ABU DHABI STATE OF ENVIRONMENT REPORT 2017

WATER RESOURCES

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A low natural recharge rate, coupled with the increasing demand for water (linked to rapid socio-economic change), is driving reliance on non-conventional water resources in Abu Dhabi Emirate.

Groundwater extraction for agriculture and forestry purposes exceeds the natural recharge rate, while domestic water consumption in Abu Dhabi Emirate is one of the highest in the world.

Over the last decade, the emirate’s overall groundwater level has continuously declined, particularly in the Al Ain Region. The usable groundwater reserve (with total dissolved solids (TDS) of less than 15,000 ppm) had slightly increased in 2016 compared to 2005.

The Al Ain Region is most affected by red zones (a groundwater level decline greater than 15 metres). These zones will increase reliance on the desalinated water supply, increasing the environmental burden from greenhouse gas (GHG) emissions and the discharge of brine water into the marine environment.

A number of entities are working across different priorities to address the water stress issue within an integrated water management framework. This aims to achieve natural water conservation while minimising pollution.

Water Resources Management Challenge
Water is a sensitive and fundamental substance that acts as insurance for life on earth. It is, therefore, essential to acknowledge the importance of water resources and the ecosystem services that they provide, as well as natural ecosystems’ reliance on water. Because of this strong connection, managing such a vital resource requires an integrated approach that acknowledges its availability for future generations in terms of quantity and quality.

In the Emirate of Abu Dhabi, water resource management is facing many challenges, particularly the scarcity of fresh water. Daily domestic water consumption in the emirate is 590 litres per capita, one of the highest in the world [1]. In addition, the expected increase in demand for water, due to the emirate’s rapid economic and human development, is making the challenge even more serious.

The Local Policy Framework of Water Resources
The UAE Vision 2021 outlines the country’s commitment to sustainable development, highlighting the preservation of the natural environment as a priority. In parallel, UAE Vision 2021 aims to achieve a balance between economic and social development in the emirates. In line with the priorities defined in the strategy, the UAE identified the water scarcity index as a key performance indicator (KPI) within the National Agenda as it progresses towards sustainability. The UAE Ministry of Energy (MoE) is the competent entity responsible for achieving the country’s target water scarcity index by 2021.

In 2016, the Emirate of Abu Dhabi issued revised Law No. (5) on Groundwater Organisation for the emirate, replacing Law No. (6) of 2006. The revised law aims to strengthen the emirate’s legal framework in order to achieve its objectives in conserving this natural resource and ensuring its optimal use. It extends the current legal mandate to cover activities such as illegal selling or transportation of groundwater, desalination unit installation and discharges of brine water into the environment. Additionally, it stipulates that metering is now required for farms, meeting technical criteria set by EAD.
The Emirate of Abu Dhabi is located in an arid region with extreme natural water scarcity. It relies almost exclusively on groundwater, desalinated water and, to a limited extent, on treated wastewater (see Figure 5.3). A heavy reliance on already scarce groundwater resources, mainly for irrigation in agriculture and afforestation, has resulted in threatening changes to groundwater quality and quantity. The assessment of these changes has been closely monitored through the established Groundwater Monitoring Network (GMN), which is managed by EAD through 1,506 monitoring wells distributed across the emirate (see Map 5.1).

**Groundwater Levels**
Groundwater is the only source of natural fresh water in the emirate. However, due to the lack of rainfall and high levels of evaporation, the rate of groundwater recharge is insignificant compared to the rate of abstraction from shallow groundwater aquifer systems. As a result, the emirate’s aquifers comprise mostly non-renewable fossil groundwater. The increasing demand for groundwater has led to reduced groundwater levels, influenced by the intensity of agriculture and afforestation activities in Abu Dhabi Emirate. Between 2005 and 2016, overall groundwater levels experienced a steady decline, with a severe decline in the Al Ain Region, mainly due to high groundwater withdrawal activities, resulting in depleted areas or ‘red zones’ (see Map 5.2).

The depletion of groundwater level is a serious issue due to the high rate of extraction. With a total of approximately 100,000 wells across Abu Dhabi Emirate, most of these are located in the Al Ain Region, which suffers from extreme groundwater level decline (see Figure 5.1 and Figure 5.2).

**Groundwater Salinity**
Groundwater salinity is the concentration of dissolved solids in a defined unit of groundwater expressed as milligrams per litre. In Abu Dhabi Emirate, most of the groundwater in the surficial aquifers is brackish, saline or brine. EAD considers the emirate’s groundwater as ‘useable’, with total dissolved solids (TDS) not exceeding 15,000 mg/l. In coastal areas and much of the area between Al Dhafra Region and Al Ain Region the brine water has higher levels of TDS, exceeding 100,000 mg/l. Fresh groundwater is found in surficial aquifers in the Al Ain Region and in Al Dhafra Region around the Liwa crescent. Besides the evident impact...
of evaporation on groundwater salinity, unsustainable groundwater abstraction and poor irrigation practice have also contributed to increasing salinisation of the aquifers in certain locations.

Map 5.4 and Map 5.5 show a direct comparison of changes in salinity between 2016 and 2008 in the Al Ain Region and Al Dhafra Region.

Groundwater Quality

Groundwater is a vulnerable resource in Abu Dhabi Emirate, and in many areas it is the only water resource available. Groundwater is also essential for sustaining wildlife in remote areas. However there is a need to better understand the details of the relationship between biodiversity and groundwater. Groundwater supplies are closely linked to soil condition and agricultural practices, with the inappropriate discharge of brine water from desalination units installed in farms and the use of fertilisers posing a real threat of contamination. In Abu Dhabi Emirate, the groundwater table ranges from just below the land surface (near sea level) along the coast to greater than 400 metres above mean sea level (MSL) in the regions around Al Ain. Regions of shallow depth to groundwater may represent areas of concern, being more susceptible to seawater intrusion and contamination from pollutants. The emirate’s coastline also includes several small shoals, islands, lagoons, channels and deltas, an inner zone of intertidal flats (where algal mats are well developed) and broad areas of supratidal salt flats designated as ‘sabkha’ (flat, salt-crusted desert).

MAP 5.3 Groundwater Salinity

MAP 5.4 Trend of Groundwater Salinity (2008 to 2016) - Al Ain Region of Abu Dhabi Emirate

MAP 5.5 Trend of Groundwater Salinity (2008 to 2016) - Al Dhafra Region of Abu Dhabi Emirate
5.2 Drivers & Pressures

Water Consumption in Abu Dhabi Emirate
The Emirate of Abu Dhabi has an extreme per capita scarcity of renewable fresh water, and demand continues to rise. Groundwater and desalinated water account for 60% and 25%, respectively, of water use in the emirate, while the recycled water contribution is just 5%.

Groundwater
Groundwater in Abu Dhabi Emirate is mainly used for agriculture and afforestation, accounting for a total withdrawal estimated at 2,013 Mm³/year. Over the last few decades, intensive agriculture and irrigation of forests have altered the hydrogeological system in the emirate. Agricultural policy in the emirate poses a serious challenge in maintaining the current agriculture sector relative to the level of groundwater depletion and deterioration. With an estimated 24,000 farms now operating in Abu Dhabi Emirate, the number of plant holdings has increased rapidly in the last four decades, with more than 38 times more now operating than in 1971 [1].

The increased demand for groundwater has also been fuelled by a number of policies in Abu Dhabi Emirate: food security, which aims to make the emirate less dependent on imported food and achieve 40% local production levels [2]; ‘greening the desert’ policies, with a view to providing habitat for wild animals and stabilising the sand around roads; public parks to enhance the aesthetic value of outdoor spaces, residential and commercial megaprojects catering to the local population and a growing tourism industry; and rapid industrialisation driven by the Government’s diversification efforts towards non-oil industries. Inefficient irrigation techniques and the inappropriate choice of crops have also contributed to the over-consumption of groundwater.

The impact of climate change on the hydrogeological cycle and groundwater use is not fully understood at present. However, it is expected that changing weather patterns will be a pressure on the demand for groundwater in the emirate, with a slight impact on recharging aquifers in the Al Ain Region [3]. Further research is required to investigate the impact of a rise in sea water levels and its potential infiltration into the groundwater basin.

Desalinated Water
The Emirate of Abu Dhabi is estimated to have one of the highest rates of daily domestic water consumption, with a per capita consumption of 580 litres per day. There is a growing reliance on desalination as an alternative to the already extremely scarce groundwater; however, this will put an extra burden on the environment. The current pattern of demand will lead the emirate to expanding its desalination capacity, which will have a greater negative impact on the environment in terms of GHG emissions and marine water discharge [4].

Although the domestic sector is responsible for 47.8% of desalinated water consumption in the emirate, the agricultural sector has become more dependent on desalinated water, posting an annual increase of 255% between 2014 and 2015 (from 55.26 Mm³ to 196.18 Mm³) [1].

Treated Waste Water
Recycled water from treated waste is not optimised due to an under-developed distribution system in the emirate. This is expected to be optimised as an alternative water source for non-drinking purposes, including the irrigation of forests and some crops [5]. Currently only 51% of all treated water is recycled (see Figure 5.4), while the rest is discharged into the environment. The current return-to-sewer rate is only 28.6%; meaning that only a small amount of the total desalinated water used goes back into the sewers (see Figure 5.4), while the rest is discharged into the desert or Gulf, due to underdeveloped transmission and distribution systems [1].

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Trans-boundary Groundwater Aquifers
With the UAE bordering Oman and Saudi Arabia, groundwater found in non-renewable aquifers is a critical resource for agriculture in each of these three countries. Shared groundwater resources are evident in the Al Ain Region, towards Oman’s Al-Buraimi region [7]. With unsustainable agricultural practices and over-exploitation of resources contributing to the depletion of aquifers, a proper understanding of trans-boundary groundwater aquifers is essential for the management of this resource.
5.3 Impacts

Ecological Impacts

Air Pollution and GHG Emissions from Desalination

GHG emissions from fossil fuel-powered desalination plants contribute to climate change and air pollution [4]. According to SCAD, the emirate’s total fuel consumption in water and electricity activities increased by 9% from 2014 to 2015 due to the coupling of energy and water, leading to an increase in emissions of GHG and air pollutants. Levels of sulphur dioxide (SO₂) become particularly acute when there is a need to use oil instead of natural gas as a fuel source. According to GHG Inventory 2012, the water and electricity sector is the largest emitter of carbon dioxide (CO₂) emissions (33%) [8].

Impact on Groundwater and Soil

The agricultural sector consumes the most groundwater by far, followed by forestry and amenities. The improper use of inorganic fertilisers leads to nitrate leaching into the soil and groundwater, as well as soil deterioration and salinisation. Soil contamination is an extremely underestimated issue, with a lack of awareness contributing to the improper discharge of brine water into the emirate’s soil, forming “crystal” patches which are beds of salt.

Marine Pollution and Loss of Biodiversity

Desalination and treatment activities threaten marine biodiversity due to the discharge of brine and thermal water into the marine environment. Brine water discharge is approximately 9-10 m³ per 1 m³ of desalinated water produced. Chemicals such as chlorine and copper, which are harmful for the marine habitat and biodiversity, remain in the brine. This issue is also intensified due to the recycled water that is also discharged into the sea, affecting marine life, while a change in groundwater levels due to over-abstraction may threaten terrestrial biodiversity.

Economic Impacts

Cost of Desalination

Ecosystem deterioration caused by treatment and desalination practices could affect biodiversity in the Arabian Gulf and the ecosystem services it provides. As a result, fisheries could be affected, with diminishing fish stocks. According to Abu Dhabi Water Strategy 2015-2020, in 2011, stocks were estimated to be 529 kg per km² compared with 1,735 kg per km² in 2002. That is, fish stocks decreased by more than two-thirds in just nine years [9]. This may have an economic impact on one of the fundamental components of food security in the region.

Contribution of Agricultural Production to GDP

Currently agriculture is responsible for more than 60% of groundwater use in Abu Dhabi Emirate; however, its contribution to the emirate’s GDP is less than 1%. Agriculture is not a sustainable sector; therefore minimising water use while improving crop productivity is necessary to achieve food security targets while reducing water use. With the agricultural and forestry sectors being the main consumers of groundwater resources in Abu Dhabi Emirate, SCAD data on the percentage distribution of GDP in 2014 shows that agricultural economic activities contribute to only 0.6% of the emirate’s GDP.

Social Impacts

Health Impacts

There is a potential risk to human health from exposure to low-quality water. With marine water quality being affected by water desalination and treatment practices, the emirate’s coastal waters could suffer from algal blooms as a result, especially due to insufficient tidal flushing around Abu Dhabi Island. Of particular concern is direct contact with sewage water and groundwater with high concentrations of nitrate, fluoride, boron and chromium. At present, there is insufficient information to assess the burden of disease due to groundwater contamination from factors such as waste sites.

National Security Impacts

Long-term Availability of Water Resources is at Risk

If the current rate of abstraction continues, groundwater in Abu Dhabi Emirate may be depleted within a few decades. Currently there is an excess capacity of desalinated water of 15.1%. However, if no further investments are made, a deficit capacity of 29.8% is forecast by 2030.

Gas limitation is another threat to the long-term availability of desalinated water. According to SCAD data, fuel consumption in the electricity and water sectors is increasing. Natural gas consumption increased by 9.4% between 2014 and 2015, rising from 618,099 Mscft to 676,155 Mscft [1]. The emirate is also increasing the use of other types of fuels, such as crude oil and gas oil, to meet the increasing demand.

Water Security Risks

Abu Dhabi Emirate currently has a low storage capacity for desalinated water. However, after the completion of the strategic water reserve project by the end of 2017, the emirate’s storage capacity will be increased to 90 days. Sea water desalination is challenged by high sea water salinity, elevated sea water temperatures and the abundance of algae, and has high exposure to any risks associated with oil spills and marine pollution.
Building a Comprehensive Understanding of Groundwater Resources

Well Inventory Project

The Well Inventory Project was established by EAD with the aim of providing information on well characteristics, water table, salinity, and water pollution from across Abu Dhabi Emirate. The project also includes additional information on soil analysis. The project is divided into three stages:

- **STAGE 1**: an inventory of all wells in the emirate (operational and non-operational)
- **STAGE 2**: collection and analysis of soil samples for the purpose of developing soil classification
- **STAGE 3**: preparation of the first Atlas of Ground Water in Abu Dhabi Emirate

Groundwater Monitoring Network Optimisation

EAD is working towards achieving a comprehensive understanding of groundwater resources in Abu Dhabi Emirate, by integrating groundwater monitoring networks under one umbrella to strengthen coverage. The agency is also building a digital model of the underground reservoir, which targets the extreme depletion zones of the Al Ain Region.

Achieving Reduced Water Use and Improving Sector Productivity

Crop Calculator

In a joint initiative with the Abu Dhabi Food Control Authority (ADFCA), EAD developed a ‘crop calculator’ to optimise water used to irrigate crops. The crop calculator will be used as a guide for permit processes by allocating a defined volume of water for farms.

Review of Subsidies

Subsidies for the cultivation of crops requiring high water intensity were reviewed in 2010. As a result, recommendations were made to discourage farms growing those crops (in particular Rhodes grass) by removing subsidies. There is an opportunity to continue a further review of subsidies to promote positive agriculture practices, optimising and improving productivity levels while minimising water use.

Maximising the Use of Treated Wastewater

The Abu Dhabi Sewerage Services Company (ADSSC) is working on maximising the use of treated wastewater in the emirate. Working in partnership with EAD, the aim is to reduce the stress on natural resources and provide recycled wastewater to irrigate the emirate’s farms and forests. At present more than 40% of produced tertiary treated wastewater is discharged into the environment, with both economic and environmental impacts.

Balancing Water Use Within Sustainable Limits

EAD and ADFCA are working together to address the unsustainable use of groundwater in the agriculture sector. The two entities are exploring policy options to reduce groundwater usage while meeting food security priorities, by promoting productive uses within defined sustainable limits. The study will be undertaken as part of a ‘water budget’ programme in collaboration with academic institutions.

Using New Innovative Technology in Agriculture

EAD and ADFCA jointly developed a demonstration centre for new innovative technologies in agriculture and food production (such as advanced hydroponic systems) to increase efficiency in the use of water resources in the agricultural sector while increasing productivity levels. The centre was commissioned in 2016.
Looking Ahead
Abu Dhabi Vision 2030 focuses on the conservation of water resources and their efficient management. The UAE’s precious water resources were further reinforced as a strategic priority through the UAE Vision 2021, which highlights water stress as a key national agenda.

Further Response
Traditionally, the region’s population relied on ‘Aflaj’, the water run-off from mountains, to meet its water requirements. With a limited quantity of water available, living conditions in the region were very harsh. Today, groundwater has been excessively exploited through drilling, with deeper wells found mainly near the Al Ain Region. The condition of Abu Dhabi Emirate’s groundwater is steadily deteriorating, both in term of its quantity and quality, and further investigation is needed to understand any impacts this may have on the emirate’s biodiversity.

EAD, along with key stakeholders, is taking extraordinary measures to address the groundwater challenge, while the Abu Dhabi Government is aware of the importance of groundwater resources as part of the emirate’s natural heritage. In 2016, the Revised Law No. (5) was issued, expanding the emirate’s regulatory capacity in order to achieve the targets for the conservation of natural resources, as stated in the Abu Dhabi Environment Vision 2030.

EAD is expanding its activities in order to gain a comprehensive understanding of aquifer conditions. There are now more than 1,300 groundwater monitoring networks across the emirate, and the agency’s largest well inventory project will enable EAD to account for all operational and non-operational wells, water salinity, water levels, water pollution and additional information to assist soil classification. ADFCA and Abu Dhabi Farmers’ Services Centre (ADFSC) are also exploring innovative initiatives to reduce water pressures in the agriculture sector through joint initiatives. Examples include: bio-saline agriculture; alternative irrigation technologies, such as hydroponics, and greenhouses to replace open-field agriculture; and the showcasing of model farms in collaboration with EAD to raise farmers’ awareness of sustainable farming practices.

Through a number of different entities, the emirate has made significant investments in technical innovations to improve groundwater levels. These include the Strategic Water Reserve project, where water is stored for up to three months in underground aquifers, and the adoption of solar-powered desalination units to produce higher quality water from mostly brackish and saline groundwater, which extends the capacity of water available for crop irrigation.

In 2015, a new water tariff was introduced to raise awareness in the domestic and commercial sectors of a more conscious use of desalinated water. This will help reduce the environmental burden from the water and electricity production sectors.