Sustainable Water Management in Coastal Urban Planning of Abu Dhabi: A Case Study of South Mussafah Eco-District

Maisa Jarjous

Master of Urban Planning, College of Art, Architecture and Design (CAAD), American University of Sharjah (AUS)

CONTENTS

INTRODUCTION

GLOBAL PERSPECTIVE

LOCAL PERSPECTIVE

STRATEGIES, POLICES, & SOLUTIONS

THEME 1: WATER PRODUCTION

THEME 2: WASTEWATER TREATMENT AND RECYCLING

THEME 3: WATER CONSERVING

THEME 4: MANAGING RAINWATER

KEY TAKEWAYS

RAISING AWARENESS

ACKNOWLEDGMENTS

CONTRIBUTING STAKEHOLDERS

AUTHOR BIOGRAPHY

INTRODUCTION: GLOBAL PERPECTIVE

Climate change is the biggest and most serious challenge we face now. Much of this challenge centres around the way we treat the most important source of human survival: Water.

> *"Alarmingly, the earth has little potable water. Of the global water supply, 97% is in the form of salt water. Only 3% is fresh, only a fraction of that is accessible, and two thirds of that is ice. Only 1% is available for human consumption and use, agriculture, and industry. The renewable freshwater on earth (rainfall) is only 0.008% of all global water".*

- Water production, conservation, and recycling methods are critical to sustain access to potable water, especially urgent in the desert areas of the Gulf generally and in countries like the United Arab Emirates (UAE).
- To that end, this research investigates urban planning strategies, techniques, and policies to deal sustainably with water management for a hypothetical coastal eco-district in Abu Dhabi.

INTRODUCTION: LOCAL PERSPECTIVE

In the context of Abu Dhabi where most developments are along the coastline much of this challenge centres around the way we treat the most important source of human survival: Water.

GROUND WATER

Groundwater is the only source of natural fresh water in the emirate of AD and mainly used for agriculture and afforestation.

DESALINATION

Desalination plants provide potable water for the emirate of Abu Dhabi - estimated to have one of the highest rates of daily domestic water consumption= 550 litters per day / per capita.

TREATED WASTEWATER

Currently only 51% of all treated water is recycled, while the rest is discharged into the environment.

STRATEGIES, POLICIES, & SOLUTIONS

THEME 1: WATER PRODUCTION

✗ **Desalination:** is not feasible for a hypothetical Eco-district site. Other recommendations for household water management:

- ✓ **Inside the house:** Micro-desalination.
- ✓ **Outside the house:** Recycled water.

✓ **Micro Desalination** a single-purpose unit to turn dirty or salt water to drinkable water that is usable for a neighborhood scale.

- **Source of energy:** Solar energy.
- **Space needed, i.e., size of the machines:** 2 m X 1.2m and can be placed either on the roof or in the backyard.

✓ **Water from Fog:** It is a technique used to capture water from fog.

- **Source of energy:** Fog or humidity.
- **Space needed, i.e., size of the machines:** a single 2 m X 24 m panel with a surface area of 48 m2.


Desalination – brine discharge


Micro-desalination


Water from Fog

STRATEGIES, POLICIES, & SOLUTIONS

THEME 1: WATER PRODUCTION

- **Solar Waterpower Collector:** is a water-production device operating with solar energy to produce water from the sun.
  - **Source of energy:** Solar energy.
  - **Space needed, i.e., size of the machines:** 6m (L) x 2m (W) x 2m (H) and weight 6000kg.
- **Water Wind Turbine:** is a single wind turbine that includes a compressor which pulls air to generate condensation.
  - **Source of energy:** Wind.
  - **Space needed, i.e., size of the machines:** 24m (H) and 13m (Diameter).
- **Rainwater Harvesting:** is to reuse rainwater captured within the building or community.
  - **Source of energy:** no energy required.
  - **Space needed, i.e., size of the tank:** it varies depending on the supply of water from the roof.

Solar Waterpower Collectors

Water Wind Turbine


Rainwater Harvesting

STRATEGIES, POLICIES, & SOLUTIONS

THEME 2: WASTEWATER TREATMENT AND RECYCLING

✓ **Eco-Machine:** also known as a “living machine” purifies wastewater without chemicals.

- **Source of energy:** Solar energy.
- **Space needed, i.e., size of the machines**: it can process up to 7,000 residents, so each neighbourhood may require one Eco-machine.

✓ **Constructed Wetlands:** a large, shallow, artificial lagoons containing vegetation and animal life.

- **Wetland size**: it depends on the catchment area size.
- **Scale**: recommended for a small neighbourhood of about 20 homes due to distance requirements to avoid odour.

✗ **Anaerobic Wastewater Treatment** is an enclosed system without the need for air or oxygen to treat wastewater.

- **Scale:** recommended for neighborhood scale to treat wastewater for several households in a shared facility.


Eco-Machine (Omega Centre)


Constructed Wetlands (Al Waist Wildlife)


Anaerobic Wastewater Treatment

STRATEGIES, POLICIES, & SOLUTIONS

THEME 3: WATER CONSERVING

- **Native Plants:** plants that have adapted to local environmental conditions that reduce and eliminate the need for irrigation.
    - Native plants (xeriscaping) can reduce water use by 50 or 75 percent.
    - ESTIDAMA code compliance reduces domestic water demand in public areas by 40% to 50% but residential up to 25% “user satisfaction”.
- **Water Conserving Fixtures:** water conserving plumbing fixtures.
    - **Showerhead:** flow rate of less than 2.5 gallons per minute.
    - **Toilets:** less than 1.6 gallons per flush compared to 3.6 gallons in older toilets.
    - **Faucets:** flow rate of 1.5 gallons compared to 2.5 gallons per minute.
    - It is important to help improve wastewater quality by using Green Cleaning Policy for cleaning agents i.e., biodegradable products to reduce load on wastewater treatment facility.

Native Plant in UAE – Red Bristle grass

Native Plant in UAE – Al Ghaf tree

Water Conserving Faucet

STRATEGIES, POLICIES, & SOLUTIONS

THEME 4: MANAGING RAINWATER

✓ **Bioswales:** on location systems that captures rainwater close to the source.

- **Scale:** on a district level, ensure water source control for each building and for streets, sidewalks, and open public areas.

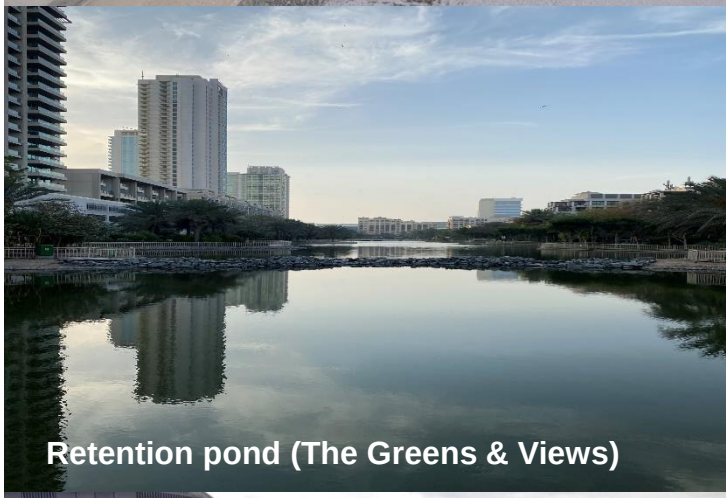
✓ **Detention / Retention Ponds:**

- **Detention Pond:** is an artificial pond that has a holding water capacity of 7 days, but only when groundwater table is low.
- **Retention Pond:** is an artificial pond that holds water then discharges it by connecting to the main network and pump stations.
- Recommended on a neighbourhood scale to minimize discharge to the main network.

✓ **Green Roofs:** capture rainwater, provides rainwater management close to the source, while decreasing greenhouse gas emissions.

- **Scale:** both neighbourhood and district scale.
- Consider indigenous plants and food production.


Bioswales

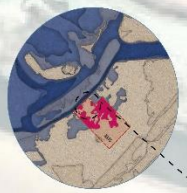

Retention pond (The Greens & Views)


Integrated Solar Panels with Green Roof

Blue infrastructure

Coastal Eco-District Abu Dhabi

UPL 680 | Urban Planning & Research Workshop | Spring 2021 | Maisa Jarjous | g00001720 | 02.06.2021



Site Location

The eco-district is located in the United Arab Emirates, and specifically in the Emirate of Abu Dhabi situated to the South West of Abu Dhabi Industrial City in Mussafah South. The eco-district site is facing Abu Al Sayoyl Nature Preserve to the North West, and mostly by desert land to the South West area of the site. Sheikh Khalifa Bin Zayed International Road is the major highway connecting the site to Abu Dhabi Island and other Emirates through E11 route.

Sealevel Rise by 2029

The present study by Intergovernmental Panel on Climate Change IPCC for the annual sealevel rise (SLR) depicts the average impact on coastal areas by 2029. For urban areas, the level of damage due to SLR would rise to 9.45% and 15.89% in a potential 1.5m and 2m SLR scenarios respectively.

The maximum damage to urban areas would reach about 40% in case SLR attains the 3m level.

Water Consumption

Daily consumption of per capita in the UAE (Environmental Agency, 2018) = 550 liters per day

56,000 people (district occupants) X 550 liters (per capita) = 30,800,000 liters

Water production upto 1000 liters per day at 51% humidity (6 months a year in Abu Dhabi) 1000 liters can serve 500 people per day.

Eco Machine

Source: DMT&S, 2019

Water Conserving

Native plants (xeriscaping)

- Native plants can reduce water use by 50 or 70 percent.

Sustainable Landscape Regulations:

- Control water demand using green building rating known as (ESTIDAMA). It is the sustainability initiative of the Abu Dhabi Urban Planning Council (UPC), follow it to reduce domestic water demand by 10% - including increase in specs for more reduction up to 40% to 50% in public areas and offices but for residential up to 25% due to "user satisfaction" factor.
- Native plants such as cactus family and desert rose can be used around homes, in gardens, in public open spaces, in pocket parks, and in a neighbourhood park to create sustainable landscapes.
- Native plants such as palm trees can be also used along transport routes to promote comfort and sustainability.

Water Conserving Fixtures

The amount of water saved from low-flow plumbing will vary, depending on the model. Example of savings by the gallon:

- Showerheads, efficient models have a flow rate of less than 2.5 gallons per minute. Newer models drop that number down to two gallons per minute.
- Low-flow toilets average less than 1.6 gallons per flush, as opposed to 3.6 gallons in an older toilet.
- Newer faucets flow rate is 1.5 gallons per minute or less compared to older faucets 2.5 gallons per minute.
- Lastly, it is important to improve water quality by using for example, Green Cleaning Policy/ Agents biodegradable products to reduce load on the treatment facility.

Water Production

Solar Waterpower Collectors: Water-production device operating with solar energy to produce 500 litres per day feasible for a neighborhood scale.

Water Wind Turbine: A single WMS1000 wind turbine that eludes a compressor which pulls in air to generate condensation. It can produce between 1200 – 1800 litres per day feasible for a neighborhood scale.

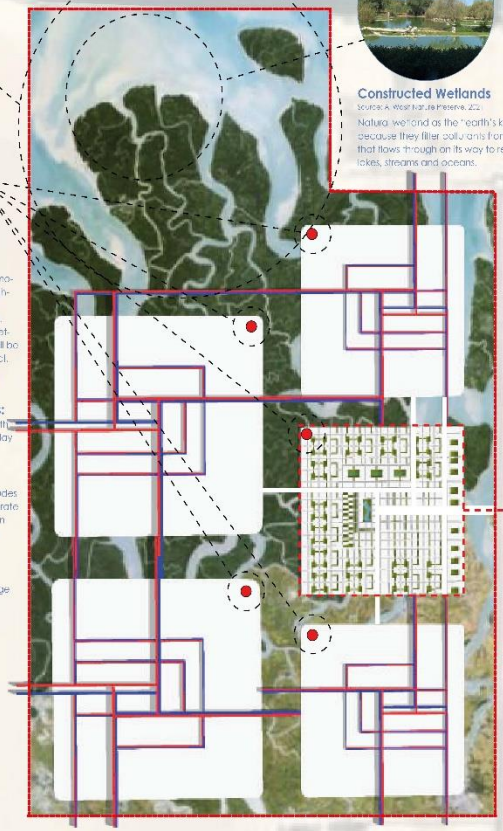
Rain Harvesting: Residential cisterns store about 1000 liters of storage per person suitable for household use.

Palms and Cycads

Low Shrubs and Bushes

Wetland Plants

Source: Landscape Engineer in ED, 2021



Constructed Wetlands

Source: A. West Nature Reserve, 2021

Natural wetland as the "earth's kidneys" because they filter pollutants from water that flows through on its way to receiving lakes, streams and oceans.

1 Eco Machine

Source: DMT&S, 2021

Section A-A

Source: Bjarke Ingels Group, 2014

Section B-B

Source: Tuttle Studios, 2014

Section C-C

Source: Sasaki Associates 2021

2 Bioswales

3 Retention Pond in a Residential Cluster

4 Shallow Water Streams

5 Water Wind Turbine

6 Green Roofs & Solar Water Panels

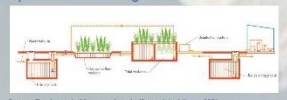
7 Retention Pond in Neighborhood Park

Wastewater Treatment and Recycling

Net Zero Water: 100% of occupants' water use must come from captured precipitation or closed loop water systems that account for downstream ecosystem impacts and that are appropriately purified without the use of chemicals.

Sustainable Water Discharge: 100% of storm water and building water discharge must be managed on-site and integrated into a comprehensive system to feed the project's demands.

Hybrid Wetland Living Machine



Source: The Journal of the American Institute of Architects, 2021

Wastewater comes in many different concentrations, with low or flow fixtures resulting in more concentrated wastewater. Because there is no surface wastewater, the potential for contact with human waste is eliminated. Fans are used to vent out most odors. Installing a Living Machine can contribute to several points under the LEED system, by reducing potable and irrigation water demand and by treating wastewater on site.

Legend

- Primary pipe of water supply
- Secondary pipe of water supply
- Primary pipe of water recycling
- Secondary pipe of water recycling
- Tertiary pipe of water supply
- Tertiary pipe of water recycling

Water Infrastructure Locations

Constrcuted Wetlands

- The size of wetland depends on the catchment area size.
- Sustainable use of wetlands shall be integrated into the district and use plans to ensure sustainable management of the resources.
- Provide water quality treatment within the wetland to protect the mangroves.
- Ensure the protection of wetlands as habitats for species of fauna and flora.

Bioswales

- On district level, ensure water source control and rain harvesting for each building, and for the streets provide bioswales.
- Bioswales will infiltrate about 80-85% of runoff events. It is used in paring lots, sidewalks and open public space areas.

Green Roofs

- Green roofs are feasible on both neighborhood and district scale where commercial and recreational facilities can have green roofs to manage rainwater in the season between November and March.
- It is important to consider indigenous plants to conserve and manage water use.

Retention Pond

- This is implemented on a community scale with local water management to ensure minimum discharge to the main network as it lacks capacity.
- Control and store water and limit the water discharge as per the area development flow rate. Other ways of storing the water within the development: Underground tanks and underground Geocells, modular tanks.

Legend

Buildings

Neighborhood Boundary

KEY TAKEWAYS

RAISING AWARENESS

All above solutions must be accompanied by a comprehensive media coverage and awareness on climate change’s relation to water, why?

- To understand the meaning of this concern and its importance for individuals and society.
- To push people to engage directly in preserving the environment and how to deal with it, while being careful not to waste water.
- To pay attention to gardening in their backyards, and in the ways and conditions of digging wells for agriculture and irrigation and issuing effective laws regarding the last.
- All media outlets must participate in this awareness fully and intensively. It suffices to present a very simple example of how much each person consumes of water per capita/ per day.

ACKNOWLEDGMENTS

A project of this scale is not an individual effort. Consequently, I dedicate this paper to the many individuals who provided support, encouragement, and assistance for its realization. A very special gratitude goes to my faculty members at the College of Architecture, Art and Design at the American University of Sharjah, Dr. Rafael Pizarro O Byrne, Dr. Varkki Pallathucheril, Dr. Jerry Kolo, for their support and input.

Contributing stakeholders

I would like to acknowledge the multistakeholder, speciality consultants, and academia that contributed through interviews and dialogue sessions:

Ministry of Energy & Infrastructure – UAE, Environment Agency – Abu Dhabi (AED), Abu Dhabi Waste Management Canter – Tadweer, Emirates Green Building Council, Emirates Planning Association, American University of Sharjah, Climatize Engineering Consultants, Milieu Environmental Consultants L.L.C., Stantec International, AQUASHI, DEFT & LEED.

Author Biography

Maisa Jarjous: is an award-winning architect and urban planner based in Dubai, United Arab Emirates. I have successfully graduated with a Master's in Urban Planning with Honors (2019-2021) and hold a Bachelor's degree in Architecture (2000-2006) both from the American University of Sharjah. She has over a decade of professional experience in consultancy as a project architect and urban planner managing internal and external working relations with stakeholders, specialty consultants, local authorities, civic leaders, and social scientists with multi-disciplinary and multicultural environments. She has ensured the design and delivery of complex architecture, master planning and city visions projects in the UAE, KSA, Qatar, and North Africa working for reputable international architecture and urban planning firms in the region.

Address: Barsha Heights, Dubai, United Arab Emirates.

Email: mesoster@gmail.com