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SOMA MATER Radical Transparency

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Harvesting Rainwater

The Untapped Potential

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Harvesting Rainwater: The Untapped Potential

Hotter Weather, Less Rainfall

The United Arab Emirates (UAE) is renowned for its iconic skylines, advanced technological integration and rapid urban development. However the arid climate and scorching summer temperatures that characterize the region, pose significant challenges when it comes to finding solutions to combat the rising temperatures and extreme weather effects of climate change.

Due to its geographical location, the Middle East is one of the most vulnerable regions to the impacts of climate change. This means that with the intensification of global warming, the Middle East is expected to experience extreme weather events more intensely. As of today, temperatures in the UAE are rising and reaching record highs. According to the Climate Change Knowledge Portal created by the World Bank, 2021 was the hottest year ever recorded in the UAE since 1901, followed by the years 2022, 2018, 2016, 2015 and 2019. Just two years prior, 2022 was the second hottest year on record for the UAE, reaching an average temperature of 28.93 degrees celsius. This data reveals that the UAE has experienced its five record high temperatures in the span of just a decade, with its hottest year being only three years ago (as shown in Figure 1).

Ranking	Observed Annual Average Mean Surface Air Temperature in UAE (1901-2022)	Year
1st	29.09°C	2021
2nd	28.93°C	2022
3rd	28.76°C	2018
4th	28.66°C	2016
5th	28.65°C	2015 & 2019

Figure 1 (data provided by the Climate Change Knowledge Portal (World Bank))

Nonetheless, rising temperatures is only one half of the challenge. The UAE is also experiencing less rainfall compared to its average for the last 19 years (NCM's Annual Climate Assessment for 2022, 2023). These two factors combined could present a challenge for the sustainability of the UAE economy, considering weather and water play an important role in tourism, urban development and a quality of life. According to a statement released by the World Bank, it is expected that by 2030 the amount of water available per person in the MENA region will have dropped to less than the absolute water scarcity threshold of 500 cubic meters per person yearly (The World Bank, 2023). With average temperatures rising and the level of rainfall in the UAE dropping, environmental stability in the region could quickly be at stake.

This paper delves into an untapped potential for water sourcing - harvesting rainwater - to address the pressing need for water conservation with the goal of mitigating average temperature rise and extreme weather impacts due to climate change in the country.

Rainfall in the UAE

Rainfall Patterns

When moist air ascends in a intertropical convergence zone (ITCZ), its moisture becomes water droplets that turn into clouds and fall as storms over rainforests located around the equator. After being rid of all moisture and drying up, that air travels either to the north or to the south to about 30° of latitude, and descends, becoming warmer as it goes down. The descent of this dry air is called subsidence and is one of the reasons for the region's arid climate and low precipitation (Paparella & Burt, 2023). Figure 2 below demonstrates this cycle, with the red arrows in the middle of the diagram representing the ITCZ zone of intense precipitation and the blue arrows around this area representing the descent of dry air which causes subsidence (and lack of precipitation) on land.

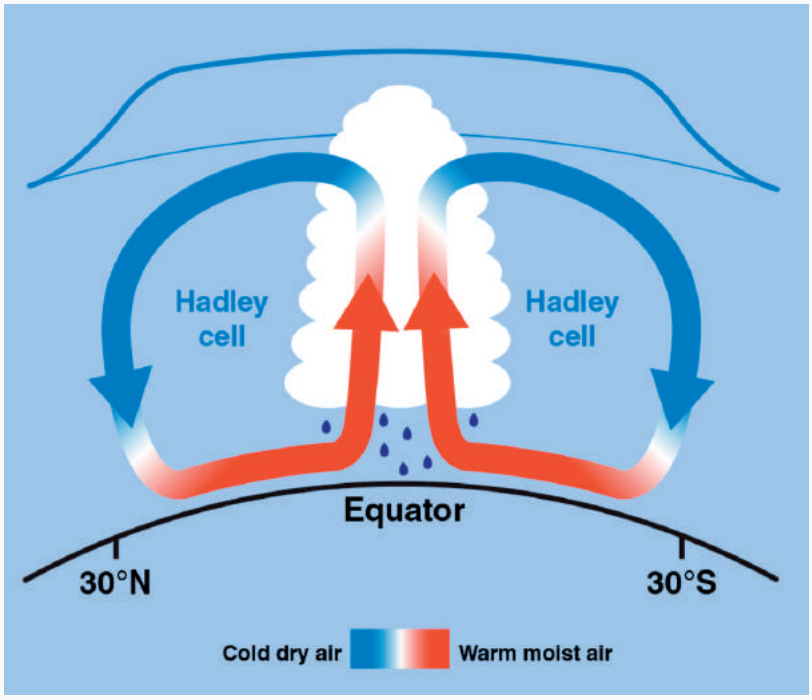

Figure 2 (Paparella & Burt, 2023)

As of today, the UAE's annual rainfall averages around 140 – 200 mm of rainfall, with the mountainous regions experiencing somewhat higher levels. For example, the Northeastern emirate of Fujairah receives the highest level of rainfall yearly, at an average of 124 mm per year, compared to Abu Dhabi's average of 52 mm per year (Climate Change Knowledge Portal, n.d.). This exemplifies the important role that the mountains have in assisting this rainfall. In fact, a majority of the natural rainfall that the UAE receives is a result of the Hajar mountains, which extends from the UAE to Oman (Paparella & Burt, 2023).

However, despite the UAE's low levels of rainfall, the country still experiences occasional extreme weather events, such as short-but-intense downpours and floods that affect livelihood and infrastructure. For instance, although the year of 2022 was the driest year on record in the UAE, it was also the year that Fujairah received 220.9 mm of rain in just two days in July. The rainfall that started on the 27th of July continued until the 28th of July and caused severe floods, disruption in the region, resulted in the death of 7 people, and had over 3,000 people displaced in temporary shelters (Annual Climate Assessment 2022, 2023; McGinley, 2023).

Source: Shouk & Amir, 2022

Despite the UAE being a country of relatively low rainfall, abnormal downpours still occur. This is a phenomenon that the AGEDI analysis predicts will not just continue, but intensify in the coming years. The analysis suggests that the number of rain days in the UAE is expected to decrease but the intensity of these rain days is expected to increase (United Arab Emirates Ministry of Climate Change & Environment, n.d.). For this reason, the UAE should brace for the expected intensification of the rainfall that occurs during the months of January, February, and March and with a special focus on the northeastern regions like Fujairah.

The UAE's historical rainfall patterns reveal that rainfall levels are higher during the cooler months of the winter (December, January, February, March) and lower during the hotter months of the summer (June, July, August, September). However, over the last couple of years, rainfall has decreased, in 2019 Dubai experienced 38 days of rain while in 2020 it was down to 25 days only (Statista, 2020). Furthermore, according to the NCM's Annual Climate Assessment for 2022, 2022 was also the UAE's driest year on record, with the annual rainfall average being a 29% deficit of its 20-year period prior. The decline can also be seen in the summertime, although rainfall is usually low, rainfall occasionally occurs during the hotter months due to the low monsoon pressure from India (Sircar, 2023-b). This downward trend can be attributed to climate change causing warmer temperatures in the region (Sircar, 2023-b).

Rainfall Realities

Implications, Challenges and Opportunities

The irregular weather patterns in the last couple of years manifest through the dry winters and flash floods in the middle of summer. These deviations can result in significant consequences on the ecosystem, agriculture, infrastructure, human health and well-being. Specifically, with rain comes the need for countries to adopt the appropriate infrastructure in order to better endure this heavy rainfall and ideally harvest it for future use. Unfortunately, the countries that lack this infrastructure tend to face several challenges during rainy seasons.

a) Financial Impact of Rainfall-Related Disasters

Every year weather and climate disasters have caused billions of dollars in damages around the world. These disasters are defined as sudden events caused by natural elements such as storms, earthquakes and floods that create important damages to infrastructure and economic activity while also destroying lives and livelihoods (Dhanhani, Duncan & Chester, 2010). The UAE has experienced multiple natural disasters such as earthquakes and floods over the last 30 years, with 25% of accidents caused by the latter (World Bank, n.d). Floods are specifically threatening in Fujairah due to the Emirate's geographical location, in the North-Eastern part of the country bordering the southeast coast of the Arabian Gulf. The damages of floods come at a very high cost and usually entail:

- Physical damage to residential, commercial and government or municipal buildings
- Material assets within a building
- Losses incurred due to disruptions in business operations
- Damage to Automobiles and boats

- Damage to Public infrastructure like roads, bridges, sidewalks
- Farm and crop damage
- Expenses associated with rebuilding and repair

In 2022 alone, the Kalba flood in Sharjah cost fodder traders Dh1 million (Khaleej Times, 2022). This amounts to large sums that accumulate over the years, unfortunately there is no data on the exact total cost of such damages in the UAE.

b) Environmental Impact of Rainfall-related disasters

In the last 10 years, wadi flash floods have become a significant problem in the UAE due to the periods of sudden heavy rainfall. These events generate wadi runoffs that often overflow the basin for long distances. These wadi flash floods can not only destroy infrastructure as stated in the previous section, but can also have consequences on the surrounding ecosystems while destroying lives.

As we see a trend of drier years in the UAE and sudden large downpours in warmer months, the potential water capture of floods and rainfall runoff becomes even more important, and the potential to construct underground dams, artificial lakes and off-stream structures should be explored (Kantoush, S. et al., 2021).

c) Environmental impact of dry-spells

Dryer years can lead to a range of consequences with significant impacts on both natural and human systems. The first one that comes to mind is water scarcity, as decreased rainfall can result in reduced water availability and thus lead to water stress as water resources in the UAE are already limited. Lower water availability impacts agriculture and the environment which affects food security and ecosystem stress respectively. Dry spells lead to soil erosion, salinization and land degradation with lack of enough water resources which are the biggest causes for low agricultural productivity (European Environment Agency, 2021). Ecosystem stress is majorly attributed to habitat alteration as dry spells can disrupt feeding habits, breeding success and migration routes of wildlife (National Geographic, n.d.).

UAE's Cloud-Seeding Initiative

A Solution to Increase Rainfall

With that in mind, cloud seeding has become the primary choice of action for rain enhancement in the UAE. The National Centre for Meteorology and the Ministry of Presidential Affairs of the UAE are the entities responsible for water security and promotion of rainfall. Over the last 30 years the UAE has developed its cloud seeding capabilities to reach over 900 hours of cloud-seeding missions every year (Sircar, 2023). Natural salts including potassium chloride and sodium chloride are usually injected into the clouds which eventually causes the water droplets in the clouds to become denser and more prone to fall as precipitation. It is difficult to identify the exact impact of cloud seeding on rainfall but studies have shown that it can enhance it to up to 15%, an additional 168 to 838 million cubic meters of rainfall each year (Sircar, 2023).

Nonetheless, cloud-seeding is not considered a complete solution to droughts since it does not produce rain abruptly, but requires the presence of already-existent clouds in order to stimulate rain (DRI, n.d.). Indeed, even without the use of cloud-seeding, the UAE experiences natural occurrences of orographic rainfall in its mountainous regions, which is caused by the rising and dropping of air over these mountains (NCM's Annual Climate Assessment for 2022, 2023). In addition, cloud-seeding can also be costly. According to Sircar (2023), every flight hour of a cloud-seeding mission in the UAE can cost around AED 29,000. Therefore, assessing the already-existent rainwater-capturing techniques in the UAE and how effectively they are being utilized across the nation is important.

Water Potential in the UAE

Current Rainwater Harvesting Solutions in the UAE

The UAE has about 150 dams around the country, built to harvest rainwater in addition to the reservoirs available to collect drained rainwater from floods in roads and neighborhoods. Research indicates that the two main types of dams used in the UAE are earth dams and concrete dams, predominantly established by what used to be the Ministry of Environment and Water, the Ministry of Presidential Affairs, and a number of municipalities (Al-Nuaimi & Murad, 2007). According to data for the year of 2017, out of the 150 dams in the UAE, 16 were made of gabion-stone fill, 18 were made of concrete, and 116 were made of rock earth fill (Dams Classification, n.d.). According to Al-Nuaimi and Murad (2007), dams in Ras Al Khaimah and Ajman were made of concrete due to the narrow nature of the stream channel in these areas, while earth dams are commonly made with the material available in bare areas. Research also shows that concrete dams are more expensive in comparison to earth dams (Solutions for dams, n.d.). These dams have already collected in previous years up to 36 million cubic meters of water after two days of rain (Khaleej Times, 2020). The capacities of the dams vary from one to the other, and are meant to recharge aquifers and natural springs, protect from floods, and assist agricultural producers who rely on groundwater for their activities (Al Nuaimi & Murad, 2007; Baldwin, 2016). Water captured in these dams can also be used to supply different regions of the UAE, with the Wadi Al Beeh dam in Ras Al Khaimah, for instance, being responsible for supplying water to Al Burairat and Al Hamraniya communities in Ras Al Khaimah (Kumar, 2020). Figure 4 demonstrates the spread of these dams across the UAE.

The relatively little amount of data on the UAE's harvest of rainwater points to the potential need for more research and investment to be directed towards such projects. Exploring the use of harvested rainwater to enhance green spaces in urban areas, should be a top priority for the UAE. Not only does it provide an alternative source of water, reducing dependence on desalination and natural resources, but it is also more cost efficient in the long-term and reduces environmental impact.

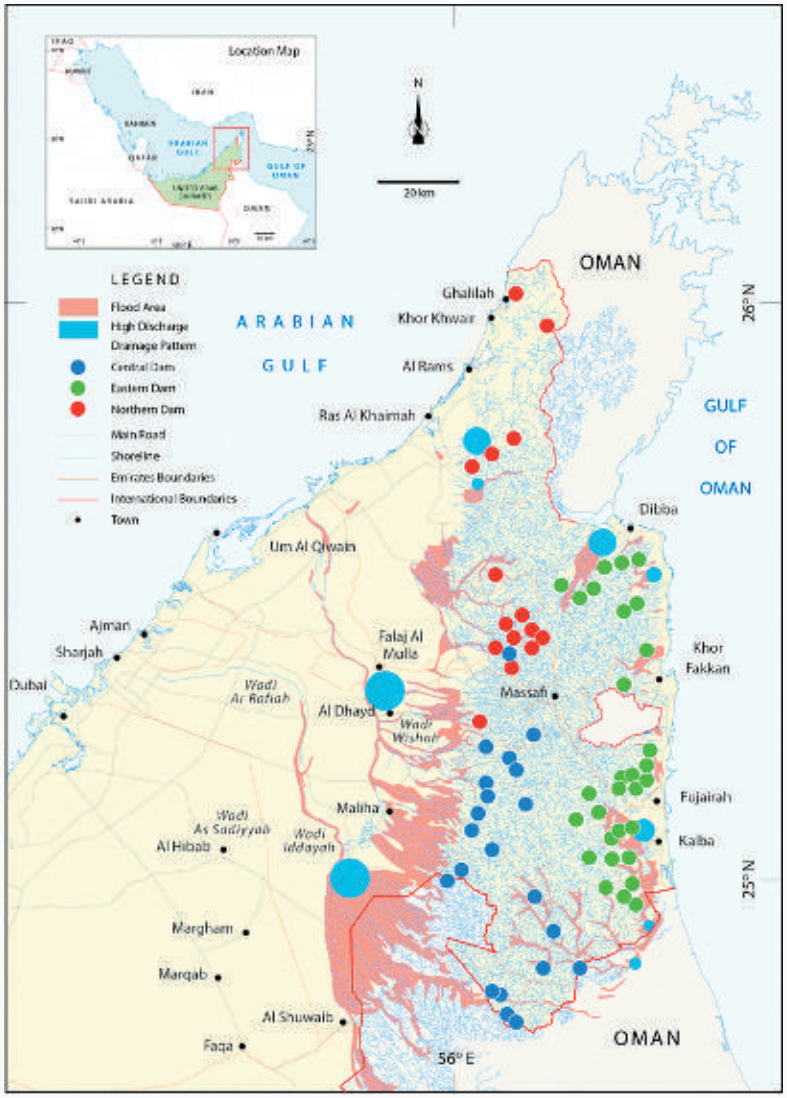

Figure 4: Sherif, M., Ebraheem, A. M., Al Mulla, M. M., & Shetty, A. V., 2018

Harvesting rainwater in rural areas vs urban areas

The map in Figure 4 above reveals that a predominant number of the UAE's dams are located mainly in the North-Eastern region of the country, recognized as the rural region of the country. The more urban areas of the country (located in the South-Western region) are significantly distant from these dams and thus, rely on desalination plants for their supply of water. For instance, regions like Al Ain rely on the Taweela and Umm Al Nar desalination plants for water supply, which lead to the need for extensive pipeline systems to connect the water facilities to the desalination plants (Khalil, Khan, & Mohamed, 2022). The authors describe how an over-reliance on these desalination plant's storage capacities can pose a potential risk considering they only range from a couple of hours to a number of days. This depicts a delineation between the rural and urban areas of the country in regards to efficient water management systems and points to the potential of harvesting this rainwater in the rural regions for use in the urban regions.

Aquifer storage and recovery

The UAE has implemented strategic water reserves primarily through aquifer storage and recovery (ASR) techniques to secure large-scale emergency water supplies in arid regions. This technique involves "the injection of freshwater into an aquifer through wells or infiltration basins to create a subsurface water supply that is recovered at a later time" (Dawoud, n.d). The concept of strategic water reserves serves to meet seasonal, long-term, emergency, natural crisis, or other demands. One notable example is the ASR project in Abu Dhabi in Al Dafrah region which was completed in 2017 (Dawoud, n.d). This project involves 300 wells which store 26 million cubic meters of water, enough to supply Abu Dhabi with water for 90 days in case of emergencies. (Dawoud, n.d.).

The integration of such technology into government policies in arid nations, exemplified by the UAE, provides a pathway for planners, policymakers, and investors to incorporate ASR techniques into investment decisions aligned with the United Nations Sustainable Development Goals (SDGs). This includes reinforcing water security, particularly during emergencies, adapting to climate change, and fostering both rural and urban development.

Nonetheless, the rate of recharge of these aquifers as a result of rain percolation has been insufficient when compared to the rate at which water is being abstracted (Sherif et al., 2021). According to the authors, recharge from rainwater percolation in the UAE averages around 132 MCM annually. However, this is only 4% of the amount that is abstracted for irrigation purposes from the same aquifers, demonstrating the recharge deficit of these aquifers. Indeed, irrigation was responsible for over 95% of groundwater abstraction in the UAE in 2021. At this rate, the article predicts fresh groundwater in the UAE could withstand only ten more years before being depleted.

However, the rate of recharge can vary depending on the rainfall harvesting techniques used. For instance, the authors state that depending on the infrastructure of rainfall harvesting set in place, the rate of recharge can vary from 1% to 42%. This demonstrates the potential that an improved rainfall harvesting system could have on improving recharge rates of these aquifers.

Application of the Urban Green Space Cooling Effect

Beating the Heat

The UAE is a destination known for its dynamic urban cities with many high-rise buildings and construction projects. Nonetheless, these structures place a severe burden on the UAE ecosystem and intensify a phenomenon known as the "Urban Heat Island", where urban regions report temperatures higher than non-urban regions by an average of up to 1.0–6.0 °C (Aram et al., 2019). Specifically the dark-colored surfaces of urban buildings, the materials they are made of, and the overall density of population in cities become intensifying factors to this urban heat island effect. In addition, the lack of urban green spaces in these big cities becomes an important factor to this effect, and is no different in the UAE.

Green spaces, referred to as "open-space areas appropriated for plant life, parks, and bodies of water" (WHO, 2017), are known to not only promote well-being and livelihood of residents in urban cities but also helps reduce temperatures, mitigate extreme heat-related accidents, protect urban biodiversity amongst others (WHO, 2017). Statista reported that the total green area in Dubai in 2022 was 15,481 km2 (Statista, 2022) which is equivalent to 0.4% of the total area of the UAE.

These green spaces are vital due to a phenomenon called the "urban green space cooling effect", proven effective in reducing the thermal effect of urban infrastructure (Aram et al., 2019). This is possible as a result of trees' evapotranspiration, where the combined processes of evaporation and transpiration lower temperatures in their surrounding areas (Using Trees, 2023).

As a result, research has shown that temperatures under trees tend to be an average 0.8 °C lower and urban forests are reported to be an average of 1.6 °C cooler than other areas in comparison (Knight et al., 2021). This phenomenon is illustrated in Figure 3 below. Interestingly, these authors' research has also shown that details are particularly important, with the size and shape of these green spaces having a direct impact on their effectiveness in helping to cool the cities they are built in, with large urban parks with areas of over 10 hectares having the most cooling effect.

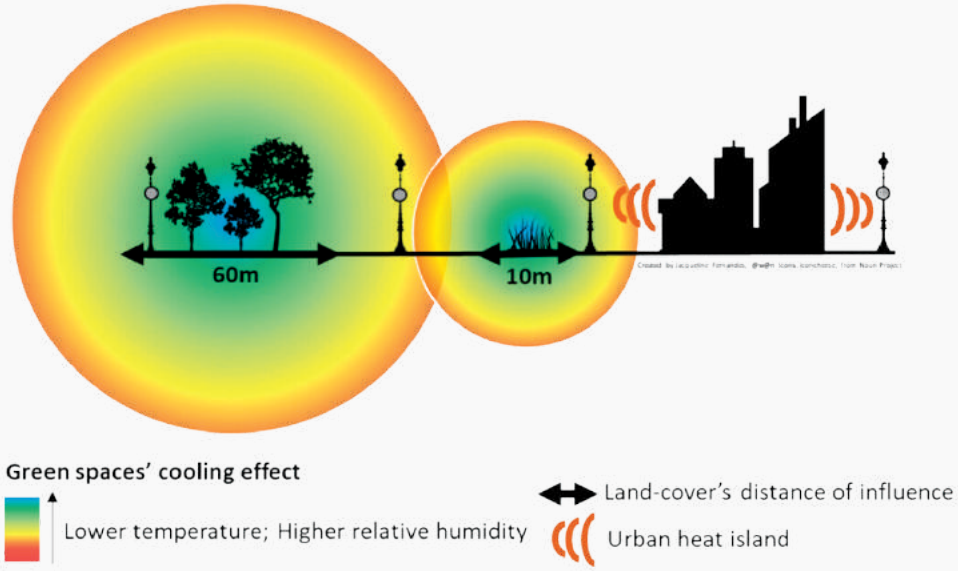

Figure 3: Grilo, et al., 2020

Interestingly, these authors' research has also shown that details are particularly important, with the size and shape of these green spaces having a direct impact on their effectiveness in helping to cool the cities they are built in, with large urban parks with areas of over 10 hectares having the most cooling effect.

In addition to alleviating the effect of the urban heat island, these green spaces could also promote the development of natural ecosystems that can support the biodiversity in these areas.

Research has shown that biodiversity in urban areas is vital for functions such as restoring contaminated soil, lessening noise, feeding and supplying locals with raw resources, and so forth (Xuancheng et al., 2022). In this case, the urban green space cooling effect demonstrates a positive impact on the wider ecosystem and the services it provides to the community.

The UAE has taken a number of strategies in its attempt to tackle water-related challenges in the country, that unfortunately don't explore rainwater capturing, some of them include:

- The Water Security Strategy 2036 aims to ensure sustainable access to water during normal emergency conditions, with targets such as reducing CO2 emissions associated with the water desalination process.
- The COP28 Presidency pushed the Water Agenda in collaboration with the Netherlands and Tajikistan, looking at "freshwater restoration and conservation, infrastructure for urban water resilience and integrated governance and management of water-food systems" (Hazem Hussein 2023)

Priority is mostly allocated to alternative solutions for potable water, to decrease the pressure on water desalination systems, as well as new water management systems for agriculture and municipal water.

SOMA MATER has a number of recommendations to be applied at a systems level which we will address later in the paper.

Water Policy Analysis

Examining Strategies for Sustainable Solutions

In order to better understand the efforts at a regional level, SOMA MATER has looked at the current leading policies and master-plans in the UAE and KSA to identify how water is being addressed as well as a comparison to the Singapore policy, representing a small state with water security challenges.

Saudi Arabia's Example

The role that the government plays in increasing urban green spaces through its policies and strategies is undeniable. Saudi Arabia for example has provided a leading example in its efforts of increasing greening nationally and reducing desertification. The Saudi Green Initiative is an investment of more than $186billion into reducing the Kingdom's emissions, protecting its land and sea, and also greening Saudi. One of its 77 initiatives include the planting of 49 million trees throughout the Kingdom, of which 4 million will be lemon trees using treated wastewater, and had its first phase initiated in January of 2023. The initiative aims to aid the kingdom's food security goals, better utilize its rainwater and groundwater, but also increase its green spaces in areas like Makkah, Asir, Al-Baha, and Jazan, Riyadh, Eastern Province, Makkah, Najran, Qassim, Madinah, Al-Baha, Asir, and Jazan (Zawya, 2023). In the beginning of 2024, precipitation in the Kingdom already begun aligning with the greening project as The National Center for Vegetation Cover Development and Combating Desertification announced that the region of Makkah reported a 600% increase in its vegetation cover from August to December of 2023 as a result of rainfall (Saudi Gazette, 2024). That is, not only is rainfall aiding the increase in green spaces over Saudi Arabia, but the government is also actively investing into increasing green spaces by the planting of trees in these regions.

Abu Dhabi's Integrated Water Resources Management Plan

In 2021, HH Sheikh Hamdan bin Zayed Al Nahyan, Chairman of the board of directors of the Environment Agency Abu Dhabi (EAD) announced the Emirate's Integrated Water Resources Management Plan to emphasize the importance of water resources for economic, social and environmental development. The plan aims to optimize water resources through governance and technical based solutions. One of the aims for recycled water is to expand it for new special development projects such as green spaces and residential parks (EAD, 2021).

Figure 5: EAD Integrated Water Resources Management Plan in Abu Dhabi

Dubai 2040 Urban Master Plan

In 2021, HH Shaikh Mohammed bin Rashed Al Maktoum, Vice President and Prime Minister of the UAE and Ruler of Dubai approved the Dubai 2040 Urban Master Plan with the objectives of upgrading urban areas, utilizing resources more efficiently, and developing greener, more inclusive communities to improve the livelihood and environment of residents in a sustainable and flexible manner (UAE Gov). The plan specifically aims to double green and leisure areas with a goal to attain a composition where 60% of the Emirate's overall area comprises nature reserves and rural areas (UAE Gov).

SOMA MATER believes that harvesting rainwater into developing more green space in major urban areas in the UAE would assist rainfall as mentioned in previous sections of this paper, but would also align with the achievement of the Dubai 2040 Urban Master Plan.

Dubai Social Agenda 33

This infrastructure will undeniably be met by an increasing population in UAE's urban areas. In early January of 2024, HH Sheikh Mohammed bin Rashed Al Maktoum announced the UAE's recent plan to double the number of Emirati families in Dubai in the following ten years. This strategy falls under the Dubai Social Agenda 33 and will be receiving a funding of over AED 200 billion in order to be accomplished. Therefore, with population expected to continue increasing in Dubai's already crowded cities, the need for intentional green spaces becomes a pressing necessity, especially if the UAE intends on maintaining its urban temperatures within a level that will truly provide its citizens with a better living standard and one of the world's best residential areas, as pointed out in the strategy (The National, 2024).

Singapore

Singapore has implemented various policies and initiatives to encourage rainwater harvesting as part of its broader strategy for sustainable water management and urban greening. The city-state faces similar challenges as the UAE's major cities with its high buildings, growing population, and low water availability making efficient water use and green space creation critical components of its urban planning.

> Most of the updates in water management systems entail incorporating rainwater harvesting systems in certain types of buildings, however they have also mandated green walls and green roofs. This not only decreases the inefficient utilization of the city's water supply but also promotes urban green space cooling effect (SmartWater Online 2024).

Rainwater is being collected for potable and not potable use. Currently, two thirds of Singapore's area is considered to be a water catchment area. For potable use, the rainwater is collected and channeled through drains and canals to be stored in of the reservoirs to be treated for consumption (Ministry of Sustainability and the Environment of Singapore, 2023).

Source: https://waterqualityinsingapore.blogspot.com/2014/06/rainwater-harvesting-in-hdb-flats-check.html

Other countries such as Australia, India and Germany also have rainwater harvesting systems integrated in their urban development strategies but mainly used to supply water in residential buildings and commercial establishments (Utilities One, 2023).

Soma Insights

Green Spaces: Enhancing UAE Rainfall

The UAE has invested large amounts of money into cloud-seeding. SOMA MATER believes that investment should also be directed towards creating natural rain water cycles in the country by creating rich green spaces that act as water capture systems. These systems can also be the focal point of lower temperature microclimates that naturally promote rainfall in the area. This would ensure the investments in cloud seeding to have long term impact into the country's geography and bring about a more permanent temperature reduction in both urban and rural areas. SOMA MATER's recommended approach is to direct investment into developing urban green spaces that focus on capturing water, creating water permeability into the earth, cooling the surrounding infrastructure, as they assist in the urban cooling effect (as described above). Investment in rural green spaces, would help manage water capture during rain periods (induced and natural) to grow larger biodiverse greenspaces, reduce flood accumulation, and protect remote residential areas and infrastructure. If these investments were to be made with sound water capture and management design and practices, the UAE could extend the return on investment of increased rainfall from cloud seeding, and potentially reverse the mean average temperature trend as well.

In line with Dubai 2040 Urban Master Plan and the country's overall transition towards a greener UAE, re-using harvested rainwater as a way to increase urban green spaces is crucial to ensure a sustainable, cost-efficient and realistic strategy. Similar strategies have been implemented in many countries around the world, to decrease dependence on natural water resources as main resources for municipal water supply such as in Singapore, Germany and Australia, and to be integrated in the building of residential and commercial establishments.

Unfortunately the UAE's infrastructure does not demonstrate effective harvesting and draining of rainwater, which causes disruption to the economy and damages infrastructure. It is crucial that the UAE identifies the best way to prevent floods from happening while ensuring the water gets utilized efficiently.

Considering that the mountainous rural areas receive larger amounts of rain than the urban areas, there is untapped potential in harnessing this water in particular. The use of rainwater captured in rural areas as a potential to improve water access for urban areas addresses water scarcity and supplements municipal water supply. The improvement of infrastructure for water collection, dams and reservoirs, is important as well as exploring the water supply network between rural and urban areas. In urban settings, rainwater harvesting can play a critical role in mitigating water scarcity and sustainable development. It can be used for non-potable applications after appropriate treatment, and its integration with other approaches such as greywater recycling and green infrastructure.

It is important to point out the limitations of such solutions, especially rainwater harvesting in arid countries. Although cloud seeding has shown to have improved rainfall to a certain extent in the UAE, the inconsistencies in rainfall patterns can cause variability in water availability for green spaces. For that reason, SOMA MATER also encourages the sector of academia in the UAE to direct their work towards urban development and how water systems can be aligned with them. Additionally, it is critically essential to compare the cost of the current rainwater harvesting system to the budget to cloud seeding and understand the impact long-term of both solutions and their value.

Conclusion

In conclusion, the UAE's geographic location points to the growing importance of water availability in the region. With irregular weather patterns and inefficient infrastructure to manage its impact, SOMA MATER urges the UAE government to develop strategies to harvest rainwater and flash floods around the country to mitigate the negative impacts and capitalize on the water capture opportunity. Furthermore, climate change and the expected population growth create challenges of keeping the urban areas at a tolerable temperature in the future. Although the UAE has invested in several cloud-seeding projects, and dams to harvest rainwater, there is still the need to better harvest this rainfall and invest into green spaces, assisting in the cooling effect, while stimulating more rain in the long-run. These spaces would also be places to establish natural ecosystems that can sustain biodiversity, further delivering value in ecosystem services.

The UAE has an untapped potential for water sourcing in harvesting rainwater. In a future where water security, mitigating average temperature rise and extreme weather impacts are all being felt, further research and investment in applied solutions are necessary. Ensuring the capital that is invested into short term solutions, like cloud seeding, can have more cumulative impact in a water capture system. The UAE then has an opportunity to bring a solution to the region.

The implications of this paper extend beyond the borders of the UAE, serving as a valuable trial case for arid and rapidly urbanizing countries regionally. While other countries have implemented their own rainwater management systems, which the UAE can learn a lot from, it has been observed that these systems specifically target houses and public establishments, working at a smaller scale.

For countries in the GCC and MENA region, the focus is very evidently on creating and improving green spaces to reduce the urban heat island effect in some, and overall temperatures in others.

SOMA MATER believes that exploring rainwater capturing solutions at large scale would be valuable for the region to thrive.

SOMA MATER sees this work as a base of inspiration for innovative solutions for the region's sustainable urban development.

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BUSINESS BAY – DUBAI, UAE

CONNECT@SOMAMATER.COM
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