## may

```
import ee
import geemap

ee.Authenticate()
ee.Initialize(project='ee-haripriyads24')
```

```
import ee
import geemap

# Initialize
Map = geemap.Map(center=[25.4358, 81.8463], zoom=11)
aoi = ee.Geometry.Point([81.8463, 25.4358]).buffer(15000)

# 1. Cloud & haze mask
def mask_s2_sr(image):
    scl = image.select('SCL')
    cloud_free = scl.neq(3).And(scl.neq(8)).And(scl.neq(9)).And(scl.neq(10)).And(scl.neq(11))
    return image.updateMask(cloud_free).copyProperties(image, ['system:time_start'])

# 2. Add NDTI band
def add_ndti(image):
    red = image.select('B4')
    green = image.select('B3')
    ndti = red.subtract(green).divide(red.add(green)).rename('NDTI')
    return image.addBands(ndti)

# 3. Add NDWI band
def add_ndwi(image):
    green = image.select('B3')
    nir = image.select('B8')
    ndwi = green.subtract(nir).divide(green.add(nir)).rename('NDWI')
    return image.addBands(ndwi)

# 4. Create river mask using NDWI from May 2019
def get_river_mask(start, end):
    collection = (
        ee.ImageCollection('COPERNICUS/S2_SR_HARMONIZED')
        .filterDate(start, end)
        .filterBounds(aoi)
        .map(mask_s2_sr)
        .map(add_ndwi)
    )
    ndwi_median = collection.select('NDWI').median()
    river_mask = ndwi_median.gt(0.00)
    return river_mask.updateMask(river_mask).clip(aoi)

# Create river mask once (May 2019)
river_mask = get_river_mask('2019-05-01', '2019-05-31')

# 5. Get NDTI median clipped to river only
def get_ndti_composite(start, end):
    collection = (
        ee.ImageCollection('COPERNICUS/S2_SR_HARMONIZED')
        .filterDate(start, end)
        .filterBounds(aoi)
        .map(mask_s2_sr)
        .map(add_ndti)
    )
    ndti_median = collection.select('NDTI').median()
    return ndti_median.updateMask(river_mask).clip(aoi)

# 6. Visualization
ndti_vis = {'min': -0.5, 'max': 0.5, 'palette': ['green', 'yellow', 'red']}
diff_vis = {'min': -0.2, 'max': 0.2, 'palette': ['blue', 'white', 'red']}
rgb_vis = {'bands': ['B4', 'B3', 'B2'], 'min': 0, 'max': 3000}
ndwi_vis = {'palette': ['blue']}

# 7. RGB base layer
s2_rgb = (
    ee.ImageCollection('COPERNICUS/S2_SR_HARMONIZED')
    .filterDate('2019-05-01', '2019-05-31')
```

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        .filterBounds(aoi)
        .map(mask_s2_sr)
        .median()
    )

    Map.addLayer(s2_rgb.clip(aoi), rgb_vis, 'Sentinel-2 RGB (May 2019)', True)

    # 8. Time periods
    periods = {
        '2019': ('2019-05-01', '2019-05-31'),
        '2020': ('2020-05-01', '2020-05-31'),
        '2021': ('2021-05-01', '2021-05-31'),
        '2022': ('2022-05-01', '2022-05-31'),
        '2023': ('2023-05-01', '2023-05-31'),
        '2024': ('2024-05-01', '2024-05-31'),
    }

    # 9. NDTI per year (masked to river)
    ndti_layers = {}
    for year, dates in periods.items():
        img = get_ndti_composite(*dates)
        ndti = img.select('NDTI')
        Map.addLayer(ndti, ndti_vis, f'NDTI (River Only) May {year}')
        ndti_layers[year] = ndti

    # 10. Differences
    def add_diff(year1, year2):
        diff = ndti_layers[year2].subtract(ndti_layers[year1])
        Map.addLayer(diff, diff_vis, f'NDTI Change (River Only) May {year2} - {year1}')

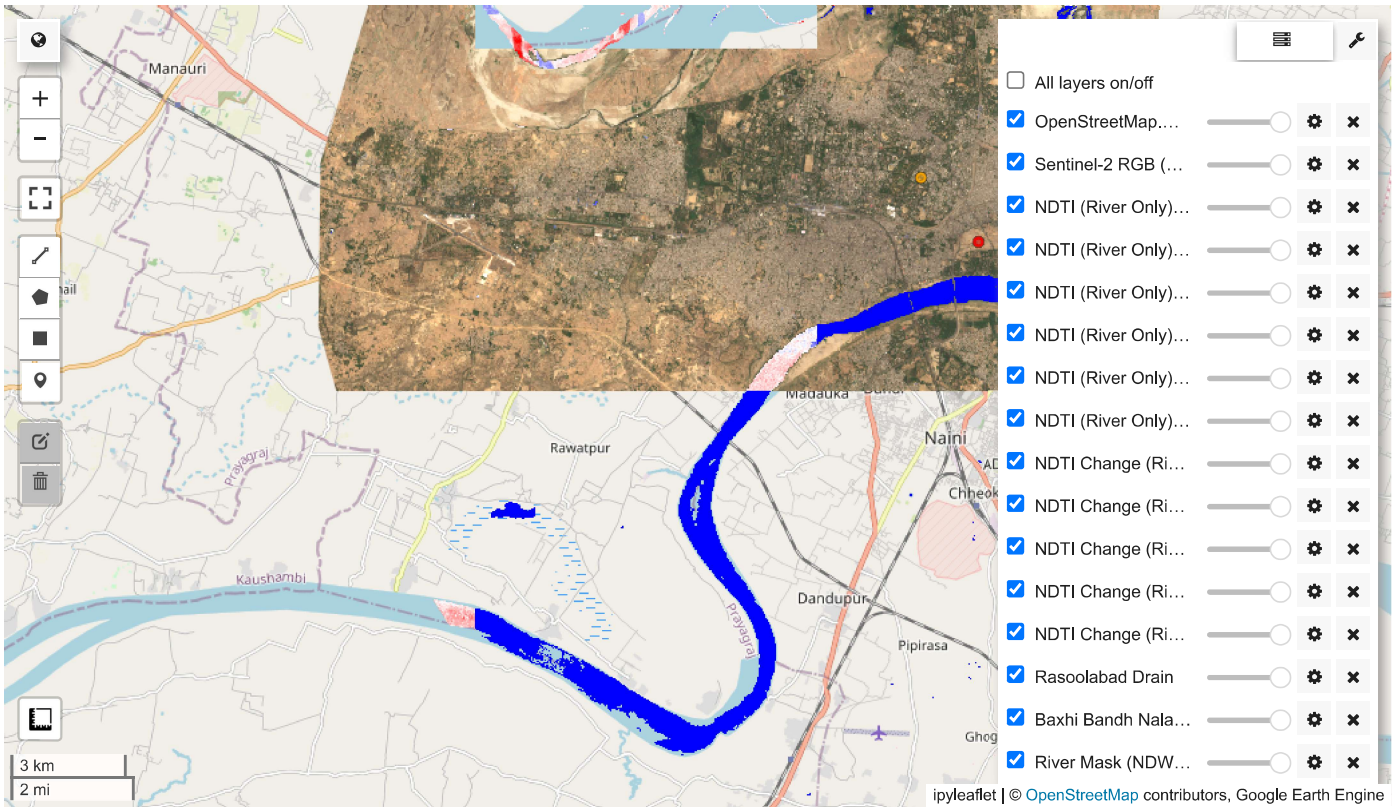
    diff_years = ['2019', '2020', '2021', '2022', '2023', '2024']
    for i in range(len(diff_years) - 1):
        add_diff(diff_years[i], diff_years[i + 1])

    # 11. Optional pollution points
    pollution_points = {
        "Rasoolabad Drain": {'coords': [81.8674, 25.4382], 'color': 'red'},
        "Baxhi Bandh Nala (Govindpur)": {'coords': [81.8529, 25.4531], 'color': 'orange'},
    }

    for name, data in pollution_points.items():
        point = ee.Geometry.Point(data['coords'])
        Map.addLayer(point, {'color': data['color']}, name)

    # 12. Add river mask layer (for visualization)
    Map.addLayer(river_mask, ndwi_vis, 'River Mask (NDWI May 2019)')

    # 13. Show map
    Map
```




```
import pandas as pd
import numpy as np
from scipy.stats import zscore
from sklearn.linear_model import LinearRegression

# 1. Extract mean and std from already computed images
year_list = []
mean_list = []
std_list = []

for year, image in ndti_layers.items():
    stats = image.reduceRegion(
        reducer=ee.Reducer.mean().combine(ee.Reducer.stdDev(), '', True),
        geometry=aoi,
        scale=10,
        maxPixels=1e9,
        bestEffort=True
    ).getInfo()

    year_list.append(int(year))
    mean_list.append(stats.get('NDTI_mean', float('nan')))
    std_list.append(stats.get('NDTI_stdDev', float('nan')))

# 2. Create DataFrame
df = pd.DataFrame({
    'Year': year_list,
    'Mean_NDTI': mean_list,
    'StdDev_NDTI': std_list
})

# 3. Compute Z-score for mean NDTI
df['ZScore_Mean'] = zscore(df['Mean_NDTI'])

# 4. Linear Regression: Trend analysis
X = df['Year'].values.reshape(-1, 1)
y = df['Mean_NDTI'].values.reshape(-1, 1)
model = LinearRegression().fit(X, y)

df['Predicted_Trend'] = model.predict(X)

# 5. Print results
print("NDTI Summary with Z-score and Trend:")
print(df.round(4))
```

```
# 6. Optional: Show slope of trend line
slope = model.coef_[0][0]
print(f"\n📈 Linear Trend Slope = {slope:.4f} (per year)")
```

```
NDTI Summary with Z-score and Trend:
   Year  Mean_NDTI  StdDev_NDTI  ZScore_Mean  Predicted_Trend
0  2019    -0.0861       0.0350      -1.2159          -0.0872
1  2020    -0.0558       0.0595      -0.4702          -0.0670
2  2021    -0.0836       0.0899      -1.1557          -0.0468
3  2022     0.0078       0.0417       1.0953          -0.0265
4  2023    -0.0153       0.0671       0.5268          -0.0063
5  2024     0.0129       0.0557       1.2196           0.0139

📈 Linear Trend Slope = 0.0202 (per year)
```

```
import pandas as pd

# Create a list to store results
compound_results = []

# Use same year pairs as in Cell 1
for i in range(len(diff_years) - 1):
    year1 = diff_years[i]
    year2 = diff_years[i + 1]
    label = f"{year2}-{year1}"

    # Get the difference image
    diff_img = ndti_layers[year2].subtract(ndti_layers[year1])

    # Reduce to mean & std over river mask area
    stats = diff_img.reduceRegion(
        reducer=ee.Reducer.mean().combine(ee.Reducer.stdDev(), '', True),
        geometry=aoi,
        scale=10,
        maxPixels=1e9,
        bestEffort=True
    ).getInfo()

    compound_results.append({
        'Period': label,
        'Mean_ΔNDTI': stats.get('NDTI_mean'),
        'StdDev_ΔNDTI': stats.get('NDTI_stdDev')
    })

# Convert to DataFrame
compound_df = pd.DataFrame(compound_results)

# Display rounded results
print("📊 Compound ΔNDTI Summary Table:")
print(compound_df.round(4))
```

```
📊 Compound ΔNDTI Summary Table:
      Period  Mean_ΔNDTI  StdDev_ΔNDTI
0  2020-2019      0.0303        0.0648
1  2021-2020     -0.0277        0.0764
2  2022-2021      0.0914        0.0812
3  2023-2022     -0.0231        0.0557
4  2024-2023      0.0282        0.0566
```

```
import matplotlib.pyplot as plt
import seaborn as sns

# Sample data (replace with your actual df if different)
data = {
    'Period': ['2020-2019', '2021-2020', '2022-2021', '2023-2022', '2024-2023'],
    'Mean_ΔNDTI': [0.0303, -0.0277, 0.0914, -0.0231, 0.0282],
    'StdDev_ΔNDTI': [0.0648, 0.0764, 0.0812, 0.0557, 0.0566]
}

df = pd.DataFrame(data)

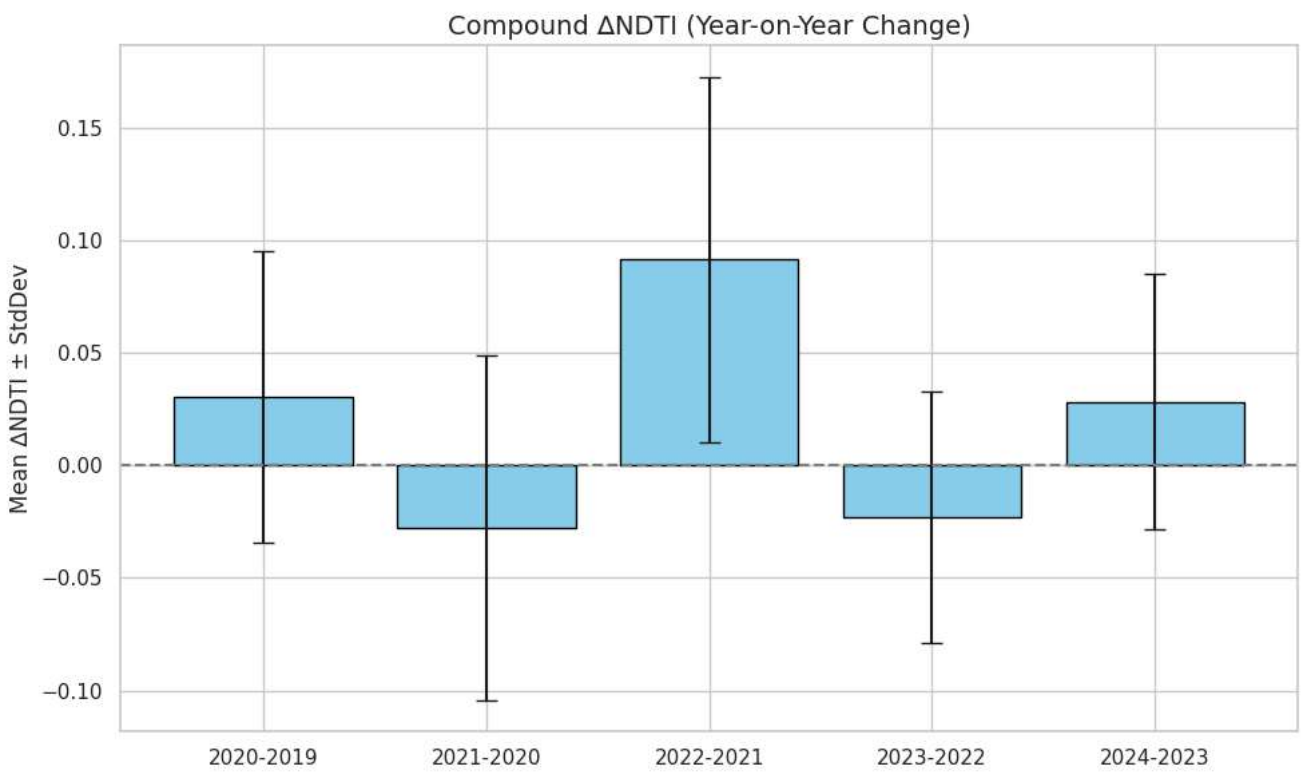
# Set seaborn style
sns.set(style="whitegrid")
```

```
# Plot
plt.figure(figsize=(10, 6))
bars = plt.bar(df['Period'], df['Mean_ΔNDTI'], yerr=df['StdDev_ΔNDTI'],
               capsize=6, color='skyblue', edgecolor='black')

# Add horizontal zero line
plt.axhline(0, color='gray', linestyle='--')

# Labeling
plt.title('Compound ΔNDTI (Year-on-Year Change)', fontsize=14)
plt.xlabel('')
plt.ylabel('Mean ΔNDTI ± StdDev')
plt.xticks(rotation=360)
plt.tight_layout()

# Show plot
plt.show()
```




```
# Assume ndti_layers is a dictionary with {year: ndti_image}
diff_layers = {}

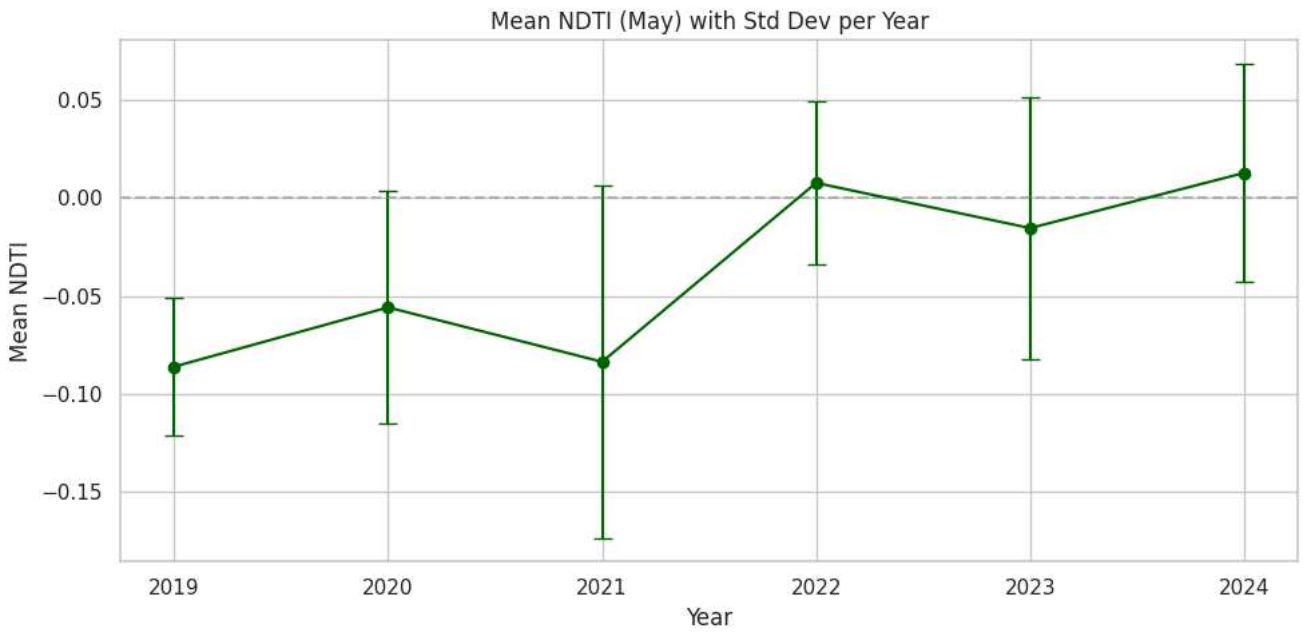
years = sorted(ndti_layers.keys())
for i in range(len(years) - 1):
    year1 = years[i]
    year2 = years[i + 1]
    delta_ndti = ndti_layers[year2].subtract(ndti_layers[year1])
    diff_layers[f"{year2}-{year1}"] = delta_ndti
```

```
import matplotlib.pyplot as plt
import pandas as pd

# Your data
data = {
    "Year": [2019, 2020, 2021, 2022, 2023, 2024],
    "Mean_NDTI": [-0.0861, -0.0558, -0.0836, 0.0078, -0.0153, 0.0129],
    "StdDev_NDTI": [0.0350, 0.0595, 0.0899, 0.0417, 0.0671, 0.0557]
}
df = pd.DataFrame(data)

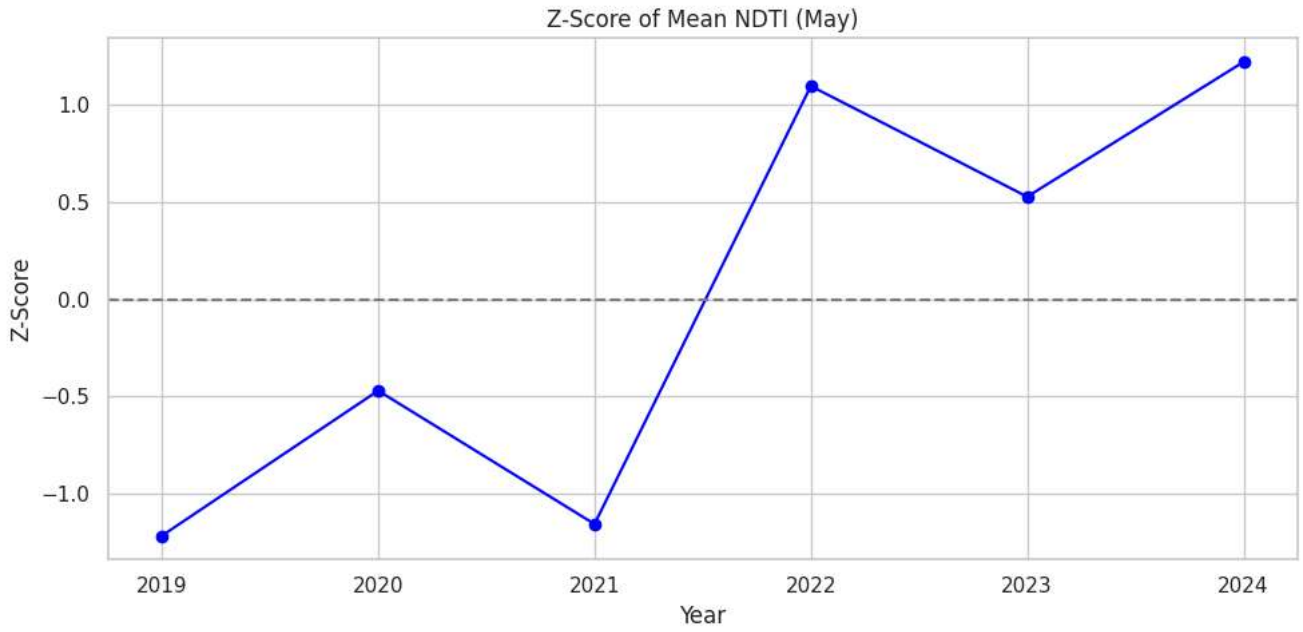
# Plot
```

```
plt.figure(figsize=(10, 5))
plt.errorbar(df["Year"], df["Mean_NDTI"], yerr=df["StdDev_NDTI"], fmt='o-', capsize=5, color='darkgreen')
plt.axhline(0, color='gray', linestyle='--', alpha=0.5)
plt.title("Mean NDTI (May) with Std Dev per Year")
plt.xlabel("Year")
plt.ylabel("Mean NDTI")
plt.grid(True)
plt.tight_layout()
plt.show()
```



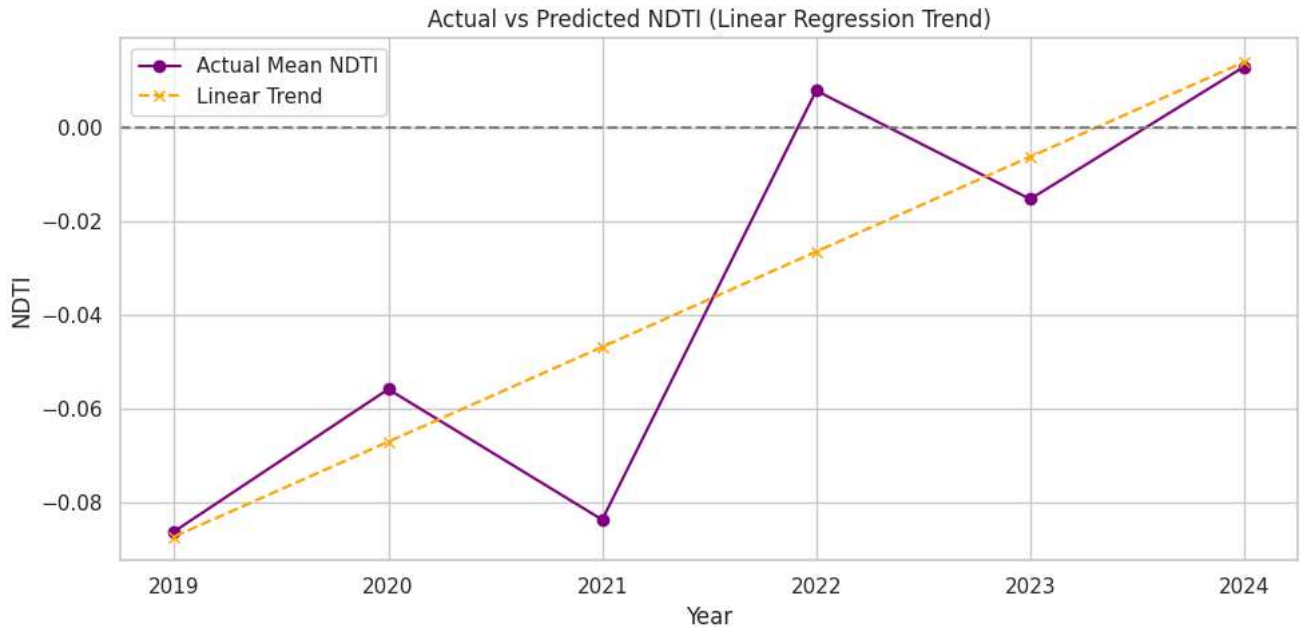

```
# Z-score data
df["ZScore_Mean"] = [-1.2159, -0.4702, -1.1557, 1.0953, 0.5268, 1.2196]

# Plot
plt.figure(figsize=(10, 5))
plt.plot(df["Year"], df["ZScore_Mean"], marker='o', linestyle='-', color='blue')
plt.axhline(0, color='gray', linestyle='--')
plt.title("Z-Score of Mean NDTI (May)")
plt.xlabel("Year")
plt.ylabel("Z-Score")
plt.grid(True)
plt.tight_layout()
plt.show()
```




```
# Regression prediction
df["Predicted_Trend"] = [-0.0872, -0.0670, -0.0468, -0.0265, -0.0063, 0.0139]

# Plot
plt.figure(figsize=(10, 5))
plt.plot(df["Year"], df["Mean_NDTI"], label="Actual Mean NDTI", marker='o', color='purple')
plt.plot(df["Year"], df["Predicted_Trend"], label="Linear Trend", linestyle='--', marker='x', color='orange')
plt.axhline(0, color='gray', linestyle='--')
plt.title("Actual vs Predicted NDTI (Linear Regression Trend)")
plt.xlabel("Year")
plt.ylabel("NDTI")
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()
```




```
# Plot
plt.figure(figsize=(12, 6))
plt.plot(df["Year"], df["Mean_NDTI"], label="Mean NDTI", marker='o', color='green')
plt.plot(df["Year"], df["ZScore_Mean"], label="Z-Score", marker='^', color='blue')
plt.plot(df["Year"], df["Predicted_Trend"], label="Trend (Regression)", linestyle='--', marker='x', color='orange')
```

```
plt.axhline(0, color='gray', linestyle='--')
plt.title("NDTI Summary Overview (May)")
plt.xlabel("Year")
plt.ylabel("Value")
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()
```