ANALYSE DES DONNÉES DU NDVI DANS LA RÉGION DE BEQAA AU LIBAN

UN PROJET GÉNÉRATIF ASSISTÉ PAR L'IA GÉNÉRATIVE PROMPT ENGINEERING

UNE SECTION DE CULTURES - RÉGION DE BEQAA, LIBAN

PAR

ING. JAD GHANTOUS

M. NAD GHANTOUS

Ensemble de données tiré de Sentinel 2 extrait d'un code utilisant Google Earth Engine pour une section de la région de la Bekaa au Liban entre les années 2020 et 2024

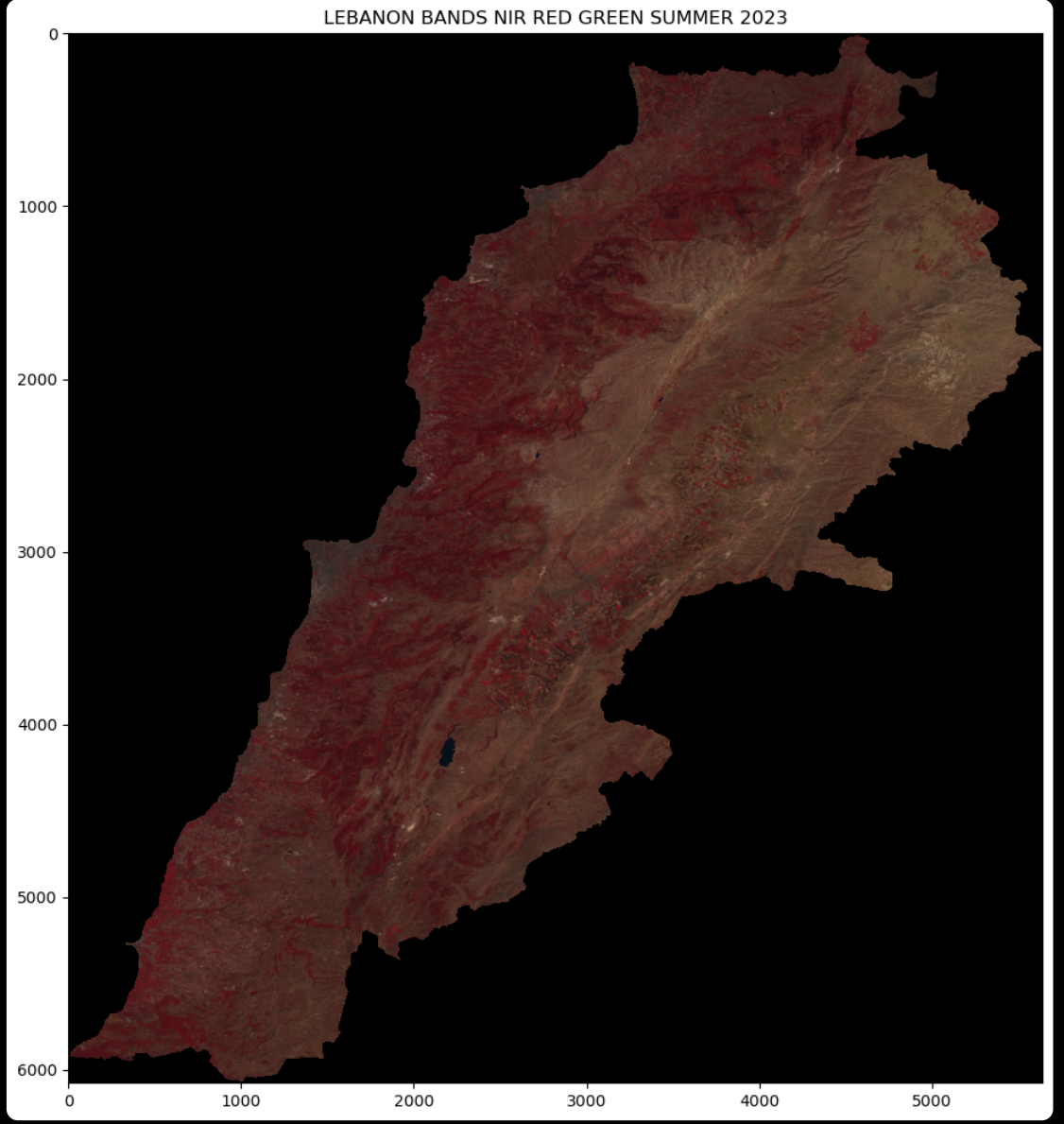
NDVI_Lebanon_Beqaa est un fichier python préparé par nos soins qui contient toutes les fonctions utilisées dans ce code.

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
```

Importer les fichiers geotiff

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')
```



Comprendre le NDVI (indice de végétation par différence normalisée)

les **Indice de végétation par différence normalisée (NDVI)** est une mesure largement utilisée pour évaluer la santé et l'abondance de la végétation dans une zone donnée. Il est calculé à l'aide d'images satellite ou aériennes, capturant la réflectance de différentes longueurs d'onde de lumière.

Formule:

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

où:

- *NIR*(Near-Infrared) est la réflectance dans le spectre proche infrarouge.
- *Rouge* est la réflectance dans le spectre rouge.

Interprétation:

- **Valeurs positives (0,2 à 0,8):** Indique une végétation saine, avec des valeurs plus élevées correspondant à une croissance végétale plus dense et plus vigoureuse.
- **Valeurs nulles ou négatives:** Suggère des surfaces non végétalisées comme un sol nu ou des plans d'eau.

Visualisation:
La formule NDVI exploite le fait qu'une végétation saine absorbe fortement la lumière rouge et réfléchit la lumière proche infrarouge. Par conséquent:

- Des valeurs NDVI élevées (vert vif) correspondent à une végétation prospère.
- Des valeurs NDVI faibles ou négatives (couleurs ternes ou sombres) suggèrent des zones sans végétation.

En analysant les cartes NDVI, les chercheurs et les environnementalistes obtiennent des informations précieuses sur la répartition spatiale et la santé de la végétation, contribuant ainsi à diverses applications, notamment l'agriculture, la foresterie et la surveillance écologique.

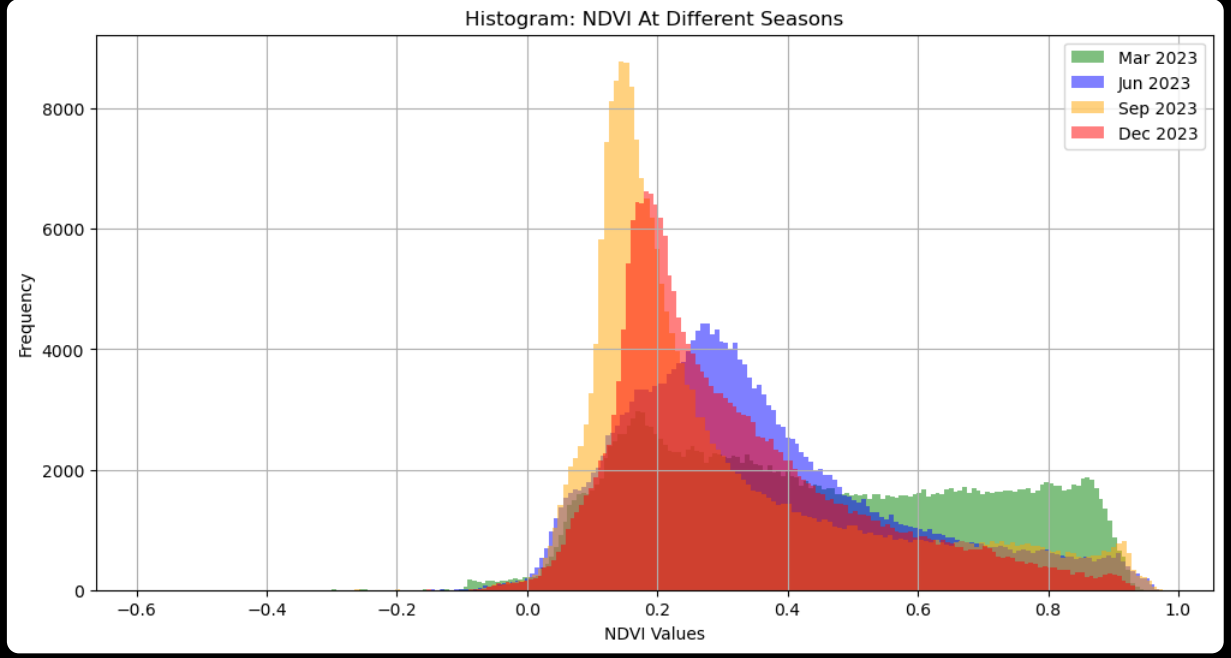
In [4]:
```
green_band, red_band, nir_band = Beqaa.read_bands_from_geotiff_1(BEQAA_03_2023)
# Calculate NDVI
ndvi_03_2023 = Beqaa.calculate_ndvi(red_band, nir_band)
# Flatten the NDVI values to create a 1D array
flat_ndvi_03_2023 = ndvi_03_2023.flatten()
```

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()
```

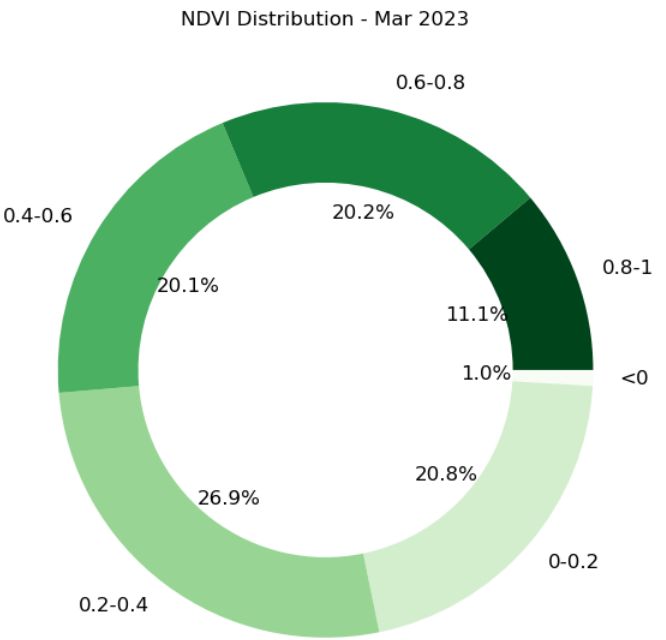
In [6]:
```
green_band, red_band, nir_band = Beqaa.read_bands_from_geotiff_3(BEQAA_09_2023)
# Calculate NDVI
ndvi_09_2023 = Beqaa.calculate_ndvi(red_band, nir_band)
# Flatten the NDVI values to create a 1D array
flat_ndvi_09_2023 = ndvi_09_2023.flatten()
```

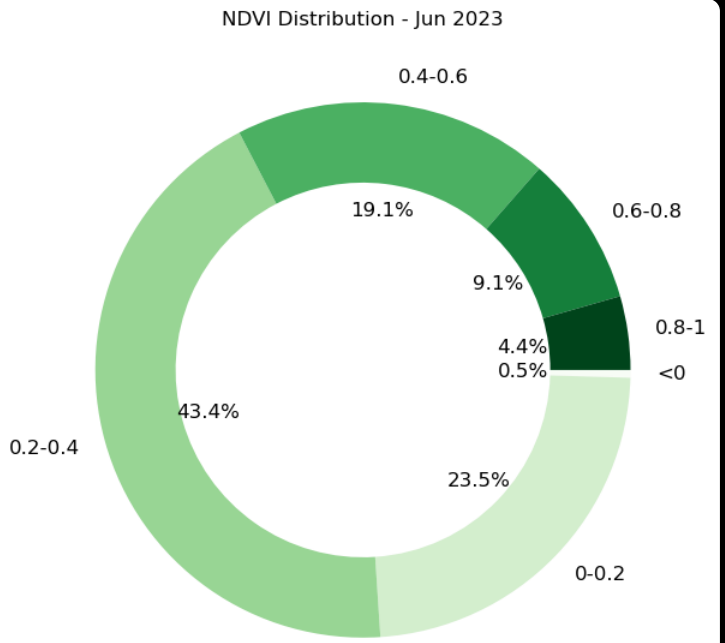
In [7]:
```
green_band, red_band, nir_band = Beqaa.read_bands_from_geotiff_4(BEQAA_12_2023)
# Calculate NDVI
ndvi_12_2023 = Beqaa.calculate_ndvi(red_band, nir_band)
# Flatten the NDVI values to create a 1D array
flat_ndvi_12_2023 = ndvi_12_2023.flatten()
```

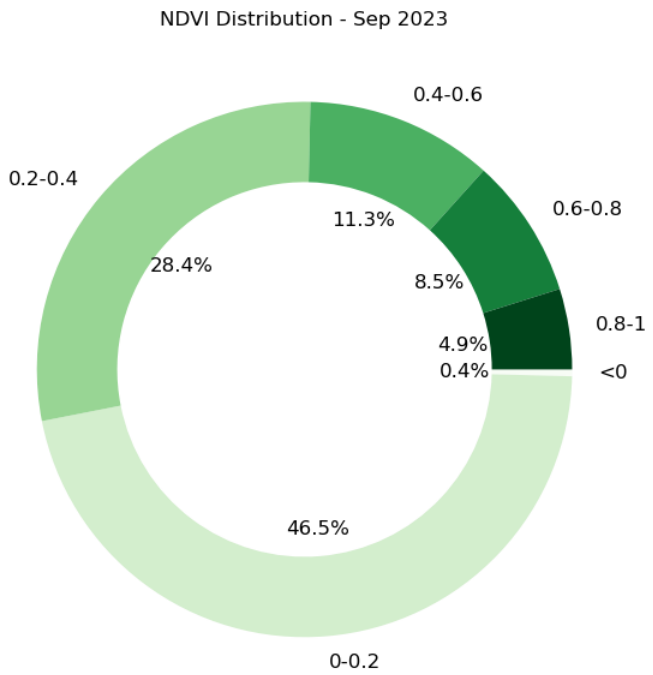
In [8]:
```
ndvi_data_list = [flat_ndvi_03_2023, flat_ndvi_06_2023, flat_ndvi_09_2023, flat_ndvi_12_2023]
colors = ['green', 'blue', 'orange', 'red']
titles = ['Mar 2023', 'Jun 2023', 'Sep 2023', 'Dec 2023']
Beqaa.plot_multiple_ndvi_histograms(ndvi_data_list, colors, titles)
```

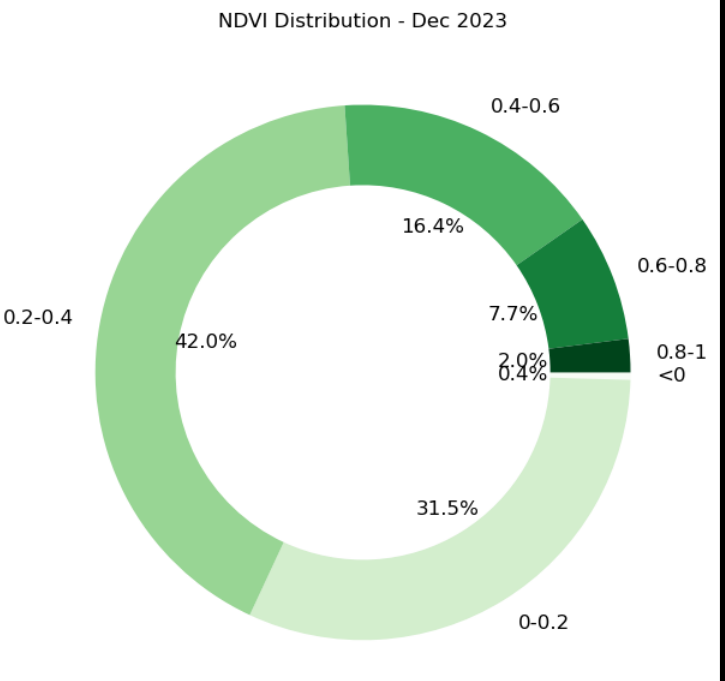


In [9]:
```
ndvi_data_list_pie = [flat_ndvi_03_2023, flat_ndvi_06_2023, flat_ndvi_09_2023, flat_ndvi_12_2023]
ndvi_labels_pie = ['<0', '0-0.2', '0.2-0.4', '0.4-0.6', '0.6-0.8', '0.8-1']
ndvi_bins_pie = [-1, 0, 0.2, 0.4, 0.6, 0.8, 1]
titles_pie = ['Mar 2023', 'Jun 2023', 'Sep 2023', 'Dec 2023']
Beqaa.plot_ndvi_pie_subplots(ndvi_data_list_pie, ndvi_labels_pie, ndvi_bins_pie, titles_pie)
```

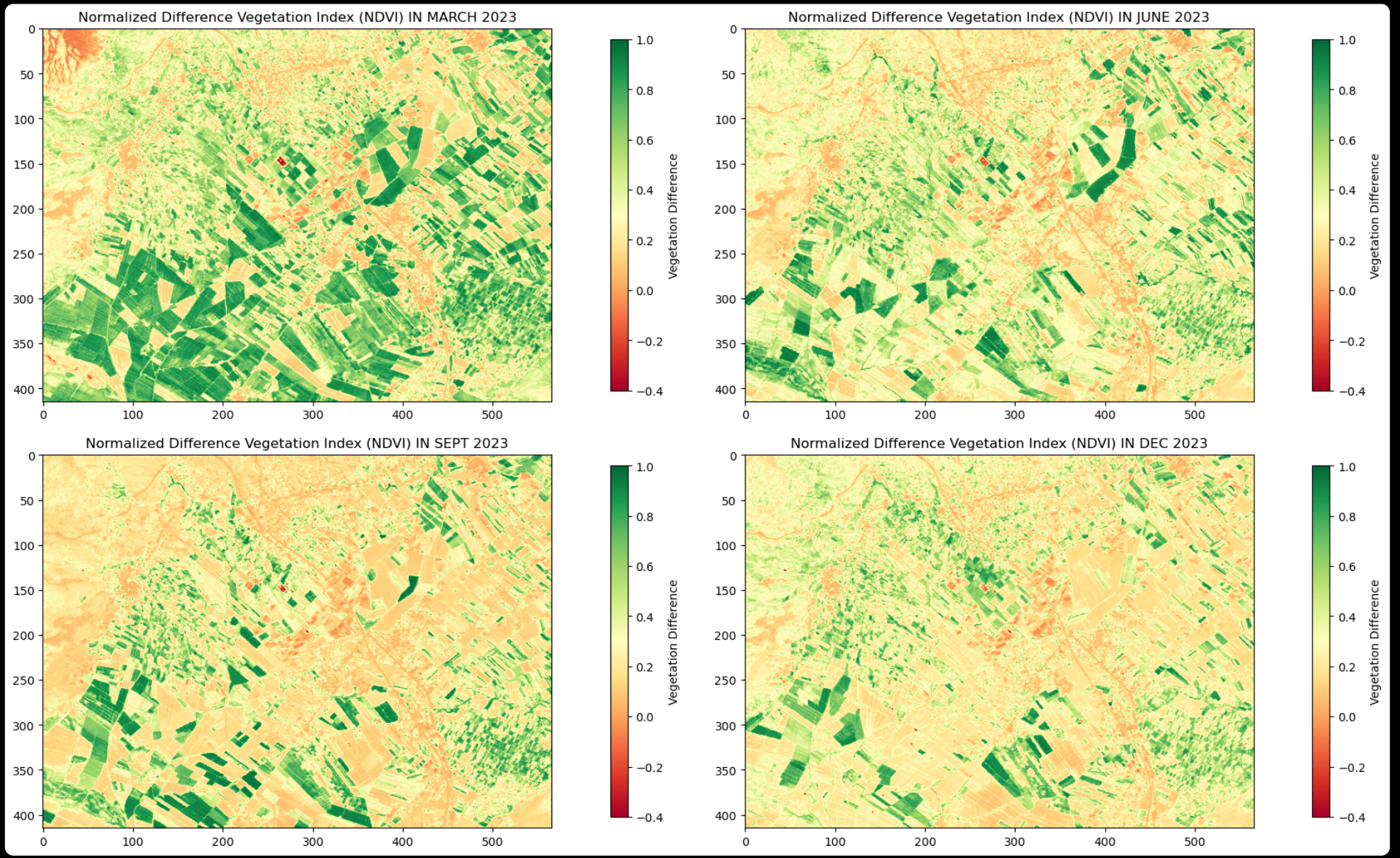

NDVI Distribution - Mar 2023
0.6-0.8
20.2%
0.8-1
0.4-0.6
20.1%
11.1%
1.0%
<0
20.8%
26.9%
0-0.2
0.2-0.4


NDVI Distribution - Jun 2023
0.4-0.6
19.1%
0.6-0.8
9.1%
0.8-1
4.4%
0.5%
<0
43.4%
0.2-0.4
23.5%
0-0.2


NDVI Distribution - Sep 2023
0.4-0.6
0.2-0.4
11.3%
0.6-0.8
28.4%
8.5%
0.8-1
4.9%
0.4%
<0
46.5%
0-0.2

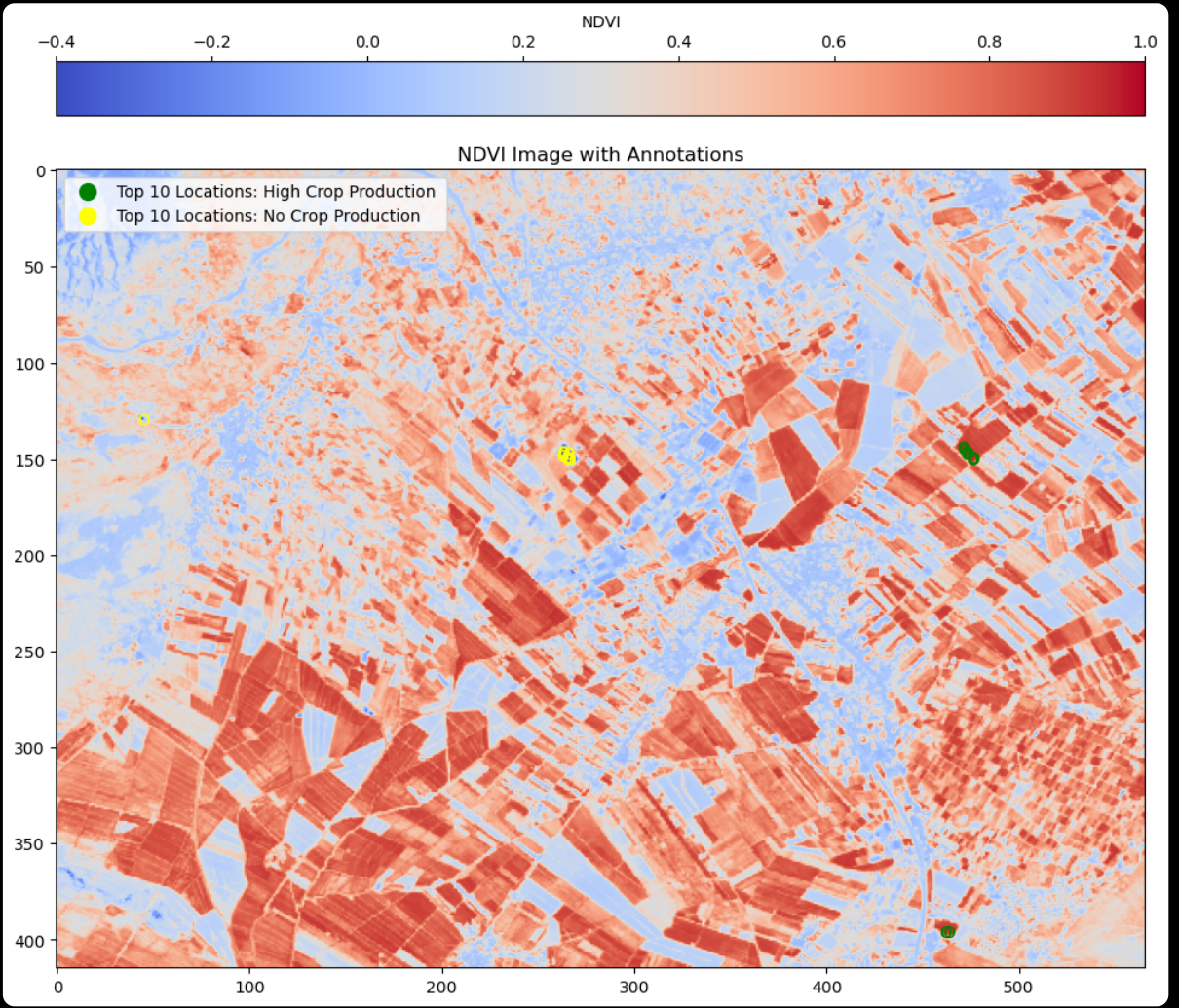

NDVI Distribution - Dec 2023
0.4-0.6
16.4%
0.6-0.8
0.2-0.4
7.7%
42.0%
0.8-1
2.0%
0.4%
<0
31.5%
0-0.2

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)
```



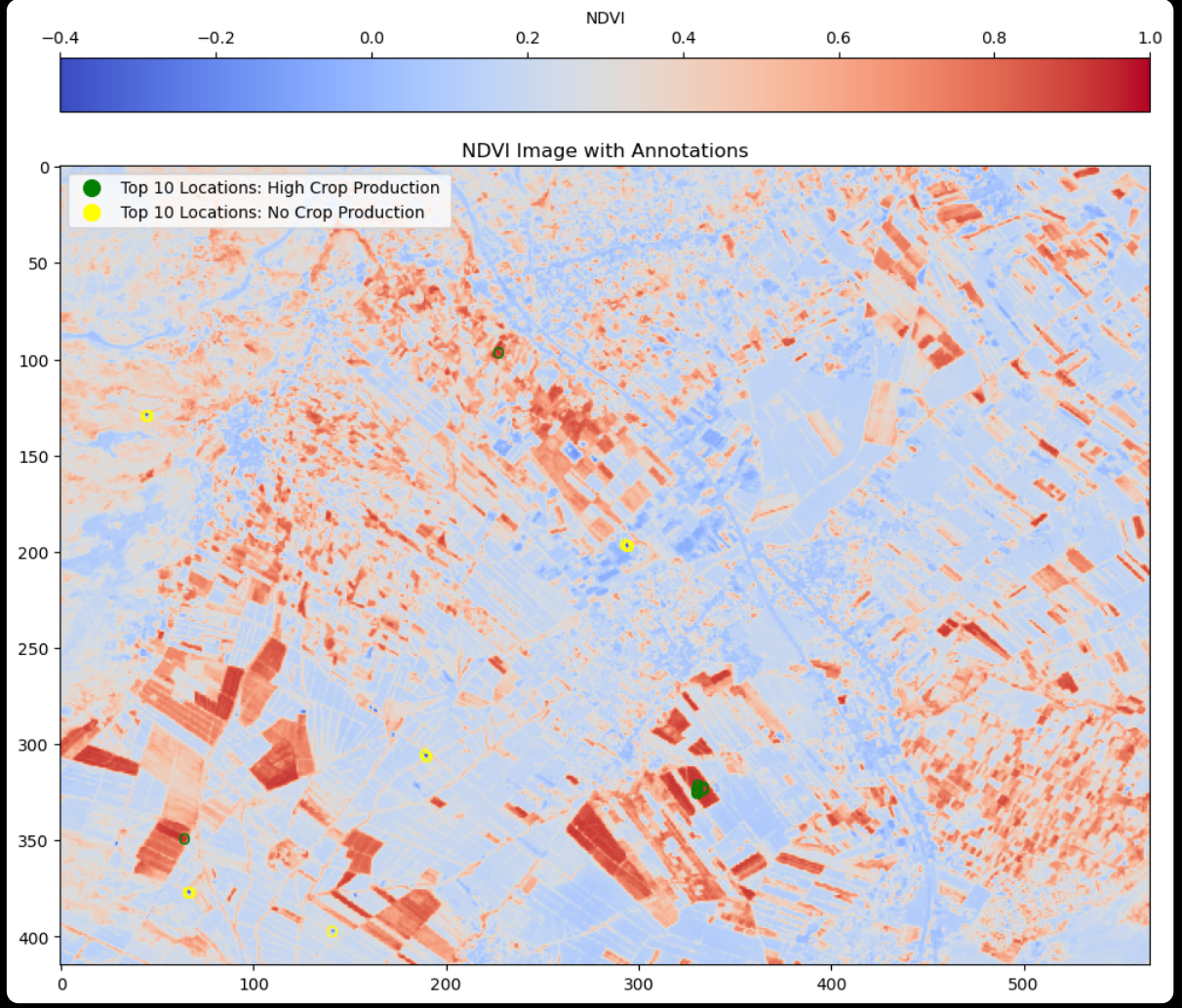
Annoter les emplacements des 10 productions agricoles les plus élevées et les plus faibles en 03/2023

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



Annoter les emplacements des 10 productions agricoles les plus élevées et les plus faibles en 12/2023

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

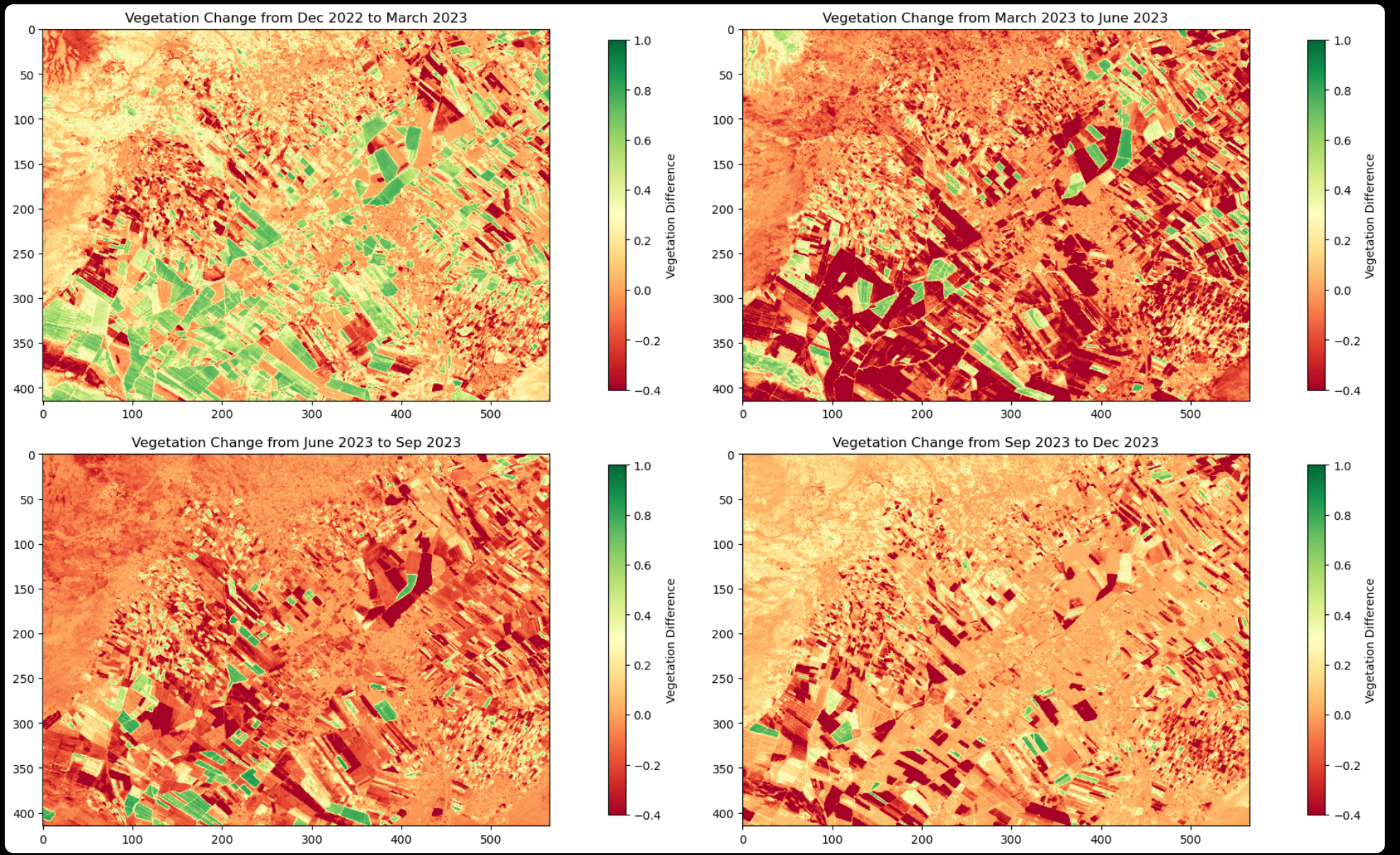


In [13]:
```
green_band, red_band, nir_band = Beqaa.read_bands_from_geotiff_5(BEQAA_12_2022)
# Calculate NDVI
ndvi_12_2022 = Beqaa.calculate_ndvi(red_band, nir_band)
# Flatten the NDVI values to create a 1D array
flat_ndvi_12_2022 = ndvi_12_2022.flatten()
```

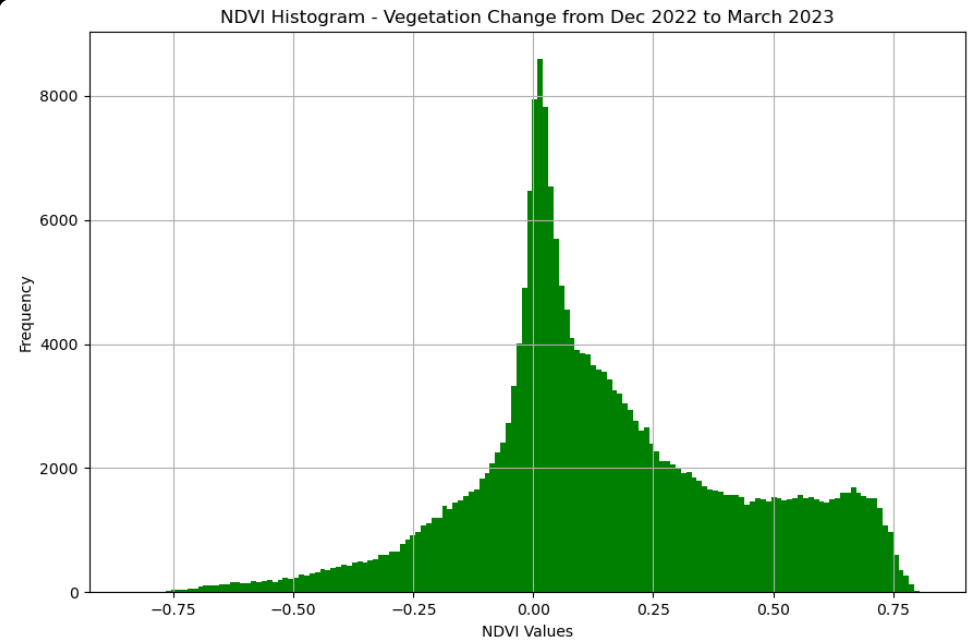
In [14]:
```
vegetation_change_spring = ndvi_03_2023 - ndvi_12_2022
vegetation_change_summer = ndvi_06_2023 - ndvi_03_2023
vegetation_change_fall = ndvi_09_2023 - ndvi_06_2023
vegetation_change_winter = ndvi_12_2023 - ndvi_09_2023
vegetation_initial_2022 = ndvi_12_2022 - ndvi_12_2023
```

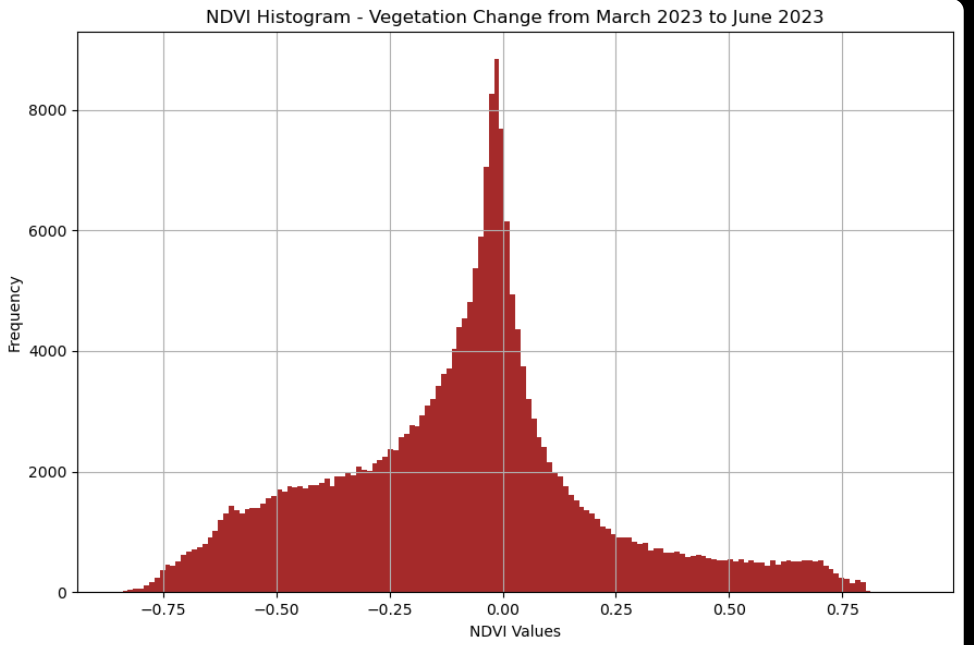
In [15]:
```
veg_diff_data_list = [vegetation_change_spring, vegetation_change_summer, vegetation_change_fall, vegetation_change_winter]
titles_veg_diff = ['Vegetation Change from Dec 2022 to March 2023',
                   'Vegetation Change from March 2023 to June 2023',
                   'Vegetation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

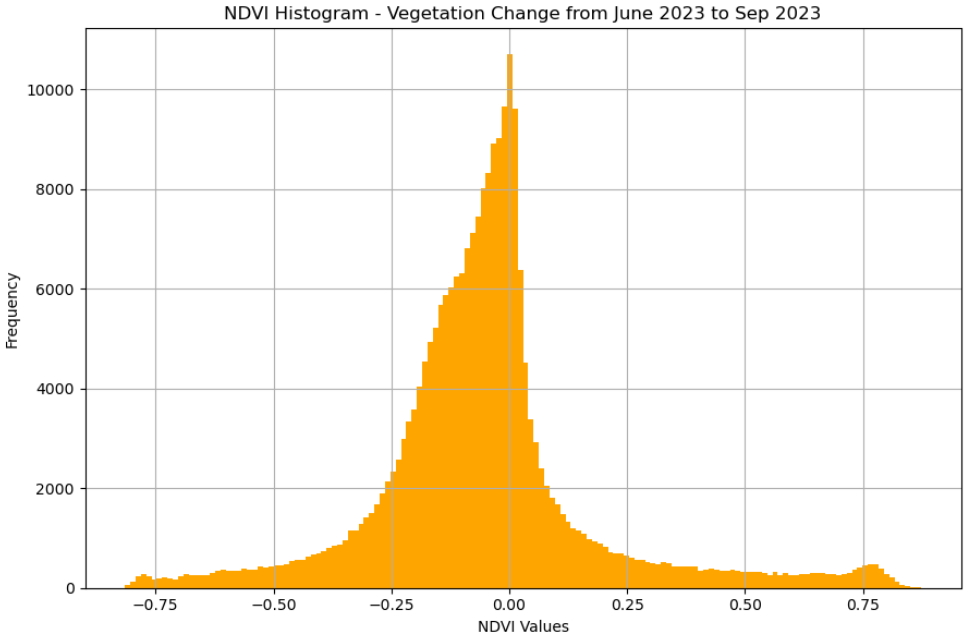
```
Beqaa.plot_veg_diff_subplot(veg_diff_data_list, titles_veg_diff)
```

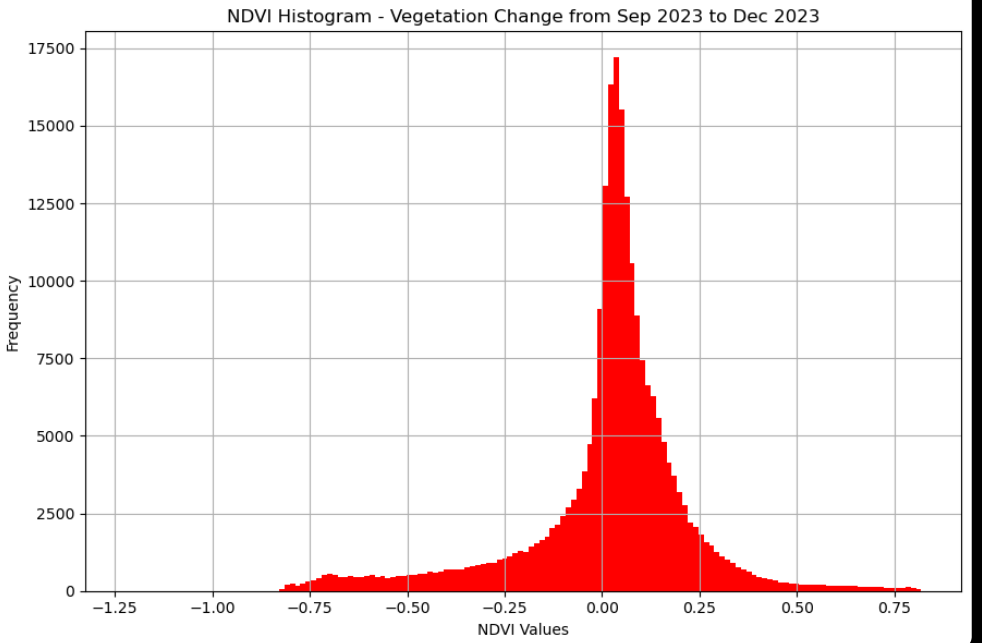


In [16]:
```
veg_change_data_list = [vegetation_change_spring.flatten(), vegetation_change_summer.flatten(), vegetation_change_fall.flatten(), vegetation_change_winter.flatten()]
Beqaa.plot_vegetation_change_histograms(veg_change_data_list)
```





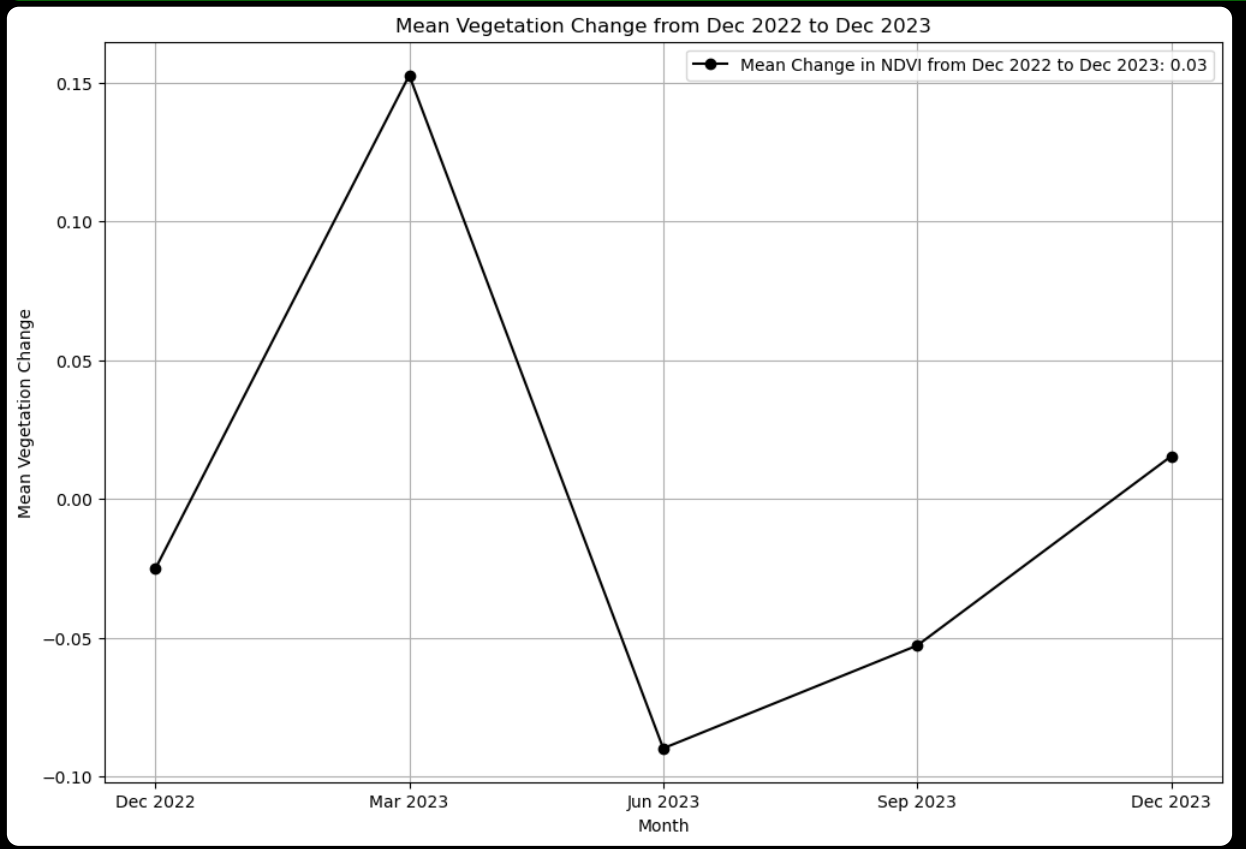




In [17]:
```
# Example usage:
statistics_spring = Beqaa.calculate_vegetation_change_statistics(vegetation_change_spring, 'Dec 2022 to March 2023')
statistics_summer = Beqaa.calculate_vegetation_change_statistics(vegetation_change_summer, 'March 2023 to June 2023')
statistics_fall = Beqaa.calculate_vegetation_change_statistics(vegetation_change_fall,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

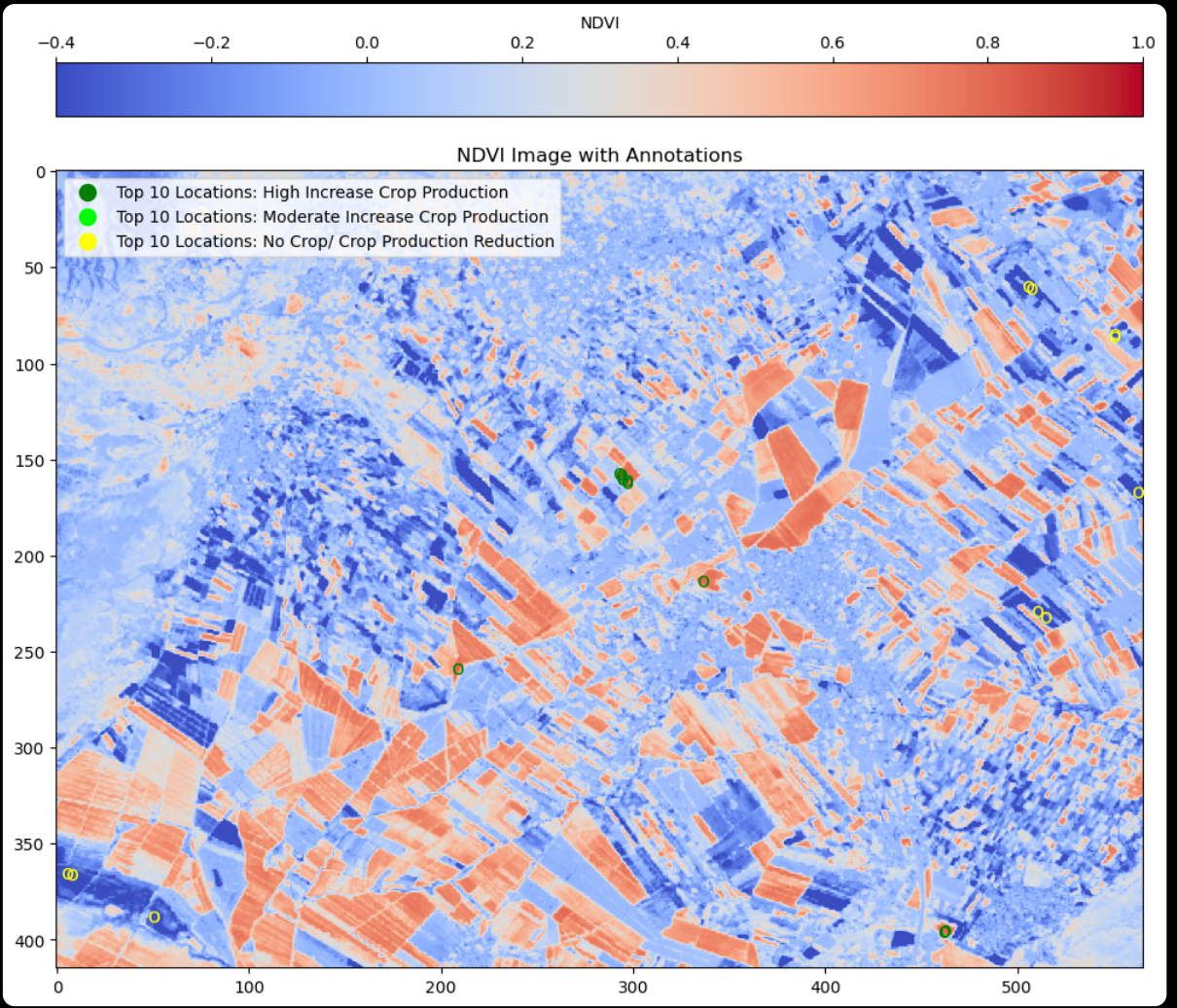
```
Statistics for Vegetation Change - Dec 2022 to March 2023:
Mean: 0.15
Std Dev: 0.28
Min: -0.84
Max: 0.82

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)
```



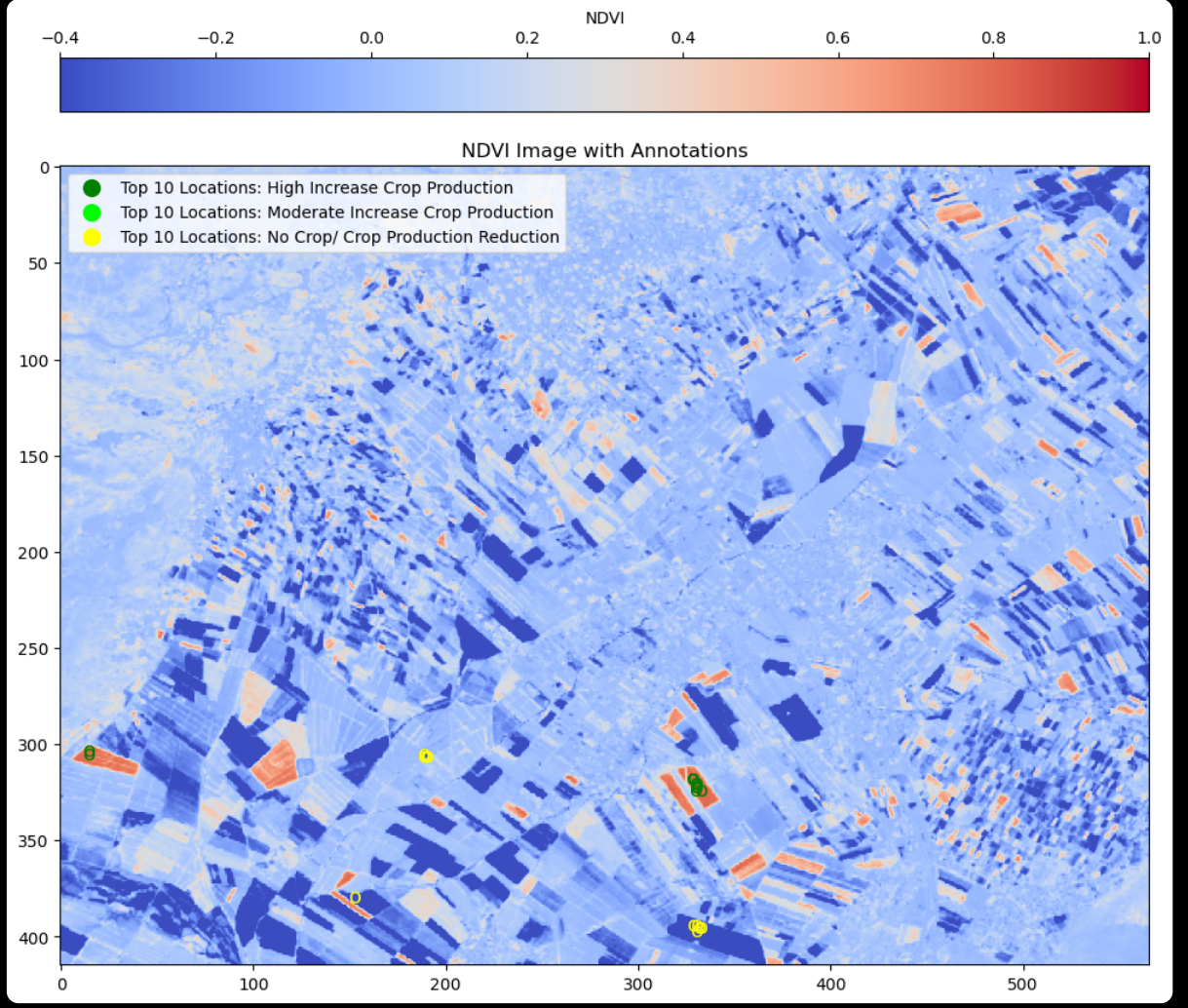
Annotez les emplacements des 10 changements de production agricole les plus élevés et les plus faibles entre 12/2022 et 03/2023

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



Annotez les emplacements des 10 changements de production agricole les plus élevés et les plus faibles entre 09/2023 et 12/2023

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

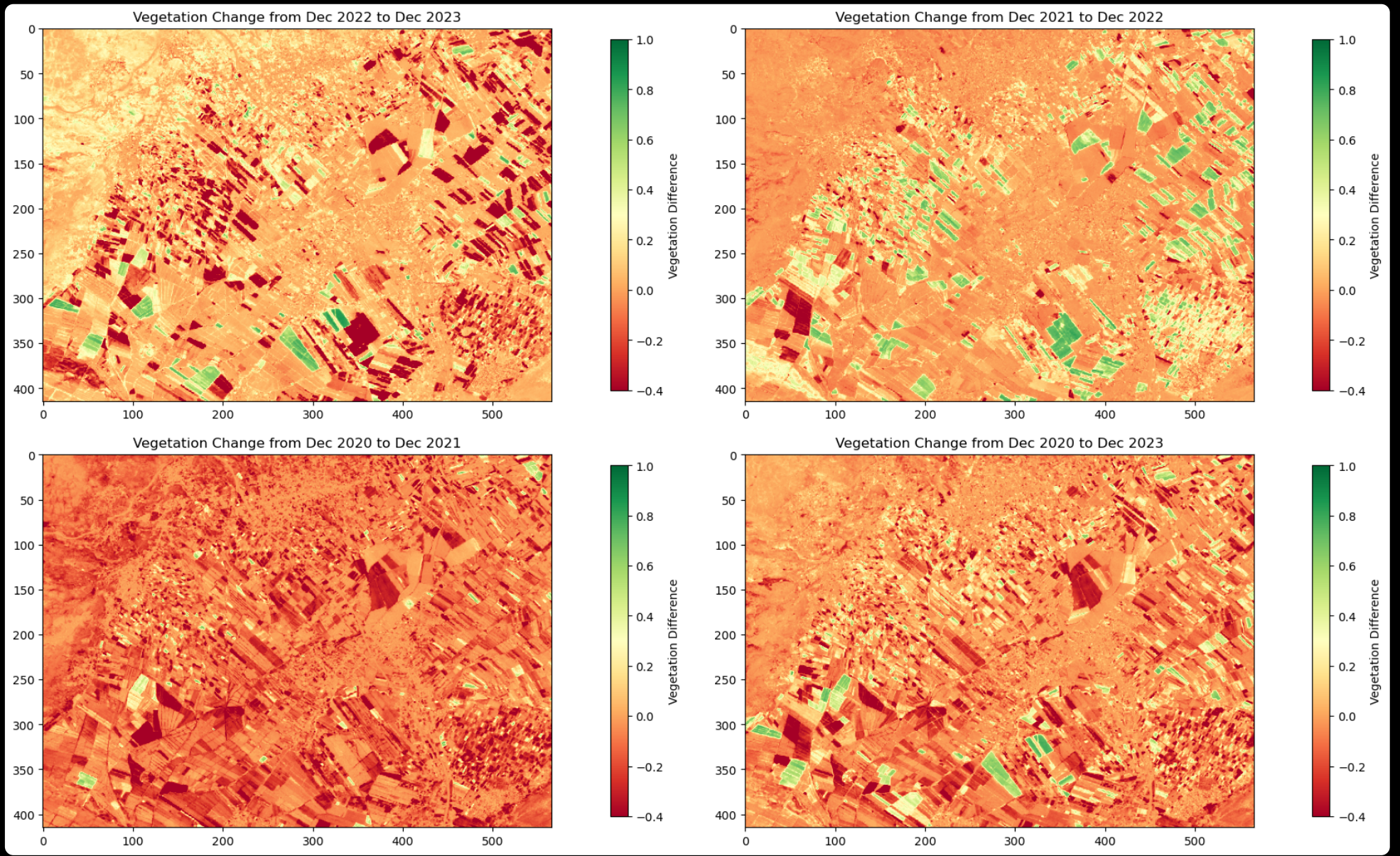


In [21]:
```
green_band, red_band, nir_band = Beqaa.read_bands_from_geotiff_6(BEQAA_12_2021)
# Calculate NDVI
ndvi_12_2021 = Beqaa.calculate_ndvi(red_band, nir_band)
# Flatten the NDVI values to create a 1D array
flat_ndvi_12_2021 = ndvi_12_2021.flatten()
```

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()
```

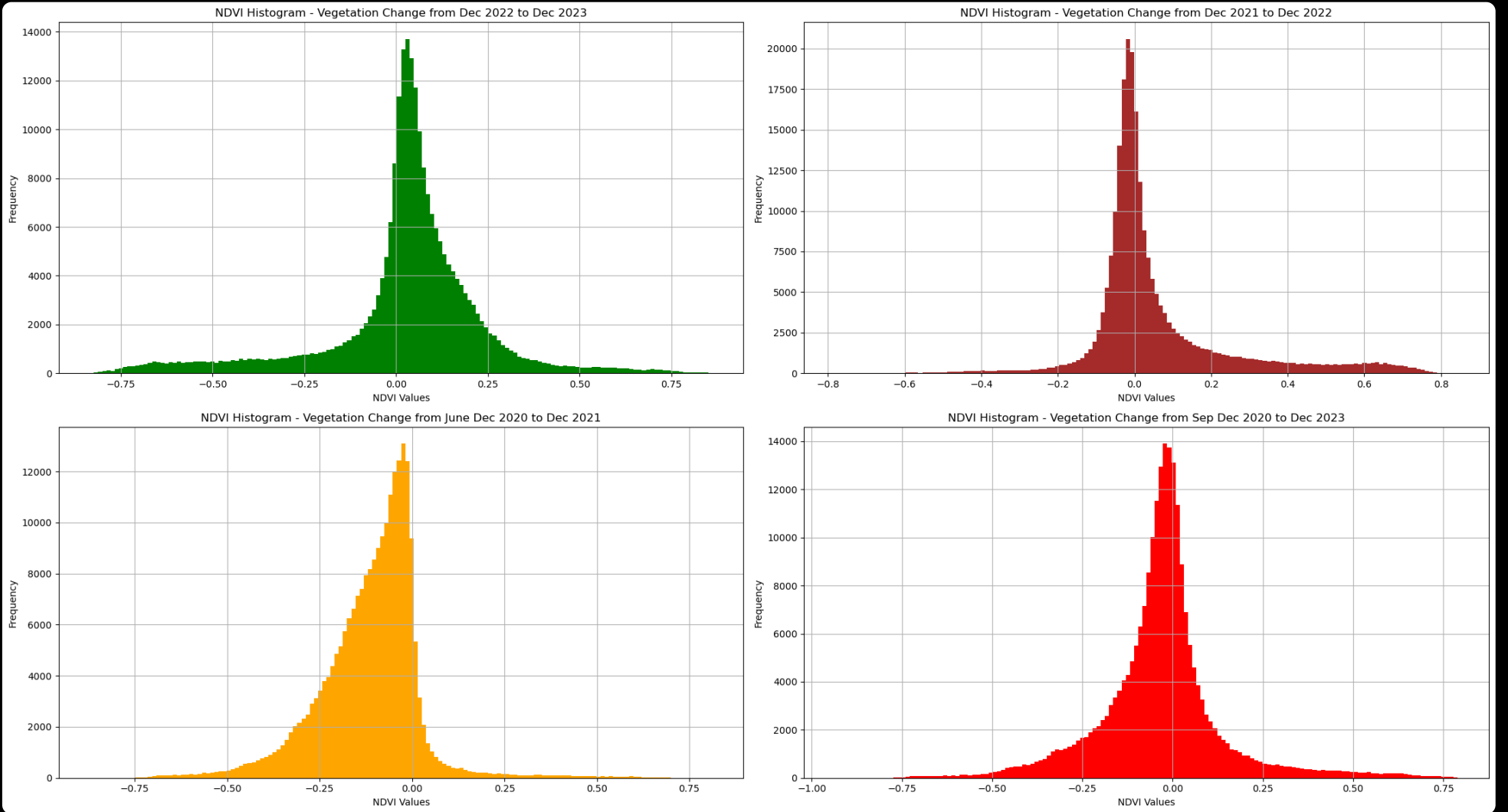
In [23]:
```
vegetation_change_from_2023_2022 = ndvi_12_2023 - ndvi_12_2022
vegetation_change_from_2022_2021 = ndvi_12_2022 - ndvi_12_2021
vegetation_change_from_2021_2020 = ndvi_12_2021 - ndvi_12_2020
vegetation_change_from_2023_2020 = ndvi_12_2023 - ndvi_12_2020
```

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)
```

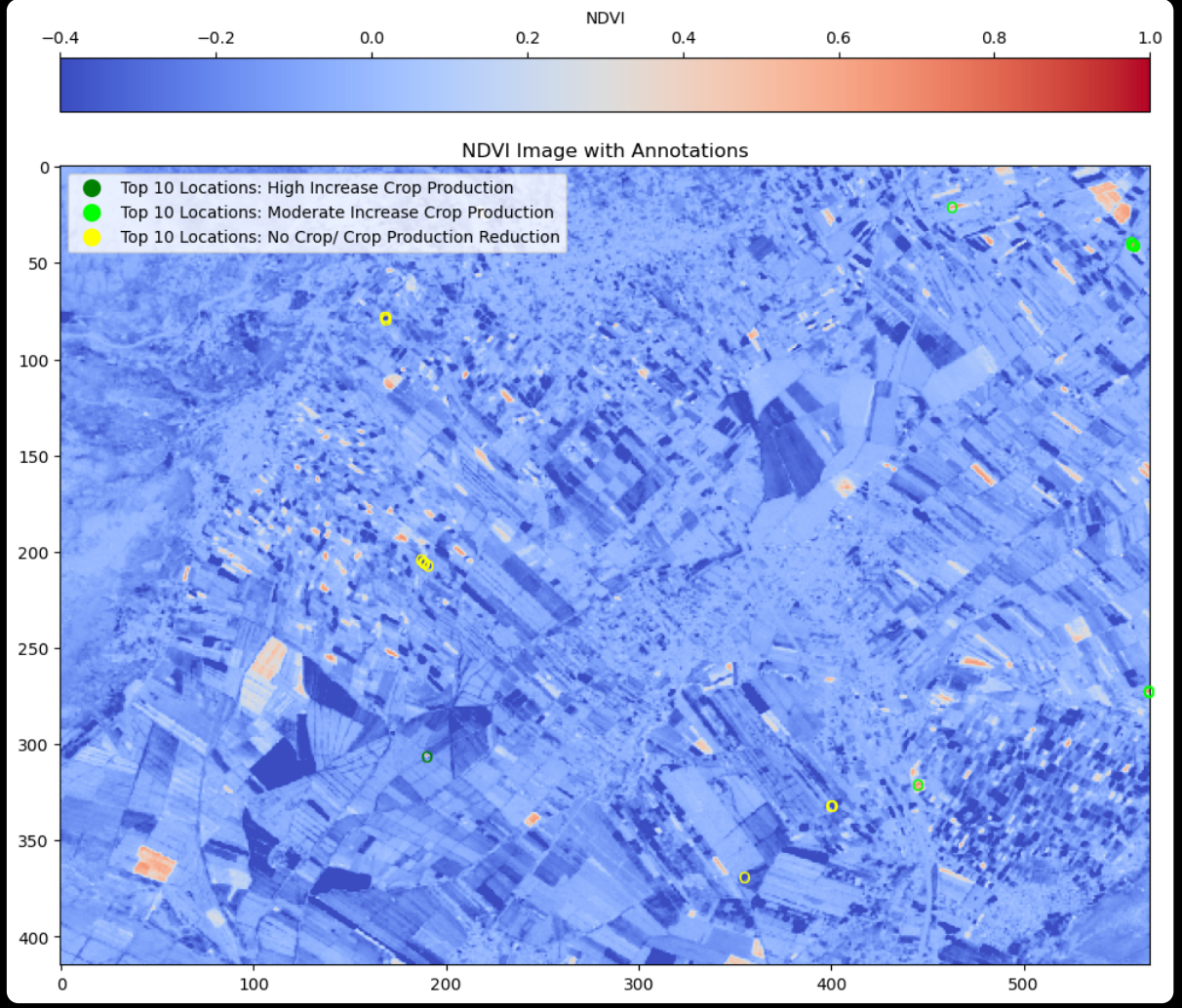


In [26]:
```
statistics_2023_2022 = Beqaa.calculate_vegetation_change_statistics(vegetation_change_from_2023_2022, 'Dec 2022 to Dec 2023')
statistics_2022_2021 = Beqaa.calculate_vegetation_change_statistics(vegetation_change_from_2022_2021, 'Dec 2021 to Dec 2022')
statistics_2021_2020 = Beqaa.calculate_vegetation_change_statistics(vegetation_change_from_2021_2020, '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
```

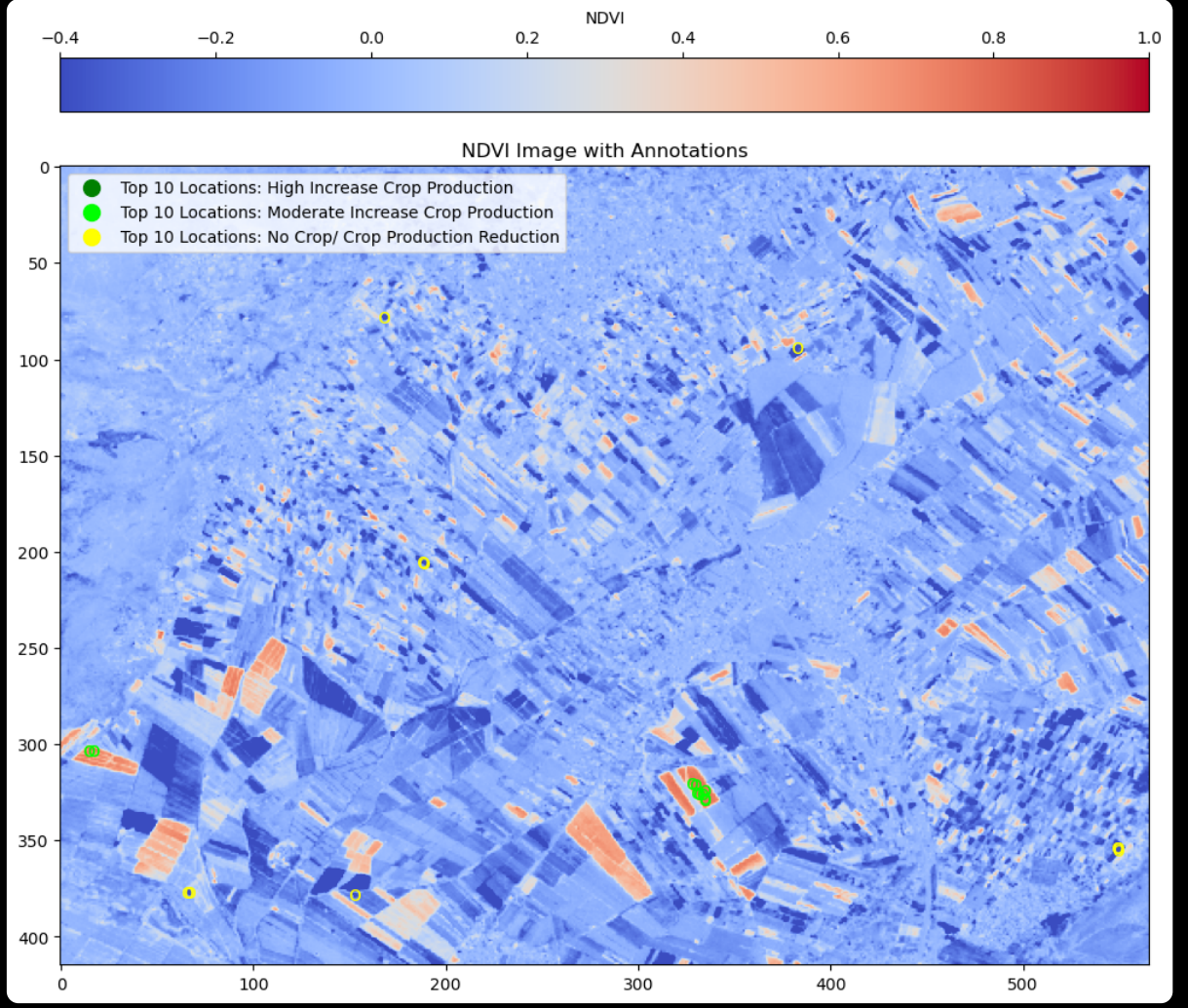
Annotez les emplacements des 10 changements de production agricole les plus élevés et les plus faibles entre 12/2020 et 12/2021

In [27]:
```
Beqaa.plot_ndvi_change_with_top_annotations(vegetation_change_from_2021_2020)
```



Annotez les emplacements des 10 changements de production agricole les plus élevés et les plus faibles entre 12/2020 et 12/2023

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



Le sommaire:

- **Changement NDVI (2020 à 2023):**
  - Réduction négligeable de la végétation: 0,03.
- **Changements saisonniers du NDVI:**
  - Pic au printemps, conforme aux attentes pour les cultures.
- **Diminution significative du NDVI (2020 à 2021):**
  - Une évaluation plus approfondie est nécessaire pour identifier les raisons de cette diminution.
- **Prochaines étapes:**
  - Explorez des ensembles de données supplémentaires liés à la température et aux précipitations.
  - Établir des liens entre les variables climatiques et les changements NDVI.
  - Travailler à la création d'un modèle prédictif pour les futures valeurs NDVI basé sur des données historiques et des variables climatiques.