الهيئة السعودية للمياه
Saudi Water Authority

Operational Excellence

in the Water Value Chain in the Kingdom of Saudi Arabia

In partnership with Metyis

Table of contents

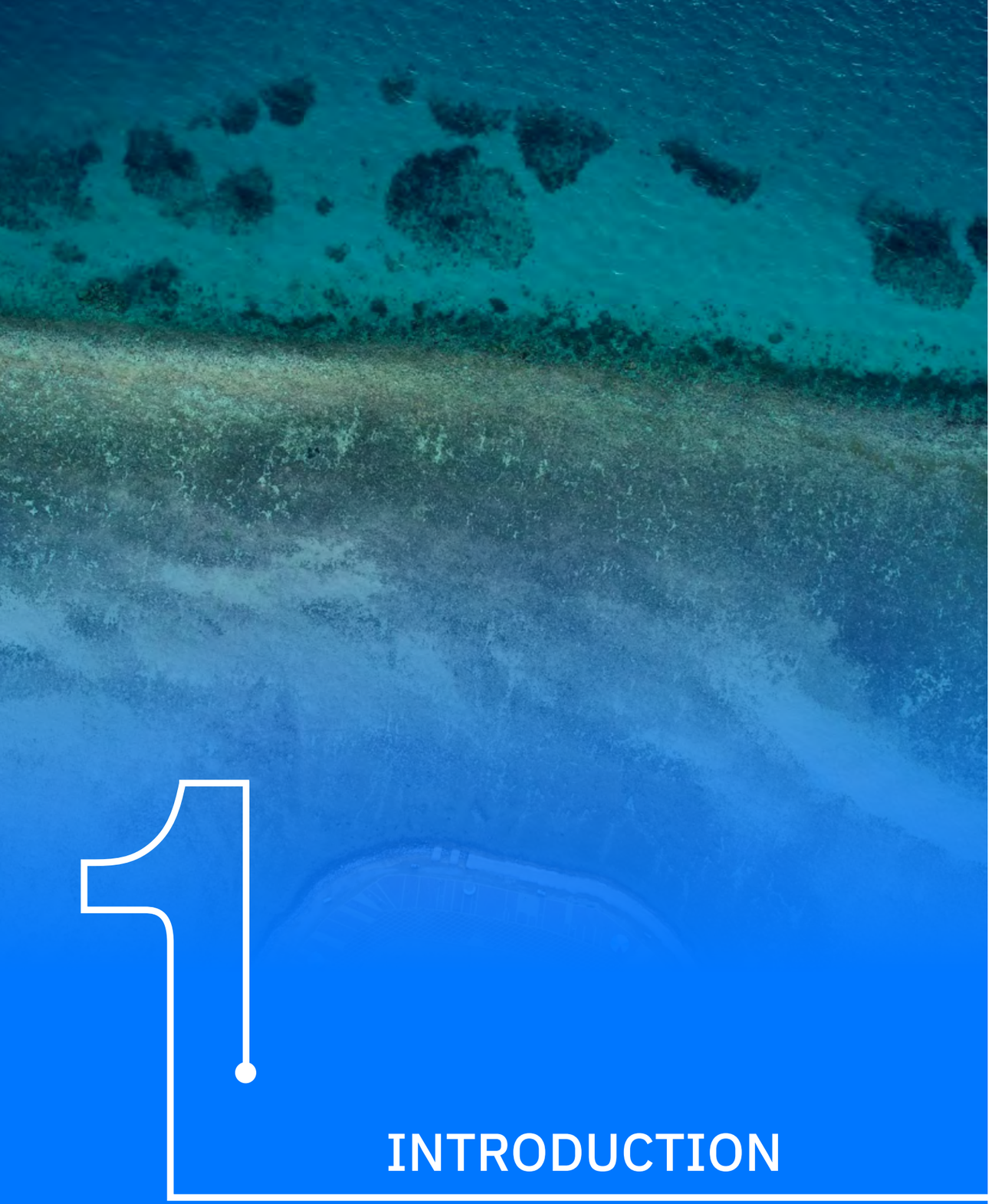
Executive
Summary

This report provides a comprehensive examination of operational excellence within the critical water value chain of the Kingdom of Saudi Arabia. Acknowledging the essential role of efficient and sustainable water management in achieving the Kingdom's development objectives outlined in Vision 2030, this study aims to investigate the principles, practices, and performance outcomes of key entities engaged in this sector. The primary goal is to identify and analyze the best practices that foster operational excellence, thereby offering valuable insights for ongoing improvement and broader adoption across the industry.

The report employs a robust methodology that includes literature reviews, document analysis, expert interviews, and key performance indicator assessment. It concentrates on eight entities that are integral to the Saudi Arabian water value chain. These entities encompass organizations pivotal to the Saudi water sector, including operational, regulatory, and other significant stakeholders. A detailed examination of the specific roles and responsibilities of these entities within the overarching water value chain provides the contextual foundation for the identification of best practices.

The findings for this report are presented as best practice case studies from the eight participating entities. Each case study elaborates on the challenges encountered, the implementation strategies employed, the outcomes achieved, and the key lessons learned. These examples encompass various operational excellence initiatives, ranging from advanced water treatment technologies and infrastructure management to regulatory frameworks and competency development programs. The report underlines the necessity of a structured approach to operational excellence, accentuating key concepts and success factors pertinent to the water sector.

In addition, the report features insights and examples that highlight the common themes and success factors identified across the various case studies. This aims to uncover broader patterns and principles that drive operational excellence in the Saudi Arabian water sector, such as the strategic application of technology, the significance of stakeholder engagement, and a commitment to continuous improvement. The report's concluding section presents a series of overarching recommendations designed to promote and sustain operational excellence throughout the water value chain, thereby contributing to the Kingdom's long-term water security and sustainability objectives.



1

INTRODUCTION

01
Introduction

Entities within the water value chain implement various strategies to enhance operational efficiency, minimise costs, and adopt sustainable practices essential for securing water resources in a nation facing limited water availability and increasing demand. Identifying critical success factors and emphasising lessons learned from case studies involving participating organisations is vital for providing actionable recommendations. These elements are integral to fostering a culture of continuous improvement within the organisations.

Achieving operational excellence in the water sector is vital for promoting sustainable, reliable, and efficient water management. This analysis examines the various entities engaged in Saudi Arabia's water sector, delineating their roles and contributions towards advancing operational excellence. The organisations involved in this study represent essential components of the water value chain, which includes water supply, desalination, transmission, conservation, wastewater treatment, and agricultural irrigation efficiency.

Emphasis is placed on the practical applications these entities have integrated into their operations. This includes adopting emerging technologies, process optimisation, and innovative water management practices. The case studies presented highlight the pivotal role of these practices in fostering operational excellence and ensuring the long-term sustainability of the water sector in Saudi Arabia.

Methodology and Approach

This report employs a qualitative research methodology centred on collecting and analysing case studies and data from eight entities engaged in water management across Saudi Arabia. The methodological approach comprises the following components:

01 **Document review:** a comprehensive review of existing literature on operational excellence was conducted to provide a foundational understanding of the concept defined by field experts. This review contextualises the study within the broader discourse on operational excellence, particularly within the water sector.

02 **Entity analysis and case selection:** each participating entity's internal and external documents were in-depth analysed. This analysis includes annual reports, strategic assessments, and technical publications detailing specific operational practices. This comprehensive review ensures that the findings are grounded in an accurate and nuanced understanding of each entity's operations.

03 **Expert meeting:** meetings were held with key decision-makers within each organisation. These meetings provided expert insights into the strategies and practices implemented by each entity, adding depth to the report's findings and enhancing its credibility.

04 **Performance indicator analysis:** the study also analysed key performance indicators (KPIs) associated with each case. This quantitative evaluation assessed the improvements achieved by each entity and the extent to which these advancements contribute to operational excellence.

The selection of case studies was guided by the principle of encompassing all major entities within the Saudi Arabian water value chain. This included organizations with key roles in water supply, desalination, transmission, conservation, wastewater treatment, and agricultural irrigation efficiency. The participating entities were identified based on their significance and contribution to the sector's operational excellence objectives, ensuring a comprehensive representation of the diverse activities involved in managing water resources in the Kingdom. Because of this, it is important to acknowledge certain limitations inherent in this study. The information presented in the case studies relies, in part, on self-reported data provided by the participating organizations. While efforts were made to corroborate this information through document review and expert meetings, the potential for reporting bias cannot be entirely excluded.

By integrating these methodological components, this report comprehensively examines best practices and success factors in operational excellence across Saudi Arabia's water value chain.

Participating entities and their roles in Saudi Arabia's Water Value Chain

The water value chain in the Kingdom of Saudi Arabia (KSA) is a critical infrastructure encompassing a series of interconnected processes designed to ensure sustainable, efficient, and reliable water management across a country facing significant resource challenges.

Given the arid climate, limited freshwater resources, and a rapidly growing population and industrial sector, efficient water resource management is vital for KSA's long-term environmental and economic sustainability. To address these challenges, the Kingdom's water value chain has evolved into a complex network involving various governmental and private sector entities, each with specific roles to optimise different aspects of water management.

This report is built on collaboration with eight key entities within KSA's water sector, each contributing to a comprehensive approach to operational excellence.

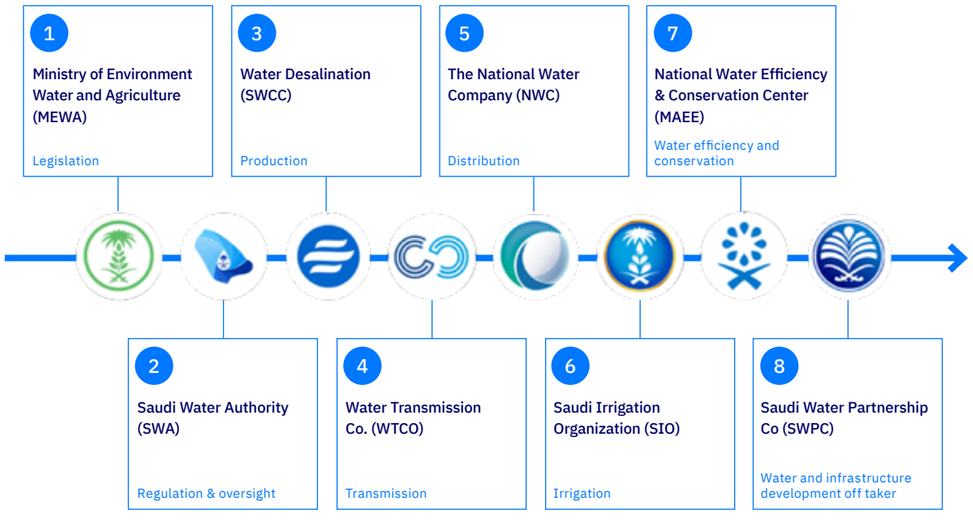


Figure 1 . Saudi Arabia's Water Value Chain

These entities represent distinct but interconnected roles across the entire water value chain, from legal oversight and regulatory oversight to desalination, transmission, distribution, irrigation, and conservation. Their combined efforts demonstrate the strategic alignment needed to address KSA's water security challenges and promote sustainable water practices.

Ministry of Environment, Water and Agriculture (MEWA):

MEWA is central to creating the legal framework governing water management in Saudi Arabia. The ministry develops and enforces comprehensive laws and policies that regulate all aspects of water use, conservation, and sustainability, setting standards for quality, usage, and environmental impact. Through legislative oversight, MEWA ensures that the water sector operates within a clearly defined legal framework, promoting accountability and supporting the long-term sustainability of water resources.

Saudi Water Authority (SWA):

SWA provides regulatory oversight and oversight across the water sector. Their role includes ensuring compliance with water regulations, monitoring water quality, and supervising water resource management. SWA's regulatory framework helps maintain high service standards and ensures that water providers adhere to best practices in water management, thereby enhancing operational efficiency and effectiveness.

This report features three pivotal sub-entities within the SWA framework, recognising their significance within the value chain. The first entity, the Water Technologies Innovation Institute & Research Advancement (WTIIRA), is vital in advancing technological innovation and developing research-based solutions.

The second entity, the Water Academy, is an essential facilitator of human capital development, concentrating on capacity building and knowledge transfer to enhance operational competencies across the water sector. Together with the third entity, the operational arm of SWA, these entities foster operational excellence through their distinct yet complementary functions.

Water Desalination (SWCC):

The operational arm of SWA, Water Desalination (SWCC), is pivotal in producing desalinated water, a critical resource for Saudi Arabia. By leveraging advanced desalination technologies, Water Desalination ensures a reliable freshwater supply. Their focus on innovation and efficiency in water production reduces costs and enhances the sustainability of water resources. SWCC's commitment to operational excellence is evident in its continuous improvement initiatives and adoption of cutting-edge technologies.

Water Transmission Company (WTCO):

WTCO manages water transmission from production sites to distribution entities. Their operations include maintaining and optimising the infrastructure for water transport. By employing state-of-the-art technologies and best practices in pipeline management, WTCO ensures efficient and reliable water transmission. This ensures water reaches its destination with minimal waste, contributing to overall operational excellence.

National Water Company (NWC):

NWC manages water distribution to residential, commercial, and industrial users, focusing on network maintenance, customer service, and efficient distribution systems. By intelligent metering and advanced distribution management systems, NWC ensures that water is delivered effectively and reliably while minimising disruptions. NWC's operational strategies are committed to optimising water delivery and enhancing user satisfaction across sectors.

Saudi Irrigation Organization (SIO):

Focused on agricultural irrigation, SIO is vital to the sustainability of Saudi Arabia's agricultural sector. SIO maximises water use in agriculture by developing and promoting efficient irrigation methods, one of the country's largest water-consuming sectors. SIO's initiatives encourage water-saving techniques and sustainable practices, supporting conserving precious water resources and enhancing water-use efficiency in agriculture.

National Water Efficiency & Conservation Centre (MAEE):

MAEE is dedicated to water conservation and efficiency, fostering a culture of sustainable water use across the Kingdom. Through public awareness campaigns, research on water-saving technologies, and conservation programs, MAEE promotes water efficiency practices within both residential and industrial sectors. MAEE helps reduce water waste and promotes sustainable use of water resources. Their efforts ensure that water conservation becomes an integral part of the operational strategies of all water sector entities.

Saudi Water Partnership Company (SWPC):

By fostering collaborations between the public and private sectors, SWPC aims to enhance the availability, efficiency and sustainability of water services in Saudi Arabia. SWPC is the Principal Buyer / Offtaker of waters, responsible for purchasing desalinated, purified, treated, and untreated water and co-generation projects, for onsell to NWC. As the Procurer, the company is mandated to tender water projects to the private sector on PPP model including desalination, strategic water reserves, transmission pipelines and sewage treatment. SWPC services encompass the entire project lifecyle from preparation to tendering to construction management, to contracting and risk management.

Collectively, these entities form a cohesive framework essential to advancing Saudi Arabia's Vision 2030 objectives for sustainable water management and resource efficiency. By executing their distinct roles across the water value chain—from regulatory oversight and desalination to conservation and agricultural sustainability—each organisation plays a pivotal part in achieving the Kingdom's vision of a secure, sustainable, and innovative water sector. Their combined efforts contribute to operational excellence and the long-term resilience of Saudi Arabia's water infrastructure, aligning with Vision 2030's goal of transforming essential sectors to meet future demands sustainably. The subsequent sections will explore specific practices and case studies from each entity, illustrating how their initiatives collectively reinforce the water sector's alignment with the ambitious objectives of Saudi Vision 2030.

2

REPORT'S OBJECTIVES

02
Report's
Objectives

The primary aim of this report is to conduct a comprehensive investigation and analysis of the principles and practices of operational excellence (OE) as implemented by organisations within the water value chain in the Kingdom of Saudi Arabia. This report intends to elucidate how these practices enhance efficiency, sustainability, and resilience within the water sector, a cornerstone of the nation's broader environmental and economic development initiatives.

A significant objective of this study is to define operational excellence in both theoretical and practical contexts, examining its fundamental principles and success factors. This investigation includes situating OE within the broader framework of organisational performance enhancement while emphasising its relevance and adaptability to the unique challenges faced by the water sector. This endeavour will establish a conceptual framework that underpins the subsequent analyses.

Another critical goal is to highlight the importance of operational excellence within the water sector by addressing its vital function in confronting pressing challenges such as resource scarcity, escalating demand, and the necessity for environmentally sustainable practices. In this manner, the report underscores the alignment of OE initiatives with Saudi Arabia's strategic objectives related to sustainable development and water security.

Furthermore, the report seeks to articulate a cohesive vision of the water value chain concerning operational excellence. This includes examining how organisations across the value chain collaborate and synchronise their operational priorities to achieve efficiency, reliability, and sustainability goals.

Finally, the report aspires to illustrate these principles by analysing specific initiatives undertaken by key stakeholders within the water value chain. The report demonstrates how these organisations have effectively implemented OE strategies by presenting concrete case studies and showcasing practical applications that reflect continuous improvement, technological innovation, and process optimisation.

Through these objectives, the report aims to contribute to the broader discourse on achieving sustainable water management in the Kingdom of Saudi Arabia.

3

OPERATIONAL EXCELLENCE AND ITS IMPACT ON THE WATER SECTOR

03
Operational Excellence and its impact on the water sector

The optimisation of operational processes has become a critical success factor for organisations across all sectors, particularly in utility companies where service reliability and resource efficiency are paramount. This chapter explores the Operational Excellence (OE) concept, first by examining its theoretical foundations and evolving definitions in organisational practice and then by analysing its specific significance in the water sector.

For this reason, the chapter is structured into two main sections: first, a detailed examination of what constitutes Operational Excellence, including its key dimensions and success factors, and second, an analysis of why and how Operational Excellence principles are particularly relevant and applicable to the water sector's unique operational challenges and objectives.

03
Overview of AI application in desalination engineering and technologies

Operational Excellence, key concepts and success factors:

Operational Excellence (OE) has been a fundamental pursuit of enterprises for decades, even before the term became widespread in organisational practice. Initially focused on manufacturing and production environments, the concept has evolved to encompass a broader spectrum of industries and operational contexts, including service organisations, municipalities, military operations, and mission-centred enterprises. The idea gained significant attention following Peters and Waterman's (1982) influential work "In Search of Excellence," which introduced the McKinsey 7S framework integrating both organisational "hardware" (strategy, systems, and structure) and "software" (style, staff, skills, and shared values). While historically focused primarily on operational efficiency, the modern understanding of Operational Excellence has evolved into a more comprehensive organisational paradigm.

In today's volatile business environment, characterised by pressing inflation, market uncertainty, rapid technological advancements, and evolving customer needs (Forliano et al., 2023; Skare et al., 2023), organisations must continuously adapt their operational practices to remain competitive. This complexity, coupled with the accelerating digital transformation of business (Kraus et al., 2022), has made Operational Excellence an increasingly critical organisational capability. Innovation has become an essential strategy for companies to survive and compete in the face of external disruptions (Li et al., 2021), making the pursuit of operational excellence more dynamic and multifaceted than ever before.

The conceptual landscape of Operational Excellence reveals considerable variation in academic literature, reflecting its evolution from a purely efficiency-focused approach to a more comprehensive organisational philosophy. Some scholars view it as an organisational state where employees can identify and rectify value-flow impediments (Duggan, 2011), while others consider it a continuous improvement process focused on customer needs (Martin, 2015). From a strategic perspective, Wiersema and Treacy (1993) frame OE as an organisation's ability to deliver superior quality, price, and service unmatched within their industry.

Perhaps most comprehensively, Seifert and Soto (2013, p. 68) define it as "the execution of business strategy more consistently and reliably than the competition, with lower operational risk, reduced operating costs and higher revenues."

Traditionally, specific metrics measured operational excellence, including actual production throughput compared to maximum potential, energy consumption efficiency, material utilisation rates, and optimal staffing levels. These metrics were to be optimised while maintaining maximum safety standards and minimising environmental impact. However, modern interpretations of Operational Excellence extend far beyond these traditional efficiency metrics to encompass broader organisational capabilities and outcomes.

The path to Operational Excellence is underpinned by systematic and structured adaptation to various business dynamics and stakeholder needs. Organisations typically achieve this through the application of various methodologies and tools, including lean management, total quality management (TQM), Six Sigma, Just-in-Time (JIT), and process re-engineering (McKinsey & Company, 2015). These approaches deliver tangible benefits such as lead time reduction, inventory optimisation, improved organisational performance, and sustainable competitive advantages. The selection and implementation of these methodologies must be aligned with the organisation's specific context, culture, and strategic objectives to be effective.

The significance of Operational Excellence extends beyond manufacturing and production environments to service industries, including hospitality, healthcare, financial services, and insurance sectors. In these contexts, excellence is measured not just in terms of operational efficiency but also in terms of service quality, customer satisfaction, and value creation. This broader applicability has led to developing industry-specific frameworks and approaches to achieving operational excellence while maintaining the core principles of continuous improvement and stakeholder value creation.

However, the journey toward Operational Excellence often faces significant implementation challenges. Despite increasing corporate interest in the OE philosophy, many organisational efforts fail to achieve desired outcomes, and the global level of operational excellence remains suboptimal (Found et al., 2018). This challenge is partly attributed to the lack of consensus in defining and operationalising the concept. As Aguilera and Ruiz (2019) note, many existing definitions, such as "being world-class" or "excellence in everything we do," prove difficult to translate into practical actions. The ambiguity in definition often leads to misaligned expectations, inconsistent implementation approaches, and suboptimal results.

The theoretical landscape of Operational Excellence also reveals several critical gaps that warrant attention from researchers and practitioners. These include the absence of a comprehensive construct definition, unclear theoretical foundations, and difficulties in conceptualisation and operationalisation (Found et al., 2018). Some researchers emphasise operational efficiency (Russell & Koch, 2009), while others focus on organisational culture and problem-solving capabilities (Aguilera & Ruiz, 2019). The Operational Excellence Society (2020) takes a broader view, describing it as enhancing organisational performance and working conditions through deliberate and systematic approaches rather than chance.

This cultural dimension of Operational Excellence has gained increasing recognition in recent years. This statement indicates that successful OE implementation requires more than just tools and methodologies; it necessitates a supportive organisational culture that encourages continuous improvement, problem-solving, and innovation. This cultural aspect is particularly evident in definitions that emphasise the role of employees in identifying and solving problems (Aguilera & Ruiz, 2019). The development of such a culture requires leadership commitment, employee engagement, and systematic approaches to capability building and knowledge management. Moreover, technology is increasingly crucial in pursuing Operational Excellence, particularly in Industry 4.0 and digital transformation.

Advanced analytics, artificial intelligence, the Internet of Things (IoT), and other digital technologies enable new approaches to achieving and sustaining operational excellence. These technologies give organisations unprecedented capabilities for real-time monitoring, predictive analytics, and data-driven decision-making, fundamentally changing how operational excellence is pursued and maintained.

In this sense, it can be appreciated that while Operational Excellence began as a pursuit of superior operational efficiency - measured through production throughput, energy consumption, material usage, and optimal staffing - it has evolved into a more holistic organisational capability. As a result, modern interpretations emphasise efficiency metrics and the organisation's ability to execute strategy consistently, foster a problem-solving culture, and deliver superior value to stakeholders. This evolution reflects the increasing complexity of the business environment and the need for organisations to develop comprehensive approaches to excellence that integrate operational, cultural, and strategic dimensions.

The ongoing challenge for organisations lies in translating these theoretical understandings into practical implementations that can deliver sustainable competitive advantages in an increasingly dynamic business environment. This challenge is particularly relevant as organisations navigate digital transformation, market volatility, and evolving stakeholder expectations, making the pursuit of Operational Excellence more complex and crucial than ever. Success requires a balanced approach that considers technical, cultural, and strategic elements while focusing on continuous improvement and stakeholder value creation.

The concept of Operational Excellence will likely continue to evolve as organisations face new challenges and opportunities. The integration of sustainability considerations, the increasing importance of digital capabilities, and the growing focus on organisational resilience will likely shape future interpretations and approaches to achieving operational excellence. This evolution underscores the need for continued research and practical innovation in Operational Excellence.

Importance of Operational Excellence in the water sector:

The water sector is vital in sustainable development and public health, making operational excellence crucial. Water utilities face unique challenges, including ageing infrastructure, increasing regulatory requirements, climate change impacts, and growing demand for water resources (Sarni & Sperling, 2020). In this context, operational excellence becomes a business and social necessity, directly impacting community well-being and environmental sustainability.

The financial implications of Operational Excellence in the water sector are significant and well-documented. According to the World Bank (2021), global investment needs in water infrastructure will exceed $114 trillion by 2030, making operational efficiency crucial for financial sustainability. The increasing complexity of water systems operations further complicates this significant investment requirement. Research by Prabhu et al. (2020) demonstrates that water utilities must balance multiple competing objectives: ensuring water quality and supply reliability, maintaining affordable tariffs, and achieving financial sustainability while minimising environmental impact.

Digital transformation has emerged as a critical enabler of operational excellence in the water sector. Stewart et al. (2020) demonstrates that utilities adopting digital technologies such as IoT sensors, advanced analytics, and automated control systems significantly improve operational performance. Their research highlights that digitally mature utilities show superior performance in key operational metrics, including leak detection, energy efficiency, and customer service response times.

Asset management represents a critical dimension of operational excellence in water utilities. Amaral et al. (2021) studied European water utilities, revealing that organisations implementing comprehensive asset management programs within an operational excellence framework significantly reduced maintenance costs while extending asset life cycles. This improvement is particularly significant given the ageing infrastructure challenges utilities face globally.

Implementing operational excellence in the water sector faces distinct challenges. A comprehensive survey by the Global Water Research Coalition (2019) identified several key barriers, including organisational resistance to change, limited resources for improvement initiatives, and difficulty measuring and quantifying benefits. Despite these challenges, utilities that successfully overcome these barriers demonstrate measurable improvements in operational efficiency, reduced water losses, and enhanced customer satisfaction.

Walsh et al. (2019) emphasise the critical role of knowledge management in achieving operational excellence within water utilities. Their research indicates that effective knowledge management practices contribute significantly to operational performance improvements, particularly in maintenance optimisation, process control, and emergency response. This becomes increasingly important as utilities face workforce demographic changes and the need to retain institutional knowledge.

The environmental dimension of operational excellence has gained increasing attention. Berglund et al. (2020) analysed the relationship between operational practices and environmental performance in water utilities, finding that organisations with mature operational excellence programs demonstrated superior environmental outcomes, including reduced energy consumption and improved resource efficiency. Their study highlights the potential for operational excellence initiatives to support sustainability objectives while maintaining operational performance.

Looking ahead, Tortajada and Biswas (2020) argue that the importance of operational excellence will continue to grow as utilities face increasing pressures from climate change, urbanisation, and ageing infrastructure. Success will require continued evolution of operational excellence approaches to incorporate new technologies, address emerging challenges, and meet changing stakeholder expectations while focusing on core service delivery objectives.

4 FRAMEWORK FOR ILLUSTRATING OPERATIONAL EXCELLENCE IN THE WATER SECTOR

Framework for Illustrating Operational Excellence in the Water Sector

Operational excellence within the water sector is fundamental to ensuring sustainable, reliable, and efficient management of water resources. This report explores the various entities involved in Saudi Arabia's water sector, their roles, and how they contribute to operational excellence. The water sector entities are characterised by heterogeneous and complex operations, necessitating a standardised framework for evaluating and classifying operational excellence best practices. The water sector's broad and highly regulated value chain involves institutions with different perspectives. Identifying and understanding best practices for operational excellence is essential while considering diverse stakeholder views throughout the chain.

To ensure an illustrative evaluation of operational excellence, a structured framework was developed that applies to all institutions involved in the water sector. This framework enables consistent and comparable information collection, facilitating understanding and implementing recommendations across diverse entities.

For the aforementioned reasons and due to operational excellence's extensive applicability, it is often necessary to establish an industry-specific framework. In this context, this report aims to illustrate operational excellence by identifying and concentrating on the eight most pertinent dimensions of the water sector. This holistic methodology ensures uniform assessment of all relevant aspects of operational excellence.

A dimension represents a broad area or aspect of operational excellence that requires evaluation. Each dimension can be a component of the organisation's operations. The description provides a detailed context for each dimension, explaining its importance and scope within the operational excellence framework.

As mentioned, the framework encompasses eight dimensions covering operational excellence across the value chain. These dimensions are:

01 The legal and policy framework examines the laws and regulations governing the water sector, ensuring operational efficiency and long-term sustainability.

02 Leadership and accountability focus on institutions' ability to lead the sector with clear vision and responsibility, ensuring alignment between actions and strategic and operational goals.

03 Project and investment management addresses the efficient planning, execution, and monitoring of projects and investments to ensure optimal use of financial resources.

04 Human resources management encompasses efficient personnel management, from hiring processes through continuous professional development, ensuring a well-trained and motivated workforce.

05 Technology and R&D focuses on adopting advanced technologies and investment in research and development to enhance operational processes and drive innovation.

06 Quality and security management addresses implementing systems to ensure operational quality and proactive security management, maintaining high standards while minimising errors.

07 Climate change and sustainability concentrate on adopting practices and strategies to mitigate climate change impacts and promote sustainability in resource management.

08 Stakeholder engagement evaluates the effectiveness of communication and collaboration with stakeholders, involving them in decision-making processes and fostering positive relationships.

Figure 2. Framework for Illustrating Operational Excellence in the Water Sector

This approach allows organisations within the water sector value chain to present their operational excellence practices in a structured manner while still accommodating their specific operational contexts. The framework's standardised methodology promotes meaningful comparisons across different entities while recognising their unique characteristics and requirements.

Consequently, Table 1 delineates the correlation between the cases presented by various entities involved in the water value chain participating in this report and the dimensions established to illustrate operational excellence within the value chain.

	MEWA	SWA	WTIIRA	Water Academy	Water Desalination	WTCO	NWC	SIO	MAEE	SWPC
Legal & Policy Framework	X	X								X
Leadership & Accountability	X	X								X
Project & Investment Mgmt	X						X			X
Human Resources Mgmt				X						
Tech. & R&D			X		X		X	X	X	X
Quality & Security		X			X	X		X		X
Climate Change & Sustainability					X	X		X		X
Stakeholder Engagement		X								X

Table 1. Framework for Illustrating Operational Excellence in the Water Sector

5

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Best Practices for Operational Excellence within the Saudi Arabian Water Value Chain

This section presents a detailed examination of operational excellence initiatives through case studies from crucial Saudi Arabia's water value chain entities. The analysis encompasses transformative projects, strategic implementations, and operational frameworks demonstrating the sector's evolution towards enhanced efficiency and sustainability. Through systematic investigation of these cases, the study provides empirical evidence of both successful implementations and areas for potential improvement, offering valuable insights into the water sector's operational transformation.

Ministry of Environment Water and Agriculture (MEWA)

About MEWA

05
Best Practices for Operational Excellence within the Saudi Arabian Water Value Chain

The Ministry of Environment, Water and Agriculture (MEWA) is the primary authority in the Kingdom of Saudi Arabia and is responsible for managing water resources, advancing agricultural practices, and promoting environmental sustainability. As the principal regulatory body within this sector, MEWA is charged with leading strategic planning and formulating policies to address significant challenges in water resource management, all while ensuring alignment with the objectives outlined in Saudi Vision 2030.

In response to critical sectoral challenges, such as excessive water extraction for agricultural applications, reliance on desalination technologies, and operational inefficiencies, MEWA has established the National Water Strategy 2030. This comprehensive framework encompasses ten distinct programs comprising 55 initiatives, collectively providing strategic direction for the Kingdom's water sector. Through systematic engagement with stakeholders and evidence-based planning, MEWA collaborates with various entities within the water sector to implement integrated solutions designed to achieve water security.

MEWA's commitment to operational excellence is evident through its adoption of advanced technologies and data-driven decision-making processes. This approach facilitates efficient policy implementation and resource allocation and fosters stakeholder collaboration. By utilising sophisticated planning tools and establishing robust monitoring mechanisms, MEWA ensures the effective execution of strategies throughout the water sector's value chain.

Through comprehensive oversight of strategy implementation and ongoing performance evaluation, MEWA actively contributes to the Kingdom's water sustainability objectives while addressing immediate operational concerns. This systematic governance approach and strategic resource optimisation initiatives position MEWA as pivotal in achieving Saudi Arabia's water security goals and promoting environmental sustainability.

05
Best Practices for Operational Excellence within the Saudi Arabian Water Value Chain

Planning of water supply and demand for urban use in KSA

Overview of the Best Practice

In response to the significant challenges articulated in the National Water Strategy 2030, the Ministry of Environment, Water and Agriculture (MEWA) has formulated a comprehensive framework for Supply and Demand Water Planning specifically for urban applications. This initiative represents a systematic approach to optimise water resources by integrating advanced technology and data-driven methodologies.

The framework established by MEWA is centred on urban usage and has been developed through a thorough analysis of international best practices and local requirements. It addresses the complexities inherent in urban water management by examining various dimensions, including the exploitation of water sources, estimation of demand, and optimisation of the supply chain. To commence this project, MEWA has opted to conduct an analysis encompassing several critical dimensions.

05
Best Practices for Operational Excellence within the Saudi Arabian Water Value Chain

Water Source Exploitation

International benchmarking reveals a variety of strategies regarding source utilisation among different nations. Numerous countries emphasise the use of surface and groundwater due to their cost-effectiveness and accessibility. Some nations adopt a strategic approach by preserving groundwater as a natural storage solution while simultaneously enhancing surface water infrastructure through the construction of dams. Advanced methodologies include artificial aquifer recharge and dedicated rainwater collection systems, while other regions focus on desalination to diminish reliance on conventional water sources.

Urban Demand Estimation

Demand forecasting methodologies incorporate various factors, including population statistics, growth rates, seasonal consumption patterns, and historical data. This approach considers urban, commercial, and industrial usage, as well as system losses, and is bolstered by direct flow metering to facilitate the measurement of actual consumption.

Per Capita Consumption Patterns

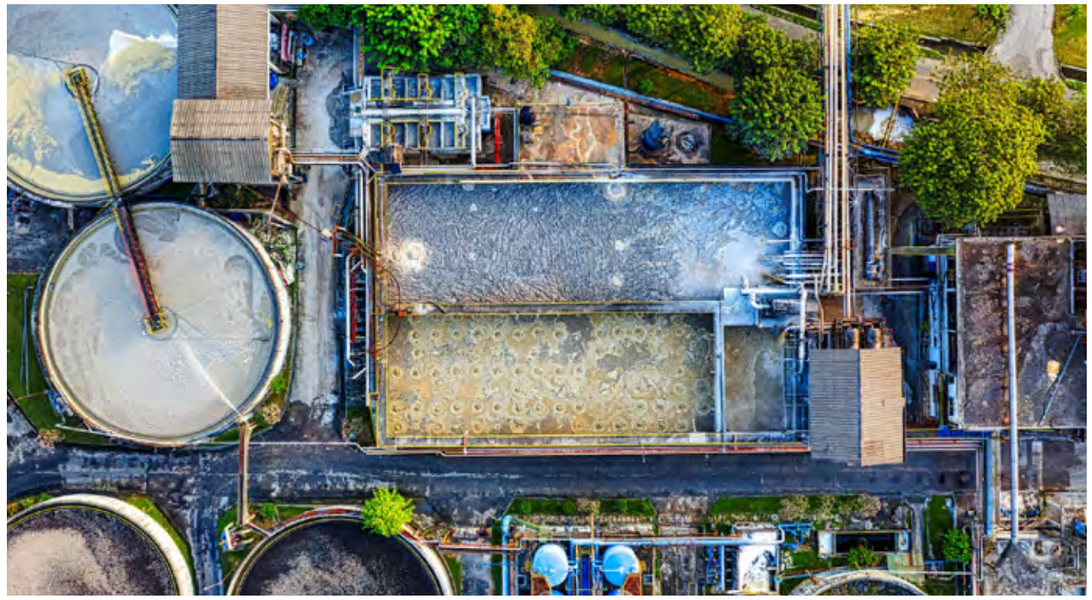
Analysis indicates significant disparities in water consumption across different regions and seasons. For instance, California exhibits a seasonal variation in usage that ranges from 242 to 413 litres per day, while Western Australia maintains an average of 418 litres. In contrast, countries such as Germany, Singapore, and Spain display more conservative consumption levels, with averages of 127 litres, 141 litres, and 142 litres per day, respectively. Numerous nations actively implement initiatives to reduce water consumption, primarily through public awareness campaigns.

Supply Chain Structure

Standard practices segment the supply chain into three primary sectors: production, transmission, and distribution. Each sector is governed by established technical parameters, including recommended pipeline velocities ranging from 2.5 to 3 meters per second and infrastructure lifespans that typically vary between 35 and 100 years. Numerous benchmark countries illustrate effective private sector engagement in the distribution dimension of the supply chain.

Strategic Planning Framework

Planning methodologies generally advance from the level of settlements to comprehensive national strategies. These methodologies encompass medium-term (10-year) and long-term (30-year) horizons to facilitate sustainable management of resources.



05
Best Practices for Operational Excellence within the Saudi Arabian Water Value Chain

Objectives / Problem Addressed

The Kingdom of Saudi Arabia encounters intricate challenges in planning and managing urban resource supply and demand. These challenges are particularly pronounced in regions where demand demonstrates non-linear patterns and experiences significant seasonal variations. Notably, the exceptional requirements associated with Hajj and Umrah in Makkah and those for tourists visiting Al-Madinah Al-Munawwarah necessitate comprehensive and meticulous planning. Additionally, it is imperative to anticipate and manage the infrastructure needs of the tourism sector and to perform capacity analyses to ensure resilience amid peaks and fluctuations in demand.

Beyond these specific challenges, the Kingdom is dedicated to advancing its comprehensive development strategy. This commitment includes fostering collaboration and integration with various Saudi entities to align supply and demand planning with their master plans.

To effectively address the critical needs associated with potable water supply, the following strategic elements were prioritised:

01 Population growth forecasting:
conducting analyses of demographic trends to forecast future water demands.

02 Source capacity assessment:
evaluating current and potential water sources to ascertain their adequacy.

03 Strategic planning of supply systems:
formulating comprehensive master plans for water infrastructure development.

04 Project planning for future needs:
designing initiatives to balance supply and demand.

05 Functional role redistribution:
clarifying the responsibilities among stakeholders within the water sector, emphasising water supply security and emergency preparedness.

06 Stakeholder support:
offering technical and strategic assistance to Saudi entities to enhance adequate supply and demand planning.

07 Security and contingency strategies:
integrating measures for supply reliability and contingency planning into long-term frameworks.

08 Economic integration:
incorporating economic parameters optimises resource allocation and enhances operational efficiency.

09 Geospatial Information System database development:
integrating measures for supply reliability and contingency planning into long-term frameworks.

10 Formal documentation:
publishing comprehensive supply and demand planning documents to facilitate implementation and informed decision-making.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

The primary aim of these initiatives was to unify and streamline data collection, analysis, and dissemination among stakeholders. This coordinated approach sought to improve the decision-making capabilities of the Ministry of Water and its partners in addressing the challenges related to water planning.

A benchmarking methodology was implemented to identify global best practices, focusing on six reference countries: Germany, Western Australia, California (USA), Japan, Singapore, and Spain. These nations were selected based on technical criteria and key performance indicators relevant to effective water management. Each case study was examined in detail to extract strategies to overcome water-related challenges, thereby formulating long-term and sustainable solutions within their distinct contexts. The insights derived from these analyses yielded actionable recommendations tailored to address Saudi Arabia's unique requirements.

Saudi Arabia's water system relies heavily on unconventional water sources and a sophisticated distribution infrastructure. Given the limited natural water reserves, the Kingdom predominantly relies on seawater desalination. Water transmission from desalination facilities necessitates extensive networks of pipelines and pumping stations, which traverse considerable distances and overcome significant elevation gradients.

This distinctive context emphasises the imperative of adopting innovative practices and sustainable strategies. By leveraging insights from global case studies and aligning them with the Kingdom's vision, Saudi Arabia aspires to develop a resilient and efficient water supply system capable of meeting current and future demands.

Operational Excellence Dimension

MEWA's planning framework demonstrates excellence across four strategic dimensions, each contributing to transforming urban water management practices while ensuring sustainable resource utilisation.

Legal & Policy Framework

The framework establishes comprehensive regulatory protocols that govern water planning practices and resource allocation. This systematic approach facilitates standardised demand estimation methodologies, ensuring sustainable utilisation of water sources through evidence-based statistical analysis. Notably, the framework emphasises the importance of balanced resource management, advocating for diversification through desalination while simultaneously preventing the over-extraction of conventional sources.

Leadership and Accountability

MEWA implements systematic leadership protocols via annual role evaluations and established accountability frameworks. Through the formation of strategic committees, the organisation directs its long-term planning initiatives towards three primary objectives: the expansion of services, assurance of supply continuity, and achieving universal access to water by 2030. This methodology ensures consistent strategic alignment throughout the water sector.

Project Investment & Management

The centralised planning approach facilitates integrated infrastructure development and resource allocation throughout the Kingdom. By employing comprehensive demand analysis and long-term strategic planning that extends to 2075, the framework delivers evidence-based investment projections that support effective project portfolio management and financial planning.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Stakeholder Engagement

Two specialized committees—the Directive Committee and the Executive Supply and Demand Committee—facilitate systematic coordination among stakeholders. This organizational structure fosters effective communication and synchronised decision-making among all partners within the sector, thereby enhancing operational performance through collaborative planning and implementation. These dimensions collectively support MEWA's commitment to operational excellence while establishing new standards for urban water planning in the Kingdom. Their integration enables comprehensive sector transformation while maintaining operational effectiveness and stakeholder alignment.

Opportunity & Implemented Strategy

Water supply and demand planning represents a fundamental cornerstone for sustainable development, both regionally and globally. MEWA identified a strategic opportunity to transform resource planning by comprehensively integrating international best practices while addressing the Kingdom's unique water challenges. This opportunity emerged from increasing pressures of urbanisation, industrial expansion, and climate change impacts, necessitating a robust and integrated approach to water resource management.

01 Population growth forecasting:

Establishment of centralised planning mechanisms incorporating international best practices and stakeholder engagement protocols. MEWA focused on developing comprehensive governance frameworks and accountability structures while ensuring alignment with national objectives through systematic stakeholder coordination.

02 Planning Enhancement:

Implementation of comprehensive planning methodologies extending to 2075, incorporating sophisticated demand estimation models. These models integrate multiple factors, including:

- Population growth projections from the General Authority of Statistics
- Development project requirements assessment
- Special consideration for Hajj and Umrah demands
- Integration of tourism sector development plans
- Direct consumption measurement data

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

03 Stakeholder Integration:

Dedicated committees for strategic oversight and operational coordination were created. This phase established structured communication channels and validation mechanisms, ensuring plan resilience while enabling effective stakeholder engagement and coordinated decision-making.

04 Implementation Framework:

Developing robust governance structures defining clear roles, responsibilities, and interfaces among stakeholders. This included establishing review and validation processes to refine assumptions and ensure plan accuracy, enabling responsive adaptation to emerging challenges.

MEWA established new standards for water resource management in the Kingdom through this systematic approach to planning transformation. The framework's comprehensive scope and evidence-based methodologies ensure adequate resource allocation while positioning Saudi Arabia to meet growing water demands sustainably and equitably. This strategic integration of global best practices with local requirements demonstrates MEWA's commitment to sustainable water resource management while enabling future development.

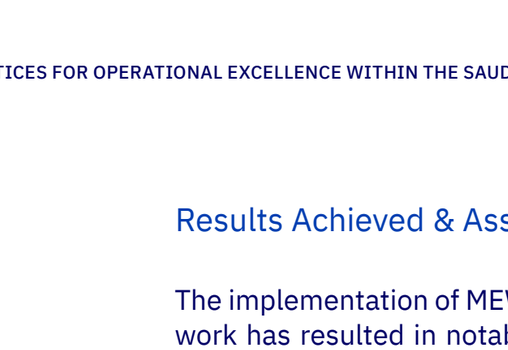
Results Achieved & Associated KPIs

The implementation of MEWA's comprehensive planning framework has resulted in notable enhancements in water resource management efficiency and operational effectiveness across various dimensions.

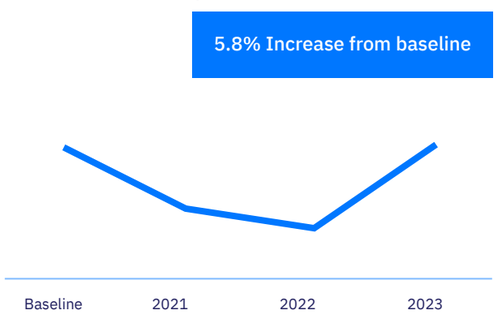
Performance Metrics

Substantial improvements in water supply continuity have been achieved, with a 17.7% increase from baseline through the first half of 2024. Resource optimisation efforts have yielded a 5.8% increase in renewable groundwater utilisation from baseline through 2023, while surface water usage in urban applications has decreased by 76%, demonstrating effective resource reallocation.

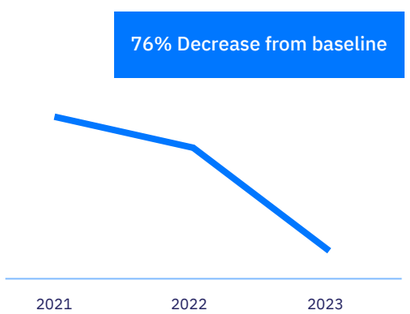
KPI Name: The water supply continuity rate (hour/day)



KPI Name: The share of renewable groundwater from the total water produced (%)



KPI Name: The share of surface water in urban



BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Operational Enhancement

The framework has established comprehensive planning capabilities, enabling precise demand forecasting and capacity optimisation. Implementing automated platforms supports real-time decision-making and scenario analysis, enhancing operational responsiveness and efficiency in resource allocation.

Infrastructure Development

Strategic master planning has improved infrastructure utilisation and ensured system reliability through optimised regional interconnection systems, augmented strategic storage capacities, and efficient project portfolio management.

Stakeholder Coordination

The framework has facilitated systematic coordination among sector entities, enabling integrated development planning across ministries and organisations. This enhanced collaboration ensures alignment between infrastructure development and national objectives while optimising resource allocation across different sectors.

These achievements demonstrate MEWA's success in transforming water resource planning while establishing new benchmarks for sector performance. The significant improvements in key performance indicators validate the effectiveness of the comprehensive planning approach in achieving sustainable water management objectives.

Lessons Learned

Implementing MEWA's water resource planning framework has yielded valuable insights for forthcoming sector development initiatives.

Strategic planning integration

The development of comprehensive planning frameworks requires systematic engagement with stakeholders and the establishment of well-defined governance structures. This approach ensures the effective alignment of strategic objectives with operational execution. Additionally, establishing transparent governance facilitates the identification of key roles and responsibilities, promotes the integration of all stakeholders, and outlines essential interactions, communication frequencies, and meeting schedules.

Data-Driven decision making

Implementing automated systems and advanced analytical capabilities is crucial for effectively managing complex resource planning. Such initiatives enable responsive adaptation to evolving conditions. Furthermore, identifying appropriate key performance indicators (KPIs) is essential for monitoring the execution of strategies in alignment with organizational objectives and plans.

Stakeholder collaboration

Engaging key stakeholders, specifically the sector entities, consistently in all strategy updates, developments, and modifications ensures a collaborative and robust connection between the strategy and the actual conditions on the ground.

Supply and demand automation opportunities

Developing an electronic platform with user interfaces is proposed to enhance supply and demand management to support data analysis and decision-making. This platform would enable comprehensive water planning portfolio management, secure data collection, automated notifications, and quality validation.

It would leverage spatial analysis tools for mapping supply and demand, integrate advanced analytics using AI and machine learning for predictive insights, and centralize document management with version control. Additionally, it would promote collaboration through digital channels, ensure role-based real-time access to data, and streamline workflows using process automation tools.

Continuous improvement

It is imperative to revisit and evaluate the performance of strategies to confirm that progress remains aligned with the desired objectives. This assessment is crucial to achieving the established targets.

These insights serve as valuable guidance for prospective water sector planning initiatives, underscoring the significance of technological innovation and stakeholder engagement in achieving sustainable resource management.

Saudi Water Authority (SWA)

About SWA

The Saudi Water Authority (SWA) is the primary regulatory body for the water sector within the Kingdom, ensuring that service providers adhere to national policies and standards. Established as a foundational institution in Saudi Arabia's water management framework, SWA oversees quality-of-service delivery, monitors resource utilisation, and enforces performance benchmarks across the sector.

The organisation's regulatory mandate includes comprehensive oversight of water sector activities, encompassing tariff setting, operational licensing, and dispute resolution. Through systematic monitoring and enforcement of established standards, SWA ensures the efficient and sustainable utilisation of water resources while fostering transparency and accountability within sector operations.

SWA's commitment to operational excellence is embodied in a strategic framework centred on three fundamental pillars: enhancing service quality through the adoption of high-performance standards, transparency in beneficiary engagement by providing accurate consumption information and improving operational efficiency via systematic administrative optimisation. This approach is bolstered by continuously updating the regulatory framework and enhancing monitoring systems, ensuring sustainable service delivery and the prevention of financial inefficiencies.

Through this comprehensive strategy, SWA employs advanced data monitoring and analytical tools to deliver real-time insights into sector performance, facilitating proactive policy adjustments and streamlined regulatory processes. This strategic emphasis positions SWA as a vital enabler in addressing emerging challenges, such as climate change and population growth, while advancing the Kingdom's water security objectives.

Moreover, within the SWA organisational structure, the Water Technologies Innovation Institute & Research Advancement (WTIIRA) and the Water Academy are fundamental pillars in driving operational excellence through distinct yet complementary functions.

WTIIRA is pivotal in advancing technological innovation and research-driven solutions. It systematically addresses operational challenges through empirical research and development initiatives. This research-centric approach facilitates evidence-based decision-making and technological advancement within the sector.

Concurrently, the Water Academy is a crucial enabler of human capital development, focusing on capacity building and knowledge transfer to enhance operational competencies across the water sector. Through specialised training programs and professional development initiatives, the Academy ensures the sustainable implementation of operational excellence frameworks by cultivating a highly skilled workforce. The synergistic relationship between these entities significantly contributes to SWA's comprehensive approach to operational excellence, combining technological innovation with human resource development to achieve sustainable operational improvements throughout the water value chain.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Water Technologies Innovation Institute & Research Advancement (WTIIRA)

The Water Technology Innovation and Institute of Research Development is at the forefront of advancing water-related technologies in Saudi Arabia. The institute focuses on research and development in desalination, wastewater treatment, and conservation technologies. It aims to provide innovative solutions to enhance water security and sustainability while reducing costs and environmental impact. The institute also serves as a hub for collaboration between academia, industry, and government, fostering a culture of innovation and knowledge sharing.

Operational excellence drives the institute's capacity to conduct impactful research and develop practical solutions. By streamlining research processes and prioritising high-impact projects, the institute ensures its efforts address the Kingdom's critical water challenges. Operational excellence also supports effective knowledge transfer, enabling the rapid adoption of innovations within the water sector and contributing to national and global advancements.

Water Academy

The Water Academy is dedicated to developing a skilled and capable workforce for Saudi Arabia's water sector. It offers specialised training programs tailored to meet the industry's current and future needs, focusing on areas like desalination, water treatment, and resource management. The academy collaborates with international organisations to integrate the best practices and advanced technologies into its curriculum. By equipping professionals with the knowledge and skills needed to address the Kingdom's water challenges, the Water Academy is vital in building human capital aligned with Vision 2030.

Operational excellence is essential for the Water Academy to achieve its mission of fostering a knowledgeable and innovative workforce. The academy optimises program design and delivery and ensures its training initiatives are relevant, effective, and aligned with industry standards. Operational excellence also enhances collaboration with local and global partners, enabling the institution to stay ahead of technological advancements and sectoral demands.

SWA presents three distinct best practices reflecting the strategic significance of its constituent entities in the water value chain. These cases examine SWA's regulatory framework implementation, WTIIRA's research advancement in agricultural cultivation, and the Water Academy's development of a comprehensive competency framework. This tripartite analysis provides insights into operational excellence from regulatory, research, and human capital development perspectives, demonstrating how different organisational functions contribute to sector advancement.

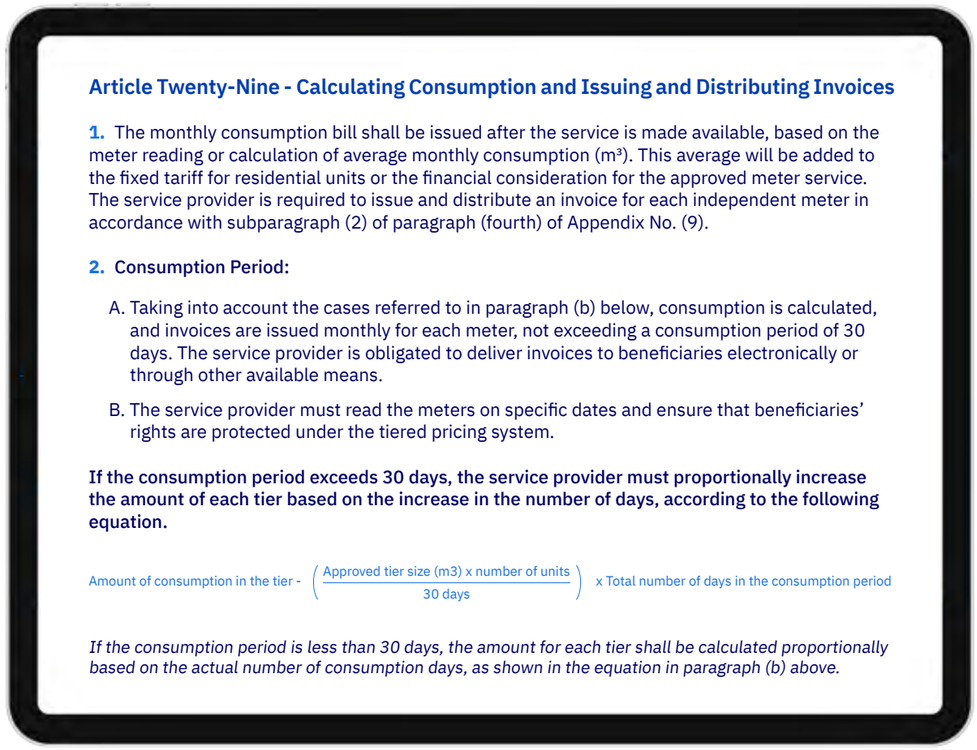
05
Best Practices for Operational Excellence within the Saudi Arabian Water Value Chain

SWA Water Regulator – Accumulation of Bills on Beneficiaries

Overview of the Best Practice

The General Administration for Beneficiary Affairs encountered a critical operational challenge regarding bill accumulation among service beneficiaries. This systemic issue emerged from inconsistencies in billing cycles, notably when consumption levels exceeded standard thresholds, leading to delayed bill issuance within the service provider's system. In response, SWA implemented a strategic regulatory solution through Article Twenty-Nine of the water and sanitation service delivery guide, establishing mandatory monthly billing cycles and specific consumption calculation protocols.

The regulatory amendment mandates that consumption bills must be issued within a strict 30-day cycle, with explicit consumption calculation and invoice distribution provisions. The framework incorporates precise mathematical formulations for cases where consumption periods deviate from the standard cycle, ensuring equitable billing practices across all consumption patterns. This regulatory intervention has yielded significant improvements, evidenced by a measurable decrease in billing-related complaints and enhanced efficiency in revenue collection processes. This demonstrates the effectiveness of systematic regulatory frameworks in addressing operational challenges.



Article Twenty-Nine - Calculating Consumption and Issuing and Distributing Invoices

1. The monthly consumption bill shall be issued after the service is made available, based on the meter reading or calculation of average monthly consumption (m^3). This average will be added to the fixed tariff for residential units or the financial consideration for the approved meter service. The service provider is required to issue and distribute an invoice for each independent meter in accordance with subparagraph (2) of paragraph (fourth) of Appendix No. (9).

2. **Consumption Period:**

   A. Taking into account the cases referred to in paragraph (b) below, consumption is calculated, and invoices are issued monthly for each meter, not exceeding a consumption period of 30 days. The service provider is obligated to deliver invoices to beneficiaries electronically or through other available means.

   B. The service provider must read the meters on specific dates and ensure that beneficiaries' rights are protected under the tiered pricing system.

If the consumption period exceeds 30 days, the service provider must proportionally increase the amount of each tier based on the increase in the number of days, according to the following equation.

$$\text{Amount of consumption in the tier} - \left(\frac{\text{Approved tier size (m3) x number of units}}{30 \text{ days}}\right) \times \text{Total number of days in the consumption period}$$

If the consumption period is less than 30 days, the amount for each tier shall be calculated proportionally based on the actual number of consumption days, as shown in the equation in paragraph (b) above.

Figure 3. Article Twenty-Nine. Calculation of consumption and issuing and distribution invoices

Objectives / Problem Addressed

The service provider encountered substantial operational inefficiencies from systematic delays in bill issuance, resulting in significant financial accumulation for beneficiaries. This systemic challenge manifested in elevated customer dissatisfaction, particularly regarding the substantial accumulated amounts and associated payment difficulties. The situation created financial and customer service implications requiring immediate regulatory intervention.

The imperative for systematic improvement emerged from two critical factors: the escalating frequency of customer complaints and the declining levels of beneficiary satisfaction. These challenges necessitated the development of a robust regulatory framework to ensure consistent and timely bill issuance. The primary objectives were to:

- Establish systematic billing periodicity
- Enhance service quality metrics
- Optimize revenue collection efficiency
- Improve beneficiary satisfaction levels
- Mitigate financial accumulation risks

Operational Excellence Dimension

The operational excellence framework of the Water Regulator demonstrates effectiveness across four strategic dimensions:

Legal & Policy Framework

The accumulation of bills on beneficiaries' initiatives exemplifies operational excellence through the systematic development of regulatory protocols, particularly as illustrated by the implementation of Article Twenty-Nine.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

This framework has established standardised billing cycles and consumption calculations, addressing operational inefficiencies.

Leadership & Accountability

The initiative highlights accountability by clearly establishing mandates governing billing procedures and service providers' responsibilities. This ensures a transparent implementation of the 30-day billing cycle requirement.

Quality & Security Management

The framework reflects quality excellence by applying precise mathematical formulations for billing calculations and standardised distribution protocols, ensuring consistent service delivery.

Stakeholder Engagement

Excellence in stakeholder management is evidenced by the systematic communication protocols directed at beneficiaries and the coordination with service providers in implementing new billing standards.

These dimensions collectively underpin the successful transformation of billing operations while establishing new standards for regulatory effectiveness.

Opportunity & Implemented Strategy

Implementing regulatory improvements to address bill accumulation challenges followed a structured, methodological approach comprising three distinct phases. This systematic development process aimed to establish quantifiable metrics, implement regulatory modifications, and institute robust monitoring mechanisms to ensure sustainable improvement in billing efficiency and beneficiary satisfaction.

01 Diagnostic analysis:

A systematic evaluation assessed the existing billing inefficiencies and their quantifiable impact on beneficiary satisfaction indices. This empirical analysis provided the foundational framework for identifying critical intervention points within the billing process.

02 Regulatory framework:

Enhancement Strategic modifications to the service provision manual were implemented through the integration of two primary regulatory mechanisms:

- Implementation of standardised 30-day billing cycles with the explicit prohibition of bill retention
- Establishment of an automated consumption variance notification system, triggered at 50% deviation from mean consumption patterns

03 Monitoring implementation:

A comprehensive monitoring framework was developed, incorporating:

- Precision consumption measurement protocols
- Automated anomaly detection algorithms for consumption pattern analysis
- Systematic beneficiary communication channels for consumption management

This methodological approach ensures continuous data-driven oversight while facilitating proactive consumption management through enhanced beneficiary engagement mechanisms.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Results Achieved & Associated KPIs

Implementing regulatory reforms yielded quantifiable improvements across multiple operational dimensions, particularly in billing efficiency and customer satisfaction metrics. The following analysis presents the empirical outcomes of the implemented regulatory framework.

Operational performance enhancement

The revised regulatory framework generated substantial improvements in two primary domains:

- Systematic reduction in billing-related complaints through standardised issuance protocols
- Enhanced revenue collection efficiency through improved beneficiary payment compliance
- Optimized billing cycle management, leading to reduced outstanding amounts

Performance metrics analysis

Pre-implementation indicators:

The baseline assessment revealed significant operational inefficiencies:

- Elevated frequency of billing-related complaints, specifically regarding accumulation
- Suboptimal collection rates due to payment difficulties
- Irregular billing patterns affecting beneficiary satisfaction levels

Post-implementation outcomes:

Quantitative analysis demonstrates meaningful improvements across key metrics:

- Substantial reduction in billing-related complaints frequency
- Enhanced beneficiary payment compliance rates
- Improved financial collection efficiency through standardised billing cycles

These results validate the effectiveness of the implemented regulatory framework in achieving its intended objectives of operational optimisation and enhanced service delivery.

Lessons Learned

Implementing this regulatory framework provided valuable insights into effective water utility management practices, highlighting two critical success factors in operational excellence.

Consumer engagement protocols

Establishing systematic consumption notification mechanisms demonstrated significant efficacy in enhancing operational transparency and facilitating proactive consumption management. This proactive approach to beneficiary communication reduced complaint frequency and strengthened the trust relationship between service providers and beneficiaries, establishing a foundation for sustainable service improvement.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Regulatory framework effectiveness

Developing and implementing precise legal regulations governing billing processes proved instrumental in transforming operational efficiency—this systematic approach to regulatory governance optimised revenue collection and minimised billing-related disputes while establishing standardised operational protocols. The success of these regulatory mechanisms emphasises the critical role of well-defined legal frameworks in achieving sustainable operational improvements within utility management systems.

05
Best Practices for Operational Excellence within the Saudi Arabian Water Value Chain

WTIIRA – Advanced Water Treatment Systems for Sustainable Agriculture

Overview of the Best Practice

WTIIRA has developed an innovative approach to agricultural water production by implementing a multifaceted water treatment and management system. This comprehensive framework integrates various water treatment technologies to optimise agricultural water provision, maintaining cost-effectiveness and environmental sustainability.

The process architecture encompasses several sophisticated water treatment methodologies, primarily centred on Brackish Water Reverse Osmosis (BWRO) technology with adaptable water polishing capabilities. The technological framework comprises:

- **Seawater Reverse Osmosis (SWRO)**

Advanced desalination technology optimised for agricultural-grade water production, with customisable treatment protocols based on specific crop requirements

- **Irrigation wastewater reuse**

Implementing minimal treatment protocols for irrigation wastewater significantly enhances cost efficiency in agricultural water delivery systems.

- **Blended water sources**

Strategic integration of desalinated water with alternative sources, including treated wastewater and greywater, optimising cost-effectiveness in irrigation systems

- **Zero Liquid Discharge (ZLD) brine management system**

Advanced brine processing technology that minimises marine discharge while facilitating mineral extraction for agricultural applications and energy storage systems

The technological framework is particularly noteworthy for its integration of renewable energy sources. This demonstrates a commitment to environmental sustainability while addressing the critical challenge of agricultural water provision. This holistic approach represents a significant advancement in sustainable agricultural water management, aligning technological innovation with practical agricultural requirements.

Objectives / Problem Addressed

The agricultural sector in Saudi Arabia faces significant challenges regarding water resource optimisation and sustainable farming practices. The primary difficulties encompass high operational costs associated with conventional water treatment methods, environmental concerns regarding brine disposal, and the need for energy-efficient water production systems suitable for agricultural applications. The imperative for developing this integrated water management system emerged from several critical factors:

- Escalating costs of traditional agricultural water production methods
- Environmental impact of conventional brine disposal practices
- Rising energy consumption in water treatment processes
- Need for water quality optimisation specific to agricultural requirem
- Limited integration between different water treatment technologies

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

The primary objectives of this technological framework were to establish a cost-effective and environmentally sustainable water production system for agricultural use through:

- Development of adaptable water treatment protocols based on specific agricultural needs
- Implementation of energy-efficient treatment processes
- Integration of wastewater recycling mechanisms
- Enhancement of brine management practices
- Optimization of operational costs while maintaining water quality standards

This systematic approach addresses immediate operational challenges and long-term sustainability requirements in agricultural water management.

Operational Excellence Dimension

Technology and research development:

WTIIRA's integrated system showcases operational excellence by combining advanced BWRO, SWRO, and ZLD technologies driven by research to enhance agricultural water management sustainably.

Opportunity & Implemented Strategy

The Kingdom of Saudi Arabia faces critical challenges in water resource management, particularly regarding agricultural water availability and production cost optimisation. This strategic context presents a significant opportunity for implementing innovative water management solutions to address these pressing challenges.

01 Technology integration:

Implementing an advanced water treatment system combining BWRO, SWRO, and ZLD technologies establishes the foundational infrastructure for sustainable water management.

02 Infrastructure optimisation:

Redesign of irrigation systems to incorporate wastewater collection and rerouting mechanisms, complemented by the strategic retrofitting of existing agricultural infrastructure to facilitate wastewater accumulation.

03 Resource integration:

Implement an innovative water blending protocol, integrating irrigation wastewater with BWRO and greywater streams. This approach reduces reverse osmosis treatment intensity while maintaining water quality suitable for agricultural applications.

This systematic strategy demonstrates the practical application of circular economy principles in agricultural water management, establishing a framework for sustainable water resource optimisation in arid regions.

Results Achieved & Associated KPIs

WTIIRA's implementation of advanced water treatment technologies for agricultural applications has yielded significant operational and environmental achievements across various performance dimensions. The integration of Brackish Water Reverse Osmosis (BWRO) technology, combined with optimised water polishing processes, has set new benchmarks in agricultural water management and furthered objectives related to sustainability.

Performance Metrics

The implementation has facilitated significant operational efficiencies to achieve energy consumption levels below 2.3 kWh/m^3 and target low operational costs of \$0.16/m^3. Once fully operational, the desalination unit consistently delivers high-quality water suitable for agricultural irrigation, reducing reliance on groundwater resources.

Agricultural Impact

This initiative has significantly enhanced agricultural productivity by providing a reliable water supply, facilitating improvements in crop yields, and expanding agricultural activities. Consequently, it has bolstered regional food security by supporting the cultivation of a wider variety of crops.

Environmental Sustainability

Incorporating sustainable energy sources has decreased the system's carbon footprint, exemplifying a commitment to environmental stewardship while preserving operational efficiency.

Lessons Learned

The implementation of the WTIIRA agricultural water optimisation system has yielded three fundamental insights pertinent to technological innovation in agricultural water management:

Technological Integration

The successful amalgamation of advanced desalination technologies with agricultural irrigation systems underscores the importance of bespoke technological solutions tailored to specific agricultural applications.

Resource Optimization

The strategic alignment of water quality requirements with energy efficiency highlights the critical significance of resource optimisation in sustainable agricultural water management.

Sustainability Framework

The formulation of renewable energy integration protocols has established new standards for environmental sustainability within agricultural water production, thereby offering a template for future implementations.

These insights afford valuable guidance for forthcoming agricultural water management initiatives, emphasising the necessity of harmonising technological innovation with sustainability.

05
Best Practices for Operational Excellence within the Saudi Arabian Water Value Chain

Water Academy - Competency Framework Integration for Water Sector Excellence

Overview of the Best Practice

The Water Academy has developed and implemented a comprehensive competency-based development framework that systematically aligns workforce capabilities with operational requirements in the water sector. This strategic initiative represents a structured approach to human capital development, integrating technical and behavioural competencies to enhance operational excellence across the industry.

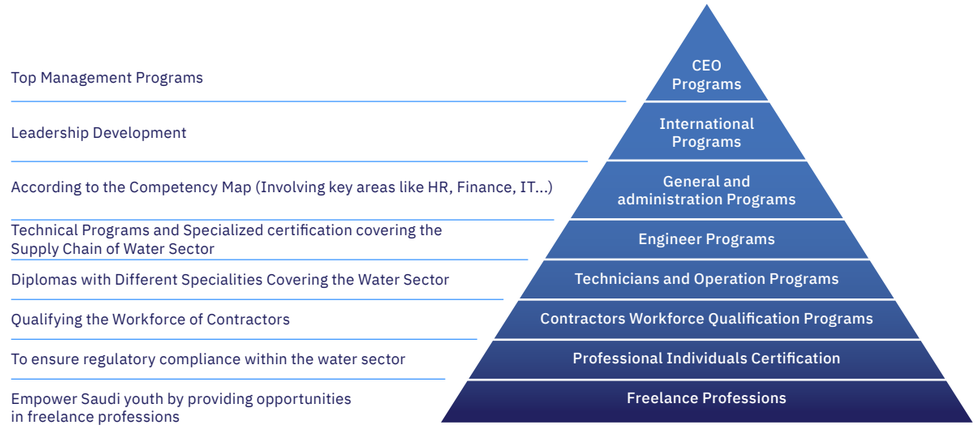


Figure 4. Competency-based Water Academy Framework

Furthermore, the framework's architecture incorporates a sophisticated four-tier mastery classification system—Junior, Average, Advanced, and Expert—thereby establishing a transparent and structured pathway for professional development. This hierarchical structure facilitates precise alignment between job-specific requirements and skill development initiatives, enabling targeted capability enhancement across the workforce. The framework distinguishes between two fundamental competency categories: behavioural competencies stratified by organisational level (leadership, managerial, and operational) and technical competencies allocated based on specific job families and functional responsibilities.

This comprehensive approach serves as the foundational architecture for human resource management systems, establishing a systematic methodology for workforce development. By integrating leadership development, behavioural modification, and technical skill enhancement, the framework creates a cohesive platform for building organisational culture and advancing operational capabilities. This strategic alignment between competency development and operational requirements demonstrates the Water Academy's commitment to establishing an autonomous, highly skilled workforce capable of driving operational excellence throughout the water sector.

Objectives / Problem Addressed

The preceding training and development framework operated through a linear, non-competency-based mechanism that relied heavily on traditional program distribution channels. This system employed a hierarchical notification structure, disseminating training opportunities through station coordinators, employee self-nomination, and subsequent filtering processes.

The previous system exhibited significant structural limitations in program delivery and accessibility. The requirement for station-specific coordinators created administrative bottlenecks, while the self-nomination process generated substantial misalignment between program participants and intended target audiences. Communication inefficiencies further compromised program effectiveness, with operational commitments and leave periods impacting awareness of development opportunities.

The framework demonstrated critical strategic deficiencies in three primary areas:

01 Program-competency misalignment:

Training initiatives focused on broad specialities rather than specific competency requirements.

02 Development planning constraints:

The absence of systematic competency mapping impeded the creation of structured professional development pathways.

03 Qualification verification:

Lack of formal certification mechanisms for validating acquired competencies and skills

These systematic challenges necessitated a fundamental restructuring of the professional development framework to establish a more robust, competency-based approach to workforce development in the water sector.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Operational Excellence Dimension

Human resources management:

The competency framework supports talent management by identifying high-performing employees and creating development pathways. It also contributes to succession planning and career development, ensuring that leadership and technical expertise are continually cultivated within the companies.

Opportunity & Implemented Strategy

The academy implemented a structured Competency Mapping Process across various roles in the water sector. The strategy involved defining and aligning competencies for each position with job objectives. By linking the competency framework to job roles, the academy has developed skilled workers who meet the specific requirements of each job.

The Competency Mapping Process at the Water Academy for the water sector is a systematic approach designed to align employee competencies with job requirements in the water sector. This structured process involves several key steps to ensure that training and development initiatives are tailored to meet the specific needs of various roles. The following outlines the main components of the process:

01 Career architecture development

The initial phase focused on establishing comprehensive career pathways within the water sector, defining role-specific responsibilities and creating clear progression frameworks across operational domains.

02 Competency framework design

Developing an integrated competency framework incorporating technical and behavioural competencies aligned with operational requirements across different organisational levels. Competencies are identified and categorised into two main types:

- Technical competencies: specific to roles within the water sector, ensuring that they meet the unique requirements of each job.
- Behavioural competencies: focus on soft skills required for effective performance, such as teamwork, communication, problem-solving, etc.

03 Competency level stratification

Implementing a three-tier mastery classification system, ranging from basic entry-level skills to expert leadership competencies, provides clear development pathways.

- Basic: fundamental skills required for entry-level positions.
- Advanced: skills needed for mid-level roles requiring more expertise
- Expert: high-level senior-level competencies, emphasising specialised knowledge and leadership capabilities.

04 Training program architecture

This critical phase established a systematic alignment between competencies and training delivery. Development programs were categorised according to specific competency levels, ensuring precise matching between employee capability requirements and learning resources. The framework enables targeted skill development through direct linkages between identified competencies and corresponding training initiatives, facilitating efficient closure of capability gaps.

05 Implementation and evaluation

Automating competency mapping processes with personalised training access, supported by continuous monitoring and effectiveness evaluation protocols, ensures sustainable capability development. The specific training programs are only shown separately for each employee according to their competencies. This strategic approach ensures systematic alignment between individual development needs and organisational capability requirements. Employee progress and training effectiveness are evaluated to ensure alignment with job requirements.

Results Achieved & Associated KPIs

Before framework implementation, the training approach was characterised by managerial discretion in employee nominations, resulting in inconsistent skill development and inequitable learning opportunities across the workforce.

Implementing the competency framework has yielded significant quantifiable improvements in workforce development and operational efficiency within the water sector.

Training engagement

A substantial increase in training participation demonstrates the framework's effectiveness:

Between 2019 and 2020, the workforce training program initiated a baseline assessment, during which the number of trainees decreased from 2,708 to 2,309. A preliminary growth phase succeeded in this decline during 2021-2022, as the number of trainees increased from 4,534 to 4,619. The most significant expansion, however, took place in 2023-2024, characterised by a remarkable rise in trainees from 5,226 to 16,379. This exponential growth trajectory highlights the effectiveness of the program's framework in systematically addressing workforce development needs.

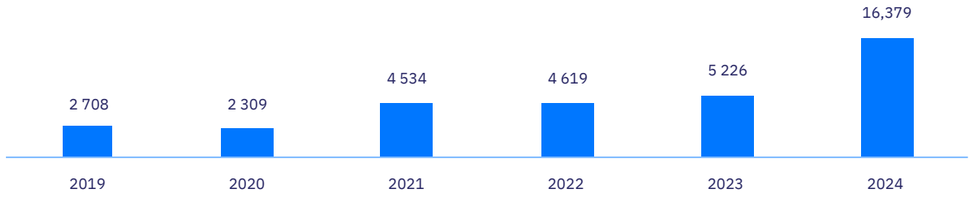


Figure 5. Training engagement evolution (trainees).

The substantial increase in trainee participation, particularly between 2023-2024, illustrates a strategic scaling of training initiatives, reflecting a deliberate effort to enhance workforce capabilities. This surge indicates that the organisation has successfully aligned its training programs with broader strategic objectives, aiming to cultivate a more skilled and resilient workforce that can meet the growing demands of the sector. Such growth signifies the successful implementation of workforce development strategies that are responsive to the evolving needs of the industry, thereby reinforcing operational excellence through the development of a highly skilled talent pool.

Transition from manager-driven to competency-based

The shift to a competency-based training approach led to notable improvements in both employee performance and the overall training program outcomes

- Enhanced job efficiency and reduced supervision requirements
- Improved alignment between employee capabilities and job requirements
- Diversified learning methodologies, including face-to-face training, simulators, VR/XR, e-learning, and certification programs

The framework has established a sustainable model for continuous professional development, evidenced by:

- Systematic alignment between training initiatives and job competencies
- Enhanced workforce capability and adaptability
- Strengthened culture of continuous improvement
- More equitable distribution of development opportunities

This comprehensive improvement in training effectiveness and workforce capability demonstrates the framework's success in achieving its strategic objectives for human capital development.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Lessons Learned

Implementing the Water Academy's competency framework has yielded valuable insights into effective workforce development practices within the water sector.

Strategic competency architecture

Establishing clearly defined competency levels proved fundamental to effective skill development. This enabled precise targeting of development initiatives and systematic progression tracking. The direct alignment between competency frameworks and job-specific requirements ensures that development initiatives maintain operational relevance.

Implementation effectiveness

Integrating diverse learning methodologies, including virtual reality and e-learning platforms, has demonstrated the importance of adaptable training approaches in modern workforce development. This multi-modal approach effectively addresses varied learning preferences while optimising skill acquisition rates.

Sustainable development framework

Regular framework updates and comprehensive assessment methodologies have proven essential for aligning with technological advancements and industry evolution. This dynamic approach ensures continuous adaptation to emerging sector requirements while maintaining development effectiveness.

These insights provide a foundation for continuous improvement in competency-based workforce development, emphasising the importance of systematic approaches to human capital optimisation.

05
Best Practices for Operational Excellence within the Saudi Arabian Water Value Chain

Water Desalination (SWCC)

About Water Desalination

Established in 1974, operational arm of SWA, Water Desalination (SWCC), operates as Saudi Arabia's foremost desalination entity and is a significant global leader in water technology. Water Desalination manages the world's largest network of desalination infrastructure, overseeing strategically located plants along the kingdom's coastlines. The corporation provides vital water resources to the Kingdom's population, achieving a production capacity that exceeds 11 million cubic meters of desalinated water daily across 32 production facilities.

SWCC's operational framework exemplifies excellence through integrating technological innovation, rigorous quality management, and commitment to environmental sustainability. The organisation employs advanced engineering capabilities and research-driven solutions while adhering to stringent quality control protocols. This systematic approach to operational excellence facilitates effective water production and promotes environmental sustainability by optimising resources and adopting innovative technologies.

The organisation's alignment with Saudi Vision 2030 is evident through its comprehensive environmental sustainability initiatives within desalination operations, economic diversification via local content development, and advancements in technology about water production processes. SWCC's commitment to research and development has set new standards in water technology innovation, significantly contributing to the sector's progress.

By fostering strategic partnerships and perpetuating a culture of continuous innovation, Water Desalination enhances the Kingdom's water security objectives and industrial capabilities. This integrated approach, coupled with a steadfast commitment to sustainability and technological advancement, positions Water Desalination as a critical contributor to Saudi Arabia's water security while furthering the nation's industrial and technological prowess within the global water sector.

Reverse Engineering for Critical Mechanical Spare Parts

Overview of the Best Practice:

Water Desalination has implemented an innovative approach to operational excellence through strategic reverse engineering of critical mechanical components, demonstrating a sophisticated solution to supply chain optimisation in desalination infrastructure. This initiative, exemplified through implementation at the Yanbu Production Plants, represents a comprehensive response to challenges in sourcing critical components such as gears, bolts, Victaulic couplings, and boiler burners.

The framework encompasses strategic partnerships with external manufacturers, enabling precise replication of essential components through advanced reverse engineering protocols. This approach addresses multiple operational objectives: reduction of OEM dependency, cost optimisation, downtime minimisation, and enhancement of local industrial capabilities. The initiative demonstrates particular significance when original components become commercially unavailable or economically unfeasible.

The methodology integrates technical specification development by SWCC's engineering teams with external manufacturing capabilities, ensuring component integrity while maintaining operational efficiency. This systematic approach enhances plant reliability and contributes to broader economic development through local content support, establishing a sustainable model for critical component management in desalination infrastructure.

Objectives / Problem Addressed

The Yanbu Production Plants of Water Desalination encountered significant operational challenges in critical mechanical component procurement, characterised by extended Original Equipment Manufacturers (OEM) lead times, escalating costs, and supply chain vulnerabilities. Initial operational assessments revealed component lead times extending to eight months, accompanied by significant operational cost increases and production capacity impacts. This dependence created considerable challenges in maintaining optimal plant operations, particularly for specialised components crucial to legacy equipment maintenance.

In response to these challenges, Water Desalination established a comprehensive framework focused on operational continuity enhancement, cost optimisation, and quality assurance. The initiative aimed to develop alternative sourcing strategies through localised reverse engineering capabilities, implement strategic partnerships with local manufacturers targeting cost reduction, and establish robust quality control protocols, including comprehensive technical documentation standards and material verification processes.

Implementing reverse engineering protocols through external partnerships emerged as a strategic solution to these challenges. It provides a framework for sustainable operational improvement while supporting local manufacturing capabilities and maintaining essential quality standards.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Operational Excellence Dimension

Technology and research development:

Leverage advanced engineering tools, including 3D scanning and CAD software, enabling precise component replication while maintaining dimensional accuracy and material specifications.

Quality and security management:

Strategic partnerships with qualified manufacturers, implementing rigorous quality control protocols throughout manufacturing.

Climate change and sustainability:

Locally sourcing parts and extending the life of existing equipment through high-quality replacements can reduce resource consumption and environmental impact.

Opportunity & Implemented Strategy

Water Desalination identified a strategic opportunity to transform its component procurement approach through reverse engineering, addressing the challenges of extended lead times and elevated costs associated with OEM dependencies. This opportunity catalysed the development of a comprehensive implementation strategy encompassing technological innovation, supplier partnerships, and process optimisation.

Partnering with external manufacturers specialising in reverse engineering to recreate needed spare parts. These manufacturers used Water Desalination technical specifications, which included 3D scans, material analysis, and engineering drawings, to fabricate high-precision parts. Close collaboration with these external suppliers helped reduce lead times and ensure part compatibility with our equipment.

The strategy execution followed a systematic approach to ensure operational effectiveness:

01 Strategic partnership development

Water Desalination executed partner selection through rigorous evaluation of specialised manufacturers, prioritising reverse-engineering expertise, adherence to quality standards, and technological capabilities for component replication.

02 Technical framework implementation

Implementing advanced manufacturing technologies established standardised protocols for component geometry capture through 3D scanning, technical specification development through CAD modelling, and precision manufacturing requirements through CNC machining. This approach ensured quality and minimised potential challenges related to compatibility and performance.

03 Process integration

Internal processes underwent systematic adaptation through modification of inventory management systems, enhancement of maintenance protocols, and development of quality control procedures supported by structured communication frameworks with suppliers.

04 Risk management implementation

Comprehensive quality assurance protocols were established by developing performance evaluation criteria, implementing regular assessment procedures, and creating corrective action protocols.

05 Sustainability integration

The final phase aligned reverse engineering operations with environmental objectives through localised manufacturing initiatives and resource optimisation strategies, ensuring long-term operational sustainability.

This systematic approach enabled Water Desalination to effectively transform its component procurement process while maintaining operational excellence standards.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Results Achieved & Associated KPIs

Internal process optimisation manifested through integrating specialised reverse engineering protocols and enhanced departmental collaboration. Water Desalination implemented quality control metrics, including compliance with material specifications, dimensional accuracy, and performance benchmarks. Ongoing assessments ensure that all parts align with SWCC's operational standards.

Implementing reverse engineering protocols also yielded significant operational improvements across key performance indicators.

Lead time:

Lead time reduction demonstrated exceptional results, decreasing from eight months to two to three weeks through optimised local manufacturing partnerships. Water Desalination implemented strict quality assurance protocols to ensure all parts meet the required standards. Coordinated logistics and clear communication with external partners also contributed to this achievement.

Cost efficiency:

Cost efficiency showed marked improvement with a 30% reduction in procurement expenses compared to OEM sourcing.

Operational continuity:

Operational continuity was enhanced substantially, evidenced by a 40% reduction in plant downtime through improved component availability.

Enhanced relationships with local manufacturers have established a foundation for continued operational excellence, while improved internal processes ensure effective management of reverse engineering projects. These outcomes validate the strategic approach to component procurement while establishing a framework for potential expansion to other operational areas.

Lessons Learned

SWCC's reverse engineering initiative has provided valuable insights into continuous improvement and program expansion. These lessons encompass technical communication protocols, quality management frameworks, strategic partnerships, scalability considerations, and systematic enhancement opportunities.

Technical communication excellence

Critical importance of precise technical specifications and structured communication protocols. Developing standardised documentation frameworks significantly reduced misunderstandings and enhanced project efficiency between Water Desalination and external manufacturers.

Quality management

Comprehensive supplier selection criteria and regular performance evaluations proved essential. Developing internal guidelines and quality control documentation enabled consistent implementation across operations, while technical challenges led to enhanced pre-production review protocols.

Strategic partnership development

Robust relationships with external manufacturers emerged as a crucial success factor. Regular evaluation procedures and transparent performance metrics helped ensure sustained quality and reliability in component production.

Scalability considerations

Potential for expansion across different facilities requires careful evaluation of local manufacturing capabilities and equipment-specific requirements. Implementation success depends on systematic adaptation to varying operational contexts.

Continuous improvement

Systematic feedback collection from suppliers and internal teams identified opportunities for ongoing enhancement, particularly in communication protocols and quality control measures. These insights continue to inform program refinement while maintaining operational excellence standards.

Water Transmission Co. (WTCO)

About WTCO

The Water Transmission Company (WTCO) plays a pivotal role in Saudi Arabia's water sector, focusing on water transmission and storage across the Kingdom. As a critical entity, WTCO ensures efficient and reliable water transmission from production facilities to distribution networks, aligning with the Vision 2030 objectives of sustainable development and water security.

With a clear mandate to support the nation's water infrastructure, WTCO addresses the critical need for seamless water transmission, contributing to Saudi Arabia's broader water security strategy. The company is committed to leveraging cutting-edge technology and innovative solutions to ensure safe and efficient water delivery, even to remote areas, thus meeting the demands of a growing population and expanding industries.

WTCO actively supports the goals of the National Water Strategy by optimising water transmission systems and implementing advanced monitoring and control mechanisms. This helps to ensure a reliable water supply, minimise losses, and enhance operational efficiency across the Kingdom, playing a crucial role in the Kingdom's sustainability agenda.

Promoting local content is central to WTCO's approach, and the company is working to collaborate with local manufacturers and service providers. The company is dedicated to nurturing local talent and aiming for a high localisation rate across its operations. This supports the local economy's growth and ensures that WTCO benefits from a highly skilled workforce, strengthening its capacity to deliver on its commitments.

WTCO's comprehensive approach to project management, covering planning, implementation, and operational phases, enables it to deliver robust solutions for water transmission. By focusing on efficiency, innovation, and collaboration, WTCO remains a critical contributor to the Kingdom's water sustainability goals, ensuring that water reaches the communities and industries that drive Saudi Arabia's growth and prosperity.

WTCO's operational excellence framework is structured across three primary dimensions:

- Operational performance: the organisation implements comprehensive quality monitoring systems, ensuring adherence to water quality standards while maintaining 100% delivery schedule compliance. Advanced storage management protocols, incorporating real-time monitoring and demand forecasting, maintain optimal resource availability.
- Process innovation: WTCO leverages sophisticated data analytics and predictive modelling capabilities to enhance operational decision-making. This analytical approach enables improved forecasting accuracy in demand management, maintenance planning, and resource allocation, establishing a foundation for continuous operational improvement.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

- Human capital development: the organisation prioritises workforce excellence through systematic talent management initiatives. This includes structured training programs targeting 70% of planned person-hours, the development of internal leadership capabilities with 30% succession readiness, and achieving superior employee satisfaction metrics exceeding 70%. This comprehensive approach ensures sustainable organisational capability development while maintaining operational excellence.

This integrated framework enables WTCO to fulfil its critical role in national water security while advancing local content development and technological innovation in the water sector.

Operational Challenges of Critical Pump Infrastructure

Overview of the Best Practice

This case study examines WTCO's strategic transformation of critical pump infrastructure across its water transmission network, focusing on operational excellence through technological advancement and system optimisation. The initiative addressed significant operational inefficiencies through a comprehensive five-phase strategy, encompassing infrastructure modernisation, electrical system reconfiguration, and standardised maintenance protocols.

Key achievements include record-breaking water transmission volumes during peak demand periods, system availability exceeding 99.5%, and matching the energy efficiency improvements as the Water Regulator requires. Advanced monitoring systems and strategic infrastructure configurations established new standards for operational excellence in water transmission while ensuring sustainable service delivery.

This transformation demonstrates WTCO's commitment to operational excellence across multiple dimensions: project management, technological innovation, quality assurance, and environmental sustainability. The case study provides valuable insights into successfully integrating advanced technology with operational optimisation in critical water infrastructure management.

Objectives / Problem Addressed

Critical pump infrastructure within WTCO's transmission network exhibited significant operational inefficiencies, presenting complex technological and operational challenges. Primary concerns centred on ageing vibration detection systems, suboptimal electrical switchgear configurations, and inefficient pump operation protocols, collectively impacting operational reliability and cost efficiency.

These operational challenges manifested in three critical areas: elevated maintenance requirements, increased operational costs, heightened risk of system failures compromising service reliability, and suboptimal energy utilisation affecting operational sustainability. The complexity of these challenges necessitated a comprehensive approach to system enhancement and operational optimisation.

In response, WTCO established strategic objectives focusing on three primary dimensions:

- Enhancement of operational monitoring systems to ensure robust reliability metrics
- Optimization of energy consumption patterns through advanced control mechanisms
- Implementation of standardised maintenance protocols to extend equipment lifecycle.

These objectives aligned with WTCO's broader mandate of ensuring efficient and reliable water transmission while advancing operational excellence in infrastructure management.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Operational Excellence Dimension

WTCO's pump infrastructure optimisation initiative demonstrates excellence across multiple operational dimensions:

Project & Investment Management:

Strategic allocation of resources for infrastructure upgrade initiatives, ensuring optimal return on investment through systematic implementation of monitoring systems and control mechanisms.

Quality & Security Management:

Enhancement of operational reliability through standardised maintenance protocols and monitoring systems, ensuring consistent performance standards.

Climate Change & Sustainability:

Optimisation of energy consumption patterns and equipment lifecycle management, contributing to reduced environmental impact and sustainable resource utilisation.

These dimensions collectively support WTCO's commitment to operational excellence while advancing sustainable water transmission practices.

Opportunity & Implemented Strategy

WTCO identified significant operational enhancement opportunities within its water transmission infrastructure, mainly focusing on pump station optimisation and system reliability improvement. The organisation developed a comprehensive five-phase implementation strategy to address these opportunities, systematically enhancing infrastructure capabilities while ensuring operational continuity during critical demand periods.

01 System Enhancement

The initial phase focused on infrastructure modernisation, mainly replacing outdated vibration sensors with advanced non-contact vibration transmitters. This technological upgrade established the foundation for enhanced predictive maintenance capabilities and precise operational monitoring.

02 Electrical Infrastructure Optimization

Implementing electrical switchgear separation at Mena & Quiza pump stations enabled independent system operation. This strategic reconfiguration enhanced maintenance efficiency and reduced system vulnerability to simultaneous failures.

03 Operational Efficiency Implementation

Enhancement of pump operations through alignment with Best Efficiency Point parameters optimised energy consumption patterns. This systematic approach yielded exceptional performance metrics, achieving an energy consumption score of 0.34, and matching the energy efficiency improvement as the Water Regulator requires.

04 Asset Management Enhancement

Developing standardised maintenance procedures based on the manufacturer’s Standard Job Instructions improved equipment reliability. This standardisation particularly benefited the Riyadh-Qassim Water Transmission System, reducing concrete pipeline breaks by 80%.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

05 Peak Performance Optimization

Integration of real-time monitoring systems and demand forecasting enabled exceptional system availability during critical periods. This optimisation resulted in a record-breaking performance, achieving 1,099,018 cubic meters of daily transmission through Shoaiba Water Transmission Systems to Makkah.

Through the systematic execution of this five-phase strategy, WTCO achieved significant operational reliability and efficiency advancements. The strategic approach, combining technological modernisation with operational optimisation, established new standards for water transmission excellence while ensuring sustainable service delivery during peak demand.

Results Achieved & Associated KPIs

WTCO’s strategic infrastructure optimisation initiatives significantly improved operational, energy efficiency, and system reliability metrics. These achievements demonstrate substantial progress in water transmission capabilities while establishing new performance benchmarks for the sector.

Operational Improvement

The implementation yielded exceptional performance metrics across key operational dimensions:

- System availability exceeded 99.5% during peak demand periods
- Record daily transmission of 1,099,018 cubic meters through Shoaiba WTS to Makkah
- 100% system reliability achieved during critical religious seasons

Energy and Efficiency Optimization

Energy management initiatives demonstrated significant achievements:

- Energy consumption performance score of 0.34, matching the energy efficiency improvement as the Water Regulator requires
- 80% reduction in concrete pipeline breaks in the Riyadh-Qassim system
- Enhanced pump efficiency through Best Efficiency Point optimisation

Infrastructure Performance

Technological upgrades yielded measurable improvements in operational reliability:

- Enhanced vibration monitoring accuracy for 45 high-speed pumps
- Reduced maintenance downtime through independent switch-gear operation
- Improved response time for system protection and issue resolution

These comprehensive performance improvements demonstrate WTCO's successful transformation of operational capabilities while establishing new benchmarks for water transmission efficiency in the Kingdom.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Lessons Learned

WTCO's transformation of water transmission infrastructure yielded three fundamental insights that collectively advance the understanding of operational excellence in critical water systems.

Technological Advancement:

Integrating modern monitoring systems, particularly non-contact vibration transmitters, demonstrated how precision technology transforms operational capabilities. This technological leap established new predictive maintenance and system monitoring standards, fundamentally enhancing operational reliability while providing unprecedented insight into system performance.

Strategic System Configuration:

The optimisation of infrastructure architecture, primarily through electrical switchgear separation, revealed the critical importance of system independence in operational excellence. This strategic approach to system design enhanced maintenance efficiency and established new benchmarks for infrastructure resilience during peak demand periods.

Maintenance Standardization:

Rigorous, standardised maintenance protocols are essential for sustainable operations. Adherence to manufacturer specifications and systematic monitoring procedures created a robust framework for equipment lifecycle optimisation, significantly reducing operational disruptions while ensuring consistent performance standards.

These insights provide a foundation for continuous advancement in water transmission infrastructure management, highlighting the essential role of technological innovation, strategic design, and standardised procedures in achieving operational excellence.

05
Best Practices for Operational Excellence within the Saudi Arabian Water Value Chain

National Water Company (NWC)

About NWC

Established in 2008, the National Water Company (NWC) is Saudi Arabia's principal water and wastewater services provider, playing a vital role in the Kingdom's water sector development. Operating across significant regions, including Riyadh, Makkah, Madinah, and Eastern Province, NWC manages comprehensive water infrastructure networks serving millions of beneficiaries. The organisation's mandate encompasses water distribution, wastewater treatment, and integrated water resource management, supporting Saudi Vision 2030's water security objectives.

NWC's operations are committed to service excellence by integrating advanced technologies and sustainable management practices. The organisation's infrastructure portfolio includes extensive water distribution networks, wastewater treatment facilities, and sophisticated monitoring systems serving residential and industrial sectors. Through strategic partnerships and continuous innovation, NWC enhances water service quality while optimising resource utilisation across its operational domains.

The organisation's vision of operational excellence is built upon a comprehensive framework integrating multiple technological and organisational dimensions. NWC emphasises cohesive operations through the systematic integration of advanced asset management systems, including Workforce Management (WFM), Enterprise Asset Management (eAM), Geographic Information Systems (GIS), and Asset Information Management Systems (AIMS). This integrated approach enables optimised data utilisation for strategic decision-making while ensuring stakeholder engagement throughout implementation processes. NWC's focus on organisational awareness and asset lifecycle management establishes a foundation for sustainable performance improvement and operational efficiency across its extensive infrastructure network.

Asset Management Improvement

Overview of the Best Practice:

The National Water Company's asset management transformation initiative demonstrates a comprehensive approach to operational excellence through systems integration and enhanced monitoring capabilities. Responding to challenges posed by expanding infrastructure and fragmented information systems, NWC developed an integrated framework combining Enterprise Asset Management, Asset Information Management System, and Geospatial Information System.

The initiative's strategic implementation encompassed four key pillars: workforce management integration, enterprise asset management, geospatial information systems, and performance optimisation. This systematic approach has yielded early positive results in operational efficiency, maintenance effectiveness, and decision-making capabilities. While still in progress, the transformation demonstrates NWC's commitment to operational excellence through technological innovation and process optimisation, establishing new water sector asset management standards.

This case study illustrates how integrated asset management systems, strategic stakeholder engagement, and systematic implementation can enhance operational efficiency while ensuring sustainable service delivery.

Objectives / Problem Addressed

The rapid expansion of NWC's water and wastewater infrastructure presented significant challenges in asset management and operational efficiency. The organisation's growing network of assets demanded enhanced monitoring capabilities and performance optimisation to maintain service quality while ensuring customer satisfaction. Fragmented information systems further complicate this operational context, leading to workflow inefficiencies and limited visibility of asset conditions.

The initial operational environment was characterised by disconnected monitoring and management systems, leading to inconsistent data flow across operational units. This fragmentation resulted in limited real-time visibility of asset performance, inefficient resource allocation processes, and suboptimal maintenance scheduling, collectively impacting service delivery and operational efficiency.

In response to these challenges, NWC established four primary objectives:

- Enhancement of customer satisfaction through improved service reliability
- Optimisation of water quality management through systematic monitoring
- Reduction of environmental impact through sustainable practices
- Cost-based optimisation through preventive maintenance strategies

The project centred on adding three critical systems: Enterprise Asset Management, Integrated Asset Management Information System, and Geospatial Information System. This technological framework aims to establish centralised monitoring capabilities, enabling data-driven decision-making while optimising operational efficiency.

This ongoing transformation demonstrates NWC's commitment to continuous improvement in asset management practices while advancing operational excellence in water infrastructure management.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Operational Excellence Dimension

NWC's asset management transformation demonstrates excellence across two primary operational dimensions:

Project & Investment Management

Strategic resource allocation and systematic monitoring protocols enhance infrastructure investment returns while optimising asset lifecycle management. Customer feedback mechanisms in investment decisions ensure alignment between infrastructure development and service requirements.

Technology & Research Development:

Advanced software systems enable real-time monitoring and data-driven decisions. Collaborative platforms for complaint management showcase NWC's advancement in service optimisation through technological innovation.

These dimensions collectively support NWC's strategic vision of operational excellence through enhanced asset management and technological advancement.

Opportunity & Implemented Strategy:

NWC identified critical inefficiencies in asset management stemming from disconnected systems and underutilised monitoring capabilities. Data fragmentation across separate platforms hindered comprehensive asset tracking and performance monitoring across Saudi Arabia's regions, limiting operational effectiveness and decision-making capabilities. Initial assessment revealed insufficient data quality and inconsistent information flow between systems, creating operational bottlenecks and impeding the organisation's ability to maintain optimal asset performance. This situation mainly affected maintenance activities, which needed more comprehensive monitoring across regional operations.

After becoming aware of a problem affecting the efficiency of its asset management, NWC developed a strategic process for identifying improvements. This process consists of 5 steps:

01 System Assessment

A comprehensive evaluation of existing data sources and quality metrics revealed significant gaps affecting asset performance insights. The assessment identified critical areas where data fragmentation impacted operational efficiency and maintenance effectiveness.

02 Gap Analysis and Stakeholder Engagement

A detailed comparison with industry standards highlighted integration deficiencies in monitoring and data management systems. Extensive stakeholder consultations revealed challenges with data format consistency and system interoperability, confirming the need for enhanced integration.

03 Solution Framework Development

Analysis of advanced asset management systems led to the selection of integrated platforms emphasising seamless data continuity. This phase included a rigorous evaluation of potential solutions focusing on WFM and GIS integration capabilities.

04 Executive Alignment

Presentation of findings to leadership demonstrated the potential operational improvements through integrated systems, securing organisational commitment to transformation.

05 Implementation Planning

Developing a phased rollout strategy ensures systematic data alignment and effective adoption across the organisation, emphasising minimising operational disruption during the transition.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

The strategic implementation framework encompasses four interconnected pillars, each addressing specific asset management aspects while enabling comprehensive operational enhancement. These pillars integrate advanced technological solutions with operational processes to establish a robust foundation for sustainable asset management.

Workforce Management (WFM) & Preventive Maintenance (PM) Integration

Preventive maintenance schedules integration with workforce management software creates a comprehensive maintenance ecosystem. The system enables automated work order generation in eAM with seamless reflection in WFM for workforce scheduling. This integration aims to reduce maintenance costs through automated processes, enhance service delivery through improved task coordination, and ensure optimal water quality through proactive maintenance completion.

Enterprise Asset Management (eAM)

Boost asset performance and lifecycle management through advanced eAM capabilities. Maximising asset utilisation and minimising failures can contribute to higher water quality and reduced operational costs. Oracle eAM is the cornerstone of NWC's asset management strategy, offering comprehensive lifecycle management capabilities. The system provides scalable solutions for preventive maintenance, work order management, and real-time performance tracking. Selected for its robust integration capabilities with WFM and GIS, Oracle eAM enables significant operating cost reduction through improved asset utilisation while enhancing water quality through systematic maintenance protocols.

Geospatial Information System

Advanced spatial analysis capabilities transform asset tracking and resource deployment across NWC's operational territory. The system enables optimised maintenance routing, precise resource allocation, and comprehensive geographical asset management. This spatial intelligence enhances decision-making processes while ensuring efficient resource utilisation across diverse geographical locations.

Performance & Cost Optimization

Sophisticated monitoring systems enable data-driven performance optimisation across all asset management strategies. The framework facilitates continuous improvement through comprehensive asset insights, optimised resource allocation, and enhanced maintenance efficiency. This systematic approach supports cost reduction initiatives while ensuring sustained service quality improvements.

This strategic framework establishes a foundation for sustainable improvement in asset management while ensuring optimal service delivery across NWC's operations.

Results Achieved & Associated KPIs

The ongoing implementation of NWC's integrated asset management framework demonstrates early indicators of operational improvement, though comprehensive performance metrics are still being established. Initial assessment of the transformation initiative reveals emerging positive trends across multiple operational dimensions.

Operational Performance

Preliminary results indicate a significant enhancement in preventive maintenance effectiveness through systematic scheduling and execution. Enterprise systems integration has enabled more precise asset monitoring and maintenance timing, reduced unplanned downtime, and enhanced equipment reliability.

Decision-Making Enhancement

The convergence of Enterprise Asset Management, Geospatial Information Systems, and Workforce Management platforms has transformed operational intelligence capabilities. This integration enables real-time asset tracking and location-based analysis, facilitating more effective resource deployment and maintenance prioritisation.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Efficiency Optimization

Early indicators suggest a positive trajectory in operational efficiency through:

- Streamlined maintenance scheduling
- Enhanced workforce allocation
- Automated workflow processes
- Optimized resource utilisation

While the transformation remains in progress, these preliminary results indicate the initiative's potential to significantly impact service delivery, water quality, and operational efficiency. The full implementation is expected to establish new benchmarks for asset management excellence in the water sector.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Lessons Learned

While analysing the problem and implementing the solution, NWC has drawn four critical conclusions about the success of systems integration in water supply companies.

Organisational Awareness

Building a comprehensive understanding of asset management requirements across all operational levels proved fundamental to successful transformation, highlighting the importance of systematic knowledge dissemination.

Data Management Excellence

Accurate data collection and sophisticated analysis frameworks emerged as essential for informed decision-making and sustainable performance optimisation.

Stakeholder Engagement

Strategic stakeholder engagement throughout the transformation process enabled smooth implementation while ensuring alignment between technical capabilities and operational requirements.

Systems Integration

Using multiple management platforms demonstrated how technological convergence enhances operational efficiency through improved data flow and system cohesion.

These insights provide valuable guidance for future asset management initiatives, emphasizing the balance between technical and organisational considerations in achieving operational excellence.

05
Best Practices for Operational Excellence within the Saudi Arabian Water Value Chain

Saudi Irrigation Organization (SIO)

About SIO

Established in 2016, the Saudi Irrigation Organization (SIO) is a crucial governmental entity that promotes irrigation sustainability within the Kingdom of Saudi Arabia. The organisation is responsible for optimising the use of treated water across agricultural, industrial, and urban sectors while ensuring equitable access to water resources throughout the Kingdom. SIO's core responsibilities encompass dam management and the conservation of water resources, thereby positioning it as an essential player in achieving national water security.

SIO's commitment to operational excellence is reflected in a comprehensive framework that aligns with five strategic pillars:

- Resource sustainability through efficient water management and the development of non-conventional resources
- Enhancement of service quality through infrastructure optimisation
- Advancement of social welfare through agricultural capacity building
- Economic contributions through cost-effective resource utilisation
- Promotion of public awareness regarding sustainable water practices

The organisation's vision of excellence in irrigation management is realised through integrated strategies that leverage modern technology and data analytics. This innovative approach has earned SIO recognition, including the Arab Award for Operation and Maintenance, for its effective implementation of Big Data in operations management. SIO's operational framework prioritises adopting intelligent systems, facilitating data-driven decision-making that accommodates climate variability and environmental conditions.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Through strategic partnerships with governmental entities, agricultural stakeholders, and research institutions, SIO is furthering its mission to enhance sustainable water resource utilisation while improving field efficiency through technological innovation. This comprehensive approach to operational excellence, paired with SIO's commitment to continuous workforce development and stakeholder engagement, positions the organisation as a pivotal contributor to the water sustainability objectives outlined in Saudi Vision 2030. By systematically executing these strategies, SIO is actively enhancing agricultural productivity while ensuring the sustainable management of water resources across the Kingdom.

Digital Transformation of Agricultural Water Management Through ICT

Overview of the Best Practice:

The Saudi Irrigation Organization (SIO), in partnership with the Food and Agriculture Organization (FAO), has instituted an innovative approach to agricultural water management by integrating Information and Communication Technology (ICT) within demonstration farms. This strategic initiative addresses significant challenges associated with traditional irrigation practices while furthering national goals related to water resource sustainability.

The project emphasises promoting efficient irrigation technologies and enhancing water productivity among Saudi farmers through systematic technology adoption. The initiative seeks to achieve a twenty per cent adoption rate of efficient irrigation technologies by deploying intelligent irrigation systems and implementing precision monitoring protocols. This comprehensive strategy merges technological innovation with capacity building, thereby establishing a framework for sustainable advancements in agricultural water management practices, all while optimising farm productivity through precise control of water application.

Objectives / Problem Addressed

The agricultural sector in the Kingdom of Saudi Arabia confronts considerable challenges related to water resource management, particularly considering the country's arid climate and reliance on non-renewable aquifers. With irrigation efficiency rates approximately 50 percent—substantially below the global best practice standard of 85 percent—the sector necessitates significant operational improvements to achieve sustainable agricultural productivity and ensure food security.

Significant inefficiencies in irrigation system monitoring and water application control characterised initial operational conditions. The primary challenges included:

- Limited availability of real-time data for water usage monitoring
- Excessive water consumption resulting from inadequate irrigation control
- Elevated operational costs associated with manual system management
- Suboptimal irrigation scheduling that did not consider environmental conditions

Through comprehensive site surveys conducted across various agricultural regions, including Jazan, Eastern Province, Al Madinah, and six additional provinces, the Sustainable Irrigation Organization (SIO) identified the necessity for adaptive irrigation systems that integrate environmental data. This assessment culminated in selecting 21 demonstration farms from 323 evaluated sites, establishing a foundation for technological innovation in agricultural water management.

In alignment with Saudi Vision 2030 and the National Water Strategy, the initiative has established three principal objectives:

- Enhancement of irrigation efficiency through the integration of information and communication technology (ICT)
- Optimization of water resource utilisation through precise monitoring techniques
- Development of sustainable agricultural practices through the adoption of innovative technologies

The implementation framework harnesses opportunities presented by digital transformation, integrating advanced monitoring systems with mobile technology while providing comprehensive training support to ensure sustainability.

Operational Excellence Dimension

The Smart Irrigation Initiative of SIO showcases exemplary performance in three of the operational dimensions outlined in the framework:

Technology and Research & Development:

The initiative showcases technological leadership in agricultural water management by integrating advanced information and communication technology (ICT) solutions, including sensor networks and mobile applications. This innovative approach combines real-time monitoring capabilities with precise control systems, thereby establishing new benchmarks for implementing irrigation technology.

Quality and Security Management:

Digital monitoring protocols enhance operational control and data security while ensuring consistent irrigation performance. A systematic system monitoring approach facilitates precise water application quality management, which supports optimal agricultural productivity through standardised operational procedures.

Climate Change and Sustainability:

The initiative promotes environmental stewardship by optimising water resource utilisation and reducing consumption patterns. By incorporating real-time ecological data with irrigation control systems, the program demonstrates significant advancements in sustainable agricultural practices and supports strategies for climate change adaptation.

Together, these dimensions reinforce SIO's commitment to operational excellence while fostering sustainable irrigation practices across the agricultural sector.

Opportunity & Implemented Strategy

In partnership with FAO, SIO has identified a significant opportunity to enhance traditional irrigation practices by implementing digital innovation. This initiative seeks to transition from conventional, paper-based irrigation scheduling to a comprehensive, innovative system responsive to real-time environmental conditions. The transformation is centred on three primary objectives: maximising water use efficiency through adaptive management, improving crop health through precise moisture regulation, and enabling robust remote monitoring capabilities.

The execution of the project adhered to a comprehensive two-year timeline structured into three distinct phases:

01 System Assessment

This initial phase thoroughly evaluated cropping patterns and water consumption profiles to pinpoint target crops and optimal demonstration sites. A comprehensive market analysis of global and national technological solutions was conducted to ascertain the most suitable systems for implementation. The selection process was designed to ensure representation across diverse agricultural conditions while considering farmer readiness and site suitability.

02 System Design and Development

During this phase, an advanced irrigation management system featuring sophisticated monitoring and control capabilities was developed. The core of this system included the integration of soil moisture sensors that provide precise ground condition data, supplemented by weather monitoring systems that facilitate the integration of environmental data. These components established a comprehensive control architecture that enables intelligent scheduling and automated system management.

03 System Integration and Training

The final phase encompassed the installation of the system across demonstration sites, accompanied by extensive training programs for farmers and irrigation teams. This phase emphasised practical knowledge transfer and hands-on experience with the new technology. Implementation efforts included the establishment of monitoring protocols for continuously assessing system performance, water consumption patterns, and crop production metrics.

The integrated solution revolutionises agricultural water management through several vital capabilities. Automated scheduling permits dynamic adjustments in response to environmental conditions, while precision monitoring of soil moisture ensures optimal water distribution based on real-time ground assessments. The integration of weather forecasts facilitates proactive irrigation management, enabling schedule adjustments based on anticipated environmental changes.

Moreover, remote system monitoring through mobile and desktop applications equips farmers with unparalleled control over their irrigation systems, allowing for real-time adjustments and immediate responses to system alerts. Advanced analytics capabilities foster data-driven decision-making, enabling tracking water usage patterns, soil moisture trends, and overall system performance to optimise agricultural practices.

This systematic approach lays a foundation for sustainable irrigation practices while showcasing the potential for technological innovation in agricultural water management.

However, the successful implementation of SIO's smart irrigation initiative necessitated the integration of sophisticated technological components across various system layers. This comprehensive infrastructure harmonises traditional irrigation methods with advanced monitoring and control technologies, establishing an efficient and automated water management system.

01 Core Infrastructure Components

The system's foundation is precision drip irrigation technology. Advanced drip emitters facilitate controlled water distribution directly to the bases of plants, while an integrated network of pipelines and connectors ensures efficient water transport throughout agricultural fields. Pressure regulation systems and sophisticated filtration mechanisms maintain consistent water flow and prevent system blockages (see Figure 7).

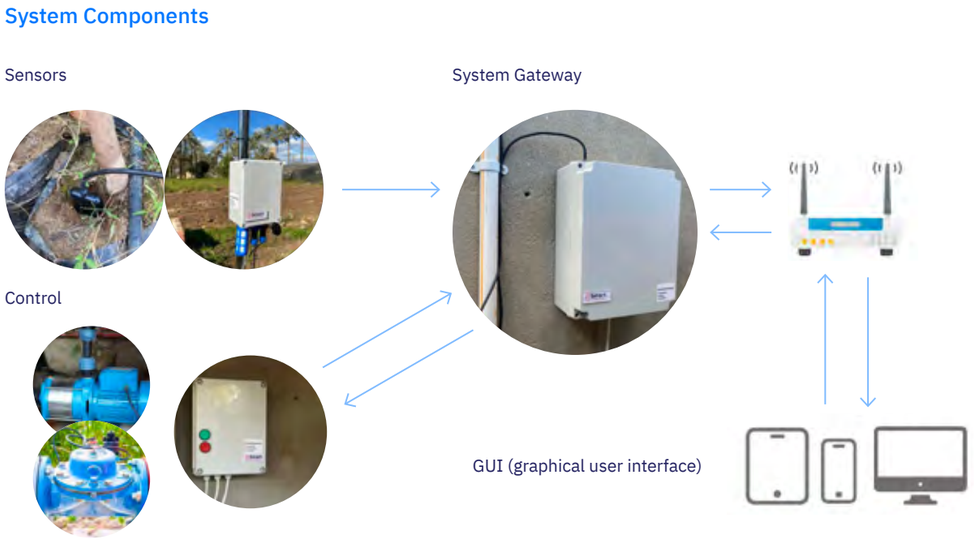


Figure 6. System components.

02 Smart Monitoring Architecture

The monitoring framework integrates multiple sensor technologies to provide a thorough environmental assessment. Soil moisture sensors deliver real-time data regarding ground conditions, while weather stations monitor critical environmental parameters, including rainfall, temperature, and humidity. Flow meters enable precise monitoring of water distribution, allowing for early detection of system irregularities and the optimisation of resource utilisation.

03 Control and Automation Systems

At the core of the infrastructure, a central control unit consolidates data from various sources to manage irrigation operations effectively. This central unit processes information from environmental sensors and adjusts irrigation schedules accordingly. Automated valves and actuators respond to control signals, facilitating precise water distribution across different irrigation zones.

04 Communication Infrastructure

The system employs Internet of Things (IoT) technology to facilitate seamless communication among components. Mobile and web applications provide user interfaces for remote system management, while automated alert systems notify operators of maintenance requirements or anomalies within the system. This connectivity ensures real-time system monitoring and responds promptly to changing conditions.

05 Agricultural Enhancement Features

Additional capabilities of the system include automated fertiliser injection systems, which enable precise nutrient delivery through the irrigation network. This water and nutrient management integration optimises crop health while minimising resource usage.

This comprehensive technological framework allows for precise control over agricultural water management and establishes new standards for sustainable farming practices in the region.

The implementation framework is demonstrated through a 1,000-square-meter model agricultural plot for illustrative purposes. This representative installation showcases the integration of all critical system components, providing a comprehensive example of smart irrigation infrastructure deployment. The model demonstrates optimal component placement and system configuration while serving as a reference for future implementations across the Kingdom's agricultural sector.

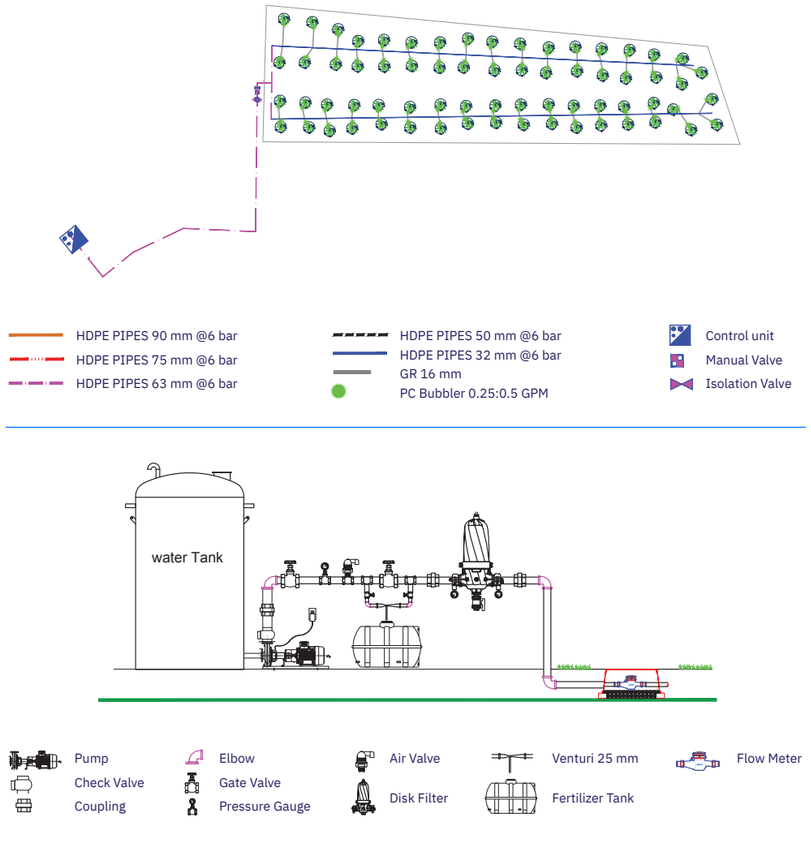


Figure 7. Layout of the smart drip irrigation system (A), including all main components (B) needed for plot of 2000 square meters.

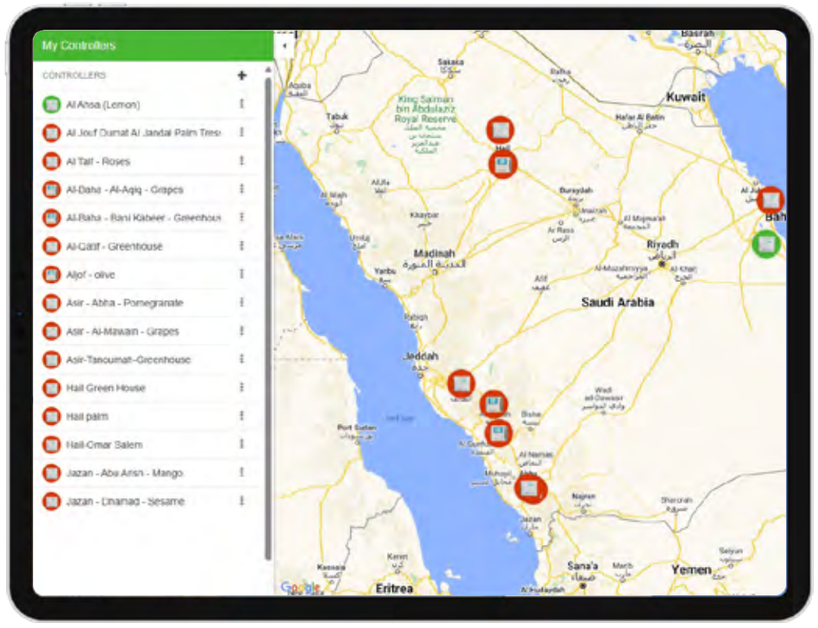
Results Achieved & Associated KPIs

The smart irrigation initiative implemented by SIO has successfully demonstrated notable enhancements in operational efficiency through the application of comprehensive performance metrics. Advanced monitoring systems with traditional irrigation infrastructure have significantly improved water resource management, particularly regarding dynamic scheduling and responsiveness to environmental changes.

Operational efficiency:

The initiative has demonstrated significant advancements in irrigation efficiency, defined as the ratio of water beneficially utilised for plant growth to the total volume of water applied to agricultural fields. Performance data reveals a 30% improvement in efficiency resulting from the implementation of real-time soil moisture monitoring coupled with weather-adaptive scheduling. This enhancement has effectively minimised instances of over-watering while optimising resource utilisation. Furthermore, the automation of irrigation processes has considerably reduced labour demands associated with operations, thereby enhancing the system's overall efficiency.

Figure 8. Irrigation system before implementation (A), implemented system (B), and piping system (C).



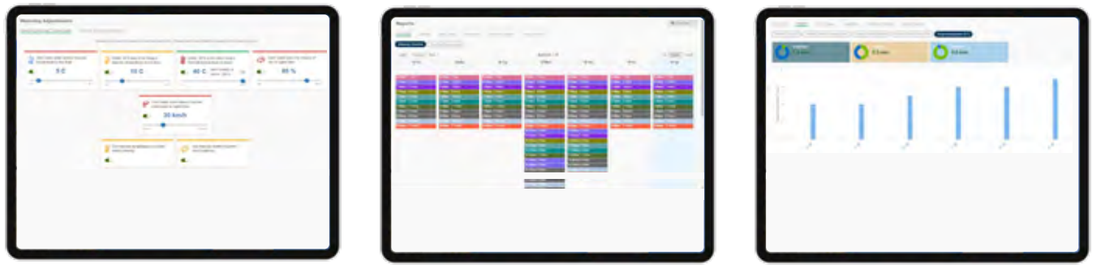


Figure 9. Visual outputs from the integrated smart irrigation system: (a) User interface of the smart irrigation monitoring system, (b) Digital report on irrigation for multiple sites, (c) Monitoring charts for weather data, (d) Programming the irrigation system based on weather data.

Economic consideration

Cost estimates for the implementation of drip irrigation systems vary according to the size of the farm and the type of crops cultivated. On average, the total expenditure per hectare for establishing a drip irrigation network is approximately SAR 15.000, while the costs associated with automation are around SAR 2.500. This figure encompasses the necessary equipment, such as sensors, weather-linked controllers, and installation services.

Research Validation

Although the project is still collecting data regarding the effects of the implemented intelligent irrigation system, numerous research studies have examined the water savings achieved through such systems. The following are significant studies and findings that illustrate how smart irrigation enhances water efficiency:

- Duke University & U.S. Environmental Protection Agency (EPA) – “Evaluation of Water Savings from Smart Irrigation Technologies”

This study, supported by the Environmental Protection Agency (EPA), assessed water conservation in residential and commercial landscaping. Smart irrigation systems, with a particular emphasis on weather-based controllers, were found to decrease water usage by 20% to 50% compared to conventional irrigation techniques. The research findings have been extensively cited in publications related to environmental management and are accessible through resources provided by the EPA WaterSense program.

- University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) – “Water Savings Potential of Smart Irrigation Systems for Homeowners”

This study, conducted in Florida, assessed the water conservation capabilities of smart controllers in residential landscaping. The findings indicated that smart irrigation systems, which utilise soil moisture and weather data, can decrease water usage by as much as 30% compared to traditional irrigation methods. Published in the journal HortTechnology, this research emphasises the efficacy of smart irrigation technologies in regions facing water scarcity.

- California Department of Water Resources (DWR) – “Smart Irrigation Technologies in California Agriculture”

In a state-funded research initiative, the Department of Water Resources (DWR) evaluated various smart irrigation technologies for crops such as almonds, grapes, and citrus. The study demonstrated that precision irrigation utilising sensor-based controllers reduced water usage by 20% to 25% while effectively maintaining or enhancing crop yields. This research is accessible through California’s water resources publications and underscores the importance of water-efficient agricultural practices.

- Agricultural Water Management Journal – “Impact of Smart Irrigation on Water Use Efficiency in Drip and Sprinkler Irrigation Systems”

A peer-reviewed study examined the water savings associated with various irrigation systems incorporating advanced smart technology. The results indicated that smart irrigation systems, particularly those combined with drip and sprinkler methodologies, enhanced water use efficiency by 15% to 40%, contingent upon the specific crop and regional climate. Published in the journal Agricultural Water Management, this study contributes significantly to the promotion of sustainable agricultural practices worldwide.

Each of these studies shows a measurable impact of smart irrigation on water conservation, whether in agriculture or landscaping, and they strongly support the benefits of adopting smart irrigation

technology. During the coming phase, the project will also focus on measuring the impact on local conditions.

The preliminary results have surpassed expectations in irrigation scheduling and water conservation which showed 20 % water saving and 35 % increase in irrigation efficiency; however, a comprehensive evaluation of additional key performance indicators is ongoing.

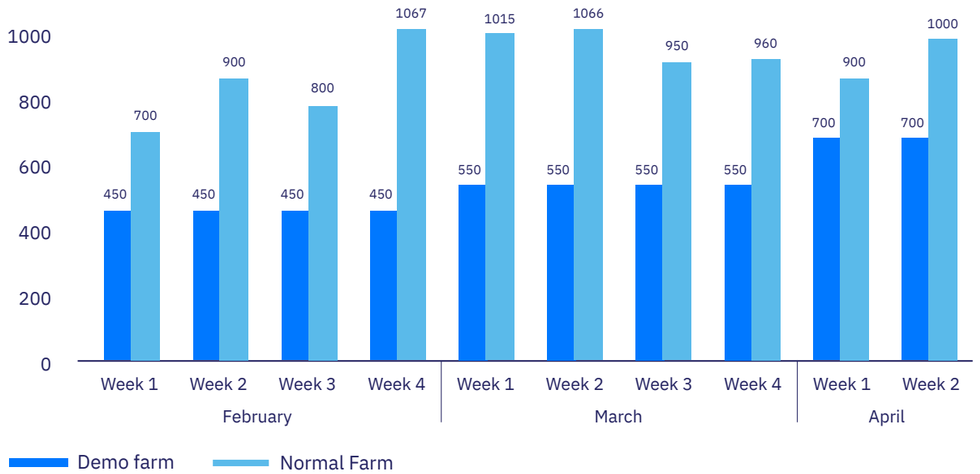


Figure 10. Water consumption (cubic meters) in demo farms compared to normal farms.

These indicators encompass farmer satisfaction indices, an in-depth cost-benefit analysis, and measurements of crop yield enhancement, which will be assessed once the growing season concludes. This continuous assessment will yield valuable insights for future system optimisation and the development of broader implementation strategies.

Lessons Learned

SIO's smart irrigation initiative has provided significant insights that enhance understanding of technology integration in agricultural water management.

Technological Innovation in Agriculture:

The successful implementation of Information and Communication Technology (ICT) within irrigation management underscores the agricultural sector's readiness for technological progression. Farmers' acceptance and engagement with digital systems highlight the potential for a broader technological transformation in conventional agricultural practices.

Environmental Data Integration:

The pivotal role of environmental monitoring has emerged as a fundamental element of efficient irrigation management. The incorporation of real-time soil condition data and weather patterns has been essential for optimising water distribution and improving overall system efficiency, thereby establishing new standards for precision agriculture.

Strategic Partnership Development

Collaboration with the Food and Agriculture Organization (FAO) has proven instrumental in ensuring that the systems are aligned with international environmental standards while preserving operational effectiveness. This partnership exemplifies the value of merging global expertise with local implementation capabilities.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Capacity Development

Robust local expertise through comprehensive training programs has been essential for sustainable system operation. This emphasis on national capacity building ensures long-term operational sustainability while fostering domestic capabilities in advanced agricultural technology.

These insights offer valuable guidance for future agricultural technology initiatives and underscore the necessity of balancing technological innovation with practical implementation considerations to achieve operational excellence.

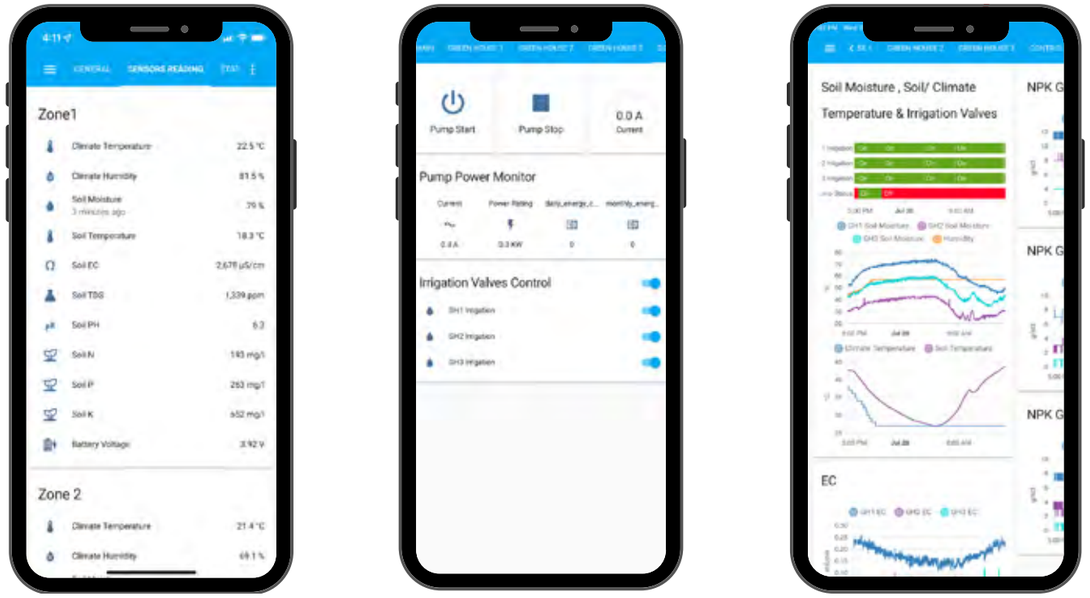


Figure 11. User interface of the Mobile application control system

05
Best Practices for Operational Excellence within the Saudi Arabian Water Value Chain

National Water Efficiency & Conservation Centre (MAEE)

About MAEE

The National Water Efficiency and Conservation Centre (MAEE) is Saudi Arabia's principal institution dedicated to promoting and implementing water efficiency practices in the urban, agricultural, and industrial sectors. Established in alignment with national strategic objectives, MAEE's mandate includes developing technical standards, regulatory frameworks, and monitoring protocols to optimise water resources throughout the Kingdom.

MAEE's operational framework is founded upon five strategic pillars: the development of legal and regulatory measures, provision of qualification and certification services, enhancement of public awareness, compliance monitoring, and information management. This comprehensive methodology allows the organisation to drive improvements in water efficiency while fostering sustainable consumption practices through strategic partnerships and stakeholder engagement.

Reference to Royal decree No. 336 issue in Feb. 2021 MAEE was established to enhance water supply chain efficiency / conservation.

MAEE's Mandate Main Pillars

Across Urban, Agrigultural and Industrial Sectors as well as the Supply Chain

Laws, Regulations and Policies
Develop national programs and policies, propose laws, publish regulations, and contribute to the development of efficiency and conservation standards and their management

Licenses, Certifications, and Consulting Services
Draft rules for the licensing and certification of technical service providers, and develop an overarching national guide for efficiency and conservation.

Awareness and Education
Develop awareness programs and campaigns, relevant educational and vocational curricula and conferences on water efficiency and conservation.

Monitoring and Compliance
Monitor compliance with water efficiency and conservation practices.

Data Management
Collect water related data in a centralized database, validate data quality, analyze it, and develop regular reports on key findings.

Investments and Partnerships
Promote and support investments and partnerships in fields related to water efficiency and conservation research and development.

Figure 12. MAEE mandate main pillars

In collaboration with pertinent authorities, MAEE significantly contributes to developing standardised specifications for equipment, irrigation systems, and water management tools. The organisation's mandate encompasses establishing essential regulations, standards, and testing procedures on efficiency measures while promoting public awareness of water conservation initiatives. This comprehensive approach enables MAEE to address water efficiency challenges holistically, addressing technical standardisation and behavioural change management.

To fulfil its mandate, the MAEE has established a comprehensive strategic framework comprising seven principal pillars, each complemented by targeted programs and initiatives.

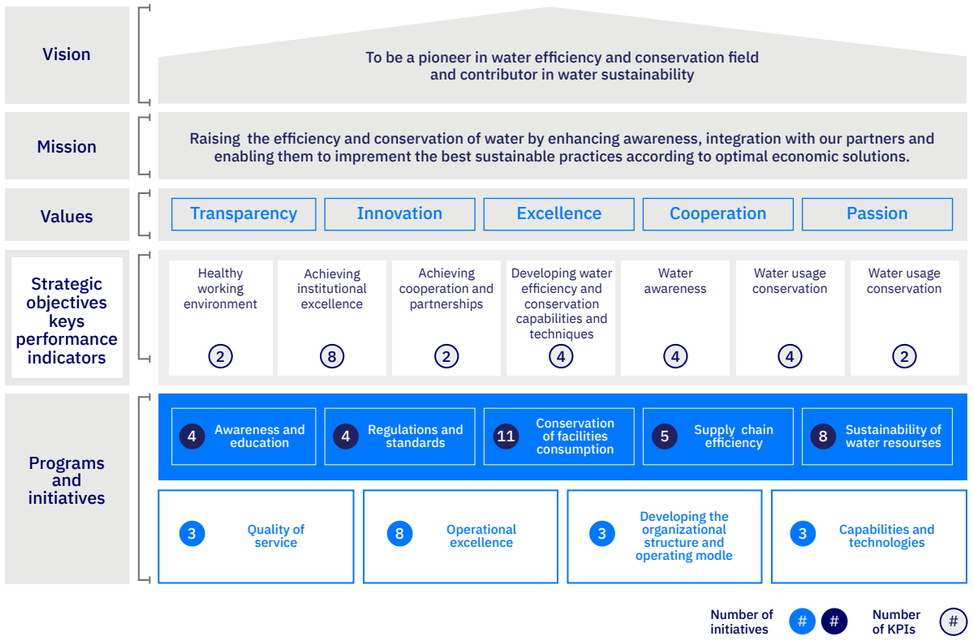


Figure 13. MAEE strategic objectives

Healthy Working Environment:

Focused on creating an optimal organisational climate that promotes efficiency and innovation through effective human resource management and institutional development.

Institutional Excellence Achievement:

Centres on developing organisational capabilities and implementing best practices to ensure operational effectiveness and service quality, supported by eight key performance indicators.

Cooperation and Partnership Development:

Emphasises establishing strategic alliances and collaborative relationships with stakeholders across the water sector, facilitating knowledge exchange and resource optimisation through two significant initiatives.

Water Efficiency and Conservation Capabilities:

It focuses on developing technical expertise and implementing advanced conservation techniques, supported by four key performance indicators and specific programs for facilities consumption management.

Water Awareness:

Dedicated to promoting public consciousness about water conservation through educational programs and awareness campaigns, measured through 4 distinct performance metrics.

Water Usage Conservation:

Implements practical conservation measures and monitors their effectiveness through 4 key performance indicators, emphasising regulatory compliance and best practice adoption.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Supply Chain Efficiency:

Concentrates on optimising water resource management across the entire supply chain, contributing to overall system efficiency with two performance indicators.

The organisation's commitment to operational excellence is exemplified through an integrated framework encompassing legal policy formulation, human resource management, technological innovation, research advancement, and stakeholder collaboration. This rigorous approach has yielded significant accomplishments in water conservation, including daily water savings amounting to 12.6 million cubic meters and the effective implementation of efficiency programs across government entities.

Through the systematic execution of water conservation initiatives, such as the landmark Kingdom's Water Conservation Initiative and private sector engagement programs, MAEE actively advances national water sustainability objectives. The organisation's performance is evaluated through stringent indicators aligned with the National Transformation Program, ensuring sustained progress toward established water efficiency targets. This strategic approach, coupled with extensive stakeholder collaboration, evidenced by 32 memorandums of understanding and 71 monitoring rounds, positions MAEE as a pivotal enabler in achieving the Kingdom's water sustainability goals.

Kashf e-application

Overview of the Best Practice:

The National Water Efficiency and Conservation Centre (MAEE) has introduced Kashf, an innovative digital platform that optimises leak detection services by systematically connecting service seekers with verified providers. This technological solution embodies a holistic approach to water conservation through digital transformation, incorporating both efficient service delivery and performance monitoring capabilities.

The application's architecture comprises multiple integrated components, including provider-beneficiary matching, service quality monitoring, and multi-channel communication systems. This systematic framework facilitates real-time service coordination while upholding quality standards through continuous user feedback and performance evaluation mechanisms.

The platform's dedication to service excellence is evident in its comprehensive communication framework, which includes in-app technical support, dedicated email channels, and social media integration. This multi-channel strategy ensures responsive stakeholder engagement, efficient issue resolution, and ongoing service improvement through systematic feedback collection and analysis. Incorporating user experience metrics and satisfaction monitoring further enables continuous optimisation of the platform, thereby establishing a solid foundation for sustainable enhancement of service delivery.

Objectives / Problem Addressed

Traditional leak detection services in Saudi Arabia have confronted considerable operational challenges. These challenges have manifested as fragmented service delivery, inconsistent quality standards, and inefficient connections between providers and beneficiaries. The lack of a centralised platform has led to prolonged response times, varying service quality, and less-than-optimal outcomes in water conservation efforts.

The water sector has experienced various operational inefficiencies in leak detection services, particularly concerning accessibility to qualified providers and the implementation of quality assurance mechanisms. The fragmented nature of service delivery has created barriers to effective communication among stakeholders, while the absence of standardised protocols has impeded effective performance monitoring and service consistency.

MAEE has established a comprehensive framework centred on three primary dimensions to address these challenges. First, developing an integrated digital platform aims to streamline service delivery and enhance connections between providers and beneficiaries. Second, systematic quality control mechanisms ensure consistent service and provider performance excellence. Third, establishing efficient multi-channel communication protocols aims to improve stakeholder engagement and responsiveness in service delivery.

The initiative aspires to enhance water conservation through improved leak detection services and establishing standardised operational protocols and performance monitoring mechanisms. This structured approach aligns with MAEE's broader mandate to promote water efficiency and conservation throughout the Kingdom.

Operational Excellence Dimension

Technology & Research & Development:

The Kashf application exemplifies operational excellence by integrating innovative technologies and systematic enhancements driven by research. By continuously advancing the platform and optimising user experience, MAEE utilises sophisticated digital solutions to revolutionise traditional leak detection services, establishing new benchmarks for water conservation service delivery.

Opportunity & Implemented Strategy

MAEE has identified a strategic opportunity to tackle water conservation challenges through the digital transformation of leak detection services. The organisation acknowledges that integrating technology with service delivery can significantly enhance water sustainability while fostering improved stakeholder engagement. To accomplish these objectives, MAEE has established a strategic plan centred around four pillars that serve as the foundation for the development of this initiative.

01 Foundation development

The organisation will establish a digital platform to facilitate connections between registered leak detection service providers and beneficiaries while implementing quality assurance mechanisms.

02 Community engagement

A series of comprehensive awareness programs will be developed to educate the community regarding leak detection and water waste, promoting investment in water conservation through systematic stakeholder education.

03 Service optimisation

Oversight mechanisms will be implemented to safeguard the rights of both beneficiaries and service providers. Performance monitoring protocols will be established to ensure the delivery of high-quality services.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

04 Sustainability enhancement

The focus will be on reducing internal network waste within buildings through enhanced leak detection services, thereby contributing to broader water sustainability objectives.

This methodical approach enables MAEE to transform traditional leak detection services and establish new standards in water conservation.

Results Achieved & Associated KPIs:

Employing the Kashf platform has yielded significant operational improvements in leak detection service delivery. The application has successfully connected over 16,250 beneficiaries with qualified service providers, demonstrating substantial scalability in service accessibility and delivery.

Water conservation impact:

The platform has achieved remarkable water conservation outcomes:

- Daily water savings of 28,999 cubic meters
- Cumulative water savings reaching 6.06 million cubic meters
- 66% reduction in consumption rates among beneficiaries

Service quality performance

Service excellence metrics demonstrate intense user satisfaction:

- 95.8% beneficiary satisfaction rate with provided services
- Successful implementation of multi-channel support systems, including technical support, email communication, and social media engagement

These comprehensive performance improvements demonstrate the effectiveness of MAEE's digital transformation in leak detection services while establishing new benchmarks for water conservation initiatives in the Kingdom. The results validate the strategic approach to service delivery optimisation through technological innovation.

Lessons Learned

The Kashf e-application platform has provided valuable insights that can significantly inform and enhance future water conservation initiatives within the Kingdom of Saudi Arabia.

Broad audience:

The platform targets a diverse audience comprising residential property owners, tenants, and real estate developers across various property types.

Tailored solutions:

It is essential to recognise the necessity of tailoring solutions to address the distinct requirements of different customer segments.

Robust partnerships:

Fostering robust partnerships and collaborative approaches with key stakeholders will facilitate the exchange of ideas and the development of comprehensive solutions.

These lessons highlight the strategic importance of audience segmentation, stakeholder engagement, and collaborative innovation in implementing best practices for water conservation and digital transformation.

05
Best Practices for Operational Excellence within the Saudi Arabian Water Value Chain

Saudi Water Partnership Company (SWPC)

The Saudi Water Partnership Company (SWPC) exemplifies operational excellence through its steadfast commitment to efficiency, innovation, and stakeholder engagement. SWPC has consistently demonstrated the capability to achieve and sustain high operational performance standards. This is evident in the company's multifaceted strategic initiatives to optimise processes, enhance productivity, and ensure sustainability. SWPC's progression toward operational excellence is a testament to its leadership and strategic vision. The company's accomplishments have fortified its position within the industry and established a benchmark for others to emulate.

SWPC's recognition as a two-time recipient of the Global Water Intelligence Award for Best Public Agency and the Most Innovative Company Award underscores its significant achievements in operational excellence. Additionally, SWPC Projects has garnered individual accolades, including the Guinness World Record for the Largest Reverse Osmosis Plant in the World for Rabigh 3 IWP.

About SWPC

The Saudi Water Partnership Company (SWPC) is the principal authority in the Kingdom of Saudi Arabia for procuring water and wastewater infrastructure through Public-Private Partnership (PPP) frameworks. As the designated off-taker for water products, SWPC operates under sovereign payment guarantees facilitated by the Ministry of Finance. This arrangement establishes a robust financial framework for infrastructure development.

In alignment with Saudi Vision 2030, SWPC has emerged as a critical institution within the Kingdom's water security strategy. Since the Vision's inception in 2016, the organisation has played an instrumental role in the development of the National Water Strategy, which was announced in 2018. This strategy delineates SWPC's expanded mandate to accelerate the development of essential water and wastewater infrastructure.

SWPC has demonstrated pioneering innovation by extending the PPP procurement model into previously uncharted territories within the water sector. While PPP frameworks were traditionally limited to desalination and sewage treatment, SWPC has successfully broadened this model to include water transmission systems, strategic storage facilities, and distributed sewage infrastructure networks—areas that have seen limited global implementation. The scale and complexity of SWPC's project portfolio represent benchmark-setting initiatives in the global water infrastructure market. A significant achievement in strategic planning is the development and annual revision of SWPC's comprehensive Seven-Year Plan Statement, which provides a framework for long-term sector advancement.

The organisation has evolved into a comprehensive procurement authority, overseeing the entire lifecycle of projects from conceptualisation to operations. This integrated approach facilitates systematic knowledge transfer and allows for implementing feedback mechanisms based on practical project execution experiences, thereby creating a continuous improvement cycle in developing and managing PPP projects.

SWPC has demonstrated a substantial commitment to economic diversification through its initiatives focused on local content development. The organisation employs strategic frameworks to promote collaboration between international developers and local enterprises while maintaining a focused commitment to human capital development, aiming for localisation rates exceeding 80% in desalination facilities.

The operational excellence strategy of SWPC is founded on five interconnected pillars:

01 Leadership Commitment and Strategic Vision

- Executive-level engagement in operational excellence initiatives
- Strategic allocation of resources in alignment with long-term objectives
- Systematic frameworks for performance monitoring and evaluation

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

02 Innovation Culture

- A systematic approach to managing innovation
- The development and implementation of pioneering initiatives within the sector
- Active encouragement of creative problem-solving methodologies

03 Technology Integration

- Automation of processes for operational optimisation
- Utilization of real-time data analytics for decision-making support
- Advanced collaboration platforms to enhance project management
- Digital transformation of core operational processes

04 Stakeholder Engagement

- Structured communication frameworks with government entities
- Transparent engagement with private sector partners
- Public communication strategies to enhance visibility within the sector
- Coordination among multiple stakeholders to improve sector-wide efficiency

05 Adaptive Capability

- Dynamic mechanisms for responding to market evolution
- Frameworks ensuring regulatory compliance
- Flexible operational models to adapt to changing market conditions

This structural framework serves as the foundation for SWPC's initiatives in operational excellence, which have demonstrably impacted operational efficiency and financial performance.

Standardisation of PPP Procurement Template

Overview of the Best Practice:

The Saudi Water Partnership Company's (SWPC) development of a standardised Public-Private Partnership (PPP) procurement template represents a paradigmatic innovation in infrastructure project management within the Kingdom of Saudi Arabia. Emerging from the transformative strategic framework of Vision 2030 and the National Water Strategy, this institutional approach addresses the intricate challenges inherent in large-scale infrastructure procurement, particularly within the water sector's complex and capital-intensive technological landscape.

Four critical strategic imperatives precipitated the template's conceptualisation:

- First, the need for accelerated infrastructure development presented a temporal challenge that demanded innovative procurement methodologies. Traditional approaches proved insufficient to meet the Kingdom's ambitious infrastructural transformation timelines.

- Second, the absence of precedential frameworks for large-scale water infrastructure PPPs in the Saudi context necessitated a comprehensive, adaptable approach to project procurement.

- Third, the initiative addressed the critical requirement for systematic risk management and stakeholder alignment. By creating a standardised template, SWPC developed a sophisticated mechanism for distributing project risks, ensuring transparent and equitable engagement across multiple stakeholder groups.

- Fourth, the template responded to the fundamental need for efficient, transparent, and competitive procurement processes that could support the Kingdom's broader economic diversification objectives.

The template can be applied to projects across segments of the water sector with minimal modification.

Procurer (SWPC)	• Efficiency on the procurement process, timelines and financial closure and compliance with relevant laws and regulations
Appointed Authority	• Efficiency on supervisory review, limited to deviations from the approved template
Kingdom	• Sustainable delivery of water services, Value for Money (VFM) and Risk Management
Private Sector	• Efficiency on bid preparation and financing process, working with an established template

Table 2. Beneficiaries of the implementation of the template

The standardised template represents a holistic approach to project development, characterised by sophisticated multidimensional components:

Structural Components represent the template's foundational architecture. This includes meticulously detailed procurement protocols, comprehensive concession agreement frameworks, and advanced risk allocation mechanisms. The approach systematically addresses developer and contractor qualification processes, creating an integrated documentation ecosystem spanning entire project lifecycles.

The documentation Framework demonstrates the template's methodological rigour. It systematically addresses multiple documentation requirements, ranging from preliminary documentation like Expressions of Interest (EOI) and Requests for Qualification (RFQ) to comprehensive Project Agreement Documentation. The template encompasses critical agreements, including the Concession Agreement (like Water Purchase Agreement (WPA) or Sewage Treatment Agreement (STA)), InterConnection Agreements with Interfacing Facilities (like the Water Connections Agreements (WCA), Power Supply Implementation Agreement (PSIA), Sewage Interconnection Agreement (SIA) and Treated Sewage Effluent Interconnection Agreement (TSEIA)), Project Development Agreements (PDA), etc.

Regulatory Compliance Dimensions reflect the template's strategic alignment with national objectives. The framework accurately aligns with the National Centre for Privatization (NCP) implementing regulations, incorporates emerging PPP legislative frameworks, and integrates broader national economic goals. These include critical national priorities such as Saudization targets, local content development, sustainability considerations, and national security imperatives.

The template's evolution manifests a sophisticated, iterative approach to institutional knowledge management. Multiple feedback mechanisms inform its continuous refinement:

- Insights from commercial agreement negotiations
- Clarifications and deviations received from bidders.
- Emerging regulatory provisions
- Extensive stakeholder feedback from external entities (MEWA, Water Desalination, WTCO, etc)
- Internal departmental insights from project construction and operational stages

The standardised template delivers nuanced value across different ecosystem participants. For SWPC, the template ensures enhanced procurement efficiency, accelerated project timelines, and improved regulatory compliance. Appointed authorities benefit from streamlined supervisory review processes with limited deviation from the approved framework.

The Kingdom realises sustainable water service delivery, optimised value for money, and robust risk management. Private sector participants gain from an established, predictable template that enhances bid preparation efficiency and financing processes.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

In summary, SWPC's standardised PPP procurement template transcends traditional procurement methodologies and represents a sophisticated institutional innovation. By creating a replicable, adaptable framework, the organisation has established a benchmark for efficient, transparent, and strategically aligned infrastructure project development.

Background of the current PPP Model of Independent Water Projects

The technological transition to Reverse Osmosis (RO) desalination represents a pivotal moment in Saudi Arabia's water infrastructure development, fundamentally transforming the institutional and technological landscape of water and power sector integration. Unlike the precedent thermal desalination processes—characterised by substantial capital expenditures on power generation facilities and significant environmental externalities—RO technology offered a more streamlined, economically viable, and environmentally sustainable approach to water infrastructure development.

This technological paradigm shift facilitated the conceptualisation of independent water projects as entirely privately owned infrastructure assets procured through sophisticated global public tender mechanisms. The technological simplification enabled a structural decoupling of water and power sectors, creating unprecedented opportunities for private sector engagement in critical infrastructure development.

In 2017, the Saudi government strategically positioned the Saudi Water Partnership Company (SWPC) as the primary procurer and off-taker of water from the private sector, marking a transformative institutional approach to infrastructure development. The subsequent year, 2018, witnessed a formal governmental mandate for SWPC to procure five desalination projects and three sewage treatment projects through Public-Private Partnership (PPP) frameworks, signalling a comprehensive restructuring of water infrastructure procurement methodologies.

The mandate's scope progressively expanded, with SWPC ultimately authorised to procure 57 water projects across multiple critical infrastructure segments. These segments encompassed:

- Independent Water Projects (IWPs)
- Independent Sewage Treatment Projects (ISTPs)
- Independent Water Transmission Pipelines (IWTPs)
- Independent Strategic Water Reserves (ISWRs)
- Small Sewage Treatment Projects (SSTPs)

To ensure financial robustness and alignment with sovereign guarantees, SWPC's ownership was fully transferred to the Ministry of Finance (MoF), providing a direct institutional mechanism for project payment guarantees and financial risk management. SWPC was strategically developed as a comprehensive, full-service procurement agency with an expansive mandate covering the entire project lifecycle—from initial planning and preparation through construction and operational phases. This holistic approach enables systematic knowledge accumulation and continuous improvement in PPP project development, allowing the organisation to leverage practical experiences throughout procurement processes.

The institutional transformation represents more than a procedural modification; it signifies a fundamental reimagining of infrastructure development paradigms. By creating a specialised, dedicated entity with end-to-end project management capabilities, the Kingdom established a sophisticated mechanism for accelerating critical infrastructure development while simultaneously creating opportunities for private sector engagement and technological innovation.

The approach demonstrates a nuanced understanding of infrastructure development as a complex ecosystem requiring sophisticated institutional capabilities. SWPC's mandate transcends traditional procurement frameworks, positioning the organisation as a strategic enabler of national infrastructure transformation objectives.

This model reflects a broader strategic vision of infrastructure development as a dynamic, collaborative process that balances public-sector strategic objectives with private-sector operational efficiency, technological innovation, and financial capabilities.

Overview of the Transaction Management Process

Transaction Management (TM) is a critical operational process within SWPC designed to facilitate complex infrastructure project procurement through a comprehensive and strategic approach. The method integrates systematic project preparation, stakeholder engagement, and rigorous regulatory compliance.

SWPC's procurement methodology involves global public tender implementation, commercial agreement negotiation, and extensive collaboration with diverse stakeholders, including government entities, regulatory bodies, and infrastructure organisations. The approach requires formal approvals across multiple project stages, ensuring transparency and strategic oversight under Public-Private Partnership (PPP) Regulations.

Figure 14. Transaction management stakeholder engagement overview

The procurement cycle typically spans 18 to 24 months, depending on project complexity, scope, and market conditions. While primarily executing public tenders, SWPC maintains flexibility by allowing selective private negotiation for strategically significant projects.

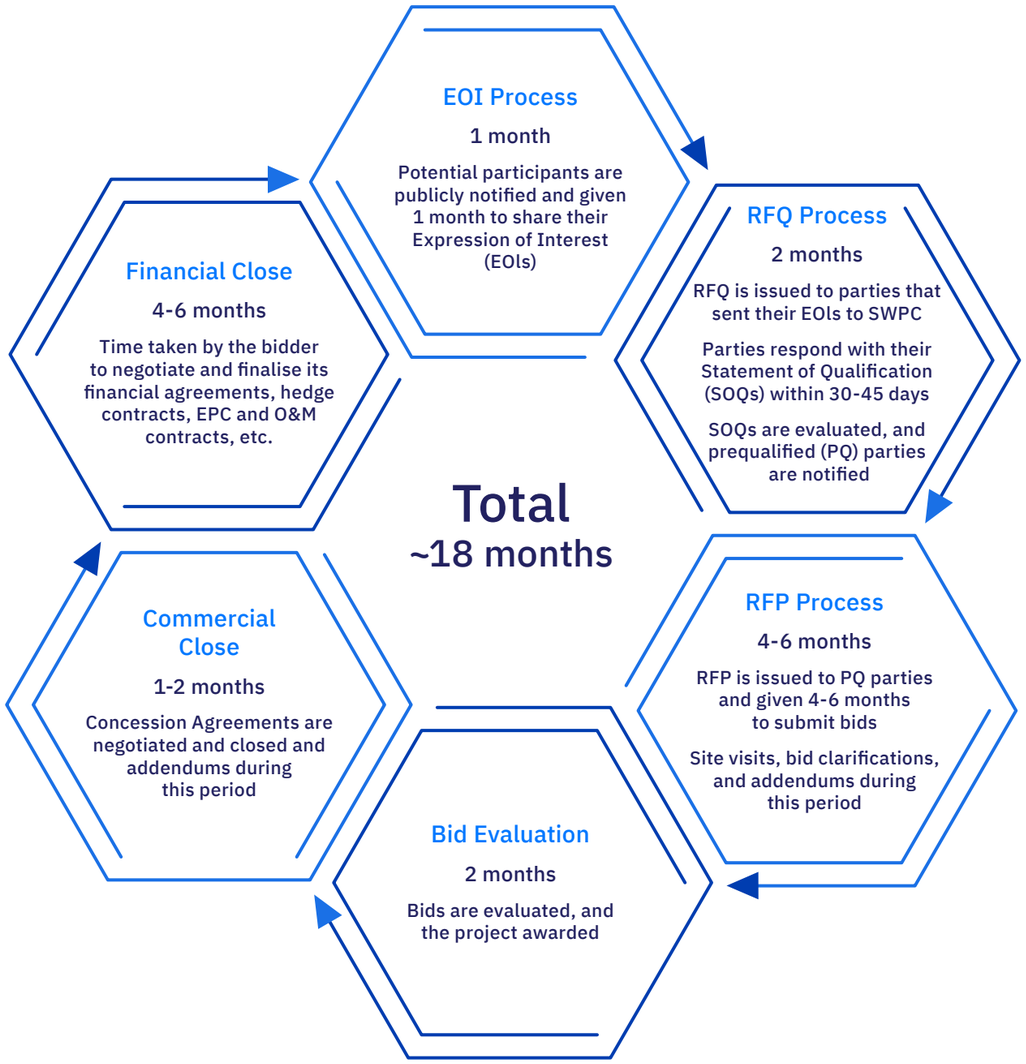


Figure 15. Public-private partnership procurement cycle

The transaction management process represents a sophisticated methodology that balances regulatory compliance, strategic engagement, and adaptive procurement mechanisms. It demonstrates SWPC's comprehensive approach to large-scale infrastructure development.

Objectives / Problem Addressed

SWPC wanted to ensure consistency and effectiveness; procurement documents in the water sector must be highly standardised. This approach guarantees they are:

- Clear and Cohesive: Minimizing scope for duplicity, contradictions, or ambiguity to streamline communication and understanding.
- Comprehensive: Addressing all relevant factors, including technical, legal, and operational considerations.
- Long-Term Compatibility: Designed for extended contractual arrangements (25+ years), ensuring resilience and adaptability to evolving needs.

Moreover, a well-established procurement process should meet the following criteria:

- Effectiveness and Efficiency: Delivering results with minimal delays or resource wastage.
- Stakeholder Alignment: Harmonizing the interests of all involved parties.
- Independence and Transparency: Upholding impartiality and openness throughout the process.
- Competitive and Comparable Bidding: Encouraging broad participation and fostering innovation.
- Regulatory Compliance: Adhering to public-private partnership (PPP) laws and regulations.

Five key objectives guided the development of this new template for managing the standardisation of SWPC templates, which it aimed to achieve during its implementation.

- Timeliness: Procurement processes must be structured to ensure the timely development of water sector capacities, meeting Vision 2030 and NWS 2030 targets. Efficient procurement and the bankability of standardised templates are critical to achieving financial closure and delivering water services as scheduled.

- Transparency: A transparent governance structure is essential to ensure fairness and public trust. This involves equitable decision-making, complete disclosure of relevant information through appropriate channels, and preventing privileged access for specific parties.

- Competition: Encouraging widespread participation from credible bidders enhances the quality of proposals and supports objectives such as innovation, reliability, energy efficiency, and cost optimisation. A competitive environment also drives the achievement of national priorities.

- Value for the Kingdom: Procurement frameworks should maximise the Kingdom's benefits by integrating technical and commercial excellence with national objectives such as Saudization, local content enhancement, sustainability, and security.

- Risk Management: Effective risk management is crucial in PPP projects. This includes appropriate risk allocation among stakeholders, compliance with functional specifications, and ensuring reliability through optimal technology selection and reduced outages. A robust framework minimises risks while optimizing obligations for the Kingdom, ensuring long-term project success.

This strategic procurement approach fosters sustainable, efficient, and competitive water sector development aligned with Saudi Arabia's ambitious goals.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

Operational Excellence Dimension

Legal & Policy Framework

By incorporating provisions and undertaking processes that ensure compliance with relevant laws and regulations.

Leadership & Accountability

Leadership by pioneering the PPP procurement model in the KSA water sector and creating a solid benchmark for other public sector entities to consider.

Accountability by ensuring value for money, transparency, and independence in public procurement.

Project & Investment Management

By efficient and effective management of a critical process associated with the substantial investment / financial commitments for the Kingdom in long-term utilities.

Technology & Research & Development

By permitting avenues for innovation to the private sector by limiting our focus to only minimum functional specifications of the project rather than detailed design/ implementation.

Quality and Security Management

By maintaining active engagement with relevant stakeholders and managing mutual interests and considerations.

Climate Change & Sustainability

By incorporating relevant provisions in the RFP template, such as a cap on energy consumption, allowing captive renewable energy utilisation, an obligation to plant trees and landscaping, and compliance with NCEC regulations covering air, noise, and marine environments.

Stakeholder Engagement

By maintaining active engagement with relevant stakeholders and managing mutual interests and considerations.

Opportunity & Implemented Strategy

The Saudi Water Partnership Company (SWPC), as the pioneer of the Public-Private Partnership (PPP) model for water sector projects in Saudi Arabia, undertook a vital and challenging responsibility. Establishing a scalable and sustainable procurement framework required addressing several key challenges:

01 Absence of Precedents

Large-scale water projects and specific segments such as Independent Water Transmission Pipelines (IWTPs), Independent Strategic Water Reserves (ISWRs), Independent Strategic Water Reservoirs, and Small Sewage Treatment Projects (SSTPs) lacked sufficient benchmarks.

02 Limited Market Capacity

The pool of developers and contractors capable of meeting the stringent qualification criteria was constrained.

03 Expertise Gaps

There was a scarcity of experienced PPP professionals to manage the procurement process.

04 Dynamic Sectoral Landscape

The evolving structure of the Saudi water sector required adaptive strategies to account for substantial reorganisation.

05 Market Specificity

Global precedents needed significant customisation to align with Saudi Arabia's unique regulatory, economic, and cultural context.

Critical aspects of the Implementation Strategy:

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

01 Leveraging Global Expertise

SWPC engaged internationally renowned advisory firms with expertise in technical, legal, financial, and commercial aspects of PPP procurement. This ensured the incorporation of global best practices tailored to the Saudi context, focusing on project financing, risk allocation, and sector-specific challenges.

02 Customizing Market Practices

A comprehensive review of regional and international procurement practices was conducted, drawing lessons from comparable markets like Oman. Ineffective practices, such as terminal value assumptions, were omitted. The procurement framework was tailored to the regulatory and operational nuances of the Kingdom's water sector.

03 Financial Market Readiness

SWPC assessed financial market capacity, identifying innovative financing mechanisms such as Equity Bridge Loans and Soft Mini Perm structures. Provisions were included for refinancing, IPOs, and bond issuance, broadening the investor base while mitigating risk.

04 Flexible Technical Specifications

SWPC adopted a Minimum Functional Specifications (MFS) approach to encourage innovation and cost optimisation. This allowed private partners the flexibility to meet performance and reliability standards without being constrained by rigid technical prescriptions.

05 Stakeholder Engagement

SWPC organised roadshows and market consultations to refine templates and ensure alignment with investor and lender expectations. Feedback mechanisms strengthened the bankability of procurement documents.

06 Market capacity assessment

SWPC assessed the availability of developers and contractors active in or interested in the KSA water sector and the adequacy of their financial and technical credentials relevant to our projects. Dry runs were conducted to assess the adequacy of potential competition (parties who could meet qualification criteria), develop a viable framework of qualifications and evaluation, and ensure adequate and credible participation.

SWPC also developed a robust global tender process for the qualification, evaluation, and engagement of Transaction Advisors to ensure that the best advisory resources are engaged. The scope of work for Transaction Advisers initially included multiple periodic training sessions for SWPC teams' members to build internal capacities.

07 Batchwise Procurement of projects and transaction advisers

SWPC introduced batch procurement to expedite project timelines and optimise market engagement. By consolidating prequalification processes and engaging transaction advisers across multiple projects, SWPC reduced procedural redundancies and ensured continuity of expertise.

This approach, to engage transaction advisers for a full batch of projects, was particularly helpful in newer segments like IWTPs and SSTPs, where there were no global benchmarks, and it would not be prudent to rely purely on the adviser's general PPP / procurement experience and credentials in other water segments or sectors.

This allowed the advisers to apply the insights gained on the initial projects to subsequent projects. It also acted as an incentive for advisers to bid competitively for a long-term engagement, leading to exclusive credentials in the specific market segment.

SWPC has implemented several innovations to optimise its Public-Private Partnership (PPP) framework to enhance procurement efficiency, foster competition, and align with national objectives. Below are key strategies SWPC has introduced:

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

01 Long-Term Prequalification for Bidders (Standardized List)

SWPC developed a "standardised list" for prequalifying bidders for multiple upcoming projects, facilitated by recent changes to procurement regulations. This system streamlines procurement, promotes competition, and ensures only qualified bidders participate. Currently, 173 parties are under evaluation, and provisions are in place for updating credentials, allowing new entrants to join as needed.

02 Comprehensive Project Scoping with Ancillary and Interfacing Facilities

To ensure successful project implementation, SWPC has taken responsibility for integrating land, easement rights, and essential infrastructure (such as power supply and access roads) into the project scope. While this may lead to higher tariffs, it optimises overall costs for the Kingdom and enhances project bankability, procurement, and delivery. Collaboration with relevant stakeholders is critical to firming up the scope and specifications and entering definitive commercial arrangements.

03 Incorporating National Objectives into the PPP Framework

SWPC recognised the opportunity to use its PPP Framework to make a meaningful contribution to many national objectives besides the core objectives targeted by its projects. Some of the provisions incorporated in the RFP template that contribute to these additional objectives are:

- Strategic Storage: Mandating up to two days of potable water storage on IWPs.
- Environmental Compliance: Ensuring adherence to NCEC regulations.

- Carbon Savings: Mandated energy usage limits (caps) and further optimized this over time. Providing incentives by sharing any energy efficiency gains over the contracted terms. Permitted renewable installations to optimize tariff and environmental impact.

- Social Development: Requiring Saudi national engagement and local content commitments. Mandated Local Content of 40% during construction, 50% in the first five years of operations and 70% after that.

- Saudi Green Initiative: Mandating landscaping and tree planting. Mandated installation of pipelines on ISTP projects to deliver TSE to SIO for distribution and sale to potential users

SWPC's strategic innovations in the PPP framework reflect a comprehensive approach to procurement, project execution, and long-term sustainability. Through prequalification processes, comprehensive project scoping, and incorporating national objectives, SWPC is optimising its ability to deliver high-quality, impactful water projects that contribute to immediate water sector needs and broader national development goals.

Results Achieved & Associated KPIs

PPP Management Improvement:

SWPC has received governmental mandates for 57 projects under the PPP model through Royal Decrees, demonstrating the government's expanding confidence in SWPC's procurement capabilities across the water value chain. The project portfolio has grown significantly from 5 concurrent projects in 2018 to 16 current projects at various procurement stages.

Many of these initiatives, particularly IWTPs, ISWRs, and SSTPs, represent first-of-their-kind implementations globally, requiring extended development periods due to the absence of international benchmarks. Although the project management team has been expanded, SWPC has achieved greater operational efficiency, enabling Project Managers to successfully oversee 2-4 concurrent projects while maintaining high delivery standards.

BEST PRACTICES FOR OPERATIONAL EXCELLENCE WITHIN THE SAUDI ARABIAN WATER VALUE CHAIN

	2018	2020	2021	Total
IWPs	5	11		16
ISTPs	3	9		12
ISWRs			14	14
IWTPs			8	8
SSTPs			7	7
Total	8	20	29	57

Table 3. The annual quantity of projects overseen by the SWPC

Regional Leadership in Water Infrastructure Procurement

SWPC has emerged as the dominant procurement entity for water infrastructure projects in the Gulf Cooperation Council (GCC) region. Since transitioning to a Global Public Tender process in 2017, SWPC has demonstrated unprecedented market leadership, executing 37% of all GCC water projects from 2016 to 2020. Projections indicate SWPC's responsibility for 88% of regional projects through 2024 (Synergy Consulting, 2022).

This market position represents a significant evolution from SWPC's initial operations (2004-2016), which comprised four limited-participation projects, primarily focused on Integrated Water and Power Projects (IWPPs) using thermal desalination technology. Post-2017, SWPC has diversified its portfolio to include reverse osmosis desalination, sewage treatment facilities, strategic reservoirs, and transmission infrastructure while achieving superior tendering parameters across all market segments.

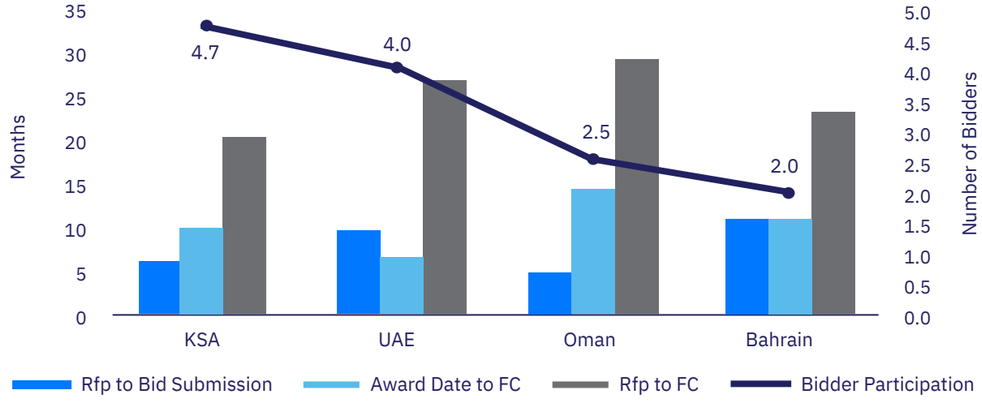


Figure 16. Participation of bidders and the time invested in each process.

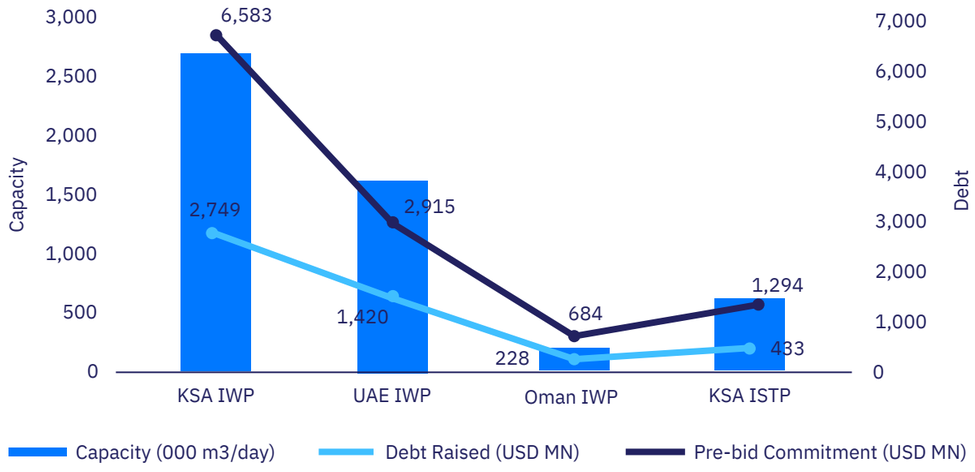


Figure 17. The capacity and associated debt raised for each project. * Source: (Synergy Consulting, 2022)

Successful Project Delivery Pipeline

Within a short span of over 6 years since receiving the governmental mandate in 2018, SWPC has demonstrated exceptional procurement efficiency, managing 25 major infrastructure projects while each project typically takes 2 to 3 years to procure. Of these, 16 projects have achieved financial close, with ten successfully transitioning to operational status and six currently under construction. An additional nine projects are in active procurement stages, with financial closure anticipated within the next two years, further reinforcing SWPC's robust project delivery capabilities.

Catalysing Private Sector Investment in Water Infrastructure

SWPC has successfully mobilised SAR 28 billion in private sector investments for water infrastructure projects since 2017, with international investment participation ranging from 20% to 60%. This substantial private capital inflow, coupled with globally competitive tariff rates (SAR/m^3), demonstrates SWPC's effectiveness in creating an attractive investment environment while maintaining cost efficiency in service delivery.

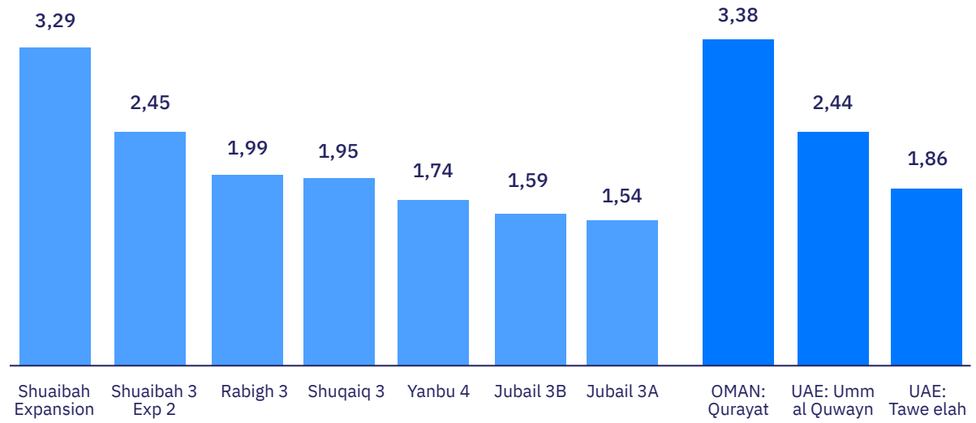


Figure 18. Tariff comparison (SAR/m3)

Strong Market Interest and Competitive Procurement Process

SWPC's procurement framework has attracted robust market participation, evidenced by 173 entities engaging in the recent consolidated pre-qualification process. Project-specific metrics demonstrate sustained investor interest, with an average of 35 Expression of Interest (EOI) submissions per project, eight pre-qualified participants advancing to the Request for Proposal (RFP) stage, and three final competitive bids received. This systematic funnel ensures optimal competition while maintaining high-quality project delivery standards.

Strong Financial Market Confidence

SWPC's projects have consistently attracted diverse financial institutions, with active participation from local, regional, and international lenders. The robust market confidence is evidenced by lender commitments typically exceeding total project financing requirements, demonstrating the bankability and credibility of SWPC's procurement framework.

Environmental and Economic Sustainability Metrics

SWPC's projects demonstrate exceptional environmental and economic performance across key sustainability indicators. Energy efficiency in Independent Water Projects (IWPs) has reached 2.46 kWh/m³, positioning them among global industry leaders. The projects maintain a solid domestic economic impact through Local Content requirements exceeding 50%, comprising 40% + during construction and 50%+ during operational phases. Additionally, the implemented projects contribute significantly to environmental sustainability, with estimated carbon savings of 10.5 million tons annually.

Exceptional Operational Excellence and Industry Recognition

SWPC has achieved remarkable efficiency in project delivery, completing 25 projects in 7 years—a scope that traditionally requires 75 years at standard procurement rates. This extraordinary acceleration has been accomplished by a lean transaction team of 10 professionals who maintain excellence across diverse water infrastructure segments and pioneer new project types.

Key Qualitative Achievements:

- Established strong market credibility and project bankability
- Attracted premier global industry participants
- Developed local contractor and developer capabilities
- Pioneered multiple first-of-kind projects
- Successfully diversified across the water value chain
- Maintained project delivery during COVID-19 challenges (Jubail 3A/3B, Yanbu 4)

Industry Endorsements:

Leading global financial institutions and advisory firms, including Alderbrook-BSF, SMBC, Mizuho, White & Case, DLA, ILF, and Fichtner, have consistently recognised SWPC's procurement process as meeting or exceeding international best practices, validating the organisation's operational excellence and market leadership.

Lessons Learned

Over the years, SWPC has garnered valuable insights into PPP procurement, adapting its framework to navigate challenges and capitalise on opportunities. These lessons reflect its commitment to maintaining agility, fostering alignment, and driving continuous improvement:

Dynamic environment enhancing need for agility

The KSA water sector operates in a rapidly evolving landscape influenced by regulatory reforms, economic shifts, and geopolitical events. Over the past few years, SWPC has contended with significant changes, including reorganising critical entities, establishing new players, and revising national policies.

External shocks, such as COVID-19 and the bankruptcy of prominent players, further underscored the need for agility. This dynamism mandates active tracking of developments and promptly assessing the need to respond through any procurement process or document updates.

Organisational Restructuring and Stakeholder Engagement

Significant structural changes within SWPC and its stakeholders required swift adaptation to new roles, responsibilities, and organisational cultures. This transformation emphasised the importance of alignment across diverse stakeholders with varying priorities and communication protocols. SWPC addressed these challenges by establishing robust communication mechanisms, such as formalised advisory meetings, proactive relationship management, and a preference for in-person engagements to build trust and resolve complex issues effectively.

Balancing Precedents with Innovation

A critical insight from SWPC's experience is balancing reliance on established precedents with flexibility to incorporate new learnings. While templates and historical benchmarks streamline processes, they can also stifle innovation. SWPC implemented a transparent feedback mechanism to mitigate this, drawing insights from bidders, project teams, and advisers. This approach has enhanced its ability to refine procurement strategies and address gaps identified during project execution and operations.

Challenges in Tariff Benchmarking

SWPC has recognised the limitations of benchmarking project tariffs against past or regional projects due to variances in scope, financing structures, and market conditions—differences in land costs, energy rates, and concession terms often make direct comparisons impractical. Instead, SWPC relies on internal planning benchmarks and bid comparisons within individual projects, adjusting for timing and scope as needed.

Streamlining Document Management

Frequent updates to procurement documents and project agreements—driven by regulatory changes, stakeholder input, and evolving project scopes—highlighted the need for meticulous version control. SWPC developed a centralised system to document all edits, classify changes, and ensure they are reviewed and authorised by relevant parties. This approach has enhanced consistency, transparency, and ease of future reference.

Leveraging Alternate Proposals

In some instances, SWPC has sought alternate proposals from bidders to assess the impact of specific decisions, such as changes in water specifications. This practice has provided valuable market insights, enabling more informed decision-making and better risk management.

Insights from Greenfield Projects Adjacent to/on Occupied Sites

Developing greenfield projects on sites adjoining or previously occupied by other facilities has posed unique challenges, requiring rigorous planning akin to brownfield projects. SWPC has emphasised the importance of clearly delineating responsibilities for demolition, removal, or redirection of legacy infrastructure to avoid delays and conflicts.

Towards Market Maturity

As the KSA water sector matures, SWPC has highlighted the need for an independent regulatory body to address market concentration and promote healthy competition. While SWPC's primary role remains to foster private sector participation, its experience positions it to support such efforts by providing relevant data and expertise.

Sharing Expertise

SWPC's evolution into a leader in PPP procurement offers valuable lessons for other sectors seeking to adopt similar models. By sharing its mature framework and insights, SWPC can help accelerate the Kingdom's ambitious development goals while avoiding redundant challenges in other sectors.

6

RECOMMENDATIONS FOR SUSTAINED OPERATIONAL EXCELLENCE

Framework for Illustrating Operational Excellence in the Water Sector

Based on the comprehensive analysis of operational excellence practices in the Saudi Arabian water value chain, several strategic recommendations have emerged to enhance operational effectiveness and promote sustainable development within the sector. These recommendations are organised across various topics to address the complex challenges identified throughout this study effectively:

01 Enhance regulatory and policy frameworks: regular assessments and updates of regulatory policies are essential to integrate emerging practices and technological innovations. Additionally, expanding regulatory measures to more operational areas within the water sector will help to address inefficiencies and standardise processes.

02 Foster technological innovation and integration: increased resource allocation toward research and development is essential to exploring new water technologies and sustainable practices. Furthermore, promoting the integration of renewable energy sources in water treatment and distribution processes will minimise carbon footprints and operational costs.

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RECOMMENDATIONS FOR SUSTAINED OPERATIONAL EXCELLENCE

04 Improve stakeholder engagement: robust communication channels must be implemented to keep beneficiaries informed and engaged with operational improvements. These channels can encourage collaborative initiatives among regulatory bodies, research institutions, and private sector entities to drive collective advancements in operational excellence.

05 Implement comprehensive monitoring and evaluation Systems: advanced data analytics tools should monitor operational performance in real-time, facilitating proactive decision-making and prompt issue resolution. It is crucial to define and track key performance indicators (KPIs) across all dimensions of operational excellence to measure progress and identify areas for continuous improvement.

06 Promote a culture of continuous improvement: leadership at all levels must foster a culture that values continuous improvement, innovation, and operational excellence. Employees should be encouraged to identify and propose improvements, fostering a sense of ownership and accountability within the workforce.

07 Supply chain optimisation and local content development: reverse engineering practices should be encouraged to reduce dependency on Original Equipment Manufacturers (OEMs), lower costs, and support local industries. Developing solid relationships with local manufacturers is essential to ensuring critical components' quality, reliability, and scalability.

08 Infrastructure modernisation and energy efficiency: state-of-the-art monitoring and predictive maintenance systems are essential to enhance infrastructure reliability and operational efficiency. Ongoing efforts to optimise energy use through advanced control mechanisms and integrate renewable energy sources must be prioritised.

7

CONCLUSIONS

The analysis presented in this report emphasizes the critical importance of operational excellence within the water value chain. As seen, this intricate network comprises policy formulation, resource planning, production, transmission, distribution, agricultural irrigation, and conservation. In light of the acute water scarcity challenges faced by the region, the secure and sustainable management of water resources is imperative. Achieving operational excellence serves not only as a fundamental requirement for daily efficiency but also as a strategic priority in alignment with broader national development objectives.

This report's main finding is that managing water resources in a joined-up and flexible way has significantly benefited the Kingdom. Various best practices for operational excellence—meticulously identified, designed, implemented, and evaluated—provide compelling evidence of how strategic initiatives can enhance every aspect of the water value chain. Initiatives like accurately predicting water needs, using data to decide how to share resources, and improving the way essential infrastructure is maintained have greatly affected the water sector. Ultimately, the coordinated actions implemented across diverse operational domains have not only streamlined daily operations but also established quantifiable benchmarks, including cost savings, minimized downtime, and enhanced system reliability.

For instance, **comprehensive planning** that utilizes **data-driven strategies** has proven highly effective in aligning resource allocation with expected demand. This form of strategic planning illustrates how robust demand forecasting and resource evaluation can lead to more efficient water management practices. Similarly, focused process improvements—such as innovative methodologies for the redesign and maintenance of essential infrastructure components—have resulted in substantial cost reductions, decreased downtime, and increased system reliability.

At the same time, **technological innovation** emerges as a recurring and significant theme throughout this report. The integration of advanced digital monitoring systems, predictive analytics, and state-of-the-art treatment methods has fundamentally transformed operational practices within the water sector. Innovations in water treatment processes have optimized production while incorporating sustainable methodologies into agricultural practices. Furthermore, the implementation of smart irrigation systems demonstrates that modern information and communication technologies can rejuvenate traditional agricultural methods, resulting in enhanced water efficiency and improved crop yields. These technological advancements have not only bolstered operational performance but have also contributed to environmental sustainability through the reduction of resource wastage and the minimization of the carbon footprint associated with water operations.

Equally critical is the focus on the **development of human capital**. The adoption of competency-based frameworks for professional development has revolutionized workforce training and skill enhancement. By ensuring that personnel attain both technical and behavioral competencies necessary to address evolving challenges, these initiatives have improved service delivery and fostered a culture of continuous improvement and innovation. This emphasis on talent development is vital for cultivating resilient organizations that can adapt to future challenges and leverage emerging opportunities.

Additionally, the report underscores the necessity for robust **regulatory and policy frameworks**. An evolving legal landscape that enforces accountability and oversight is essential for sustainable water management. When these regulatory frameworks are complemented by proactive stakeholder engagement and **effective communication channels**, they facilitate the synchronization of operations across the entire water value chain. Such coordinated efforts ensure that the diverse interests of public institutions, private enterprises, and research organizations are aligned, thereby enhancing the sector's overall resilience.

Financial and operational efficiencies have also emerged as notable benefits associated with the adoption of operational excellence practices. The strategic implementation of **innovative procurement models** has expedited project timelines and attracted significant private investment. Standardized procurement processes and templates have established new benchmarks in infrastructure project management, creating a competitive environment that promotes cost optimization and sustainable development. These practices have enabled the timely and efficient modernization of critical water infrastructure projects.

Despite achieving considerable achievements, the pursuit of operational excellence in the water sector remains a continuing endeavor. The findings of this study indicate that continuous adaptation and innovation are imperative to address persistent challenges, including aging infrastructure, vulnerabilities within the supply chain, and the evolving nature of water demand. The recommendations proposed—such as enhancing regulatory frameworks, fostering technological integration, fortifying human capital development, improving stakeholder engagement, implementing comprehensive monitoring systems, and optimizing supply chains—are not mere remedial measures but rather strategic imperatives necessary for ensuring sustained progress.

For the future, the water sector needs to be able to change as the environment, economy, and technology evolve. A comprehensive strategy that uses advanced technologies, develops a skilled workforce, and ensures clear and responsible management is crucial. This strategic approach not only tackles immediate water security issues but also positions Saudi Arabia as a leader in sustainable water management. The report's analysis of best practices reveals several critical success factors consistently driving operational excellence across the water value chain, including a strong emphasis on:

Technology Adoption and Digital Transformation: Several case studies emphasize the significant role of advanced technologies and digital solutions in improving efficiency, accuracy, and decision-making.

Data-Driven Decision Making: The importance of collecting, analyzing, and utilizing data to identify areas for improvement, track performance, and make informed operational decisions is a recurring theme. This includes the use of KPIs to measure progress and the application of data analytics to optimize processes.

Focus on Efficiency and Optimization: A consistent focus on optimizing existing processes, reducing waste, and improving resource utilization is evident across the case studies. This includes initiatives aimed at cost reduction through reverse engineering, enhancing infrastructure availability, and improving billing efficiency.

Capacity Building and Knowledge Sharing: Investing in human capital through training programs and competency frameworks, as well as facilitating knowledge sharing and collaboration within the sector, appears to be a key factor in achieving sustained operational excellence.

Proactive Risk Management: Several case studies address the importance of identifying, assessing, and mitigating operational risks to ensure the reliable and sustainable delivery of water services.

Stakeholder Engagement and Collaboration: Effective communication and collaboration among different entities, regulatory bodies, and other stakeholders are crucial for the successful implementation and scaling of best practices across the water value chain.

In conclusion, the collaborative initiatives and best practices outlined in this report have established a robust foundation for achieving operational excellence across the water value chain. This comprehensive approach ensures that water resources are managed sustainably while simultaneously facilitating national growth. The strategic incorporation of innovative practices, accompanied by an unwavering commitment to continuous improvement, is fundamental to securing a resilient, efficient, and sustainable water infrastructure that supports long-term developmental goals.

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