturing and maintenance—supporting SME participation and national employment goals.
- Creation of circular service markets (e.g., PaaS for membranes, pumps, and sensors).

3. Environmental and Climate Gains

Position CEWAVE as a measurable tool for national reporting:

- Contributes to GHG reductions through energy efficiency, digital optimization, and waste diversion.
- Reduces landfill volume and marine discharge, supporting MWAN and NCEC objectives.
- Integrates digital monitoring that enables data-driven compliance verification.

4. Institutional and Governance Impact

Explain how CEWAVE strengthens sector governance:

- Establishes a unified reference for all water entities (Water Desalination, WTCO, NWC, SIO, SWPC) under SWA supervision.
- Provides standardized guidance notes and KPIs, ensuring consistent implementation and benchmarking.
- Builds the foundation for ESG reporting and Data management system, improving transparency and accountability.

5. Innovation and Capability Development

Highlight long-term transformation:

- Encourages digital-circular innovation ecosystems in collaboration with universities and local tech firms.
- Positions Saudi Arabia as a regional model for circular water management.
- Strengthens human capital through technical training and operational upskilling under SWA's Innovation & Human Capital pillars.

Path 1

Embedding Circular Business Models and Design Principles

Path 1

Vision 2030 calls for sustainable management of vital resources and efficient use of natural assets to drive national prosperity (Vision 2030).

The National Water Strategy (NWS) reinforces this through its Strategic Objective 4: “Safeguard and optimize the use of water resources while preserving the local environment.” (MEWA – NWS)
These efforts align with the Saudi Green Initiative (SGI), which targets national emissions reduction and waste minimization across sectors (SGI.gov.sa).

The Saudi Water Authority (SWA) operationalizes these goals through its Sustainability and Operational Excellence pillars, guiding entities to enhance efficiency, reuse components, and recover value across the water value chain (SWA.gov.sa).

1. Circular Business Models

Circular business models represent a fundamental shift from the linear "take-make-dispose" approach to systems that preserve value and eliminate waste.

A. Retain Product Ownership (RPO)

Instead of selling products, companies lease them and retain ownership. This model incentivizes durability, maintenance, and end-of-life recovery.

Example: HP leases printers, handling maintenance and cartridge refills, thus retaining ownership of the asset and its components.

Example: Car-sharing models allow users to pay per use, while the company manages vehicle servicing, upgrades, and recycling at end-of-life, ensuring the vehicles remain in high-value circulation.

Water Sector Example:

"Water Pumps-as-a-Service" where clients pay per cubic meter of water pumped. The service provider retains ownership, handles maintenance, and ensures lifecycle recycling of the pumps. Similarly, "Filtration-as-a-Service" in industrial or desalination settings involves leasing membranes, with providers handling installation, monitoring, replacement, and recycling, even recovering rare materials like lithium from brine. "Water-as-a-Service" offers small-scale or modular treatment systems, where clients pay for treated water while providers manage operations and maintenance (O&M) and material recovery.

B. Product Life Extension (PLE)

Products are reused, repaired, or remanufactured to extend their usable life.

Example: Apple's certified refurbished program restores used devices to like-new condition, reducing the demand for new materials.

Example: Patagonia's Worn Wear program takes back used clothing, repairs it, and resells it at lower prices, extending product life and promoting reuse.

Water Sector Example:

Utilities extend the life of water flow meters and pressure sensors by refurbishing electronic components and replacing worn seals or housings instead of full replacement. This reduces e-waste, cuts procurement costs, and keeps valuable electronics in circulation.

2. Frameworks Supporting Circular Business Models

European Union frameworks provide a robust policy environment for circular business models, offering guidance applicable globally.

What SWA can do

- Create circular policy for water.
- Align procurement and public tenders with circular targets.
- Set up innovation hubs to test circular pilots in water utilities.

ReSOLVE Framework

The Ellen MacArthur Foundation's ReSOLVE model identifies six practical actions that accelerate circular transformation across industries. Each can be directly applied to water utilities and service providers.

Regenerate
Replace finite resources with renewable inputs.
- Solar and wind energy powering desalination and wastewater facilities

Share
Maximize asset utilization through reuse and shared access.
- Joint reuse or storage facilities between municipalities and industrial zones.

Optimize
Improve performance through data and automation.
- Smart metering and IoT-based leak detection.

Loop
Keep materials and water in closed cycles.
- Membrane refurbishment, brine mineral recovery, sludge-to-energy programs.

Virtualize
Deliver services digitally instead of physically.
- Remote monitoring and digital customer service.

Exchange
Adopt low-impact technologies.
- Transition from diesel to electric high-efficiency pumping.

Water Sector Value:

Provides a clear operational guide for embedding circular practices across stakeholders.

Accenture's Circular Advantage Archetypes

Accenture defines five business-model archetypes that translate circular thinking into value creation.

Circular Supplies
Use renewable or recycled inputs.
- SASO-certified recycled pipes and bio-based materials.

Resource Recovery
Capture value from waste streams.
- Brine-to-minerals and sludge-to-energy initiatives.

Product Life Extension
Repair and remanufacture to extend asset life.
- WTCO pump-refurbishment and SWCC membrane reconditioning centers.

Sharing Platforms
Share under-used capacity.
- Shared treatment plants and emergency storage between cities.

Product-as-a-Service (PaaS)
Sell performance instead of products.
- "Filtration-as-a-Service" or "Energy-Efficiency-as-a-Service."

Water Sector Value:

Encourages public-private collaboration and performance-based service models.

Circular Finance and Water Credit Model

A forward-looking business model that monetizes circular performance and embeds financial incentives for efficiency, reuse, and resource recovery.

CBM Category	Description	Water Sector Example
Circular Finance Models	Use green or performance-based financing instruments to fund circular projects and tie repayments to verified savings	Green sukuk or ESG-linked loans financing energy-efficient desalination and reuse infrastructure.
Water Credit / Trading Models	Create tradable credits for water savings, reuse, or pollution reduction.	Utilities earning tradable "reuse credits" for reducing demand or increasing treated wastewater use.
Public-Private Performance Partnerships (PPPPs)	Align investors, utilities, and regulators through shared outcome-based returns instead of fixed contracts.	Private operators paid for achieving reuse targets rather than fixed fees.

Water Sector Value:

Introduces financial circularity by turning efficiency, reuse, and carbon reduction into measurable, investable assets aligned with Vision 2030 and the Saudi Green

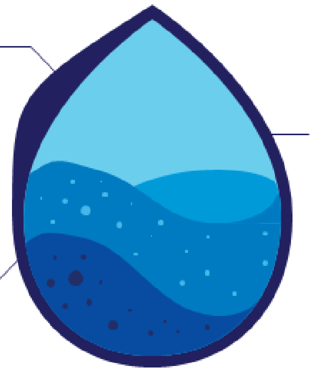
InitiaRoles & Ownership: Finance, Procurement, Operations

3. Product-as-a-Service (PaaS) in the Water Sector

PaaS models shift from selling a product to selling its function, with the provider retaining ownership and responsibility for maintenance, upgrades, and end-of-life management.

LEAK DETECTION-AS-A-SERVICE:

Instead of buying and managing leak detection equipment, water utilities subscribe to a service provider continuously monitors pipeline networks using smart networks. The provider owns, maintains and upgrades all hardware and software.

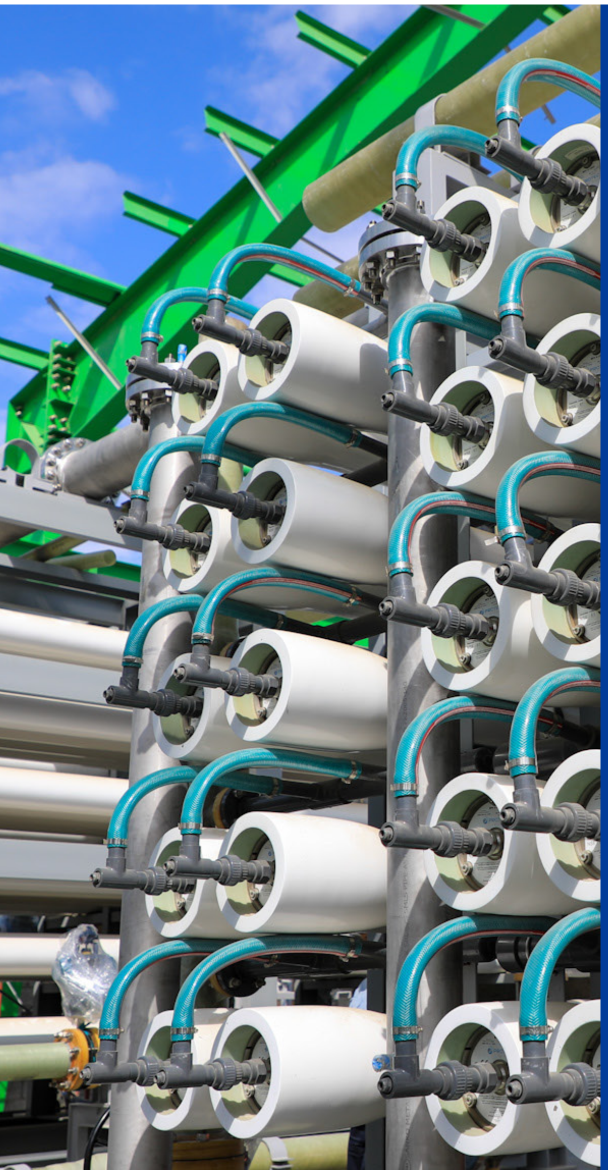


FILTRATION-AS-A-SERVICE:

In industrial or desalination settings, membranes are leased. Providers handle installation, monitoring, replacement, and recycling—even recovering rare materials like lithium from brine.

WATER-AS-A-SERVICE:

Small-scale or modular treatment systems (e.g., containerized RO) are deployed, and clients pay for treated water. Providers handle O&M and material recovery.



Enablers:

Digital twins, IoT, and smart meters help track performance, predict maintenance, and optimize operations for these service models.

Benefits:

- Increases efficiency and circularity.
- Reduces Capital Expenditures (CAPEX) for users.
- Encourages longer-lasting, repairable design.
- Supports decarbonization goals and ESG (Environmental, Social, and Governance) scoring. Challenges:

CIRCULAR BUSINESS MODELS

Challenges:

- Asset ownership remains with the provider, requiring robust service and logistics infrastructure.
- A mindset shift is needed for clients accustomed to buying assets.
- Legal and contract complexity.

4. Stahel vs. Modern Circular Economy

Walter Stahel's industrial circular economy laid foundational principles, while the modern circular economy expands on these with systemic redesign and digital integration.

A. Stahel's Industrial Circular Economy:

Focus: Extend product life, foster local jobs, and create service-based models.

Example:

- Apple Refurbished: Refurbished electronics keep materials in use longer.
- Michelin: Sells "km of tires," offering performance instead of product ownership.
- Repair Cafés: Community-run spaces that promote local repair work and skill-sharing.

B. Modern Circular Economy:

Focus: System redesign, regeneration, and integration of digital tools.

Example:

- Amsterdam's Doughnut Economy model: Integrates housing, transport, and food systems for holistic urban circularity.
- Loop by TerraCycle: Enables brands to deliver products in reusable packaging, creating closed-loop systems for consumer goods.

Activation Plan: Path 1: Circular Business Models

This guidance note sets out how entities in the Saudi water sector can begin adopting circular business models through practical, low-cost measures. Instead of focusing only on large-scale redesigns, entities are expected to implement service contracts, refurbishment programs, and modular upgrades that extend asset life and reduce costs. These steps translate the principles of retain, reuse, and service-based thinking into daily operational practices.

Key Principles with Zero/Low-Cost Actions

Product Life Extension

- **Action 1: Create an Asset & Parts Catalog.**

  Develop a simple, shared inventory of all major pumps, pipes, valves, and control systems. For each item, note its purchase date, expected lifespan, and last service date. This simple step provides a clear picture of asset health and helps in planning for maintenance before equipment fails, rather than reacting to breakdowns.

- **Action 2: Reuse Spare Parts**

  Before ordering a new component, establish a protocol to check if a functioning part from a decommissioned or older piece of equipment can be repurposed. Designate a specific, organized storage area for old parts that are still in good condition. This simple change in habit can dramatically reduce procurement costs.

- **Action 3: Implement an 'End-of-Life' Checklist**

  For every asset that is removed from service, create a checklist for technicians to follow. This checklist should include instructions to check for salvageable parts, assess the condition of the housing for potential remanufacturing, and properly segregate materials for recycling.

Standard Work & Visual Maintenance

- **Action 1: Post Visual Standard Operating Procedures (SOPs**

  For key tasks like pump start-up, valve calibration, or filter backwashing, create simple, visual, step-by-step guides and post them in the work area. This ensures consistency and reduces errors, which in turn extends equipment life.

- **Action 2: Implement a 15-Minute Leak Walkdown**

  Mandate that a brief (15-minute) leak inspection be part of the daily shift handover protocol for all operational teams. This focused task encourages operators to actively look for signs of leaks or Non Revenue Water NRW in their work zone.

ReSOLVE Framework – Guidance Note

- **Action 1: Conduct a Circular Asset Audit**

  Identify areas where finite inputs can be replaced with renewable or shared alternatives.

  Map current energy sources, shared equipment, and potential opportunities for solar integration across facilities.

  This provides a clear picture of where renewable substitution or shared-use models can reduce costs and improve efficiency.

- **Action 2: Standardize Component Reuse and Material Flows**

  Create a simple inventory of frequently replaced components such as valves, membranes, and seals that can be reused or refurbished.

  Develop a rotation plan across sites to extend component life and reduce procurement frequency.

  This simple system strengthens the “Loop” and “Optimize” principles by keeping materials in circulation and minimizing waste.

Accenture's Circular Advantage Archetypes – Guidance Note

- **Action 1: Pilot a Circular Supply Tender**

  Integrate minimum recycled or bio-based content requirements into one upcoming procurement tender.

- **Action 2: Implement a Performance-Based Service Contract**

  Select one existing operations or maintenance contract and link a portion of supplier payment to performance outcomes such as energy reduction or non-revenue-water improvement.

  This shifts the focus from product ownership to service performance, reinforcing Product-as-a-Service principles across the sector.

Quick Wins Roadmap

0–1 Year

Now:

The focus is on foundational actions that require no extra cost. This includes conducting internal audits of assets and "waste" streams, formally reclassifying byproducts as "resources," and implementing new visual standard work for key tasks.

2-3 Years

Medium Term:

These actions build on the initial quick wins and require minimal cost but a commitment to change. This involves implementing new walkdown procedures for NRW, expanding internal remanufacturing programs, and actively seeking out partnerships with local industries for waste exchange.

4+ Years

Long Term:

The final stage involves linking circular practices to major systemic projects and investments. This includes integrating circular principles into all strategic plans and actively working with industrial partners and academic institutions to develop a formal ecosystem for industrial symbiosis, aligning with the National Water Strategy (NWS) and Vision 2030's sustainability goals.

Implementation Tools

Roles & Ownership: Operations, Maintenance.

3 KPIs: Non Revenue Water reduction %, on-time maintenance %, operational waste reduction %.

Evidence Log: Baseline → 6 months → 12 months

Path 2

Designing for Multiple Product Life Cycles

Path 2

Under Vision 2030, Saudi Arabia drives industrial diversification and innovation to enhance competitiveness and extend product lifecycles (Vision 2030).

The NWS supports this through Strategic Objective 5: "Ensure water sector competitiveness and positive contribution to the national economy through promoting effective governance, private-sector participation, localization of capabilities, and innovation." (MEWA – NWS)

The SGI complements this by promoting sustainable production and low-carbon design to reduce embodied emissions (SGI.gov.sa). Through its Engineering and Procurement frameworks, the SWA translates these ambitions into technical criteria emphasizing durability, modularity, and resource efficiency (SWA.gov.sa).

1. Circular Design Principles

Principle	Description	Example
Design for Durability	Make products that last longer.	Cast iron water meters that last decades.
Design for Disassembly	Make products easy to take apart for repair or recycling.	Modular RO skids with easily replaceable membranes and valves.
Design for Upgradability	Allow parts to be upgraded rather than replaced entirely.	SCADA systems with plug-and-play modules.
Design for Standardization	Use universal parts for easier maintenance and reuse.	Pipe fittings and valves with standard specifications.
Design for Repairability	Use modular, labeled parts and standard tools to enable users to repair products easily.	Submersible pumps designed with replaceable motors and impellers for easy on-site repair
Design for Aging Gracefully	Products should look and feel acceptable as they wear, extending usability.	Weather-resistant casings for water meters.
Weather-resistant casings for water meters.	Offer trade-in schemes.	SWA meter procurement incentives for returned units.
Circular Behavior	Design to promote sharing, modularity, return incentives.	Shared containerized RO units rotated across rural SWA regions.

Water Sector Application of Circular by Design

1. **Reuse**
   Transferring used equipment between utilities.
2. **Modular Design**
   Upgradable SCADA or membrane components.
3. **Refurbishment**
   Refurbishing smart meters, valves, or pumps.
4. **Leasing Models**
   Durable filtration/pumping systems offered as-a-service.
5. **Remanufacturing**
   Cleaning and rebuilding motors and gearboxes.

A. Design-for-Recycling (DFR)

Products are intentionally designed to be easily disassembled, repaired, and recycled.

Example: IKEA designs furniture with modular parts that are recyclable and reusable, facilitating material recovery.

Water Sector Example:

Designing modular filtration units in Reverse Osmosis (RO) systems for easy disassembly and repair.

2. Digital Enablers Supporting Circular Design

01 IoT Sensors
Enable real-time monitoring of product performance and condition, facilitating predictive maintenance and optimal timing for repair or refurbishment.

02 Digital Twins
Virtual models of physical assets that allow for testing design changes, simulating lifecycle impacts, and optimizing resource use.

03 AI-driven Analytics
Process vast amounts of data from IoT and digital twins to identify patterns, predict failures, and optimize circular interventions.

3. Barriers to Implementation of Circular Design

Barrier	Description
Design Culture	Designers may still follow linear logic, lacking awareness or incentives for circularity.
Economic Models	Circular design may appear costly upfront compared to conventional linear production models.
Customer Demand	Users may prioritize low-cost, disposable items over durable, repairable, or service-based products.
Service Ecosystem	A robust support service ecosystem is needed for repairs, upgrades, and take-back programs, which may not yet exist.

A. Design for Recycling

Minimize material types and count to simplify recycling processes.

Use recyclable adhesives and mechanical fasteners for easy disassembly.

Ensure clear disassembly instructions and component separation to facilitate effective recycling.

B. Narrowing Material Resource Flow

Use less material

Through design optimization:

Example: Designing valves, pumps, or water meters with fewer materials or lighter components without compromising performance.

Select Low-Impact and Recyclable Materials

Reducing environmental footprint:

Example: Using recycled plastic, stainless steel, or modular components in water infrastructure that can be recycled or reused.

Miniaturize

To reduce overall material volume:

Example: Compact water treatment units or decentralized filtration systems that require fewer materials and take up less space.

Dematerialize

By replacing hardware with software (e.g., Cloud-based platforms systems, digital twins, cloud-based water management):

Example: Instead of installing physical meters at every site, utilities can use cloud-based monitoring to track water flow and system performance remotely.

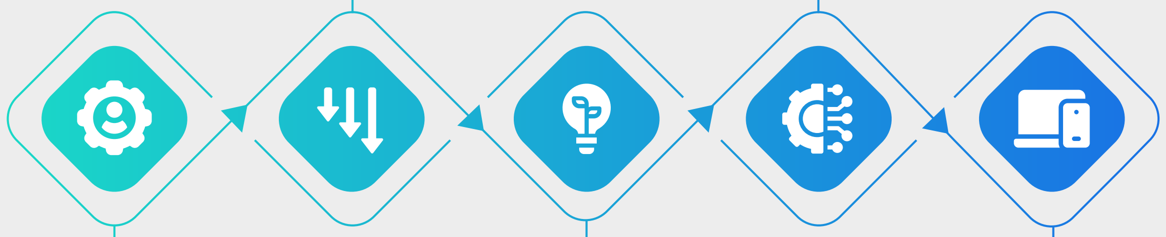
Source Materials Locally

To reduce transport emissions and support local economies:

Example: Using locally manufactured pipes, valves, or water storage tanks to cut supply chain emissions and boost regional job creation.

C. Design for Resource Efficiency

Designing for resource efficiency means optimizing products, services, and systems to use fewer resources and generate less waste throughout the entire lifecycle



01
Use fewer resources per unit of product or service:
Example: Water meters or pumping systems designed to use fewer rare metals or high-impact plastics.

02
Reduce waste in production processes:
Example: In pipe or membrane manufacturing, reusing production scrap material instead of sending it to landfill.

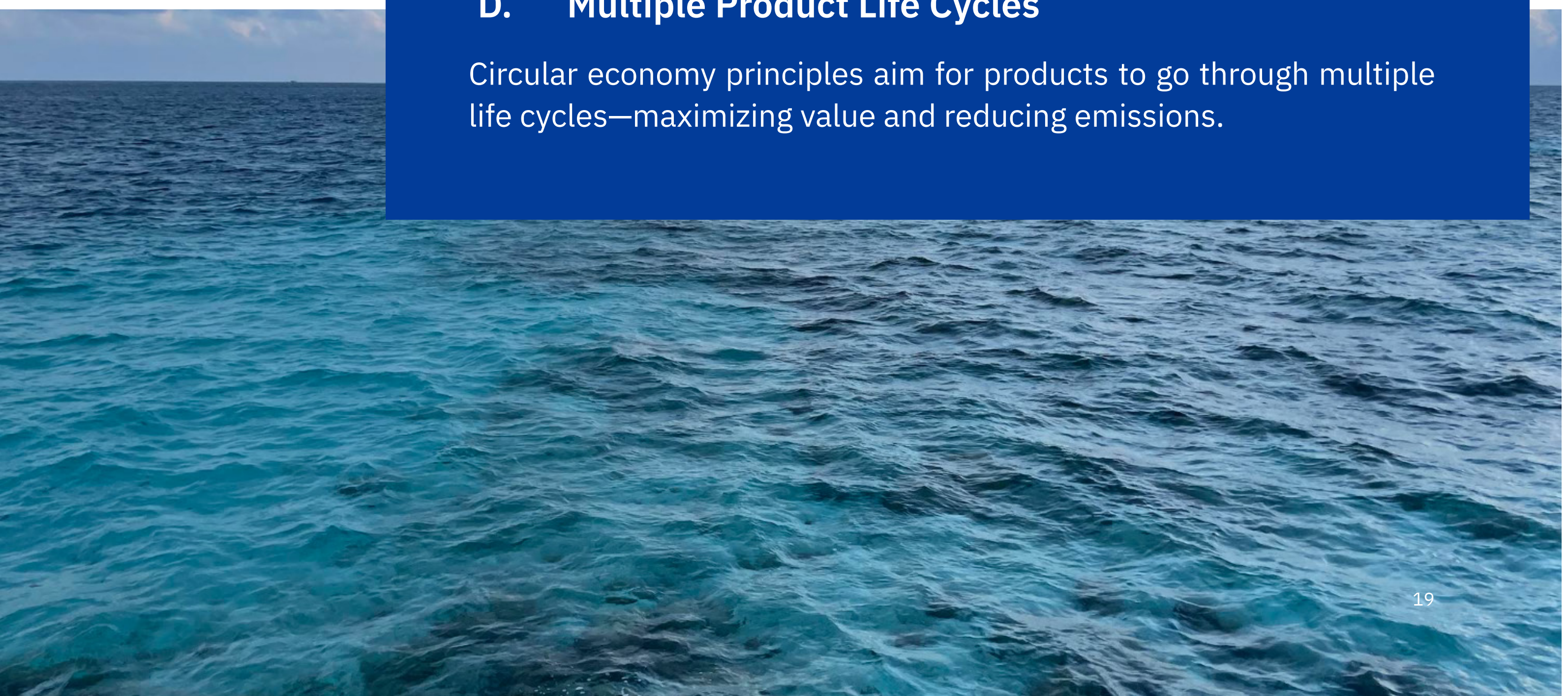
03
Improve energy efficiency during manufacturing and use phases:
Example: Water treatment plants using energy-efficient pumps and motors with optimized flow control.

04
Adopt digital fabrication to reduce cuts and overproduction:
Example: 3D printing of replacement parts for water infrastructure, avoiding unnecessary bulk production and logistics.

05
Use digital platforms to distribute products locally:
Example: Localized production of filtration units using modular designs, reducing transport emissions and lead time.

Water Sector Example:

Adopting energy-saving membrane fabrication techniques in desalination or digital twins for optimizing water treatment plant operations.



D. Multiple Product Life Cycles

Circular economy principles aim for products to go through multiple life cycles—maximizing value and reducing emissions.

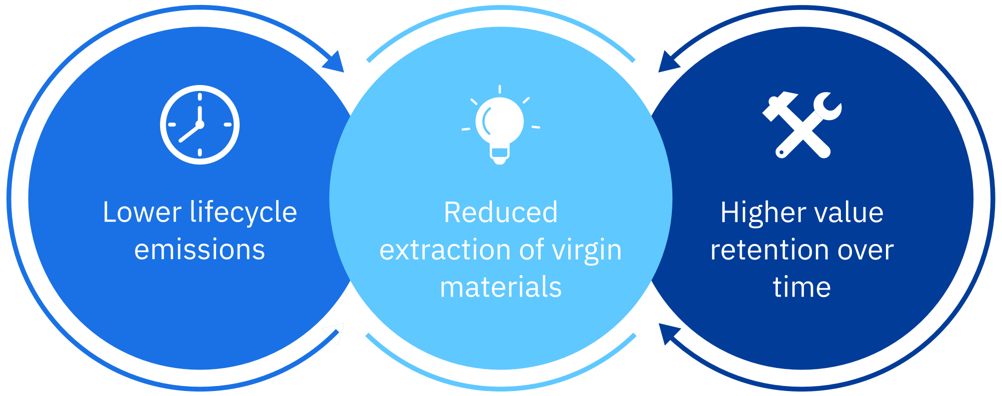
Key Strategies:

Products are designed for:

Reuse	Repair	Remanufacture	Component harvesting (recovery of valuable parts)

Benefits:

Products are designed for:



Water Sector Example:

Membranes used in desalination could be designed for:

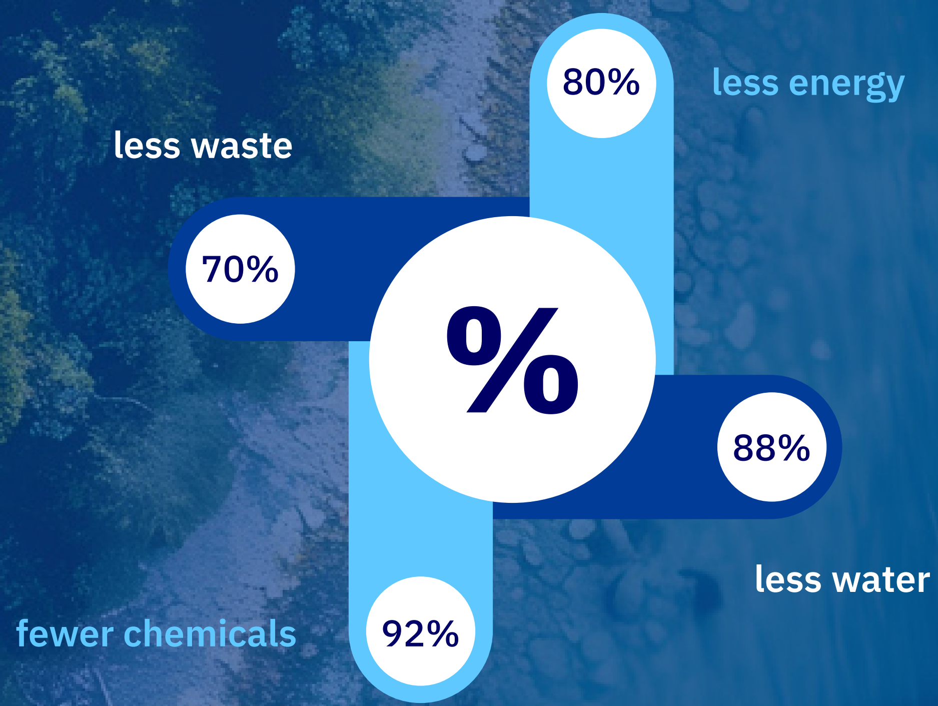
- Refurbishment: Cleaning and reuse for less intensive applications.
- Component Harvesting: Recovery of valuable polymer or metal parts for manufacturing new products.

Similarly, modular pumps or valves with interchangeable parts can be maintained over multiple cycles instead of being discarded.

E. Remanufacturing Benefits

Remanufacturing is a high-value circular strategy that restores used products to a like-new condition, often with a warranty equivalent to new.

Benefits of producing a remanufactured part compared to new production:



https://www.mckinsey.com/capabilities/sustainability/our-insights/remaking-the-industrial-economy

ROI is up to 5x greater compared to new production, highlighting economic advantages.

Water Sector Example:

- Water utilities remanufacture pumps and motors instead of replacing them.
  - Components like rotors and impellers are cleaned, repaired, and tested to meet original standards.
  - This reduces Capital Expenditures (CAPEX), shortens downtime, and keeps valuable materials in the loop

F. Downcycling vs. Upcycling

These terms describe different approaches to material recovery, with varying levels of circularity.

Downcycling:

- Converts waste into lower-value materials.
- Least circular, as it involves value loss.

Example:

Turning bottles into park benches, where the material loses its original purity and functionality for higher-value applications.

Upcycling:

- Turns waste into higher-value products.
- Avoids using virgin materials and creates new value.

Example:

Fire hoses converted into designer bags (Elvis & Kresse), or denim into insulation.

Summary Table:

Type	Outcome	Circularity Level
Downcycling	Lower-value product	Low
Upcycling	Higher-value product	High (closed-loop)

G. Design for Biodegradation

This strategy is particularly relevant for short-life, natural materials where recycling or reuse isn't practical.

Key Principles:

- Materials should decompose safely without leaving toxic residues.
- Biodegradation must happen in natural conditions or controlled composting environments.

Water Sector Examples:

- Algae-based filters: Biodegradable filters being tested for water purification in rural or emergency settings.
- Biopolymer single-use testing kits: Single-use water quality testing kits designed from bioplastics that break down safely after use (currently in pilot trials in some regions).

These innovations avoid long-term plastic pollution while still meeting technical needs.

H. Design By Nature

Biomimicry involves nature-inspired systems where "waste becomes food" or input for another process.

Example:

- Farm Waste to Animal Feed: Leftover food or plant waste is fed to animals instead of being thrown away
- Mushroom packaging replaces Styrofoam, offering a natural and decomposable alternative.
- Algae-powered wastewater treatment systems clean water and generate biomass energy, demonstrating a dual benefit from biological processes.

National Water Company Application:

- Convert sludge from wastewater treatment into organic fertilizer.
- Reuse treated wastewater in agriculture or landscaping, reducing demand for freshwater.
- Support startups that use bio-based solutions, fostering local innovation in circularity.
- Water Sector Advanced Example: Test kits made from compostable biopolymers are being piloted, reducing plastic waste in water quality testing.

Activation Plan: Path 2: Circular by Design

Design decisions must drive long-term value. By applying durability, modularity, and biomimicry in procurement and asset management, entities can lower lifecycle costs, simplify maintenance, and enable reuse and upgrade of assets. This guidance note provides direction on how circular design principles should be embedded into planning, procurement, and infrastructure management.

Key Principles with Practical Applications

Design for Durability

- **Action 1: Enhance Preventive Maintenance**

  Move from reactive repairs to a strict, data-driven schedule for preventive maintenance based on manufacturer guidelines and real-world performance. This simple but critical step can significantly extend asset life.

- **Action 2: Track Performance Data**

  Systematically record the operational hours and breakdown frequency for key components. This data, stored in a simple spreadsheet or existing asset management software, can pinpoint recurring issues and help you specify more durable, reliable equipment in future procurement.

- **Action 3: Specify Durability in Tenders**

  When purchasing new assets, add specific durability metrics to your tender documents, such as guaranteed operational hours, resistance to high temperatures, or a minimum number of service cycles.

Design for Disassembly

- **Action 1: Create a Salvage Inventory**

  Establish a dedicated, organized storage space for collecting and cataloging all usable parts from decommissioned equipment. Train technicians to carefully disassemble broken assets and identify components that are still in good condition for future use.

- **Action 2: Update Repair Procedures**

  Develop internal protocols that require staff to check the salvage inventory for a needed part before ordering a new one. This habit can lead to significant savings on spare parts and reduce procurement time.

Design for Standardization

- **Action 1: Map Common Components**

  Conduct an internal audit to identify which pumps, valves, and control systems already use the same or similar components. Based on this, create a "preferred vendor list" for new procurement to ensure future equipment uses these standardized parts.

- **Action 2: Consolidate Spare Parts Inventories**

  Where possible, merge the inventories from different facilities into a central, accessible stock of common spare parts. This reduces total inventory levels and improves the speed of repairs.

Modular Design

- **Action 1: Prioritize Modularity in Procurement**

  When writing tenders for new equipment, add criteria that favor modular designs. Specify that units should have easily swappable components (e.g., filter banks, pumps, or control panels) that can be replaced without shutting down the entire system.

- **Action 2: Pilot a Single Modular Upgrade**

  Choose one non-critical system and assess its potential for a low-cost, modular upgrade. For example, replace a single-unit pump system with a modular parallel pump configuration that allows for easy maintenance and replacement.

Design for Recycling & Biodegradability

- **Action 1: Segregate Materials for Recycling**

  Implement a simple on-site sorting system to separate materials like plastic pipes, metal fittings, and electronic waste. Connect with local recycling partners to ensure these materials are recovered instead of landfilled.

- **Action 2: Specify Material ID/Marking**

  Require that new products, especially plastic piping and complex components, have clear material identification marks (e.g., resin codes or metal grades). This ensures that when the product reaches its end-of-life, it can be easily sorted and recycled correctly.

Industrial Symbiosis

- **Action 1: Map Your Waste Flows**

  Conduct a simple, internal audit to identify all "waste" streams leaving your facilities—sludge, rejected water from desalination, or even spent chemicals. Document the volume, composition, and current disposal method. This process often reveals potential resources that can be used on-site or by a partner.

- **Action 2: Identify Internal Reuse Opportunities**

  Look for ways to keep these "waste" streams on-site and in use. Can treated wastewater be used for landscaping at the same facility? Can rejected brine be used for on-site dust control on unpaved roads?

- **Action 3: Pilot a Waste-to-Partner Exchange**

  Identify a single, local industrial partner—such as a construction company, agricultural firm, or chemical plant—and discuss the possibility of providing them with a small volume of a byproduct. For example, a partnership with a cement factory could explore the use of sludge ash as a raw material.

Remanufacturing & Upcycling

- **Action 1: Establish an Equipment Catalog**

  Start keeping a simple log of all old or broken equipment that has been pulled from service. Identify which parts are still functional and could be used to repair other assets. This is a low-cost internal step that can provide immediate savings.

- **Action 2: Pilot a Single Remanufacturing Project**

  Identify one type of common equipment, like a certain pump or valve, and establish a simple internal procedure to disassemble, clean, and rebuild it using spare parts. This builds internal capacity and proves the concept without major investment.

Biomimicry

- **Action 1: Reclassify Byproducts**

  Formally change the designation of treated wastewater and sludge from "waste" to "resource" in all internal policies and reports. This simple shift in language can unlock new opportunities and change the way employees view these streams.

- **Action 2: Engage with Internal Experts**

  Organize a brainstorming session with engineers and operations staff. Ask them to identify natural systems that solve problems similar to theirs—for example, how mangroves filter saltwater or how deserts manage water scarcity—and explore how those concepts could be applied to your processes.

Quick Wins Roadmap

0–1 Year

Now:

The focus is on foundational actions that require no capital investment. This includes conducting internal audits of asset durability and component standardization, establishing a salvage and reuse program for parts, and updating tender documents with basic circular design criteria to signal a new strategic direction to suppliers.

2-3 Years

Medium Term:

These actions build on the initial steps and involve strategic, low-cost changes. This includes formally adopting a procurement policy that gives preference to suppliers who offer modular and easily disassembled products, securing formal agreements with local recycling firms, and piloting a small-scale modular design upgrade on a non-critical system to demonstrate its benefits.

4+ Years

Long Term:

The final stage involves fully embedding circular design into the sector's long-term strategy. This includes creating a comprehensive "Circular Design Guideline" for the entire Saudi water sector, partnering with research institutions to develop and test new circular materials and technologies, and working with suppliers to ensure all new assets come with clear material identification and disassembly instructions, in direct alignment with Vision 2030 and the Saudi Green Initiative.

CIRCULAR BY DESIGN

Implementation Tools

- Roles & Ownership: Operations, Maintenance, Procurement.
- 3 KPIs: % tenders with circular design criteria, total salvaged parts reused, recycled material volume (tons).
- Evidence Log: Baseline → 6 months → 12 months.

Path 3

Driving the Circular and Digital Economy Transition

Path 3

Vision 2030 identifies digital transformation as a foundation for transparency, efficiency, and sustainable development (Vision 2030).

The NWS operationalizes this direction through programs focused on innovation, digital governance, and smart water systems (MEWA – NWS).

These initiatives reinforce the SGI's monitoring and reporting efforts by enabling accurate environmental and emissions data collection (SGI.gov.sa).

Within its Innovation and Digital Transformation pillar, the SWA supports entities in deploying automation, IoT, and predictive-analytics tools for improved performance and optimized resource management (SWA.gov.sa).

1. Digital Transformation and the Forthcoming Digital Economy

Digital Fluency is a core enabler in the transition toward a Circular and Digital Economy. It consists of four main pillars: Digital Foundations, Digital Operations, Digital Leadership & Culture, and Digital Workforce. Each pillar plays a role in embedding digital tools, collaboration, and innovation into the value chain.

2. Why Digital Fluency?

Digitally fluent companies demonstrate significant advantages:

- 2.7 times more likely to have achieved high revenue growth over the past three years.
- 5.4 times more likely to continue growing.

Lead their peers in customer satisfaction, innovation, and operational efficiency.

Considered better workplaces by 69% of employees.

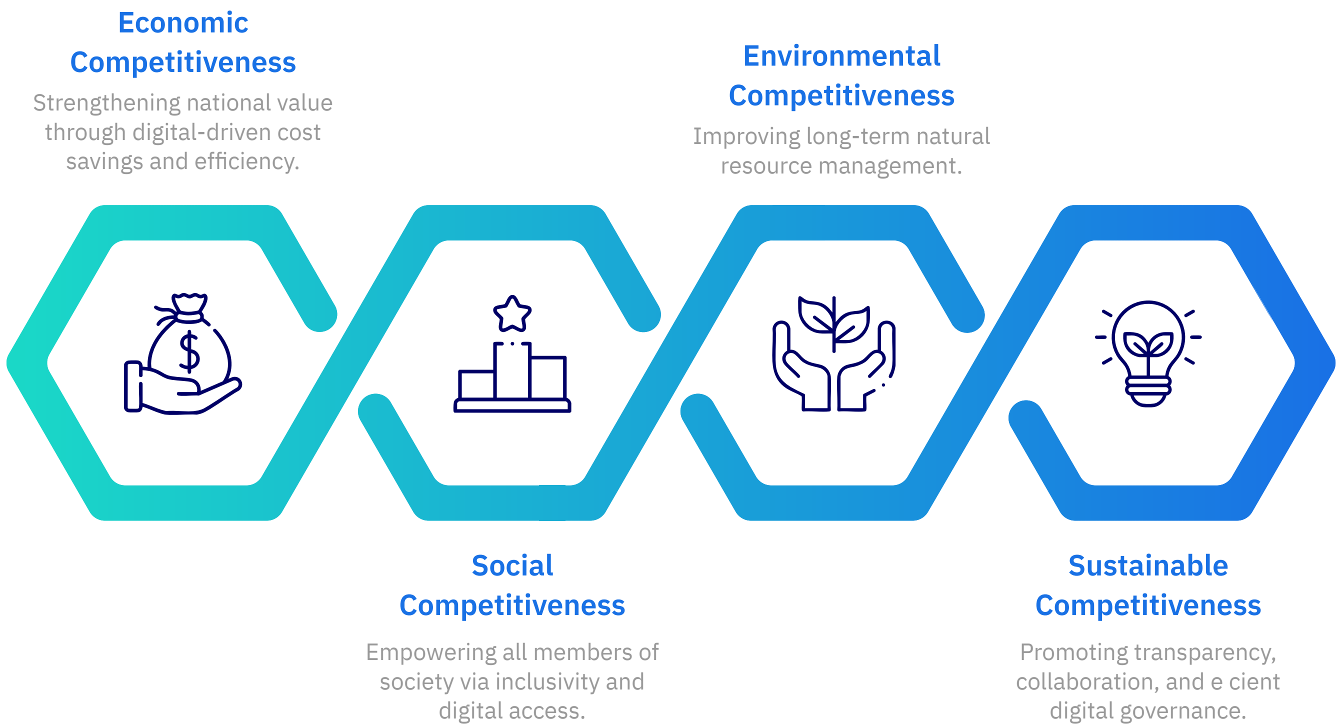
3. Integration Dimensions Driving the Dual Transition

The integration of digital solutions across sectors enables improvements in:

- Skills and digital awareness.
- Connectivity (IoT, automation, smart sensors).
- Visibility (transparency and traceability).
- Global value chain coordination.
- Development of sustainable circular products and materials.

4. Digital Competitiveness Dimensions

Digital transformation enhances competitiveness across multiple dimensions:



5. Industrial Symbiosis (Closing Resource Flows CBM)

Industrial symbiosis refers to a network where one company's waste or by-product becomes another's resource, closing material loops.

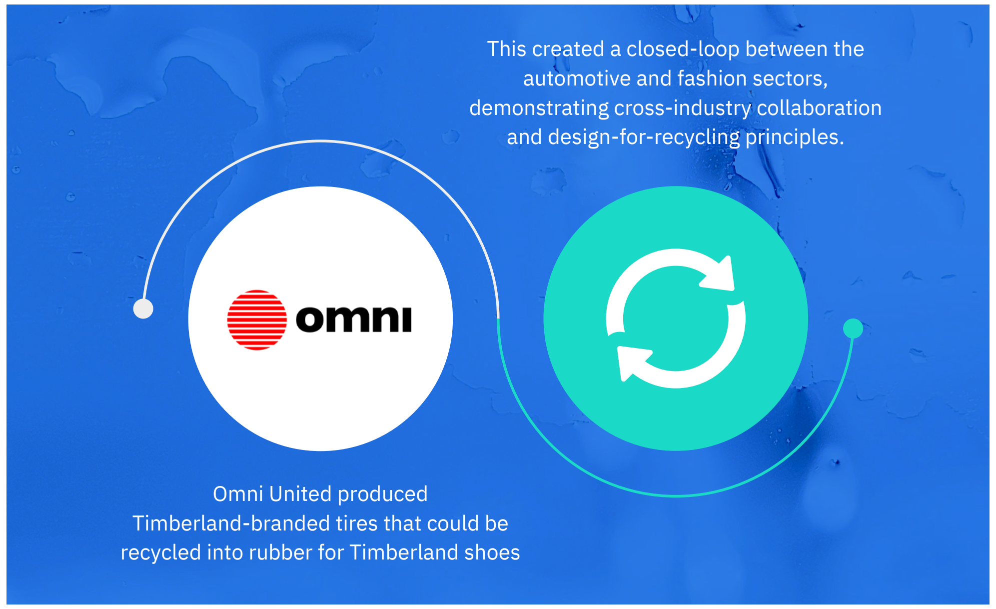
70% of SDG targets can be supported via Industry 4.0 technologies.

AI, blockchain, IoT, and data platforms play significant roles in mapping and supporting specific targets.

Example:

The UN's Building Blocks program used blockchain to support Syrian refugees and improve fund distribution transparency, directly supporting SDG 16 (Peace, Justice, and Strong Institutions).

6. Case Study: Timberland Tires



7. Use Cases of AI and Blockchain for SDGs

Digital transformation enhances competitiveness across multiple dimensions:

Artificial Intelligence (AI)

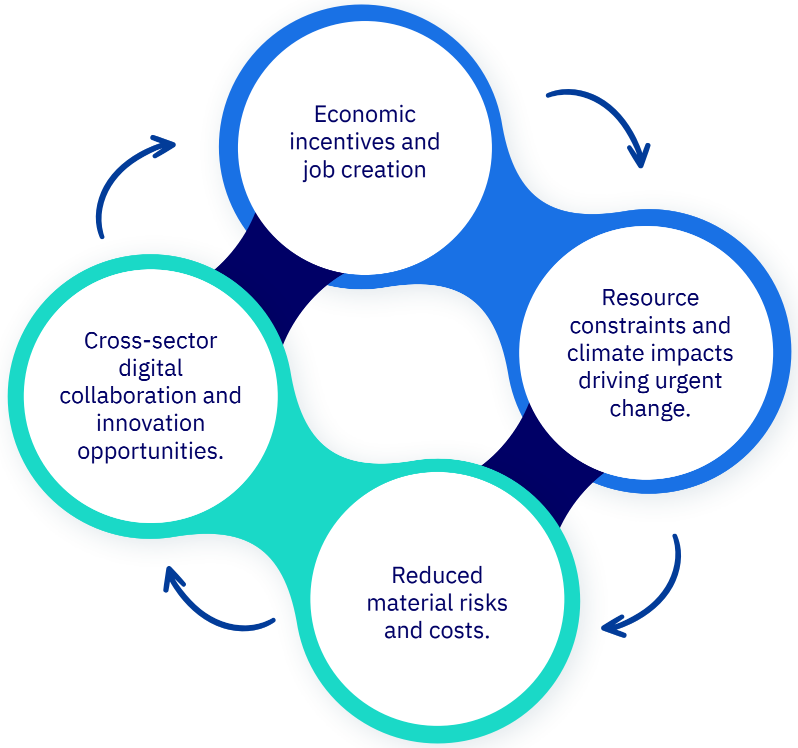
- Supports early warning systems for climate events
- Satellite monitoring for deforestation
- Smart agriculture for optimized resource use
- Data-driven decisions for sustainable development

Blockchain

- Improves traceability in water and food systems
- Ensures transparency
- Enhances digital identity for inclusive development

8. Circular Economy Drivers in the Digital Era

Key drivers for the circular economy in the digital era include:



9. Circular Economy + Digital in the Water Sector

Digital technologies provide concrete benefits for circularity within the water sector.

Digital Technology	Circular Benefit	Example Application
IoT Sensors	Real-time usage and leak tracking	Smart water meters (NWC)
AI Predictive Models	Extend asset life, avoid failure	WTCO pipeline pump systems
Digital Twins	Asset modeling and lifespan planning	RO and disinfection system upgrades
Cloud Platforms	ESG & KPI integration	Centralized tracking for circular KPIs

Activation Plan: Path 3: Circular + Digital Transition

Digital innovation is critical for advancing the circular economy in the Saudi water sector. Entities should adopt IoT, digital twins, and AI to reduce leakage, optimize energy use, and improve material traceability. This guidance note highlights specific digital applications that can be prioritized to strengthen efficiency, transparency, and resource recovery across the sector.

Key Digital Enablers with Practical Actions

IoT Sensors

- **Action 1: Active Dashboard Monitoring**

  Train operators to actively monitor data from existing smart meters and sensors. Instruct them to flag any unusual spikes in water consumption or pressure drops that could indicate a leak. This requires a shift in mindset, not new technology, and can catch leaks before they become major problems.

- **Action 2: Basic Performance Tracking**

  Use a simple spreadsheet or existing asset management software to log real-time data from a few key pumps or valves. Track their energy consumption versus output to identify underperforming units that need maintenance or replacement, thereby reducing energy waste.

- **Action 3: Pilot a Digital Leak Detection Program**

  For a small section of the network, use data from existing IoT sensors to create a simple digital leak detection model. This could involve setting up automated alerts based on pressure drops or minimum night flow (MNF) data.

CIRCULAR & DIGITAL ECONOMIES

AI Predictive Models

- **Action 1: Start a Failure Log**

  Begin creating a simple, shared database or spreadsheet to log every equipment failure. For each entry, record the date, time, type of equipment, a brief description of the failure, and any contributing factors (e.g., pressure spike, high temperature). This structured data is the essential foundation for any future AI analysis.

- **Action 2: Manual Pattern Recognition**

  Before deploying complex AI, use a simple visual check of the failure log. Look for common patterns—do certain models fail after a specific number of operational hours? Do certain conditions precede a breakdown? This human-driven analysis is a powerful first step towards predictive maintenance.

Digital Twins

- **Action 1: Pilot a Single "Process Twin"**

  Do not attempt to build a full digital twin of an entire plant. Instead, start small. Create a virtual model of a single, critical process, such as the flow and pressure dynamics of a pump station. Use existing sensor data to simulate how different operational settings would affect energy use.

- **Action 2: Visualize Data in 3D**

  Use a simple software tool (or even existing CAD files) to create a basic 3D model of a plant. Overlay data from your asset log onto this model to visualize where old equipment is located, helping to plan for future upgrades.

Cloud Platforms

- **Action 1: Standardize Reporting Formats**

  Create a single, standardized template for all operational reports (e.g., daily water production, maintenance log, etc.). This makes data entry and consolidation much simpler, regardless of where it is stored.

- **Action 2: Use Shared Cloud Storage**

  Implement a simple, secure cloud storage solution (such as a shared drive) for all operational data. This breaks down departmental silos and makes information accessible to all relevant teams, from maintenance to management.

Traceability Ledger (Blockchain-Ready)

- **Action 1: Pilot a Digital Log of Reuse**

  For one specific reuse project (e.g., using treated wastewater for a nearby park's irrigation), create a simple, sequential digital log. Record the volume of water treated, the quality tests, and the final delivery point. This is the conceptual start to a blockchain-like traceability system.

- **Action 2: Engage with local recyclers**

  When old assets are sent for recycling, pilot a digital record of the transfer. Note the material type and the recycling company, providing a simple, verifiable record for future reference.

Quick Wins Roadmap

0–1 Year

Now:
The focus is on foundational actions that require no extra cost. This includes standardizing all data formats, training teams to use existing digital dashboards more effectively, and using cloud storage to centralize data. These steps will break down data silos and prepare the organization for more advanced digital practices.

2-3 Years

Medium Term:
These actions build on the initial steps and involve low-cost investments in simple tools. This includes piloting a predictive maintenance model for a critical asset using the collected data, testing a small-scale digital twin for a single process, and initiating a digital traceability pilot for a specific material or water stream.

4+ Years

Long Term:
This stage involves full integration. It includes developing a single, integrated digital platform that connects all plant data, customer data, and asset management systems. It also involves a full alignment of all operational data with SWA (Saudi Water Authority) standards, ensuring all digital initiatives support the National Water Strategy (NWS) and Vision 2030's digital transformation goals.

Implementation Tools

- Roles & Ownership: IT/Digital teams, Operations, Maintenance.
- 3 KPIs: Data reporting completion %, NRW from leaks (m^3), operational downtime (hours).
- Evidence Log: Baseline → 6 months → 12 months.

Path 4

Advancing Circular Procurement Strategies

Path 4

Vision 2030 promotes government efficiency and fiscal sustainability by elevating procurement as a lever for transformation (Vision 2030).

The NWS aligns with this through objectives on governance, private-sector participation, and sustainable investment to strengthen resource efficiency (MEWA – NWS).

The SGI and the National Center for Waste Management (MWAN) target 90 % landfill diversion by 2040, reinforcing circular procurement and waste-reduction measures (SGI.gov.sa, MWAN.gov.sa, MWAN Strategic Plan).

Through its Governance and Partnership Development pillars, the SWA embeds lifecycle, energy, and waste-efficiency criteria into procurement decisions to ensure measurable circular outcomes (SWA.gov.sa).

1. Overview of Saudi Arabia's Waste

Profile

Saudi Arabia generates over 106 million tons of waste annually. Understanding the national waste composition is crucial for developing targeted circular economy strategies.

Waste Category	Key Figures / Facts	Source	National Relevance
Municipal Solid Waste (MSW)	Riyadh produces 3.4 million tons/year, with a national target to recycle 81% under a multi-agency MoU.	MEWA News – Riyadh Waste Recycling Agreement	Represents the Kingdom's first large-scale integrated circular-waste initiative.
Construction & Demolition Waste (C&D)	Annual volume of ~5 million tons in Riyadh; target to recycle 47%per year.	MEWA News – Riyadh Waste Recycling Agreement	Major contributor to landfill volume; national regulation for reuse and recycling is expanding.
Food Waste	Over 33% of food produced is wasted annually, at an estimated SAR 40 billion loss.	MEWA News – Food Waste Reduction Initiative	Identified by MEWA as a key national priority for behavioral and systemic change.

Waste Category	Key Figures / Facts	Source	National Relevance
National Waste Diversion Target	Aim to divert 90% of total waste from landfills by 2040, with detailed waste-type classification (municipal, industrial, sludge, agricultural, special).	MWAN Strategic Plan	Central pillar of MWAN's circular-waste governance strategy
Solid Waste Management Systems	Implementation of material recovery, composting, C&D recycling, and waste-to-energy conversion.	MEWA – Solid Waste Management Page	Forms the operational backbone of the Kingdom's national waste-management framework.

The transformation of Saudi Arabia's waste sector is being driven primarily by the strategic goals of MWAN and MEWA.

According to MWAN's Strategic Master Plan, the Kingdom seeks to divert 90% of all waste from landfills by 2040, establishing a unified national classification that encompasses municipal, industrial, agricultural, sludge, and hazardous waste streams.

In parallel, MEWA's recent Memorandum of Understanding (MoU) in Riyadh targets recycling 81% of 3.4 million tons of municipal waste and 47% of 5 million tons of construction waste annually. This initiative effectively establishes Riyadh as the national pilot for circular-waste programs.

Despite these advances, food waste remains a critical challenge: one-third of all food produced is lost each year, costing the economy approximately SAR 40 billion.

To manage these streams, MEWA is actively expanding recovery infrastructure, which includes building new sorting facilities, composting centers, C&D recycling operations, and waste-to-energy projects as part of its comprehensive solid-waste management program.

2. MWAN's Strategic Response to National Waste Challenges

The National Waste Management Center has developed a comprehensive strategy to address waste challenges and drive circularity in Saudi Arabia.

National Strategy Targets
Divert 90% of waste from landfills by 2040.

Recycling Goals
40% recycling by 2030 ; 31% composting; 16% waste-to-energy (WTE). MWAN aims for 42% recycling and 19% waste-to-energy by 2035.

Cluster-Based Plans
25 regional clusters tailor waste stream management based on local needs and resources.

Infrastructure Projects
Development of Materials Recovery Facilities (MRFs), WTE plants (e.g., Riyadh, Jeddah), compost facilities, and C&D recovery sites.

Sector Regulations
Dedicated strategies for municipal, industrial, C&D, healthcare, and e-waste.

Technical Standards
Issued for temporary storage, hazardous waste transport, and facility licensing.

Digital Monitoring
Integrated tracking for violations, performance, and emissions across waste operations.

Public-Private Partnerships
Collaboration with entities like NESMA, Beeah, Averda, and ACWA Power to scale solutions.

Public Awareness
Campaigns, recycling apps, and community - based training to promote waste segregation and responsible consumption.

MWAN's national framework supports infrastructure for source segregation, data systems, and compliance mechanisms.

3. Waste Generated from the Water Sector in Saudi Arabia

The water sector in Saudi Arabia, encompassing desalination, water transmission, wastewater treatment, and irrigation, contributes a unique set of waste streams to the national profile. While smaller in volume compared to municipal or construction waste, these streams carry critical environmental risks and opportunities for circular solutions.

A. Key Waste Types from the Water Sector:

- **Brine Discharge (from Desalination):**

  High-salinity concentrate that, if not managed properly, can cause marine ecosystem disruption.

- **Sludge (from Wastewater Treatment Plants):**

  Includes organic and inorganic sludge; may contain pathogens or heavy metals.

- **Screenings and Grit:**

  Solid residues captured during pre-treatment in sewage plants, including sand, plastic, rags, and debris.

- **Chemical Residues:**

  From water treatment processes (e.g., lime, ferric chloride, polymer sludge).

- **Maintenance Waste:**

  Includes filters, membranes (e.g., RO membranes), and chemical containers.

STRATEGIC CIRCULAR PROCUREMENT

C. Waste by Entity in the Water Value Chain:

WD (Water Desalination):

- Brine discharge: High-salinity water from desalination, posing marine ecosystem risks.
- Chemical sludge: Resulting from water treatment processes, rich in coagulants and metals.
- Used RO membranes and filters: Require specialized recycling or disposal.
- Oil and grease: From pump stations and desalination units.
- Construction debris and packaging: From spare part deliveries and maintenance work

WTCO - (Water Transmission Company)

- Pipeline flushing water: Wastewater generated during maintenance.
- Corrosion products: Rust, metallic flakes, and pipeline coatings.
- Pumping station waste: Lubricants, coolants, and failed mechanical parts.
- E-waste: Obsolete sensors and electronic control components from SCADA systems.

NWC (National Water Company):

- Wastewater sludge: Generated from municipal sewage treatment.
- Screened solids: Non-biodegradable waste like plastic, wipes, and sediment.
- Chemical containers: Used in disinfection and pH control.
- Damaged meters and piping materials: Includes metal and plastic fragments.

SIO (Saudi Irrigation Organization):

- Irrigation plastics: Drip tapes, hoses, and mulch films.
- Canal sediment: Organic and inorganic buildup from water flow.
- Agrochemical traces: Residues in reused water.
- Maintenance debris: Old sprinkler heads, valves, and pipe offcuts.

Sludge-to-Resource Initiative within the Circular Economy

A specialized initiative has been developed to manage sludge generated from wastewater treatment plants, through the application of Windrow Composting technology as an interim solution. The initiative aims to transform sludge from an operational burden into a value-added resource. It focuses on producing natural organic fertilizer that supports local demand, reduces reliance on landfills, and improves the efficiency of waste management operations across the water sector.

Technical and economic feasibility studies for the initiative have demonstrated high viability, with the potential to cover approximately 67% of local demand for organic fertilizer, generate financial returns, contribute to the activation of circular economy principles, improve environmental impact, and support national sustainability targets.

D. Circular Opportunities for Water Sector Waste:

- Brine Valorization: Circular service models in desalination could include closed-loop membrane management, where providers handle installation, performance monitoring, and end-of-life recycling.
- Sludge Composting or Energy Recovery: Use treated biosolids in agriculture or as biofuel feedstock.
- Membrane Recycling: Pilot programs are underway to recover polymeric materials from used RO membranes.

- Zero Liquid Discharge (ZLD): Technologies being piloted to minimize wastewater and recover usable resources, reducing both waste and freshwater demand.

4. Designing Out of Waste

Designing out waste is a core principle of the circular economy. Instead of managing waste at the end of a product's lifecycle, circular strategies aim to prevent waste by designing smarter from the beginning. This includes optimizing materials, product durability, repairability, and systems that encourage reuse, remanufacturing, and recycling.

5. Extended Producer Responsibility (EPR)

EPR is an environmental policy approach in which producers take responsibility for the entire lifecycle of their products, especially for take-back, recycling, and final disposal. It promotes eco-design, reduces landfill use, and shifts the financial and operational burden from governments to producers. Saudi Arabia is exploring national-level EPR frameworks with MWAN supporting pilot programs, particularly in the packaging, electronics, and construction sectors.

Case Study: Furniture EPR in France:

In France, the furniture sector's EPR system collects used items, sorts them by material (wood, foam, metal), and directs them to Blockchain centers. This model supports job creation, material recovery, and reduces landfill dependency. It could be adapted for Saudi Arabia’s hospitality and municipal bulk waste sectors.

6. Saudi Arabia’s Plastic Waste Footprint

7. How to Conduct a Waste Audit in the Water Sector

A waste audit involves identifying, measuring, and analyzing waste streams generated by a facility or process.

1. Define Audit Objectives: Clarify the goals (e.g., identify major waste streams, evaluate recycling opportunities, assess compliance).
2. Select Audit Site and Period: Choose a representative site (e.g., treatment plant, desalination facility, office) and time period (usually 1–7 days).
3. Assemble Audit Team: Include operations, HSE, and facility management personnel.
4. Categorize Waste Types: Define categories such as plastics, sludge, brine, e-waste, packaging, organics, chemicals, etc..
5. Collect and Sort Waste Samples: Gather all waste generated during the audit period and sort into pre-defined categories.
6. Measure Volume and Weight: Use digital scales or estimation methods to quantify each waste category.
7. Record and Analyze Data: Use a standardized form to capture types, sources, weight/volume, and handling practices.
8. Identify Circular Opportunities: Assess possibilities for reuse, recycling, or elimination of specific waste streams.
9. Report Findings: Compile results and recommendations into a clear, actionable report with visuals and benchmarks.
10. Implement and Monitor Improvements: Launch pilot actions and track performance over time.

Example: Waste Audit at a Desalination Plant (WD): A one-week waste audit was conducted at an WD-operated desalination plant on the Red Sea coast. The goal was to quantify waste streams and identify opportunities for improved recycling and reuse. The audit was carried out by a multidisciplinary team from operations, maintenance, and HSE. The collected waste was categorized, measured, and analyzed based on the following breakdown

Waste Type	Source	Daily Avg. Weight (kg)	Potential Treatment
Brine Discharged	RO desalination process	80,000	Deep-well injection, brine valorization
Used RO Membranes	Filter replacement	150	Recycling pilot program with polymer recovery
Sludge	Chemical pretreatment	300	Landfilling or potential use in construction materials
Packaging Waste	Material supply logistics	200	Recyclable (cardboard/plastic)
General Waste	Admin and staff areas	120	Segregation and landfill diversion
E-Waste	Sensor upgrades	10	Certified electronics recycler

8. Best Practices for Waste Segregation in the Water Sector

Proper segregation is essential to enable high-quality recycling

- **Place Bins Near Work Areas**
  Encourages proper use and boosts compliance.
- **Train Staff**
  On-site waste generators must be educated on proper sorting.
- **Keep Hazardous Waste Separate**
  Avoid contamination by isolating harmful materials.
- **Seal Liquid Waste**
  Used oil, brine, and chemicals must be in leak-proof containers.

- Organic Waste
- General Waste
- Hazardous Waste
- E-waste
- Recyclables

Activation Plan: Path 4: Circular Procurement

Procurement is a primary mechanism for embedding circular economy principles. Entities must integrate requirements for recyclability, durability, and waste reduction into tenders and supplier contracts. This guidance note provides a framework for how procurement processes should be adapted so that every project contributes to national sustainability objectives.

Key Procurement Principles with Practical Actions

Designing Out Waste

- **Action 1: Request Minimal & Reusable Packaging**

  Add a simple but clear line to all tender documents and purchase orders requesting suppliers to use minimal or reusable packaging. Specify that they should avoid single-use plastics and non-recyclable materials where possible.

- **Action 2: Reuse Shipping Containers Internally**

  Implement an internal system to reuse all incoming shipping crates, pallets, and durable containers for internal transport, storage, or as part of your waste segregation system. This is a no-cost action that immediately reduces waste.

Extended Producer Responsibility (EPR)

- **Action 1: Add "Take-Back" Clauses to Contracts**

  When negotiating new contracts with suppliers, include a clause that requires them to take back used or expired products, such as chemicals, membranes, or large equipment components, for proper disposal, recycling, or remanufacturing.

- **Action 2: Pilot a Single Take-Back Scheme**

  Focus on one high-volume waste stream, such as used RO membranes from a desalination plant, and engage with a single supplier to pilot a take-back program. This builds a working model for future, broader implementation.

Circular Material Flows

- **Action 1: Specify Recycled Content**

  For non-critical applications, such as piping for non-potable water, add a requirement in your tenders that a certain percentage of the material must be recycled content. This creates market demand for secondary raw materials.

- **Action 2: Contract for End-of-Life Options**

  Require suppliers to provide a clear, documented plan for the end-of-life of their product, including options for refurbishment, remanufacturing, or recycling.

- **Action 3: Mandate Supplier Documentation**

  Require suppliers to provide a material breakdown and technical specifications that detail how a product can be disassembled, repaired, and sorted for recycling.

Bioplastics and Alternative Materials

- **Action 1: Switch to Biodegradable Bags**

  For on-site use, switch to readily available biodegradable bags for waste collection and other purposes. This is a simple change with a low-cost impact.

- **Action 2: Replace Single-Use with Reusables**

  Implement a policy to replace disposable items with durable, reusable alternatives where possible, such as providing reusable coffee mugs and water bottles to staff.

Smart Waste Technologies

- **Action 1: Use Color-Coded Bins**

  Implement a clear, simple, color-coded bin system across all facilities for different waste streams (e.g., green for recyclables, brown for organics, black for general waste).

- **Action 2: Train Staff on Waste Sorting**

  Provide a short, mandatory training session for all staff on proper waste segregation. Post simple, visual signage above the bins to remind everyone of the correct sorting rules.

Quick Wins Roadmap

0–1 Year

Now:
The focus is on foundational actions that require no capital expenditure. This includes updating tender templates to include a simple circular criteria checklist, conducting an internal waste audit to understand what is being discarded, and implementing a color-coded waste segregation system with clear signage and mandatory staff training.

2-3 Years

Medium Term:
These actions build on the initial quick wins and involve strategic planning and negotiation. This includes actively negotiating and implementing take-back agreements with key suppliers for high-volume items, forging partnerships with local recycling companies, and piloting a program to test the use of biodegradable or reusable materials in one operational area.

4+ Years

Long Term:
This stage involves embedding circular procurement into the very fabric of the organization and aligning with national strategies. This includes fully integrating circular criteria into all procurement policies, working with suppliers to co-develop circular solutions, and aligning the procurement strategy with the Saudi National Waste Management Strategy and the National Water Strategy (NWS).

Implementation Tools

- Roles & Ownership: Procurement, Operations.
- 3 KPIs: % tenders with take-back clauses, cost savings from reduced waste disposal, % purchases with recycled content.
- Evidence Log: Baseline → 6 months → 12 months.

STRATEGIC CIRCULAR PROCUREMENT

Path 5

Enabling Circular Business Models through Digital Innovation

Path 5

Vision 2030 highlights innovation and human-capital development as pillars of long-term economic and environmental sustainability (Vision 2030).

The NWS emphasizes research, innovation, and capability building to modernize water services and accelerate smart, sustainable management (MEWA – NWS).

The SGI strengthens these objectives by advancing national resilience and adaptation initiatives that build technical expertise and environmental capacity (SGI.gov.sa).

Through its Innovation and Human Capital pillars, the SWA develops sector-wide capability in digital sustainability and circular operations via training, partnerships, and applied research programs (SWA.gov.sa).

1. Digitally Empowered Industries (xTech)

Technologies integrate into existing industries or create entirely new ones, leading to "xTech" industries. These include:

- FINTECH – Financial Technology
- AGRITECH – Agricultural Technology
- Tech Health – Healthcare and Medical Technology
- insurtech HUB – Insurance Technology
- EduTech – Educational Technology
- SPACETECH – Space Technology
- CLIMATE TECH – Climate Technology

These xTech industries open new markets and innovation opportunities by interconnecting several sectors, empowered by advanced technologies like AI, analytics, and blockchain.

A. FinTech

FinTech leverages digital technologies to provide financial services. It is a strong enabler for the circular economy, sustainable competitiveness, and SDGs by promoting financial inclusion and access to funds for green projects.

> Example: Saudi Arabia's leading digital wallet, offers cashless payment solutions that reduce the need for physical infrastructure, printed currency, and manual processing. By digitizing financial services, STC Pay promotes resource efficiency, dematerialization, and supports the transition to a low-carbon, digital economy—key enablers of the circular economy and sustainable consumption.

B. RegTech

Regulatory Technology (RegTech) efficiently facilitates regulatory compliance processes. Initially a subset of FinTech, it now extends to many sectors, including the environment. RegTech solutions provide transparency on the carbon footprint of businesses across value chains, empowering the circular economy, sustainable competitiveness, and SDGs.

> Example: a Saudi-based open banking platform, enables secure financial data sharing and digital KYC in compliance with SAMA regulations. By automating compliance and reducing the reliance on paper-based verification, Lean's RegTech solutions support resource efficiency, transparency, and regulatory alignment for financial institutions—empowering a more circular and responsible financial ecosystem.

C. AgriTech

AgriTech combines IoT, AI, big data, robotics, satellites, and drones to improve agricultural yield profitability and efficiency.

DIGITALLY EMPOWERED CIRCULAR BUSINESS MODELS

> Example: a Saudi AgriTech pioneer, uses solar-powered greenhouses and saltwater-based agriculture to reduce freshwater consumption by up to 90%. Their circular approach minimizes resource inputs, cuts waste, and enhances food security in water-scarce environments—supporting sustainable agriculture and circular value creation in the Kingdom.

Water Sector Example:

AgriTech solutions can precisely monitor soil moisture and weather patterns to optimize irrigation schedules, significantly reducing water consumption in agriculture and preventing runoff.

D. SpaceTech and ClimateTech

SpaceTech, including Earth observation technologies, provides crucial information about Earth's systems. ClimateTech leverages these insights with AI, big data, and IoT to offer prognoses and predictions for preventive measures against natural disasters, supporting sustainable mobility, supply chains, and urban resilience.

> Example: leverags satellite data, AI, and predictive models to improve weather forecasting and disaster preparedness. By enabling better resource planning and risk reduction, these ClimateTech solutions help industries lower energy use, prevent waste, and build resilience—contributing to circular economy principles of efficiency, prevention, and adaptation.

Water Sector Example:

Satellite data from SpaceTech can monitor water levels in reservoirs, snowpack for future melt, and even detect large-scale unauthorized water diversions, contributing to water security and efficient management. ClimateTech can predict drought severity or flood risks, allowing water utilities to prepare and manage water resources more effectively.

2. Everything as a Service (XaaS) Business Models

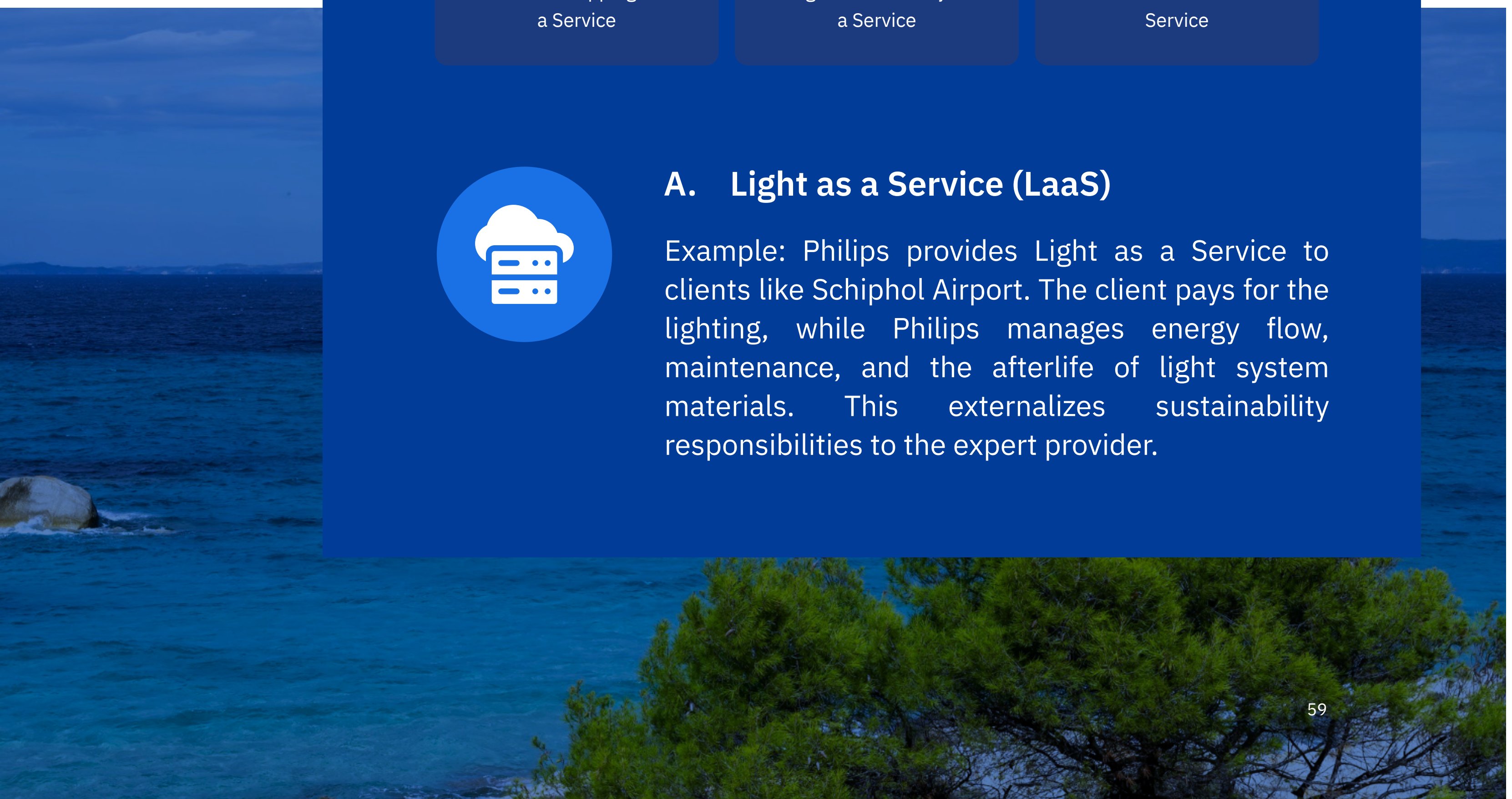
Everything as a Service (XaaS) is a field in technologically empowered business model innovation where performance and results are delivered as a service, rather than selling the product it self. This reduces costs and improves efficiency. XaaS solutions promote sustainable competitiveness and reduce carbon footprints in operations.

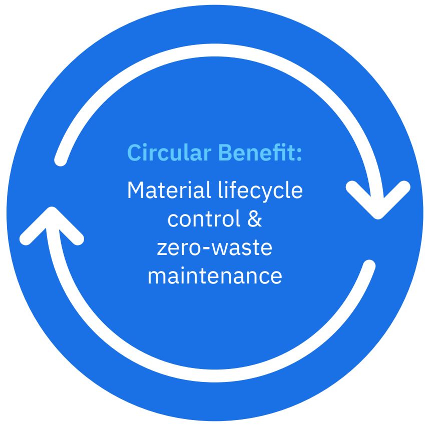
Types of XaaS:

SaaS Software as a Service	**Paas** Platform as a Service	**Iaas** Infrastructure as a Service
LaaS Light as a Service	**Alaas** Artificial Intelligence as a Service	**IoTaas** Internet of Things as a Service
Virtual Shopping Virtual Shopping as a Service	**ARaas** Augemnted Reality as a Service	**Baas** Blockchain as a Service

A. Light as a Service (LaaS)

Example: Philips provides Light as a Service to clients like Schiphol Airport. The client pays for the lighting, while Philips manages energy flow, maintenance, and the afterlife of light system materials. This externalizes sustainability responsibilities to the expert provider.





B. Artificial Intelligence as a Service (AIaaS)

AIaaS solutions use data to capture information and derive insights in order to provide efficient solutions to the customer. AIaaS solutions leverage the power of AI to deliver diverse types of enterprise solutions such as robotic process automation in manufacturing, marketing and sales such as chatbots, and data security solutions for adaptive rewalls, HR and talent management, and customer management solutions. They bring cost reduction and save the overall energy consumption in AI training by delivering performance and results so that clients do not need to implement AI solutions in house but instead, outsource the service. The AIaaS market is predicted to grow over the next couple of years at a CAGR of above 40%.

- Chatbots
- Cybersecurity
- RPA in manufacturing
- Talent & customer management
- Reduces energy used in AI training

C. Internet of Things as a Service (IoTaaS)

The Internet of Things as a Service (IoTaaS) supports clients through the provision of specialized sensors and the required services in different contexts, such as the growing markets of smart home and smart cities solutions.

Monitoring, reporting, and improving security and energy consumption are among the rapidly growing markets. The convergence of IoT as a Service, Big Data as a Service, and AI as a Service have significant applications in intelligent manufacturing.

Water Sector Example:

IoTaaS can enable Water Quality Monitoring as a Service, where real-time sensors continuously track key water quality parameters—such as pH, turbidity, and chlorine levels. Service providers analyze the data remotely and provide alerts, ensuring compliance with regulatory standards while optimizing chemical usage and improving public health outcomes.

D. Virtual Shopping as a Service

Virtual shopping as a Service and phygital retail is another example of technologically empowered business model innovation. The convergence of virtual reality with online shopping provides a virtual shopping experience which simulates the experience of traditional shopping with a significant reduction of energy and cost for improved supply chains and inventory management.

Example: TESCO , trigo , and retailVR implemented this model in South Korea and installed digital shelves in bus and train stations and other highly frequented public spaces. Customers simply scan the QR code of the products and place their orders to be delivered at home. Most of the orders are placed around the peak commute hours, bringing shopping closer to the busy working population while drastically reducing costs of customer acquisition for Tesco.

E. Augmented Reality as a Service (ARaaS)

Augmented Reality as a Service (ARaaS) can help with maintenance and repair of machinery to extend the lifecycle of products and cut the consumption of energy and resources in sending the products back and forth to repair shops. Such business models empower consumers to take better care of their products and get more value for the investment, while positioning the brand as responsible, environmentally friendly, and customer centric.

Benefits: Reduces unnecessary travel and associated emissions while saving cost and time for the client and the company.

Water Sector Example:

ARaaS can provide step-by-step visual instructions to maintenance technicians repairing complex water pumps or filtration systems in the field, reducing errors, training time, and the need for multiple site visits.

Example: a California-based rm, has designed an augmented reality 'smart helmet' for waste management, comprising a headset, inertial measurement unit, multiple cameras[1], and thermal imaging to allow identi cation of useful materials and help with manual sorting from piles of waste. Scope, a Canadian rm, uses AR to provide WorkLink Smart Instructions, replacing paper-based instructions for tasks like mounting, assembling, disassembling, repair, maintenance, and handling dangerous waste and hazardous materials.

F. Blockchain as a Service

Blockchain as a Service has remarkably interesting applications in a variety of industries such as supply chain management, fashion, agriculture, mining, banking, academia, public services, and consumer goods. Blockchain facilitates the traceability of materials from sourcing, production, distribution, and afterlife. It delivers accountability and transparency as some cornerstone requirements in achieving the SDGs, improving sustainable competitiveness, and the transition to the circular economy.

Circularise provides traceability of materials and product lifecycle tracking, advanced analytics, and automated reporting on compliancy, using QR, NFC, and RFID to record product information on blockchain. Porsche uses Circularise's solution to enhance supply chain management and track carbon footprint in operations.

The De Beers Group uses the Track solution to tag and track diamonds from the mine to the buyer. EverLedger is another BaaS provider for high-value goods like diamonds, used by Rare Carat to ensure sustainably and ethically sourced products from conflict-free sources.

In the fashion industry, BaaS solutions use QR, IoT, and RFID to promote sustainable production and consumption. EON has launched a digital product ID that embeds brand, size, color, manufacturer, and retail price of a garment, and a digital material ID with information on material content, dye process, and thread type. Provenance uses integrated smart labels (QR codes) providing blockchain-secured digital history of garments from farm to assembly, and information on recyclability. Seal provides trust and product authentication via NFC technology for authenticity verification of registered objects on its blockchain network.

Ford and LG Chem use IBM's BaaS solution to track cobalt used in their lithium-ion batteries sourced from the Democratic Republic of Congo.

Water Sector Example:

BaaS can be used to track the origin and lifecycle of critical water infrastructure components (e.g., pipes, valves, membranes) to ensure responsible sourcing, verify recycled content, and facilitate end-of-life recycling or remanufacturing. It can also enhance transparency in water quality data by recording it on an immutable ledger.

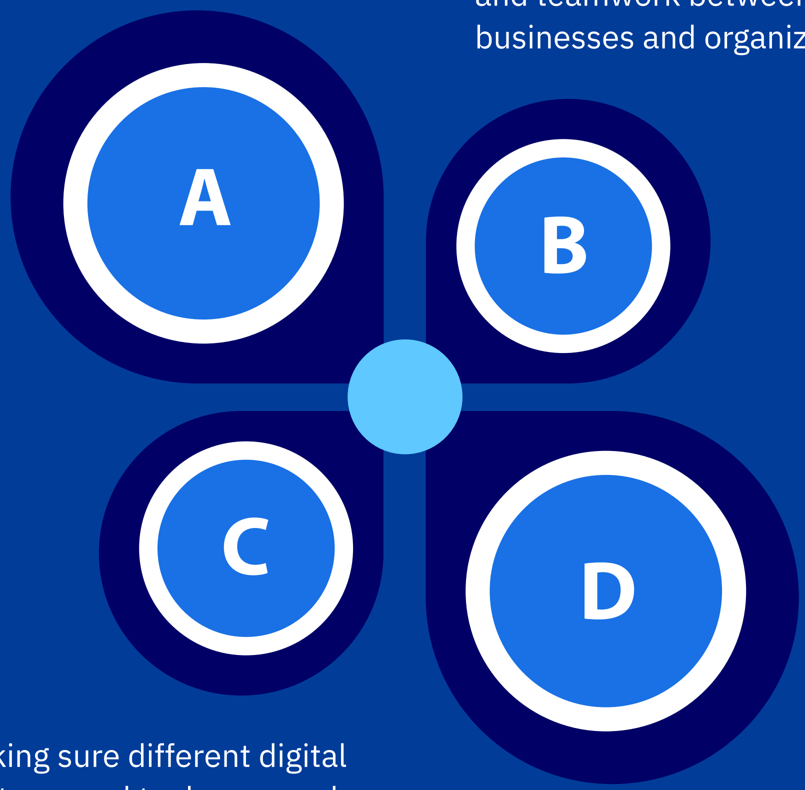
3. Digitally Empowered Multistakeholder Ecosystems

The economy is made up of many connected systems, businesses, and communities that rely on each other. Technology is helping these connections grow stronger, bringing people, markets, and industries closer together.

To successfully move toward a circular economy and achieve sustainability goals, it is important to build strong networks where different groups work together. This means:

Connecting digital, physical, and natural systems.

Improving communication and teamwork between businesses and organizations.



Making sure different digital systems and tools can work well together.

Sharing knowledge, increasing trust, and ensuring transparency through digital tools.

Efficient data management is key to this process. Data from different systems must be consistent, secure, and transparent. Technologies like blockchain can help by:

- Tracking environmental impact.
- Preventing data from being lost or changed.
- Making supply chains more open and accountable.

In the circular economy, businesses cannot work alone. Every company is part of a bigger system where materials and products move in cycles instead of being thrown away. Smaller companies must work together in a coordinated way to keep materials flowing and create shared value.

Even if one business operates in a simple, linear way, it still plays an important role in the wider circular system. Together, these companies help build a sustainable economy where resources are reused, waste is reduced, and benefits are shared.

Efficient data management requires coherence and compatibility across digital infrastructure, assets, and systems (e.g., Cloud, decentralized, and distributed systems). Transparency (e.g., via blockchain for environmental footprint) and data integrity (e.g., via blockchain to prevent data omission) are crucial elements for effective strategies in a circular economy. Accountability via blockchain is another factor often absent in linear economic models due to lack of systemic transparency requirements. Security of data is a major concern where tamper-proof technologies like blockchain can significantly help with a functional digital economy.

The interconnection of technology, the circular economy, sustainable competitiveness, the SDGs, multistakeholder ecosystems, policy initiatives and strategies, and business model innovation is essential. The transition to the circular economy is heavily dependent on multistakeholder engagement within well-functioning ecosystems. Businesses and companies cannot be circular in isolation; a closed-loop economy requires harmoniously coordinated processes run by various well-connected smaller entities systematically collaborating toward commonly agreed values. Each smaller entity might be seen as a linear subsystem in isolation, but as part of an ecosystem, it contributes to forming the value cycles for the flow of materials within a circular economy.

4. Bioplastics and Alternative Materials

Bioplastics are materials that are either bio-based, biodegradable, or both. Examples include PLA, PHA, and PBS. These materials offer solutions to reduce dependency on fossil-based plastics. However, biodegradability often depends on specific industrial composting conditions. Saudi Arabia is a high per-capita plastic consumer. Efforts like SASO's biodegradable plastic standards are helping shift to better alternatives.

5. Smart Waste Technologies

Emerging technologies, including smart bins (IoT), AI sorting, and robotics, enhance waste collection efficiency, reduce labor, and improve the purity of recyclables. In KSA, cities like Riyadh and Jeddah are testing smart segregation models and robotic sorting in collaboration with private sector partners.

Activation Plan: Path 5: Digital Innovation for Circular Business Models

Digital innovation enables entities to transition toward service-based and performance-based models that deliver measurable outcomes. Entities are encouraged to pilot Everything-as-a-Service models, adopt smart contracts, and leverage AI-enabled analytics to create financial and operational benefits. This guidance note outlines how digital innovation should be aligned with circular outcomes to accelerate adoption across the Saudi water sector.

Key Digital Innovation Models with Practical Applications

Everything-as-a-Service (XaaS)

- **Action 1: Review IT Contracts**

  When renewing or starting new contracts for IT systems, software, or cloud storage, opt for a service-based model (SaaS or IaaS) instead of purchasing licenses and equipment outright. This is a low-risk, immediate step.

- **Action 2: Pilot a "Performance-as-a-Service" Contract**

  Begin by piloting a service-based contract for a non-critical asset, such as a pump. Instead of paying for the pump itself, pay for a guaranteed performance outcome, such as "liters of water pumped per hour." This incentivizes the supplier to provide a durable and reliable product.

FinTech / Pay-per-Use Models

- **Action 1: Pilot a Mobile Billing & Alerts System**

  Use existing mobile payment and communication platforms to send real-time billing updates and consumption alerts to high-volume water users, such as farms or industrial estates. This simple feedback loop can encourage more efficient use.

- **Action 2: Pilot a Prepaid Water Model**

  . For a small group of non-critical users, test a prepaid water model. Users can load credit onto an account, which is then depleted as they consume water. This approach makes consumption more visible and manageable.

RegTech (Digital Compliance)

- **Action 1: Digitize Reporting Templates**

  Convert all regulatory reporting templates—from water quality logs to waste disposal records—into a standardized digital format, such as a cloud-based spreadsheet or a simple internal database.

- **Action 2: Align with SWA Standards**

  Align your internal digital reporting templates with SWA (Saudi Water Authority) reporting standards to ensure a seamless transition to future centralized digital platforms.

AgriTech / SpaceTech for Water

- **Action 1: Share Existing Data**

  Partner with national satellite and meteorological centers to access and share existing water-use and weather data. Use existing digital channels, like a mobile app or a simple email newsletter, to provide farmers with insights on optimal irrigation schedules.

- **Action 2: Host a Data-Driven Workshop**

  Organize a simple, no-cost workshop for agricultural partners. Demonstrate how they can use publicly available satellite imagery or weather data to improve their water efficiency, and explain the link between efficiency and circularity.

Blockchain-as-a-Service (BaaS)

- **Action 1: Initiate a BaaS Pilot**

  For one specific reuse project (e.g., providing treated water to an industrial park), use a BaaS platform to track the water's volume, quality, and delivery, ensuring a transparent record from treatment to end-use.

- **Action 2: Track Recycled Material Transactions**

  When a tender is issued for the recycling of old assets (e.g., pipes or membranes), use a BaaS platform to create a secure, verifiable record of the transaction, building trust in the recycling process.

Quick Wins Roadmap

0–1 Year

Now:
The focus is on foundational actions that require no extra cost. This includes reviewing IT and hardware contracts to incorporate service-based clauses, digitizing all reporting templates, and creating a simple system to share existing water-use data with external partners.

2-3 Years

Medium Term:
These actions build on the initial steps and involve low-cost pilots. This includes piloting a pay-per-use billing system with a limited number of users, and initiating a small-scale BaaS pilot for a single material or water stream.

4+ Years

Long Term:
This stage involves a full-scale digital and circular transformation. It includes a full transition of key asset procurement to XaaS models and collaboration with the SWA to establish a sector-wide digital ecosystem for circularity, fully aligning with Saudi Vision 2030 and the National Water Strategy (NWS).

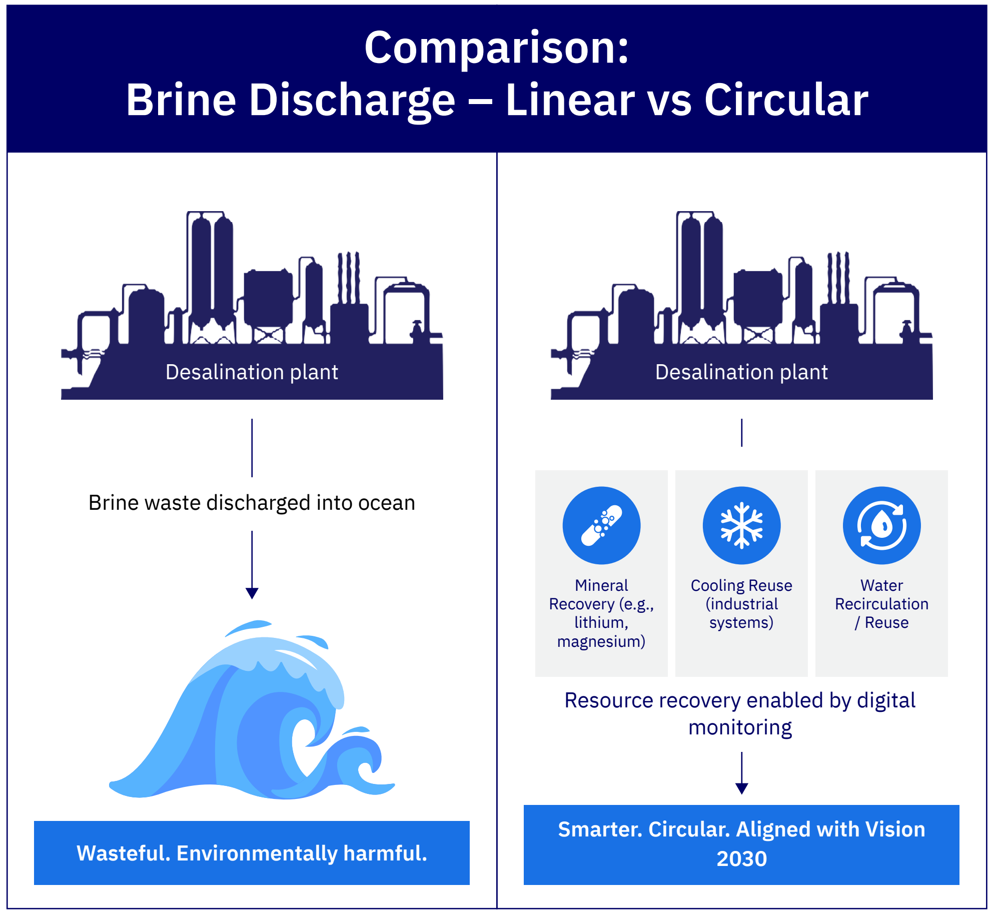
Implementation Tools

- Roles & Ownership: Procurement, IT/Digital Teams, Finance.
- 3 KPIs: % of new tenders with service-based clauses, revenue from reuse, stakeholder trust score.
- Evidence Log: Baseline → 6 months → 12 months.

Appendix References

Appendix

- New technologies are creating new ways of doing business. Digital tools, data, and innovation are helping organizations work more efficiently and sustainably, while also opening doors to new business models and services.
- To stay ahead, organizations need to understand how technology is reshaping markets, services, and supply chains. Keeping up with these changes is essential for building resilience and long-term success.
- Business models like FinTech, AgriTech, RegTech, ClimateTech, and “as-a-service” solutions (such as Software as a Service or Blockchain as a Service) are changing how we create and deliver value. These approaches can make industries more sustainable, efficient, and adaptable.
- Moving toward a circular economy is not only good for the environment—it also creates social and economic benefits. Everyone across the value chain has a role to play in making this transition happen.
- Digital solutions like AI, blockchain, IoT, and platform technologies can help organizations collaborate better and apply circular economy principles. However, many projects still face challenges with scaling, cost, and system integration.
- Successful circular economy transformation requires collaboration. No single company or organization can do it alone. Working together across industries, sectors, and communities is key.
- Even small steps matter. Building circular thinking into products, services, and infrastructure—little by little—helps close resource loops over time and supports national sustainability goals.
- Accelerating the use of digital technologies alongside circular strategies will help organizations stay competitive, create new business opportunities, and contribute to a more resilient future.



Barriers to Circular Economy

Implementing a circular economy faces several common barriers:

Regulatory

Existing laws may not permit the reuse of certain materials or may have restrictive waste definitions.

Financial

High upfront costs for new technologies or infrastructure can deter investment in circular systems.

Organizational

Lack of internal coordination, siloed departments, or resistance to change can slow implementation.

Consumer

Resistance to reused or recycled products, particularly in sensitive areas like water reuse, can hinder adoption.

Value Chain

Suppliers may not offer circular options, or there may be a lack of collaboration across the value chain.

Technical

Missing or non-localized technologies and infrastructure can block progress.

What SWA can do:

- Identify barriers in operations and supply chains.
- Prioritize pilot projects in low-risk areas to gain experience and build confidence.
- Update procurement frameworks to require circular criteria, creating market demand for circular solutions.

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