Hydrological Analysis and Flood Hazard Mitigation in Al Ain City, United Arab Emirates (UAE), SE Arabia: GIS and Remote Sensing Implications

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Introduction

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- The lack of fresh water resources is a critical problem that hinder the development in the UAE, rainfall is random and infrequent (~ 110 mm/y). Potential evaporation is very high ~ (1000 mm/y) (Al-Abdein, 2008).

- Groundwater constitutes 70% of the total water production in the UAE (Al Qayidi et al. 2005), facing a problem of increasing salinity due to excessive use for industry and agriculture. Sea water desalinization using oil is an expensive process and implies high carbon footprint.

- Therefore, harvesting rainfall and constructing dams for collecting surface runoff is necessary for supplying the freshwater need and recharging the groundwater aquifers in the study area.

Objectives

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- Investigating the main morphometric properties of Hafit mountain drainage basins (flow direction, stream order, accumulation flow & drainage basins boundaries).
- Identifying the pour points where the maximum amount of surface runoff can be accumulated.
- Suggesting some sites for collecting surface water and constructing dams in Al Ain City.

Methodology

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- The DEM (Digital Elevation Model) that is used in this study is “ASTER GDEM 2”. It has a resolution of 1 arc second & referenced to the WGS84/EGM96 geoid.
- In-order to perform spatial analysis, the DEM has been projected to “WGS 1984 UTM 40N” with a uniform pixel size of 30 m.
- Small imperfections in the surface raster (sinks and peaks) were removed by filling.
- Arc GIS, version 10.1, hydrology tools were used to investigate the flow direction, flow accumulation ratio and stream order, and delineate the sub-basins in the study area.

Study Area

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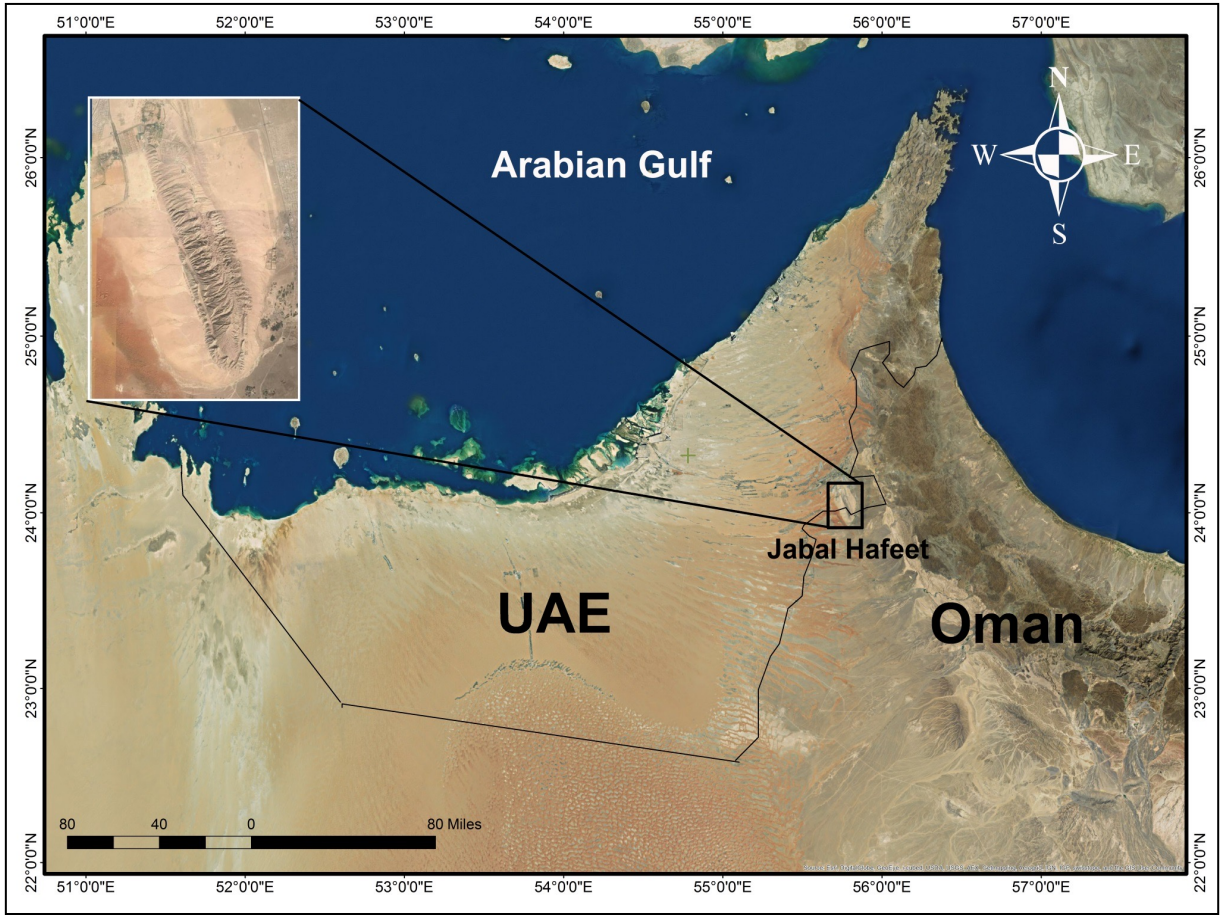
- Hafit Mountain located SE of Al-Ain city, between the UAE and Oman (40° 06' - 23° 58' N and 55° 50' - 55° 42' E) with an altitude of ~1200 m a.s.l.

- It's an elongated NNW-SSW anticline, formed in Tertiary at ~ 60-24 million years ago (Ali et al., 2007).



Result: TIN Surface

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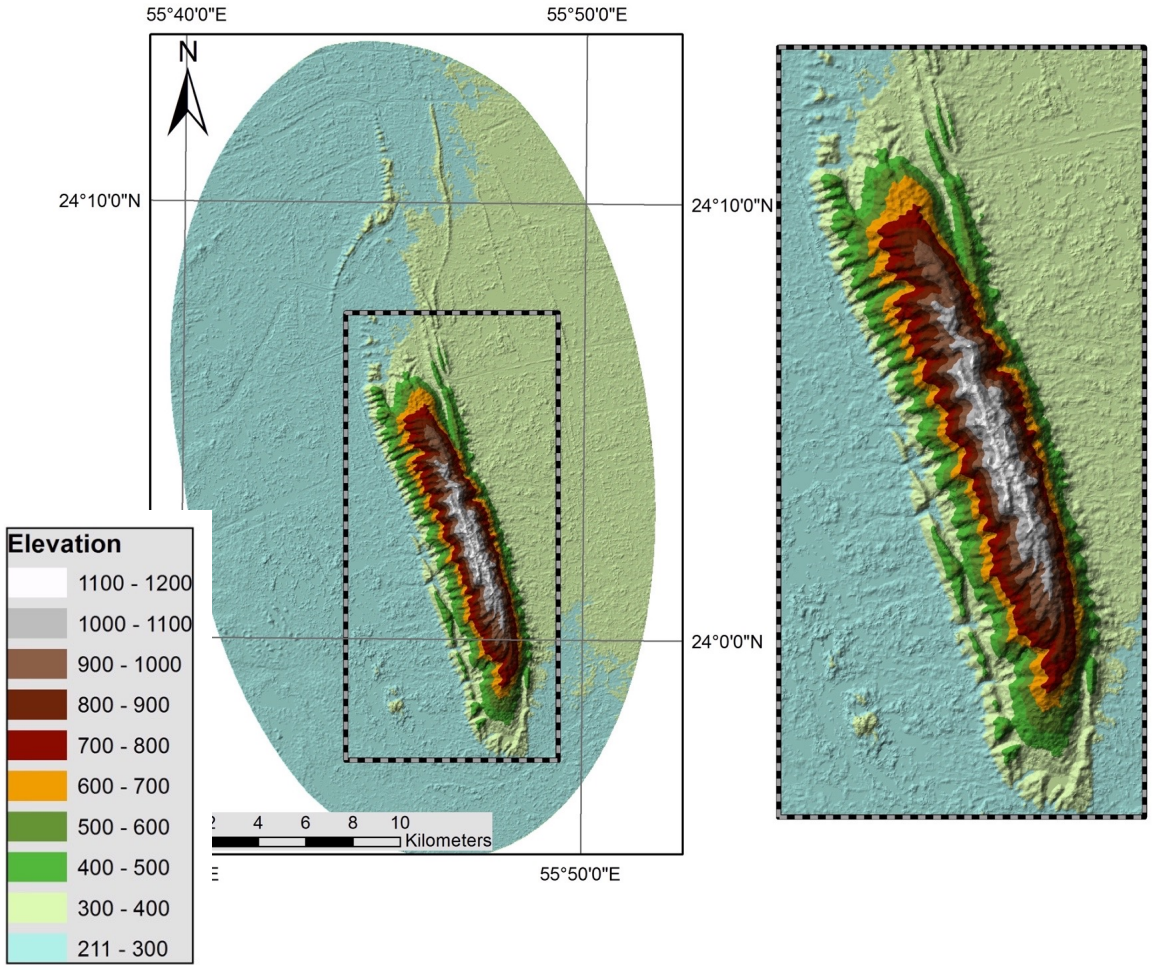
- The TIN surface has been generated from the DEM in order to show the surface morphology.
- It shows a maximum altitude of Hafit Mountain of ~ 1200 m, while the foot of the mountain are at 260 m, where alluvial fans are formed from both sides.
- The high terrains were cut and dissected by gullies and wadis, leaving behind steep ridges, cuestas and hogbacks.
- The low terrains are dominated by deposition and filled with fluvial deposits from the east and west draining wadis creating a quaternary bajada.



Results: Flow Direction

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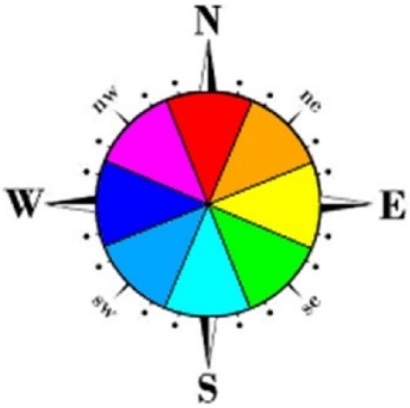
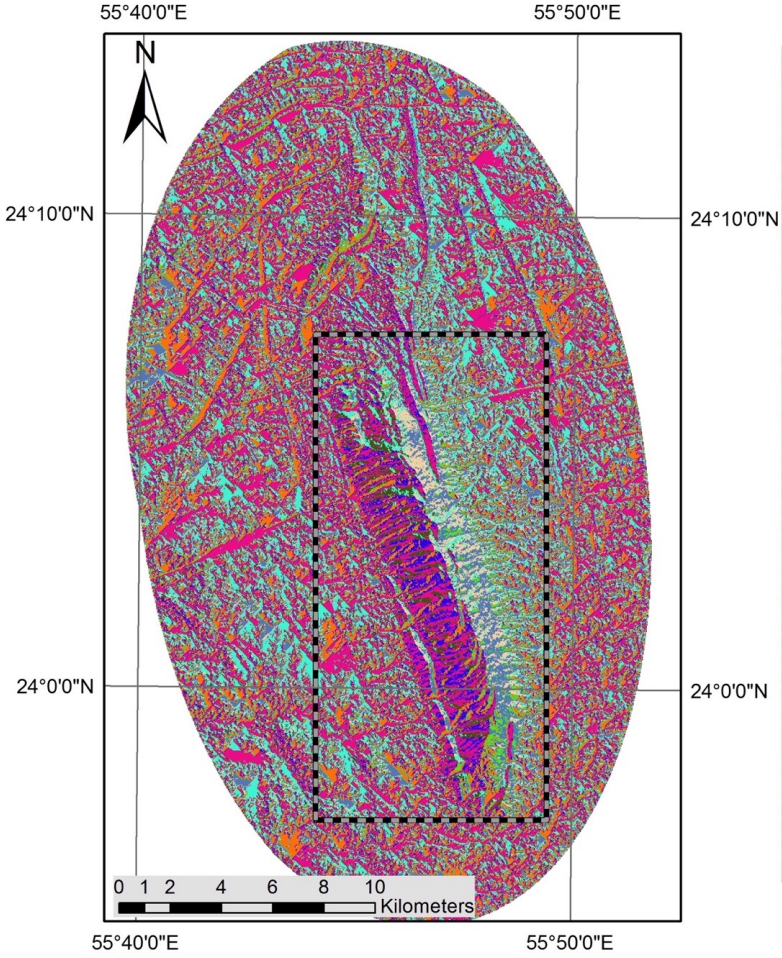
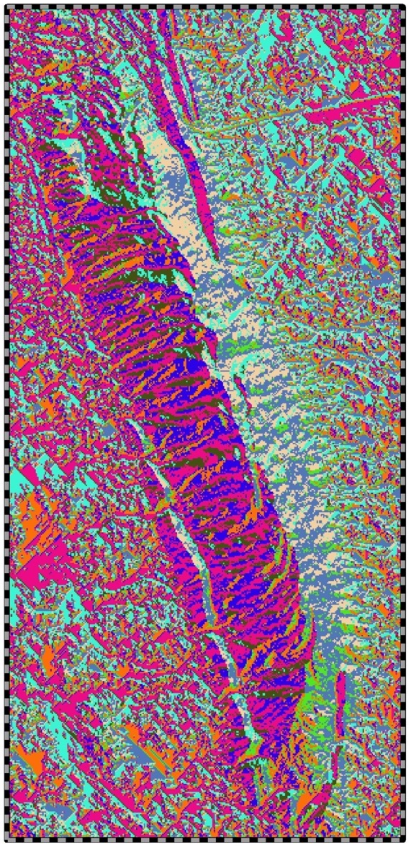
- The main flow direction is toward the northwest, west and southwest west of the study area, following the surface topography and the dipping slopes.
- This explain the abundance of surface and groundwater northwest and west of Hafit Moutain.







Results: Flow Accumulation

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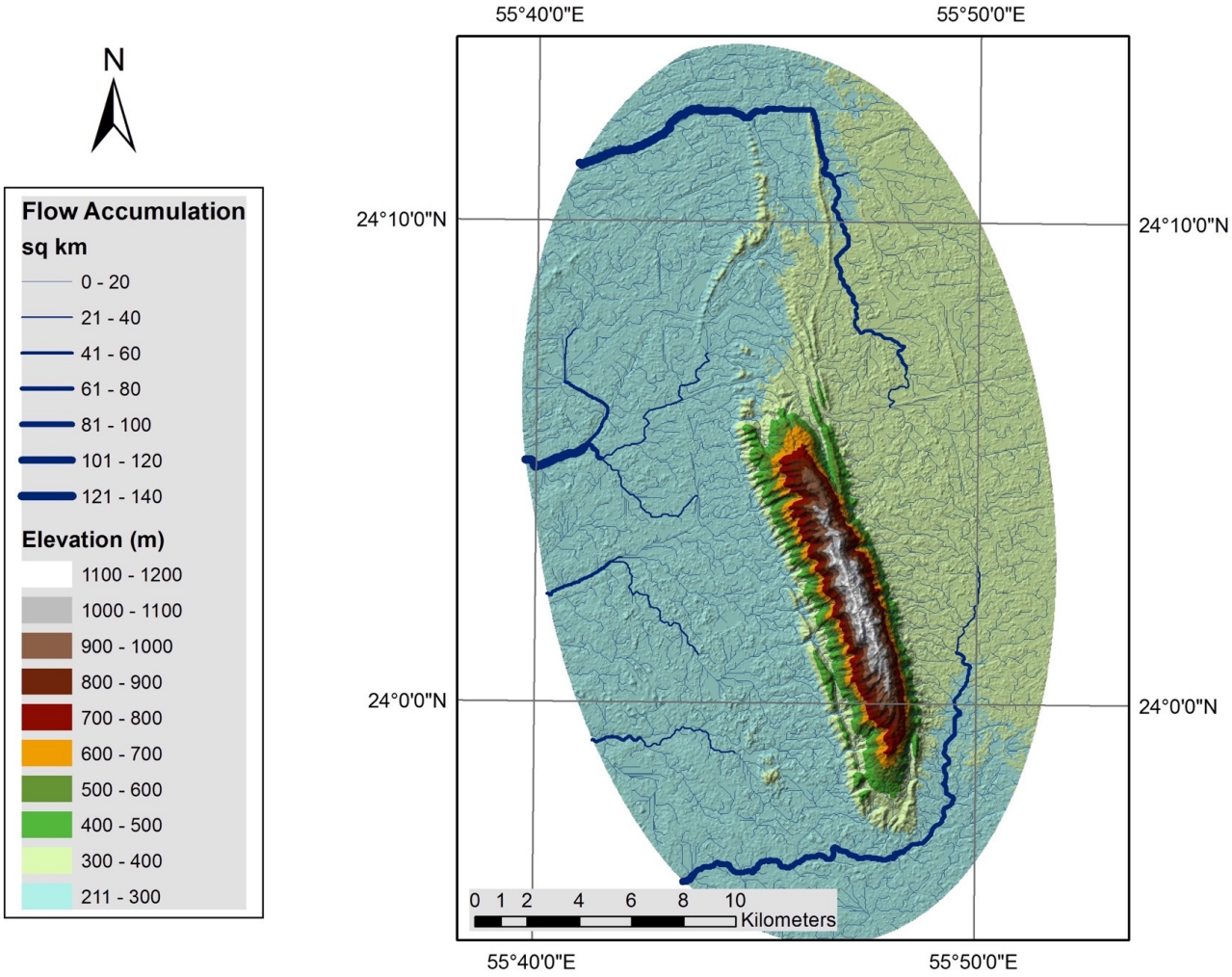
- Flow accumulation operation creates a raster that enable delineating all drainage basins. Water Input for these basins is the flow accumulation.
- the highest flow accumulation occurs in the northwestern part of Wadi Al Ain (140 km^2). This explain the reoccurence of flood in Al Ain City in several years.
- Surface water input that feeds Wadi Al Ain originate from both Hajar Omani Mountains to the east and Hafit Mountain to the west.



Result: Stream Order

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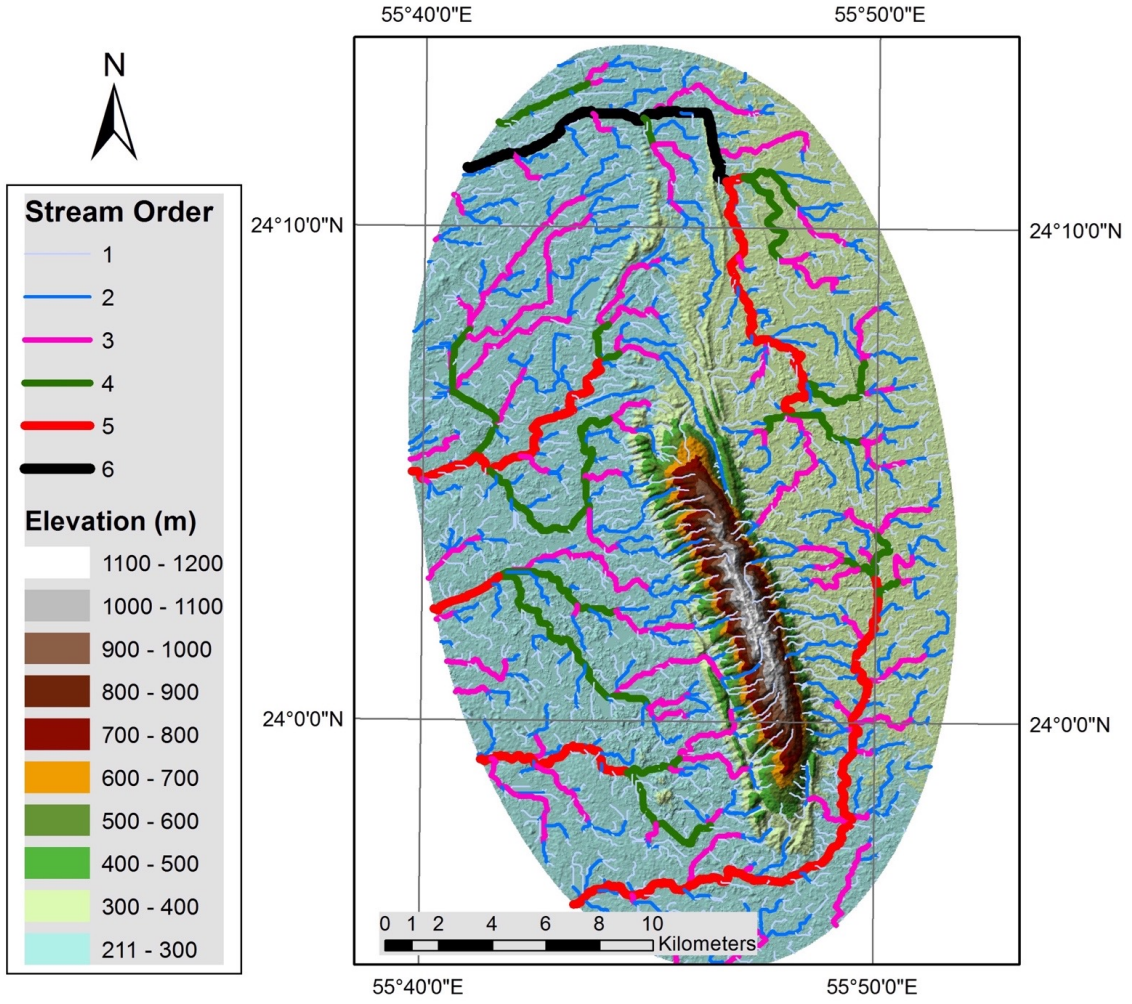
- Stream order was computed in Arc GIS using stream raster and flow direction based on the method suggested by Strahler 1964.
- The drainage network of the study area is of sixth order.
- The highest stream order of six occurs in Wadi Al Ain NW of Al Ain City and the rest sub-basins are of the fifth order. This explain the highest flow accumulation in Wadi Al Ain with frequent floods.



Watershed Analysis and Pour Points

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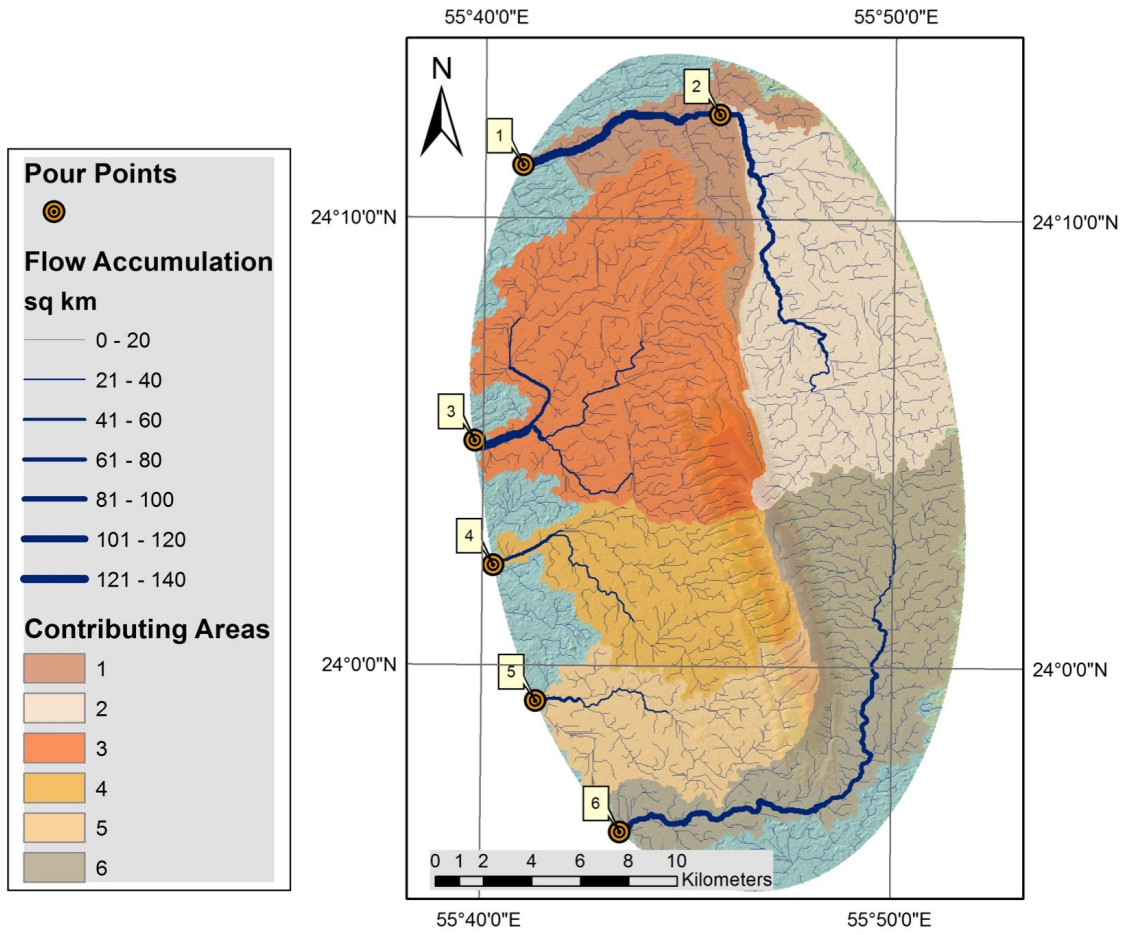
- Five main sub-basins have been identified in the study area, all of them are drained to the west as they influenced by the topography.
- The outlet (pour point) is the point on the surface at which water flows out of an area. It is the lowest point in the drainage basin along the boundary of two drainage basins.
- Five pour points has been placed on the lowest point of each basin where the highest accumulation ration occur. Another pour point was added where a big change in stream direction occurred.
- These pour points are considered as potential sites for constructing dams and stream gauges.



Conclusion

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- Morphometric and watershed analysis of Hafit Mountain using GIS and remote sensing helped to analyze the main hydrological properities of Hafit drainage basins, which are difficult to be done in the field as Hafit Mountain is located between two countries, United Arab Emirates and Oman. Moreover, this method save the cost, effprts and time required in the field work.

- Six pour points have been suggested in the study area,which serve as potential sites for constructing dams and water gauges. These dams could be used to collect surface water and/or recharge exploited groundwater aquifer in Al Ain area.

- The study results contribute significantly to sustaiable water resource managemnet in the study area as well as help to mitigate the flood hazard in Al Ain City.

References

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- Aster Global DEM 17-Oct-2011.

- Google Earth, 2013.