GIS Application in Groundwater Potential Estimation

CRP 514 – Term Paper

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Outline

1. Introduction
2. Methodology
3. Literature Review
4. Case Study 1
5. Case Study 2
6. Analysis
7. Conclusion

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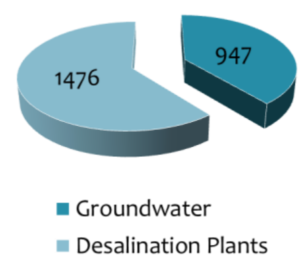
Introduction

* Water is life
* Scarce water in Saudi Arabia
* Groundwater provides **39%**
* Majority of water is used in agriculture

Water Source 2011 (mcm) [3]



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Introduction (cont.)

* Fossil aquifer will be depleted
* Excessive withdrawal in Khobar [2]
* Desalination Plants increase salinity
* Water should be used sustainably
* Hydrogeologists use GIS to estimate quality/quantity of water

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Introduction: Scope

* Data quality and quantity can improve predictions [6]
* Several methods to conduct groundwater estimations
* Two case studies from Saudi Arabia are studied:
  * Wadi Rabigh
  * Wadi Aurnah

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Methodology

Research and literature review are the only method for study in this paper.

Special focus is given to applications in Saudi Arabia.

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Literature Review

947 million cubic meters of groundwater in 2011

7,114 Government wells

240 new wells in 2011

* Agriculture uses **86%** of water usage
* Encourage agriculture out-of-kingdom to reduce demand

Literature Review (cont.)

* In the last decade Hydrologists adopted GIS
* Mapping quality and quantity of groundwater
* Drinking water specifications:
    1. World Health Organization
    2. Ministry of Municipal and Rural Affairs [5]

Literature Review (cont.)

* GIS Capabilities used by Hydrologists:
  * Geo-database
  * Spatial processes
  * Layers overlaying
* GIS enables effective groundwater management

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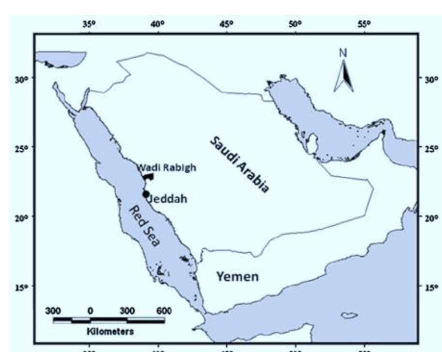
Case Study 1

"A GIS approach for the assessment of groundwater quality in Wadi Rabigh aquifer, Saudi Arabia"



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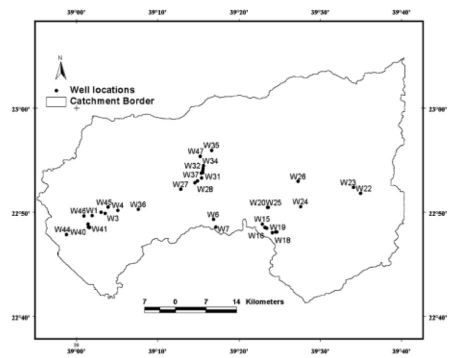
Case Study 1: Data

* Utilize existing well data
  * Locations
  * Analyzed water samples
  * Production data
* Predict well quality



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Case Study 1: Sample Data

* Water samples results:

Well no.	Ca	Mg	Na	K	HCO_3	SO_4	Cl	TDS
1	622.44	133.03	1,250	16.5	162.69	1,228.21	2,198.64	5,964
2	1,270.54	303.27	1,950	72.39	259.49	1,610.18	5,018.47	12,008
4	554.31	24.32	975	19.64	299.82	448.64	2,059.81	4,818
6	152.3	233.47	1,660	19.49	195.23	1,117.08	2,533.55	6,254
7	89.78	50.83	250	14.56	210	272.48	523.12	1,474
16	211.62	112.84	300	6.416	202.2	520.26	612.56	2,206
18	131.66	69.53	130	7.73	156.9	298	388.85	1,380
19	113.43	53.5	125	4.135	237.06	194.28	289.8	1,158

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Case Study 1: Drinking Water

* Comparison with WHO chemical specification:

Parameter	Range in study area	WHO range	Samples within the WHO range
TDS (mg/l)	612–16,780	1,000	4
PH	7.16–8.32	6.5–8.5	30
EC (μs/cm)	1,123–24,500	1,400	1
Ca^{++} (mg/l)	35.27–2,106.22	500 as $CaCo_3$	16
Mg^{++} (mg/l)	10.46–352.64	–	–
Na^{+} (mg/l)	40–4,800	200	11
K^{+} (mg/l)	2.49–72.39	–	–
HCO_3^{-} (mg/l)	36.21–316.83	–	–
SO_4^{-} (mg/l)	60.09–3,026.91	400	12
Cl^{-} (mg/l)	181.51–7,819.74	250	4

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Case Study 1: Methodology

* Select 4 minerals for decision criteria (Ca, Na, Cl and SO_4)
* Total Dissolved Solids (TDS) used for comparison
* Each parameter data is processed separately
* Extrapolated areas are overlaid

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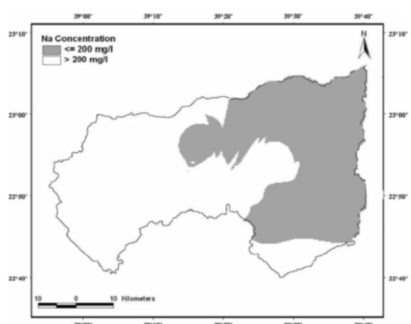
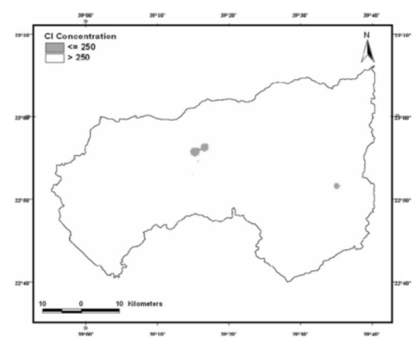
Case Study 1: Geoprocessing





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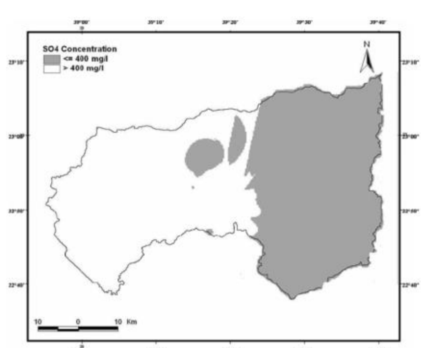
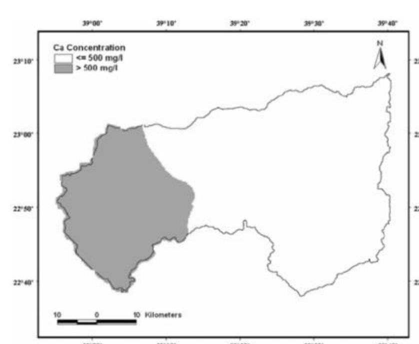
Case Study 1: Geoprocessing





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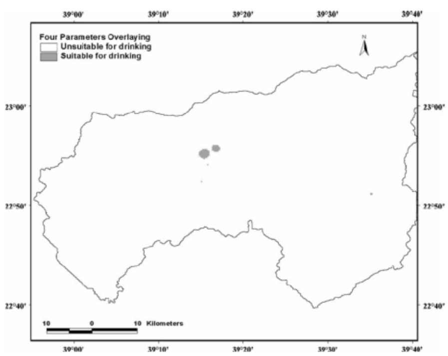
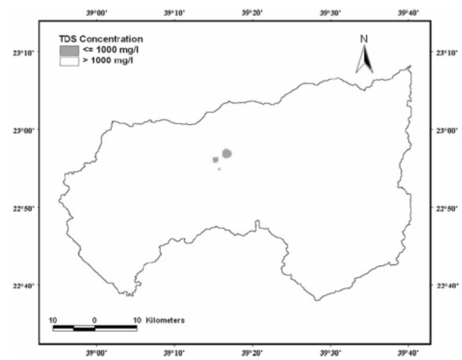
Case Study 1: Results





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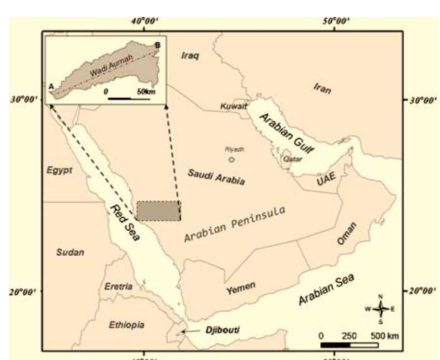
Case Study 2

"Mapping potential areas for groundwater storage in Wadi Aurnah Basin, western Arabian Peninsula, using remote sensing and geographic information system techniques"



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Case Study 2: Data

* 6 Thematic maps created from:
  * ASTER satellite imagery (15 m)
  * Landsat 7 ETM (30 m)
  * Topographic maps
* Calculate potential groundwater areas.

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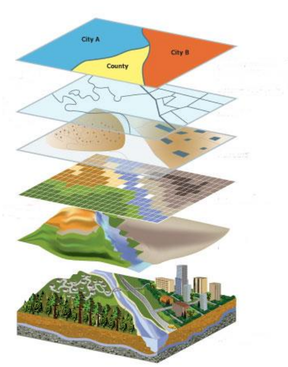
Case Study 2: Thematic Maps

1. Rainfall
2. Lithology
3. Rock Fractures
4. Slope
5. Drainage
6. Land cover



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Case Study 2: Methodology

- Create thematic maps (layers) from satellite imagery
- Classify the layer data
- Assign weights to layers and rates to classes
- Generate groundwater potential map
- Evaluate map based on dug wells

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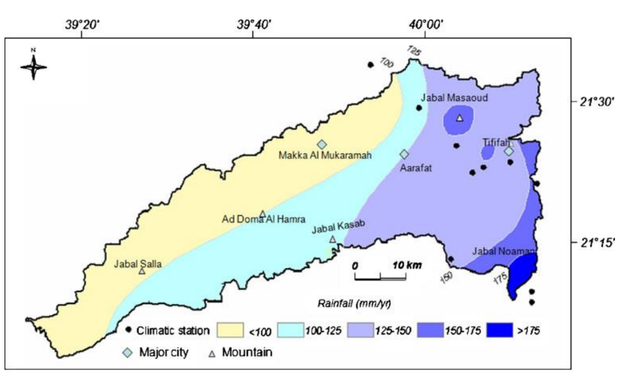
Case Study 2: Rainfall



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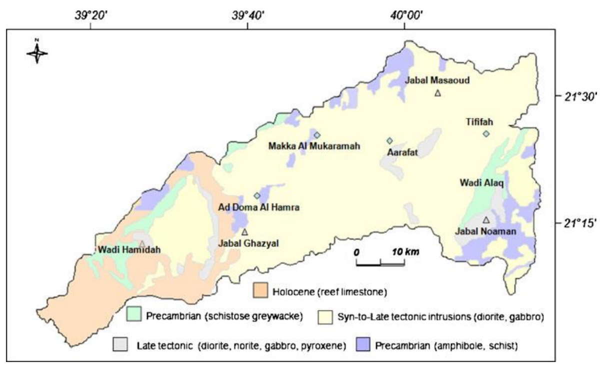
Case Study 2: Lithology



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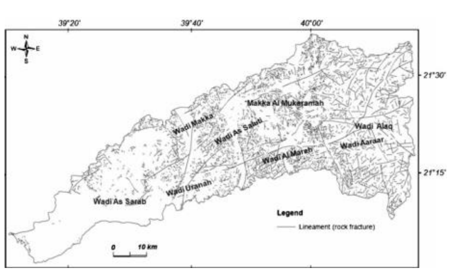
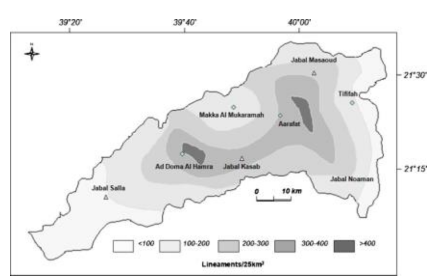
Case Study 2: Rock Fractures





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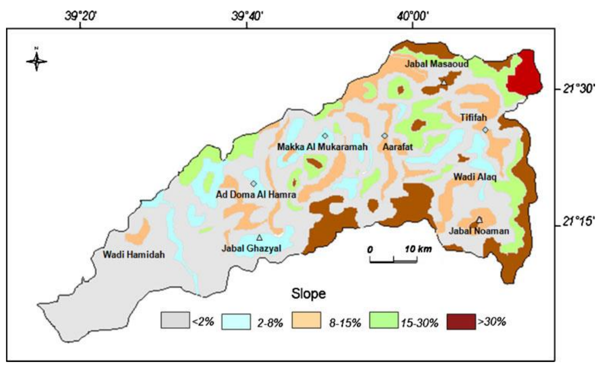
Case Study 2: Slope



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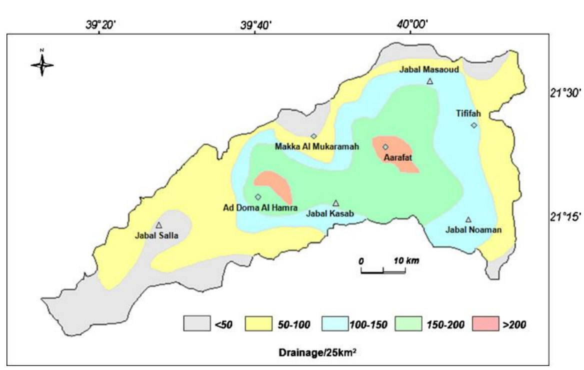
Case Study 2: Drainage



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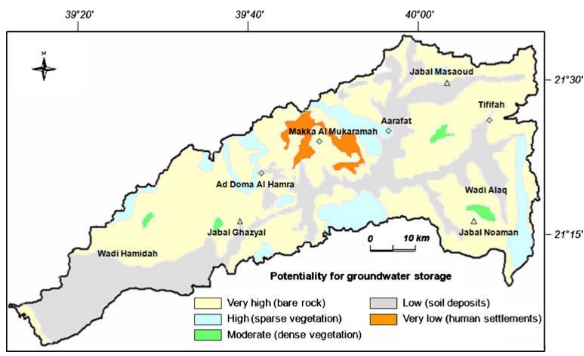
Case Study 2: Land Cover



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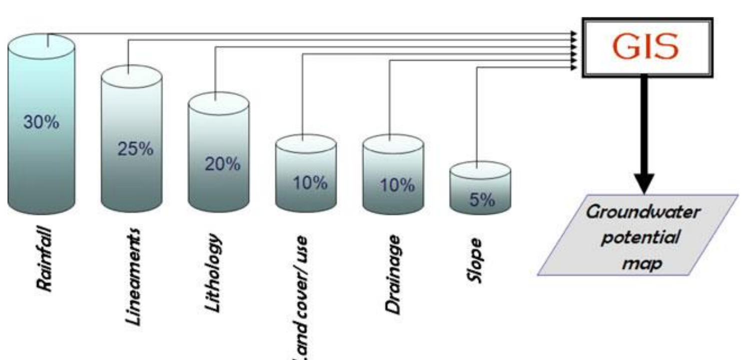
Case Study 2: Geoprocess



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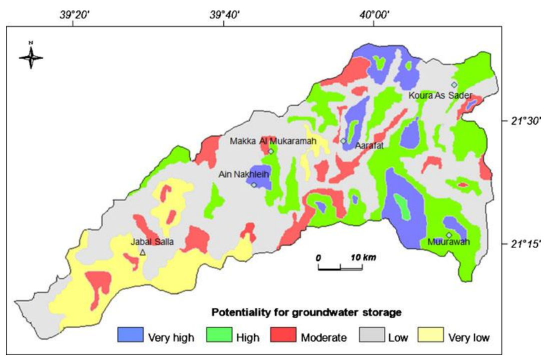
Case Study 2: Results



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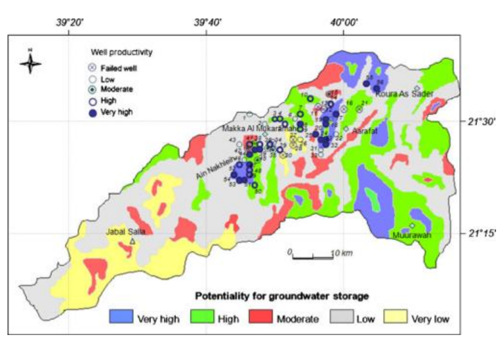
Case Study 2: Verification Wells

* Existing Wells were used to assess accuracy of result (65%)



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Analysis

Case Study 1

* Only water sample results
* Acceptable zones for 4 parameters
* Overlay 4 parameter
* No verification of predictions

Case Study 2

* Multiple remote sensing imagery
* Digitized and processed data
* Calculated potential areas
* Used wells for verification

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Conclusion

* Water shortage call for groundwater management
* Groundwater analysis and prediction by GIS
* Discuss examples of GIS application in groundwater
* More data can be integrated for better predictions.

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Thank You

Q & A