# DATA ANALYSIS OF NDVI IN BEQAA REGION LEBANON

## A PROMPT ENGINEERING GENERATIVE AI AIDED PROJECT

## A SECTION OF CROPS - BEQAA REGION, LEBANON


### BY

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Dataset taken From Sentinel 2 extracted from a code using Google Earth Engine for a section of the Beqaa Region in Lebanon between the years of 2020 and 2024

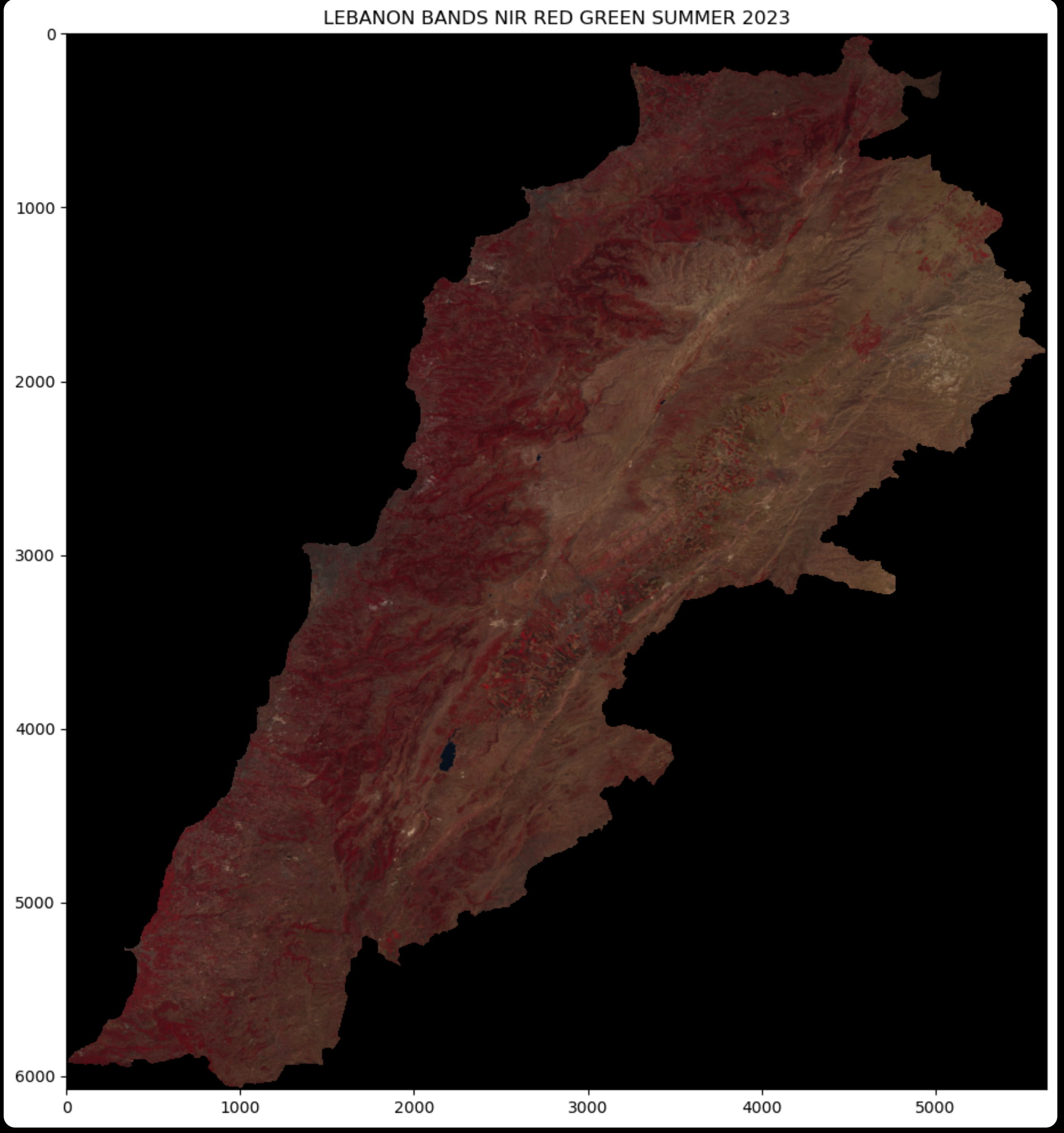
NDVI_Lebanon_Beqaa is a prepared python file by us that contains all the functions used in this code.

In [1]:
```
# These libraries were used for the code to operate
import rasterio
import numpy as np
import matplotlib.pyplot as plt
import scipy.stats
from skimage import io
import NDVI_Lebanon_Beqaa as Beqaa
```

Import the geotiff files

In [2]:
```
Lebanon_Map = r'D:\Greenovation_Engineer\NDVI\LEB_SUMMER_2023.tif'
BEQAA_03_2023 = r'D:\Greenovation_Engineer\NDVI\Sentinel2_BEQAA_SECTION_CROPS_MID_MARCH_2023.tif'
BEQAA_06_2023 = r'D:\Greenovation_Engineer\NDVI\Sentinel2_BEQAA_SECTION_CROPS_MID_JUNE_2023.tif'
BEQAA_09_2023 = r'D:\Greenovation_Engineer\NDVI\Sentinel2_BEQAA_SECTION_CROPS_MID_SEPT_2023.tif'
BEQAA_12_2023 = r'D:\Greenovation_Engineer\NDVI\Sentinel2_BEQAA_SECTION_CROPS_MID_DEC_2023.tif'
BEQAA_12_2022 = r'D:\Greenovation_Engineer\NDVI\Sentinel2_BEQAA_SECTION_CROPS_MID_DEC_2022.tif'
BEQAA_12_2021 = r'D:\Greenovation_Engineer\NDVI\Sentinel2_BEQAA_SECTION_CROPS_MID_DEC_2021.tif'
BEQAA_12_2020 = r'D:\Greenovation_Engineer\NDVI\Sentinel2_BEQAA_SECTION_CROPS_MID_DEC_2020.tif'
```

In [3]:
```
Beqaa.display_rgb_leb(Lebanon_Map, 'LEBANON BANDS NIR RED GREEN SUMMER 2023')
```




Understanding NDVI (Normalized Difference Vegetation Index)

The **Normalized Difference Vegetation Index (NDVI)** is a widely used metric to assess the health and abundance of vegetation in a given area. It is calculated using satellite or aerial imagery, capturing the reflectance of different wavelengths of light.

Formula:

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

where:

- *NIR* (Near-Infrared) is the reflectance in the near-infrared spectrum.
- *Red* is the reflectance in the red spectrum.

Interpretation:

- **Positive Values (0.2 to 0.8):** Indicates healthy vegetation, with higher values corresponding to denser and more vigorous plant growth.
- **Zero or Negative Values:** Suggests non-vegetated surfaces like bare soil or water bodies.

Visualization:
The NDVI formula exploits the fact that healthy vegetation strongly absorbs red light and reflects near-infrared light. As a result:

- High NDVI values (bright green) correspond to thriving vegetation.
- Low or negative NDVI values (dull or dark colors) suggest non-vegetated areas.

By analyzing NDVI maps, researchers and environmentalists gain valuable insights into the spatial distribution and health of vegetation, aiding in various applications, including agriculture, forestry, and ecological monitoring.

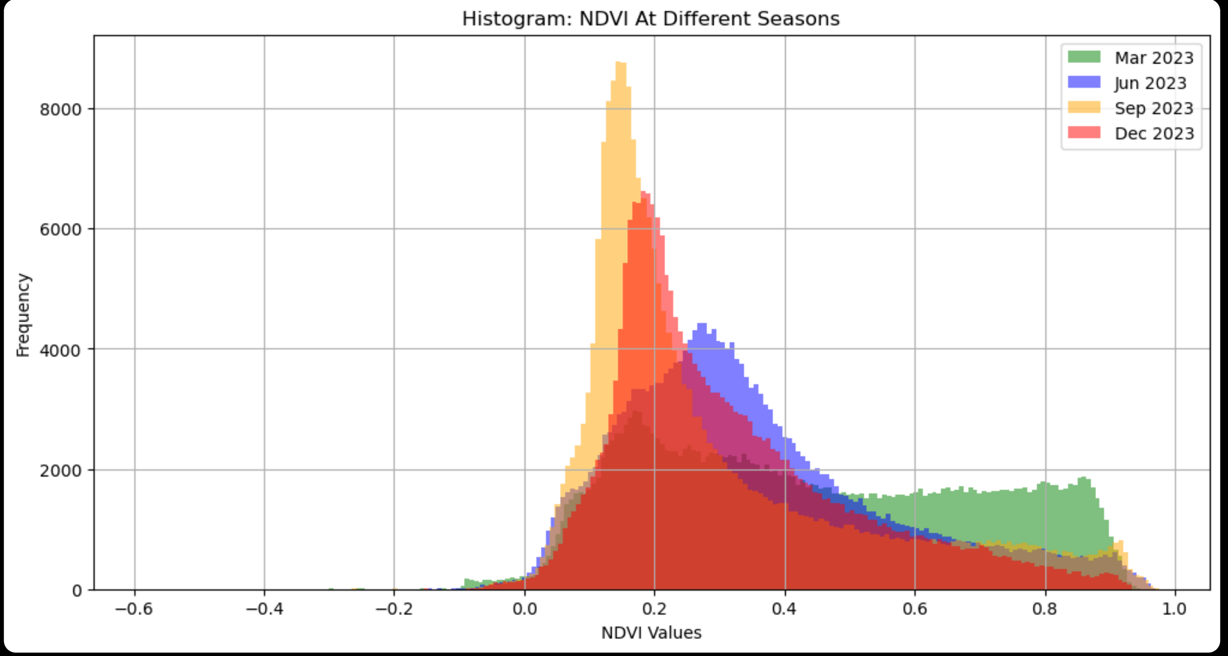
In [4]:
```
green_band, red_band, nir_band = Beqaa.read_bands_from_geotiff_1(BEQAA_03_2023)
# Calculate NDVI
ndvi_03_2023 = Beqaa.calculate_ndvi(red_band, nir_band)
# Flatten the NDVI values to create a 1D array
flat_ndvi_03_2023 = ndvi_03_2023.flatten()
```

In [5]:
```
green_band, red_band, nir_band = Beqaa.read_bands_from_geotiff_2(BEQAA_06_2023)
# Calculate NDVI
ndvi_06_2023 = Beqaa.calculate_ndvi(red_band, nir_band)
# Flatten the NDVI values to create a 1D array
flat_ndvi_06_2023 = ndvi_06_2023.flatten()
```

In [6]:
```
green_band, red_band, nir_band = Beqaa.read_bands_from_geotiff_3(BEQAA_09_2023)
# Calculate NDVI
ndvi_09_2023 = Beqaa.calculate_ndvi(red_band, nir_band)
# Flatten the NDVI values to create a 1D array
flat_ndvi_09_2023 = ndvi_09_2023.flatten()
```

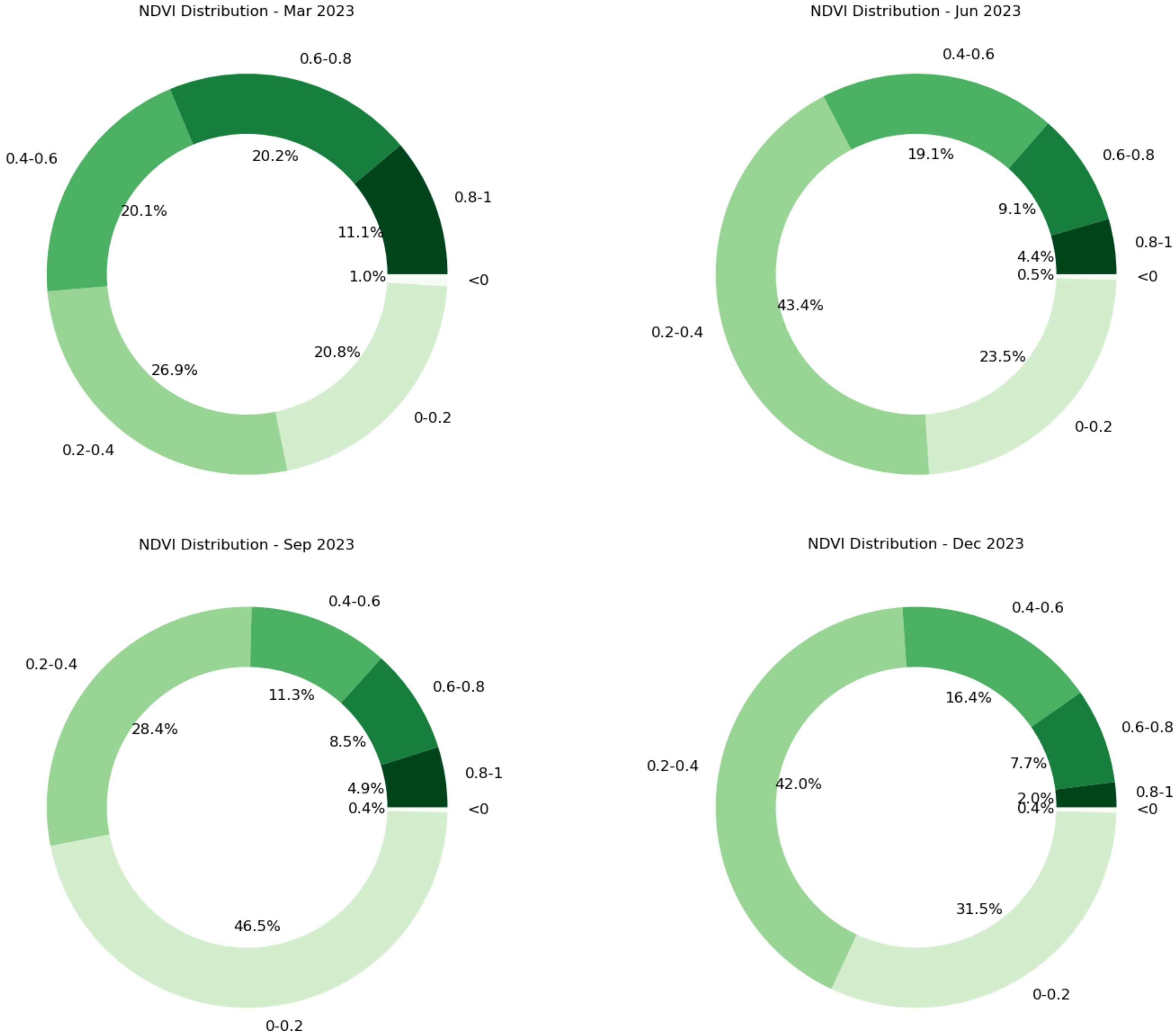
In [7]:
```
green_band, red_band, nir_band = Beqaa.read_bands_from_geotiff_4(BEQAA_12_2023)
# Calculate NDVI
ndvi_12_2023 = Beqaa.calculate_ndvi(red_band, nir_band)
# Flatten the NDVI values to create a 1D array
flat_ndvi_12_2023 = ndvi_12_2023.flatten()
```

In [8]:
```
ndvi_data_list = [flat_ndvi_03_2023, flat_ndvi_06_2023, flat_ndvi_09_2023, flat_ndvi_12_2023]
colors = ['green', 'blue', 'orange', 'red']
titles = ['Mar 2023', 'Jun 2023', 'Sep 2023', 'Dec 2023']
Beqaa.plot_multiple_ndvi_histograms(ndvi_data_list, colors, titles)
```



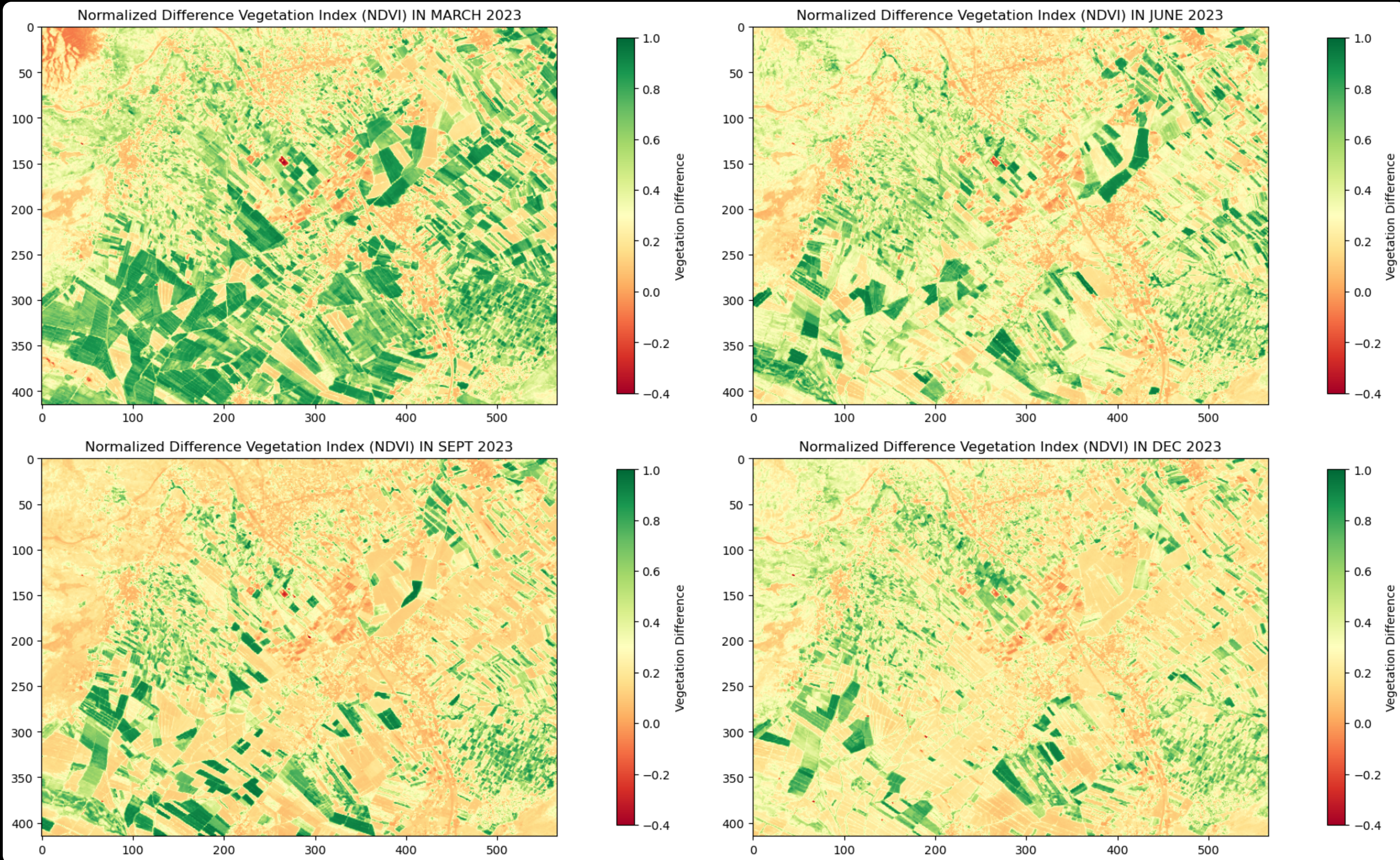

In [9]:

```
ndvi_data_list_pie = [flat_ndvi_03_2023, flat_ndvi_06_2023, flat_ndvi_09_2023, flat_ndvi_12_2023]
ndvi_labels_pie = ['<0', '0-0.2', '0.2-0.4', '0.4-0.6', '0.6-0.8', '0.8-1']
ndvi_bins_pie = [-1, 0, 0.2, 0.4, 0.6, 0.8, 1]
titles_pie = ['Mar 2023', 'Jun 2023', 'Sep 2023', 'Dec 2023']
Beqaa.plot_ndvi_pie_subplots(ndvi_data_list_pie, ndvi_labels_pie, ndvi_bins_pie, titles_pie)
```


NDVI Distribution - Mar 2023
0.6-0.8
0.4-0.6
0.8-1
<0
0-0.2
0.2-0.4
20.2%
20.1%
11.1%
1.0%
20.8%
26.9%
NDVI Distribution - Jun 2023
0.4-0.6
0.6-0.8
0.8-1
<0
0.2-0.4
0-0.2
19.1%
9.1%
4.4%
0.5%
43.4%
23.5%
NDVI Distribution - Sep 2023
0.4-0.6
0.2-0.4
0.6-0.8
0.8-1
<0
0-0.2
11.3%
28.4%
8.5%
4.9%
0.4%
46.5%
NDVI Distribution - Dec 2023
0.4-0.6
0.6-0.8
0.2-0.4
0.8-1
<0
0-0.2
16.4%
7.7%
42.0%
2.0%
0.4%
31.5%

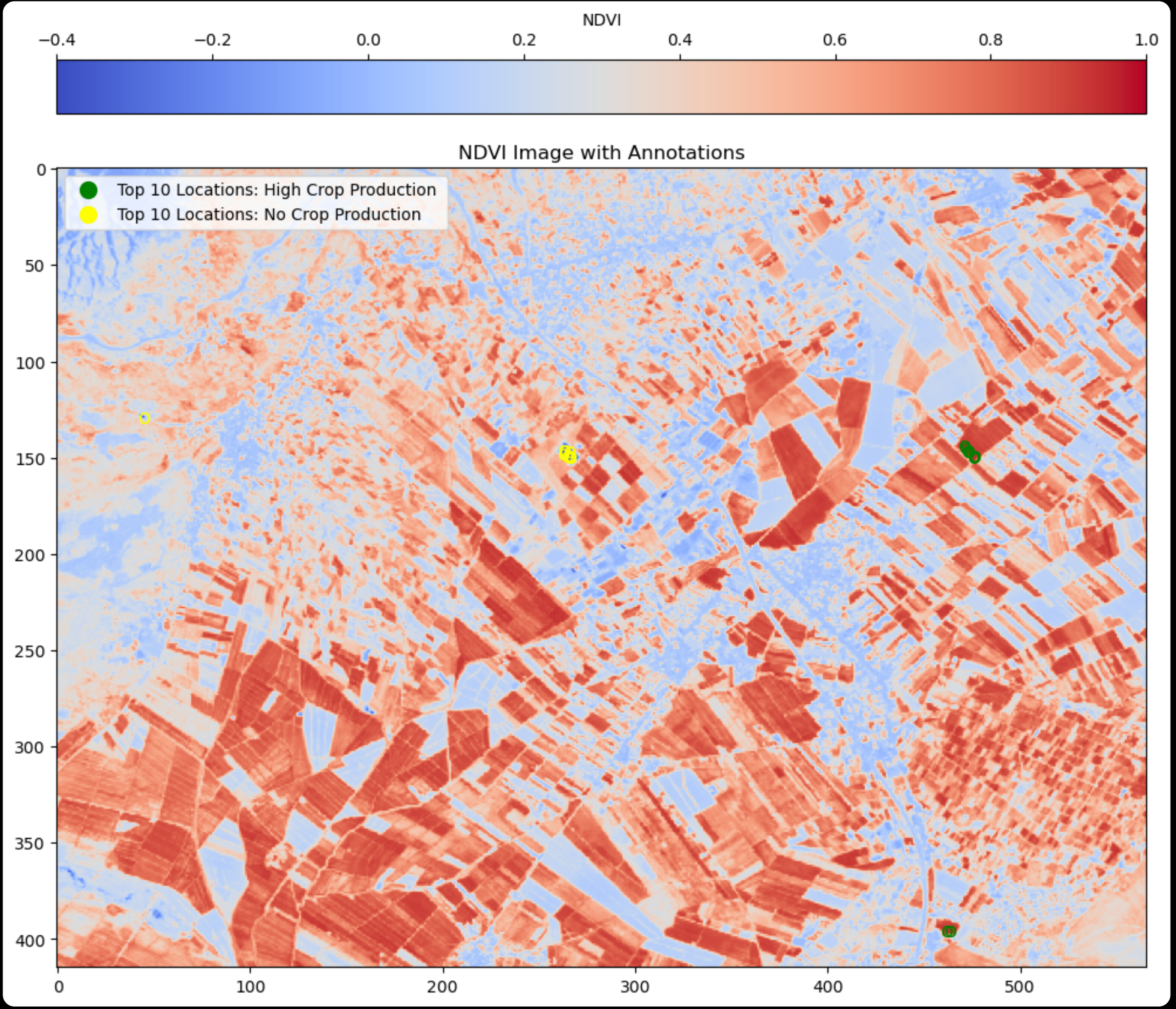
In [10]:

```
ndvi_data_list = [ndvi_03_2023, ndvi_06_2023, ndvi_09_2023, ndvi_12_2023]
titles = ['Normalized Difference Vegetation Index (NDVI) IN MARCH 2023',
          'Normalized Difference Vegetation Index (NDVI) IN JUNE 2023',
          'Normalized Difference Vegetation Index (NDVI) IN SEPT 2023',
          'Normalized Difference Vegetation Index (NDVI) IN DEC 2023']
Beqaa.plot_veg_diff_subplot(ndvi_data_list, titles)
```



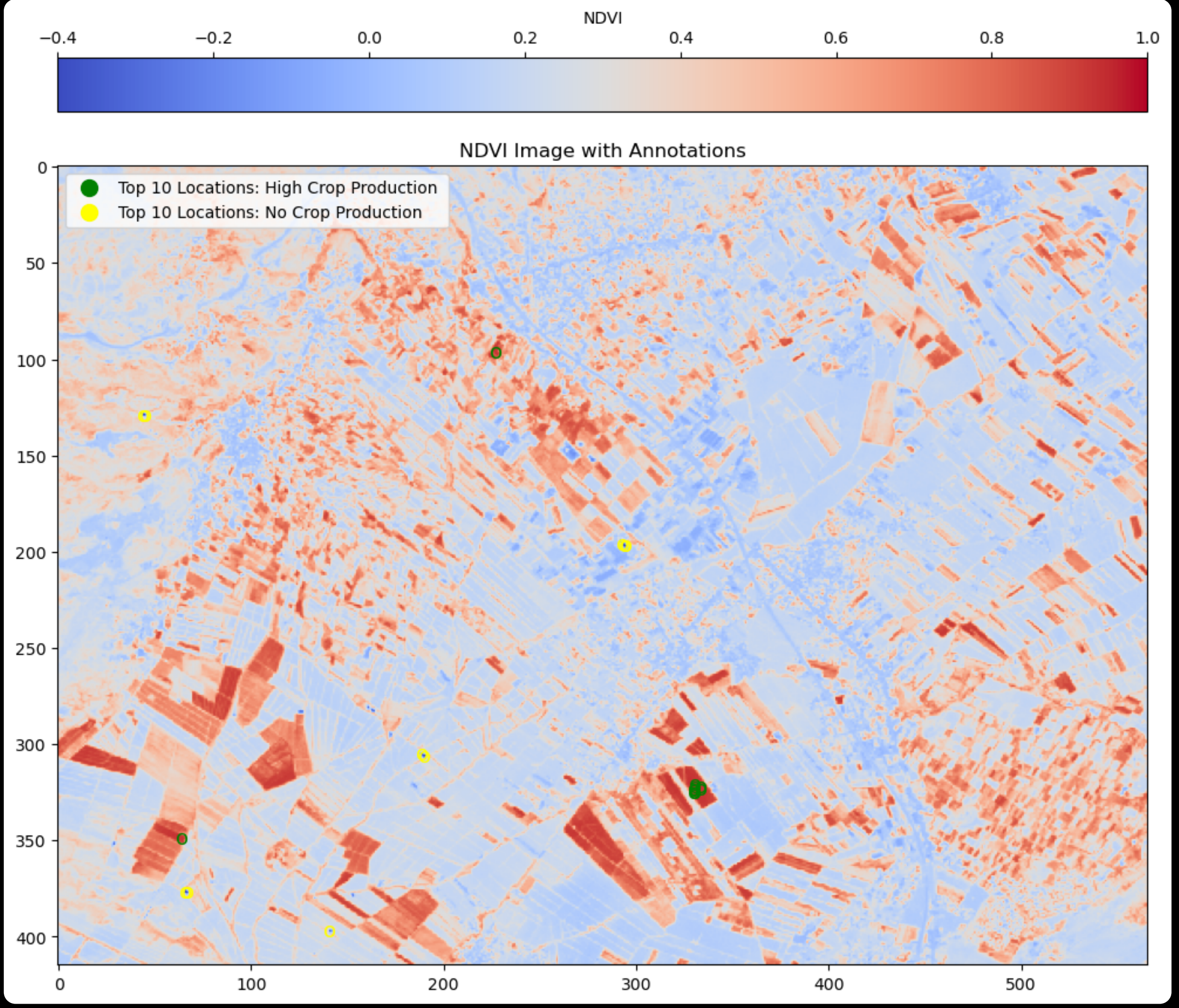

Annotate the locations of the top 10 highest and lowest crop production in 03/2023

In [11]:
```
Beqaa.plot_ndvi_with_top_annotations(ndvi_03_2023)
```




Annotate the locations of the top 10 highest and lowest crop production in 12/2023

In [12]:
```
Beqaa.plot_ndvi_with_top_annotations(ndvi_12_2023)
```

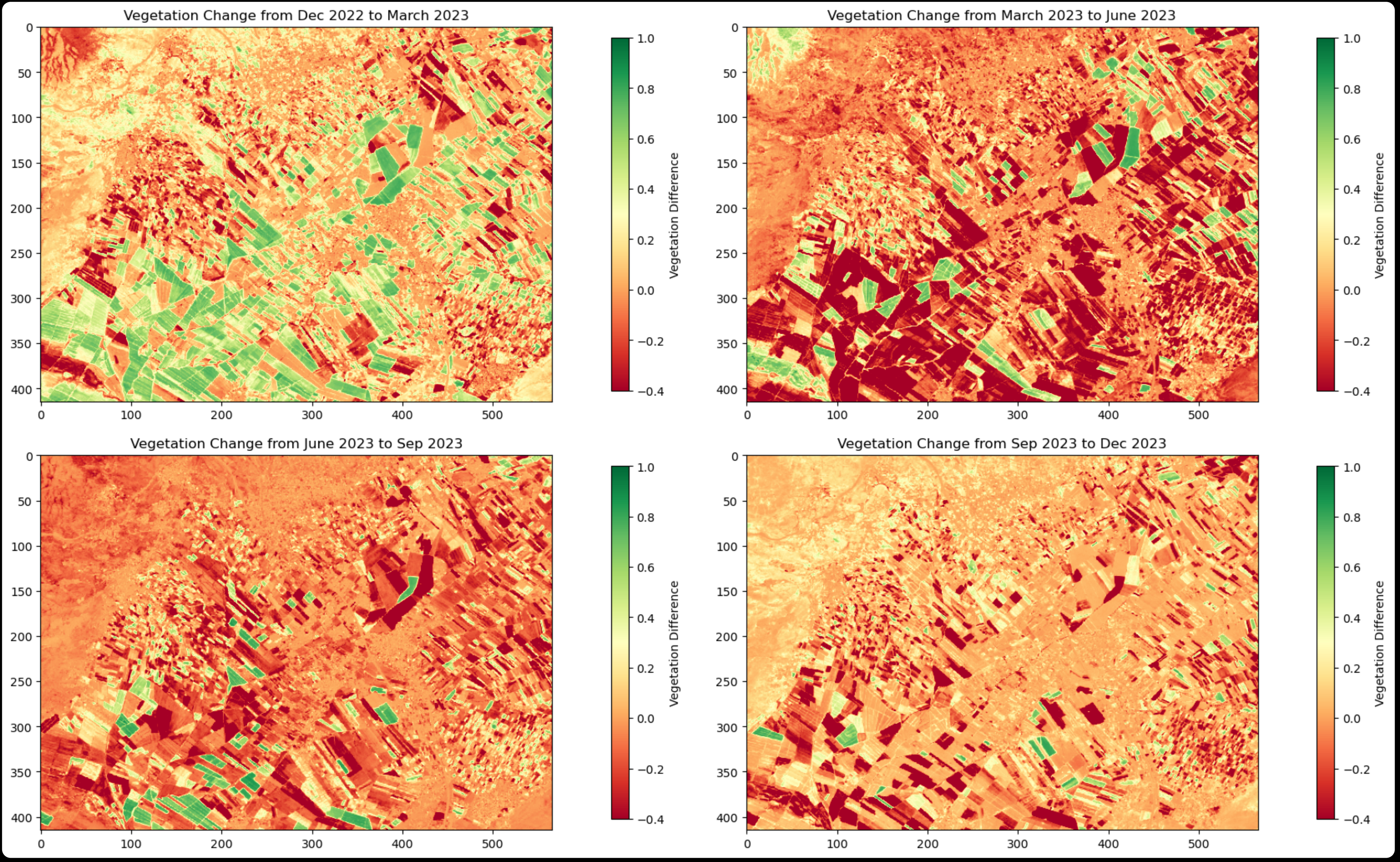



In [13]:
```
green_band, red_band, nir_band = Beqaa.read_bands_from_geotiff_5(BEQAA_12_2022)
# Calculate NDVI
ndvi_12_2022 = Beqaa.calculate_ndvi(red_band, nir_band)
# Flatten the NDVI values to create a 1D array
flat_ndvi_12_2022 = ndvi_12_2022.flatten()
```

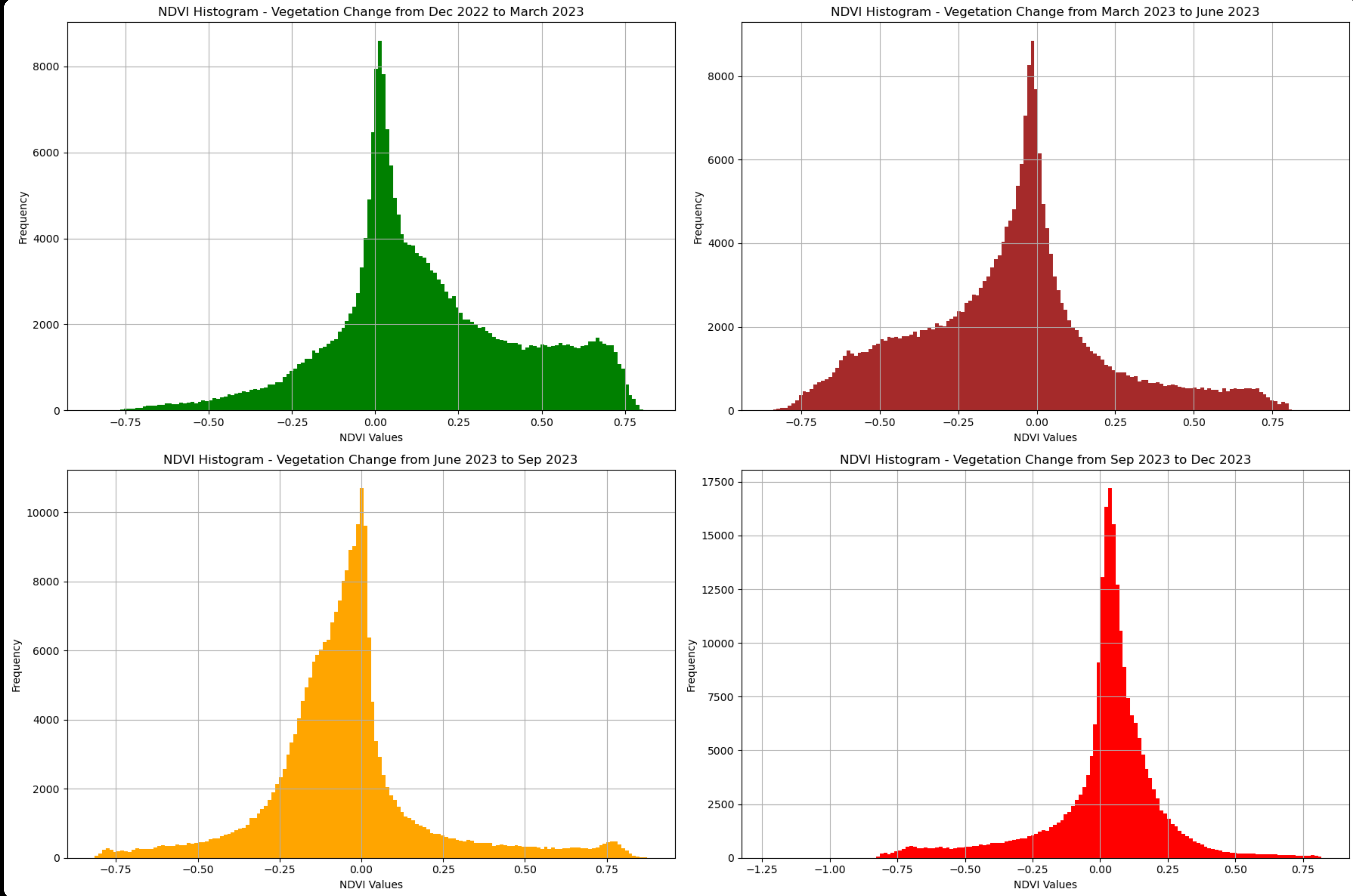
In [14]:
```
vegetation_change_spring = ndvi_03_2023 - ndvi_12_2022
vegetation_change_summer = ndvi_06_2023 - ndvi_03_2023
vegetation_change_fall = ndvi_09_2023 - ndvi_06_2023
vegetation_change_winter = ndvi_12_2023 - ndvi_09_2023
vegetation_initial_2022 = ndvi_12_2022 - ndvi_12_2023
```

In [15]:
```
veg_diff_data_list = [vegetation_change_spring, vegetation_change_summer, vegetation_change_fall, vegetation_change_winter]
titles_veg_diff = ['Vegetation Change from Dec 2022 to March 2023',
                   'Vegetation Change from March 2023 to June 2023',
                   'Vegetation Change from June 2023 to Sep 2023',
                   'Vegetation Change from Sep 2023 to Dec 2023']
```

```
Beqaa.plot_veg_diff_subplot(veg_diff_data_list, titles_veg_diff)
```




In [16]:
```
veg_change_data_list = [vegetation_change_spring.flatten(), vegetation_change_summer.flatten(), vegetation_change_fall.flatten(), vegetation_change_winter.flatten()]
Beqaa.plot_vegetation_change_histograms(veg_change_data_list)
```

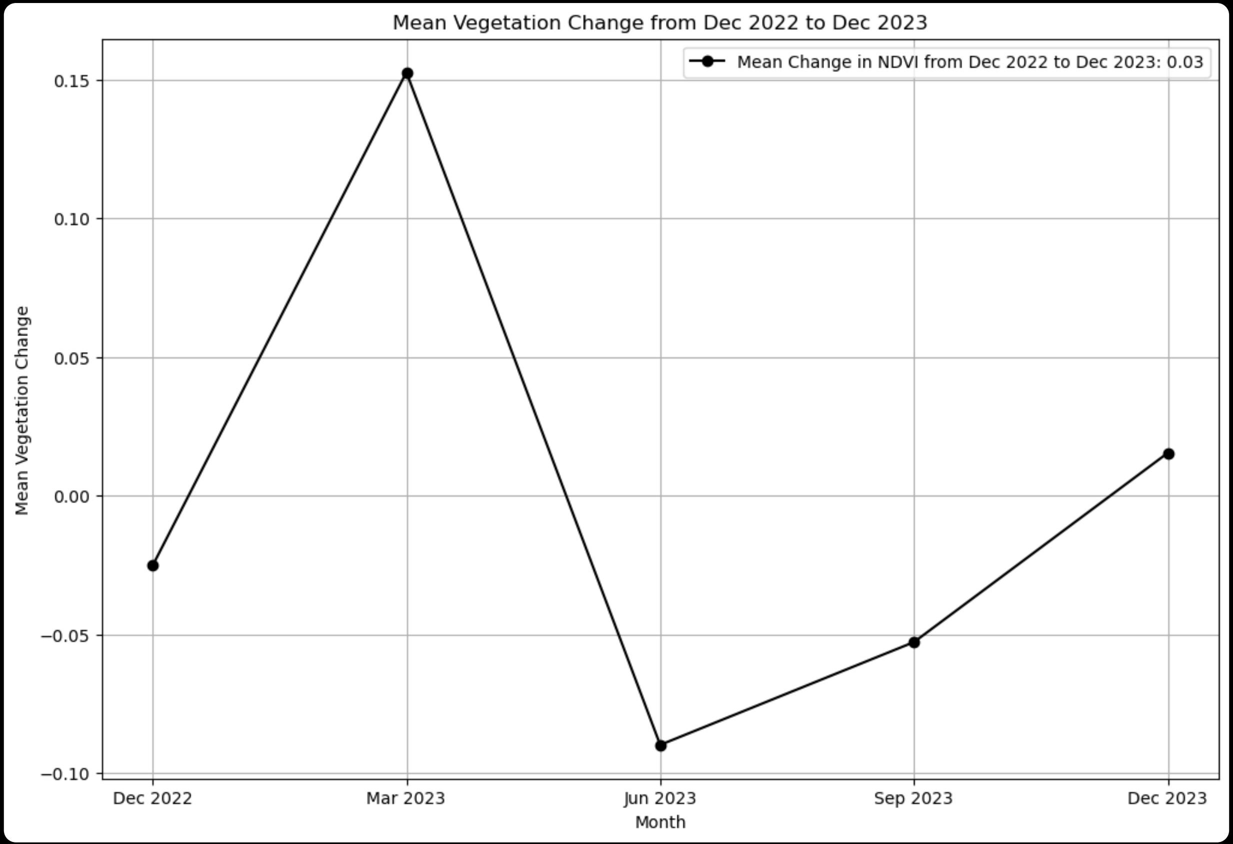



In [17]:
```
# Example usage:
statistics_spring = Beqaa.calculate_vegetation_change_statistics(vegetation_change_spring, 'Dec 2022 to March 2023')
statistics_summer = Beqaa.calculate_vegetation_change_statistics(vegetation_change_summer, 'March 2023 to June 2023')
statistics_fall = Beqaa.calculate_vegetation_change_statistics(vegetation_change_fall, 'June 2023 to Sep 2023')
statistics_winter = Beqaa.calculate_vegetation_change_statistics(vegetation_change_winter, 'Sep 2023 to Dec 2023')
```

```
Statistics for Vegetation Change - Dec 2022 to March 2023:
Mean: 0.15
Std Dev: 0.28
Min: -0.84
Max: 0.82

Statistics for Vegetation Change - March 2023 to June 2023:
Mean: -0.09
Std Dev: 0.30
Min: -0.85
Max: 0.91

Statistics for Vegetation Change - June 2023 to Sep 2023:
Mean: -0.05
Std Dev: 0.24
Min: -0.81
Max: 0.87

Statistics for Vegetation Change - Sep 2023 to Dec 2023:
Mean: 0.02
Std Dev: 0.22
Min: -1.22
Max: 0.82
```

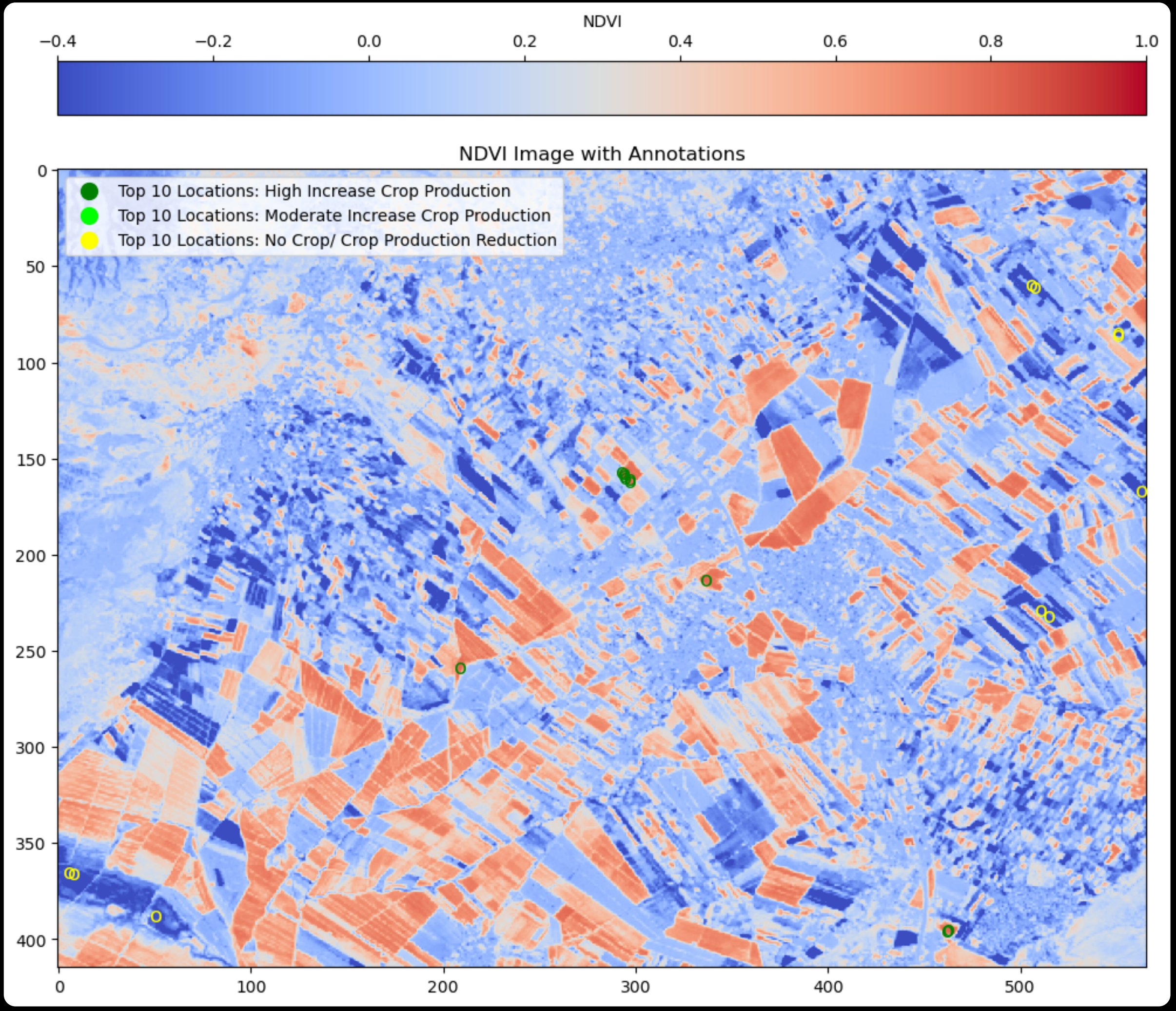
In [18]:

```
vegetation_change_data_list = [vegetation_initial_2022, vegetation_change_spring, vegetation_change_summer, vegetation_change_fall, vegetation_change_winter]
months_labels=['Dec 2022','Mar 2023', 'Jun 2023', 'Sep 2023', 'Dec 2023']
Beqaa.plot_mean_vegetation_change_2023(vegetation_change_data_list,months_labels)
```



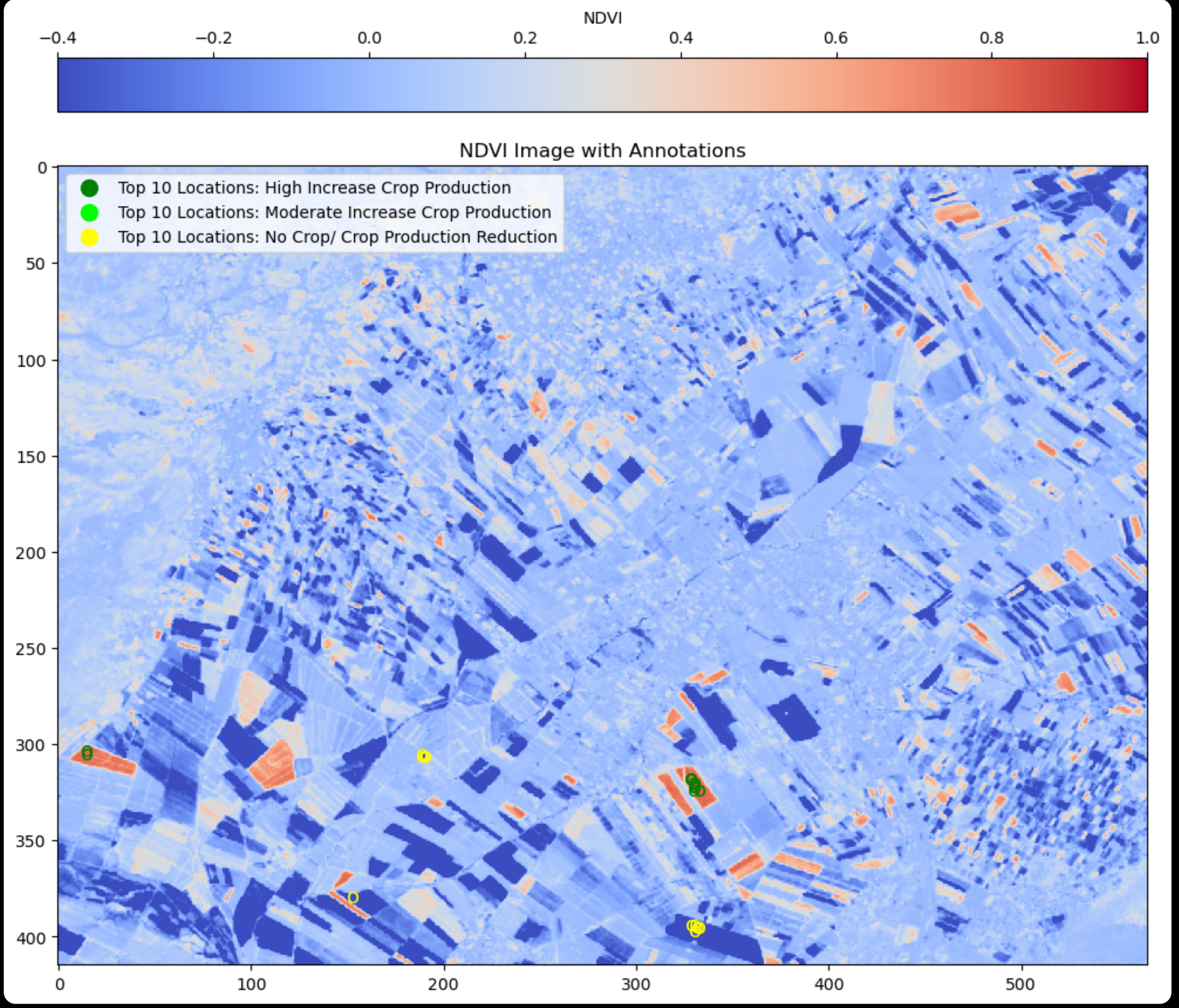
Annotate the locations of the top 10 highest and lowest crop production changes between 12/2022 & 03/2023

In [19]:
```
Beqaa.plot_ndvi_change_with_top_annotations(vegetation_change_spring)
```




Annotate the locations of the top 10 highest and lowest crop production changes between 09/2023 & 12/2023

In [20]:
```
Beqaa.plot_ndvi_change_with_top_annotations(vegetation_change_winter)
```

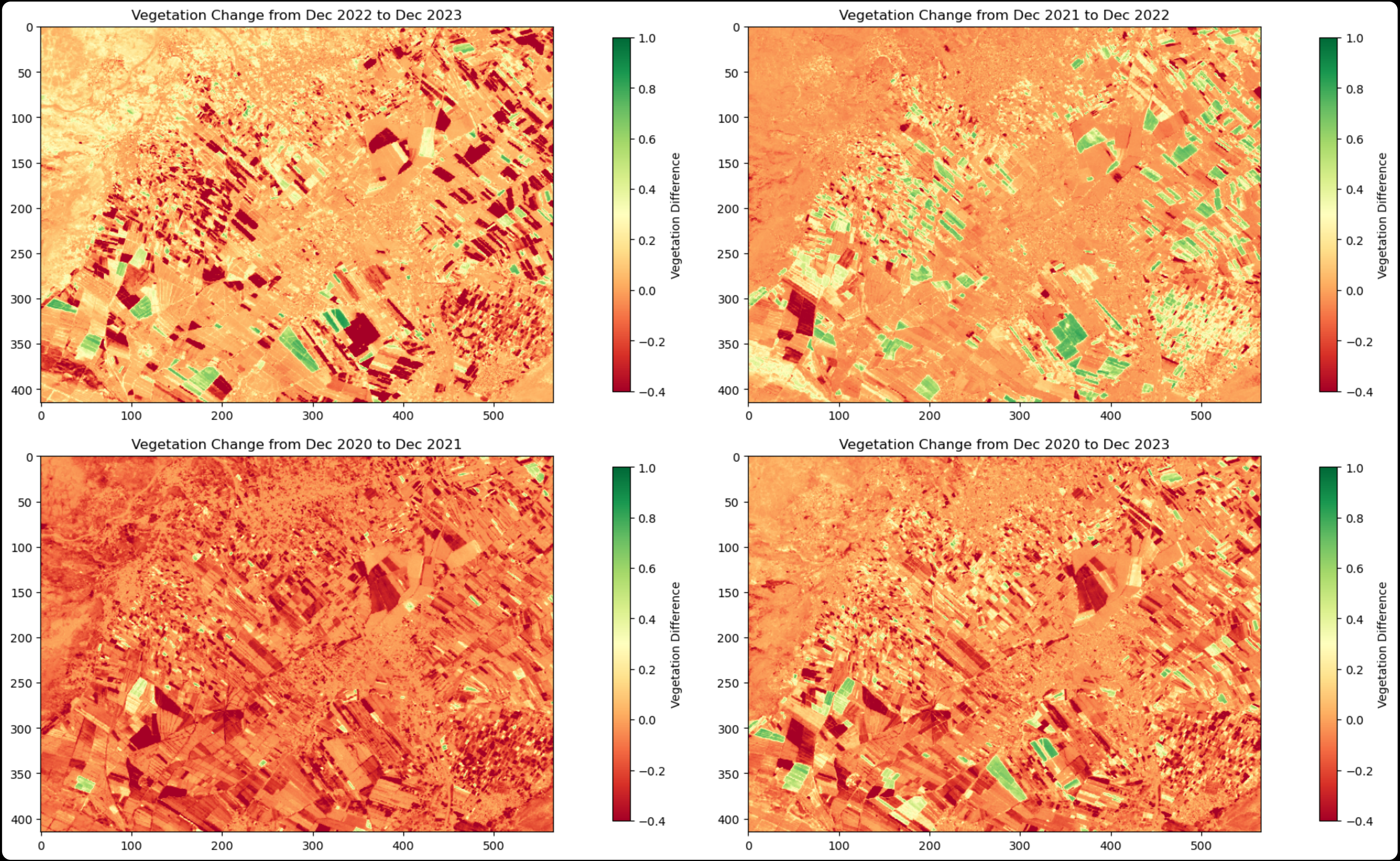



In [21]:
```
green_band, red_band, nir_band = Beqaa.read_bands_from_geotiff_6(BEQAA_12_2021)
# Calculate NDVI
ndvi_12_2021 = Beqaa.calculate_ndvi(red_band, nir_band)
# Flatten the NDVI values to create a 1D array
flat_ndvi_12_2021 = ndvi_12_2021.flatten()
```

In [22]:
```
green_band, red_band, nir_band = Beqaa.read_bands_from_geotiff_7(BEQAA_12_2020)
# Calculate NDVI
ndvi_12_2020 = Beqaa.calculate_ndvi(red_band, nir_band)
# Flatten the NDVI values to create a 1D array
flat_ndvi_12_2020 = ndvi_12_2020.flatten()
```

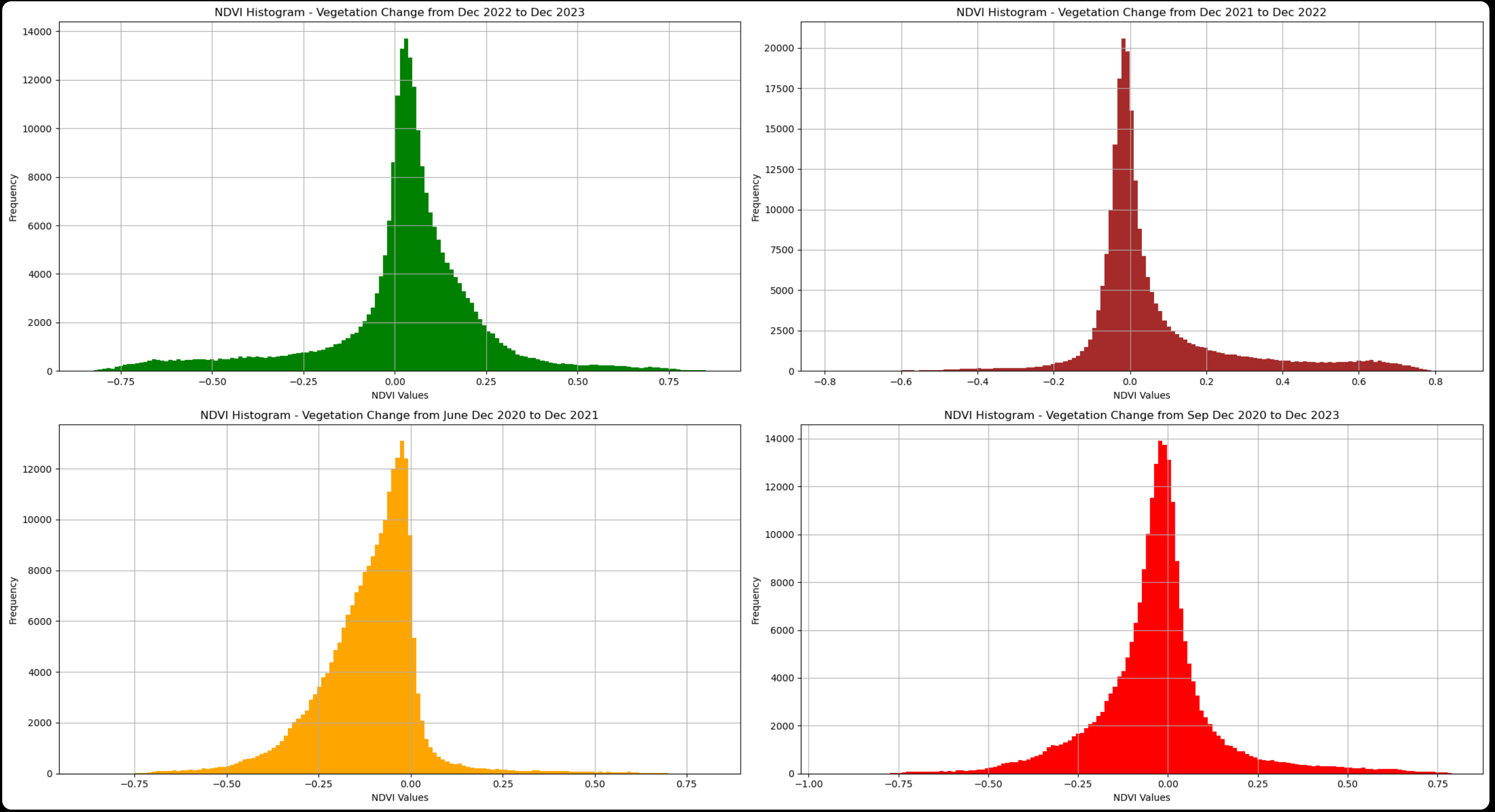
In [23]:
```
vegetation_change_from_2023_2022 = ndvi_12_2023 - ndvi_12_2022
vegetation_change_from_2022_2021 = ndvi_12_2022 - ndvi_12_2021
vegetation_change_from_2021_2020 = ndvi_12_2021 - ndvi_12_2020
vegetation_change_from_2023_2020 = ndvi_12_2023 - ndvi_12_2020
```

In [24]:
```
veg_diff_data_list = [vegetation_change_from_2023_2022, vegetation_change_from_2022_2021, vegetation_change_from_2021_2020, vegetation_change_from_2023_2020]
titles_veg_diff = ['Vegetation Change from Dec 2022 to Dec 2023',
                   'Vegetation Change from Dec 2021 to Dec 2022',
                   'Vegetation Change from Dec 2020 to Dec 2021',
                   'Vegetation Change from Dec 2020 to Dec 2023']

Beqaa.plot_veg_diff_subplot(veg_diff_data_list, titles_veg_diff)
```




In [25]:
```
veg_change_data_list_2 = [vegetation_change_from_2023_2022.flatten(), vegetation_change_from_2022_2021.flatten(), vegetation_change_from_2021_2020.flatten(), vegetation_change_from_2023_2020.flatten()]
```

```
Beqaa.plot_annual_vegetation_change_histograms(veg_change_data_list_2)
```




In [26]:

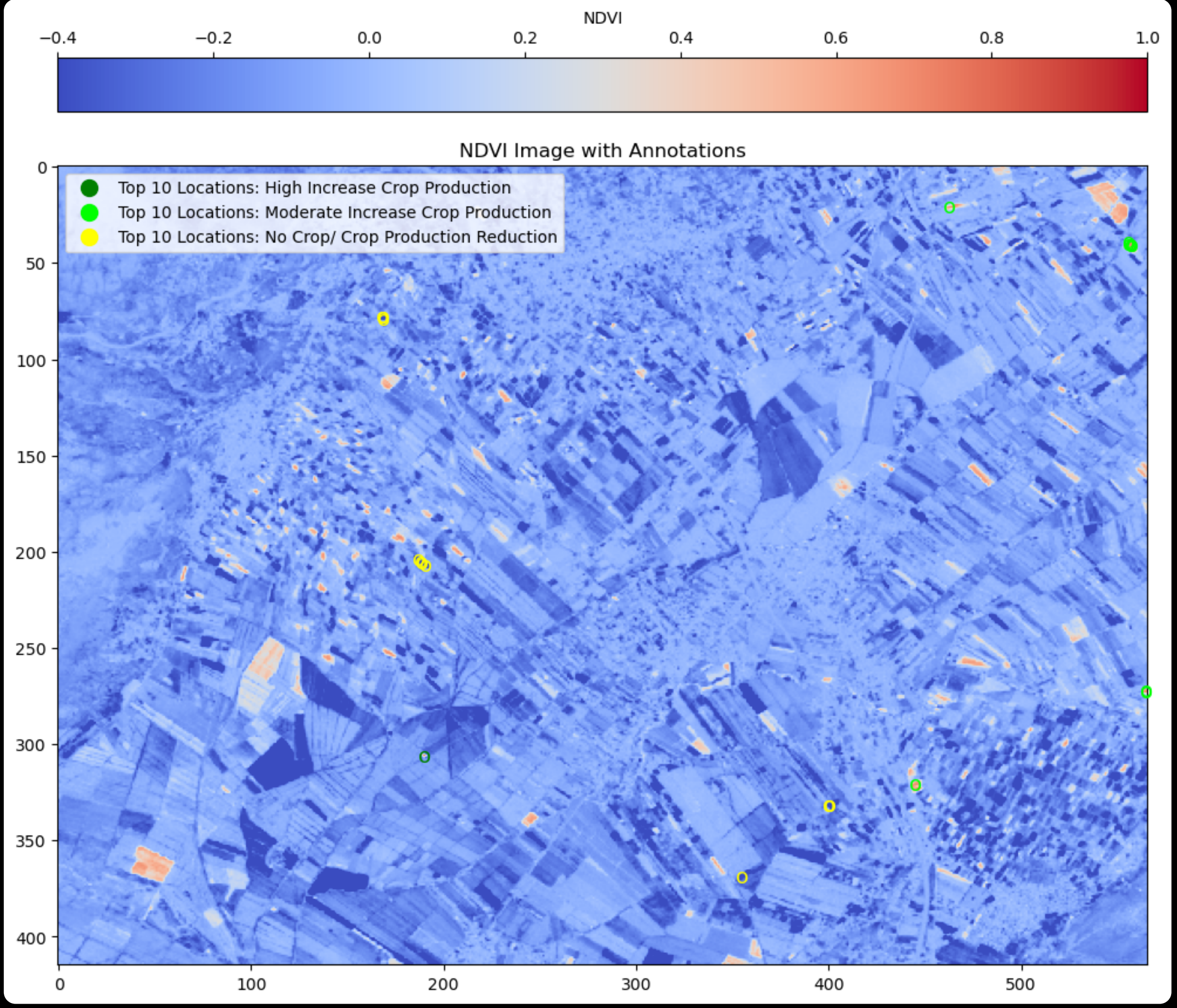
```
statistics_2023_2022 = Beqaa.calculate_vegetation_change_statistics(vegetation_change_from_2023_2022, 'Dec 2022 to Dec 2023')
statistics_2022_2021 = Beqaa.calculate_vegetation_change_statistics(vegetation_change_from_2022_2021, 'Dec 2021 to Dec 2022')
statistics_2021_2020 = Beqaa.calculate_vegetation_change_statistics(vegetation_change_from_2021_2020, 'Dec 2020 to Dec 2021')
statistics_2023_2020 = Beqaa.calculate_vegetation_change_statistics(vegetation_change_from_2023_2020, 'Dec 2020 to Dec 2023')
```

```
Statistics for Vegetation Change - Dec 2022 to Dec 2023:
Mean: 0.03
Std Dev: 0.22
Min: -0.83
Max: 0.86

Statistics for Vegetation Change - Dec 2021 to Dec 2022:
Mean: 0.06
Std Dev: 0.19
Min: -0.78
Max: 0.84

Statistics for Vegetation Change - Dec 2020 to Dec 2021:
Mean: -0.11
Std Dev: 0.14
Min: -0.87
Max: 0.81

Statistics for Vegetation Change - Dec 2020 to Dec 2023:
Mean: -0.03
Std Dev: 0.17
Min: -0.94
Max: 0.79
```

Annotate the locations of the top 10 highest and lowest crop production changes between 12/2020 & 12/2021

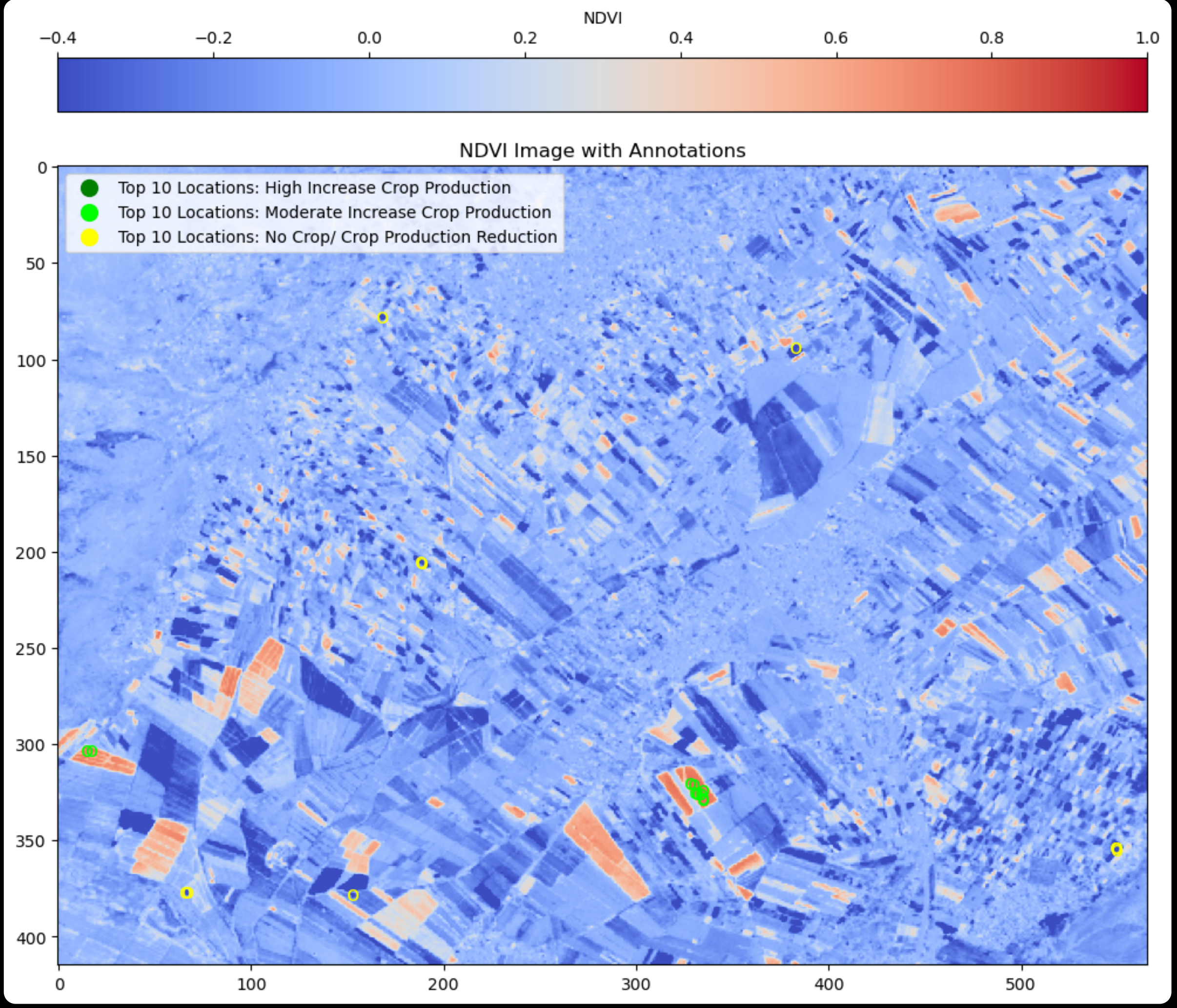
In [27]:

```
Beqaa.plot_ndvi_change_with_top_annotations(vegetation_change_from_2021_2020)
```




Annotate the locations of the top 10 highest and lowest crop production changes between 12/2020 & 12/2023

In [28]:
```
Beqaa.plot_ndvi_change_with_top_annotations(vegetation_change_from_2023_2020)
```




**Summary:**

- **NDVI Change (2020 to 2023):**
  - Negligible reduction in vegetation: 0.03.
- **Seasonal NDVI Changes:**
  - Peak in spring, aligning with expectations for crops.
- **Significant NDVI Decrease (2020 to 2021):**
  - Further evaluation needed to identify the reasons behind the decrease.
- **Next Steps:**
  - Explore additional datasets related to temperature and precipitation.
  - Establish connections between climatic variables and NDVI changes.
  - Work towards creating a predictive model for future NDVI values based on historical data and climatic variables.