Development of Flood Risk Mapping and Mitigation Strategies for Al-Qassim Region

Atef Qasem Kawara
Ph.D Student
439106883@student.ksu.edu.sa

Overview

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Introduction

- Floods have a more detrimental impact on both urban and non-urban areas compared to other types of natural disasters (Khosravi et al., 2016).
- Floods may be caused by a variety of sources, including climate change and human activity (Kourgialas & Karatzas, 2011).
- Flood risk mapping can reliably expect the locations of flood disasters, therefore aiding in mitigating their impacts (De Risi et al., 2020).
- GIS techniques may be used to perform spatial analysis through the integration of several datasets (Mishra & Sinha, 2020).

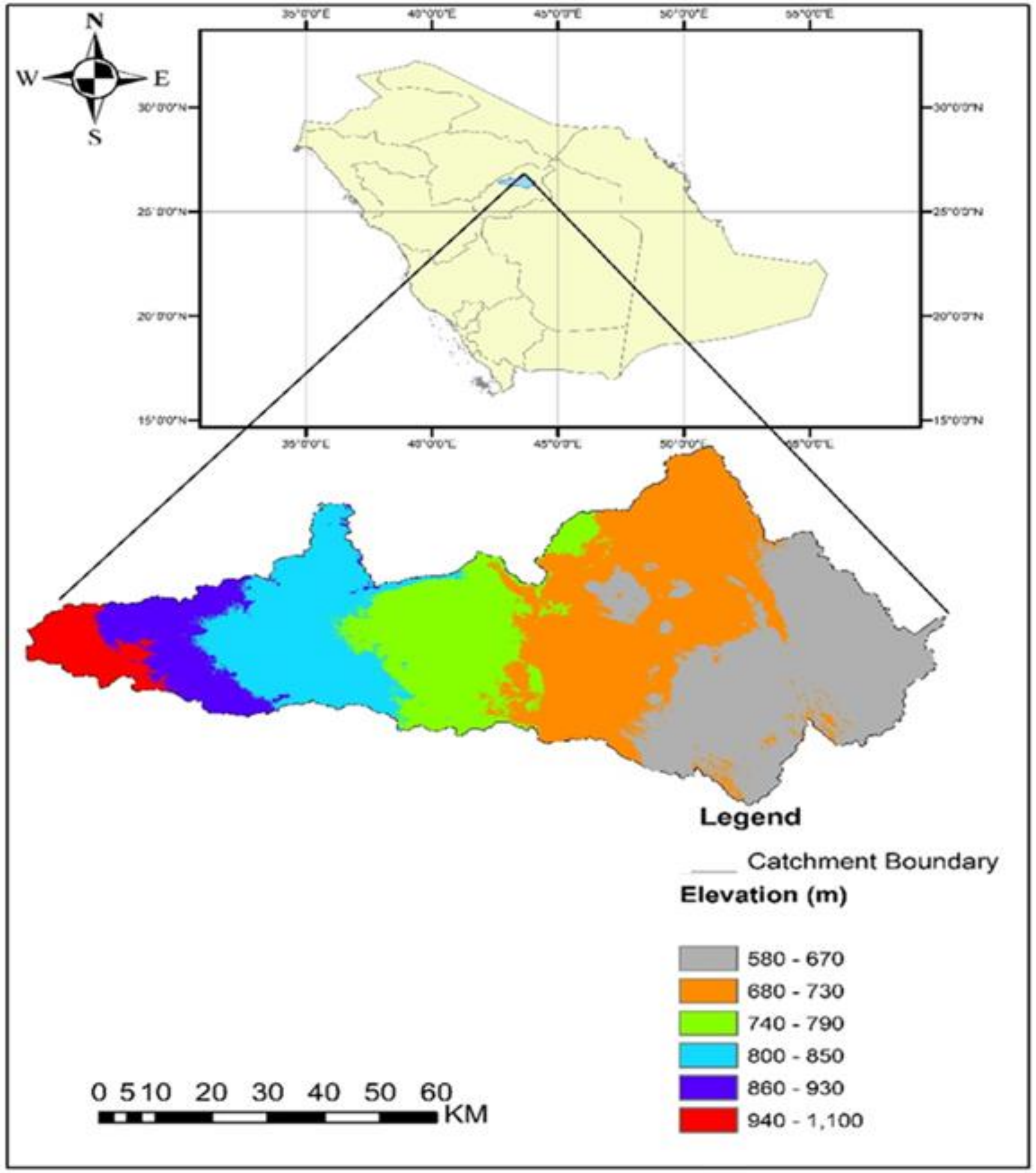
Flooding in the city of Buraydah (Alhumaid et al., 2018)

- This study aims to create flood risk mapping in the Al-Qassim region.
- Six factors will be investigated in the study, including elevation, slope, drainage density, rainfall, soil and land use/land cover.
- The watershed will be divided into five regions: very high, high, moderate, low, and very low flooding danger areas.
- The obtained results will provide helpful knowledge for the policy and decision-makers to make the right decisions regarding the effectiveness of the protective structures of the study area against the risk of flash flooding in the future.

Recent flood in Buraydah (30 May 2023)

Study Area

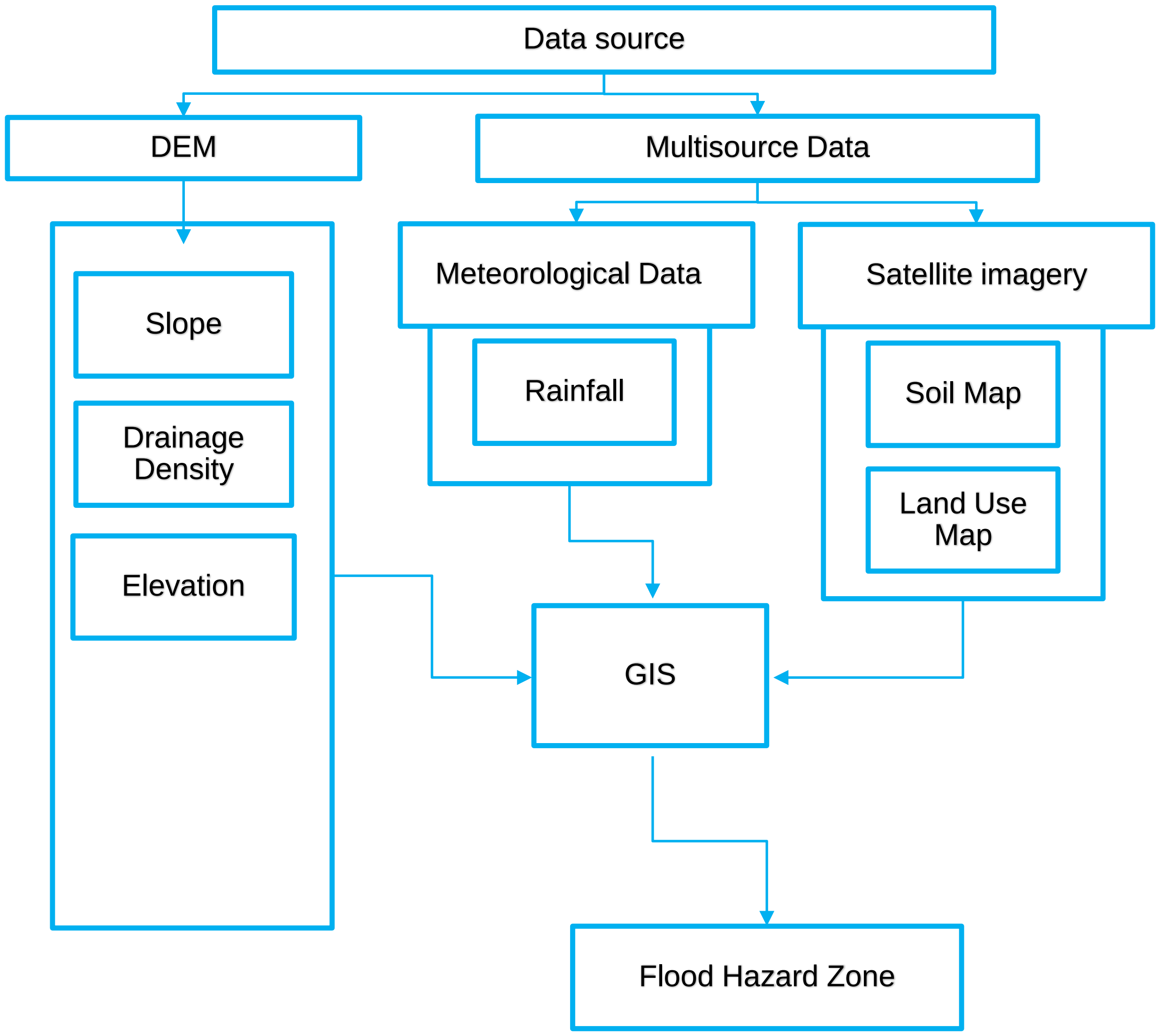
- Buraydah is the capital of the Al-Qassim Region.
- Buraydah has a desert climate, with cold winters with unusually heavy rainfall, and very hot summers and low humidity.
- In the summer, the temperature varies from 32 °C to 36 °C at night and from 43 °C to 48 °C during the day.
- Almost 50% of the catchment has an elevation range between 730-850 m.
- Most of the urban area is located on the low level of the catchment area.



Coordinates and digital elevation model of Burydah

Methodology

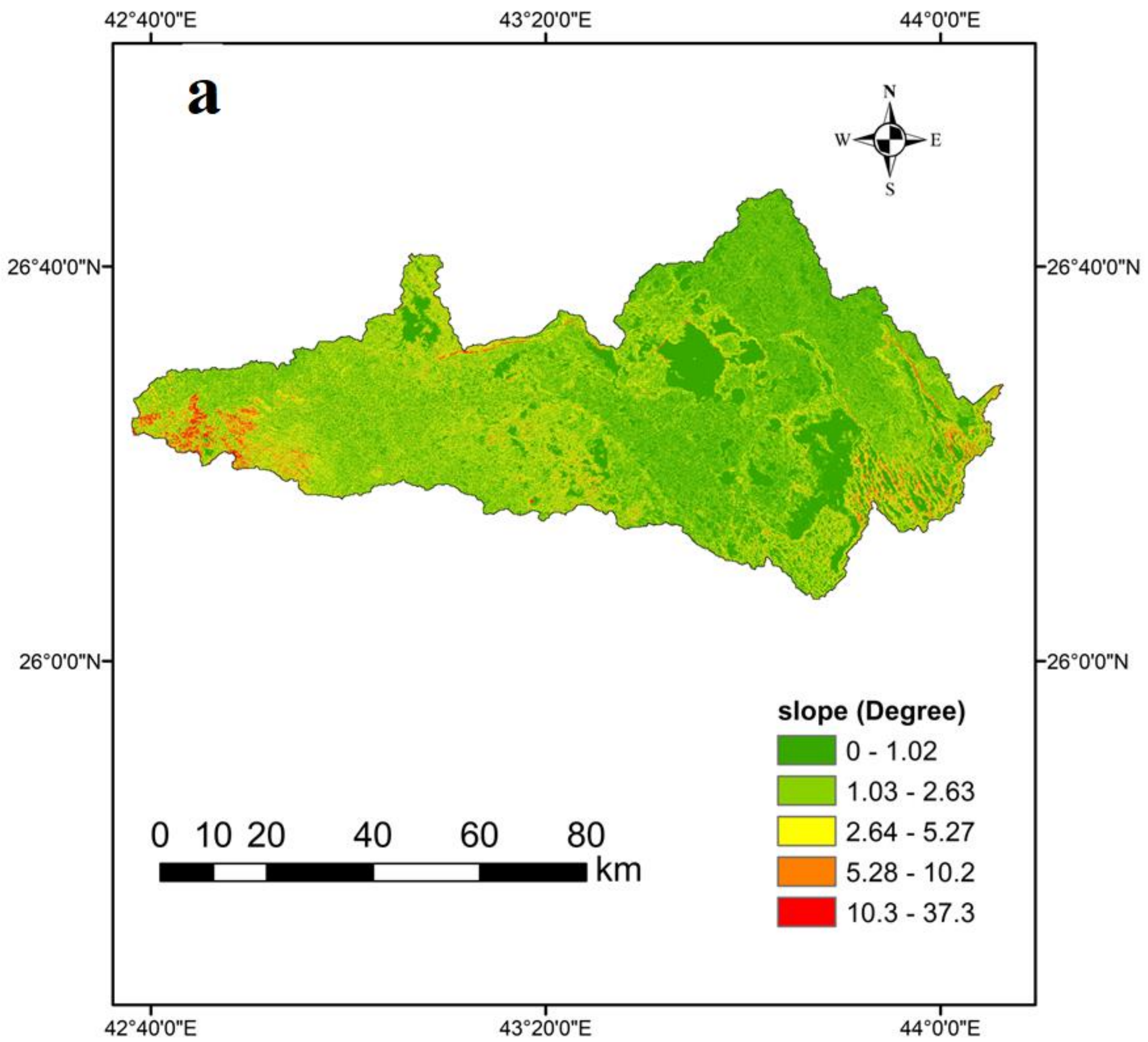
- In the present study, six factors like elevation, slope, drainage density, rainfall, soil and land use.
- All parameters/factors were selected as the primary parameters associated with designating flood zones in the study area.
- Input data preparation is generally based on three data types: DEM, remote sensing data, and meteorological/hydrologic data, using ArcGIS 10.5 software.
- DEM was used to derive the main important hydrological factors which include slope, drainage density, slope, and elevation.



Methodological flowchart

Results and Discussion

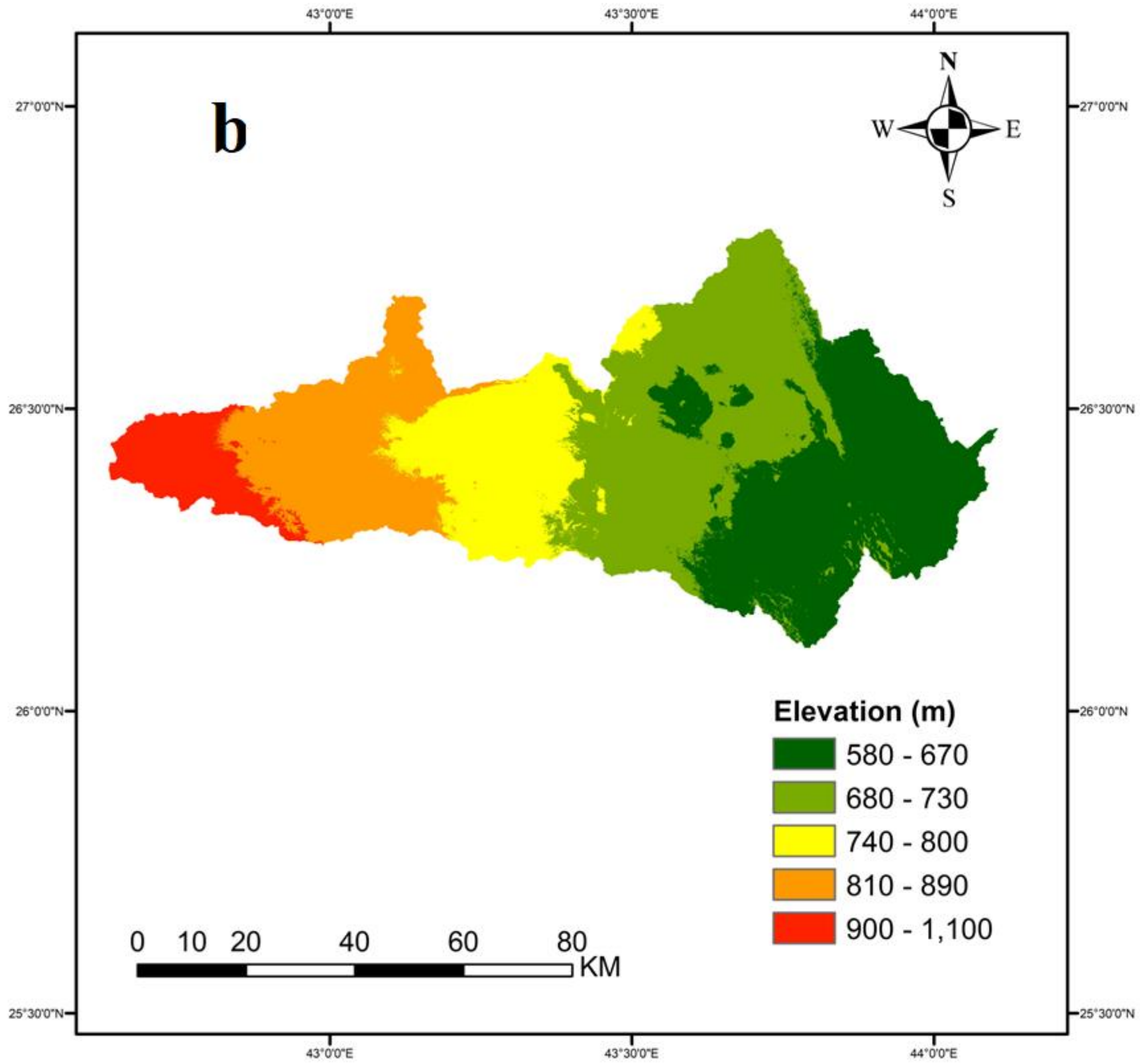
- The slope factor is an important indicator of surface areas at risk of floods.
- The slope has a significant influence on both the duration and velocity of water flow.
- Flatter surfaces are more vulnerable to flooding than steeper land because the water travels more slowly, and gathers for longer periods, resulting in water accumulation.
- The lower range of slope indicates more risk of flooding.



Slope map of the study area

Results and Discussion

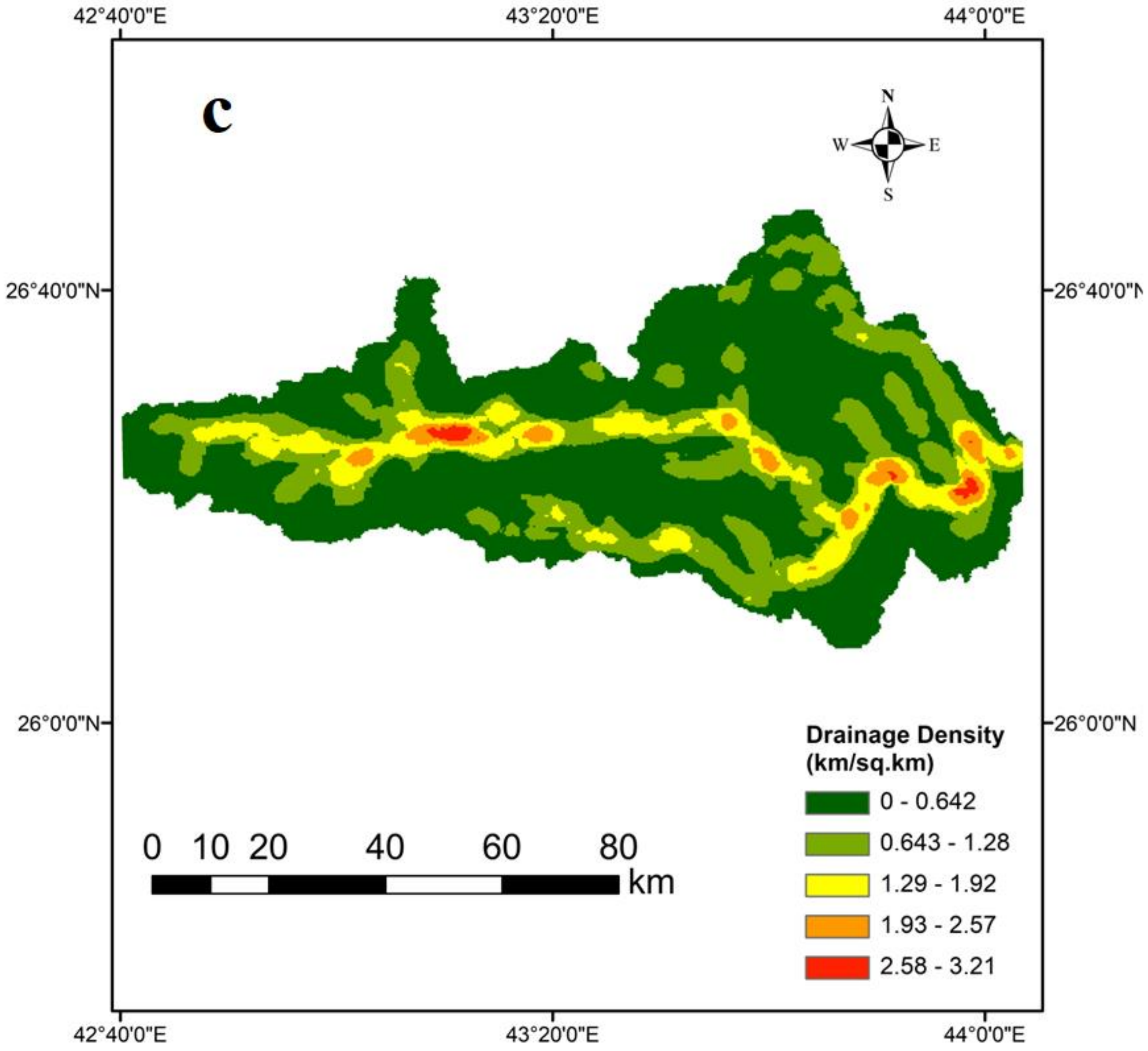
- Elevation ranges between 900-1100 m at the west of the catchment and it decreases towards the East where ranges between 580-670 m
- Elevation is an important factor that influences the overflow direction and how deep the water level is.
- Flooding is less likely in higher elevation places than in lower elevation areas.
- The lower range zones of elevation have the highest risk of flooding.



Elevation map of the study area

Results and Discussion

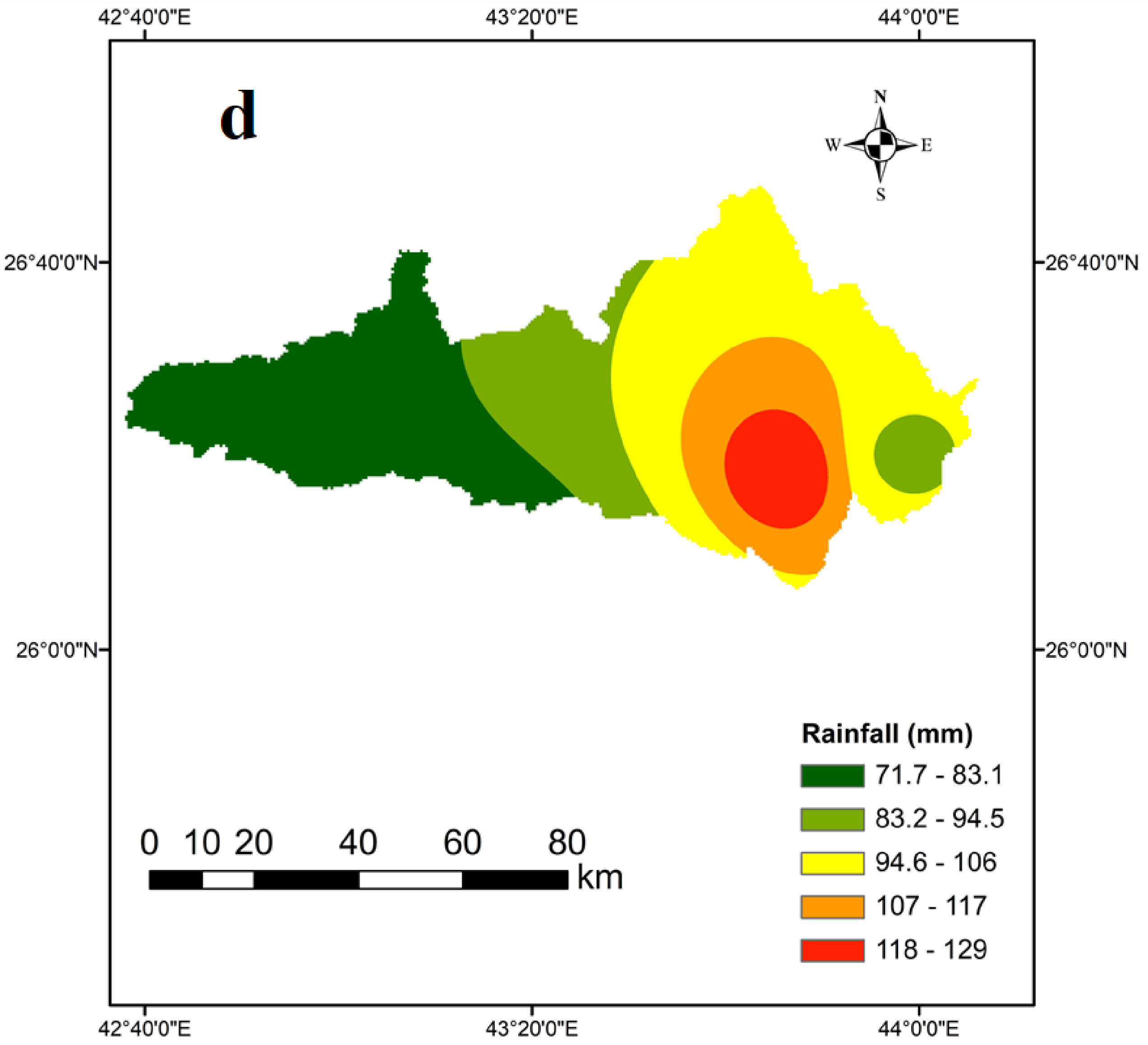
- The drainage density was expressed in km/km^2 and characterized as the total length of all the streams divided by the total area of the drainage basin.
- The higher density of streamlines means a greater amount of excess runoff and therefore indicates more risk of flooding.
- The higher range of drainage density shows higher chances of water accumulated.



Drainage density map of the study area

Results and Discussion

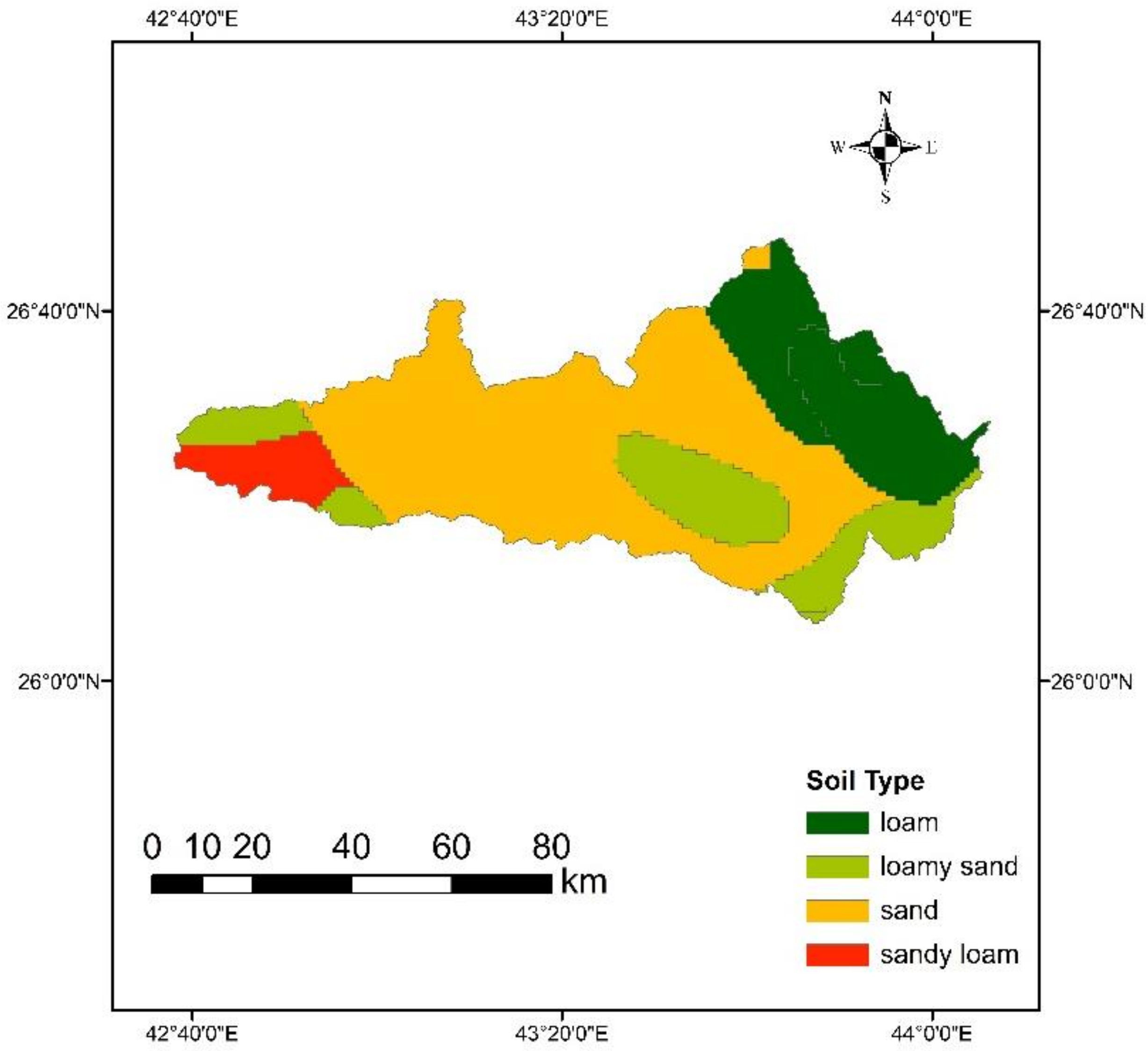
- One of the primary causes of flash floods is heavy rainfall in a short period.
- Annual rainfall data of the study area were collected from the available Meteorological station for the present study.
- The spatial distribution map of rainfall was prepared using the Inverse distance weighting (IDW) interpolation method in the GIS platform.
- The quantity and intensity of the rainfall affect the surface runoff and infiltration rates.
- The higher range zones of rainfall is the most vulnerable to flood risk.



Rainfall map of the study area

Results and Discussion

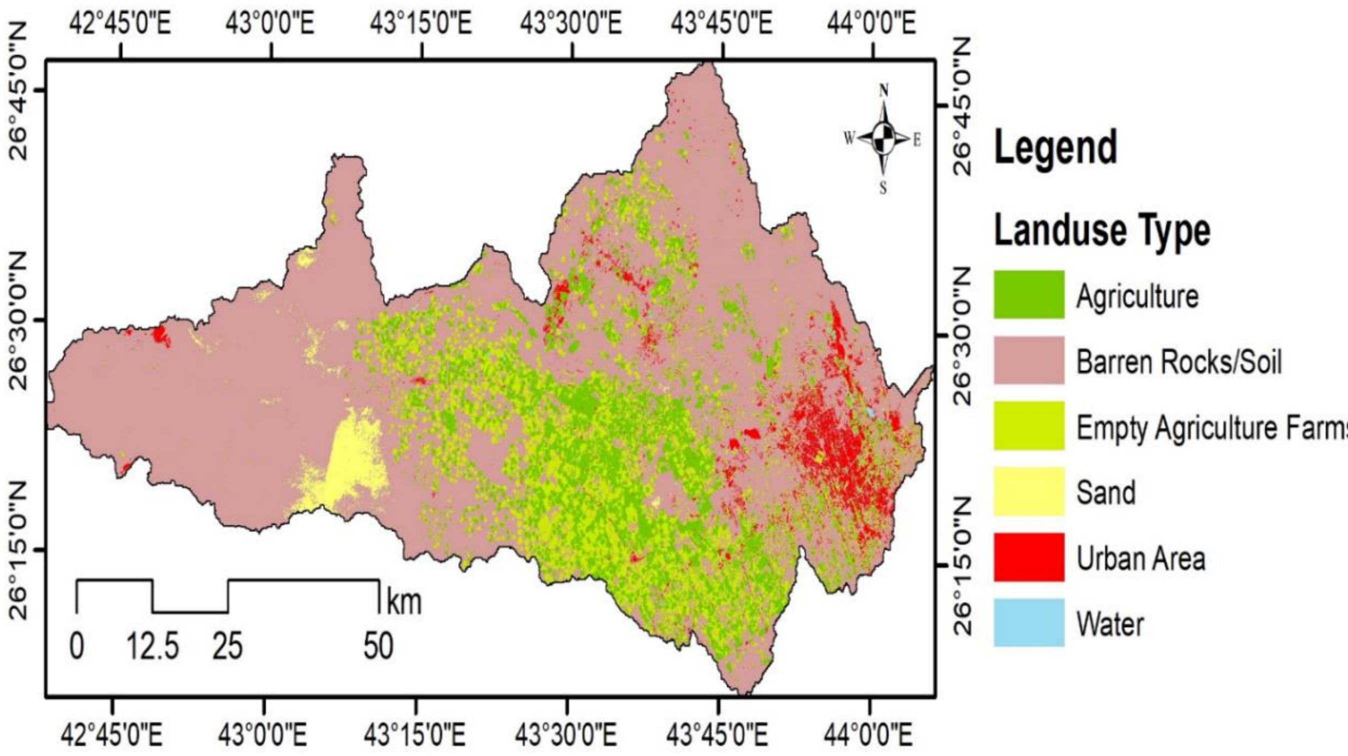
- Soil parameters in a basin, such as the soil layer thickness, permeability, infiltration rate, and the quantity of wetness in the soil before the rainfall event, directly influence the rainfall-runoff process.
- Different soil types have varying capacities for infiltration, therefore a lower capacity for infiltration causes more surface runoff, which increases the danger of flooding.
- When the water supply rates exceed the soil's ability for infiltration, water moves down the slope as runoff over sloped land, resulting in floods



Soil map of the study area

Results and Discussion

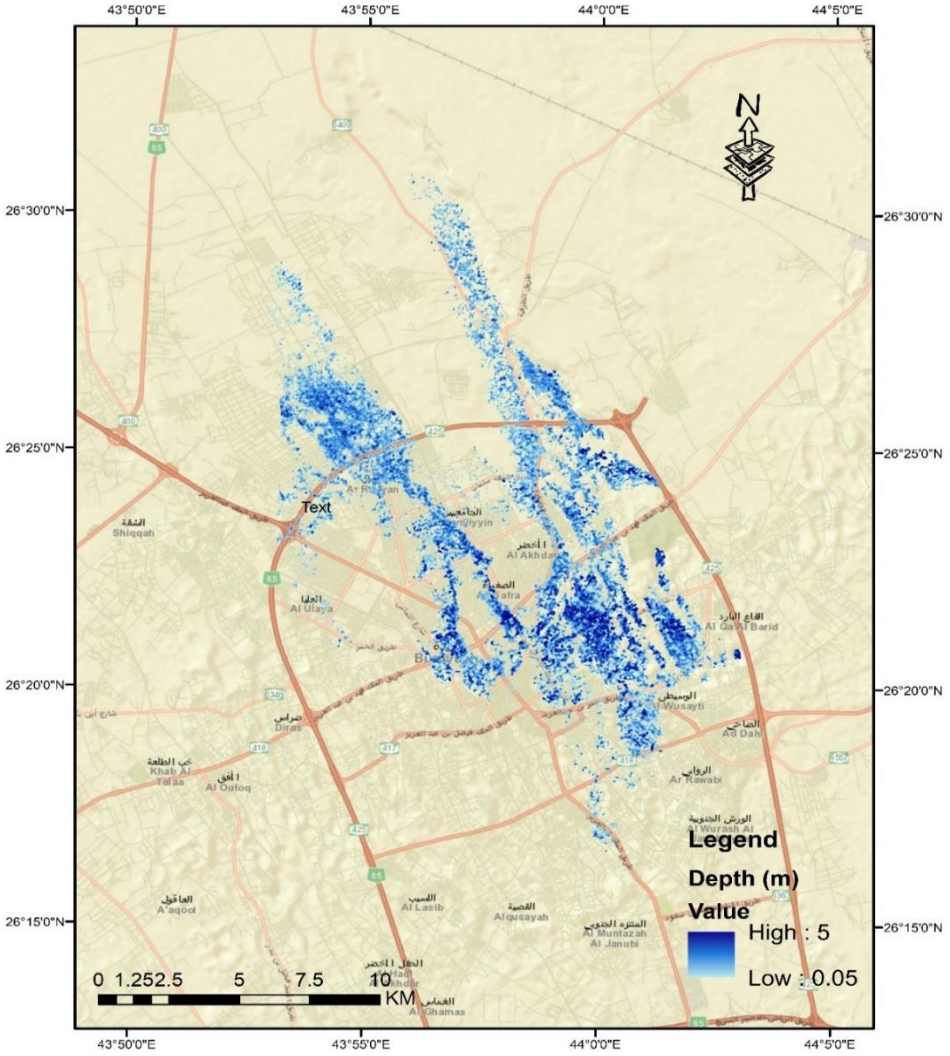
- Many experts on the subject of flooding hazard management agree that land use/land cover change is a significant component of floods.
- Impervious cover has increased while forest cover has decreased within urban areas as a result of urban land development.
- An increase in the process of surface runoff rate is the result of these modifications taken together



Land use map of the study area

Results and Discussion

- HEC-RAS was used to assess the success and forecast proportion of the flood danger map.
- The model was validated by comparing the water runoff depth map generated by the HEC-RAS to the flood hazard maps.
- The extent of the flood zone for a return period of 100 years was used.
- The depth of surface runoff ranges between 0.05 and up to 5 meters in very few places, especially in pond zones.



Water runoff depth using HEC-RAS with a 100-year return period

Conclusion and Recommendations

- The research area identifies slope, rainfall, drainage density, land use/land cover (LU/LC), soil composition, and elevation as the primary parameters associated with designating flood zones.
- Areas with extracted drainage and high drainage density exhibit elevated surface runoff and less infiltration.
- Based on an analysis of these factors, it is observed that the area most vulnerable to the risk of floods is located in the eastern part of the catchment.
- Based on the results, it is recommended to propose different alternatives for flash flood protection and surface water harvesting plans, which may include establishing dams and developing existing storm drainage networks.

Further work

- Future research will analyze and determine the most important parameters and a flood risk map will be developed by combining Analytic Hierarchy Process (AHP) and GIS.
- Also, this analysis will be expanded to include a thorough investigation of computer technologies, such as artificial neural networks (ANNs) and machine learning methods, for predicting flood risks in the watershed.

Thank You