Dubai: Regional Case Study Before and After Rain

In recent times, extreme weather events have been noticed across the globe, especially unusual rainfall, which demand immediate attention and proactive steps. These events are critical for our attention because they affect nature, economies, and people's well-being in many ways. When precipitation deviates from normal patterns, unusual rainfall can cause devastating floods and put infrastructure and public health at risk. To respond effectively, there is an increasing need to grasp how these unpredictable weather changes impact our society. Climate change, deforestation, growing urban areas, and how land is used, are all factors that make these abnormal rains more frequent and severe. Therefore, understanding their impact is vital for keeping communities safe from the increasing dangers brought by unpredictable rainfall.

Figure 1: Before Rain

Figure 2: After Rain

Regional Case Study 1 (from Dubai): On April 16, 2024, the United Arab Emirates experienced an unusual rain event that severely affected many areas, causing significant disruptions to daily life. Dubai, in particular, was hit hard, receiving an entire year's worth of rain within just 12 hours. This extreme weather event, attributed to changing environmental conditions, led to widespread flooding, flight cancellations, and impassable roads. As part of our investigation, we have chosen a specific area in Dubai to study the extent of the impact caused by this intense rainfall. A Sentinel-2 [1] satellite captured imagery with a 10-meter resolution, shown in Figures 1 and 2. The after-rain image taken on April 17, 2024, clearly depicts the extent of water accumulation post-rainfall. This event brings a rapid rise in water levels, disrupting social activities and majorly affecting the roads, as well as critical infrastructure like restaurants, hospitals, schools, malls, etc. Such rain occurrences are relatively uncommon in dry regions like the Emirates, highlighting the significant impact of this natural disaster.

We have used Sentinel-2 imagery for our initial study, which helps us see how rain affects various aspects of society. Following the acquisition, we eliminate clouds from areas where they exist to minimize noise in the data. This process is crucial because it helps ensure that the data we gather is as accurate as

possible. By removing clouds, we can reduce interference and better analyze the information we obtain. By comparing images before and after the rain, we can identify roads impacted by water accumulation, shown as yellow lines overlapping flooded areas. We also mark a 200-meter radius around such areas to pinpoint key spots like malls, schools, markets, food places, and hospitals to see how they are affected. The number of affected structures includes 460 cafes & restaurants, 75 hospital facilities, 116 stores, 11 schools & universities, and 4 malls. In our case study patch in Dubai, there are 2,963 kilometers of mapped roads out of a total of 18,800 kilometers [2] in the city. From our analysis, we found that 140 kilometers out of 2,963 kilometers are impacted by rain, including primary, residential, service, and highways. We also assess how residential and industrial areas are affected by rainfall. Our data comes from OpenStreetMap, where volunteers worldwide contribute geographic information like streets, points of interest, and landmarks. Furthermore, our analysis involved the application of machine learning technique to extract the built-up area, revealing that 6 km^2 of this area was inundated out of a total of 94 km^2. This observation indicates that approximately 6.4% of the built-up area was affected by the flooding event. Figure 3 can be seen for a summary of our findings in our case study area.

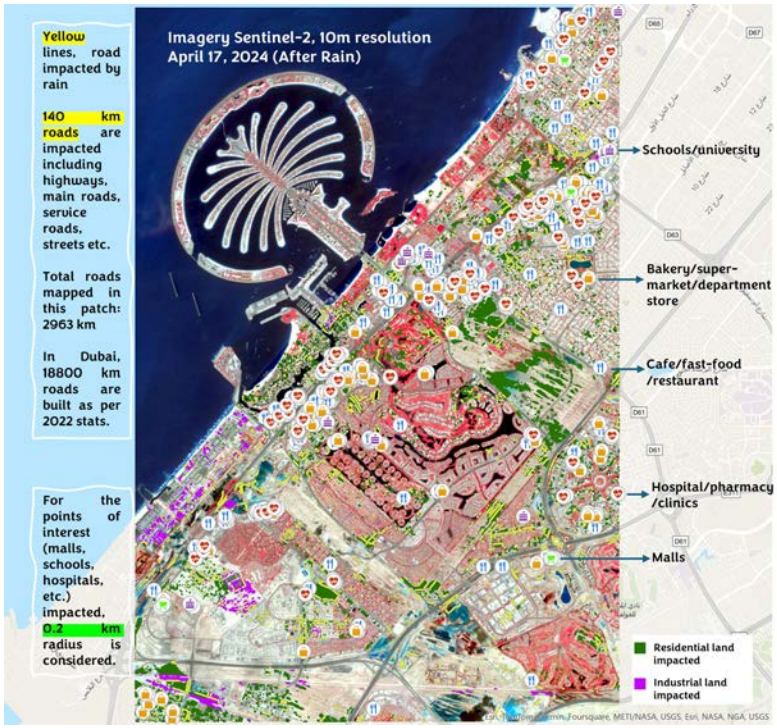

Figure 3: Analysis: Region for our case study.

Regional Case Study 2 (from AbuDhabi): The April 16 weather system also impacted Abu Dhabi and neighboring regions. Our study expands its focus to specific regions within Abu Dhabi, leveraging data from sources such as Sentinel-2 imagery dated April 17, 2024. This examination unveiled widespread impacts on critical infrastructure, including schools, hospitals, and restaurants within a 200-meter radius. To ensure precision, regions covered by clouds in the images were substituted with noise-free data. Numerous vital facilities were impacted, along with approximately 21 kilometers of road, out of a total

network spanning 837 kilometers, sustaining damage across various categories of roads. Furthermore, we meticulously computed the number of eateries, medical facilities, retail outlets, and educational institutions affected, revealing a potential disruption in the operations of 240 restaurants & cafes, 55 healthcare facilities, 78 stores, and 6 educational institutions. Employing machine learning techniques, we outlined the built-up areas in the Sentinel-2 imagery. We observed that approximately 2 km^2 of land within a 40 km^2 area was flooded, signifying a flooding extent of 5% in the targeted region of Abu Dhabi.

Figure 4: Before Rain

Figure 5: After Rain

Figure 6: Analysis: Case Study

Regional Case Study 3 (from Oman): In our comprehensive analysis, we have expanded our investigation to include the impact of rainfall on regions beyond the Emirates, specifically focusing on the area in the Oman region close to the Al Ain border. We found that out of a total road network spanning 1270 kilometers, 58 kilometers of roads have suffered damage across different types of roads due to abnormal rains. Additionally, we assessed the impact on some important facilities, finding potential disruptions in the operations of 5 restaurants and cafes, 2 healthcare facilities, and 7 stores. The potential danger is comparatively lower given the relatively limited residential facilities and commercial places in this border area. Leveraging machine learning techniques, we analyzed Sentinel-2 imagery to identify built-up areas. We observed that approximately 5 km^2 of land within an 88 km^2 area experienced flooding, indicating a flooding extent of 5.7% in the targeted region of Oman.

Figure 7: Before Rain

Figure 8: After Rain

Figure 9: Analysis: Case Study

Future Interests: In the future, we aim to expand our study to include more areas in the Emirates, especially those heavily impacted in Dubai and Abu Dhabi to provide a useful tool for the local municipalities and authorities in rapidly assessing the impact of heavy rains in the country. We will also look into how water accumulation affects population density and urbanization. Additionally, we will study how long it takes for flooded areas to dry up as a part of temporal analysis. Our information and analysis can help authorities in many ways, like working with communities to make them more resilient, planning infrastructure to handle these events, and creating policies to adapt to long-term water resource and infrastructure changes.

References

[1] C. D. S. Ecosystem, "Sentinel-2 — dataspace.copernicus.eu," https://dataspace.copernicus.eu/explore-data/data-collections/sentinel-data/sentinel-2, [Accessed 29-04-2024].

[2] "UAE: length of roads in Dubai — Statista — statista.com," https://www.statista.com/statistics/1343465/uae-dubai-total-length-of-roads/, [Accessed 29-04-2024].