Assessing Urban Flooding and Vegetation Impact in Dubai Creek Following the April 2024 Extreme Rainfall

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Abstract

During April 2024, the United Arab Emirates experienced an unusual phenomenon of an intense rainfall episode between April 14 and 18 that resulted in massive flooding in urban environments, particularly low-lying areas such as Dubai Creek. As a tidal waterway with dense urban development and environmentally sensitive zones surrounding it, Dubai Creek is an ideal site for assessing environmental changes caused by to floods. The study employed pre-flood (14 April) and post-flood (18 April) high-resolution PlanetScope satellite images, in combination with QGIS analysis, to evaluate vegetation health and surface water changes. Quantification of affected areas from flooding was achieved through using the Normalized Difference Water Index (NDWI), where the Normalized Difference Vegetation Index (NDVI) was applied in assessing the stress and damage on vegetation. Results showed minimum water presence before the flood, and post-flood NDWI showed extensive water coverage on roads, parks, and vacant land with difference values being mostly between +0.2 and +0.4. NDVI analysis exhibited severe vegetation loss near the creek, with difference values greatly varying from −0.1 to −0.3, indicating submersion and stress. These findings demonstrate the feasibility of integrating high-resolution satellite imagery with remote sensing indices in monitoring impacts of floods, showing the significance of continuous environmental monitoring and improved flood management in urban planning.

1. Introduction

Flooding and extreme rainfall are becoming an increasing concern in the Gulf region, being an arid and semi-arid region, especially with the impact of climate change and rapid urbanisation. In recent years, extreme weather events as such are becoming more frequent and intense. The region experienced extreme rainfall in April 2024. This event from 14th to 18th of April was particularly intense in the United Arab Emirates (UAE) (World Weather Attribution, 2024). This event marks the heaviest rainfall the Arabian Peninsula has experienced in 75 years (Francis et al., 2025; Hussein et al., 2025).

In Dubai, a fast-growing metropolitan area, heavy precipitation and flooding pose challenges to its environmental sustainability, infrastructure, and urban resilience. The rain in Dubai started on the evening of April 15th, increasing the following morning, and finally halting on the 17th of April. The city recorded about 142 mm over 24 hours, equivalent to more than one and a half times its annual average of 95–100 mm, and nearby stations in the UAE peaked at ~255 mm (Al Jazeera, 2024; The Guardian, 2024; National Center of Meteorology, 2024).

According to reports, flooding spread into residential areas, leaving many homes waterlogged and suffering from outages or lack of supplies. The flash floods inundated major highways, which resulted in 5 casualties across the Emirates. In Dubai International Airport alone, almost 1,500 flights were cancelled (Reuters, 2024).

Zones of high ecological sensitivity flooded significantly. Notably Ras Al Khor Wildlife Sanctuary, a major part of Dubai Creek, is emerging as one of the most severely impacted sites. This event caused not only immediate disruptions to transportation, property, and human activities but also lasting environmental disturbances, particularly in vegetation cover and surface water dynamics (Francis et al., 2025; Hong, Da, & Wei, 2025).

As a natural tidal waterway surrounded by dense urban development and ecologically sensitive zones, Dubai Creek represents a strategic location for analysing flood-induced environmental change (Ali et al., 2024; Francis et al., 2025).

This study utilized PlanetScope satellite imagery from pre-rainfall (April 14) and post-rainfall (April 18) periods to assess flood impacts and vegetation disturbances. Two remote sensing indices, the Normalized Difference Water Index (NDWI) and Normalized Difference Vegetation Index (NDVI), were employed to quantify and visualize changes with a focus on environmental degradation and resilience (Hong, Da, & Wei, 2025).

PlanetScope imagery captured from a pre-rainfall and a post-rainfall day was used to map the flooded areas and vegetation changes in Dubai Creek. The main remote sensing techniques applied for the analysis were NDWI and NDVI. The primary objectives of this research were: (1) to evaluate flood-induced surface water expansion using NDWI, and (2) to detect vegetation health and losses using NDVI. Dubai Creek was selected due to its flood-prone lowland characteristics, ecological importance, and the significant damage observed following the rainfall event (Francis et al., 2025). The area of

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interest (AOI) included the creek corridor and surrounding urban land, as outlined in Figure 1.

2. Methodology

2.1 Study Area

The study is focused on Dubai Creek, Dubai's natural tidal waterway that is surrounded by ecologically sensitive zones, residential areas, and dense urbanisation, neighbouring Dubai's International airport. The area of interest (AOI) covers approximately 93km^2. It encompasses the creek corridor, bordering urban developments, including residential and commercial areas. AOI also covers adjacent vegetative land and critical wildlife habitats like the Ras Al Khor wildlife sanctuary. Due to its sunken and flood prone nature, Dubai Creek is a strategic location for this assessment of the impact of the April 2024 floods on surface water and vegetation health.

2.2 Satellite Data

PlanetScope satellite imagery was utilized for this study due to its high spatial resolution. It has a special resolution of 3 meters approximately per pixel, which is ideal for capturing fine-scale urban and vegetation features. It includes multispectral bands with Red, Green, Blue, and Near-Infrared, the four-band product used for the calculation of NDVI and NDWI indices. PlanetScope allows for daily revisits, which is ideal for timely execution of comparisons of pre and post flood conditions.

The imagery was acquired from April 14, 2024 (pre-flood) and April 18, 2024 (post-flood) for this study. Data processing and visualization were conducted using QGIS. Data preprocessing steps included image alignment and cloud masking to ensure accuracy and coverage consistency. Surface reflectance products were used so that atmospheric corrections could be applied, allowing for accurate mapping of flood-induced surface water expansion and vegetation changes in Dubai Creek.

2.3 Data Preprocessing

Data preprocessing was conducted using QGIS and included the following steps: Image Alignment: Co-registering pre- and post-flood images for accurate pixel-based comparison. Cloud and Shadow Masking: Removing erroneous pixels to improve analysis reliability. AOI Subsetting: Extracting only the creek corridor and surrounding areas.

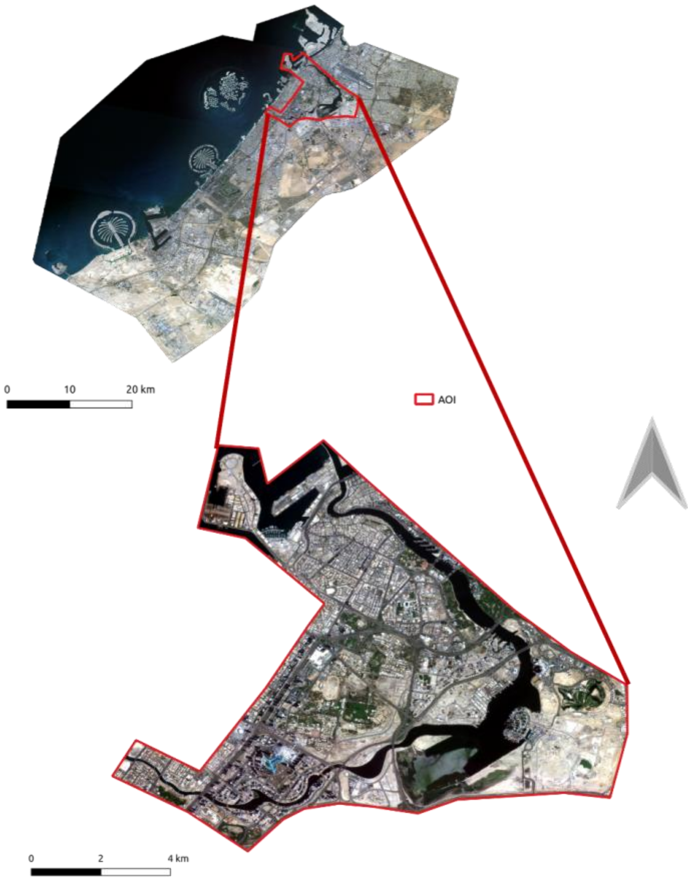

Figure 1. Study Area Map – Dubai Creek and AOI boundaries.

2.4 index calculation

The NDWI was derived from the green and NIR bands, and the NDVI was calculated using the red and near-infrared (NIR) bands of the PlanetScope imagery. The differences in NDWI and NDVI were also calculated to detect the flooded areas and the spatial changes of vegetation density. The above-mentioned calculations are based on the following equations:

$$NDWI = (NIR - Green) / (NIR + Green) \quad (1)$$

$$NDVI = (NIR - Red) / (NIR + Red) \quad (2)$$

$$NDWI_{diff} = NDWI_{Apr18} - NDWI_{Apr14} \quad (3)$$

$$NDVI_{diff} = NDVI_{Apr18} - NDVI_{Apr14} \quad (4)$$

2.5 Change Detection and Analysis

Identified areas of flood-induced surface water expansion. NDVI Difference Maps: Highlighted vegetation stress or loss caused by flooding. Statistical Analysis: Histograms and summary statistics quantified the magnitude and distribution of changes. Spatial Analysis: Overlay of flood and vegetation changes with urban and ecologically sensitive areas in QGIS.

3. Results and discussion

The NDWI and NDVI of PlanetScope imagery provides the spatial and temporal impact of the April 2024 flood on Dubai Creek. Based on the evaluation between pre- and post-rainfall imagery, the results display extensive surface water coverage and vegetation stress, specifically in low-lying urban and ecologically sensitive areas. This discussion takes these trends into account, linking the changes witnessed to land use, urban infrastructure, and environmental vulnerability, considering the limitations of this remote sensing approach.

3.1 Surface Water Analysis (NDWI)

The analysis began with surface water detection using NDWI, followed by vegetation change analysis using NDVI, based on PlanetScope imagery and spatial processing in QGIS. For surface water analysis, the pre-rainfall NDWI map (Figure 2) shows negative values across much of the AOI, indicating dry ground conditions except within the creek itself. The histogram (Figure 3) confirms these conditions. Post-flood NDWI mapping (Figure 4) displays strong positive changes in water index values across roads, parks, and undeveloped plots. Histogram (Figure 5) supports this, showing a major increase in positive NDWI values above 0.3.

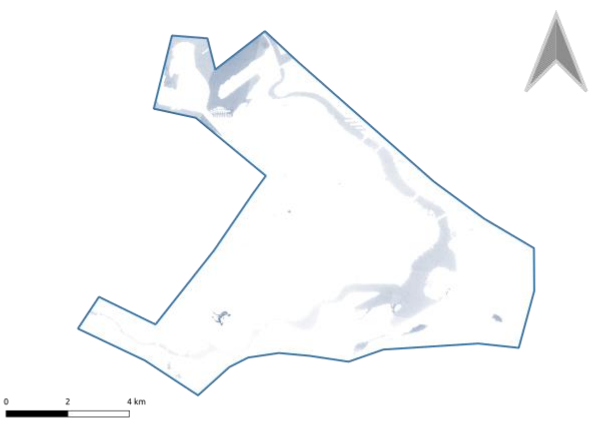

Figure 2. NDWI Map (April 14 (Pre Rainfall).

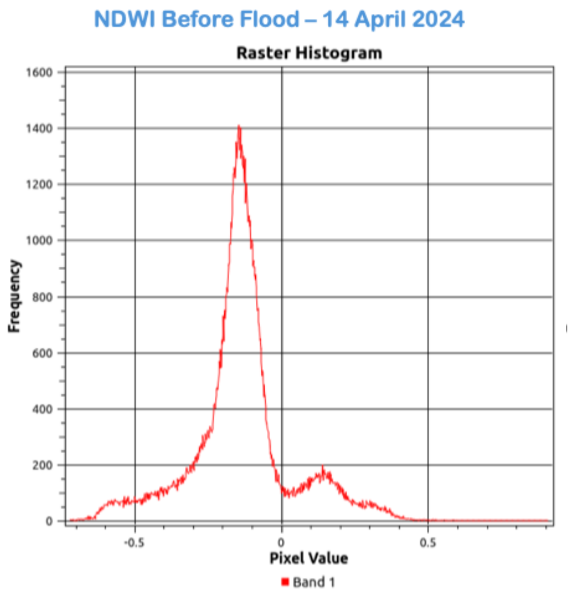

Figure 3. Histogram – NDWI (April 14, pre-rainfall)

Figure 4 NDWI Map (April 18 ,post rainfall)

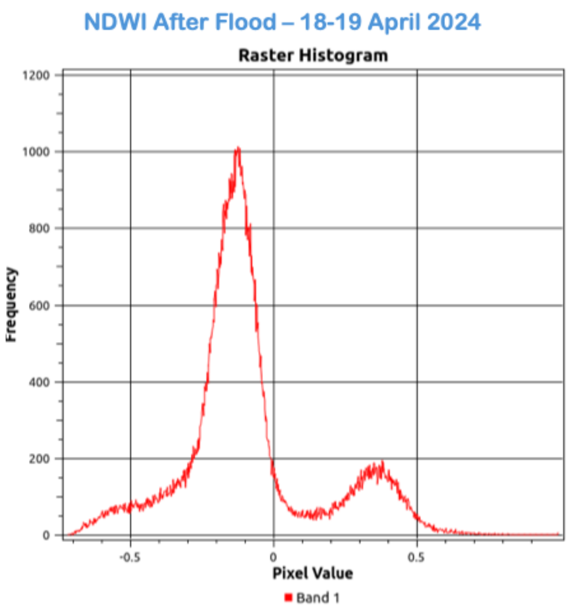

Figure 5, NDWI Histogram – (April 18, post-rainfall)

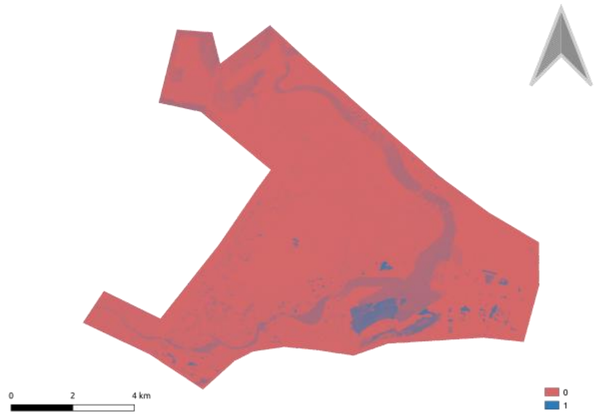

Figure 6 NDWI Difference Map (Post – Pre)

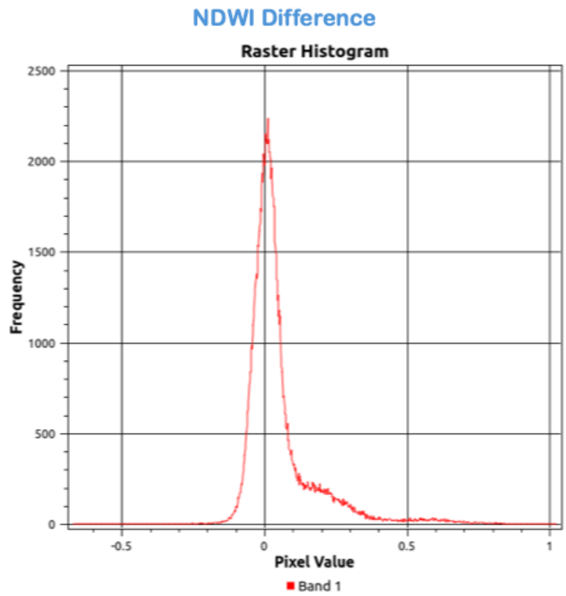

Figure 7. Histogram – NDWI Difference (Post – Pre)

The NDWI difference map (Figure 6) highlights areas of flood-induced surface water gain. Its histogram (Figure 7) reveals that most values increased between +0.2 and +0.4, confirming the spatial extent and intensity of flooding. All spatial analysis, including overlay and classification steps, was carried out within QGIS, allowing for accurate pixel-based comparison across dates.

These NDWI values are a suitable representation of the flooded versus non-flooded locations, in line with urban roadways, parkland, and creek edges expectation. A few anomalies were also observed, likely due to shadows or extremely reflective built-up cover, and these are representative of possible NDWI limitations over very highly urbanized locations. Overall, NDWI was helpful in rapid flood mapping of the AOI.

3.2 Vegetation Analysis (NDVI)

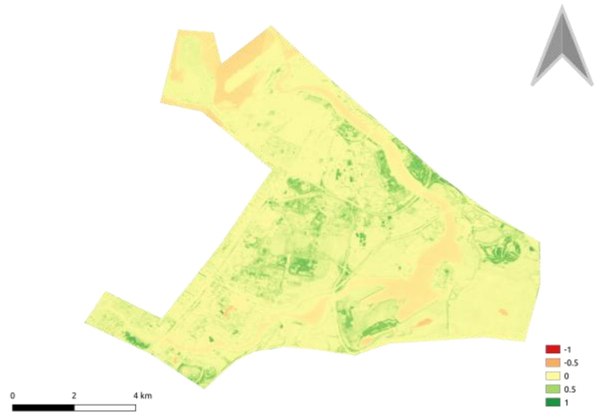

Figure 8. NDVI Map (April 14 (Pre Rainfall)

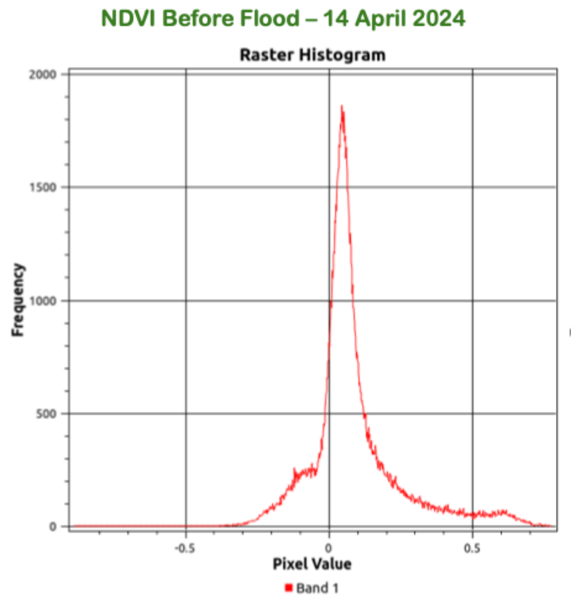

Figure 9. Histogram – NDVI (April 14, pre-rainfall)

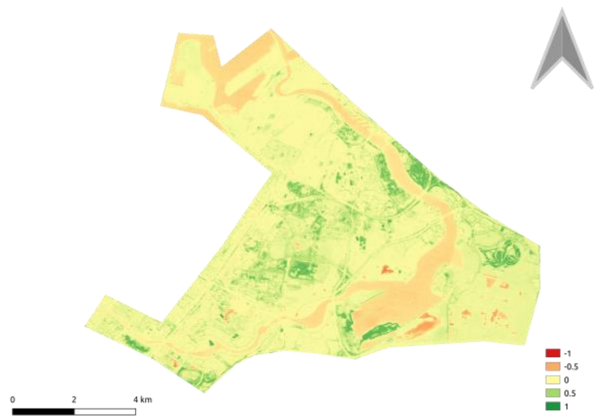

Figure 10 NDVI Map (April 18, post rainfall)

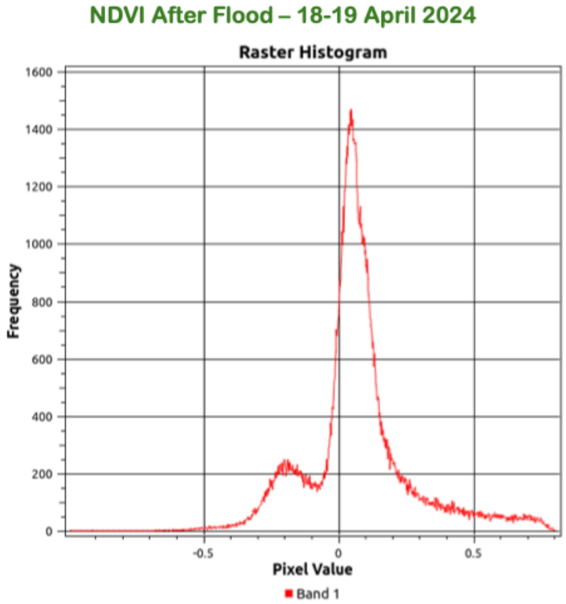

Figure 11. NDVI Histogram – (April 18, post-rainfall)

Before the flooding event, the study area presented showed typical sparse urban vegetation, mainly found in landscaped and riparian zones. This can be seen from the NDVI imagery (Figure 8) and NDVI histogram values, where most of the values were between 0.1 and 0.3 (Figure 9). After the flood, vegetation health significantly decreased, particularly near the creek (Figures 10 and 11). The NDVI difference map (Figure 12) illustrated widespread vegetation degradation with values primarily between −0.1 and −0.3.

The histogram (Figure 9) confirms this distribution. Immediately after the rainfall, the NDVI map from April 18–19 (Figure 10) reveals a marked decrease in vegetation health across the study area, particularly along creek-adjacent zones. The histogram (Figure 11) shows a shift toward lower values, indicating vegetative stress or submersion. The corresponding histogram (Figure 13) illustrates the shift, with most values falling between −0.1 and −0.3.

Figure 12. NDVI Difference Map (Post – Pre)

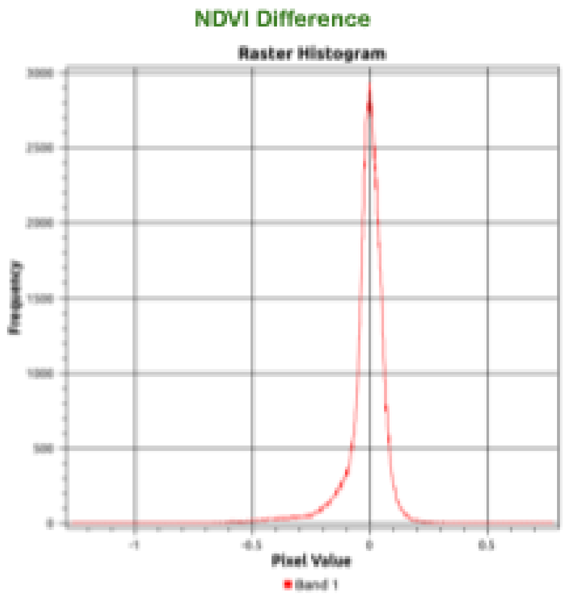

Figure 13 Histogram – NDVI Difference (Post – Pre)

Index	Date	Key Values	Observation
NDWI	Apr 14, 2024	Mostly negative	Dry ground, water mainly in creek
NDWI	Apr 18, 2024	>0.3 in many areas	Flooded roads, parks, and plots
NDWI Diff	Apr 18–14, 2024	+0.2 to +0.4	Flood-induced surface water gain
NDVI	Apr 14, 2024	0.1–0.3	Sparse urban vegetation
NDVI	Apr 18, 2024	Decreased	Vegetation stress, especially near creek
NDVI Diff	Apr 18–14, 2024	−0.1 to −0.3	Widespread vegetation degradation

Table 1. NDWI and NDVI Values Pre- and Post-April 2024 Flood in Dubai Creek

NDVI variations reflect vegetation stress or flooding submersion. Creek side zones and the Ras Al Khor sanctuary displayed stark declines, indicating serious ecological impacts. NDVI accuracy may be reduced by mixed pixels, shadows, and human-made surfaces, especially in urban settings. However, NDVI effectively identified areas of vegetative stress and probable habitat disturbance.

In combining NDWI and NDVI values, the increased surface water is linked with declined vegetation health and clearly displays flooding and ecological interaction. The two indices combined provide a robust methodology for identifying environment changes due to flooding, but serial monitoring would add temporal precision and allow for better observation over replenished vegetation or further decline.

3.3 Ras Al Khor Wildlife Sanctuary Flooding

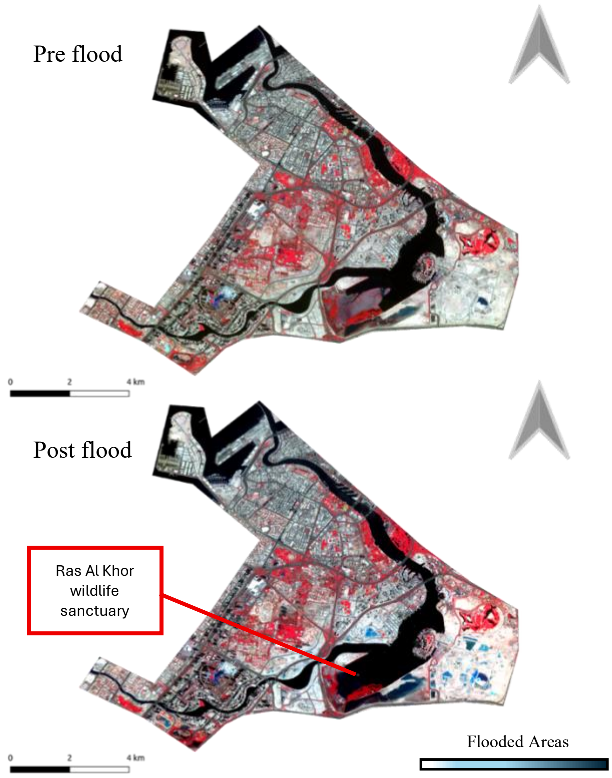

Figure 14. AOI pre and post rainfall; Ras Al Khor wildlife sanctuary flooding level.

As figure 14 shows, Ras Al Khor sanctuary experienced an immense amount of flooding. The Low-lying wetlands and mudflats, which provide critical habitat for migratory birds and other wildlife, were significantly flooded. This sudden rise in water levels likely triggered vegetation stress and disturbed the feeding and nesting grounds of various species. This highlights the vulnerability of ecologically sensitive areas to extreme urban flooding events.

While the results are valuable for interpretation of flood and vegetation dynamics in Dubai Creek, certain of its limitations need to be considered when placing the results within a broader context. The PlanetScope imagery has 3-meter spatial resolution, so finer water channels or high-resolution details in vegetation may not be detected. It also sampled only two dates (pre- and post-flood), which limits the comprehension of temporal dynamics of flood building and short-term vegetation response. NDWI and NDVI indices, while successful, are susceptible to errors in highly urbanized areas by way of mixed pixels, shadows, or artificial surfaces. Following preprocessing, the residual effects of cloud, haze, or shadows can also affect the accuracy of the detected changes. Finally, the findings hold only for the Dubai Creek location and the April 2024 flood event and caution should be exercised in extrapolating results to other locations or flood events with different environmental and urban settings.

4. Conclusion

This study demonstrates the effectiveness of combining conventional remote sensing indices with high spatial resolution PlanetScope imagery and QGIS-based analysis to assess the environmental impacts of urban flooding. The April 2024 rainfall event had a measurable impact on both surface water distribution and vegetation health in the Dubai Creek area, emphasizing the need for continued monitoring and improved flood management strategies within urban planning frameworks.

The use of PlanetScope data within a QGIS environment enabled accurate detection of flood-induced changes across the landscape. Surface water analysis, conducted through NDWI, showed minimal water presence before the flood (April 14), as evidenced by the NDWI map and histogram (Figures 2 and 3). In contrast, the post-flood NDWI map (Figure 4) displayed extensive surface water spread across built-up and vegetated areas. The histogram (Figure 5) confirmed this shift, with values increasing significantly. The NDWI difference map (Figure 6) and its histogram (Figure 7) revealed that surface water expanded substantially, with most values rising between +0.2 and +0.4.

Riparian environments and environmentally sensitive areas, like Ras Al Khor wildlife sanctuary, were especially affected. The results highlight the importance of constant high-resolution monitoring to record flood behaviour and vegetation recovery. Recommendations include the use of flood-tolerant urban planning, the protection of vulnerable ecosystems, and the use of remotely sensed data to guide emergency response and restoration efforts. Such actions increase environmental resilience and urban flood preparedness in arid, rapidly urbanizing regions like the UAE.

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