Flood mapping and estimation of affected population, contributing factors to the flood, and recovery rate of the area using GEE products

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Background

- Gorgan in one of the northern districts of Iran. And Golestan is the capital of it.
- Figure one shows the surface water flow in the main watershed of Golestan (Gorganrud-Gharesoo basin) and dams within the area.
- Figure 2 shows the main surface water resources flow and water demands of this area. The main water demands are agricultural, fishery, and industrial.
- About 500,000 people live in Gorgan district.

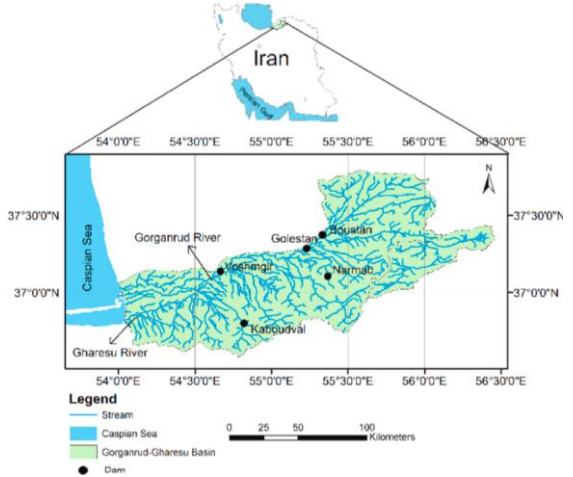

Figure 1: The General location of Golestan district with respect to Iran and GorganRood and GhareSoo basin and its dams (Vahedizadeh et al, 2023)

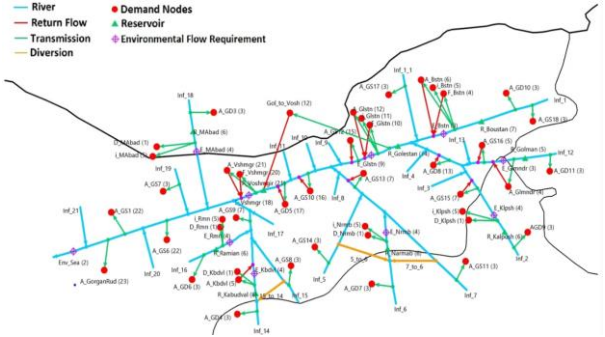

Figure 2: A schematic configuration of water resources and demands in the GorganRood and GhareSoo Basin (Jahanshahi et al, 2023)

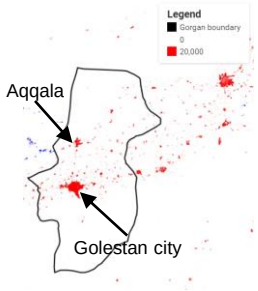

Figure 3: The case study and its population density in 2020

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Background

- Following a prolonged and severe drought spanning multiple years, a series of flood occurrences of unparalleled geographical magnitude occurred in various regions of Iran from March 17th to April 1st, 2019 (Alborzi et al, 2022).

- Northern Iran was hit by frontal precipitation events (March 17–22, 2019) that caused the first major flood.

- GorganRood and GhareSoo Basin in Golestan Province received 50% of the local mean annual rainfall in three days, including 338 mm at TooskaChal Station, breaking the one-day and three-day records in over 70 years (Beitollahi et al., 2019).

Figure 4: An aerial picture of the Gonbad-E Qabus Tower (one of the landmarks of Golestan) before and after the flood

Figure 5: 2019 Flooded area of Aqqala in Golestan district

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Objectives and brief methodology

- 1) The primary objective of this project is to generate a flood extent map to estimate the areas affected by flooding in Gorgan, utilizing the Google Earth Engine (GEE) platform. The flood extent is determined through the application of a change detection methodology on Sentinel-1 SAR GRD (C-band Synthetic Aperture Radar Ground Range Detected) data developed and validated by UN-SPIDER.

- 2) After identifying the impacted regions, it is feasible to examine the demographic composition of these locations to ascertain the extent of the population affected. The GHS POP data collection will be utilized for this objective.

- 3) The utilization of NDVI (by using sentinel data) can be employed to compare long-term (and before and after the flood) surface characteristics alterations within the area, to detect some of the contributing factors to this flood.

- 4) The night light is utilized to ascertain the potential detection of alterations in urban dynamics before and after the occurrence of a flood event. Additionally, the duration required for the restoration of night light following its diminishment can serve as an indicator of the area's recovery rate. The VIRS dataset was used for this purpose.

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Rain data

- By looking at the historical precipitation of the area it is obvious that this flood is a 223 (or 413) year flood.
- Normally urban flood control infrastructures are designed to withstand 100-year floods.
- Two other factors may play a role, 1) deforestation and 2) snowmelt (since the area has high mountains), this hypothesis will be tested using NVDI values.

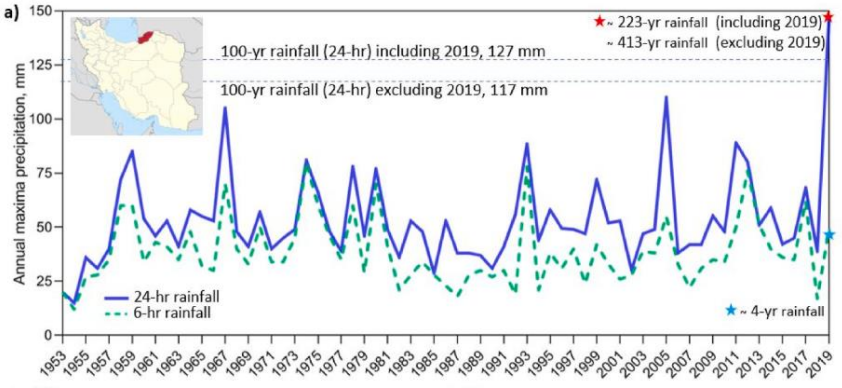

Figure 8: historical data of a rain gage maximum annual rainfall for 24-hr and 6-hr rains in Gogran

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Flood inundation Methodology

- Following the guidelines provided by UN-SPIDER
- Select images from before and after the flood event
- Employ the VH band for urban flood detection.
- Utilize the speckle filter.
- Calculate the difference and apply a threshold.
- Utilize masks to eliminate permanent water bodies, individual flooded pixels, and areas with a high slope gradient.
- Calculate the inundated area.

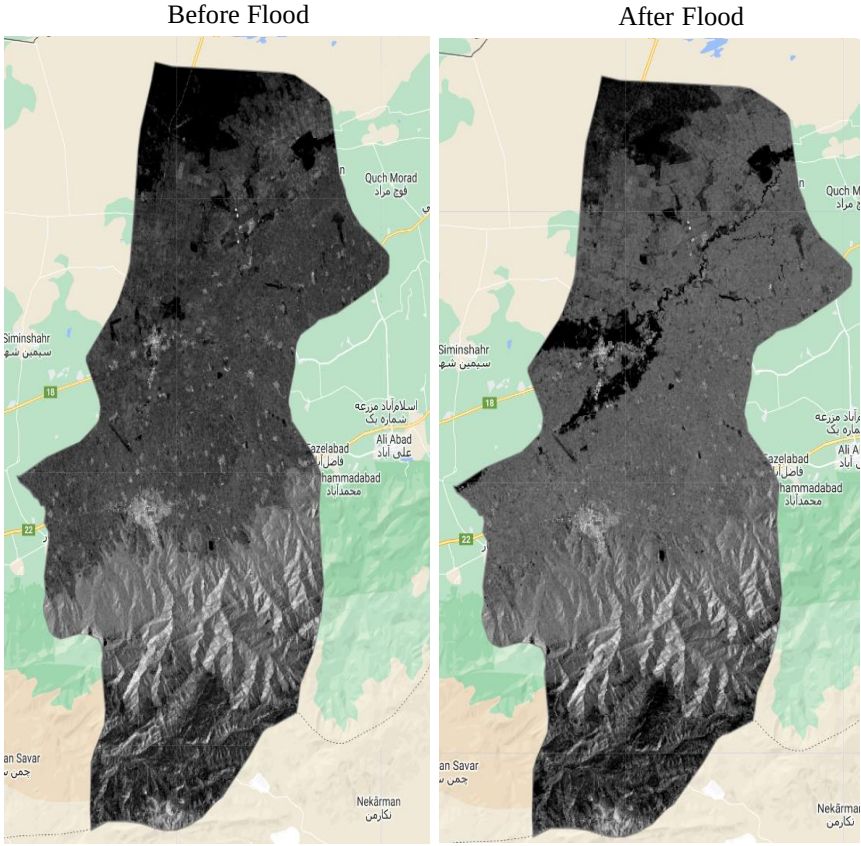

Figure 6: Utilization of VH to differentiate between water bodies and flooded areas

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Flood inudation area result

- The red areas show flooded parts of the ROI. Based on inspection reports Aqala is the most flooded city in Golestan which is compatible with analysis results.
- Also the report said that most flooded parts of Gorgan were on the roads which is compatible with the reports. The Gorganrud River is also flooded (Figure 7) which is compatible with the reports.
- Flooded Area is 5956 (Ha), which sounds like an underestimate Tourani et al., (2023). This is because the revisited rate of the sentinel 1 for both satellites is 6 days so it can not catch the peak of the flood.
- By using GHS POP data and clipping it to the flooded areas, the number of people affected by this flood was 4,750.
- The most important question is why such a flood happened and what drivers contributed to it.

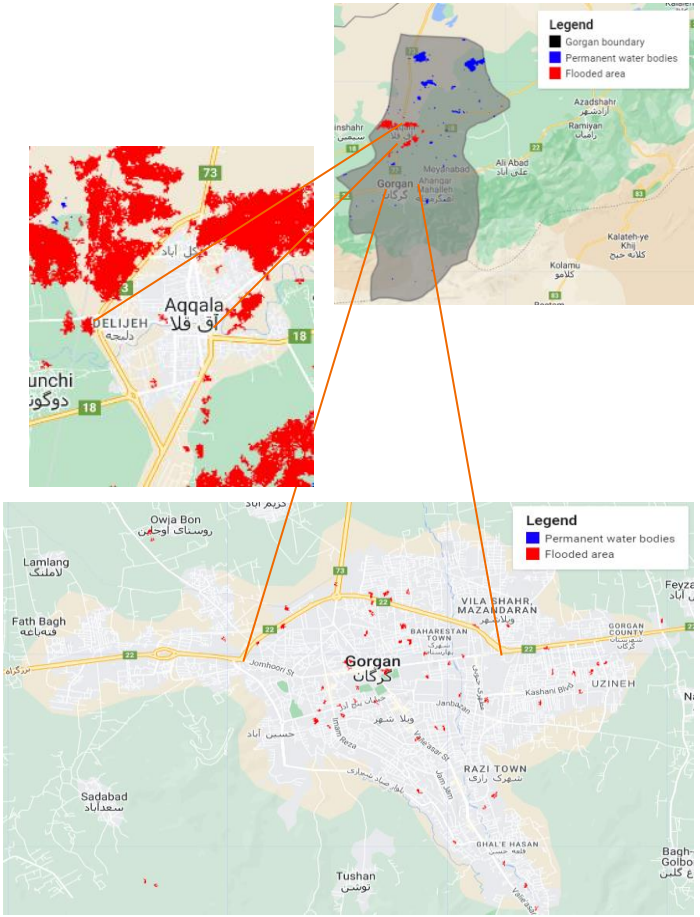

Figure 7: Flood inundation map of Grogan based on analysis of Sentinel 1 SAR data using the UN-Spider method

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Normalized difference vegetation index

- 1) The NDVI values are calculated two times once for comparing the before and after the flood and once for long-term analysis.
- By looking at NDVI values for March of 2019 and 1999 it appears that a lot of deforestation has happened (since the area has a Mediterranean climate a lot of deforestation happens for villa construction)
- Before and after the flood Green spaces do not vary a lot since they are resilient to floods (the dominant crop type of the area is rice)
- By looking at NDVI values we can see in the southern parts of the region the NDVI values increased from less than zero to values more than zero, which could be due to snow melt in this area.
- The snow melt is another contributing factor to the 2019 Gorgan flood (Alborzi et al, 2022).

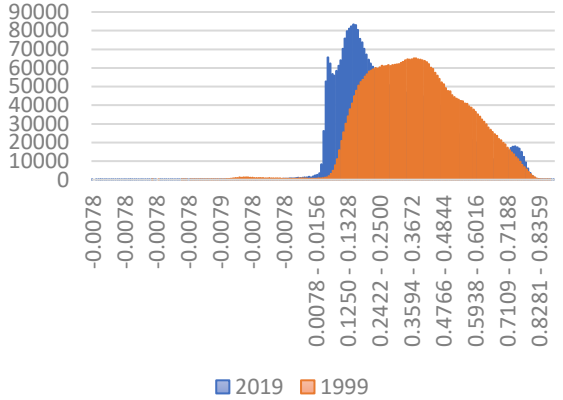

Figure 9: Landsat VNVI values T1 is for year 1999 and T2 is for 2019

Before Flood

After Flood

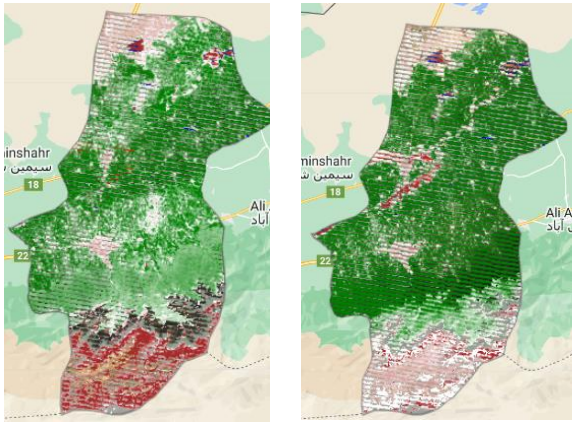

Figure 10: Landsat NDVI values before and after the flood the red areas are negative values white areas are zero and green areas tend to one

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Night light

- The Monthly Night light for this is presented in Figure 11 and the 3-month moving average of it is presented in Figure 12.

- the area's night light intensity has an increasing trend.

- After the decrease of March the night light both monthly night light and 3-month averaged night light restored to their previous values by 5.5 months.

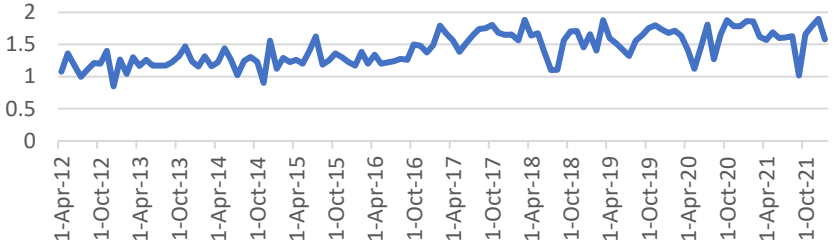

Figure 11: Night light monthly intensity for the area of the interest

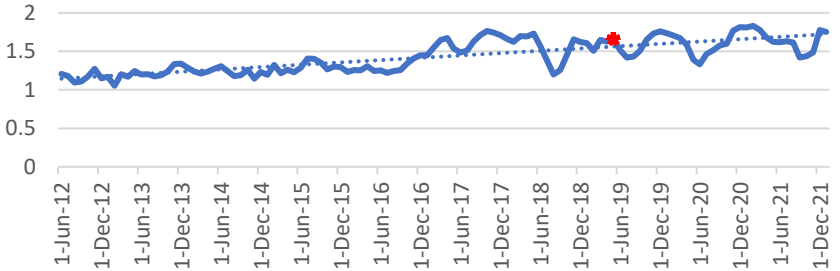

Figure 12: Night light 3-month moving averaged intensity for the area of interest, the red dot shows the flood event

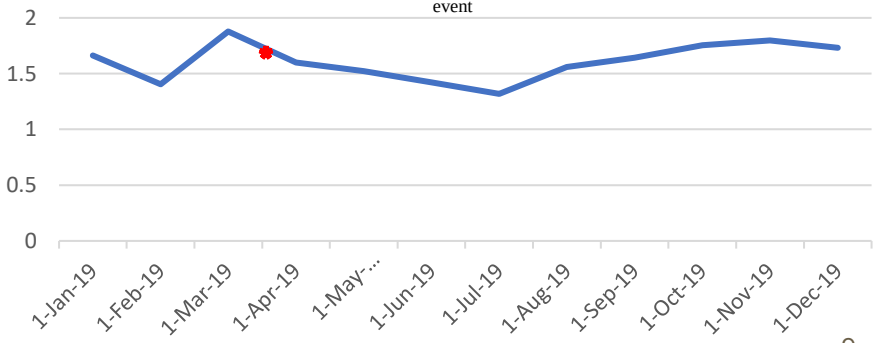

Figure 13: Monthly night light for 2019, the red dot shows the flood event

Future research

- One of the most interesting research directions is improving flood inundation mapping using remote sensing data.

- Notti (2018) used different for flood mapping and SAR was indicated as the most promising one. One of the ways to improve flood mapping is through using the temporal z-scour method (DeVries et al., 2020).

- Currently researchers are trying to improve flood mapping using SAR data and combining it with convolutional neural networks and Bayesian approaches (Hertel et al, 2023).

- Another interesting research question is to develop a methodology to automatically understand the correlation of different factors to severe historical floods using remote sensing data and suggest some intervention strategies.

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Thanks for your attention!