CAPACITY DEVELOPMENT AND RELATED SERVICES FOR AN INTEGRATED SUSTAINABLE DEVELOPMENT AND MANAGEMENT OF THE WATER SECTOR IN THE KINGDOM OF SAUDI ARABIA IN THE FRAMEWORK OF THE VISION 2030

PROJECT REPORT 2018-2022

FEBRUARY 2022

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ACRONYMS

Aquifer storage and recovery **(ASR)**

Central Electronic Water System **(CEWS)**

Center for Hydrometeorology and Remote Sensing **(CHRS)**

Center for Water Management and Control **(CWMC)**

Decision support system **(DSS)**

Integrated water management information system **(IWMIS)**

Integrated water resources management **(IWRM)**

King Abdullah University of Science and Technology **(KAUST)**

Kingdom of Saudi Arabia **(KSA)**

Letter of Understanding **(LOU)**

Memorandum of Agreement **(MOA)**

Memorandum of Understanding **(MOU)**

Millennium Development Goals **(MDGs)**

Ministry for the Environment, Water and Agriculture **(MEWA)**

National Center for Performance Measurement **(ADAA)**

National Centre for Water Research and Studies Support Services **(NCWRS)**

National Transformation Plan **(NTP)**

National Water Strategy 2030 **(NWS 2030)**

Normalized Difference Vegetation Index **(NDVI)**

United Nations Development Programme **(UNDP)**

United States Bureau of Reclamation **(USBR)**

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Reimbursable Advisory Services **(RAS)**

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SECTION ONE

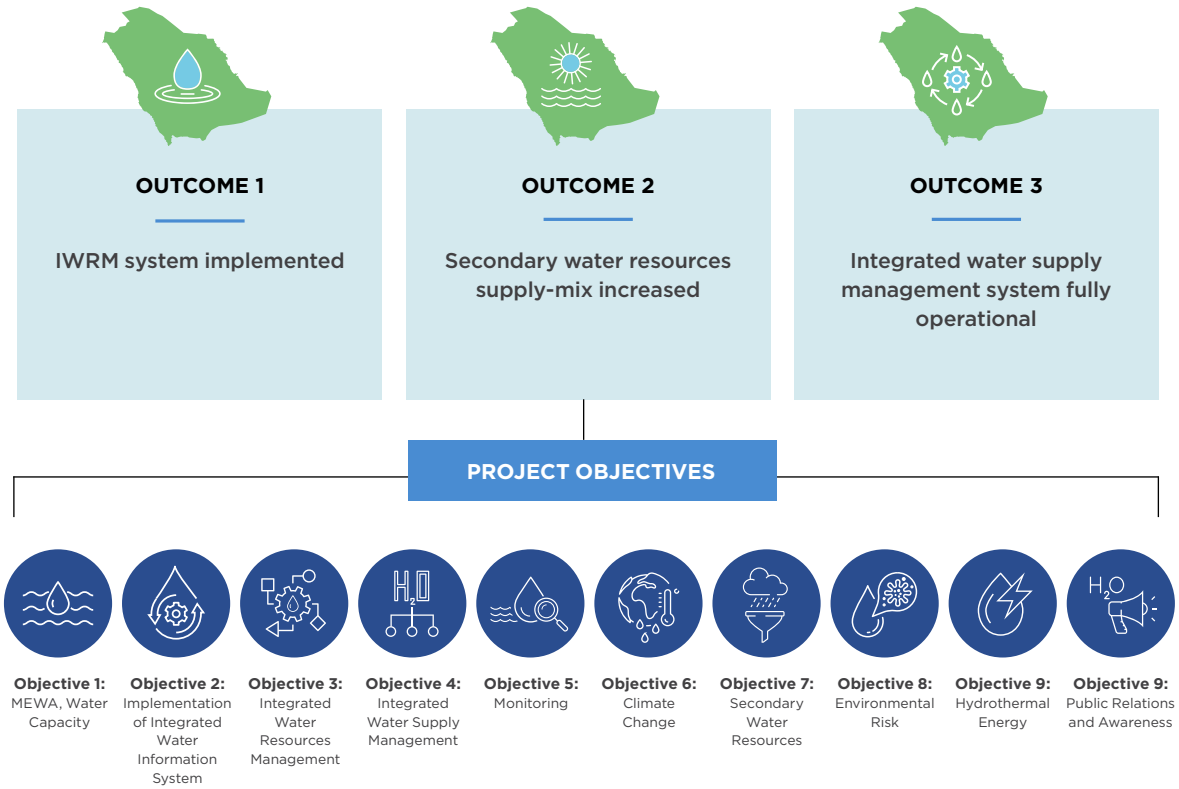
EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

THE PROJECT

To support the achievement of water management resilience and sustainability in the Kingdom of Saudi Arabia, the United Nations Development Programme (UNDP), in partnership with the Ministry for the Environment, Water and Agriculture (MEWA), launched the ***Capacity Development and Related Services for an Integrated Sustainable Development and Management of the Water Sector in the Kingdom of Saudi Arabia in the Framework of the VISION 2030*** project in March 2018. The original project concluded on 28 February 2022 but has been extended for a year. This final project report will focus on the impact and achievements of the project, and the support it has provided both to the Water Deputyship, within the Ministry for the Environment, Water and Agriculture, and towards the achievement of Saudi Arabia's broader social, economic and environmental goals.

Ultimately, the project has aimed to strengthen and optimize the technical and organizational capacities of the Water Deputyship, allowing staff to successfully implement Integrated Water Resources Management principles in Saudi Arabia. To do this, the project ten objectives, which are outlined in the table below:



THE RETURN ON INVESTMENT

The positive economic impact of integrated water resources management (IWRM) implementation is a global fact and UNDP at MEWA has played the key role in initiating and implementing the concept within the framework of Kingdom's economic transformation.

The Kingdom of Saudi Arabia (KSA) announced a new strategic vision and comprehensive roadmap for economic development in the Kingdom in April 2016 formally called Saudi Vision 2030. Vision 2030 is a strategic framework to reduce Saudi Arabia's dependence on oil, diversify its economy, and develop public service sectors such as health, education, infrastructure, recreation, water sector and tourism. Key goals include reinforcing economic and investment activities, increasing non-oil international trade.

Ensuring the availability of water is key to economic and social growth. On 7 June 2016, the Council of Ministers approved the National Transformation Program (NTP) which set out the goals and targets to be achieved by various economic sector in the Kingdom and thus water is part of it. Overall, NTP aims to achieve government operational excellence and establish the necessary infrastructure to improve economic enablers and raise the standard of living through its eight strategic themes. Furthermore, NTP will develop the necessary infrastructure and create an environment that enables the public, private and non-profit sectors to achieve the Kingdom's Vision 2030.

In light of the Kingdom's Vision 2030 and the NTP, the Ministry of Environment, Water and Agriculture has developed the National Water Strategy 2030 (NWS 2030) in 2017 based on the principles of IWRM tailored to locally assessed water sector status in relation to Kingdom's plans. The project played the key role in its launch, implementation, and tracking of it KPIs.

> ***"A sustainable water sector, safeguarding the natural resources and environment of the Kingdom and providing cost-effective supply and high-quality services. Efficiency contributes to economic and social development in the Kingdom"***

The NWS 2030 included 10 programs to achieve the strategy objectives for 2030 starting from the baseline. The MEWA Water Deputy Ministry (WDM) monitors the progress of implementing the NWS 2030 and is mandated to implement key parts of its programs.

THE UNDP EXPERTS

This UNDP project has provided a cost-effective, full time high level consulting and capacity building resource for the MEWA's needs, to support the achievement of Vision 2030, the National Transformation Plan, and the National Water Strategy 2030. **The cost effectiveness lies in the diversity of expertise, robustness, loyalty, years of experience, and agility of its work force** that practically superseded local or international consulting firms on the subject matter.

Furthermore, the cost benefit of the UNDP contribution versus cost of operating the project significantly exceeds any other option of contracting a commercial consultant. From international benchmarking, the economic gains of UNDPs contributions in MEWA put the long-term economic gains in the country-scale GDP.

Through the provision of **world-class expertise** UNDP is strengthening and optimizing the human, technical, and organizational capacities of the WDM for an Integrated Water Resources Management and sustainable development.

The current UNDP team of experts includes:

7 Individuals with Bachelor of Science degrees

13 Individuals with Masters degrees

8 Individuals holding PHDs

6 UNDP experts have sat as General Directors since 2018

1 Association of Consulting Engineering Companies (2016). Schedule of Recommend Fees to be Charged for General Engineering and Geoscience Projects and Services.

THE UNDP CONTRIBUTION

The project took three approaches for capacity building, included:

Organizational **Technical** **Human**

In the **organisational capacity building**, the UNDP played the key role in the restructuring of the Water Deputyship during the formation of its new organization and assumed leadership to newly formed General Directorates. The leadership role UNDP played in those Directorates proved to be pivotal to support the realignment of resources to the IWRM process. Among the two leadership roles that of greatest significance are for the Water Regulation General Directorates and The Water Planning General Directorate where the Water Law and the National Water Strategy were launched and implemented, respectively

In the **technical capacity development**, UNDP experts have served in all General Directorate in a participatory role leading to on-the-job training for MEWA staff while each expert is assuming a technical specific topic. These roles include:

- Dam Planning & Management
- Groundwater Modelling
- Project Management
- Strategy & Water Management
- Remote Sensing
- Hydraulics
- Water Supply & Demand Planning
- Water Regulations & Implementation
- Law
- Geophysics
- Hydrogeology
- Media & Advocacy
- Linguistics
- Water Monitoring
- Project Financing
- GIS

22 **training courses in management and core skills and specialised technical skills for** **316** **civil servants**

UNDP experts have provide project development and management services, providing significantly better value for money in comparison to commercial consultanting companies. This service provided by UNDP experts has helped support the implementation of some of the Kingdom's most complex water infrastructure projects.

UNDP has provided high level technical supervisory consultation for MEWA water projects mounting to a total cost of **2** **Billion Saudi Riyals**

This project proposed the development of Integrated Water Information System (IWIS) and the **Centre for Water Management and Control was established and led by UNDP expert**

The Centre was able to **revive legacy electronic database** that was otherwise inaccessible and is in the process of updating it

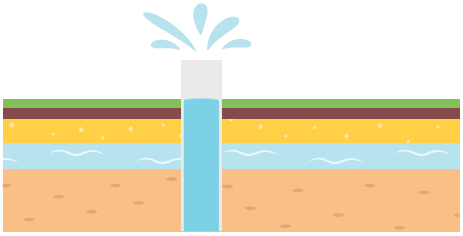
UNDP experts are leading other efforts to **enhance the performance of existing remote water monitoring systems** for ground and surface water

Remote sensing application to water regulations and monitoring have also been developed

The UNDP project funded and directed the establishment of a high-tech laboratory to support groundwater and surface water modelling as well as high resolution remote sensing

The lab also serves as a **high-tech training and meeting room**

Licencing has now also been converted into a digital process and many of the formalities that previously required travelling to Riyadh by clients have been dropped, allowing for a more client-centred, efficient process



In terms of **resource management, studies of non-renewable mega aquifer were reviewed and numerical models have been put for operation and calibration** to prepare to understand available water reserves and areas of potential exploitation based on groundwater modelling. To protect these aquifers from depletion, UNDP experts supervised studies to allocate water quotas to crops and assign tariffs to excess consumption. UNDP experts also contributed to the development of criteria to select managed aquifer storage and recovery sites.

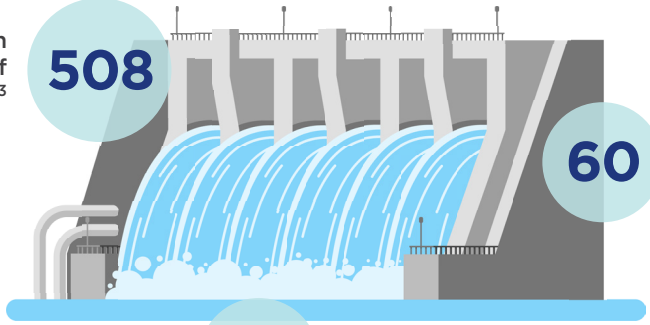
The General Directorate of Planning, led by UNDP expert, **prepared a comprehensive supply and demand plan with a corresponding database**. Moreover, UNDP experts in the General Directorate are in the process of **developing a water risk and threat management plan** and are supervising the implementation of National Water Strategy programs.

WATER & ELECTRICITY REGULATORY AUTHORITY

To support the implementation of the Water Act, UNDP experts within the Water Regulation Directorate and the Water and Electricity Regulatory Authority (ECRA) jointly adapted ECRA criteria, for drinking water, TSE, trade effluent and biosolids. The experts also worked to develop a draft Urban Water and Wastewater Quality Standard and developed a draft Agricultural Water Quality Standard.

The UNDP project established an updated regional climate change model for Saudi Arabia; after considering the results of the initial modelling and supported the construction of **more than 500 dams remaining under the National 1,000 Dams Plan**, supporting flash flood mitigation in the vicinity of villages and to protect vital infrastructure. **To date, UNDP expert work has supported:**

508 Dams were managed, with a total storage capacity of (2.2) billion m^3



60 Tender for a study to construct 60 dams in various parts of the Kingdom, with 24 of these dams reserved for drinking water supply

40 Dams currently under construction

UNDP experts also supported the establishment of an environmental awareness office, the Water Extensional Education Centre. During its work, the office:

Designed and conducted campaigns to raise awareness about water use efficiency and demand-side-management programs

Designed and established 12 publications and **3 videos** about water rationalization

Took leading role in **organizing conferences, workshops, symposia and seminars**

Has put out **more than 110 tweets in support of spreading water awareness** and of the importance of water

4 public educational campaigns have been run, raising awareness and building public knowledge of water issues. It is estimated that **more than 500,000 people were reached** through these campaigns

G20 SAUDI ARABIA 2020

The UNDP water research team supported the development of a comprehensive business plan for the National Centre for Water Research and Studies (NCWRS), including a regulatory status that legalized and regulated NCWRS functions and provided operational and procedural guidelines. In line with its mandated initiatives in the NWS 2030, the NCWRS developed TOR for a detailed SAUDI ARABIA Water Industry Localization study. In accordance with HRH Prince Mohammad Bin Salman Speech at Osaka about the Saudi G20 presidency and its inclusion of the topic of water, the 2020 Saudi G20 presidency, the NCWRS, during the Saudi G20 presidency, led the activities of water meetings. **The Centre developed the policy paper for the G20 summit in SAUDI ARABIA titled "Fostering Sustainable and Resilient Water System Globally"** as well as leading the G20 negotiation process up to the final approval of water outcomes. This resulted in the Kingdom's water team success in putting water sustainable and resilient management as a separate topic in the G20 forum for the first time in the G20 history and in the format of the Dialogue on Water and the G20 Water platform hosted at MEWA. Also, since this Kingdoms success, G20 leaders included separate statements in their declarations in 2020, 2021 in Italy, and the sherpa is carrying it to 2022, highlighting the importance of scaling up the work to achieve sustainable and resilient water management.

THE LESSONS LEARNED

Over the course of the project, important synergies and other positive strategic advantages have emerged, many of which can potentially be applied to future projects. The key recommendations to take forward in the future are as follows:

RESEARCH AND ECONOMIC DEVELOPMENT

1

The economic benefits of water resource management in Saudi Arabia should be further explored and documented, and research to understand the specific economic return on investment in the water sector in the Saudi context be undertaken.

2

To more fully represent the integral, cross-sectorial nature of water resource management, quantifying the contribution the water sector has made over time, and presenting this in parallel with progress as shown through **National Water Strategy Key Performance Indicators and/or SDG Goal 6 targets or indicators, could present a powerful message of the importance of the water sector** across all sectorial areas.

3

In future project iterations, **UNDP must adopt a proactive approach in identifying water needs for all economic and social sectors** by working collaboratively with these sectors to identify holistic and sustainable solutions, scoping new economic benefits and filling gaps arising from global changes such as political conflicts.

4

Consideration could be given to other forthcoming economic opportunities in the water sector, and research undertaken accordingly. New water sector project opportunities in rural communities, for example, could drive higher rates of employment and socioeconomic opportunities in these areas.

PROCESS AND ORGANISATION

5

The highly collaborative UNDP-MEWA policy process that led to the development of the National Water Strategy, **and subsequent Project to facilitate implementation, should be fully documented in a lesson(s) learned study**. Collaborative public policy process that are successful not only in the development, but also the implementation of policy are rare, and this successful approach could benefit other countries looking to undertake a similar process.

6

In future projects, clear reporting guidelines should be set out that are specifically designed to make appropriate divisions of responsibility while also enabling all participants in the project to provide the benefit of their experience and expertise to both the Ministry and UNDP.

7

The structural design of any future project be thought through in detail in such a way as to enable all participants to have a high level of **clarity and consistency** as to their own responsibilities and the way in which they are expected to contribute to the overall success of the project.

CAPACITY BUILDING AND DEVELOPMENT

8

This project has done an excellent job at building capacity of MEWA civil servants. Further opportunities lay in broader capacity development initiatives; building cross-government capacity in water issues, for example.

9

Additional scientific areas are emerging that could be powerful tools for water resource management in Saudi Arabia. **Continuance of technical support from UNDP experts in areas such as water accounting could continue to increase the capacity within the Water Deputyship**.

These lessons learned can be applicable to a wide international range of projects, and in the particular context of collaborative endeavours between UNDP and the Kingdom of Saudi Arabia, the close and harmonious relationship referenced above gives every reason to look to the future with great optimism.

SECTION TWO

BACKGROUND

BACKGROUND

In April 2016, the Kingdom of Saudi Arabia (KSA) announced the launch of Saudi Vision 2030, a new strategic vision and comprehensive roadmap for economic development in the Kingdom, which, in turn, demands a parallel and aspiring water management scheme. Vision 2030 is a strategic framework to reduce Saudi Arabia's dependence on oil, diversify its economy, and develop public service sectors in areas such as health, education, infrastructure, recreation, water sector and tourism. In June 2016, the Council of Ministers approved the National Transformation Program (NTP), which sets out the goals and targets to be achieved by various economic sectors in the Kingdom. The NTP aims to achieve government operational excellence and establish the necessary infrastructure to improve economic enablers and raise the standard of living through its eight strategic themes which are highly dependent on water supply availability and sustainability. The NTP is an enabling mechanism, and is developing the necessary infrastructure and creating an efficient and transparent operational environment, that enables the public, private and non-profit sectors to achieve the Kingdom's Vision 2030.

To support the achievement of water management resilience and sustainability, the United Nations Development Programme (UNDP), in partnership with the Ministry for the Environment, Water and Agriculture (MEWA), launched the Capacity Development and Related Services for an Integrated Sustainable Development and Management of the Water Sector in the Kingdom of Saudi Arabia in the Framework of the VISION 2030 project in March 2018. The original project concluded on 28 February 2022 but has been extended for a year. This final project report will focus on the impact and achievements of the project, and the support it has provided both to the Water Deputyship, within the Ministry for the Environment, Water and Agriculture, and towards the achievement of Saudi Arabia's broader social, economic and environmental goals.

Achieving MEWA priorities, with UNDP support, is critical to the achievement of broader policy goals in the Kingdom of Saudi Arabia. Saudi Arabia has been classified by the United Nations as a water-scarce nation. In 2015, the country's water availability sat at 89.5 cubic meters per capita per year[2], well below the global water scarcity threshold of 500 cubic meters per capita per year (Figure 1). Average rainfall across the country is 114 mm per year; however the volume of rainfall varies from 100 and 200 mm annually in the north to below 100 mm per year further south.

2 DeNicola, Erica et al (2015). Climate Change and Water Scarcity: The Case of Saudi Arabia, Annals of Global Health, 81(3), 342-352. https://www.sciencedirect.com/science/article/pii/S2214999615012217#bib4

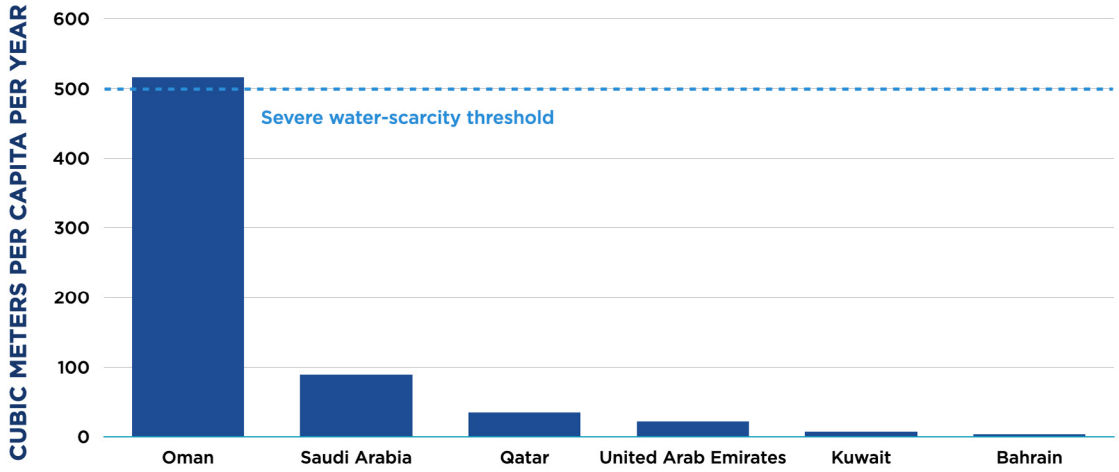


Figure 1: Water Scarcity per cubic meter per capita per year Acknowledging both the reality of water scarcity and the crucial importance of water sustainability to the achievement of the broader goals set out in the Vision 2030 and NTP, the Ministry of the Environment, Water and Agriculture developed the National Water Strategy 2030 (NWS 2030) based on the principles of integrated water resources management tailored to locally assess water sector status in relation to Kingdom's plans. The National Water Strategy was launched in 2017.

> *"A sustainable water sector, safeguarding the natural resources and environment of the Kingdom and providing cost-effective supply and high-quality services. Efficiency contributes to economic and social development in the Kingdom" National Water Strategy 2030*

This project adopts the principles of integrated water resources management (IWRM), which forms the conceptual foundations of the NWS 2030 as well, and is acknowledged globally as a leading framework to support the implementation of sustainable water resources management. IWRM acknowledges the diverse pressures on water resources, which often cross sectoral lines, complicating management practices and policy implementation[3]. The importance of sustainable water management, however, also crosses sectorial lines and the overall economic benefits of improved water management are well documented[4].

In order to support the development and implementation of the National Water Strategy, UNDP and the Water Deputyship developed the project entitled, Capacity Development and Related Services for an Integrated Sustainable Development and Management of the Water Sector in the Kingdom of Saudi Arabia in the Framework of the VISION 2030. The project aimed to provide a cost-effective and holistic capacity building approach to facilitate the achievement of the NWS 2030 goals and objectives, ultimately also supporting the implementation of Vision 2030 and the National Transformation Plan. Through the project, UNDP provided a diverse pool of highly specialised expertise with significant depth of technical experience and an agile and innovative work force that supplemented and complemented the need for engaging costly consulting firms.

3 United Nations Economic and Social Commission for West Asia (2019). Status Report on the Implementation of Integrated Water Resources Management in the Arab Region: Progress on SDG indicator 6.5.1.

4 Stockholm International Water Institute (2005). Making water a part of economic development: the economic benefits of improved water management and services.

Ultimately, the project has aimed to strengthen and optimize the technical and organizational capacities of the Water Deputyship, allowing staff to successfully implement Integrated Water Resources Management principles in Saudi Arabia. To do this, the project set out ten objectives, which are outlined in the table below:

The Objectives		
1	**MEWA, Water Capacity**	The first project objective is to facilitate the optimized Water Deputyship, technical and organizational capacity developed for water resources and water supply management.
2	**Implementation of Integrated Water Information System**	The second project objective is to implement the Integrated Water Information System (IWIS). IWIS will provide visual data oversight and provide automated (real-time) decision-making support at both ends of the water sector supply and demand chain (provider and customer). The IWIS is envisioned as a key Center for Water Management and Control (CWMC) output.
3	**Integrated Water Resources Management**	The third project objective is for the design of an overall Water Resources Management system with implementation and compliance. Expected results of this objective include groundwater and hydrological (surface water) modelling for water resources assessments.
4	**Integrated Water Supply Management**	The fourth project objective is for the design of an overall Urban Water Supply Management System, including implementation.
5	**Monitoring**	The fifth project objective is to establish an all-encompassing monitoring system for the surface water and groundwater processes.
6	**Climate Change**	The sixth project objective is to assess the effects of climate change on society and nature not only in the water business.
7	**Secondary Water Resources**	The seventh project objective is for assessment(s) of secondary water resources (secondary and remote aquifers, surface run-off and rainwater harvesting).
8	**Environmental Risk**	The eighth project objective is to evaluate environmental risks associated with the water cycle (groundwater pollution, seawater intrusion, radioactive contamination) and elaborate counter measures.
9	**Hydrothermal Energy**	The ninth project objective is to help the Water Deputyship to develop its capacity to deliver its mandate and implement the Saudi National Water Strategy 2030. However, as hydrothermal energy is not part of either the mandate or Strategy, it is no longer included in the revised scope of the UNDP Project.
10	**Public Relations and Awareness**	The tenth project objective is to establish an Environmental Awareness Center (Water Extensional Education Center) for public awareness. The main objective of the establishment of the Water Extensional Education Center is to raise public awareness about the challenges related to the water sector in Saudi Arabia.

Ensuring that the project worked in harmony with the NWS 2030, which is a key principle in IWRM to adjust the process to national priorities as reflected in the Strategy, required the Water Deputyship and UNDP to undertake an assessment and reorganisation of project to make sure:

1

The project aligned with results-based management structures introduced under Vision 2030, the NTP, and NWS 2030, ensuring monitoring mechanisms were streamlined across policy and project mechanisms, alleviating reporting requirements and increasing efficiency.

2

The project supported the development and implementation of new Water Deputyship organisational structures, formulated to ensure capacity within the organisational was structured in a way that would support the implementation of Integrated Water Resource Management principles.

The ongoing refinement of the project is indicative of the flexibility and effectiveness of the UNDP project, particularly in relation to the goals of adaptation of IWRM. The UNDP project team and experts continue to work closely with the Water Deputyship to support strategic decision making and put in place the organisational structures to support those decisions and goals. As demonstrated through Figure 2 (below), the implementation of the three project outputs is facilitated through the ten project objectives.

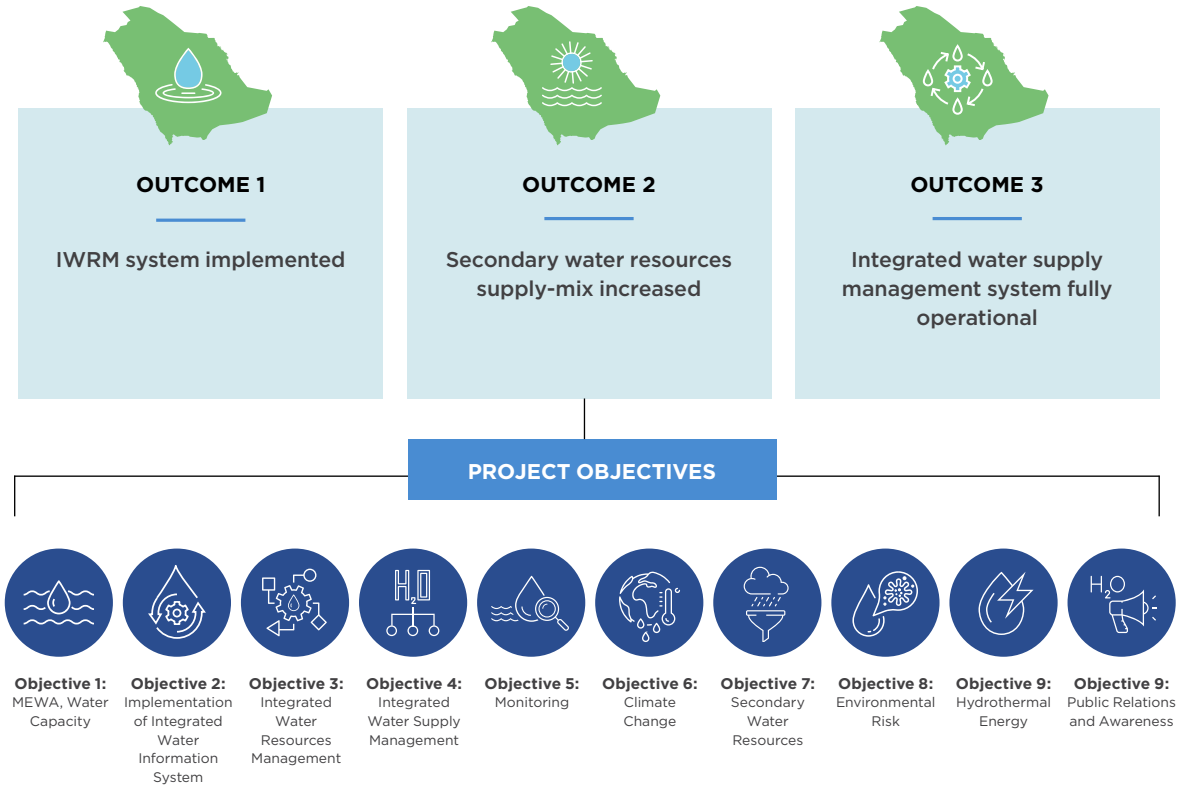


Figure 2: Project outcomes and objectives

SECTION THREE

SHAPING NATIONAL STRATEGIC DIRECTION

SHAPING NATIONAL STRATEGIC DIRECTION

SUPPORTING DELIVERY AGAINST NATIONAL GOALS

Saudi Arabia has a comprehensive policy framework which supports sustainable and strategic development, leveraging the country's geographic, cultural, social, demographic and economic assets. Over the past five years, progress has been made against strategic objectives, as illustrated below, not only through the dedicated work of the Ministry of Environment, Water and Agriculture, but also through important cooperation with key partners, such as the United Nations Development Programme (UNDP).

Progress towards broad policy goals have been supported by significant progress in the water sector, implemented through the Water Deputyship, supported by UNDP. Figure 3 illustrates the fundamental and foundational support provided by the UNDP project to national level goals and objectives.

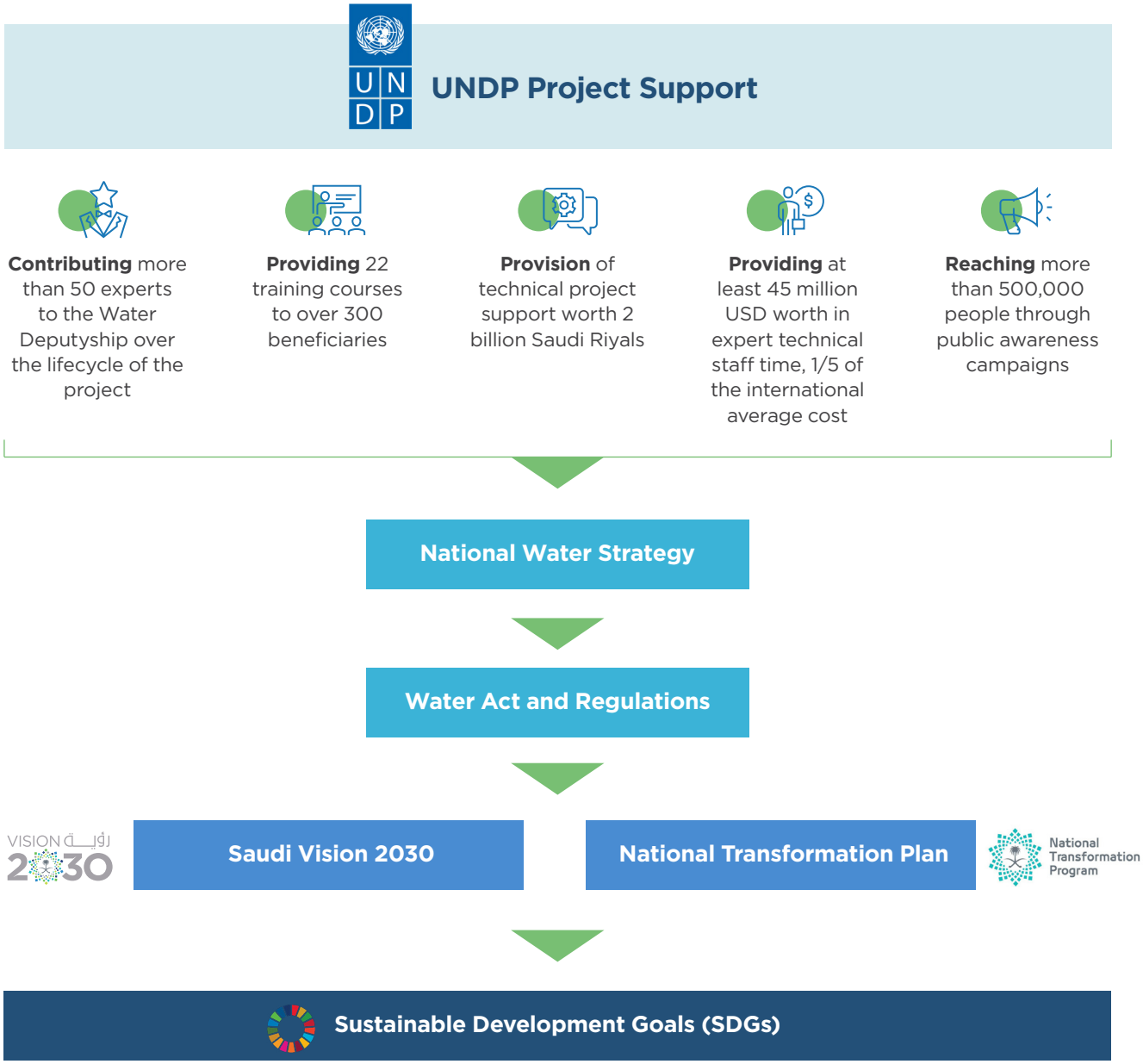


Figure 3: UNDP project in support of national and global goals

Overall, in order to ensure joined-up, sustainable development consideration for water and water resource management, water economics must be integrated into each phase of policy development (see Figure 4). To support this cutting-edge technical input, the UNDP project has provided the institutional structure and world-leading expertise in water resource management to support the growth of a water resource sector in Saudi Arabia that will help achieve national, cross-sectorial goals.

Figure 4: Integration of water economics into decision making[5]

WATER SECTOR CONTRIBUTION TO ECONOMIC PROSPERITY

Both the Saudi Vision 2030 and the National Transformation Plan (NTP) are positioning Saudi Arabia to be a global leader economically, socially and environmentally. Both are working towards a vibrant society and a thriving economy. Water is a driver of economic growth, and the UNDP project has worked towards realising these ultimate objectives through guiding priorities in the water sector by providing world-leading expertise and guidance, which has benefited not only the sector itself, but contributed to the achievement of overall policy goals.

In order to achieve the visions laid out in Saudi Vision 2030 and the NTP, it is important to recognise that water sustainability is critical. Sustainable access to water over the long term is a cornerstone for building the resilience and functioning of ecosystems and communities. Water is a prerequisite for human health, food production, tourism services and all other sectors that support the vibrant society laid out in Saudi policy plans.

Globally, trends of over-exploitation of non-renewable water resources and climate change, which affect levels of renewable aquifers, mean that threats to water sustainability represent one of the foremost threats to achievement

5 Ouda, Dr. Omar. An Introduction to Water Economics (2019). National Centre for Water Research and Studies.

of developmental policy goals and prosperous societies. Figure 5 illustrates the "perfect storm scenario," where global demand for food and energy increases by 50% by 2030, resulting in an increased demand for water of 30%, globally. These increases, taking into account climate change, would present serious challenges globally, and particularly in water scarce nations such as Saudi Arabia.

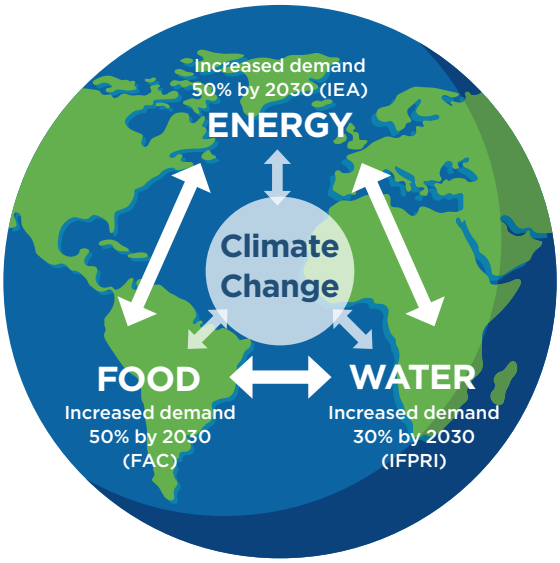


Figure 5: The "perfect storm" scenario[6]

While the intrinsic centrality and importance of water sustainability is essential, it is important also to recognise the cross-sectorial benefits that investment in water and water infrastructure brings. Dr. Omar Ouda, a UNDP expert, reported that:

The economic returns on investment in water resources range from US$ 3 to US$ 34 per US$ 1 invested (depending on the region and technologies applied);

Benefits can also be seen through positive health impacts (less illness, less hospital capacity and treatment cost); and

Providing reliable and sufficient water supplies is critical for business development and reduces investment risk[7].

This section will outline some of these benefits in greater detail.

// UNDERPINNING A VIBRANT ECONOMY

The project realised that a core objective of Saudi Vision 2030 is a thriving economy, and access to sustainable water resources is a prerequisite for ambitious growth and economic diversification. Access to water is also a driver of economic growth, in and of itself. In 2012, it was assessed that countries can gain 5% or more of their annual GDP by meeting the water related goals set out in the Millennium Development Goals (MDGs)[8]. This increases to more than 15% of annual GDP, if universal water access is achieved[9]. It has been shown that investment in water related infrastructure and activities has a multiplier effect, and return on investment is significant. Table 1 demonstrates the potential return on investment in terms of economic gain when it comes to water infrastructure. It is important to note that investment in water infrastructure does not necessarily mean only physical expansion of infrastructure, but also increase in efficiency and effectiveness, which has been a major focus of UNDP's work through this project.

6 UN Department of Economic and Social Affairs (UNDESA), 2015. The Critical Role of Water in Achieving the Sustainable Development Goals: Synthesis of Knowledge and Recommendations for Effective Framing, Monitoring, and Capacity Development.

7 Ouda, Dr. Omar. An Introduction to Water Economics (2019). National Centre for Water Research and Studies.

8 MDG water related objective: "to reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015 compared with 1990 levels".

9 Frontier Economics (2012). Exploring the links between Water and Economic Growth: A report prepared by Frontier Economics for HSBC.

> *"In 2012, it was assessed that countries can gain 5% or more of their annual GDP by meeting the water related goals set out in the MDGs[10]. This increases to more than 15% of annual GDP, if universal water access is achieved"*

	One-off investment requirements (million USD, 2010)		Annual potential economic gain		Benefit-cost ratio	Payback period (years)
Country	Water	Sanitation	Million (USD)	% of GDP		
Brazil	5,396	15,064	16,824	0.8%	18.6	1.2
India	64,070	242,835	43,556	5.2%	3.2	7.0
China	8,498	83,217	53,279	0.9%	5.9	1.7

Table 1: Return on investment: water sector infrastructure[11]

While the return on investment varies regionally, it is estimated that countries in the MENA region would see a cost benefit ratio of 4.2 if universal access to water is achieved and maintained[12]. The water sector is also a significant contributor to GDP per capita and a large employer. Table 2 shows the combined value of the water, electric and gas sectors, estimated at more than 47,000,000 Saudi Riyals (2019) and employing 108,000,000 people.

Economic Sector	GDP at current price (2019) SR Millions	Number of Employment ('000)
Agriculture Forestry & Fishing	66,411	85,240
Mining & Quarrying	1,909,047	184,527
Manufacturing	476,947	824,735
Electricity, Gas, Steam & AC Supply, Water Supply, Sewage, Waste mgt, and Remediation Activities	47,174	108,001
Construction	163,655	2,252,259
Wholesale & Retail Trade, Repair of Motor Vehicles & Motorcycles, Restaurants & Hotels	298,009	2,341,121
Transport, Storage, Information and Communication	182,071	313,479
Finance Insurance, Real Estate, Professional and Administrative Services	952,222	1,316,408
Community, Social & Personal Services	67,626	959,746

Table 2: Sectorial contributions to GDP in Saudi Arabia[13]

10 MDG water related objective: "to reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015 compared with 1990 levels".

11 Ibid.

12 Ibid.

13 Al Arjani et al (2021). A new framework for the sustainable development of Saudi Arabia. Journal of King Saud University, 33(6).

// PROMOTING RESILIENCE

Water is a cornerstone of a resilient economy. Resilience is understood in this context as the ability to withstand shocks and strains as well as to recover quickly when these inevitably occur. It is increasingly recognised that the most pressing risks of shocks come not only from market variability but also from environmental pressures, which are exacerbated by climate change. While the world begins to recover from the COVID-19 pandemic, it is important to recognise that the impact of global environmental emergencies, such as climate change and biodiversity loss, have the potential to cause economic (and social) damage far greater than what has been seen during and following the pandemic[14].

Building resilient economies and societies needs to be at the forefront of all policy goals. Investment in data-driven water resource decision-making tools and structures is important to building water resiliency into policy plans. Decoupling economic growth from rainwater variability is one critical way that water resource management can contribute to more resilient economic growth[15]. For example, Australia and Ethiopia have similar degrees of climate variability. However, while Australia has over 4,700 cubic meters of water storage capacity per person, Ethiopia has significantly less, with 43 cubic meters. In this case, it is estimated that annual income lost in Ethiopia due to land and water mismanagement stands at around USD 60 to 70 billion a year when preventive, corrective and rehabilitative measures that could prevent this would cost no more than 25–50% of the annual losses[16].

// GROWING A VIBRANT SOCIETY

With rapid urbanisation trends, comes increased pressure on water resources. With urban development typically privileging spatial and land use planning, the strain on water resources can become intense, which, in turn, affects communities and also has cross sectorial impact. Saudi Arabia is seeing significant urban growth, as shown by Figure 6, which reflects the urbanisation trend and shows that 84% of Saudi Arabia's population currently lives in cities[17].

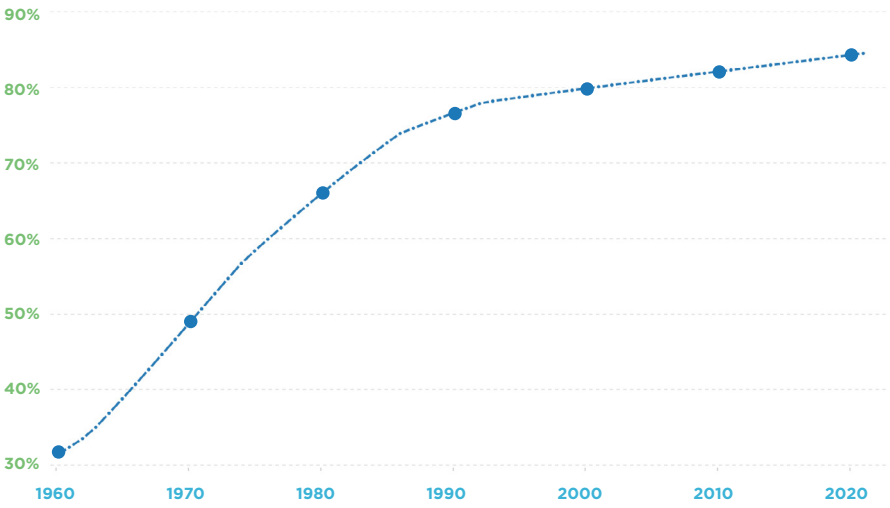


Figure 6: Urban population (% of total population), Saudi Arabia (World Bank)

Urban areas are places where food, energy and water consumption take place, and therefore consumption patterns and resource access in cities can have significant impact on other sectorial areas. Public spaces, for example, are important to community development in cities and UN Habitat suggests that urban areas should dedicate around 50% surface area to public spaces[18]. Both in urban areas and beyond, the water sector has an impact on all facets of society. Figure 7 shows the linkages with other sectors such as energy, food production, WASH, etc. Through this lens, the criticality of water for the achievement of all SDGs becomes clear.

14 OECD (2020). Building back better: A sustainable, resilient recovery from COVID-19.

15 Stockholm International Water Institute. Making water a part of economic development: The economic benefits of improved Water Management and Services.

16 Ibid.

17 The World Bank (2022). https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=SA Accessed May 2022.

18 UN Habitat, (2022). The Global Public Space Programme.

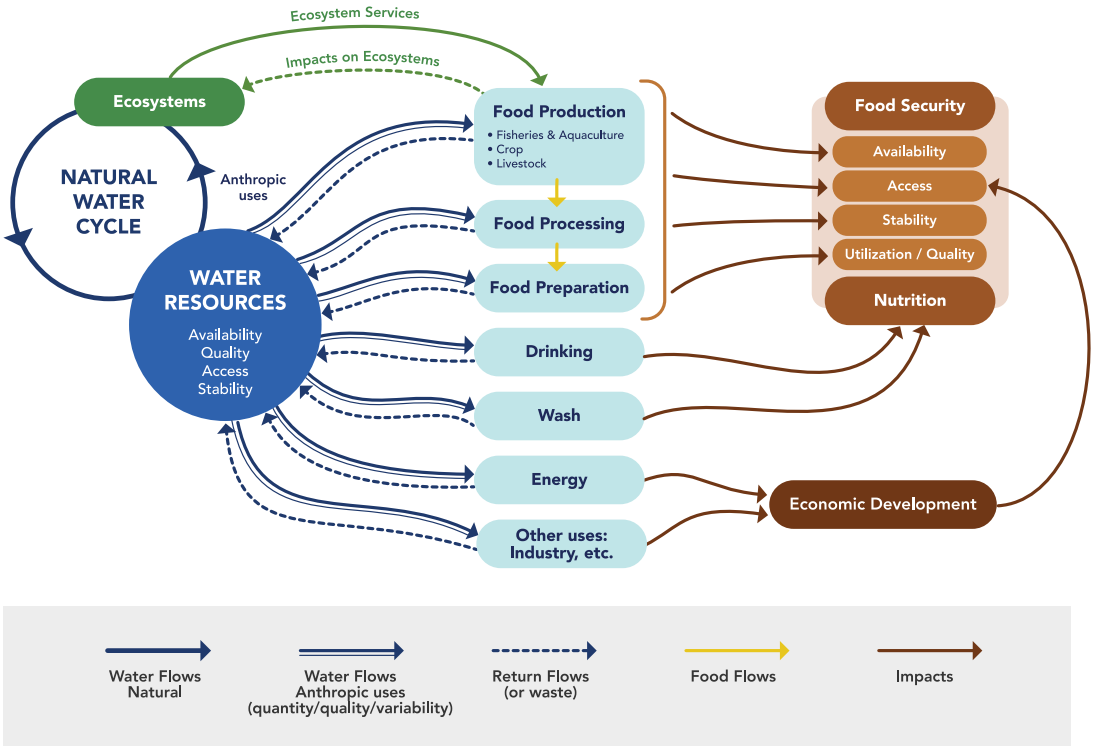


Figure 7: Cross-sectorial influences of water resources[19]

// UNDP PROJECT CONTRIBUTING TO ECONOMIC DEVELOPMENT

As demonstrated above, it is recognised that water and water services must be part of any economic and societal development plans. Together the Saudi Vision 2030 and the National Transformation Program form key components of Saudi Arabia's overarching policy framework, promoting economic, social and environmental development.

UNDP, recognising the social and economic value of water particularly in a water-scarce country, has taken a high-level approach to infuse economic principles into the practices of water management across the water sector. Figure 8 shows how economic sustainability of the water sector, including the economic contribution of the sector, is integrated into national Water Management principles, as guided by UNDP project experts.

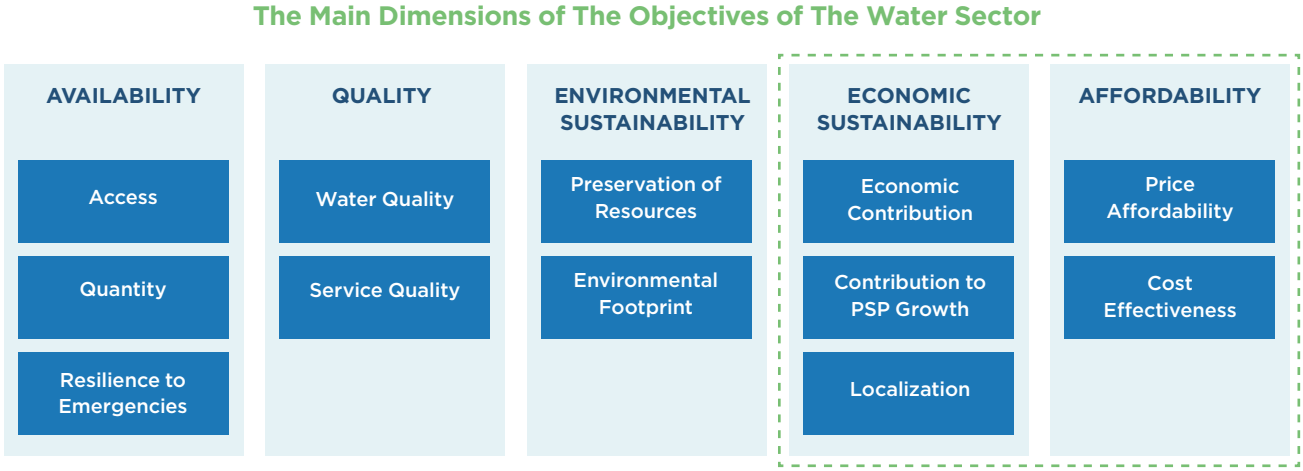


Figure 8: The main dimensions of the objectives of the water sector[20]

19 Merrey, Douglas (2015). Critical roles of water in achieving the proposed SDGs: A nexus perspective (water-energy-food-climate change). Presented at the Workshop on "Capacity Development in Advancing Water and Sustainable Development", United Nations, New York City, NY

20 Ouda, Dr. Omar. An Introduction to Water Economics (2019). National Centre for Water Research and Studies.

The UNDP project organized a Water Economics workshop with local and international speakers on the different aspects of the economics of water. In addition, scientific papers were published and internal, ministerial-level, highly focused reports on the topic were delivered. To this effect, MEWA is highly prioritizing and is tendering projects to deeply study the economic value of water with a focus on its value.

In the Water Economics workshop conducted by the project at MEWA, the UNDP keynote speaker Dr. Omar Ouda concluded that:

- Water Economics is at the centre of the National Water Strategy 2030, towards efficient and sustainable water management system in the Kingdom.
- Water economic analysis is an extensive, detailed, time-consuming and challenging exercise and requires comprehensive information gathering from all water sector stakeholders.
- This analysis has different dimensions and levels of analysis and accordingly, it should be linked and associated with policy decision making.
- Water economics analysis can support the development of water resources allocation plans towards meeting the National Water Strategy 2030 vision and goals.
- The proposed water allocation study will facilitate information-based decision making process
- The proposed study will integrate all aspects of water resources management including social, environmental and technical.

Through these initiatives, and supporting policy frameworks such as the National Water Strategy 2030, Saudi Arabia is progressing an ambitious development agenda and, through working with partners such as UNDP, is ensuring consideration of water resources remains at the core of these plans.

> ***"Past failure to recognize the economic value of water has led to wasteful and environmentally damaging uses of the resource. Managing water as an economic good is an important way of achieving efficient and equitable use, and of encouraging conservation and protection of water resources"***
> ***Fourth Dublin Principle***

UNDERPINNING SAUDI VISION 2030

In 2016 the launch of Saudi Vision 2030 was announced, and unveiled an ambitious plan to further economic development through reducing dependence on oil and diversifying the economy. Recognizing that economic development is closely linked to development in many sectors, Vision 2030 is also working to develop other public service sectors such as health, education, infrastructure, recreation, water sector and tourism.

Vision 2030 sets out three Pillars:

رؤية VISION 2030
المملكة العربية السعودية
KINGDOM OF SAUDI ARABIA

Projects under the three Pillars either pertain directly to water resources, or require water resources to succeed. For example, in the Taif Governate in the rugged Sarwat Mountains, the longest tunnel in the world was dug to transport desalinated water. The tunnel was dug at a speed of 60.3 meters per day and has a total length of 12.5 km.

Other key achievements of Vision 2030 to date have been in sectors which will require substantial levels of water resource in order to be successful. For example, since the launch of Vision 2030, Saudi Arabia has organised more than 2000 events, including 1750 entertainment events, 50 sporting events and 56 cultural events. In total, these events have been visited by more than 45 million visitors. This is a significant tourism boost to the Kingdom, but one that only emphasises the need for sustainable water resources to cater to these visitors. It is estimated that 46 million visitors would use a total of **XX** litres of water.

Since the launch of Vision 2030, there has also been an increase in the percentage of green areas in the Kingdom. An area representing 37 million square meters of green space in the Kingdom has been rehabilitated and 14 million trees and roses have been planted. This is a significant achievement, as public space is crucial for sustainable cities and communities: providing ecosystem services, improving health and wellbeing, ensuring social inclusion and economic exchange[21]. The maintenance of green spaces, however, can be water intensive and requires sustainable water management practices to be able to be maintained. 37 million square meters of green space, for example, will require an estimated **XX** litres of water annually to be maintained.

SUPPORTING THE NATIONAL TRANSFORMATION PROGRAM

To complement Saudi Vision 2030, the Council of Ministers approved the National Transformation Program (NTP) in 2016. The Program is designed to set out the goals and targets to be achieved by various economic sectors in the Kingdom. **The strategic objectives of the NTP are based upon seven key themes:**

National Transformation Program

1. Achieve government operational excellence
2. Ensure sustainability of vital resources
3. Social empowerment and non-profit sector development
4. Labour market accessibility and attractiveness
5. Digital transformation
6. Private sector empowerment
7. Develop economic partnerships

The NTP was one of the first programs to be created under Saudi Vision 2030. As such, NTP was assigned to deliver the largest number of strategic objectives, equivalent to more than 35% of total Vision 2030 goals. The NTP has had significant impact on the water sector, particularly through the second key theme: ensuring sustainability of vital resources.

In the 2021 achievement report, the NTP reported several key achievements within the water sector. A selection of those achievements is summarised below:

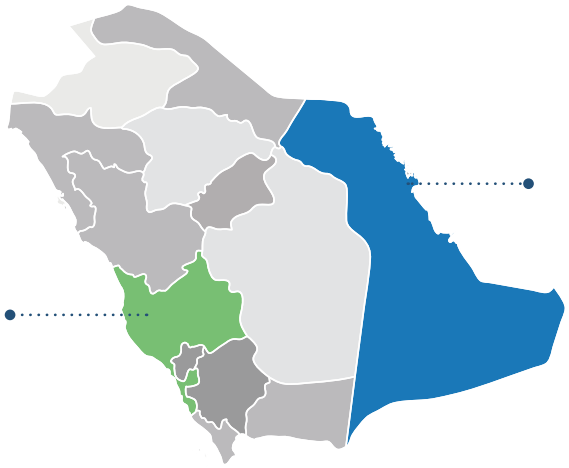
21 UN Habitat (2022). Global Public Space Programme. https://rb.gy/tlulsk, accessed May 2022.

1 ENHANCEMENT OF DESALINATED WATER RESOURCES:

To date, the Saline Water Conversion Corporation is operating the world's lowest energy-consuming desalination place (2.27 kilowatt-hours/m3), while growing overall production capacity of water from 4.6 million m3 in 2017 to 5.9 million m3 in 2021[22]. Desalination production systems have been launched in Al Wajh and Haql provinces. In Al Wajh, desalinated water production is currently 25,500 m3/day and in Haql, desalinated water production rose from 5,000 m3/day to 17,000 m3/day.

Work has also started to expand the desalination network, with new desalination units opened in Jubail, which will have a capacity of 5,000 m3/day. The Arafat-Taif water network has also been expanded, and now supplies Taif via a water network that can pump 60,000 m3/day. The broader network, which supplies water to Taif, Turbah, Rania and Al Khurma, has a pumping capacity is 176,400 m3/day. Also in Taif, storage tanks have been installed, with an overall storage capacity of 2,890,000 m3.

Further work is planned, with **Rabigh**, **Jeddah** and **Mecca**, in the region of Mecca, all targeted for a desalinated water pumping project, which will see **600,000 m3/day** of pumping capacity and an overall design capacity of **1.3 million m3/day.**



Finally, a project in **Jubail**, the eastern Region Cities, will see construction of an initial tank in **Ras Tanurah** and ultimately an overall design capacity of **900,000 m3/day.**

Ultimately, this new system is built to sustain a growing population as well as the growing economy of Saudi Arabia, delivering the water resources it will require.

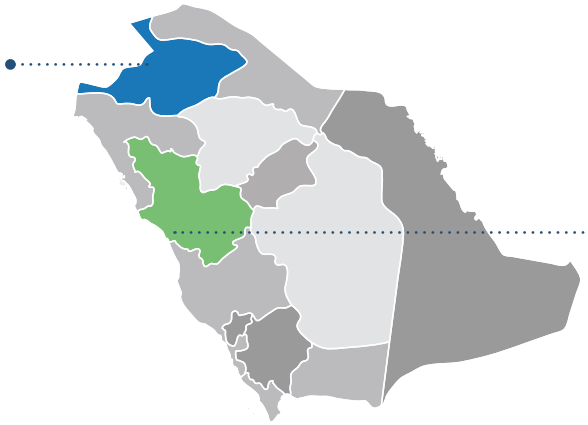
Photo: The National Transformation Program's 2021 Achievement Report

22 Vision 2030 and the National Transformation Program (2021). National Transformation for our Present and Future; The National Transformation Program's 2021 Achievement Report.

2 ENSURE SUSTAINABLE USE OF WATER RESOURCES:

Ensuring water is used and managed responsibly is critical to overall sustainability. To date, the NTP has worked to ensure sustainability by diversifying and increasing supply.

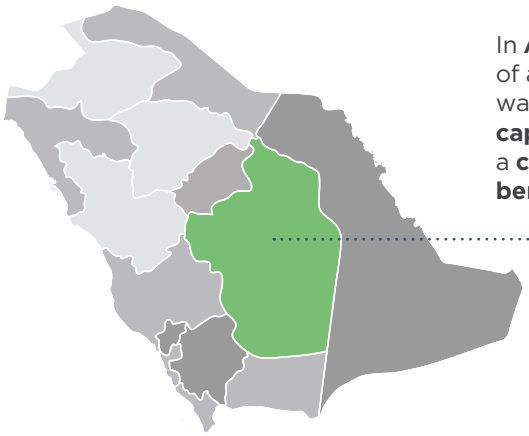
For example, the **Al Tamriat well in Al Jawf Region** now has a **capacity of 2,200 m3** and provides water for livestock, contributing to both water and food security.



In **Yanbu**, one production station had an increase of capacity of 9.3%, with a total design **capacity of 566,160 m3.**

3 CONSTRUCTION OF WASTEWATER TREATMENT PLANTS:

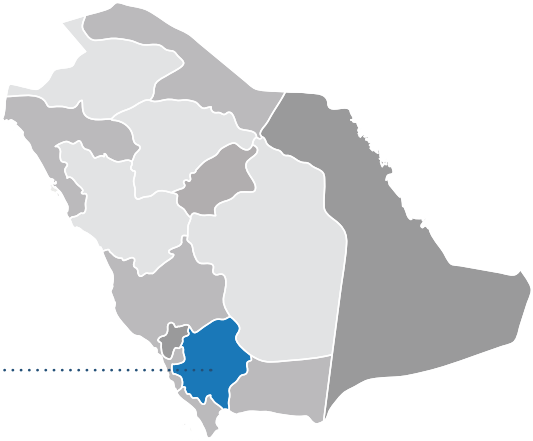
Treating wastewater and removing pollutants is a critical step towards mitigating harmful toxins in water and maintaining a clean water system.



In **Al Quwaiya** the construction of a wastewater treatment plant was finalised. The plant has a **capacity of 10,000 m3/day** and a **catchment area with 50,000 beneficiaries**

4. DELIVER DRINKING WATER TO CONSUMERS:

Drinking water networks were expanded in **Asir**, with **a total length of 64.2 km and 400 home connections**. Ultimately this expansion has brought drinking water to the **homes of 4,800 beneficiaries** located in **Al Khalidiya** and **Al Hidar**.



As detailed in further sections of this report, UNDP project contributions have supported the implementation of NTP achievements in the water sector through providing technical expertise, capacity development and research and analysis.

DEVELOPING AND IMPLEMENTING THE NATIONAL WATER STRATEGY

In 2017, the Ministry for Environment, Water and Agriculture began work to define a Saudi National Water Strategy. Understanding the centrality of water-based resources to the economic and social development of the country, the NWS brings together a vision and strategic direction for the supply, demand and management of the country's water resources. The NWS is based on the principle of integrated water resources management and envisions "a sustainable water sector, safeguarding the natural resources and the environment of the Kingdom and providing cost-effective supply and high-quality services". In order to achieve this goal, the NWS includes five strategic objectives:

1. **Ensure** continuous access to adequate quantities of safe water, under normal operations and during emergencies.
2. **Enhance** water demand management across all uses.
3. **Deliver** cost-effective and high-quality water and wastewater services, accounting for affordability.
4. **Safeguard and optimize** the use of water resources, while preserving the local environment for the highest benefit of Saudi society in this generation and the future.
5. **Ensure** water sector competitiveness and positive contribution to the national economy through promoting effective governance, private sector participation, localization of capabilities and innovation.

In order to translate these objectives into actionable measures, the NWS includes 10 strategic programs, which are outlined in Table 3 below. MEWA Water Deputyship is responsible for 5 out of 10 strategic programs.

Name of programme	Objective	Responsibility
Water Law and Resource Management Regulations	Introducing a comprehensive set of policies and implementing an adequate legal and regulatory framework.	MEWA
Water Resource Management	Implementing integrated resources management and planning at the national level and optimizing the use of available water resources.	MEWA
Sector Resilience	Ensuring that the water and wastewater sectors are prepared to meet any disruption to day-to-day operations.	MEWA
Innovation and Capability Building	Promoting research and development and localization and enhancing leadership and water management capabilities.	MEWA
Supply Chain Efficiency and Service Quality	Improving the sector's operations and service delivery.	MEWA
Water Services Regulations	Ensuring that the economic regulator (ECRA) fulfils its role to regulate water services, alongside electricity and cogeneration.	ECRA
Saline Water Conversion Corporation Reconstructing	Part of the SWCC privatization strategy for restructuring and transforming the SWCC to achieve its revised mandate.	SWCC
Involving the Private Sector in the Production and Treatment of Wastewater	Assembling production assets and wastewater treatment for privatization purposes.	Water and Electricity Company
Distribution Restructuring and Privatization	Transforming the distribution sector by streamlining distribution utilities and preparing them for privatization.	NWC
Saudi Irrigation Organization Restructuring and Irrigation Improvement	Restructuring the Saudi Irrigation Organization (SIO) to achieve its expanded role.	SIO

Table 3: National Water Strategy 10 strategic programs

The National Water Strategy is supported by a cross-government governance model, bringing multiple actors into decision making bodies and creating shared accountability by spreading implementation through different government entities. This arrangement was intentional: water resources are a cross sectorial responsibility, and require active engagement from cross-government actors. Figure 9 illustrates the NWS 2030 governance model.

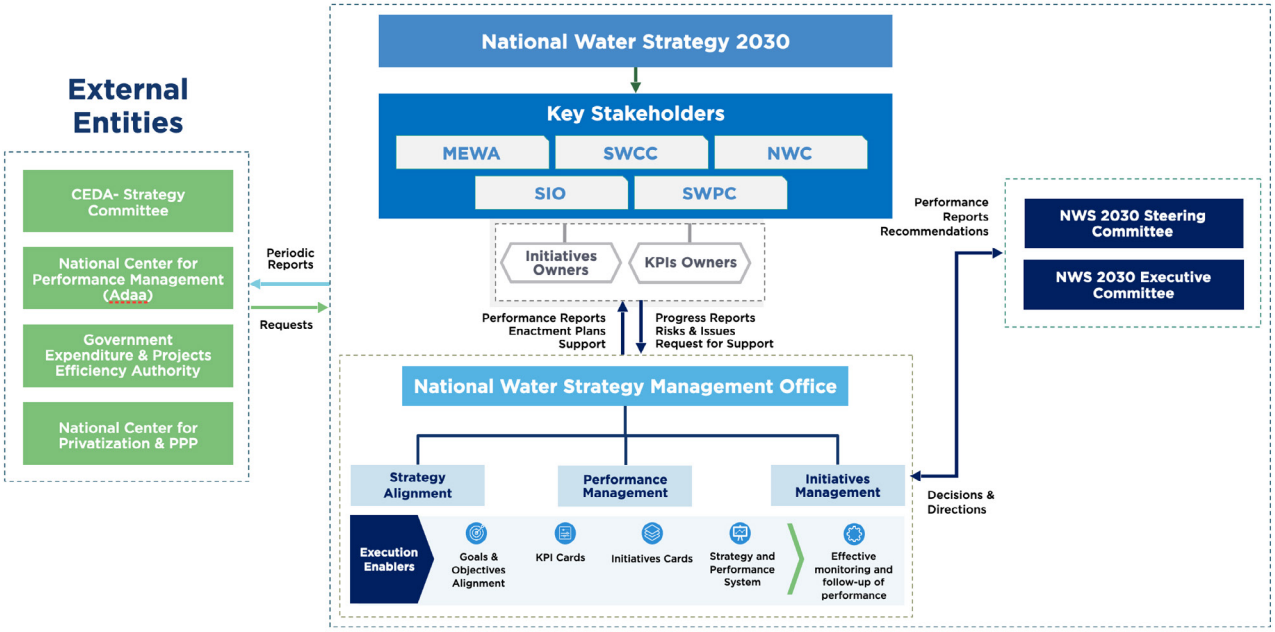


Figure 9: NWS 2030 governance model

The NWS is based on the water supply and demand abstraction balance (2016) and projections (2030 conservative and optimistic) shown in Table X. In the absence of appreciable rainfall:

Water withdrawal = water consumption - drainage return flow

Efficiency = consumption/withdrawal

Treated sewerage effluent (TSE) is a form of drainage return flow and not withdrawal or abstraction from the other primary sources of the supply of water in Table 4. Furthermore, Table X does not include the other drainage return flows particularly from irrigated agriculture.

Supply				Demand			
Description	**2016**	**2030c**	**2030o**	**Description**	**2016**	**2030c**	**2030o**
Surface water	0.6	0.8	0.8	Industrial	1.4	2.1	2.0
Treated sewage effluent	0.1	2.2	1.9	Urban	3.2	3.9	3.6
Desalinisation	2.2	2.4	2.2	Agriculture	21.2	11.2	6.7
Renewable groundwater	2.3	3.3	2.6				
Non-renewable GW	20.6	8.8	5.0				
Total	**25.9**	**17.5**	**12.5**	**Total**	**25.9**	**17.5**	**12.5**

Table 4: Saudi Arabian water abstraction balances (BCM)[23] Legend: c = conservative and o = optimistic.

23 MEWA. 2018. Saudi National Water Strategy 2030.

In July 2019, the National Water Strategy Management Office (NWSMO) was formed within the Water Deputyship Planning Directorate and headed by a UNDP expert, who was named the Planning Director. The NWSMO is the leading management and implementation body for the NWS 2030, and works to support strategic alignment with Water Deputyship, and cross-government, objectives. The NWSMO is also responsible for overall performance monitoring and analysis and management of NWS initiatives. In order to facilitate the implementation and overall management of the NWS 2030, the National Water Strategy Management Office has undertaken the following key activities.

Photo: Studying structural geology

// NWS 2030 IMPLEMENTATION STUDY

In July 2019, National Water Strategy Management Office signed a contract with Devoteam Management Consultants for an NWS 2030 Implementation Study. The Implementation Study aimed to provide a foundation of data and analysis from which decisions around future implementation plans for the NWS could be made. The contract started on 1 January 2020. Figure 10 outlines the key study milestones.

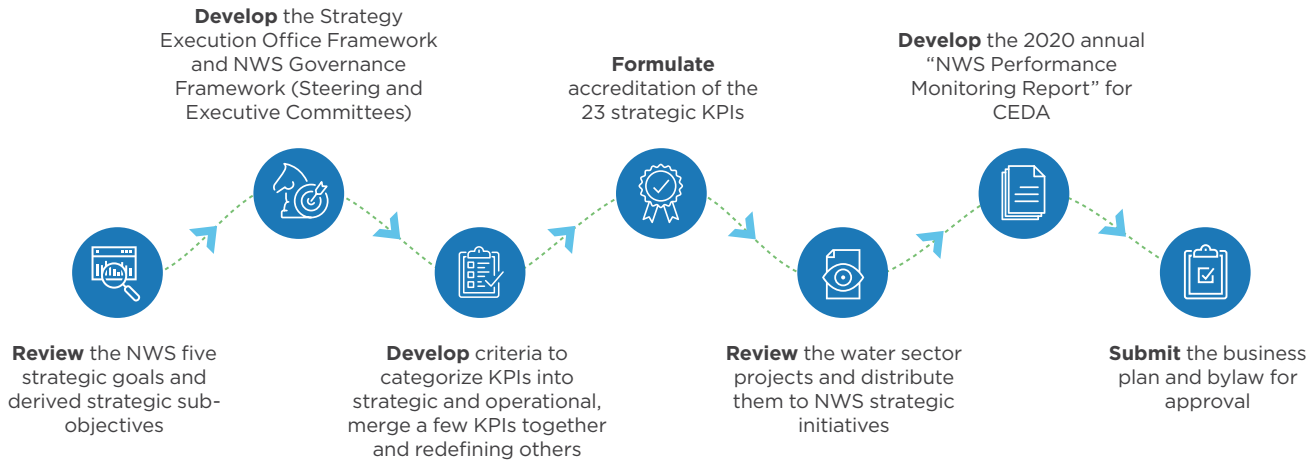


Figure 10: Achievements to date of the NWS 2030 Implementation Study

To complement the five NWS 2030 Objectives, the NWS Implementation Study proposed 14 additional strategic sub-objectives and 23 associated strategic key performance indicators (Table 5). The NWS Implementation Study also reclassified 17 key performance indicators (KPIs) as operational KPIs.

NWS Strategic Objective	Additional Sub-objective		Strategic KPI	
Ensure continuous access to adequate quantities of safe water in normal and emergency situations	1.1	Providing adequate urban water supplies	01	Urban water supply network coverage
	1.2	Ensuring adequate storage in emergencies	06	Strategic storage (days) for urban water use
Improve water demand management for all uses	2.1	Enhancing optimum utilization of urban water	05	Average per capita urban water consumption
			38	Urban water losses (unaccounted water)
	2.2	Reducing agricultural water abstraction	03	Groundwater abstraction for agriculture
			32	Non-renewable GW abstraction for agriculture
	2.3	Increasing water use from wastewater	24	Reuse of treated wastewater
	2.4	Enhancing billing for water services		
	2.5	Strengthening control over groundwater	14	Non-renewable groundwater abstraction
Deliver high-quality, cost-effective water and sanitation services at affordable prices	3.1	Improving the quality of water services	08	Supply continuity rate
			09	Urban water quality
	3.2	Improving the quality of wastewater services	02	Urban sewerage network coverage
	3.3	Improving cost management of water and WW	37	Urban water supply cost recovery rate
Safeguard and optimize use of water resources, while preserving the local environment, for the benefit of present and future Saudi society	4.1	Optimal use of non-renewable water resources	15	Share of non-renewable GW in urban water supply
			16	Share of non-renewable GW in total water supply
	4.2	Maximize the use of renewable water	17	Share of renewable GW in total water supply
			31	Share of renewable water in Agricultural water
	4.3	Increase treated wastewater	21	Treated wastewater from collected water?
			22	Tertiary treated wastewater
Promote effective governance, private sector participation and nationalization of capabilities and innovation to ensure water sector competitiveness and positive contribution to the national economy	5.1	Enhance public – private partnerships	33	Private sector share of desalinated water
			34	Private sector share of wastewater treatment
	5.2		36	Share of national content in the water sector

Table 5: NWS strategic objectives, proposed sub-objectives and strategic KPI

// DEVELOPING A STRATEGY AND PERFORMANCE MANAGEMENT SYSTEM

In addition to this study, the National Water Strategy Management Office also developed the Strategy and Performance Management System (SPMS) design document, system functionality specification, prototype and SPMS implementation business plan and technical requirements. This included working with the MEWA information technology team to prepare the server, database and operating system infrastructure required to implement the SPMS.

Initial progress towards the achievement of the NWS was measured via the SPMS in 2020. The progress of the strategic initiatives was evaluated based on the discrepancy between the actual completion rate of the initiative and the rate of completion according to the plan (Figure 11). Whereas, performance of the 23 strategic indicators was calculated based on the comparison of the actual value of the indicators with the target value for the year 2020.

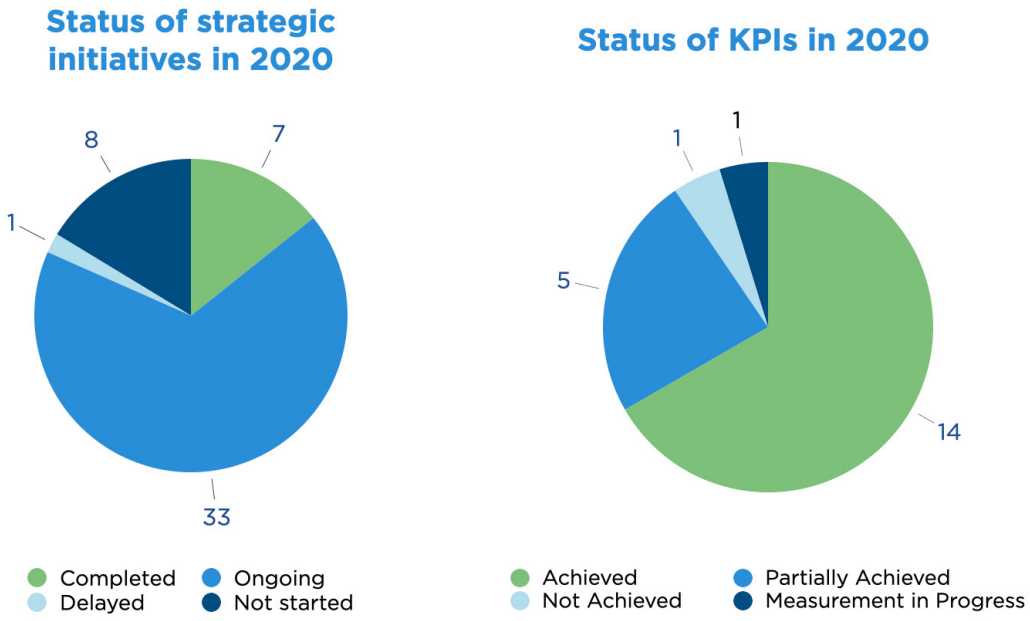


Figure 11: Implementation progress of NWS 2030

National Water Strategy 2030 Alignment with Vision Programmes

At the end of 2021/beginning of 2022, with the support of UNDP experts, the National Water Strategy Management Office team worked with the National Center for Performance Measurement (ADAA) to align all initiatives that are being executed under the Vision 2030 Programs and related to water sector with National Water Strategy 2030. As result of this effort, the number of initiatives to be executed under the umbrella of National Water Strategy 2030 has reached 55 initiatives.

Based on that, the National Water Strategy Management Office team, started to monitor the execution and reported on 55 initiatives and 39 KPIs (Figure 12).

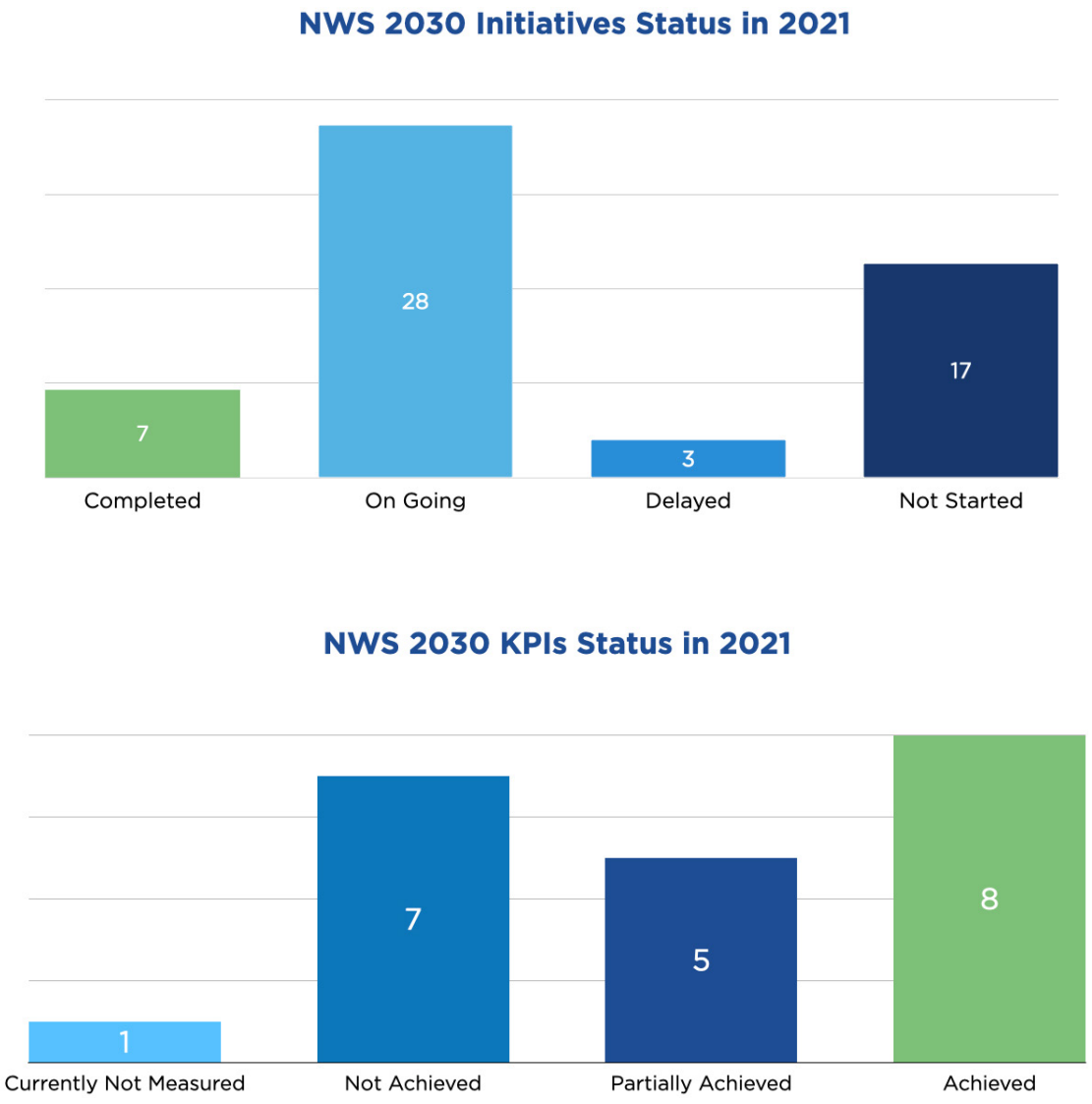


Figure 12: National Water Strategy Initiatives and KPI status in 2021

ESTABLISHING THE WATER ACT AND REGULATIONS

While a policy framework provides strategic direction, legislative frameworks provide a critical implementation mechanism for that strategy. Following the finalisation of the NWS 2030, UNDP experts contributed to the development and implementation of the Water Act, well water abstraction licensing regulations, and water and wastewater quality standards, regulation and monitoring. Together, this legislative framework provides an important enforcement tool, helping to ensure effective implementation.

SUPPORTING SAUDI ARABIA'S GLOBAL LEADERSHIP IN SUSTAINABLE WATER MANAGEMENT

CHAMPIONING WATER MANAGEMENT IN THE G20 SECRETARIAT

Saudi Arabia's presidency of the G20 meetings began on December 1, 2019 and concluded at the end of November 2020. For the duration of Saudi Arabia's presidency, the Group worked towards goals under the theme of Realising Opportunities of the 21st Century for All. To achieve this, there were three aims:

Empowering People, by creating the conditions in which all people – especially women and youth – can live, work and thrive.

Safeguarding the Planet, by fostering collective efforts on food and water security, climate, energy and environment.

Shaping New Frontiers, by adopting long-term and bold strategies to share benefits of innovation and technological advancement.

In contributing to the achievement of Goal 2 Safeguarding the Plant, experts from MEWA and UNDP prepared a Water Policy Paper entitled Fostering Sustainable and Resilient Water Management Globally (see Box 1).

Box 1: Fostering Sustainable and Resilient Water Management Globally

Water insecurity is one of the greatest challenges of the 21st century and one of the most pressing issues facing the world. Given its importance for human survival and sustainable development, its scarcity can pose a serious challenge to sustainable development. Changing demographics, a projected sharp increase of the world's population, rapid urbanisation aging of water resources infrastructure, and lack of investment in water infrastructure are factors posing an ever-increasing pressure on water resources worldwide. Currently more than 1.2 billion individuals of the world's population suffer from water scarcity. Unless effective measures are implemented to manage water resources efficiently and equitably, the number of people affected by water insecurity is set to increase to more than 1.8 billion people by 2025 and reach about 5.7 people by 2050.

Considering the challenges of managing water resources – affecting most countries across the world, including most G20 members to varying degrees over the coming years, it is necessary for the G20 to discuss and cooperate on measures that would enhance efficiency in the use of water and improving water resources management. Measures to preserve water resources include efficient utilization of existing water resources; enhanced water asset management and promotion of sustainability; capacity building and knowledge sharing; development of non- conventional and renewable water resources; raising public awareness on the value water; increased agricultural productivity; as well as agriculture water use efficiency through the introduction of modern technologies and innovative delivery systems. Such measures will boost water use efficiency and foster sustainable management of water resources. Desired outcomes as proposed in this paper, will seek to further enhance global efforts to achieve Goals of the 2030 Agenda for Sustainable Development (SDG), and particularly Goal 6, which relates to ensuring the availability and sustainability of water and sanitation for all.

The development of this paper brought to the fore the importance of water sustainability and the criticality of water management to broader social, economic and environmental goals. G20 countries appreciated the discussion of water in the G20 framework and close consultations resulted in considerable progress in the integration of water issues and challenges in the outcome of the Saudi Presidency.

Achievements included the re-naming of the Agriculture Working Group to the Agriculture and Water Working Group and the formation of water-focused working groups within the G20. The working groups held socialization meetings and ultimately agreed on the water section paragraphs in the Ministerial Communiqué.

The Water team also held Ministerial meetings for G20 countries focused on water issues, and discussed and agreed effective outcomes towards sustainable, resilient and integrated water management. With the support of these meetings, G20 countries developed, agreed on and held the first G20 Dialogue on Water focused on water, sanitation and hygiene (WASH) to combat diseases and pandemics such as COVID-19. Future Dialogues on Water have been encouraged and may carry out the following activities, at their discretion: (i) select a topic in consultation with G20 countries on which best practices will be collected within the framework of G20 mandates, (ii) design and disseminate a questionnaire/template to collect best practices on the selected topic, (iii) invite members to present their best practices in a dialogue on Water meeting and (iv) publish the compiled best practices in a report and upload the report on the Platform.

Under the leadership of MEWA and UNDP experts, the G20 summit also saw the development and agreement on G20 Water Coordination Roadmap and the G20 Water Best Practice Roadmap. The establishment of a Platform for sharing best practices on Sustainable and Resilient Water Management was also confirmed. The G20 countries agreed to establish an open-source digital platform to promote the exchange of IWRM information, best practices, and experiences amongst G20 and invited countries. Saudi Arabia provided the initial design, setup and maintenance costs for up to five years of operation. This included IT administration, server hosting, and all other maintenance and operation costs. The collected best practices will be published soon in the G20 Water Platform.

> ***"We acknowledge that affordable, reliable, and safe water, sanitation, and hygiene services are essential for human life and that access to clean water is critical to overcome the pandemic. We welcome the G20 Dialogue on Water as a basis to share best practices and promote innovation, and new technologies, on a voluntary basis, that will foster sustainable, resilient, and integrated water management"*** [24]

Photo: Launching G20

24 G20 Leaders Declaration: For the first time, the G20 Leaders' Declaration, of 21 November 2020, included the following statement on Water:

Finally, the group issued the Communiqué of G20 Agriculture and Water Ministers, with a full section on water called Fostering Sustainable and Resilient Water Management. Ministers committed to:

- As part of an environmentally sustainable, resilient, and inclusive recovery, cooperate closely and take concrete actions to maintain existing services and expedite increased access to safe, resilient, and sustainable water, sanitation, and hygiene services across the world (Paragraph 23);
- Promote dialogue and the sharing of best practices to foster innovation in addressing water challenges (Paragraph 28);
- Commit to increase collaboration at all appropriate levels to advance research and capacity development to tackle water stress and other risks (Paragraph 29);
- Appreciate the valuable work of the G20 Dialogue on Water, including the implementation of the Water Coordination Roadmap for G20 water-related activities and actions, the best practices compiled on the topic of managing water, sanitation, and hygiene to combat water-related diseases and pandemics, in the face of COVID-19, and the Best Practices Roadmap for a digital platform of countries' best practices and experiences related to sustainable and resilient water management. We encourage considering the continuation of this work, on a voluntary and non-binding basis and within the mandate of the G20, under future presidencies (Paragraph 30).

The Kingdom of Saudi Arabia encouraged Italy, in its role as G20 president, to consider the following in 2021:

- Rename the Environment Work Group as the Environment and Water Work Group;
- Hold a Dialogue on Water meeting and invite G20 countries to share their best practice on regulations and safe re-use of treated wastewater in a circular economy;
- Implement the agreed Water Coordination Roadmap for G20 water-related activities;
- Develop and agree a mechanism to increase collaboration at all appropriate levels to advance research and capacity development to tackle water-related risks, particularly water stress as committed in paragraph 29 in the 2020 Ministerial Communiqué.

Photo: Water economics forum

IMPLEMENTING THE SUSTAINABLE DEVELOPMENT GOALS

Since the inception of the Sustainable Development Goals (SDGs), Saudi Arabia has taken an active part in consultations and has pledged its commitment to meet the goals when they were endorsed in September 2015. Since then, Saudi Arabia has always reaffirmed its commitment during its participation in various regional and international conferences and forums. Alignment of Saudi Arabia's sectorial policies, such as the National Water Strategy, is a critical component of achieving not only national level policy objectives, but international objectives such as the SDGs. The SDGs are based on five interrelated policy areas (see Figure 13), representing the interrelated nature of all forms of development.

Figure 13: SDG priority policy areas: People, Planet, Prosperity, Peace and Partnership

UNDP's Human Development Report (2020) positioned Saudi Arabia at the 40th place, out of 189 UN member states, and noted that country is classified into the very high human development category. Over the 30 years between 1990-2019, Saudi Arabia has seen an increase in life expectancy (+6.1 years), expected years of schooling (+5.3 years) and Gross National Income (GNI) per capita (+4,490) (Table 6).

	Life expectancy at birth	Expected years of schooling	Mean years of schooling	GNI per capita (2017 PPP$)	HDI value	HDI rank[a]
1990	69.1	10.8	5.7	43,006	0.697	52 (144)
1995	71.1	11.4	6.2	43,542	0.722	45 (148)
2000	72.6	12.0	6.7	42,183	0.743	51 (174)
2005	73.3	12.7	7.6	44,735	0.770	51 (185)
2010	73.9	14.3	8.9	44,723	0.809	45 (188)
2015	74.7	17.1b	9.8	50,125	0.859	36 (188)
2016	74.8	17.0b	9.9	49,683	0.859	37 (188)
2017	74.9	16.1	10.1	48,044	0.852	41 (189)
2018	75.0	16.1	10.2	48,094	0.854	40 (189)
2019	75.1	16.1	10.2	47,495	0.854	40 (189)
Change 1990-2019						
Absolute Change	6.1	5.3	4.6	4,490	0.157	
Relative change (%)	8.4	49.1	78.9	10.4	22.6	
Average annual change rate (%)	0.29	1.39	2.07	0.34	0.71	

Table 6: Saudi Arabia's progress in each of the HDI component-indicators[25]

In the water sector, Saudi Arabia has made significant achievements towards the attainment of SDG Goal 6, to ensure availability and sustainable management of water and sanitation for all.

Goal 6 **indicator 6.1.1** is the proportion of population using safely managed drinking water services. Figure 14 demonstrates Saudi Arabia's progress to date towards the achievement of indicator 6.1.1, with 100% of the population reported to have access to safely management drinking water services, an increase of 3% since 2000.

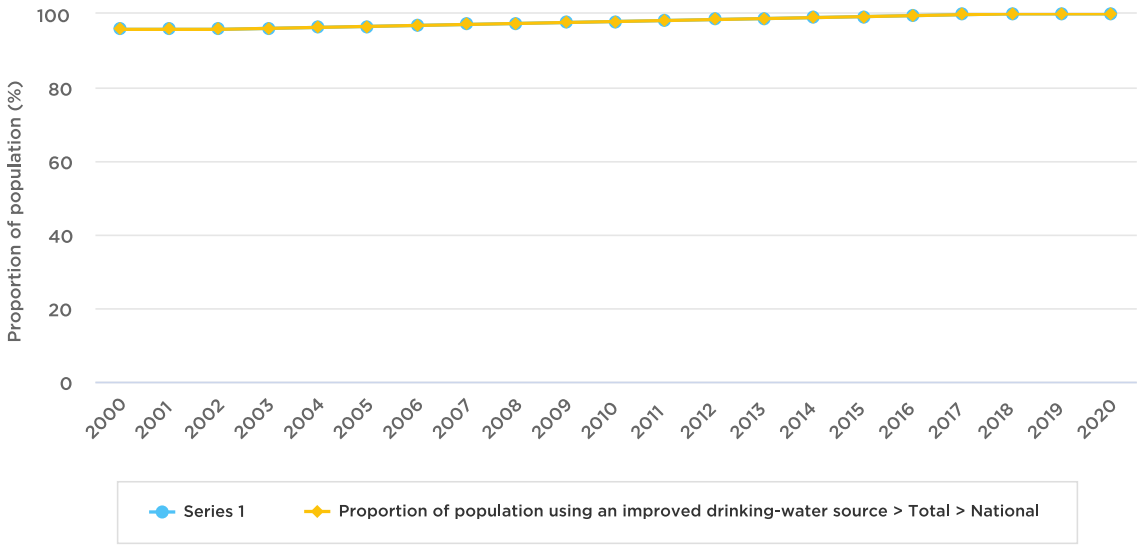


Figure 14: Proportion of population using safely managed drinking water services in Saudi Arabia[26]

25 Kovacevic, Milorad (2021). Comparative assessment of the Human Development Level of the Kingdom of Saudi Arabia relative to selected groups of countries – the High-income, the Very High Human Development, G20 and GCC.

26 UN Water (2022). https://www.sdg6data.org/country-or-area/Saudi%20Arabia#anchor_6.5.1 Accessed April 2022.

Goal 6 **indicator 6.3.1** reflects the proportion of wastewater which has been safely treated. As of 2020, Saudi Arabia report 80% of wastewater flow being safely treated. Figure 15 shows this, as well as comparison with other MENA states.

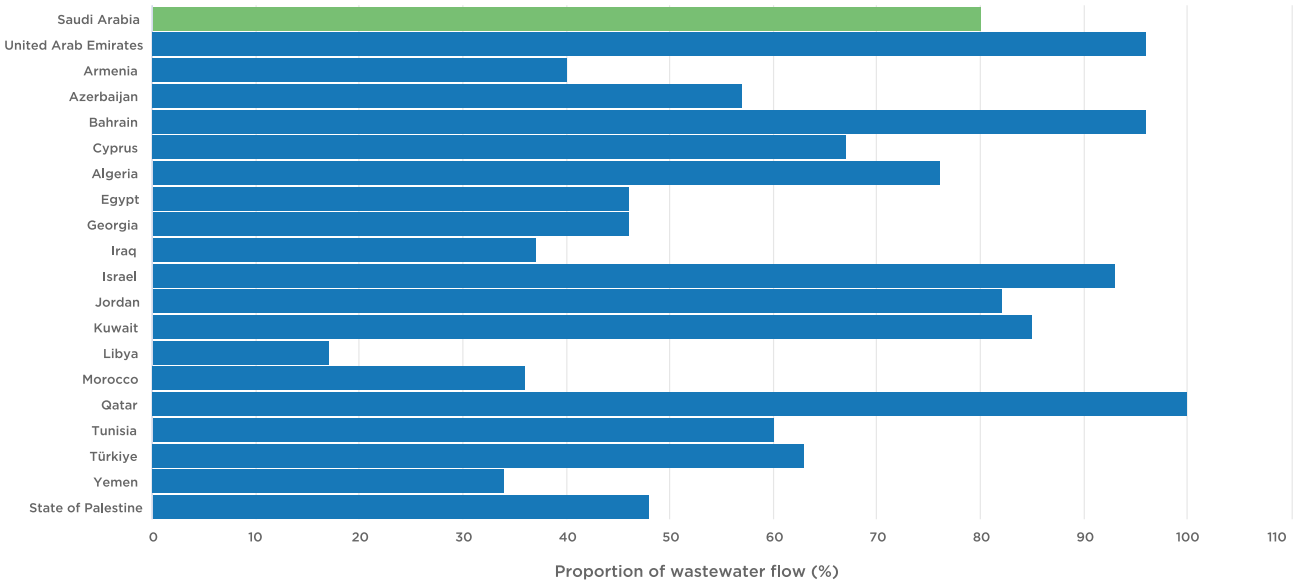


Figure 15: Proportion of wastewater flow (safely) treated > Domestic in Saudi Arabia (2020), compared to other countries (and areas) in the region[27]

Goal 6 **indicator 6.4.1** indicates the change in water-use efficiency over time. In Saudi Arabia, agriculture, forestry and fishing account for withdrawal of 83 billion cubic meters per year (Figure 16).

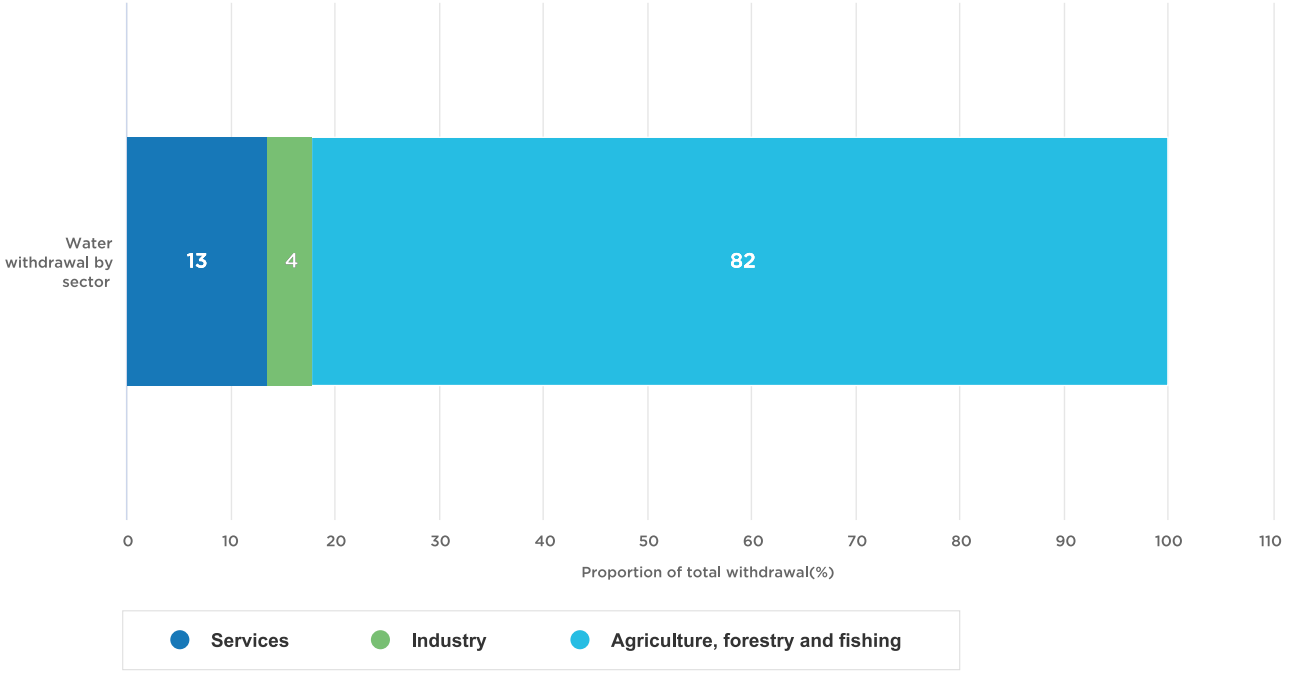


Figure 16: Change in water-use efficiency over time in Saudi Arabia (2017)[28]

27 Ibid.

28 UN Water (2022). https://www.sdg6data.org/country-or-area/Saudi%20Arabia#anchor_6.5.1 Accessed April 2022.

Saudi Arabian irrigation efficiency is estimated to be only about 50%, which is reflected in the amount of water consumed within the agricultural sector. However, water consumption (actual crop evapotranspiration (ETa) lost to the atmosphere) is not routinely measured or accounted for and ETa and drainage return flows are not accounted for separately[29]. In practice, ETa is often as little as 50% of potential (maximum) crop evapotranspiration (ETc). In the absence of measured ETa, ETc is often used to estimate irrigation efficiency. This indicates that, presently unaccounted for agricultural drainage return flows are likely to be between 10.6 BCM to 15.9 BCM. Their reuse, by pumping from drains and unconfined aquifers, offers a potential opportunity to reduce agricultural water abstraction considerably.

Goal 6 **indicator 6.4.2** indicates level of water stress, particularly the amount of freshwater withdrawal as a proportion of available freshwater resources. Saudi Arabia has reported water withdrawal of 23.35 billion cubic meters per year and renewable water resource of 2 billion cubic meters per year (Figure 17).

In order to relieve stress on fresh water resources, the Saline Water Conversion Corp (SWCC) has established a specialized research institute to conduct research studies in the field of water desalination. The institute is located next to one of the biggest desalination and power generation plants in the Jubail province, on the eastern coast of the Kingdom of Saudi Arabia. The institute made big strides in the field of research and development, contributing to improvements in desalination technology, water treatment techniques, increasing efficiency in operations and maintenance and reducing production cost in the operating stations. Currently, the Kingdom is the world leader in desalinated water production with 16.5% of world production.

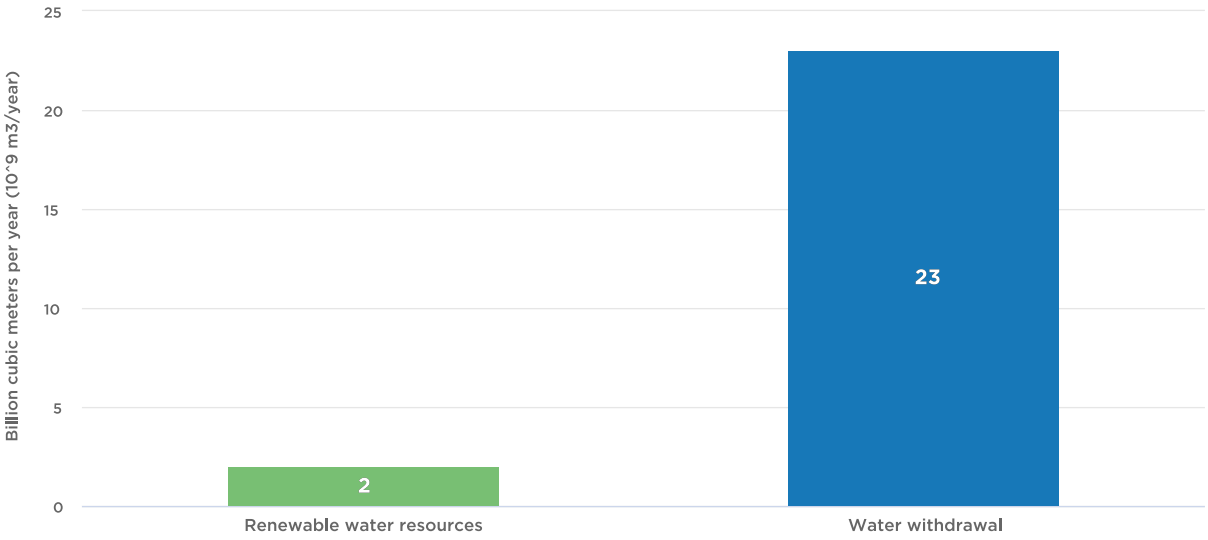


Figure 17: Water resources and withdrawal in Saudi Arabia[30]

Overall, water and wastewater projects are working rapidly to achieve sustainable environmental development in line with Vision 2030. Initiatives of the Kingdom of Saudi Arabia to produce clean water through the Water Deputyship are as follows:

508 water dams with combined storage capacity of 2.2 billion cubic meters

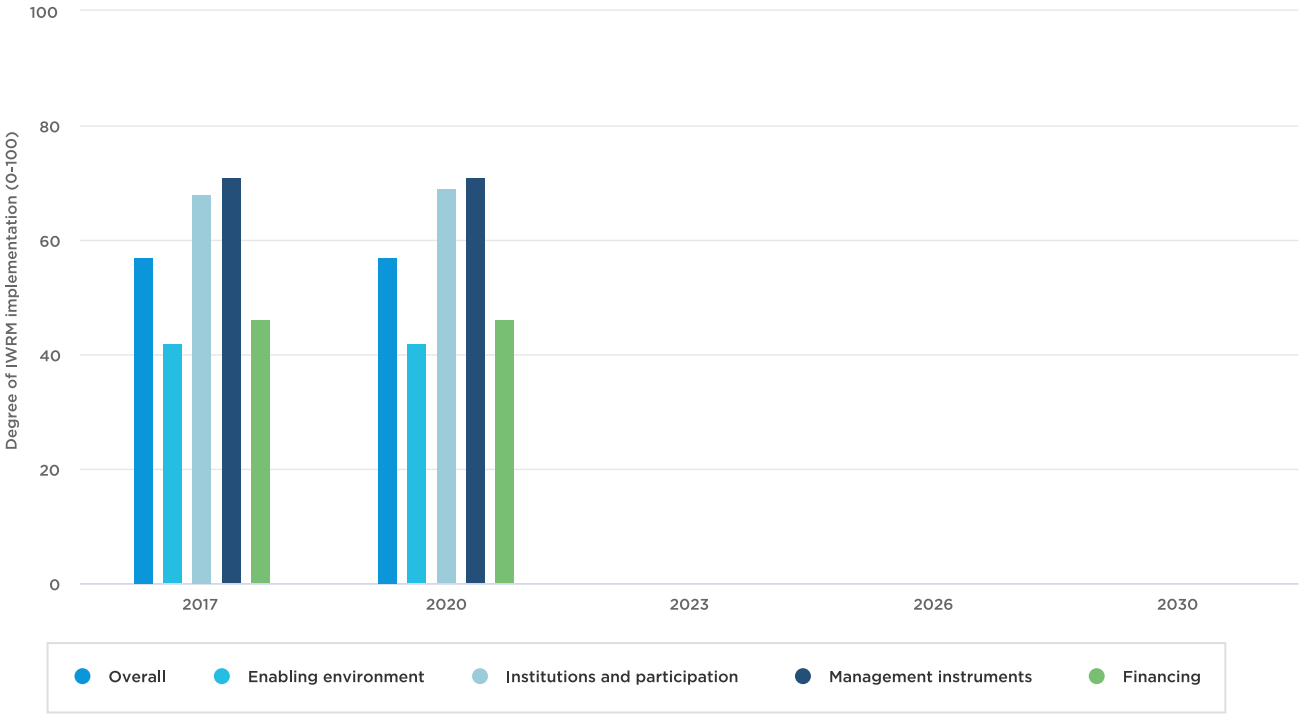
establishment of a further 1,000 dams to promote the sources of surface water [31]

Goal 6 **indicator 6.5.1** represents the degree of integrated water resources management implementation. The indicator recognises four contributing factors to IWRM implementation: enabling environment, institutions and participation, management instruments and financing. Outcomes for Saudi Arabia ranged from the medium-high to high category (Figure 18).

29 FAO. 2016. Water Accounting and auditing: A Sourcebook, http://www.fao.org/3/i5923e/i5923e.pdf.

30 UN Water (2022). https://www.sdg6data.org/country-or-area/Saudi%20Arabia#anchor_6.5.1 Accessed April 2022.

31 Government of Saudi Arabia (2021). https://www.my.gov.sa/wps/portal/snp/content/SDGPortal . Accessed May 2022.



Very low (0-10) – Low (11-30) – Medium-low (31-50) – Medium-high (51-70) – High (71-90) – Very high (91-100)

Figure 18: Degree of integrated water resources management implementation (0-100) in Saudi Arabia, progress over time, by dimension[32]

Photo: Studying structural geology

32 Ibid.

DRIVING FORWARD INTEGRATED WATER RESOURCES MANAGEMENT

With the support of UNDP experts, the Water Deputyship has put the principles of Integrated Water Resource Management (IWRM) at the core of its policy approach. The Global Water Partnership (GWP) definition of IWRM is widely accepted: IWRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.[33]

Figure 19 presents the stages in the IWRM cycle 3 and indicates that implementation, including the enabling environment and the associated institutional (legal, policy and organization) structures, is central to IWRM. Implementation is also an integrated stage in the IWRM cycle. IWRM is also an iterative spiral process, where step five (monitoring and evaluation), of the first IWRM cycle, is an input into step one (issue assessment) of the second cycle, etc.[34]

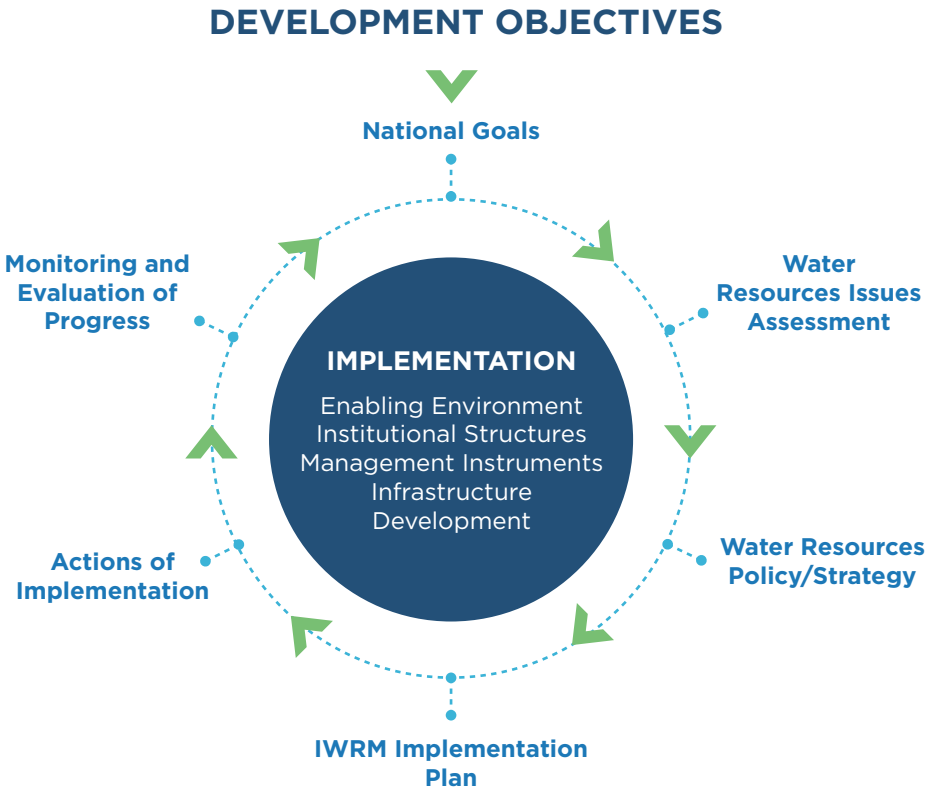


Figure 19: Integrated Water Management Cycle

MEWA seeks to adopt an approach whereby emphasis is placed on water demand management, rather than merely satisfaction of demand and management of supply. With this approach, measures are being put in place to reduce water demand and well as further develop more sustainable supply practices. Significant progress has been made in this respect, as shown in Table 7.

	2015	2021
Overall water demand	24,833 m^3	
	2015	**2022**
Agricultural purposes	20,860 m^3	11,400
Municipal purposes	2,980 m^3	3,557
Industrial purposes	993 m^3	Under study

Table 7: Water demand in Saudi Arabia

33 Global Water Partnership. 2000. Integrated Water Resources Management, https://www.gwp.org/globalassets/global/toolbox/publications/background-papers/04-integrated-water-resources-management-2000-english.pdf.

34 UNESCO. 2009. Integrated Water Resources Management in Action, https://unesdoc.unesco.org/ark:/48223/pf0000181891.

SECTION FOUR

IMPACT AND ACHIEVEMENTS

IMPACT AND ACHIEVEMENTS

ATTRACTING AND CONTRIBUTING TALENT AND EXPERTISE

Supporting project objective(s):

Objective 1:
MEWA, Water Capacity

One of the key objectives of this project has been to enhance the technical and organizational capacity for water resources and water supply management in the Water Deputyship, Ministry for Environment, Water and Agriculture. This capacity development work has contributed to enhancing both the organisational capability of the Water Deputyship as well as developing and strengthening the capacity and capability of the employees of water sector at a national level.

ACCESSING LEADING INTERNATIONAL AND NATIONAL EXPERTISE

Through provision of international and national water sector specialists, UNDP has provided leading sector expertise to the Water Deputyship, to support project work and capacity development, supporting civil servants to meet the highest standards, in order to carry on all tasks at the best possible level. Since the initiation of the project, the overall operational efficiency and effectiveness of the Water Deputyship is appreciably higher, relative to when the project started in 2018. This is attributable largely to the high quality of expertise provided by UNDP experts, and the high level of leadership and technical support provided to the Water Deputyship.

Over the duration of the project, UNDP provided 19 international experts and 33 national experts, recruited via UNDP's procurement systems and selected via competitive processes, ensuring the selection of the most suitable and technically superior experts. At time of reporting, the UNDP expert team consisted of 7 individuals with Bachelor of Science degrees, 13 with Masters degrees and 8 holding PhDs. As is demonstrated through this report, the UNDP expert team has supported numerous activities within the Water Deputyship that support the longer-term capacity development of civil servants, such as the development of a master degree program in collaboration with the King Saud University, development of a comprehensive technical training program, provision of technical support, delivery of the first and second Water Saudi Forums and providing on-job training.

The UNDP team plays a significant role in the structure of the Deputyship. The experts have provided General Directorate leadership across the Deputyship, with six experts in total sitting as Directors since 2018. UNDP experts are providing technical and management support to all directorates in implementing their mandates. In the **Water Regulation Directorate**, for example, UNDP specialists were appointed to help develop its water licensing, regulation and compliance capacity. In the **Water Planning Directorate**, a UNDP expert was initially appointed as Director. Within the **National Centre for Water Research and Studies (NCWRS)**, UNDP specialists, with full professor accreditation, were appointed as Director and Deputy Director. Currently, NCWRS staff include three PhD scholars and UNDP experts with substantial international experience in developing decision support studies and research. Within the **Center for Water Management and Control (CWMC)**, a UNDP expert was appointed as Director to establish the Centre and develop its information management capacity. At the **Directorate of Communication and Supporting Works**, a UNDP expert was appointed as Director to manage the CSW Center.

Moreover, in response to regular requests from the Royal Court, His Excellency the Minister and Deputy Minister MEWA, Water, the UNDP team has provided policy advice and produced more than 50 short reports, white papers and country briefs to support executive decision-making. A few representative topics include policy advice on water economics, markets, governance, management and institutional challenges and experience of various relevant countries etc.

A full representation of the distribution of UNDP experts across the Deputyship is outlined in Figure 20.

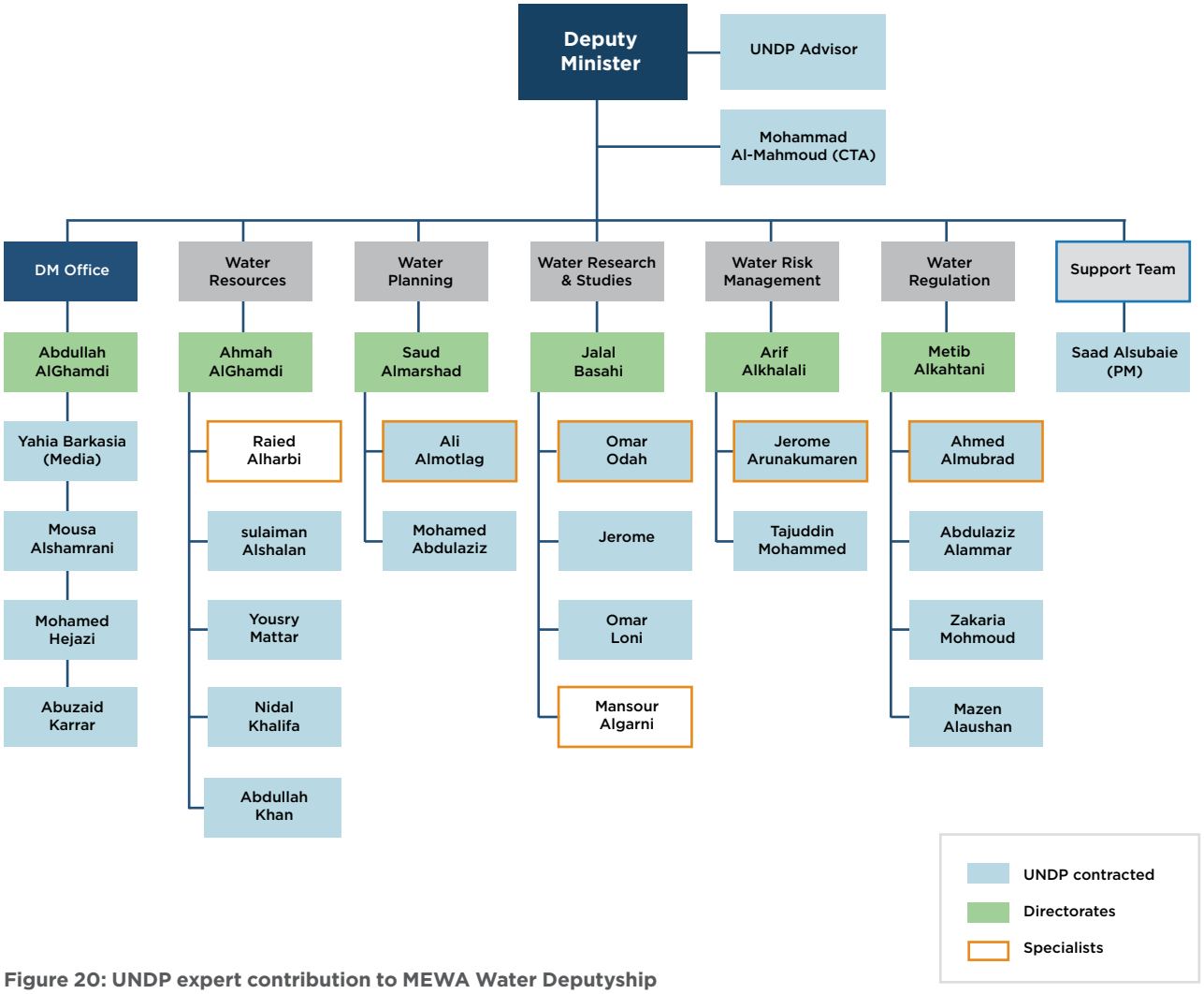


Figure 20: UNDP expert contribution to MEWA Water Deputyship

Photo: Field training

OPTIMIZING POLICY AND PROJECT DELIVERY

Supporting project objective(s):

Objective 1:
MEWA, Water Capacity

Objective 4:
Integrated Water Supply Management

Objective 3:
Integrated Water Resources Management

Objective 7:
Secondary Water Resources

PROMOTING ORGANISATIONAL CAPACITY DEVELOPMENT

Before 2017, the Water Deputyship in the Ministry for Environment, Water and Agriculture was structured in a way that was oriented towards developing the supply capacities and water supply infrastructure of water resources (see Figure 21). The ultimate aim of this structure was to provide water supply services to a fast-growing urban population.

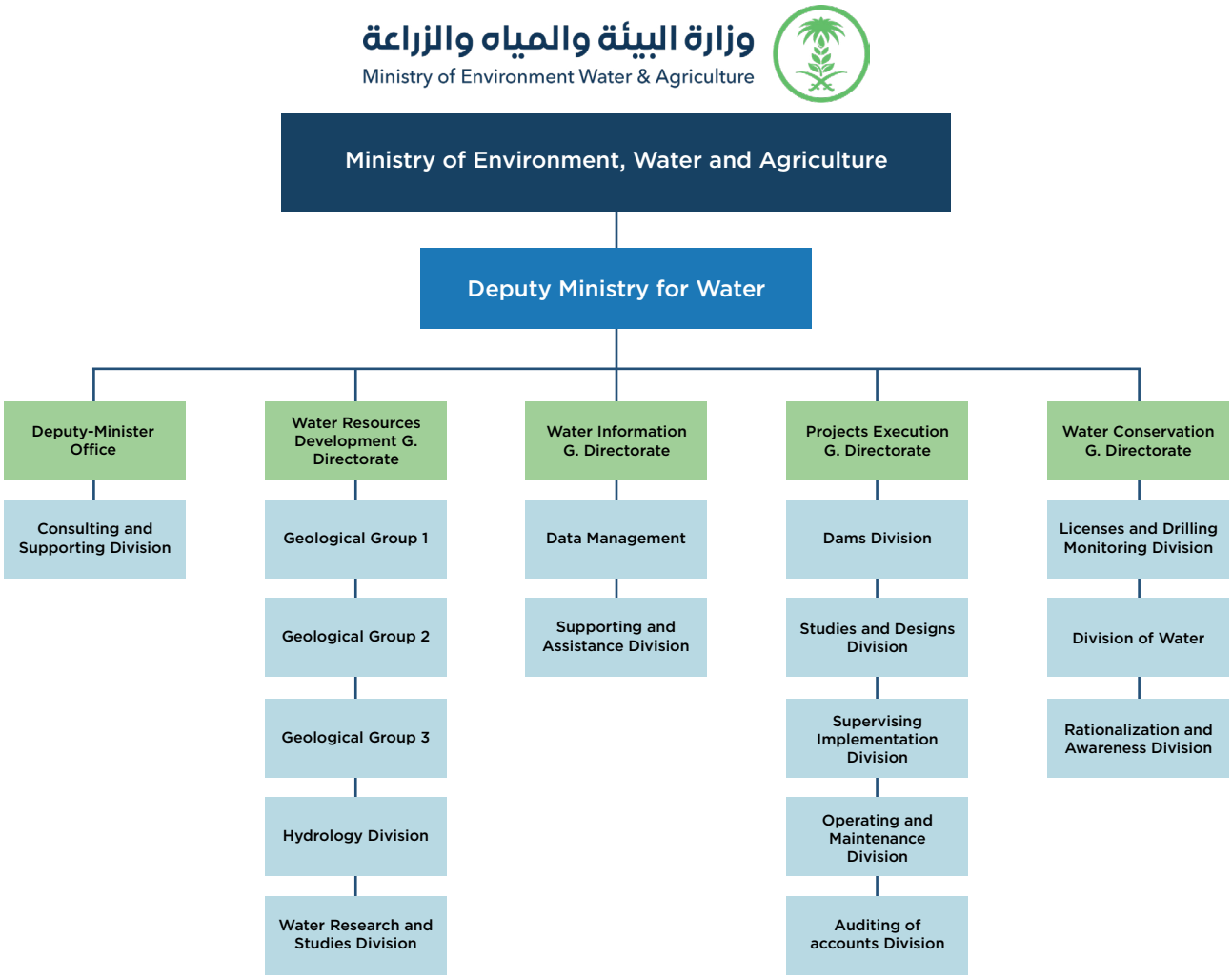


Figure 21: Previous organizational structure of the Water Deputyship, MEWA

However, with the approval of the National Water Strategy (NWS) there was a need to adapt and enhance the structure of Deputyship, in order to provide the enabling environment for a more holistic approach to water management, embodying the principles of Integrated Water Resource Management envisaged in the NWS. Led by UNDP Specialists, the Water Deputyship assessed its former institutional structure, identified the key organizational structure for implementing the Integrated Water Resource Management-based NWS, and developed the new Water Deputyship structure (Figure 22), including the establishment of new Water Regulation Directorate, Water Planning Directorate, National Center for Water Research and Studies (NCWRS), Center for Water Management and Control (CWMC), Directorate of Communication and Supporting Works and Water Projects Following-up Office. UNDP experts led the initial assessments of the Deputyship structure, providing analysis and input to optimize organisational design. Experts also contributed the Terms of Reference, including design, mandate and structure, for the newly established Directorates, listed above.

The new design of the Deputyship has enhanced overall capacity, supporting processes to plan and implement water resources management interventions, regulate water resources and services, collect and analysis water data and information to support decision-making, assess water sector performance and enhance the Water Deputyship's capacity to facilitate an evidence-based IWRM decision-making process and manage and implement its NWS programs and initiatives.

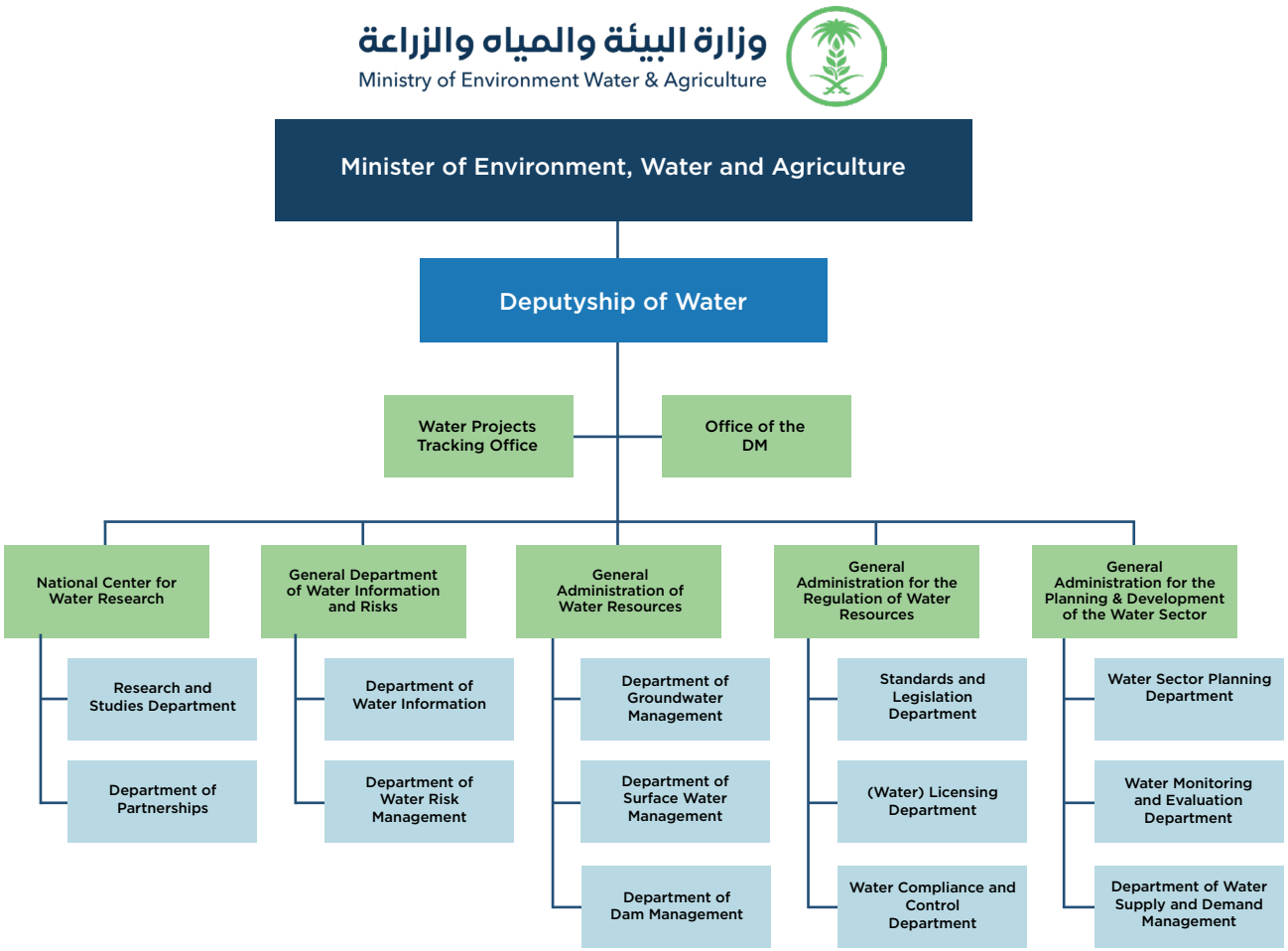


Figure 22: Present organizational structure of Water Deputyship

PROVIDING WATER INFRASTRUCTURE ASSESSMENT AND MANAGEMENT

UNDP project experts have contributed significant technical capacity across the Water Deputyship.

35

Other benefits of UNDP expertise include:

- **Transparency** and competitiveness
- **Improved** risk management and risk mitigation built into the process
- **Establishment** of realistic schedules and budgets
- **Facilitating** consistent service
- **Optimization** of the opportunity for lower project life cycle costs
- **Fewer** change orders and disputes
- **Better** life-cycle value
- **Promoting** stronger business relationships between the parties

Inputs from UNDP experts have been multifaceted, but two significant areas of impact have been through project management of Water Deputyship infrastructure projects and through extensive technical assessment. This section further elaborates on those contributions.

35 Association of Consulting Engineering Companies (2016). Schedule of Recommend Fees to be Charged for General Engineering and Geoscience Projects and Services.

// PROJECT MANAGEMENT EXPERTISE

Over the course of the project, UNDP has provided high level technical supervisory consultation for MEWA water projects mounting to a total cost of 2 billion Saudi Riyals. Those include projects in the IWRM-related spectra both regulatory and infrastructure nature. The support spanned the stages of inception, procurement, execution, technical steering, and evaluation. The nature of projects supported by UNDP experts is shown in Figure 23.

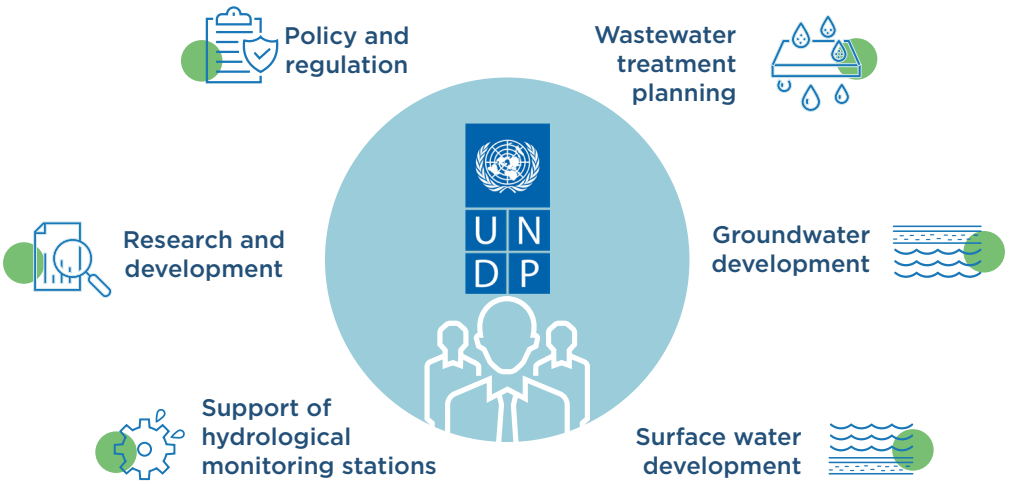
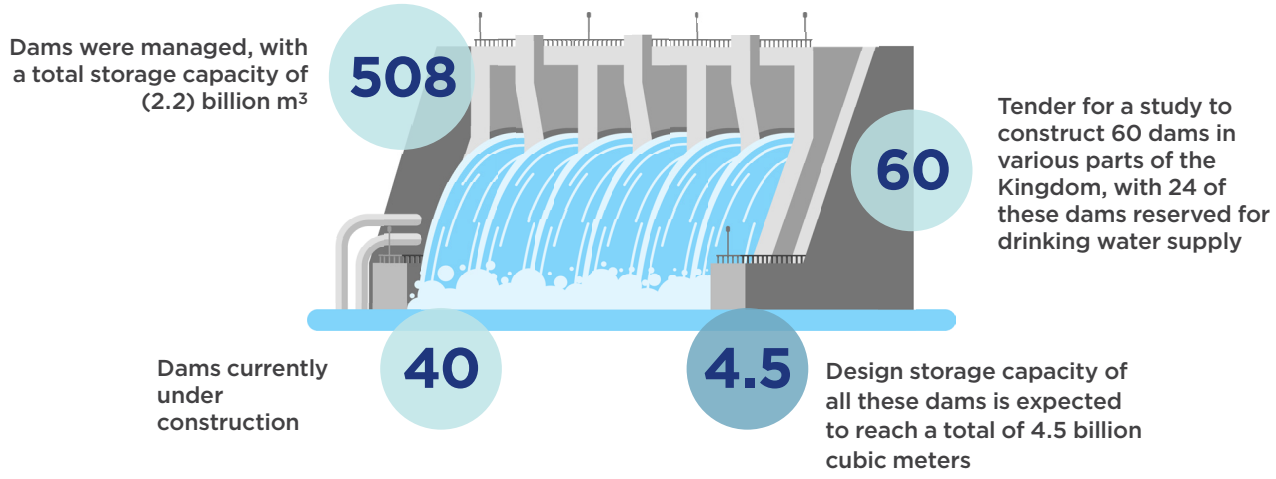


Figure 23: Nature of projects supported by UNDP experts

This led to, among several levels of positive impact, improvement in contractor quality assurance practices and improved project tailoring to the objectives of the NWS 2030 and the implementation of the Water Act. In addition, in all the projects, MEWA staff were closely involved, which provided hands on capacity building in all the skills required for the spectrum of project inception and follow up. Some key projects were either revived or steered to target with active engagements from the UNDP. Nonetheless, the projects have increased the resilience of the water supply capacity and facilitated the monitoring of both surface water and groundwater.

For example, UNDP experts have been supporting the development of an integrated water supply plan. This plan will ensure that supply will be commensurate with the growing demand and to meet the needs of the Kingdom's population. Currently, UNDP experts are also supporting a process of implementing an initiative to promote surface water resources. To date, this work has supported:



// UNDERTAKING RESOURCE ASSESSMENTS

Technical assessments form the foundation for decision making within the Water Deputyship. UNDP experts have conducted numerous assessments in areas of secondary water resources, renewable groundwater and non-renewable groundwater, the details of which are outlined below.

ASSESSING SECONDARY WATER RESOURCES

Secondary water resources, such as secondary and remote aquifers, surface run-off and rainwater harvesting, are important complements to a country's primary water resource, and essential to maintaining long-term water sustainability. Assessment of these resources is critical to understanding the baseline of resource availability and, to those ends, UNDP experts contributed hydrology and surface water assessment, renewable groundwater assessment, aquifer storage and recovery and surface water and storage.

// IMPROVING THE QUALITY OF HYDROMETEOROLOGICAL DATA

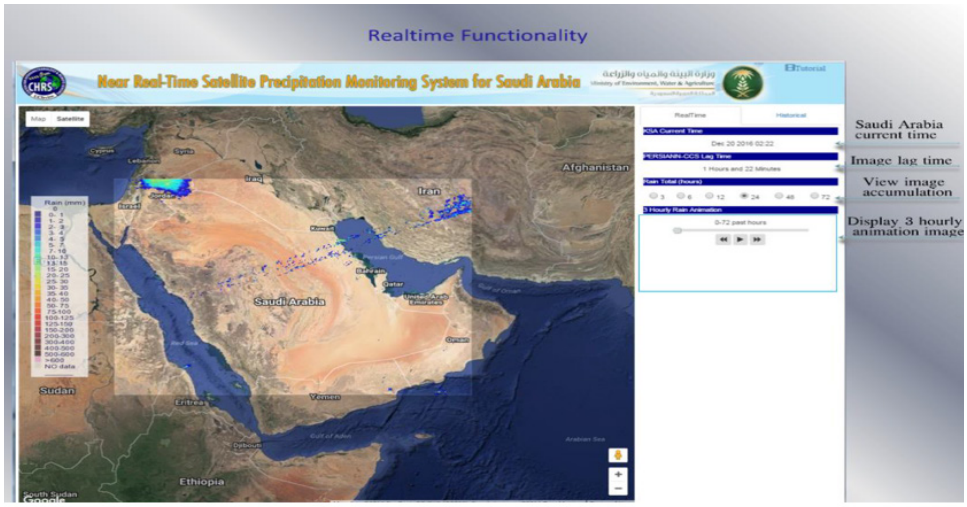
Hydrology is the scientific study of water in the environment, and its movement through the water cycle. With the ongoing rise in water demand and the increasing scarcity of water resources, the risk associated with unsustainable water resources management grows and proactive water resource management becomes more important than ever. The concept of hydrology is central to water management, in order to attain an accurate sense of the current and future water balance.

Over the course of the project, UNDP experts assisted the Water Deputyship with improving the quality of hydrometeorological data.

The historical rainfall record from 1983 to 2020, which is critical baseline data for future water management, contained missing data. To provide a continuous rainfall record, all missing values were interpolated by UNDP experts, using global satellite products and the most applicable scientific methods.

The Center for Hydrometeorology and Remote Sensing (CHRS) at the University of California Irvine, is one of the very few research institutes that have access to the global satellite data for real-time for rainfall estimation. With the support of UNDP experts, a contract put in place from 1 March 2016 and ended on 31 December 2017 in order support the development a near real-time satellite precipitation monitoring system for Saudi Arabia.

Over the course of this contract, the Water Deputyship was able to access the data through a bespoke geo-server (Figure 24). Realtime access to this data enhanced strategic plans, maximizing the benefit of initiatives led by the Water Deputyship. Moreover, the data allowed MEWA staff to maximize the benefit from existing dams by providing near real-time information to support the operational plans of the dams to meet their purposes and strengthen flood risk management plans by providing a high reliability database. Future agreements will ensure that MEWA will permanently access the global satellite data in real-time for rainfall estimation.



Source: http://ksa-rain.eng.uci.edu/

Figure 24: Near real-time satellite precipitation monitoring system for Saudi Arabia

// IMPROVING THE ACCURACY OF SURFACE WATER MODELLING

In order to gain an accurate assessment of surface water resources and bolster processes to predict future resources, hydrological modelling of peak flood discharge and surface runoff and groundwater recharge was undertaken by UNDP experts.

Development of a flood hydrological model

Over the course of the project, a hydrological model was developed by a UNDP expert, in coupling satellite rainfall data, gathered through a product entitled Integrated Multi-satellite Retrievals for Global Precipitation Measurement with soil moisture reterived from a soil moisture active passive satellite and ground points to predict flood runoff volume. The schematic of the model is in Figure 25.

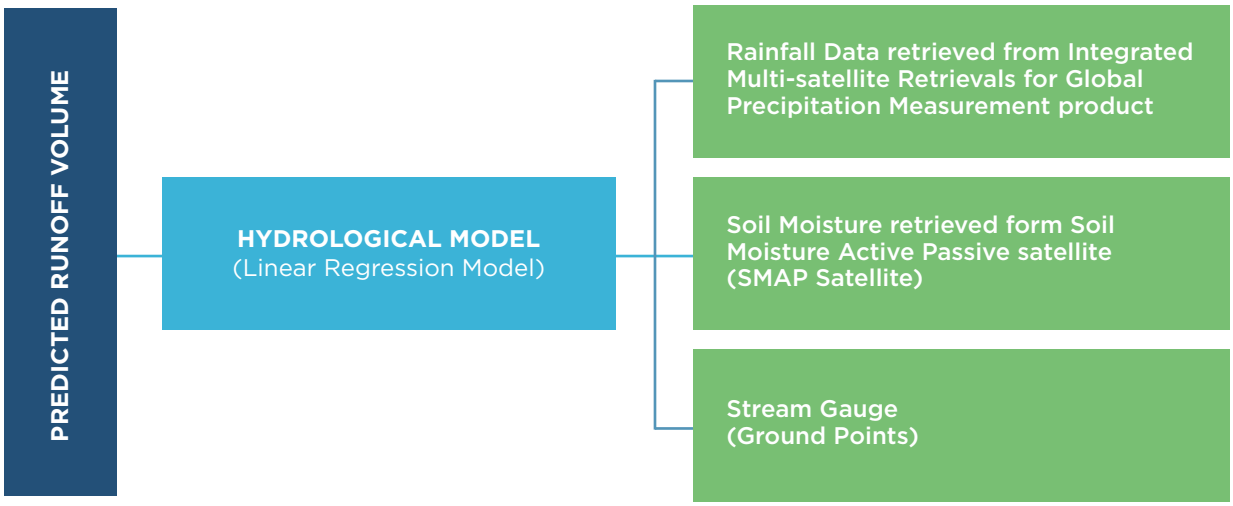


Figure 25: Schematic diagram of the flood hydrological model

The flood hydrological model was tested during a pilot assessment of Wadi Alhasba. The pilot model test results are in Figure 26. The results indicate that the method is widely applicable and can be used in different catchments. During the next stages of the project the model will be extended to cover more dams, and the analysis of the satellite images will be used for flood hazard risk assessments to minimize the impacts of the floods.

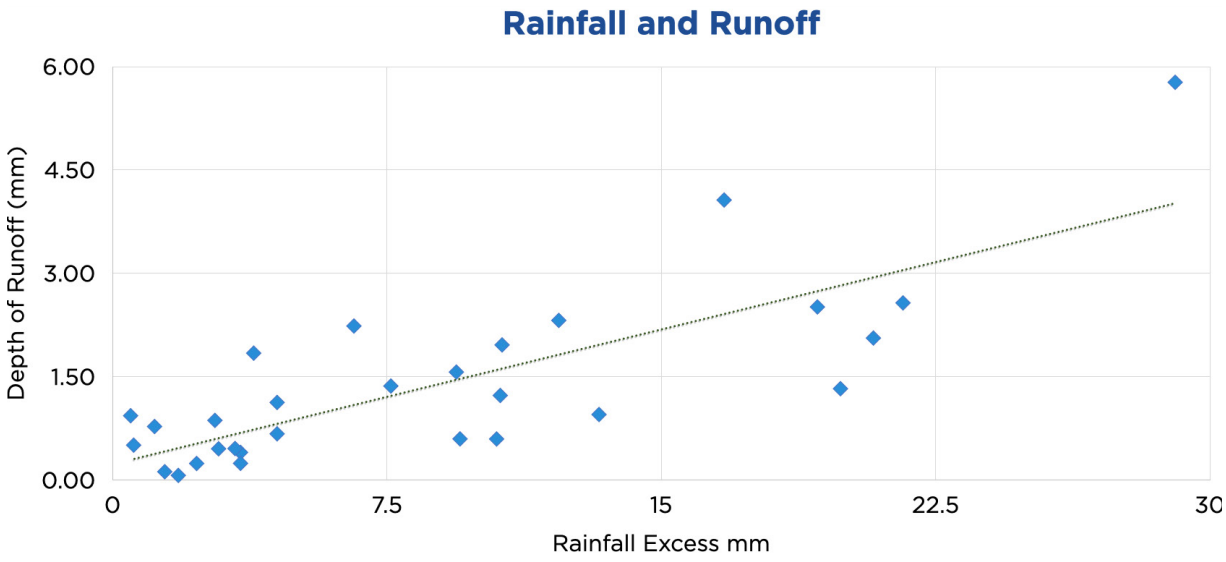


Figure 26: Wadi Alhasba regression model

Box 2: Assessing wadi catchment water balances

Over the course of the project, the UNDP Deputyship commissioned two studies to assess renewable groundwater resources (recharge) in both alluvial unconfined wadi aquifers and harrat volcanic lava flow aquifers. Figure 27 shows the areal extents of these quaternary sediments and volcanic rocks. These studies were commissioned before the project began; however, they proved conceptually challenging and UNDP experts worked to develop the capacity of Water Deputyship civil servants and controlled the quality of conceptual and mathematical modelling and analysis, and interpretation of results.

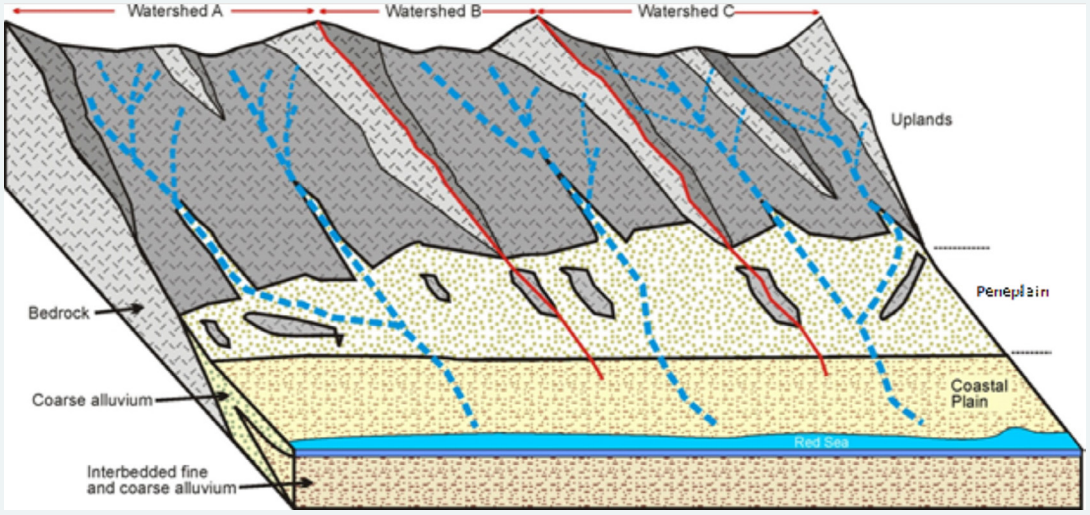


Figure 27: Physiographic catchments in the Western Coastal Plain

The first hydrological study concerned assessment of 54 wadis in the Western Coastal Plain (WCP) draining west to the Red Sea. The study assessed the water balance of the upper catchment at the boundary between the peneplain and the coastal plain. For the large 6,400 km2 Wadi Baysh, mean annual evapotranspiration of 1,044.6 MCM (83.5%), percolation and channel losses of 137.0 MCM (11.0%) and runoff of 69.0 MCM (5.5%) account for the mean annual rainfall of 1,250.6 MCM over the upper catchment. The runoff of 69.0 MCM entering the coastal plain is input to the hydrogeological model to assess recharge of the unconfined alluvial aquifer.

Runoff entering the coastal plain (the source of recharge) is less than 10 MCM for 31 wadis (57.4%), between 10 and 20 MCM for 12 wadis (22.2%), between 20 and 30 for six wadis (11.1%) and between 30 and 40 MCM for two wadis (3.7%). Wadi Baysh (69.9 MCM), Wadi Hamd (76.2 MCM) and Wadi Hali (78.9 MCM) have the most surface runoff.

The second hydrological study concerned assessment of 12 harrats and 19 wadis located east of the Al-Hijaz mountains. For the largest Wadi Bisha, with King Fahad Dam, mean annual evapotranspiration of 2,159 MCM (78.0%), direct recharge of 219 MCM (7.9%) and surface runoff of 391 MCM (14.1%) account for mean annual rainfall of 2,769 MCM (not reported). The reported range in annual evapotranspiration (280 MCM to 4,114 BCM) is remarkable.

The largest wadis are Wadi Bisha (direct recharge of 219 MCM, surface runoff of 391 MCM), Wadi Turabah (154 MCM, 242 MCM), Wadi Tathlith (152 MCM, 98 MCM), Wadi Rumah (131 MCM, 113 MCM), Wadi Sahi Rukbah 125 MCM, 92 MCM), and Wadi Ranyah-Tharad (103 MCM, 104 MCM). The largest Harrat is Harrat Rahat (102 MCM, 182 MCM). The above hydrological rainfall, runoff modelling results were inputs to hydro-geological modelling to estimate aquifer recharge.

PROVIDING COMPREHENSIVE REVIEWS OF RENEWABLE GROUNDWATER

Renewable groundwater resources are rechargeable through natural hydrological cycles. However, if they are overexploited, then groundwater aquifers and surface water like rivers and lakes can be compromised and be unsustainable in the long term. Understanding the status of renewable groundwater resources, therefore, is critical to long-term water resource sustainability. Over the course of the project, UNDP experts provided comprehensive reviews of project undertaken by the Water Deputyship that assess the conventional renewable water resources in the Arabian shield. The findings of the review(s) facilitated significant improvements to these projects.

The first study covered an area extending from the watershed of the Al-Hijaz Mountains in the west to the Arabian Platform in the east, and from the Saudi – Jordanian border in the north to the Saudi – Yemeni boundary in the South. The area is approximately 1,600 km long and about 200 km wide. The second study, the Harrats Project ("Detailed Water Resources Studies in All Al-Harrat Within the Kingdom and in Main Valleys of the Arabian Shield Located East of Al-Hijaz Mountains") was implemented by CDM Arabia in partnership with the Bureau de Recherches Géologiques et Minières of France (BRGM) on behalf of the Water Deputyship. Finally, a third project assessed the water resources of the Western Coastal Plan.

Through all these projects, UNDP experts provided oversight, review and quality control, particularly related to the numerical simulation models. The technical complexity of these assessments necessitated a high level of oversight to ensure accuracy, and therefore the contribution of the UNDP experts was critical to overall success.

// DEVELOPMENT OF CRITERIA FOR AQUIFER STORAGE AND RECOVERY

Aquifer storage and recovery is a process comprised of identifying sustainable groundwater resources and facilitating the storage water underground during wet periods for future use, especially during dry periods. Particularly in extremely dry, hot climates this water resources management technique can allow for longer term sustainable water access through limiting surface level evaporation. Figure 28 demonstrates the aquifer storage and recovery process.

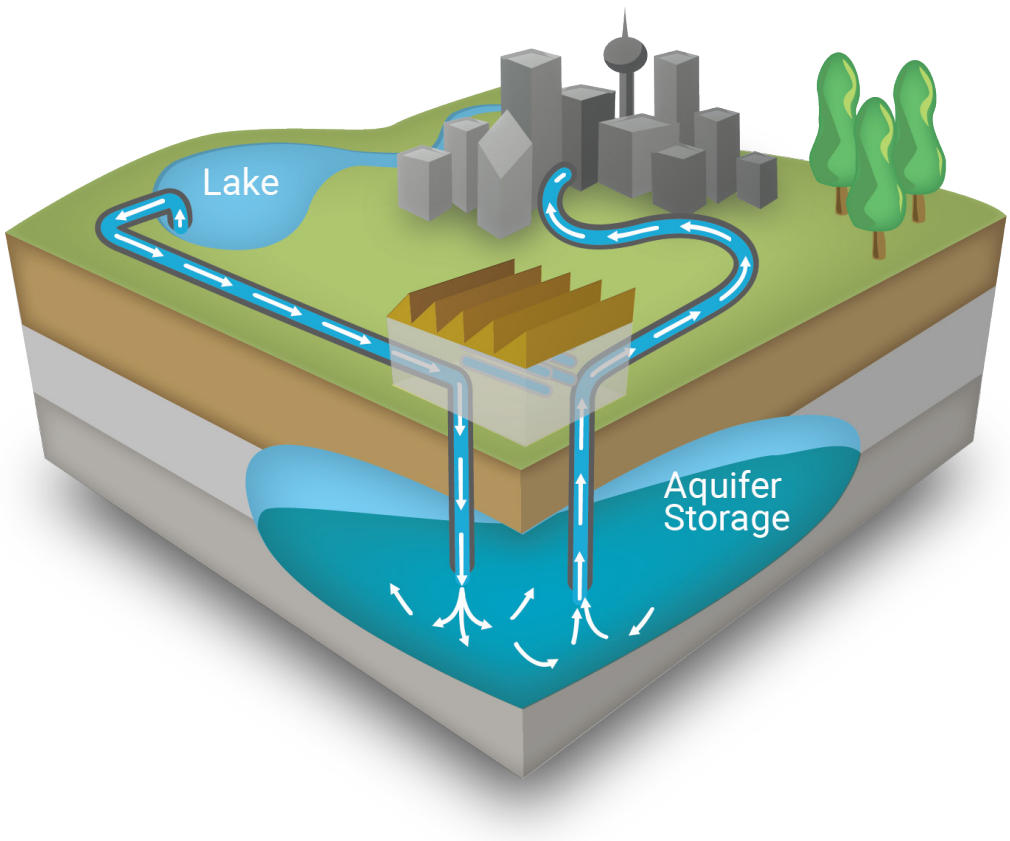


Figure 28: Aquifer storage and recovery process

Over the course of the project, UNDP experts contributed to development of criteria to select managed aquifer storage and recovery (ASR) sites. The criteria developed by UNDP experts to be applied to potential ASR sites, to determine suitability and facilitate prioritisation. The criteria are as follows:

Site can be developed cost-effectively

Site can supply water for long periods during drought

Ability to maximize the utilization of surplus winter water to recharge the aquifer

Based on these criteria, UNDP experts contributed to site assessment and selection of four ASR pilot projects in the aquifers of Abyar Al Mashi, Malakan Valley, Rabigh Dam reservoir and Khulais Dam reservoir.

With the support of UNDP experts, preliminary studies were carried out for the selected locations, and Terms of Reference for future advisory studies were written. The UNDP experts will review and approve the results of the advisory studies, to be undertaken through the private sector. Finally, UNDP experts will work with MEWA staff to develop strategic plans to expand the number of reservoirs based on the lessons learned from these pilot projects and to define priorities that are commensurate with the vision of the Kingdom.

// DEVELOPMENT OF DAM MANAGEMENT MASTER PLAN

This project has contributed to a dam management master plan, including operation and maintenance guidelines and dam implementation including planning, design and construction supervision.

A UNDP Specialist provided inputs to support MEWA, Water, design of 57 storage dams. For each assessment and design there are technically complex and laborious studies required, in order to select the most suitable sites. A **geological study** (undertaken to understand of the geological setting and the geological conditions in dam site) is one of the main inputs into dam design, where the completely weathered rocks would be prone to seepage-induced piping through such rock zone. A **morphometric study** is conducted to assess geomorphology and the physical characteristics of the catchment area such as area, shape, slope, mainstream length, and the basin slope of the controls the hydrograph shape and determines the Lage time. A **hydrological study** aims to predict the peak discharge value and the hydrograph as input to the hydraulic and structural design of the dam. Finally, a **geotechnical study** assesses the geotechnical and engineering properties of both soil and rocks at the dam site, which is used in the dam design. Also, the subsurface geological conditions of the dam are among the necessary requirements for a safe design of the dam body.

Of the 57 assessment and design processes undertaken by UNDP experts, 10 were at the conceptual design stage, 30 were at preliminary design stage and 17 were at the final-pre-construction design stage (see Table 8 and 9 and Figure 29).

Name	Region	Stage	Type	Purpose	Height	LS	EC/DF
Al Shaqah	Makkah	CD	UG	WS/IA	30	21	32
Rabigh	Makkah	CD	UG	WS	25	21	41
Meghaysal	Al Madinah	CD	UG	WS	20	4.5	17
Abu Dhubaa	Al Madinah	CD	UG	WS	20	4.6	11
Al Faydh	Asir	CD	UG	WS/IA	20	4.5	9
Tathlith	Asir	CD	UG	WS/IA	20	8	24
Al Hajarah	Al Baha	CD	UG	WS	20	5	33
Jazan	Jazan	CD	UG	WS/IA	20	10	11
Dhamad	Jazan	CD	UG	WS	20	11	12
Najran 2	Najran	CD	UG	WS/IA	40	24	36
Hurob	Jazan	PD	Con	WS	30	5	25
Khulab	Jazan	PD	Con	IA	9	5	20
Al Hayjah	Jazan	PD	Con	IA	50	15	40
Al Janbah	Jazan	PD	Con	WS	16	1	15

Name	Region	Stage	Type	Purpose	Height	LS	EC/DF
Khulab	Jazan	PD	UG	IA	20	10	25
Shahdan	Jazan	PD	UG	IA	25	2	10
Qura	Jazan	PD	UG	IA	26	2	10
Sabiya	Jazan	PD	UG	IA	22	8	10
Damad	Jazan	PD	UG	WS	20	12	15
Al Atif	Asir	PD	RF	IA	40	8	60
Tarj	Asir	PD	Con	WS/IA	20	8	30
Al Heelah	Asir	PD	Con	WS/IA	30	8.5	20
Al Magzahah	Asir	PD	Con	IA	18	1	15
Wadi Tayah	Asir	PD	RF	WS/IA	50	30	80
Hawiyah Tehama	Asir	PD	Con	IA	15	1.5	20
Bani Rezam	Asir	PD	Con	WS	20	1	25
Al Subaiykhah	Asir	PD	RF	IA	10	1.5	25
Khubash	Najran	PD	UG	IA	40	25	20
Jawah	Al Baha	PD	RF	WS/IA	21	8	20
Rash	Al Baha	PD	UG	IA	20	8	15
Al Hajarah	Al Baha	PD	UG	WS/IA	20	8	20
Al Hefayriyah	Makka	PD	Con	WS/IA	20	50	40
Dhari	Makka	PD	RF	FC/WS	23	28	40
Al Baydaa	Makka	PD	RF	IA	25	2	30

Legend: AR = aquifer recharge, CD = conceptual design, Con = concrete, DF = design flood (m3 sec-1) (FD), EC = estimated cost (million SAR) (CD, PD), EF = earth fill, FD = final design, FC = flood control, IA = irrigated agriculture, LS = live storage (MCM), PD = preliminary design, RF = rock fill, UG = underground and WS = water

Table 8: Water Deputyship dam geology and hydrology supported by UNDP Specialist 1/2

Name	Region	Stage	Type	Purpose	Height	LS	EC/DF
Saiyah	Makka	PD	Con	IA	25	4.5	30
Feedah	Makka	PD	Con	IA	16	2	15
Farat Beni Sehaym	Makka	PD	UG	WS/IA	20	10	25
Shuwaq	Makka	PD	UG	IA	30	8	15
Yalamlam	Makka	PD	UG	IA	25	12	20
Al Shaqah	Makka	PD	UG	WS/IA	30	20	20
Al Madarah	Al Baha	FD	Con	AR	19	0.2	117
Humayraa	Al Baha	FD	Con	AR	14	0.5	403
Al Nasabah	Al Baha	FD	Con	AR	13	0.1	248
Al Shubah	Riyadh	FD	EF	AR	7.5	0.3	53
Wadi Aseamer	Riyadh	FD	EF	AR	12	0.7	162
Al Nabbaa	Riyadh	FD	EF	AR	9	0.2	41
Dhebiyah	Eastern	FD	EF	FC	6	5.7	225
Baej	Riyadh	FD	EF	AR	8	0.1	15
Batat	Al Baha	FD	UG	WS	18	2.2	180
Doqah	Al Baha	FD	UG	WS	15	5.0	220
Aba Allasaf	Riyadh	FD	EF	FC	9	0.3	114
Al Khudhr	Riyadh	FD	EF	AR	8.5	0.3	54
Turaif	Riyadh	FD	Con	AR	16	0.4	128
Al Baqqar	Tabuk	FD	EF	FC	16	3.7	402
Teriyam	Tabuk	FD	EF	AR	11	1.7	816
Al Naam	Tabuk	FD	EF	AR/FC	13	4.5	160
Al Sur	Tabuk	FD	Con	AR/FC	15	1.4	571

Legend: AR = aquifer recharge, CD = conceptual design, Con = concrete, DF = design flood (m3 sec-1) (FD), EC = estimated cost (million SAR) (CD, PD), EF = earth fill, FD = final design, FC = flood control, IA = irrigated agriculture, LS = live storage (MCM), PD = preliminary design, RF = rock fill, UG = underground and WS = water supply.

Table 9: Water Deputyship dam geology and hydrology supported by UNDP Specialist 2/2

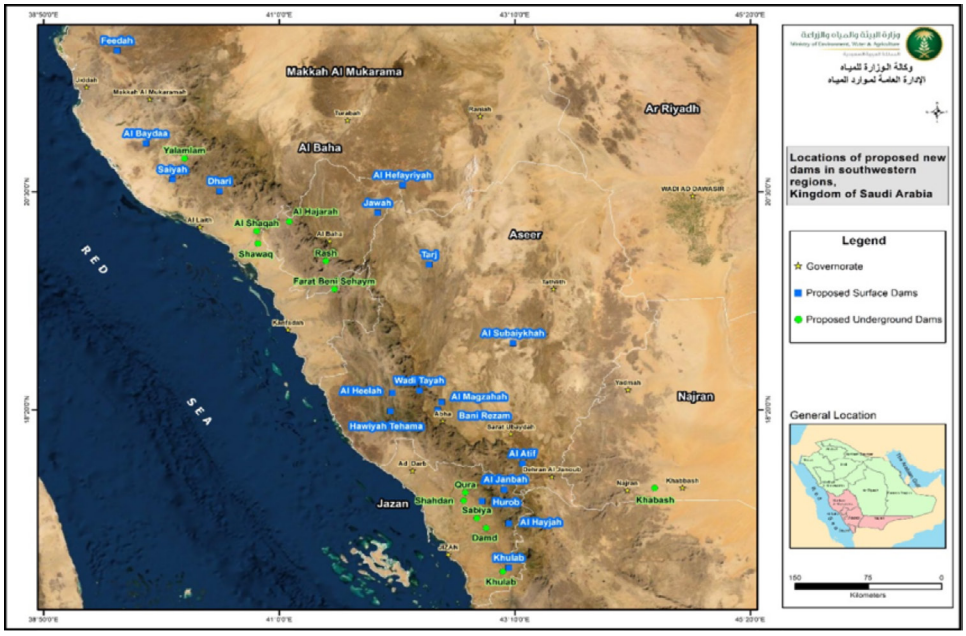


Figure 29: Locations of proposed new dams in south-western regions

Box 3: The final design of Al Baqqar Dam

The assessment and design of Al Baqqar Dam, in Tabuk Region, was undertaken with the support of UNDP experts, and is a typical example of the process undertaken for the 56 other dam sites assessed as part of this project. The earth fill surface dam for Al Baqqar Dam is in Wadi Al Hadra, a main tributary of Wadi Al Baqqar, 37 km south of Tabuk City. Its main purpose is to protect the asphalt Tabuk Road from floods. It is to have a height of 16 meters, live storage of 3.7 MCM and a 1-in-100-year design flood of 402 cumec (m3 sec-1) (See Table 10).

MORPHOMETRIC PARAMETER	UNIT	VALUE
Catchment Area (km2)	Km^2	162.7
Max Stream Length (km)	Km	37.940
Centroid Stream Distance (km)	Km	17.94
Basin slope	%	0.2024
Basin Average Elevation (m)	M	1323.2
Basin Perimeter (m)	M	116,773
Basin Shape Factor	Unit	5.6
Basin Sinuosity Factor	Unit	1.26
Curve Number	Unit	90

Table 10: Morphological parameters of Al Baqqar Dam

Geological Study: According to the geologic map shown in Figure X, most of the catchment area of Al Baqqar dam is located within Harrat Al Raha Tertiary basalts (Qtb). The dam abutments consist of fine-grained sandstone belonging to the lower part of Qassim Formation belonging to Tayma Group and dating as Late Cambrian - Early Ordovician.

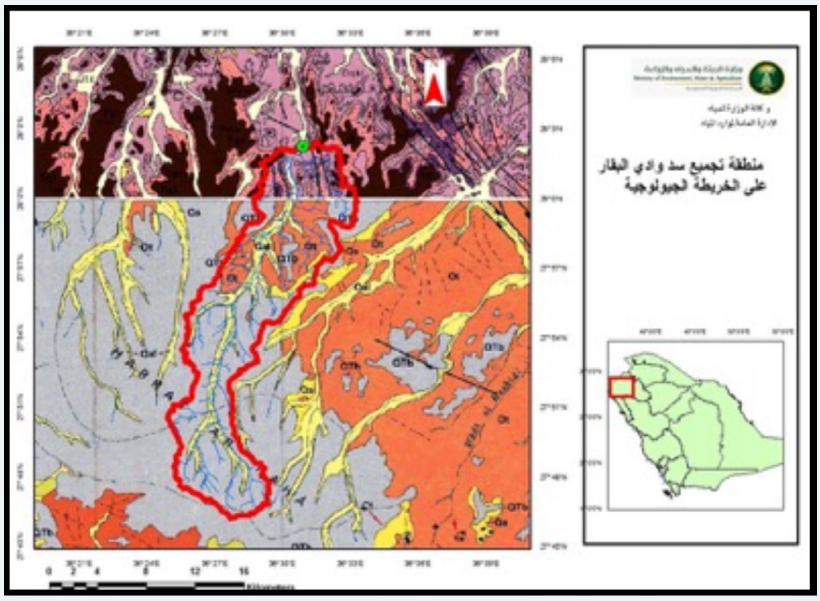


Figure 30: Geologic map of the Al Baqqar Dam catchment area (Tabuk Quadrangle, Sheet 28B, 1985)

Morphometric study: Al Baqqar dam is located at Wadi Al Hadrah which flows south – north from Harrat Al Raha and Jabal Nawf to the dam site, and the Wadi continues downstream to meet Wadi Eirin and Wadi Qena before it enters Tabuk city. The boundaries and the morphometric parameters of the watershed were extracted from the digital elevation model (SRTM_V3_ DEM30m) using

(WMS) programme as illustrated in Figure X. The catchment area is 162.7km2, the mainstream length is 38km and the mainstream slope is 0.0215 m /m. The morphometric parameters are illustrated in Figure 31.

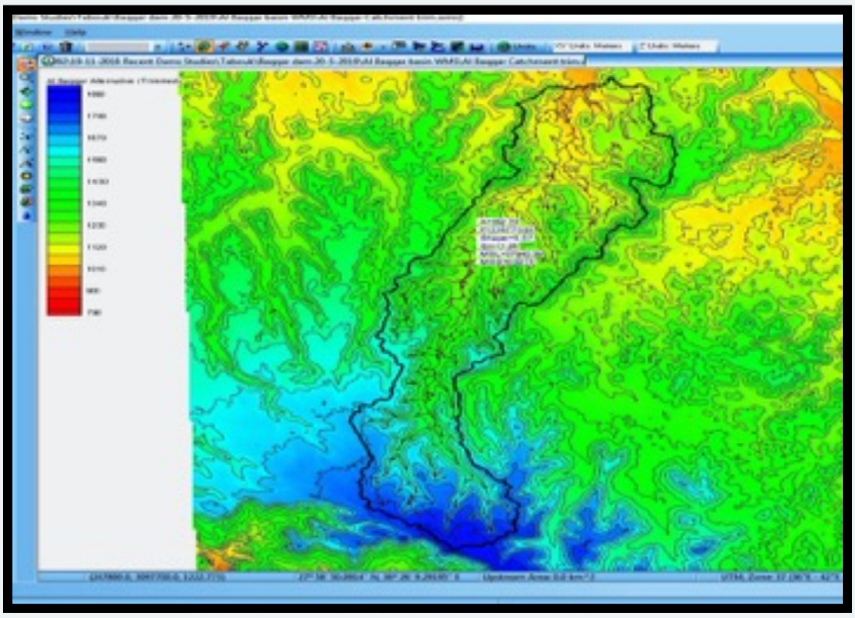


Figure 31: Catchment area of Al Baqqar Dam

Hydrological study: There is no rainfall station located within or near the borders the catchment area (Figure 15). Ashwaq rainfall station (W104-837 is the closest station, located at a (43) km at the south having good record of (40 years), extending from (1966 - 2013). The average annual rainfall is about 60 mm and the maximum daily rainfall is 84 mm. Statistical rainfall depth – duration (daily) - frequency (probability) analysis, using HYFRANPLUS for Rainfall station (W104-837), is in Figure 32.

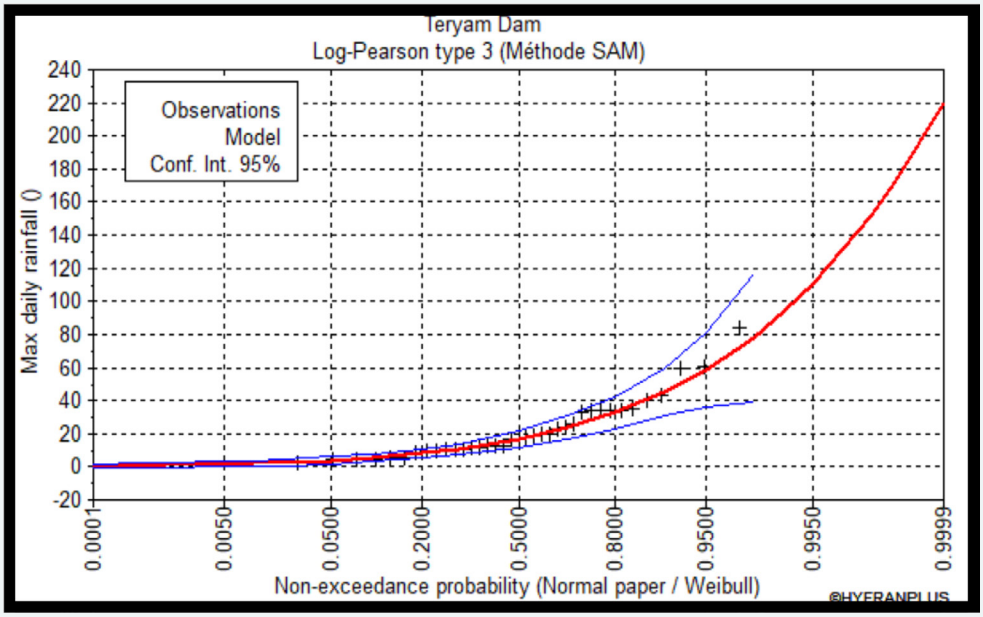


Figure 32: Rainfall depth – duration (daily) – frequency analysis

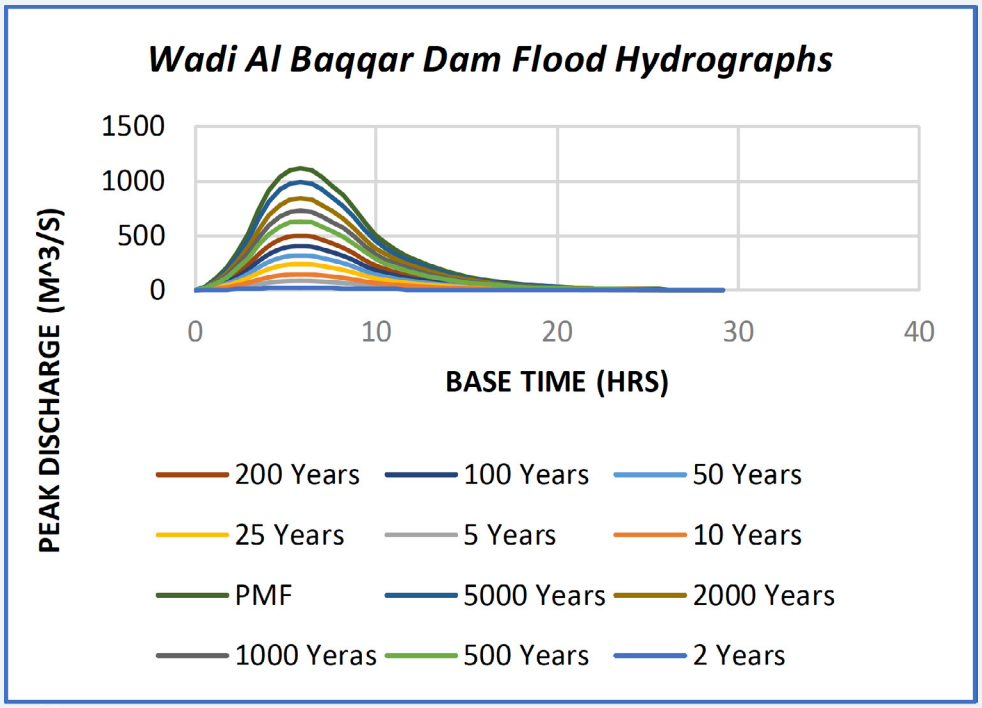


Figure 33: Wadi Al Baqqar Dam Flood Hydrographs for different return periods

Geotechnical study: Eleven boreholes were drilled on the dam axis to determine the type and thickness of alluvium, overlying the bed rocks. The boreholes depths are ranging from (10 m) to (20 m). The field permeability test (Water Pressure Packer Test) was performed in (BH5) at depth (7.5m) to estimate the average hydraulic conductivity, which is estimated as relatively medium attaining (8 Lugeons).

Table 11: Al Baqqar Dam hydraulic design parameters

PARAMETER	UNIT	DAM
Dam length	m	478
Wadi Bed Elevation	m	995
Dam Crest Elevation	m	1,111
Dam Crest Height	m	16
Spillway Crest Elevation	m	1,007
Spillway Length	m	150
Spillway Height	m	12
Peak Discharge (200 years storm)	$m^3 s^{-1}$	496
Water Head over Spillway crest	m	2.04
Peak Discharge (PMF)	$m^3 s^{-1}$	1,115
Water Head over Spillway crest (PMF)	m	2.78
Mean Annual Runoff	MCM	0.58
Annual sediment yield	M^3	25,000
Dam Reservoir storage	MCM	3.725

ASSESSING NON-RENEWABLE GROUNDWATER RESOURCES

Over the course of the project, UNDP experts have supported the preparation modelling work to estimate existing groundwater reserves, including the organisation of a Letter of Understanding with the United States Geological Service.

Non-renewable groundwater sits in very large aquifers with large reserves but negligible recharge. Renewable groundwater is in much smaller aquifers with relatively appreciable recharge. Non-conventional water resources are drainage return flows that are equal to withdrawal or abstraction minus consumption. In this context, consumption is actual evapotranspiration (ETa) lost to the atmosphere.

Aquifers are described and compared in the 1984 Water Atlas of Saudi Arabia (WASA). Igneous and metamorphic bedrock occurs throughout Saudi Arabia. Aquifers occur in:

The Arabian Shelf: which covers the central-east two-thirds of Saudi Arabia. Multiple layers of sedimentary rock overly bedrock and form the main non-renewable groundwater aquifers with highly variable hydrogeologic properties;

The Arabian Shield: which covers the west-central third of Saudi Arabia. Bedrock outcrops and small aquifers are confined to local basalt lava flows and alluvial deposits in wadis.

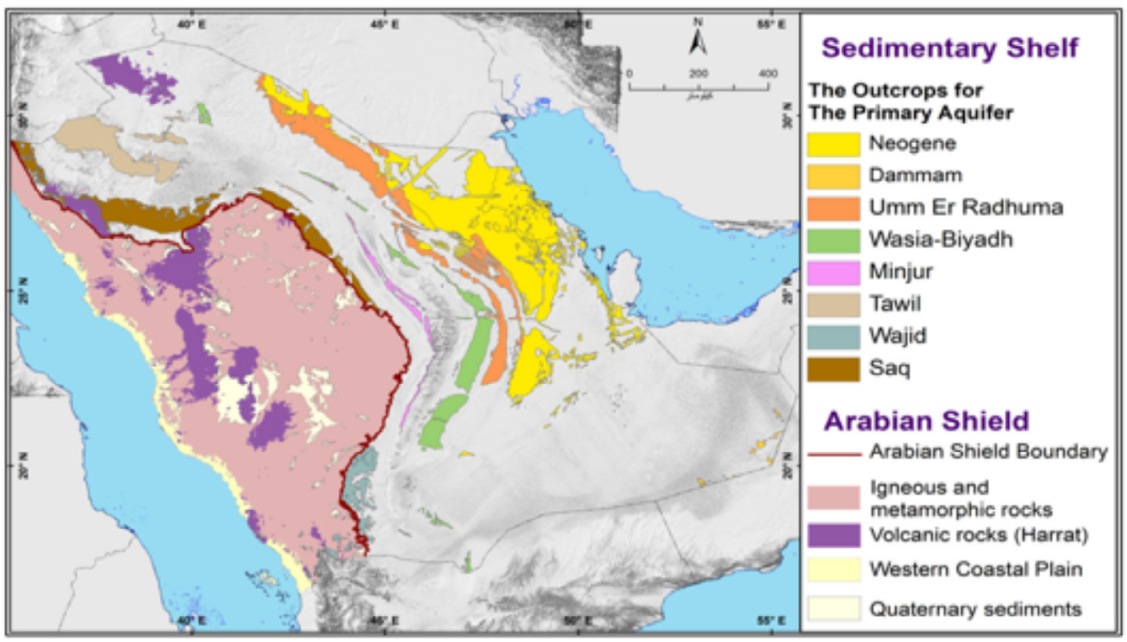


Figure 34 shows the areal extent of the surface outcrops of the primary Saudi Arabian aquifers.

UNDP experts have supported the Water Deputyship to compile, analyse and interpret relevant data available in eight previous reports and to prepare a first foundation to start assessing reserves in 11 aquifers; six of the eight principal and five secondary aquifers[36]. The economically extractable groundwater reserve is less than the groundwater resource (total volume of water stored in the aquifer).

36 MEWA and UNDP. 2019. Groundwater Reserves in the Major Aquifers in the Kingdom of Saudi Arabia.

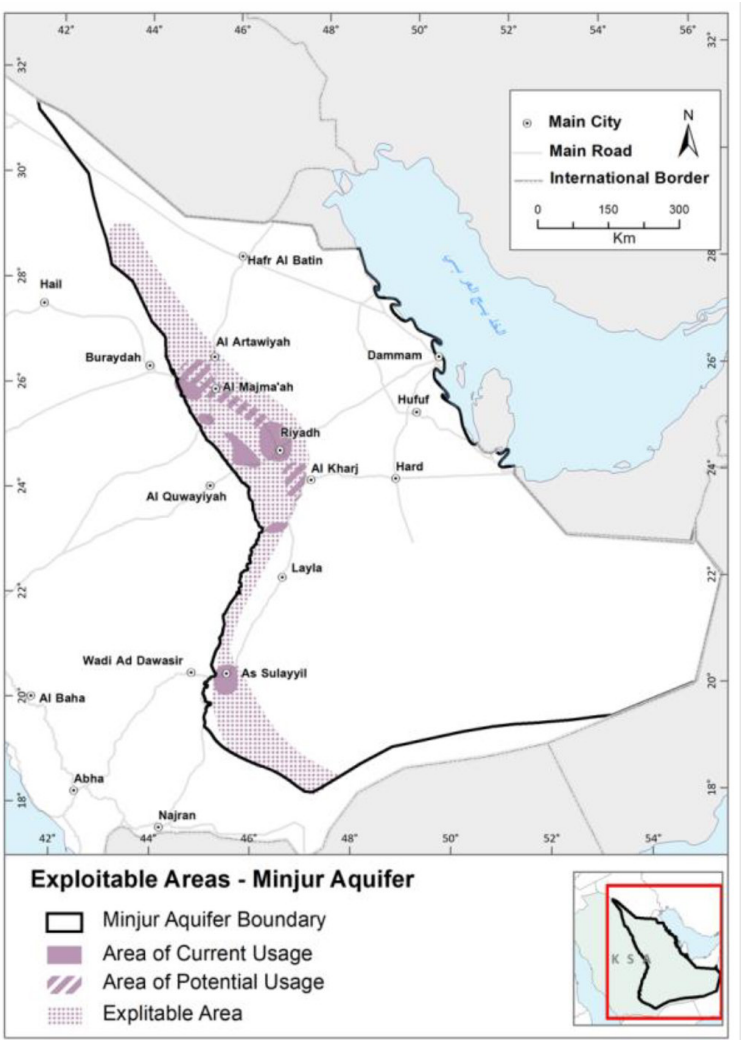


Figure 35: Groundwater reserves and exploitable areas of the Minjur Aquifer

It is important to remember that the estimates will present a stationary snapshot of present groundwater reserves but do not take account of dynamic effects of groundwater abstraction, flow and resulting changes quality. To prepare dynamic estimates of groundwater reserves, UNDP is working to recruit groundwater flow modelling and hydro-chemistry specialists and facilitating a long-term Memorandum of Agreement (MOA) between the Water Deputyship and the United States Geological Survey (USGS).

In October 2019, the United States Geological Service (USGS) and the Water Deputyship proposed a joint Memorandum of Understanding (MOU) to support scientific and technical cooperation in the earth sciences. Indicative areas of cooperation included water resources, ecosystems, natural hazard, risk and resilience assessments and informatics and data integration.

UNDP experts supported the drafting of a Letter of Understanding (LOU) concerning the first cooperation Project to be implemented under the proposed MOU. This was to be an initial USGS scoping mission to review related documents, evaluate current types of data and data management systems, understand technical assistance and capacity development needs, and produce a report of the findings and propose next steps.

In parallel, UNDP and USGS are negotiating a separate Project Agreement for UNDP to finance an initial USGS Scoping Mission to define and agree an ongoing program of cooperation activities to be implemented under the proposed inter-governmental MOU. Cooperation under the proposed MOU will cover, but is not limited to groundwater modelling, water database, geochemistry, atlas, existing storage dams and associated capacity development, including the United States Bureau of Reclamation (USBR) Safety Evaluation of Existing Dams: International Technical Seminar and Study Tour, which will provide technical support for existing dam safety and management.

PROVIDING ONGOING TRAINING AND SUPPORT

Supporting project objective(s):

Objective 1:
MEWA, Water Capacity

Objective 10:
Public Relations and Awareness

One of the central contributions to the Water Deputyship by UNDP experts has been the provision of training and support to MEWA staff. This support has enhanced the skills of individual staff members as well as contributed to training programs, which will have a scalable impact across the Deputyship. The details of the training and support provided are outlined below.

UNDERTAKING A TRAINING NEEDS ASSESSMENT

In April 2021, UNDP experts supported the procurement of services and subsequent delivery of the report entitled Design Capacity Building Concept with Training Needs for the Employees of the Ministry of Water Affairs. The assessment exploring capacity, education and technical gaps and on-the-job training needs of Water Deputyship staff members. The assessment and report was delivered by Applus+.

The training needs assessment (TNA) report had a number of objectives, including:

- Analysis of existing training programs in the Kingdom of Saudi Arabia
- Evaluation of additional needs to fulfill proposed training programs for MEWA employees.
- Priorization of training actions:
  - Priorization of training courses
  - Priorization of directorates/branches
  - Priorization of employees
- Sustainable proposal of urgent training actions (one year-training plan)
- Meetings with Universities and other local academic institutions to coordinate implementation process of urgent training program.

The process included assessment of each national directorate (eight) and each regional branch (13). For each of these organisational organs, the report included its description, organizational chart, current mission, responsibilities and tasks, list of employees, their job descriptions and employee gaps analysis and training needs. Training needs were defined as the gaps between requested and present knowledge and skills.

As well as technical skills, the TNA also assessed administrative, leadership, communication and management skills. For each MEWA staff member, a personal file included assessed capacity gaps, training needs, recommended assignment to a MEWA, Water directorate and recommended training courses to be attended during the next five (5) years.

PROVIDING MENTORSHIP TO CIVIL SERVANTS

Perhaps the most significant contribution of UNDP experts to the Water Deputyship has been through both formal and informal mentorship of MEWA staff. During the development of this report, MEWA staff referenced the importance of the mentorship that had been provided to them by UNDP experts. Mentorship was delivered through technical advice and guidance, but also through provision of broader career guidance and development of soft skills. Box 4 outlines the experience of one MEWA staff member.

Impact story: Essam Mohammed Fallatah

Essam Mohammed Fallatah is the Geophysics Director of Partnership Department and has been working in the Water Deputyship for almost 7 years. Essam works closely with UNDP expert Dr. Arif Alkalali. Through working with Dr. Aref, Essam has benefitted from gaining a better understanding of the working practices and culture of large companies like Aramco. He has also benefitted from Dr. Arif's scientific expertise in geology in general and hydrology in particular.

Critically, Essam has found a mentor in Dr. Arif, and has benefitted from constant encouragement on a personal level to develop his soft skills. For example, the mentorship has focused on building Essam's public speaking skills, which cumulated in a presentation during an official mission at the United Nations in Geneva.

"I feel and know that I am fortunate to work with him," said Essam, "he still gives me advice and assistance in any matter."

Box 4: Impact story, Essam Mohammed Fallatah

DELIVERING THE UNDP EDUCATIONAL PROGRAM FOR THE EMPLOYEES OF MEWA

In 2019, an in-house professional staff development program was proposed for the Water Deputyship. The suggest title for the programme was the UNDP Educational Program for the Employees of MEWA. **Twelve technical subject matter modules were envisaged, including:**

1. **Preparatory program**
2. **Leadership skills**
3. **Hydro-informatics**
4. **Geosciences**
5. **Hydrogeology and groundwater management**
6. **Geophysical exploration**
7. **Hydrology and dam management**
8. **Water resources management**
9. **Extension education**
10. **Water laws**
11. **Water projects**
12. **Water desalinization, treatment and reuse**

For each subject matter module, a program was developed including defining an objective, description, and learning outcomes. The team also worked to identify target participants, the prerequisites for taking the course and the overall duration. Finally, instructors responsible for module development and delivery were identified. Many of the instructors were UNDP experts.

In additional to this formal course, UNDP experts also supported the preparation and delivery of monthly seminars that cover a specific topic and technical on-the-job training (transfer of technology) to Water Deputyship counterparts.

DELIVERY OF THE WATER SAUDI FORUM

Organised by the Water Deputyship, the first Saudi Water Forum (WSF) took place in 2019 and the second WSF took place in 2022. The National Centre for Water Research, and the UNDP experts within the Centre, played the key role in the running of both Forums.

Through the Water Saudi Forums, the Water Deputyship can demonstrate the efforts made and future directions with the aim of finding investment opportunities in water sector in the Kingdom and strengthen scientific research in the fields of water and the prospects for National Water Strategy (NWS).

More than 760 delegates have attended the Water Saudi Forums, and UNDP experts acted as expert speakers, authored many news media items and published papers in leading national and international scientific journals.

BUILDING MANAGEMENT SKILLS, HIGHER EDUCATION AND LANGUAGE TRAINING

The UNDP project has provided a number of opportunities, both international and with Saudi Arabia for MEWA civil servants to further build their technical capacity.

With the support of UNDP experts, this project has organised 22 training courses in management and core skills and specialised technical skills, for 316 civil servants. A summary of the course topics and number of attendees is in Table 12 and Table 13 below.

Course title	Number of participants	Course title	Number of participants
Problem-solving and decision-making	15	Skills for dealing with superiors	15
Work team building	15	Skills for dealing with subordinates	15
Administrative leadership	15	Business letter writing	15
Creative thinking in the field of solving problems	15	Time management	14
Introduction to EXCEL	15	Technical report writing	15
PowerPoint Presentation	15	Effective communication at work	15
Meetings management	14	Presentation and recitation skills	15
		TOTAL NUMBER OF CIVIL SERVANTS UPSKILLED	**208**

Table 12: Management and core skills courses and number of participants

Course title	Number of participants
Geographical Information Systems (GIS)	20
Global Mapper software	18
Stratigraphic and sedimentation	18
Structural geology	9
General introduction to water resources	19
Hydrogeology	10
Integrated Water Resources Management (IWRM)	14
TOTAL NUMBER OF CIVIL SERVANTS UPSKILLED	**108**

Table 13: Specialised technical skill courses and number of participants

Two advanced degree scholarships have been awarded to two MEWA staff members with government funding. The scholarships were at in Kingdom and out of Kingdom universities. After undertaking their studies, these MEWA employee returned and now conducting high-level dam management analysis to support water allocation decisions.

With the support of UNDP experts, King Saud University prepared and approved an MSc program in water science for MEWA employees. This is a non-thesis MSc in water resources which provides an opportunity for staff from the Water Deputyship to upgrade their technical capabilities in groundwater and surface water resources as well as secure a pipeline of talented young experts in water sciences.

Obtaining this MSc degree in the program requires completing 36 credits spread over two years. The program started by registering 12 staff members from the Water Deputyship for the Fall Semester which started in March 2022.

Impact story: Hussain J Alfaifi

Hussain J AlFaifi is an Associate Professor of Hydrogeology at King Saud University, where he has been working since 1997. The MSc program developed in conjunction with UNDP is an Integrated Water Management and Application program for Hydrogeology. Enrolled students, Professor Hussain explains, will gain the technical skills and practical solutions in water treatment and monitoring, information technologies, efficient water use and reuse. Also, they'll gain foundational business skills, improving their understanding of groundwater management concepts

"The program will give them opportunities to lead teams and projects and strengthen their personal skills," he says.

Asked why this is important in Saudi Arabia, Professor Hussain reflects that it is a chance for someone who wants a professional degree in hydrogeology and who want to be professional, excel, and drive innovation in sustainable water management preliminaries. He explains that, in his opinion, the Masters degree of Hydrogeology program is seeking professionals with the multidisciplinary technical skills and integrated perspective to develop sustainable solutions for water resources.

Those who enrolled in the program need to understand the frameworks and a detailed knowledge of the physical, chemical and biological aspects of operations and processes. Critically, they are also looking for the people who have the business insight and skills to lead multidisciplinary teams and guide change to look forward to manage new priceless resources.

Box 5: Impact Story, Hussain J Alfaifi

Finally, through this project three different English language sessions, each comprised of three different proficiency groups, were provided for Water Deputyship staff members, at the British Council and the Institute of Public Administration. Unfortunately, due to the advent of the global COVID-19 pandemic, this training was discontinued in 2020.

PROGRAM COMPONENTS	COURSE NAME		NUMBER OF TRAINEES
English Courses	Session 1	First level course	11
		Second level course	8
		Third level course	6
	Session 2	First level course	2
		Second level course	1
		Third level course	3
		Fourth level course	3
	Session 3	Second level course	1

Table 14: Participants in English courses

WATER EXTENSIONAL EDUCATION CENTER

This project has not only provided education and capacity development for Water Deputyship staff, but also for the general public. The project aimed to support the establishment of an Water Resources Awareness Center for public awareness. **The development of a Water Extensional Education Center has two main objectives:**

To raise public awareness about the entire challenging situation of the water sector in Saudi Arabia.

To strengthen and optimize the technical and organizational capacities of the Water Deputyship with respect to Saudi Arabian water resources and water supply management.

Achievements of the Water Extensional Education Centre to date include the design and implementation of some ten campaigns to raise awareness about water use efficiency and demand-side-management programs and the development of 12 publications and 3 videos about water rationalization.

Led by UNDP experts, the Water Extensional Education Centre has put out more than 110 tweets in support of spreading water awareness and of the importance of water. In addition, to date four public educational campaigns have been run, raising awareness and building public knowledge of water issues. It is estimated that more than 500,000 people were reached through these campaigns.

“From remaining water we save lives” Campaign: An awareness campaign, for all segments of society, aimed at making use of the remaining water in bottled water cans and reusing it in different fields thought social media such as the Water Awareness account, Saudi Press Agency (SPA) account, MEWA’s account, and a group of online newspapers and MEWA events.

“Water Law” Campaign: An awareness campaign aimed at spreading awareness of Water Law and executive regulations thereof.

“Ramadan Water System Competition” Campaign: An online campaign raising awareness of the importance of water and its conservation.

“Can You Imagine?” Campaign: A public awareness campaign focused on the importance of water in various fields. The campaign aimed to:

- Raise citizens’ awareness of the importance of water in our beloved Kingdom, considering it a wealth that must be preserved.
- Urge citizens to rationalize water consumption to ensure its sustainability.
- Support citizens to understand the role played by MEWA to provide water in the Kingdom.
- Support citizens to understand MEWA’s role in the initiatives related to the environment and water in G20.

PROMOTING REGULATION, COMPLIANCE, MONITORING AND LIMITING RISK

Supporting project objective(s):

Objective 5: Monitoring

Objective 8: Environmental Risk

DEVELOPING REGULATION AND COMPLIANCE SYSTEMS

As part of a groundwater resources assessment, the project supported the development of an agricultural water abstraction control and data transition system. The system will work to support an agricultural and urban groundwater resource abstraction licensing systems and compliance mechanisms.

Tariff rates (SAR m^{-3}) will be established to serve both urban and agricultural water users. In the case of agriculture, tariffs will be collected on abstractions that will exceed the water allocated by KACST per crop. Both user groups are important, but ultimately they are different. As is shown in Table X, urban tariffs are paid by customers and paid to well owners. In principle, the purpose of these tariffs is to recover the costs of providing water and maintain hydrologic systems.

Tariff	Paid By	Paid To	Purpose
Urban	Customers	Well owners (Public Utilities)	Recover costs of providing and sustaining acceptable water and wastewater services
Agricultural	Well owners	MEWA, Water	Reduce non-renewable groundwater abstraction for irrigated agriculture in excess of crop water allocation

Table 15: Different purposes of water tariffs

Agricultural tariffs are paid by well owners and are collected only if excess of water crop allocation is reached.. These tariffs are a mechanism that can be used by the Water Deputyship to facilitate the reduction of non-renewable water resources by the agricultural sector. Customers that qualify for these agricultural tariffs on excess, such as the Saudi Irrigation Organization (SIO) and individual private farmers (well owners), pay their own operation and maintenance costs. The intended purpose of the agricultural tariffs is to support the implementation of one of the main National Water Strategy Key Performance Indicator, to reduce annual non-renewable groundwater abstraction drastically, by between 57% and 76%, from a 2016 baseline of 20.6 billion cubic meters (BCM) to between 8.8 BCM (conservative) and as little as 5.0 BCM (optimistic) in 2030.

A key component of establishing a tariff framework is to implement a supervision and compliance system. In October 2020, the Water Deputyship engaged Dornier CST Saudi Ltd (Dornier) for the design, implementation and supervision of a Central Electronic Water System and Database, and to supervise water meter installation. The agricultural tariff component of the Central Electronic Water System will:

- Receive real-time climate data (temperature, relative humidity, wind speed and solar radiation) and use the FAO Penman-Monteith equation to estimate real-time potential reference crop evapotranspiration (ETo);
- Receive real-time crop type, variety, growth stage and area data and use it to estimate real-time crop coefficient (Kc), potential crop evapotranspiration (ETc = Kc x ETo) (m^3 ha^{-1}) and total crop water requirements (CWR) (m^3);
- Ignore effective rainfall, apply stationary irrigation efficiency (e) estimates and provide real-time estimates of irrigation water requirements (IWR = ETc/e);
- Receive electronic well water abstraction[37] (WWA) meter data, record instances of excess abstraction (WWA > IWR) and sum excess abstraction seasonally (m^3);

37 This report will follow standard water accounting terminology where: (i) abstraction is groundwater withdrawn from aquifers via wells and (ii) consumption is actual evapotranspiration (ETa) lost to the atmosphere.

- Apply standard tariff rate(s) ($ m^{-3}) to seasonal abstraction excess (m^3);

Dornier will be responsible for progress associated with the last two components. The King Abdulaziz City for Science and Technology (KACST) is responsible for the implementation of outputs to estimate real-time agricultural water abstraction demand and establish agricultural tariff rates (components i-iii).

Issuance of Well Abstraction Licenses

Issuance of well abstraction licences is an important component of the broader system needed to collect data via the Central Electronic Water System. These activities relate directly to the implementation of the National Water Strategy. Particularly, the KPI that measures the proportions (%) of wells from which abstraction is licensed for (i) urban and industrial water supply and (ii) agriculture, is being measured through this activity. Baselines and 2030 targets are 0% and 100%, respectively. Well water abstraction licensing progress is in Table 16.

Category	Total 2030	Progress end 2020	
		Licensed	%
Municipal	5,046	751	15
Industrial (all)	300	90	30
Agriculture	26,936	4,059	15

Table 16: Water abstraction licensing progress[38]

Installation of Water Meters and Transmitters

As part of the National Water Strategy, certain KPIs also measure the proportion of wells installed with electronic metering for agricultural, urban/municipal and industrial wells. The progress below shows the increase from zero (baseline) until the end of 2020. The aim is to have 100% of meter installation complete by 2030.

Use	Total 2030	Progress end 2020	
		Installed	%
Municipal	5,046	2446	48
Industrial (large)	34	11	32
Agriculture	26,936	880	3

Sources: Table 8.

Table 17: Meter installation progress

Electronic well meters and data transmitters will be financed and installed separately:

1. Well owners (SIO and farmers) will pay for well meters. By end 2024, Dornier will supervise installation of electronic water meters on 10,700 agricultural, municipal and industrial wells that account for 80% of present water abstraction. Remaining 16,236 meters will be installed by end 2030 at a rate of 2,706 wells per annum;
2. The Water Deputyship will pay for automatic data transmitters. Dornier will determine the number and types of transmitters and include their installation in the forthcoming request for proposals (RFP) for implementation of the CEWS.

This work is complex and not without its challenges. Dornier are concerned about the lack of farmer incentives to install water meters. These water meters will be used to regulate and charge the farmers for excess abstraction, therefore there are significant incentives for the farmers not to install the meters. Even if the Water Deputyship installs both meters and transmitters, farmers can readily disable them. This is an example of why state-centered groundwater governance often proves ineffective.[39] The Water Deputyship is considering the modality to facilitate farmer participation in co-management of groundwater.[40]

38 Sources: Dornier (active agricultural wells) and Saudi Authority for Industrial Cities and Technology Zones

39 Molle and Closas. 2019. Why is State-Centred Groundwater Governance Largely Ineffective? A Review, https://www.researchgate.net/publication/336695227.

40 Molle and Closas. 2019. Comanagement of Groundwater: A Review, https://www.researchgate.net/publication/337161553.

ESTABLISHING TARIFF RATES

Urban and agricultural tariffs will require different methods to establish tariff rates[41] and work through this project to support their establishment is ongoing. **The KACST was commissioned to undertake a study on the identification of the rational consumption (abstraction) level and determination of tariff of excessive water consumption.** There have been a number of key milestones towards the preparation of the report, including submission of a Technical and Financial Proposal (4 December 2018), signing of the contract (25 November 2020), submission of the first technical report (15 October 2020) and submission of the second technical report (18 February 2021).

The second technical report worked to provide the foundational evidence for the tariff establishment methodology. However, the second technical report from the KACST concentrates on agricultural demand and does not yet address the water tariff or propose the method to establish the tariff rate. UNDP has proposed that UNDP experts and the Water Deputyship, undergo a process of debate and discussion, reviewing international best groundwater governance practice, including tariffs versus quotas[42], and adaptation to the context within Saudi Arabia.

There is a large body of academic and technical work exists which can support this ongoing discussion. Selected relevant references include but are not limited to:

- **World Bank. 2012. Achieving Financial Sustainability and Recovering Costs in Bank Financed WSS and Irrigation Projects,** https://openknowledge.worldbank.org/handle/10986/17226?locale-attribute=en.
- **Molle. 2009. Water Scarcity, Prices and Quotas: A Review of Evidence on Irrigation Volumetric Pricing,** https://www.researchgate.net/publication/225868871.
- **HR Wallingford. 2002. Water Charging in Irrigated Agriculture: Lessons from the Literature,** https://www.researchgate.net/publication/272171061.
- **HR Wallingford. 2003. Water Charging in Irrigated Agriculture: Lessons from the Field,** https://www.researchgate.net/publication/237566269.
- **World Bank, 2006. Sustainable Groundwater Management Concepts and Tools (GW-MATE Note 0 in Arabic),** https://www.researchgate.net/publication/306286516.
- **IWMI. 2007. Irrigation Water Pricing: The Gap Between Theory and Practice, Comprehensive Assessment of Water Management in Agriculture Series No 4,** https://www.researchgate.net/publication/269762637.
- **IWMI. 2016. Groundwater Governance in the Arab World: A Synthesis,** http://gw-mena.iwmi.org/wp-content/uploads/sites/3/2017/04/Rep.6-Groundwater-Governance-SYNTHESIS.pdf.
- **Closas and Villholth. 2020. Groundwater Governance: Addressing Core Concepts and Challenges,** https://www.researchgate.net/publication/336423292.

MONITORING WATER QUALITY STANDARDS

One of the project objectives is to establish an all-encompassing monitoring system for the surface water and groundwater processes. There are different components of an all-encompassing monitoring system, including well monitoring, for non-renewable and renewable groundwater resource assessment, which has been outlined earlier in this report, and real-time electronic monitoring of production wells and abstraction entitlements is outlined in the section above.

Water quality standards and monitoring are also a critical part of a monitoring system of surface water and ground water processes. In 2020, the Water Regulation Directorate (MEWA) and the Water and Electricity Regulatory Authority (ECRA) jointly adapted ECRA criteria for drinking water, TSE, trade effluent and biosolids, and developed a draft Urban Water and Wastewater Quality Standard. In November and December 2020, the Water Deputyship and ECRA adapted feedback from the National Water Company, Irrigation Authority and the MEWA Environment Deputyship, and incorporated additional criteria into the Urban Water and Wastewater Quality Standard. The proposed document awaits the Minister's approval.

41 World Bank. 2012. Achieving Financial Sustainability and Recovering Costs in Bank Financed WSS and Irrigation Projects, https://openknowledge.worldbank.org/handle/10986/17226?locale-attribute=en.

42 Molle. 2009. Water Scarcity, Prices and Quotas: A Review of Evidence on Irrigation Volumetric Pricing, https://www.researchgate.net/publication/225868871.

Also in 2020, the Water Regulation Directorate (MEWA) developed a draft Agricultural Water Quality Standard. The process incorporated feedback from the Irrigation Authority and the Agriculture Deputyship.

This work is contributing to particular KPIs within the National Water Strategy. To achieve the aims of the National Water Strategy, the proportion of water and TSE quality, meeting standards, should each increase from zero (baseline) to 100% in 2030. In 2030 there are projected to be 1,800 urban municipalities (1,500) and private industries (300) and about 15,000 private farms with individual wells. The annual monitoring target is to sample 10% of each category. The Water Deputyship started water and wastewater quality monitoring in 2020 (see Table 18 below). Following the initiation of monitoring, six government facilities were warned that radiation in their water supply samples exceeded allowable limits. The other samples complied with quality standards. Once the Minister approves the standards, the Water Regulation Directorate (MEWA) will sanction any violations.

Category		Total 2030 Number	Target	Progress end 2020	
				Sampled	%
Urban and Industrial	WQ	5,346	535	40	7
	TSE	5,346	535	5	1
Agriculture	WQ	29,936	2,994	80	3

Table 18: Water and wastewater quality monitoring progress

EVALUATING ENVIRONMENTAL RISK

One of the project objectives is to evaluate the environmental risks associated with the water cycle (groundwater pollution, seawater intrusion, radioactive contamination) and elaborating counter measures. As part of the project, an RFP will be issued to assess water risk and support the development of a national risk registry and mitigation plan. The RFP will assess water and wastewater risks and emergency procedures in the water sector. UNDP experts have prepared the RFP, and it is ready and waiting to be launched.

Once the RFP is launched, the project will support the development of an appropriate and unified methodology for identifying and updating risks along the water supply and the roles of all stakeholders. It will also work to define the methodology regarding best practices and standards for assessing and classifying water risks along the water supply chain and resources in Saudi Arabia. Ultimately, the project under this RFP will establish a system to review the emergency plan and risk assessment and building an archive of risks (software) to be a reference for the water sector.

This plan will require buy-in from stakeholders across Saudi Arabia, and therefore the Water Strategic Department (MEWA) is ensuring coordination with 70 cities, the Business Continuity Plan, the National Security Center and the National Risk Unit.

Photo: Water economics forum

FACILITATING DATA-DRIVEN DECISION MAKING

Supporting project objective(s):

Objective 1: MEWA, Water Capacity

Objective 2: Implementation of Integrated Water Information System

Objective 3: Integrated Water Resourse Management

ESTABLISHING THE NATIONAL CENTER FOR WATER RESEARCH AND STUDIES

In October 2017 a Ministerial Decree established the National Centre for Water Research and Studies (NCWRS) as a Directorate within the Water Deputyship. ***NCWRS is the owner of NWS 2030 Program 4, which includes three Initiatives:***

1. **Developing and implementing research and promoting strategy in the water sector**
2. **National water sector capacity building**
3. **Localization of water industry**

Since its establishment in 2017, NCWRS has made significant progress on all three initiatives. NCWRS is led by a UNDP expert and more than 3/4 of staff members within the Centre are experts. The contribution UNDP has made to NCWRS is vast, and selected achievements of the UNDP expert team working in NCWRS are outlined below.

// DEVELOPING THE NCWRS BUSINESS PLAN

The establishment of NCWRS was rooted in the development of a detailed business plan, outlining goals and objectives and including a regulatory Statute that legalized and regulated NCWRS functions and provided operational and procedural guidelines. Led by UNDP experts, the business plan development process was complex. Figure 36 outlines the process that was undertaken:

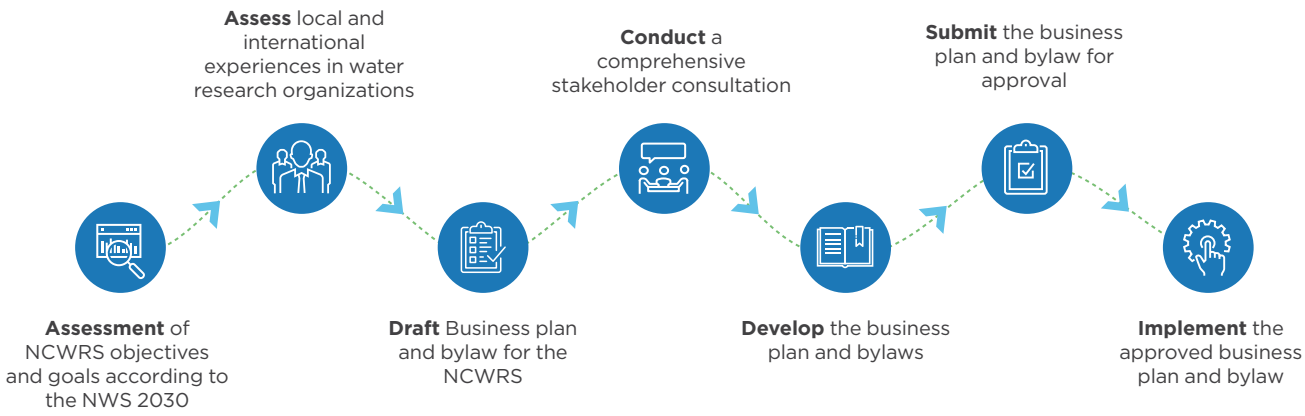


Figure 36: NCWRS Business plan development process

// DEVELOPING THE NATIONAL WATER RESEARCH STRATEGY

The purpose of the National Water Research Strategy (NWRS) is to bridge the science-policy interface to help establish a sustainable water management system. The NWRS will harmonise all Saudi Arabian water research and development activities through innovative partnerships. The purpose of the NWRS is not to replace ongoing research and development, but rather to consolidate objectives and goals, providing policy-led strategic direction to research partners.

UNDP experts in the NCWRS led the Strategy development process, first establishing a preliminary inventory of organizations engaged in areas related to water sector research and development, and the main research and development activities undertaken by these organisations between 2014-2019. Figure 37 shows the organisations surveyed.

Figure 37: National Water Research Strategy stakeholders

Of 74 national water research projects, 36 (nearly 50%) concerned water treatment and quality and 14 (19%) concerned water sources (aquifers and desalinisation). No projects related to wastewater effluent discharge, economic considerations, water consumption, extension education about water use (the demand side of the water balance), water policy, governance and management, legislation frameworks or stakeholder participation.

The process to develop the NWRS has been thorough (see Figure 38).

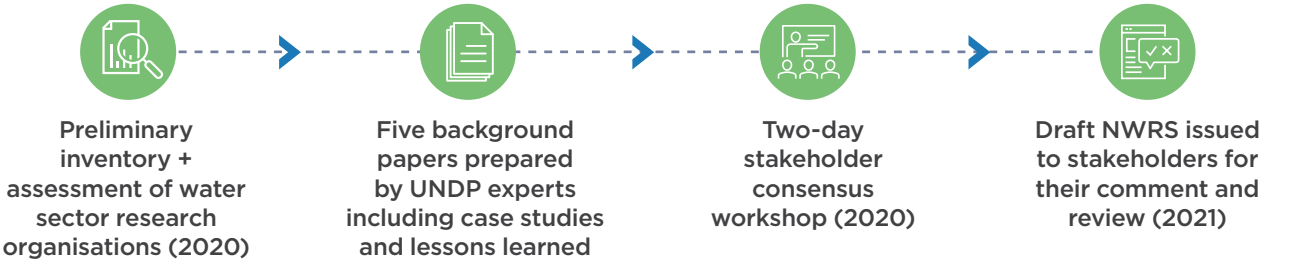


Figure 38: National Water Research Strategy development process

In preparation for a two-day stakeholder consensus workshop, UNDP experts developed five background papers, prepared by eminent national specialists, highlighting relevant case studies and lessons from **Australia**, **California**, **Mexico** and **New Zealand** and **World Bank** investments in science and technology.

In November 2020, the NCWRS conducted a two-day workshop, which was attended by more than 100 water experts, policy makers and water users. The workshop aimed to articulate the role of science and technology in implementing NWS 2030, suggest scientific tools needed to design and implement the 10 programs of the NWS 2030, and monitor and evaluate the performance of each program and the cumulative impact on the water sector in Saudi Arabia.

Workshop participants agreed on a number of key principles, as follows:

Many governments have increased investment in science and technology because it is rewarding practice with high economic return for the national economy;

Successful research is based on building strong partnership between academic and private research institutions and public entities to expand the benefits of innovations;

There is a need for creative funding options from public and private sources to increase investment in science and technology;

It is important to enhance transparency and good governance to improve the performance of public research institutions; and

Cooperative research activities with international research centers should be established.

During the workshop, participants were asked to identify priority water research topics. A total of 24 water research topics were identified. However, prioritisation of these topics was not straightforward, and no consensus was reached among the participants. For example, 84% of participants voted for the first-ranked research on the economics of groundwater resources. However, 54% of participants also voted for the last-ranked research on water harvesting.

Despite not reaching a consensus, this was, nevertheless, a helpful outcome from the stakeholder workshop. Based on this, the draft NWRS proposes to not expand the scope of water research topics. Rather the strategy suggests a limited number of more strategic, policy-oriented research themes to be defined. To identify potential water research topics, the NWRS proposes to review and synthesize relevant international water research and development results and prioritize further research opportunities on the basis of their expected contribution to achieving the key performance indicators related to a particular research theme. For each priority water research theme, the NWRS proposes to clearly define a purpose and expected outcome, and link these to the key performance indicators of the National Water Strategy; ensuring, therefore that research and policy are joined up.

Following this consultation process, in January 2021 the Water Deputyship issued a draft NWRS for stakeholder review and comment. Finalisation is ongoing.

// CONDUCTING NCWRS RESEARCH AND STUDIES

One of the NCWRS objectives is to identify, undertake and lead research activities in water resources management, water supply and wastewater treatment and reuse, to advance the implementation of the NWS 2030.

The UNDP NCWRS team conducted multifarious research that has been published more than 10 scientific papers, published in internationally recognised journals and presented at international conferences. Table X below details one such research project. In addition, some further ongoing work is outlined below:

- Mapping groundwater abstractions from irrigated agriculture: big data, inverse modelling, and a satellite–model fusion approach;
- Drivers and challenges to water tariff reform in Saudi Arabia;
- Water for mining in the Kingdom of Saudi Arabia: An Overview;
- Understanding the value of water – a comparison between policy and public attitudes in Saudi Arabia and Ireland;
- Economic and Technical Potential of Geothermal Energy in Saudi Arabia;
- Geological and geophysical investigations of an engineering site characterization for construction purposes in western Saudi Arabia: accepted in J. Applied Geophysics.

// CONTRIBUTING NCWRS PROJECT MANAGEMENT SUPPORT

Over the duration of this project, UNDP experts and civil servants from the National Centre for Water Research and Studies Support Services (NCWRS) supported work on 18 major projects. UNDP experts provided leadership and technical support, including the development and preparation of Terms of Reference (TOR), review of project technical reports, engagement in meetings and field visits and assessments.

Box 6: Quantifying Agriculture Groundwater Abstractions in Saudi Arabia

The UNDP NCWRS team managed a major Water Deputyship project for Quantifying Agriculture Groundwater Abstractions in Saudi Arabia. The overall objective was to develop an integrated water accounting observation and modelling system and demonstrate it over a number of representative agricultural regions. A framework based on satellite remote sensing image interpretation combined with a sophisticated modelling scheme was developed by King Abdullah University of Science and Technology (KAUST) in coordination with the Water Deputyship.

Numerical weather prediction simulations were performed in this project using the Weather Research Forecasting (WRF) model. The simulations were performed over two, two-way nested domains with resolutions of 9 km and 3 km, and 40 vertical levels covering the Arabian Peninsula. These were produced with an hourly time resolution and for the proposed study period of 2011 to 2015. The satellite-based biophysical and surface parameters and the meteorological data (radiation, air temperature, wind speed & humidity) were used to run a remote sensing-based model to obtain crop water use estimates at 30 m resolution.

Work done in this project also included mapping the key agricultural regions throughout the Kingdom of Saudi Arabia at an unprecedented scale and resolution, including with individual fields' delineations being a key output of the project. This was done using an object-based image analysis procedure based on the Normalized Difference Vegetation Index (NDVI) retrieved from satellite data. Over 30,000 fields were identified in the Kingdom using this strategy.

Next, a datamining approach was implemented to obtain information of the growing seasons for each individual field, giving an unparalleled amount of detail to the Ministry. Using all of the above products, an estimate of the groundwater abstraction for each field was obtained. This was done using an iterative procedure requiring several land surface hydrology model runs, each of which simulated dynamic interactions between soil, canopy and atmospheric layers. The underlying distributed land surface model used in this approach was the CSIRO Atmosphere-Biosphere Land Exchange (CABLE) model. Finally, a prototype for a web-based tool was developed to visualize the results of the study on an interactive map.

Using this data-modelling framework, estimates of regional scale water accounts that provide up-to-date assessments of monthly-to-quarterly crop water use and an assessment of total agricultural water use over recent years have been developed. The approach developed herein has potential to provide water assessments on an on-going basis, with the advantage of benchmarking estimates against a developing ground-based observation network.

Seven agricultural domains were identified as key agricultural regions within the Kingdom of Saudi Arabia. These are: Hail and Qassim (4640 km2), Al Jawf (2476 km2), Wadi Ad-Dawasir (1601 km2), Eastern Province (1254 km2), Riyadh (636 km2), Tabuk (588 km2), and Jizan (411 km2) (see also Figures 1.1 and 5.1). The total annual agricultural groundwater abstraction throughout the years 2011-2015 was determined to vary between 17.8 km3 and 22.9 km3 (1 km3 is equivalent to 1 billion cubic meters, i.e. 1 BCM), as Figure 39:

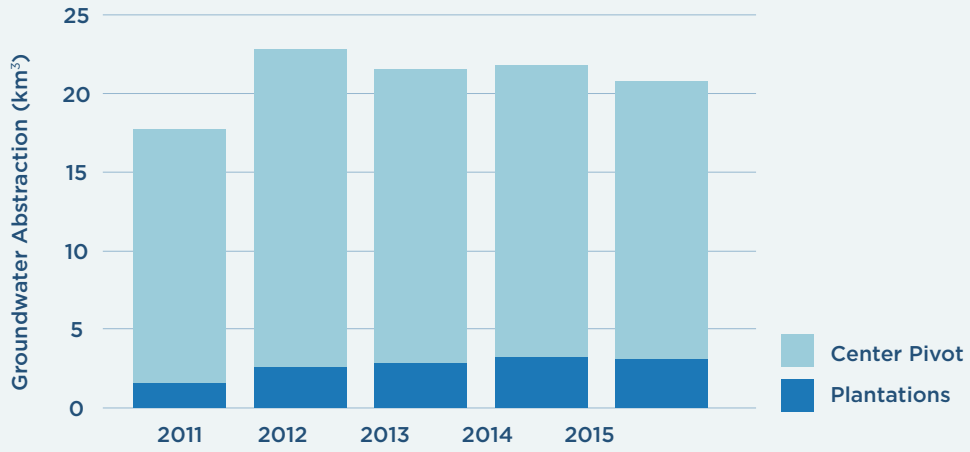


Figure 39: Key agricultural regions within the Kingdom of Saudi Arabia

Fields identified with center-pivot irrigation were the most prevalent in the entire Kingdom, covering more than 80% of the total agriculture and consuming more than 85% of the total groundwater abstraction. This was also the case in five of the seven regions, with the exception being Riyadh (39% center-pivot irrigation in terms of acreage and 46% in terms of groundwater abstraction), and Jizan (both less than 1%). This research project has produced a sophisticated state-of-the-art framework for the estimation of groundwater abstraction as a result of agricultural water use. Future efforts should focus on the translation of these research findings into an operational system for near real-time monitoring and observation.

// DELIVERY OF WATER INDUSTRY LOCALIZATION STUDY

An additional achievement of the NCWRS has been the development of the Terms of Reference for a detailed Saudi Arabian Water Industry Localization study. Developed by UNDP experts, this study will provide a foundational assessment of the status of localization, including an assessment of human capital, industries and technologies. Based on this understanding, the Study will develop a strategy and action plan to enhance the localization level in the water sector.

The study will be tendered soon and is expected to start in June 2021. The duration of the project is 18 months, and it is still under implementation.

CENTER FOR WATER MANAGEMENT AND CONTROL

In 2017, the Minister approved the formation of the Center for Water Management and Control (CWMC) to support the IWRM process and facilitate stakeholder decision-making. In support of the development of the CWMC, UNDP experts developed a Business Plan for the Centre. As part of this business plan, the core mandate of the CWMC has been set out as follows:

- Conduct data analysis in real-time, classifying and analysing data using various methods, including modelling and remote sensing, and evaluate and document the daily data that come from other systems related to the water sector;
- Empower stakeholders to make fast, informed decisions by analysing indicators and developing proposed solutions;

- Support disaster risk management by providing accurate and timely information to enable decision-making based on comprehensive data and considered analyses.

Once fully established, the CWMC will play a key role in optimization of IWRM, which will reduce costs of water production, conveyance and delivery and reduce non-revenue water. It will significantly reduce decision-making time, serve as a single point of control in regulatory processes and use advanced technology to estimate water consumption for all uses. Planning for certain activities is underway, as outlined below.

// DEVELOPING AN INTEGRATED WATER SUPPLY MANAGEMENT SYSTEM

An integrated supply management system requires complex planning and modelling. In order to support this activity, the CWMC will support the activities outlined below.

Modelling of Water Supply Infrastructure

An understanding of water supply infrastructure is necessary foundational knowledge to begin the process of designed an integrated water supply management system. To facilitate this, UNDP experts have developed a Request for Proposal (RFP) for a project which will support the development and transmission modelling and preparation of a masterplan for pipelines and reservoirs. The RFP was issued; however, the start of the work was delayed because of COVID-19.

Once work is completed, this study is expected to identify five best practice benchmarking methodologies for water supply system planning for production, transportation and strategic storage. A review of previous studies will also be done, focusing on assessing the methodologies of those studies, particularly the data collected and stakeholders consulted. Data management will also form a key component of this RFP and the project will aim to transform all current data of production sources, transmission lines, strategic and operational storage into GIS databases. Finally, the project will review the water transportation system within the Kingdom. The project will evaluate the available transportation pipelines system, collecting basic data and determining the surplus/deficit comparing to the targeted supply for each administrative area in the Kingdom and also determine a standard design for water supply areas, supply gate locations and strategic storage sites for all regions of the Kingdom.

Water Demand and Supply Model Development

The development of a comprehensive Saudi Arabian water demand model will support long term planning of water resources. Initially, the CWMC will undertake a water demand breakdown and implementation for 50% of Markaz sub-regions. In order to develop an urban water supply and demand plan a number of key data points are needed:

- **Population Estimates:** to help planners develop population programs, plans and policies the General Authority for Statistics (GAS) provides standard 2050 population projections for Saudi Arabia (see Figure 40).

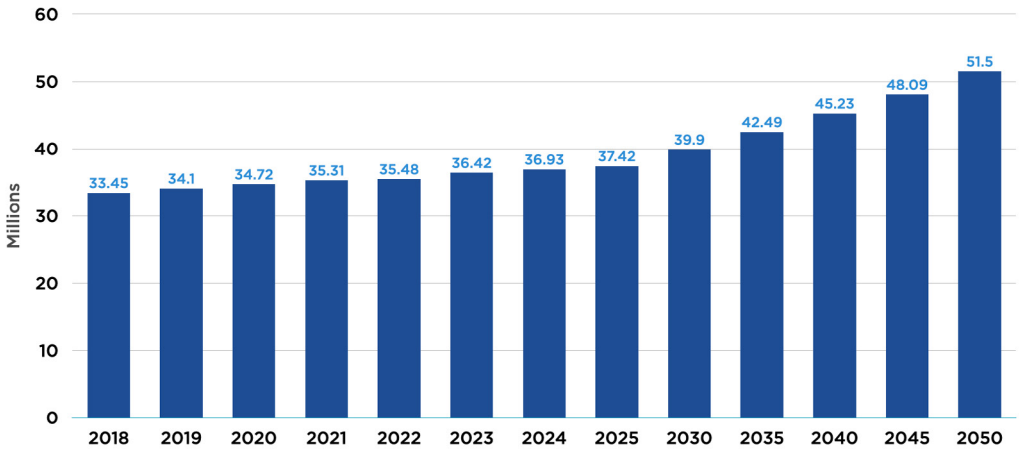


Figure 40: Population projections up to 2050 (General Authority for Statistics)

- **Water Demand for Urban Use:** using the above GAS population projections, the Water Deputyship Planning Directorate prepared the Saudi Arabian urban water supply demand projections shown in Figure 41. In 2016, daily urban water supply demand was 12.8 MCM and is projected to increase by 40% to 17.9 MCM in 2050.

Figure 41: Saudi Arabian urban water demand projections (MEWA, Water)

- **Supply of Water for Urban Use:** Assessments show that from 2020 to 2030 the use of surface water will remain much the same, use of non-renewable groundwater will decrease and use of desalinated water will increase by 85% from 7.3 MCM to 13.6 MCM (to account for population and economic growth and the reduced use of non-renewable groundwater). Further details are reflected in Table X. An understanding of these trends is critical to infrastructure planning across the Kingdom.

Source	Year										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Desalinated	7.34	8.58	12.24	13.18	13.03	13.62	13.62	13.62	13.62	13.61	13.60
Groundwater	2.24	2.33	1.61	1.62	1.62	1.33	1.33	1.32	1.31	1.31	1.01
Surface W	0.33	0.33	0.34	0.35	0.35	0.28	0.28	0.28	0.28	0.28	0.27
Total	**9.91**	**11.23**	**14.19**	**15.15**	**15.00**	**15.23**	**15.23**	**15.22**	**15.22**	**15.21**	**14.88**

Table 19: Projected daily water supply demand (Municipal Water Demand and Supply Plan)

- **Treated Sewage Effluent:** the Water Deputyship will supervise the preparation of an integrated treated sewage effluent (TSE) supply and demand plan that includes the basic standards, pillars and plans to maximize the utilization of TSE for each of the 120 treatment plants. The plan will specify the type of use, distributed quantities, targeted sites, utilization start and end dates, integrated economic feasibility, impact on GDP growth in each targeted area by use (agricultural, industrial, urban, environmental) from 2020 to 2075. The Water Deputyship has signed a contract with Khatib & Alami to develop TSE supply and demand plan.

// DESIGNING AN INTEGRATED WATER INFORMATION SYSTEM

Since the initiation of this project, UNDP experts have been working on the development of an Integrated Water Information System (IWIS). The goal of an IWIS is to provide visual data oversight and provide automated (real-time) decision-making support at both ends of the water sector supply and demand chain (provider and customer). On operation, IWIS was to be a key Center for Water Management and Control (CWMC) input.

UNDP had previously completed an extensive proposal to design, implement and govern an integrated water management information system (IWMIS)[43]. The UNDP proposal covered data acquisition (e.g. automatic water abstraction metering and transmission), storage and processing to facilitate real-time IWRM decision-making.

43 UNDP. 2017. Development of Water Management Tools: IWMIS.

Water sources were to include aquifers, surface water, treated sewage effluent (TSE) and desalinated sea water. IWMIS was also to include linkages to the other government and private sector organizations involved in integrated water resources management (IWRM) including planning and implementation.

// COMPILING A NATIONAL WATER DATABASE

In October 2020, the Water Deputyship engaged Dornier CST Saudi Ltd (Dornier) to support the design and implementation of a Central Electronic Water System (CEWS) and Database and water meter installation supervision). UNDP experts were involved throughout the whole process (outlined in Figure 42), supporting drafting of the Request for Proposal, evaluation of proposals and final selection of Dornier CST Saudi Ltd.

Prior to drafting the Request for Proposal, initial work was undertaken by UNDP experts within CWMC assessed the initial landscape of data sources and software. A number of existing systems were found (listed below), but all are inactive. The existing systems are as follows:

- **Hydro-manager:** A database (and servers) developed for MEWA via the Information Technology Directorate. The system contains a massive data legacy data but is inaccessible and unusable.
- **Information Production System (IPS):** a system to collect urban water production data from all regions of the Kingdom and fed manually by specially trained staff. The system is not updated and is inactive. It sits within the Water Deputyship.
- **Info-mate:** an inactive decision support system and business automation reporting system that is connected to Hydro-manager and other entities from the sector.

CWMC has accessed these three platforms and assessed that they are not fit for purpose. The data on the Hydro-manager system has been accessed, and a platform to retrieve that data has been developed and is in operation, with data migration to the new server complete.

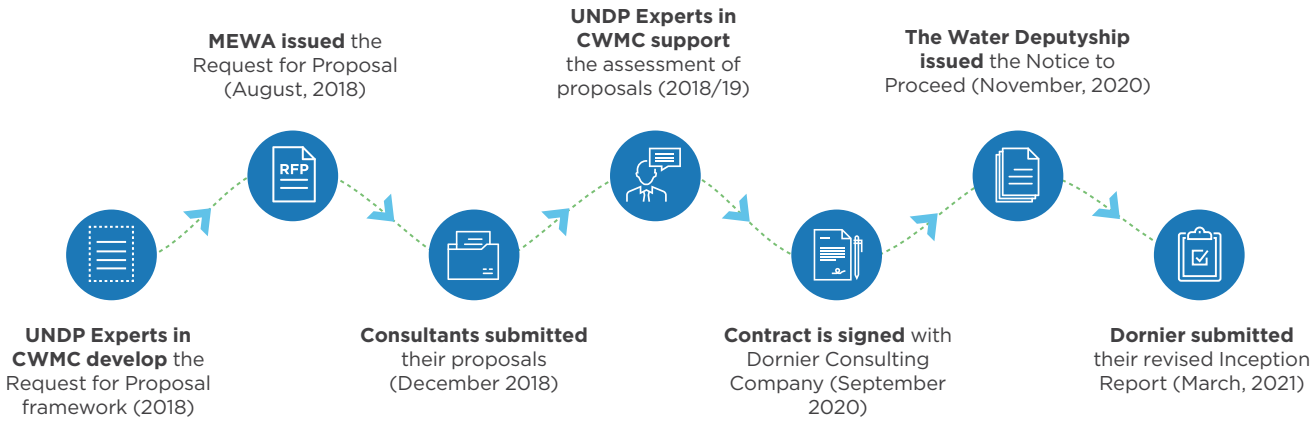


Figure 42: Development of the National Water Database

In early 2020, the Water Deputyship advertised for an international Water Database Management Specialist (WDDS), and this was readvertised again in 2021. However, there were no applicants in either pool that would be suitable to undertake the work. Before advertising a third time, the Water Deputyship, with support from UNDP experts, is going through the lengthy process of pre-identifying international WDDS candidates that are suitable, interested and available.

// ESTABLISHING A HYDRO-INFORMATICS LAB

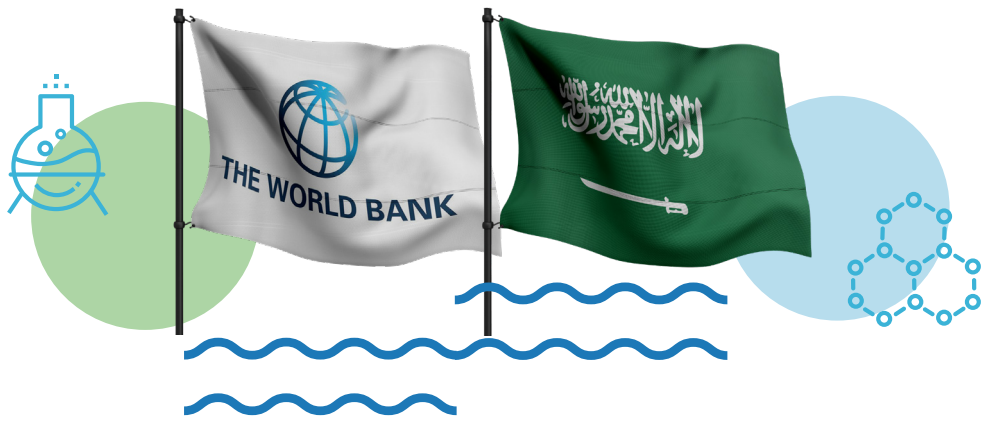
In 2019, the UNDP proposed establishment of a hydro-informatics unit in CWMC[44]. In order to support the delivery of the National Water Strategy, the Water Deputyship requires access to sophisticated software for groundwater modelling, GIS and visualization, database, remote sensing, hydro-chemistry and Groundwater Manager. Access to this type of data manipulation specialisation will help to better inform policy decision and help to ensure that all water sector activities are driven by the most up to date and sophisticated data sources.

To enable the Water Deputyship to undertake sophisticated GIS and remote sensing and modelling, UNDP experts at the CWMC led the establishment of a hydro-informatics unit (interim name), equipped with high performance computer systems and specialised staff to run data modelling programs and provide training to other staff, as needed.

The hydro-informatics unit also serves as a high-tech training room and hosts the interim database for the Water Deputyship projects and models. Analytical tools within the hydro-informatics unit serve multiple purposes including future groundwater and surface water resource assessment projections, high level estimation of water conveyance infrastructure and estimating agriculture water abstraction using spectral analyses of remote sensing data.

Under the Reimbursable Advisory Services (RAS) Agreement, between the Saudi Arabian Government and World Bank, the CWMC Director, a UNDP Specialist, facilitated the preparation of draft terms of reference with the World Bank, for the development of an artificial intelligence (IA)-based hydro-informatics decision support system (DSS).[45] The Water Deputyship is reviewing the draft terms of reference proposed by the World Bank, to consider potential applications of a national water information system/database and decision support system, other than the Central Electronic Water regulation and compliance (agricultural tariff) System (CEWS) as well as relevant international water information system/database and DSS best practice.

At the end of 2020, the UNDP Modelling and Remote Sensing Specialist was transferred from the Water Deputyship Resources Directorate to the CWMC. UNDP also started recruiting a high-calibre international groundwater resource assessment modeller to work with CWMC.



44 UNDP. 2019. Establishment of a Hydroinformatics Unit: Outline (October) & Phase I Completion (November).

45 World Bank. 2020. Draft Terms of Reference for AI-Based Decision Support Systems.

SECTION FIVE

LESSONS LEARNED AND RECOMMENDATIONS

LESSONS LEARNED AND RECOMMENDATIONS

Over the course of the project, important synergies and other positive strategic advantages have emerged, many of which can potentially be applied to future projects. UNDP involvement in the development of Saudi Arabia's National Water Strategy not only nurtured a strong and cooperative relationship between UNDP and the Kingdom's MEWA, but also provided a bridge to the implementation phase of the strategy. UNDP and MEWA were able collaboratively to build an insightful institutional memory of many interlocking elements of effective water management in the Kingdom, meaning that implementation could proceed from the setting of the strategic objectives.

That the project was in full accord with principles essential to UNDP, and to the United Nations as a whole – notably in being harmonized with the Sustainable Development Goals and with the imperative that effective water management is an essential priority for global human well-being – meant that the longstanding UNDP-MEWA partnership has deep foundations that can be expected to persist in future collaborations. The international significance of the innovative approaches adopted is also evident, meaning that – while drawing upon experience in other global regions where water management is crucial – the project has contributed in turn to the evolving international effort to maximise water conservation and its sustainability, and to refining UNDP's mechanism of intervention and making it more adaptable to a crucial area that is constantly changing and evolving.

Being hosted by UNDP, with its forward leaning procurement and recruitment practices, also allowed the project to be remarkably nimble, and restructure in accordance with need. For example, integral to the design of the capacity development elements of the project was the plan to send people abroad for higher education programs in key areas, but unanticipated was the need for detailed approvals, from different areas of government, of such undertakings. Due to this setback, the need for capacity development could have been met with some hindrances that would have hampered the progress of project towards fully realizing its expected outcomes. However, the UNDP team was able to restructure this outcome, reoriented it towards UNDP expert-led training sessions, which provided capacity development by leading technical experts, which could be rolled out and delivered quickly and efficiently.

At the same time, as with any project and perhaps especially with one that is fresh and innovative, there are lessons to be learned and areas in which in retrospect the approaches were not fully successful. One of these concerns ambiguities in the reporting lines. Some of the Directorates are led by UNDP experts, who should invariably report to the overall team leader, the Chief Technical Advisor (CTA). However, a UNDP expert assigned to a Directorate will frequently experience a potentially complex sense of obligation to report also to the relevant Deputy Minister. That contributing both to the UNDP and to the Directorate is of course the ideal, nevertheless a blurring of the lines of communication does not necessarily advance that goal. Also impacted by any confusion in this area is the ability of the CTA to report effectively on the overall achievements of the project. Therefore, a lesson to be learned is that clear reporting lines not only enhance efficient operation of the project but also have the ability to enhance the cooperative relationships that are such a major strength of the project as a whole.

A related question has to do with the processes for structuring and restructuring of the project. Successive Deputyships have held rather different perspectives on the appropriate structures and, in particular, as to the degree to which the roles of project staff and UNDP staff should be integrated. The assignment of UNDP experts to be directors of four Directorates represents one result of an effort to integrate, while another has been the assignment at time of UNDP staff to routine duties that have resulted in limited time to devote to areas of capacity development and technical expertise in which they would have been well pleased to lead. Again, therefore, a sharper definition of roles and – when appropriate – making appropriate divisions of responsibility would lead to greater clarity and effectiveness.

RECOMMENDATIONS

RESEARCH AND ECONOMIC DEVELOPMENT

1

The economic benefits of water resource management in Saudi Arabia should be further explored and documented, and research to understand the specific economic return on investment in the water sector in the Saudi context be undertaken.

2

To more fully represent the integral, cross-sectorial nature of water resource management, quantifying the contribution the water sector has made over time, and presenting this in parallel with progress as shown through **National Water Strategy Key Performance Indicators and/or SDG Goal 6 targets or indicators, could present a powerful message of the importance of the water sector** across all sectorial areas.

3

In future project iterations, **UNDP must adopt a proactive approach in identifying water needs for all economic and social sectors** by working collaboratively with these sectors to identify holistic and sustainable solutions, scoping new economic benefits and filling gaps arising from global changes such as political conflicts.

4

Consideration could be given to other forthcoming economic opportunities in the water sector, and research undertaken accordingly. New water sector project opportunities in rural communities, for example, could drive higher rates of employment and socioeconomic opportunities in these areas.

PROCESS AND ORGANISATION

5

The highly collaborative UNDP-MEWA policy process that led to the development of the National Water Strategy, **and subsequent Project to facilitate implementation, should be fully documented in a lesson(s) learned study**. Collaborative public policy process that are successful not only in the development, but also the implementation of policy are rare, and this successful approach could benefit other countries looking to undertake a similar process.

6

In future projects, clear reporting guidelines should be set out that are specifically designed to make appropriate divisions of responsibility while also enabling all participants in the project to provide the benefit of their experience and expertise to both the Ministry and UNDP.

7

The structural design of any future project be thought through in detail in such a way as to enable all participants to have a high level of **clarity and consistency** as to their own responsibilities and the way in which they are expected to contribute to the overall success of the project.

CAPACITY BUILDING AND DEVELOPMENT

8

This project has done an excellent job at building capacity of MEWA civil servants. Further opportunities lay in broader capacity development initiatives; building cross-government capacity in water issues, for example.

9

Additional scientific areas are emerging that could be powerful tools for water resource management in Saudi Arabia. **Continuance of technical support from UNDP experts in areas such as water accounting could continue to increase the capacity within the Water Deputyship**.

These lessons learned can be applicable to a wide international range of projects, and in the particular context of collaborative endeavours between UNDP and the Kingdom of Saudi Arabia, the close and harmonious relationship referenced above gives every reason to look to the future with great optimism.

CAPACITY DEVELOPMENT AND RELATED SERVICES FOR AN INTEGRATED SUSTAINABLE DEVELOPMENT AND MANAGEMENT OF THE WATER SECTOR IN THE KINGDOM OF SAUDI ARABIA IN THE FRAMEWORK OF THE VISION 2030