ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 12, Issue, 09, pp. 58827-58831, September, 2022
https://doi.org/10.37118/ijdr.25356.09.2022

RESEARCH ARTICLE OPEN ACCESS

INVESTIGATION OF THE EFFECTS OF HEAVY RAIN AND FLOOD IN EMIRATES OF FUJAIRAH- UAE AND CONSTRUCTION AND COMPILATION OF FLOOD MAP AND ELEVATION CHART USING STATE OF THE ART GIS TECHNOLOGIES

Fatmah Rashed Mohamed Obaid Alhefeiti, Manar Ahmed Mohammed Alblooshi, Reem Y Yaqoub Yousif Ahmed Abdalla, Muhammed Sirajul Huda Kalathingal, Shaher Bano Mirza* and Fouad Lamghari Ridouane

Fujairah Research Centre, Sakamkam Road, Fujairah, United Arab Emirates

ARTICLE INFO

Article History:
Received 11th July, 2022
Received in revised form
27th July, 2022
Accepted 10th August, 2022
Published online 23rd September, 2022

Key Words:
Fujairah, Flood, Heavy rain, GIS, QGIS, Emirates, MyMap, FloodMaps, ASPOSE, municipality.

****Corresponding author: Shaher Bano Mirza***

ABSTRACT

Fujairah is the fifth largest emirate in the United Arab Emirates and is considered as one of the most fertile lands of the country. In July 2022, one of the most perilous floods occurred in Fujairah city following highest amount of rain that fell on the country during the month of July in 27 years, since 1995. The floodresulted in 7 reported casualties and enormous property loss andinfrastructure damages. The Fujairah flood map is constructed, and elevation chart has been compiled in this study to provide insight to the effects of flood. This can alsoprovide useful platform to look at for government institutions, as a starting point to consider, in such scenarios, to take the quick and accurately focused actions for the safety of lives and resources of the people of Fujairah. The advanced QGIS, ASPOSE tool, MyMap and FloodMaps have been used. The devised protocol used to map the flood and elevation chart can be applied to map the flood risks for the other emirates of United Arab Emirates.

Citation: ***Fatmah Rashed Mohamed Obaid Alhefeiti, Manar Ahmed Mohammed Alblooshi, Reem Y Yaqoub Yousif Ahmed Abdalla, Muhammed Sirajul Huda Kalathingal, Shaher Bano Mirza and Fouad Lamghari Ridouane.*** "Investigation of the effects of heavy rain and flood in emirates of fujairah- uae and construction and compilation of flood map and elevation chart using state of the art gis technologies*", International Journal of Development Research*, 12, (09), 58827-58831.

INTRODUCTION

Fujairah is the fifth largest emirate in the United Arab Emirates, and it covers approximately 1450 square kilometer. The emirate is endowed by the presence of a series of rugged mountains that separate it from the Gulf of Oman and the Eastern Coastal Plain. Fujairah is considered as one of the most fertile lands of the country where there are many farms besides the mountain ranges, plateaus, plains, oases, and some desert areas. The climate in Fujairah is semi-continental, and temperatures vary according to the months of the year with rain and varying levels of humidity (Fujairah municipality, 2020). The rain falls on Fujairah for the 4% of the year on average (Figure 1). The level of precipitation in Fujairah reaches about 8.33 millimeters (0.33 inches) annually. In July 2022, one of the most perilous floods occurred in Fujairah city since 1995. The ground stations of the National Centre of Meteorology (NCM) recorded the highest amount of rain was in Fujairah Port with 221.8 mm, which is the highest amount of rain that fell on the country during the month of July in 27 years. Also, NCM recorded the amount of rain in Fujairah Airport, which was 153 mm, Masafi 122.8 mm, Dhadna 98.2 mm, and large amounts of rain were recorded in Mirbah 81 mm (Figure 2) (Khalifa et al., 2022). The flood affected Fujairah in various perspectives which caused direct and indirect losses with 7 causalities according to the UAE ministry of interiors.

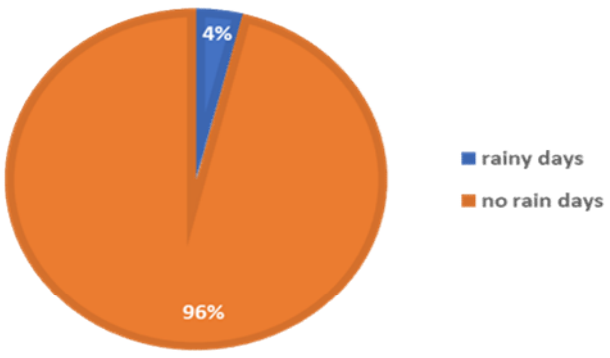

Figure 1. The percentage of rainy and no-rain days annually in Fujairah

The total of 4225 people were evacuated with the aid of 1638 personnel and 582 vehicles got involved in rescue operations. In addition, the authorities said the specialized police crews worked in collaboration with the National Emergency and Crisis and Disasters Management Authority to handle any emergencies as a result of excessive rains and floods in different areas of the country. About 3897 have been sheltered and 870 people were rescued (Gulf Today, 2022). On the other hand, widespread floods in the Fujairah port area disrupted the bunker fuel deliveries which is the world's third largest bunker canter (Aliyev, 2022).

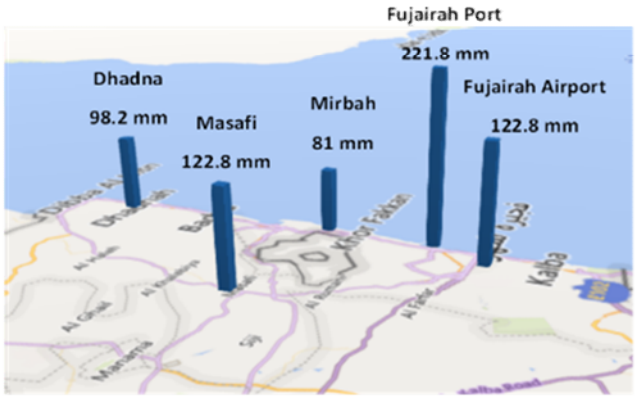

Figure *2.* The rain level of different districts in Fujairah recorded by NCM

Similarly, the residential and agricultural areas were also affected by the flood by various factors such as dams, hills, areas near to the sea, low elevation, and holeswhich led to terrible destruction of vehicles, property, hospitals, shopping malls, farms, schools, and the electrical cables. Keeping in mind the severity of the issue, theproject is to map and identify flood prone hot spots in emirates of Fujairah. This will provide a platform and a chart sheet for government agencies and municipalities to respond timely and accurately on specific areas, on such upcoming incidents to avoid any damages that can be caused.

MATERIALS AND METHODS

Data Collection: Data were collected from 6 different sources such as Media Centre of Fujairah Environment Authority (FEA), Mohammed Bin Rashid Space Center (MBRSC) utilized Khalifa Sat to get a Sentinel-1 Satellite image in high resolution (al Mansoori et al., 2019), Google Map (Google, 2005), Sentinel Hub using EO Browser (Castro Gómez, 2019), and Social Media posts. Interviewing residents about the incident has also played significant part in data collection process. High resolution satellite images are required to identify and differentiate areas effected by flood and the areas with high elevation. The initial high-resolution images have been provided by MBRSC as courtesy.

Data Mapping and Analysis: Mapping flooded areas is achieved using satellite remote sensing. The variety and frequency of free satellite data have significantly expanded in recent years, enabling the generation of flood maps cost effectively across the world (Notti et al., 2018). The amount of rain cloud is configured by using Sentinel Hub (EO Browser) Sentinel-2 and filtered it by false colour later-on. The desired area selected as Fujairah-UAE. An open source, cross-platform desktop geographic information system QGIS is used to edit the acquired maps. The high-resolution image taken from MBRSC has been used in a new project and polygon feature is added to mark the desired areas and shape files created in GeoJSON format. The coordinates from marked areas were copied to Google maps to receive before and after images in this collection and an excel database created for these records. QGIS makes it easy to map the affected areas by adding a polygons or feature attribute or even other shapes to indicate the flood after inserting the satellite images (qgis.org, 2022). The GeoJSON files are converted to KMZ format using ASPOSE tool (https://products.aspose.app/gis/conversion/convert-to-kmz). Geospatial data visualization is an art form that aims to depict data in a way that non-technical audiences may understand and analyze it more effectively. The shape files are visualized in MyMaps of google maps. All the shape files coordinates mapped on google maps and description given for before and after images. MyMaps gives the features to make own custom layers, pins, classification, and styling a map based on own geographical data and coordinates. Additionally, the videos and images can be added to represent the flooded area and show the before and after status. The elevation levels of Fujairah have been obtained using FloodMap (FloodMap, 2019). Since it is known that the land is uneven, it is impossible for the regions of the Emirate of Fujairah to be equal. For this reason, five points were chosen from each region in Fujairah and the average was calculated to normalize the elevation levels of each region of Fujairah including the affected areas as Sakamkam, Al Faseel, Madhab, Al Shirya, Murishid, Rugaliat, Al Gurfa, Al Farfar, Al Hilal City, Al Hail, Guzaimri, Al Ittehad, Rumailah, Mudok, Safad, Al Nujaimaat, Al Mahata, and Al Hulaifat. Additionally, detailed experimental protocol is explained stepwisein supplementary material.

RESULTS AND DISCUSSION

The fact that GIS offers a basis for mapping and analysis that are used in science and virtually every business is one of the most significant benefits it has over other types of software. GIS aids users in comprehending trends, connections, and geographic context. Figure 3 shows the rain cloud image taken from the satellite sentinel 2 as a starting point to map rain. The purple-colored area showed the heavy rain clouds and blue showed comparatively wispy clouds.

Flood mapping

Figure 3. Rain cloud image taken from sentinel2 satellite for emirates of Fujairah. The purple area mean it have more rain clouds.

The high andlow risk areas are mapped as shown in Figure 4. The total of sixteen (16) districts have been examined for the study, collectively making the area of 1587.15 km2. Based on our investigation, Fujairah has 13% residential and populated area, and all comes under high-riskzone. Rest of the 87% comes under medium to low-riskzones. The composite flood danger index was created by taking five factors into account including elevation, areas near to the sea, dams, and the presence of holes and hills. To assess the severity of the hazard, distinct rankings have been given to each of the components considered. The high-riskareas are colored as red zones and medium to low-risk areas are colored as grey (Figure 4). All red zones are residential areas and more importanc eshould be given to theseareas. Different icons are shown to distinguish one kind of area from other. Farms and parks are shown in tree icons and most of which falls under high risk zone. Similarly, Dams are shown as blue icons and comes under high risk zone due to chances of overflow of water with heavy rain.

Elevation: Elevation is the height above sea level. The elevation of a certain areamay contribute to the occurrence of floods in specific areas if it's close to the sea levels. When assessing the likelihood of floods, the indices for low elevation, moderate slope and slope aspect, water area, and soil texture have a significant impact. In contrast, locations with a lot of plant, little rainfall, high elevation, and soil with good infiltration have themoderate to lower danger. We gathered the elevation data from 18 districts in the Emirates of Fujairah and calculated the median and average as shown in Table 1, Figure 2. Lower the elevation, highest the risk of flood and its effects. AlShirya is the closest to the sea level with average elevation of 0.6 m (Table 1). As shown in Table 1, point 1 is below sea level with elevation -8 mand point 2 at exactly the sea level with elevation 0m. similarly point 2 in Al hilal city, point 4 in Alfaseel district are below the sea reference point and fall under high-risk areas. Algorfa and Skamkam, Rugaliat districts with average elevations 8, 6.6,4 are the areas where the elevation is near or equal to the sea reference point which too,

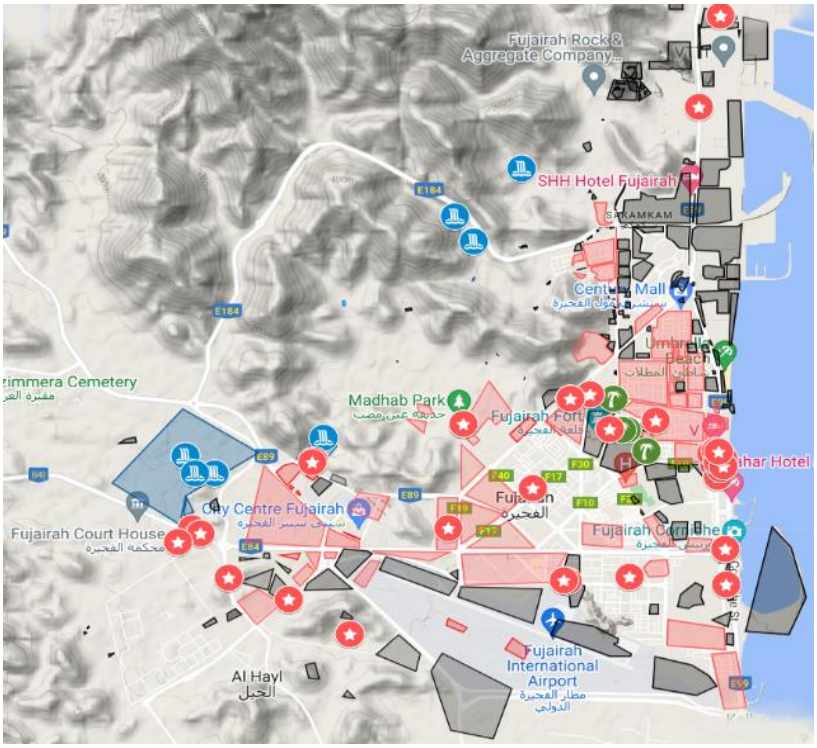

Figure 4. This map created by following five factors to show the impact of the flood. The red regions highlight the locations that were the most severely damaged, Gray with medium risk, the star icon showing the critical areas, blue icons for the dams, and green trees for the farms.

Table 1. Elevation level of different districts of emirates of Fujairah (Urban). Average values for four points are taken to show elevation level in each area. Values are mentioned in meters (m)

Elevation Above sea level (meters)							
Sr. No.	Area	Point 1	Point 2	Point 3	Point 4	Point 5	Average
1	Skamkam	8	9	10	7	6	8
2	Al faseel	5	4	1	-1	6	3
3	Madhab	15	11	13	17	12	13.6
4	Alshirya	-8	5	0	4	2	0.6
5	Murishd	10	11	7	17	6	10.2
6	Rugaliat	5	7	9	4	8	6.6
7	Algurfa	3	0	2	8	7	4
8	Al farfar	127	121	118	119	130	123
9	Al hilal city	4	-2	1	3	5	2.2
10	Al hail	148	140	138	73	116	123
11	Guzaimri	128	142	137	135	121	132.6
12	Al itthad	17	14	20	16	23	18
13	Rumailah	12	14	10	15	11	12.4
14	Mudok	217	224	208	223	232	220.8
15	Safad	10	8	11	12	13	10.8
16	Al nujaimat	28	31	25	37	33	30.8
17	Al mahata	13	9	11	15	10	11.6
18	Al hulaifat	58	54	43	67	52	54.8

comes under the most affected areas. Point 2 in Mudok and Alhail district with a high elevation were affected, however, with a medium level of damage. Although these areas have elevation more than 200 m, The factors that may have been involved in damage of these areas could be dams, and the heavy rain. The Almadhab, Almurishd,Alitthad, Rumailah,Alnujaimat,Al mahata, and Al hulaifat fall under medium to low risk level of elevation.The areas that have elevation below 200 meters are more prone to be affected by the flood or any other heavy rain incident in the future. Additionally, Figure 6 shows the before and after images of effects of flood and heavy rain on few districts of Fujairah.

Sakamkam area with 8m elevation above sea level show the in the left image before the flood and right image after the flood effects. The image clearly showed the plai area becomes pond of water after the heavy rain and flood. Similarly, farm in Rugaliat is filled with water after the heavy rain. The effects of heavy rain can be seen in Algurfa, ALshirya and Al-hilal city. All collection of before and after images can be find at this link: (https://www.google.com/maps/d/viewer?mid=1qbaRe-3MNRjUm AEY_9_8zyKa9q-J1J4&ll=25.131131127346592%2C56.3725178 3650687&z=13).

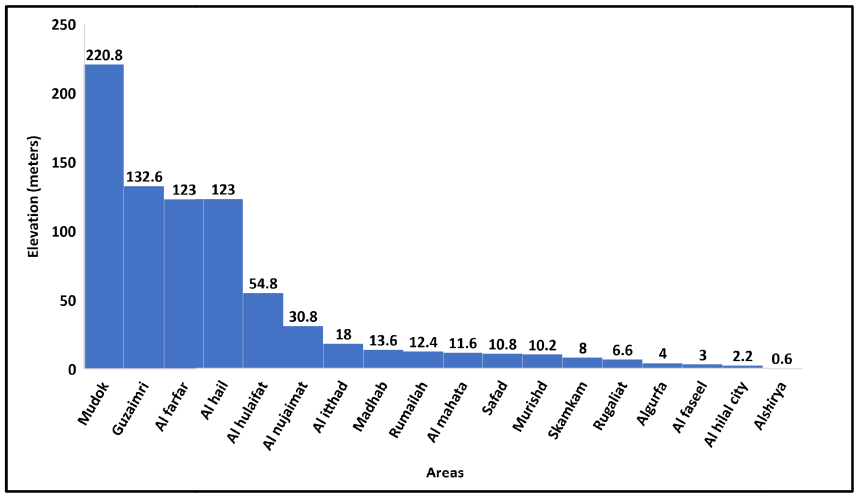

Figure 5. Elevation levels of the 18 districts of emirates of Fujairah. The names of the district are shown in horizontal axis ad the elevation level in meters on vertical axis

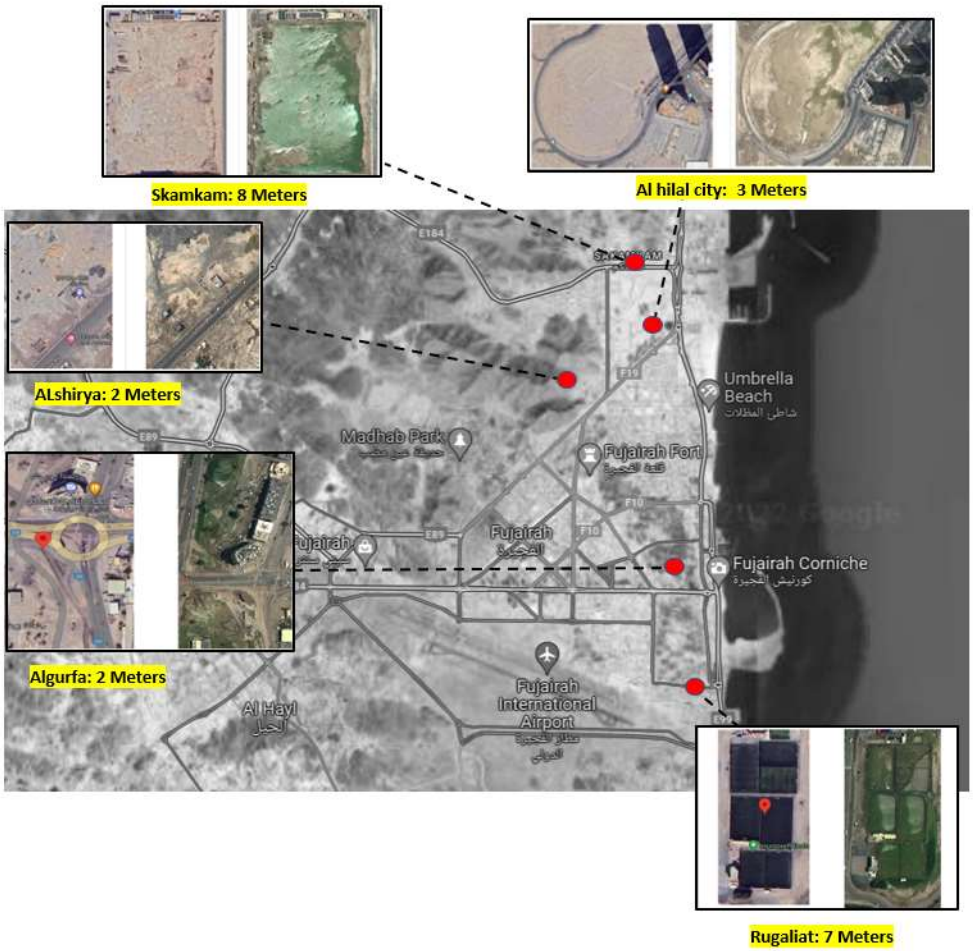

Figure 6. Before and after pictures of the urban/residential areas of Fujairah. Red dots show residential high-risk areas with low elevation, black boxes show before and after images left present before and the right images present after the flood.

CONCLUSION

Floods is affecting Fujairah city and its natural and biological resources, and weather events are becoming more extreme due to the climate change. Making informed decisions is a fundamental step that is growing increasingly complicated for every organization. The boundaries between strategic, tactical, and operational decisions are blurred, and far larger factors must be taken into consideration. The visualization and flood mapping may provide profound identification of flood prone areas that can be severely affected if further flood incidents occur in future. The Fujairah flood map and elevation chart can provide useful platformto look at for government institutions, as a starting point to consider, in such scenarios, to take the quick and accurately focused actions for the safety of lives and resources of the people of Fujairah. The devised protocol used to map the flood and elevation chart can be applied to map the flood risks for the other emirates of United Arab Emirates.

Conflicts of interest: The authors declare that they have no conflict of interests.

Acknowledgments: The authors thank the Fujairah Research Centre (FRC) for their financial and technical support, MBRSC for providing high resolution images of Fujairah to use in mapping and Fujairah Environment Authority (FEA) for technical support. Authors appreciate the continuous support of H.E. Aseela Al Moalla throughout the project and initiatingthis project.

REFERENCES

Al Mansoori, S., al Shamsi, M., al Maazmi, A., AlMarzouqi, F., & AlBesher, S. 2019. Applications of Khalifasat Mission. *Applications of Khalifasat Mission*.

FloodMap. 2019. *Flood Map: Elevation Map, Sea Level Rise Map*. https://www.floodmap.net/

Fujairah municipality. 2020. *Emirate of Fujairah*. https://web.archive.org/web/20201124150106/https://www.fujmun.gov.ae/page.aspx?id=73&template=default&lang=ar

Google. 2005. *Google Map*. https://www.google.com/maps

Notti, D., Giordan, D., Caló, F., Pepe, A., Zucca, F., & Galve, J. P. 2018. Potential and limitations of open satellite data for flood mapping. *Remote Sensing*, *10*(11). https://doi.org/10.3390/rs10111673

Castro Gómez, A. 2019. *ESA UNCLASSIFIED-For Official Use Exercise with EO Browser: Air Pollution (Sentinel-2, Sentinel-5P)*.

qgis.org. 2022, May 18. *A Gentle Introduction to GIS - QGIS Documentation documentation*. https://docs.qgis.org/3.22/en/docs/gentle_gis_introduction/index.html

Khalifa, M., Ahmed, O., & Abo El fetoh, A. (2022, July 28). *The highest amount of rain in July in 27 years*. https://www.albayan.ae/uae/news/2022-07-28-1.4484514

Aliyev, E. 2022, July 29. *Fujairah bunker ops remain disrupted after flood*. https://www.argusmedia.com/en/news/2355927-fujairah-bunker-ops-remain-disrupted-after-flood

Gulf Today. 2022, July 29. *Fujairah's Flood*. https://www.gulftoday.ae/news/2022/07/29/at-least-six-dead-due-to-uae-floods

****