



Identifying Optimal Locations for MAR by Rainwater in the Kingdom of Bahrain

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Overview

- Introduction
- Groundwater System & Development in Bahrain
- Objective & Methodology
- Results
- Conclusion & Recommendations

Introduction

- Arid conditions, low endowment of renewable freshwater resources
- Since the 1970s sustained socio-economic development, accelerated population growth
- Significant increase in water demands
- Groundwater over-exploitation (Groundwater levels decline and quality deterioration due to seawater intrusion)
- Groundwater management and rehabilitation efforts
 - ❑ **Demand-side:** banning well drilling, wells metering, groundwater tariff, awareness, subsidizing modern irrigation system, banning high water consuming crops (alfalfa), ...
 - ❑ **Supply-side:** major water supply augmentation programs (desalination and treated wastewater reuse), **MAR (by TSE and Rainwater)**

Kingdom of Bahrain

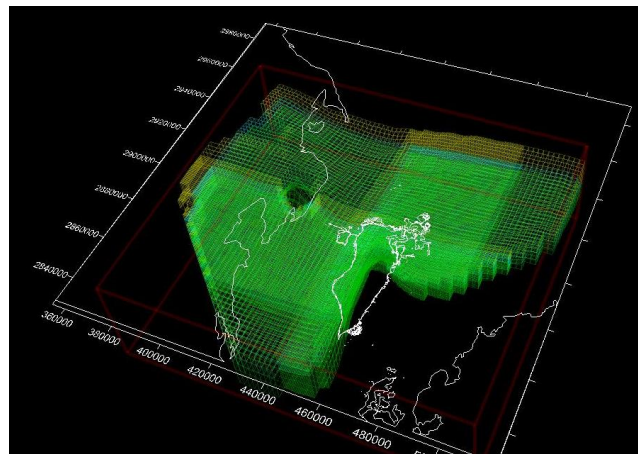


MAR Projects in Bahrain (by Sources of Water)



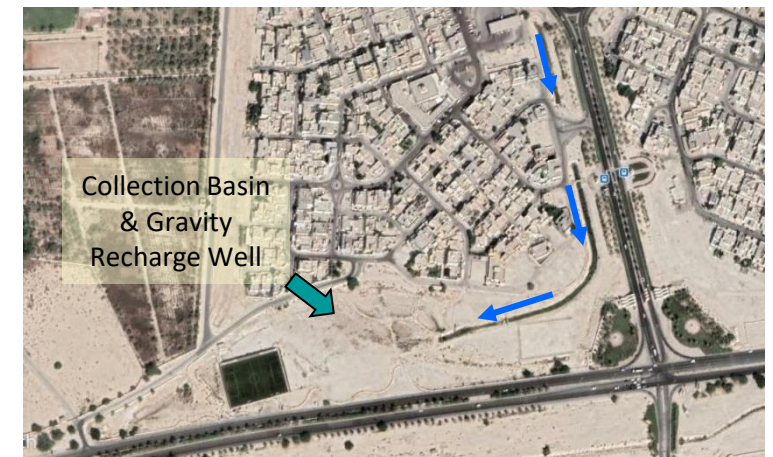
Tertiary Treated Wastewater

- **In progress:** being investigated by Bahrain Water Resources Council
- Within an integrated treated wastewater reuse plan to enhance groundwater storage and combat seawater intrusion
- Currently surplus tertiary treated wastewater = 80,000 m³/day discharged to the sea
- Groundwater Numerical Modeling investigation
- Pilot studies, monitoring & evaluation



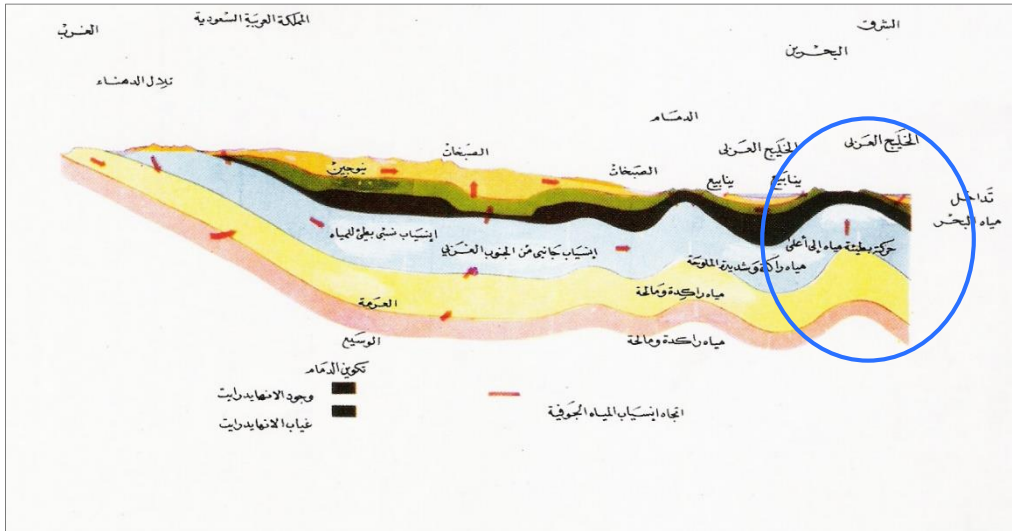
Rainwater/Storm Runoff

- Projects started since 1984
- ~12 project (Al-Noaimi, 2012)
- Majority are ad hoc, isolated investigations
- Variable successes obtained
- Inadequate monitoring and follow-up

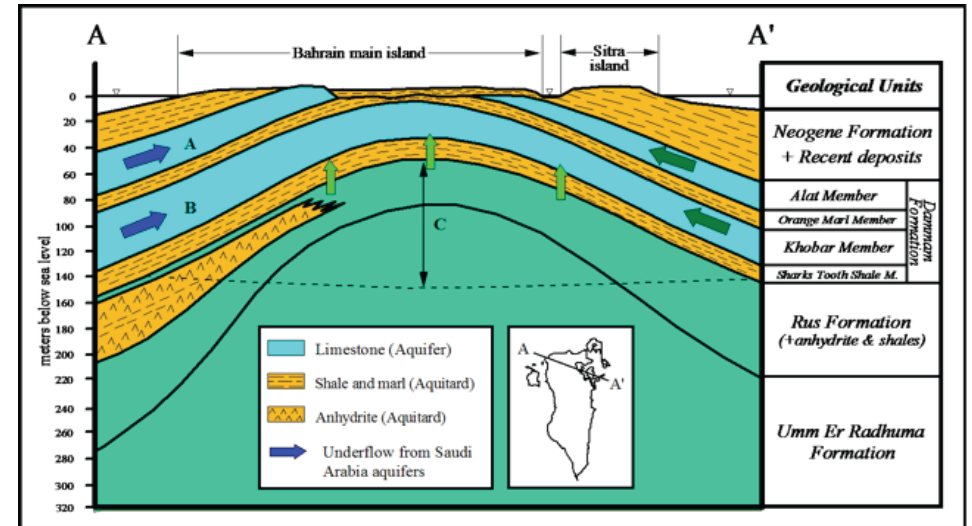


Groundwater System & Development in Bahrain

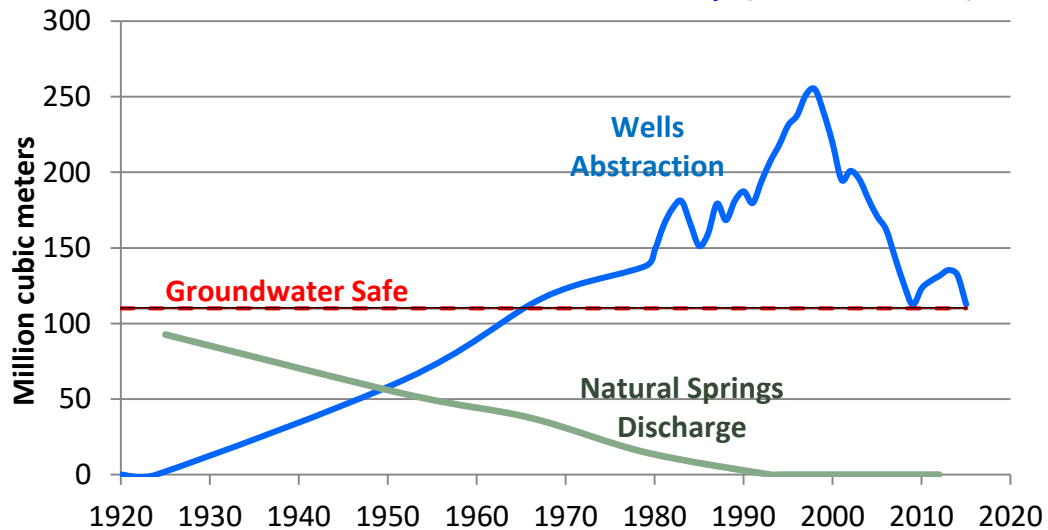
Regional Groundwater System (Eastern Arabian Aquifer)



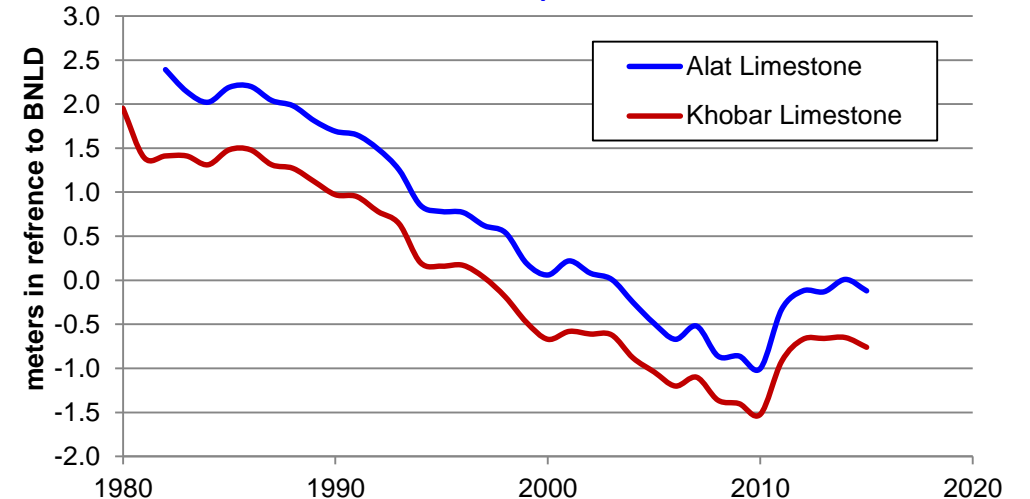
Groundwater System in Bahrain



Groundwater Abstraction History (1920-2017)



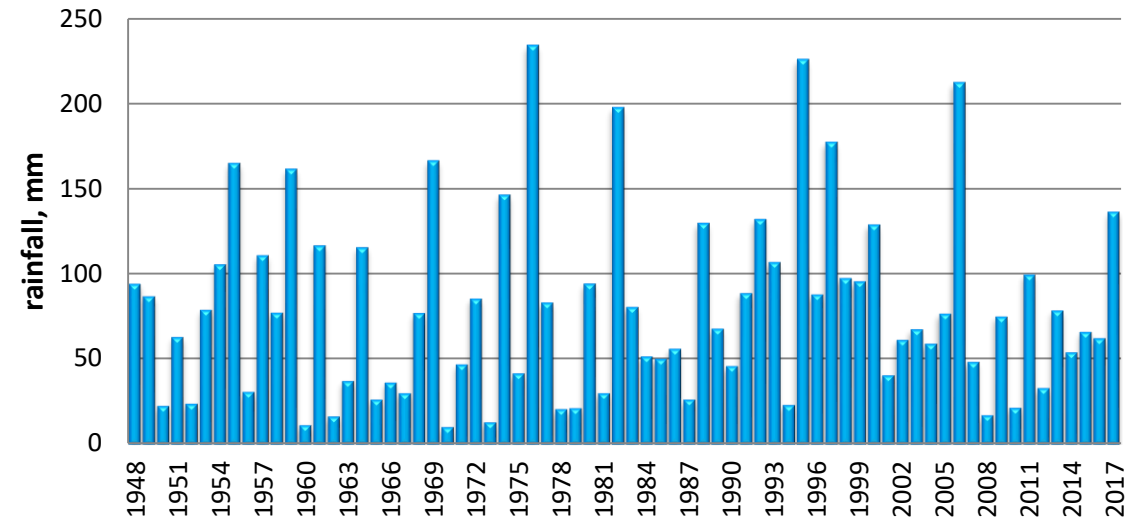
Trends in Dammam Aquifer Water Levels



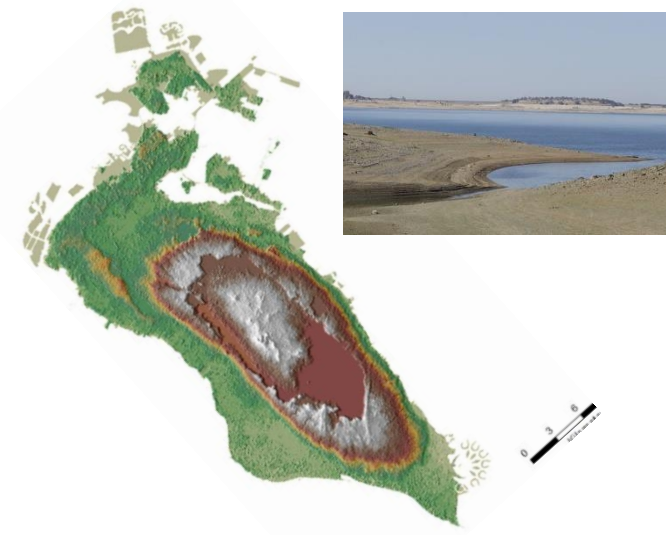
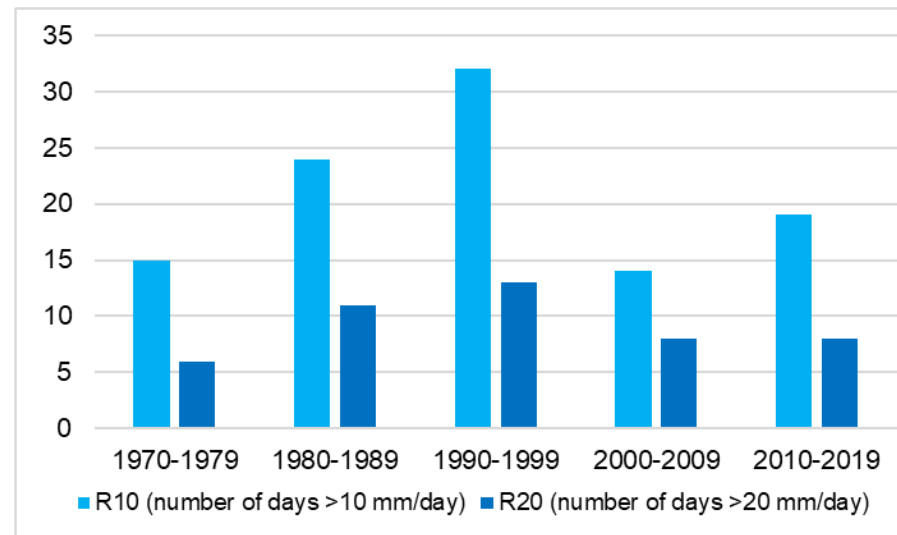
Objective & Methodology

- **Objective:** identifying potential surface locations for WH and MAR by rainwater
- **Methodology**
 - MCDM (criteria definition, standardization, ranking & weighting, and validation)
 - GIS tool (Raster)
 - 8 Criteria selected
 - Geology
 - Geomorphology
 - Soil Type
 - Land Use/Land Cover
 - Slope
 - Curvature
 - Drainage Density
 - Lineaments

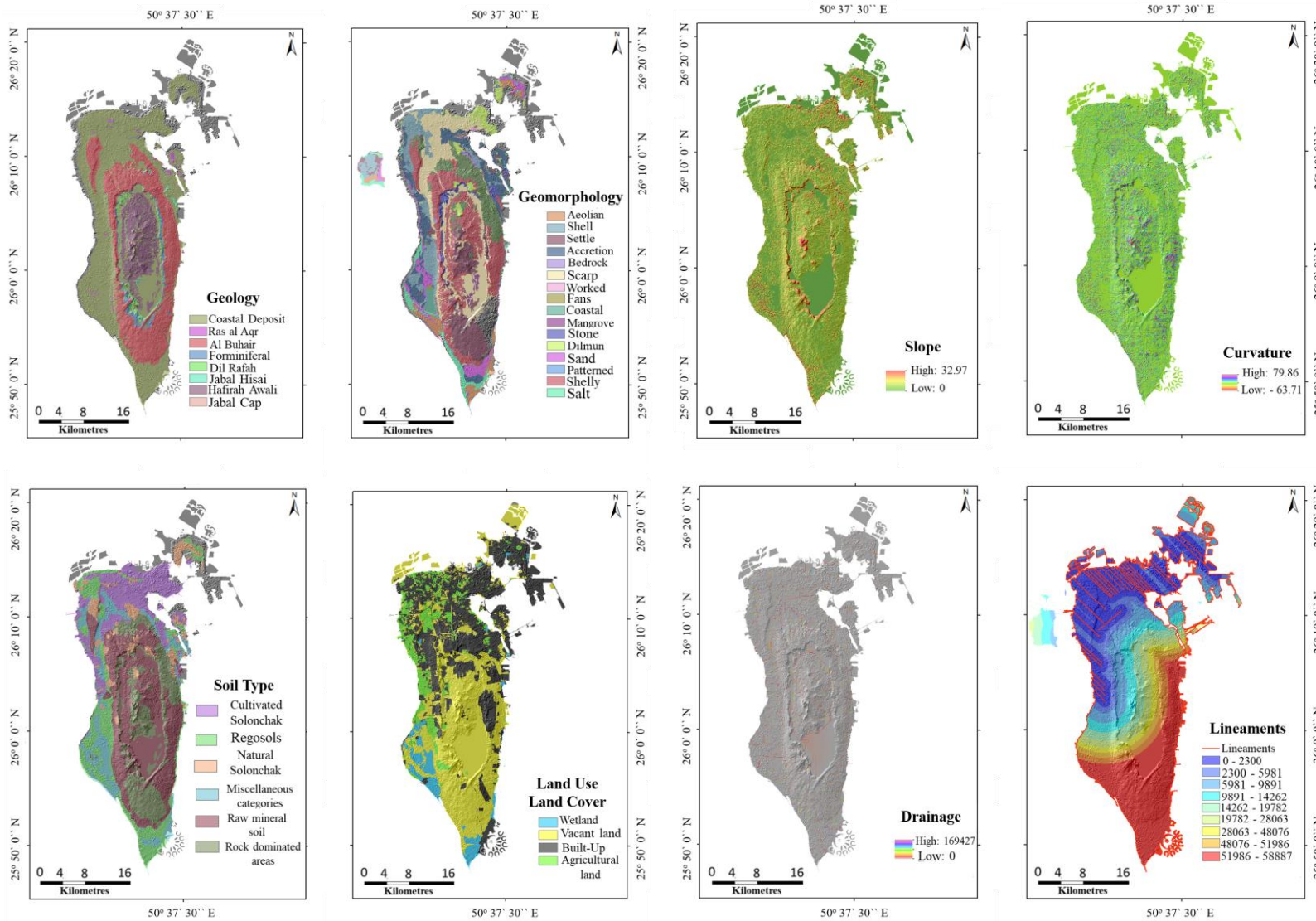
Bahrain Annual Rainfall (1948-2017)



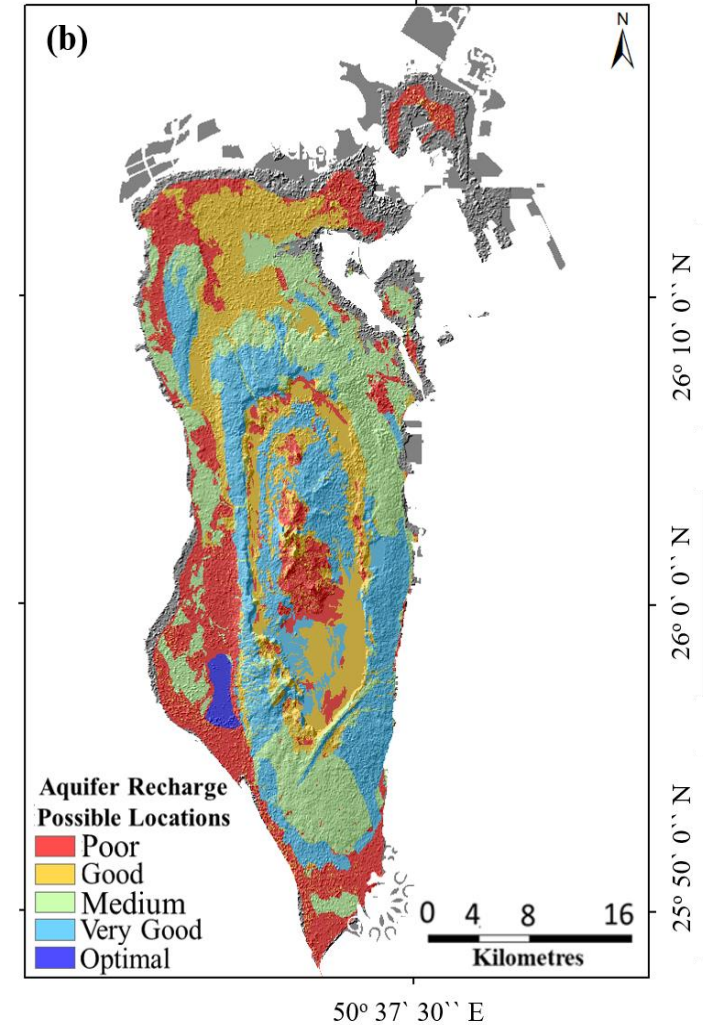
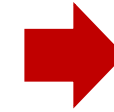
Trends in Participation Extremes (R10 & R20) Bahrain DEM



Results



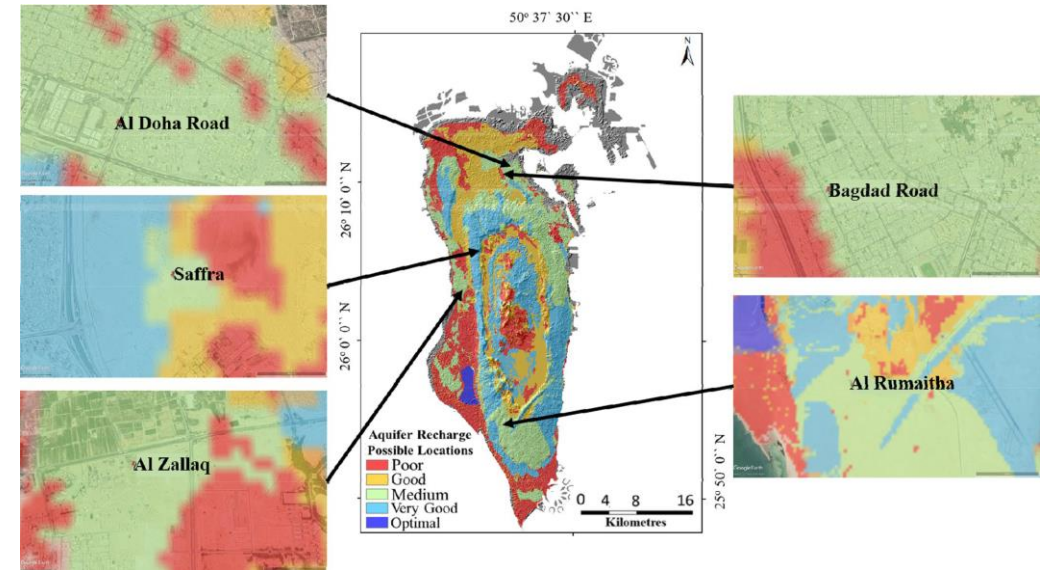
MAR Optimal Locations in Bahrain



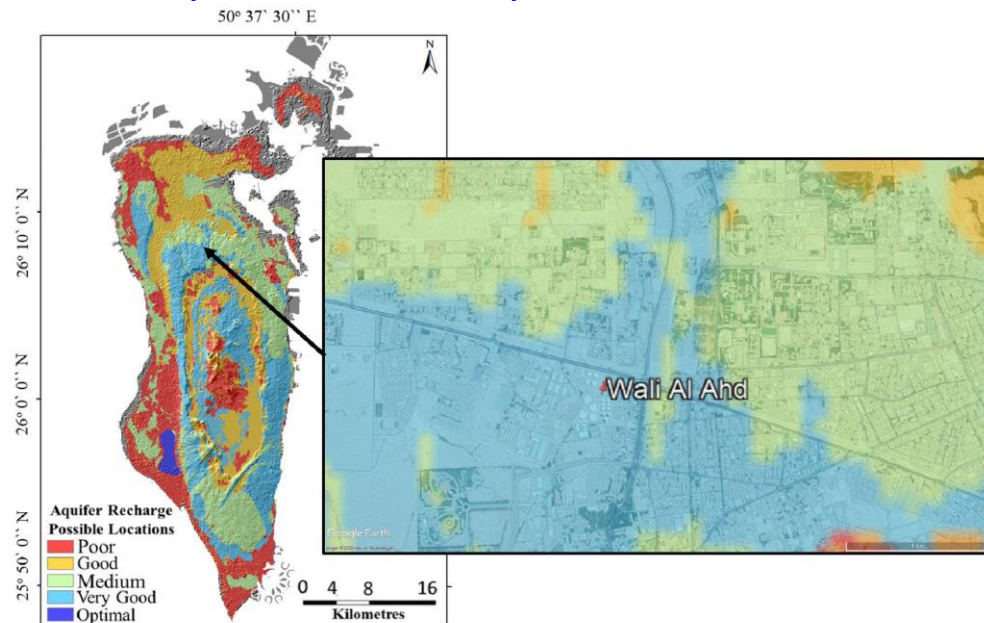
Optimal Suitability for MAR Location



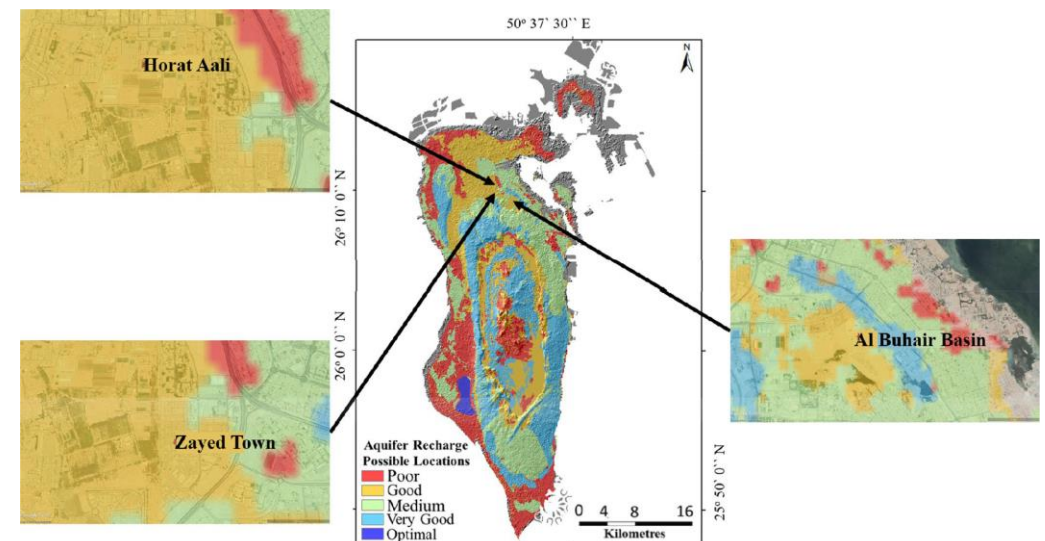
Medium Suitability for MAR Location



Very Good Suitability for MAR Location



Good Suitability for MAR Location



Conclusion & Recommendation

- Implemented MCDM methodology is effective in identifying optimal locations for WH and MAR
- Suitable locations for MAR by rainwater have been identified and have been ranked (most suitable to less suitable)
- Further in-depth investigation for MAR implementation is to be carried on these locations using higher resolution satellite images (current is 30x30m), utilities infrastructure, and depth to groundwater
- To be followed by field investigation (pilot studies) of the selected locations (including monitoring of water levels and water quality), prior to implementing large scale MAR

Credits & Further Details

Earth Systems and Environment

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ORIGINAL ARTICLE



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Thank You!