

# MONITORING PO RIVER WATER EXTENTS ANALYSIS

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# PROJECT GOAL:

## Topic:

Monitoring the water extents of the Po River flowing south of Cremona during Spring-Summer 2023 and comparison with the same period in 2022.

## Tasks:

1. To extract the water extents as accurately as possible by classifying the data or by using indexes applied to Sentinel-2 data.
2. To compute the total water surface extents statistics (histogram, mean, variance, max and min values) in the period of interest.



# Introduction

- Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft).
- This report shows the methodology to calculate and compare water surface areas of the Po River south of Cremona during the Spring-Summer periods of 2022 and 2023 using Sentinel-2 satellite imagery and Google Earth Engine (GEE).

# GOOGLE EARTH ENGINE CODE LINK:

<https://code.earthengine.google.com/28b28c318af97f8d229f432151523ea8>

# Task 1: Water Surface Area Calculation.

## Objective:

To develop a method that estimate the water surface area of the Po River south of Cremona using Sentinel-2 imagery.

## Steps Performed:

1. **Define Area of Interest (AOI):** The AOI is defined as a geographic polygon encompassing the region south of Cremona along the Po River.
2. **Select Sentinel-2 Images:** Sentinel-2 images is filtered to select those with less than 20% cloud cover for the periods April 1 to September 30 in 2022 and 2023, to ensure the use of high graphics images.
3. **NDWI Calculation:** The Normalized Difference Water Index (NDWI) is used to identify water bodies. NDWI is calculated using the green (B3) and near infrared (B8) bands of Sentinel-2. The formula for NDWI is:
  - $$\text{NDWI} = (\text{NIR} - \text{Green}) / (\text{NIR} + \text{Green})$$

- 4. Water Threshold Definition:** A threshold value of 0.3 is used to classify pixels as water. Pixels with NDWI values greater than 0.3 is classified as water bodies.
- 5. Water Mask Generation:** For each image, a binary water mask is generated where pixels exceeding the NDWI threshold is mark as water, and others as land.
- 6. Water Pixel Count:** The total number of water pixels is counted for each image within the AOI using a regional reduction operation.
- 7. Water Area Calculation:** The pixel count is multiply by the area of each Sentinel-2 pixel (10m x 10m) to convert the count to actual water surface area.
- 8. Total Water Area:** Water area estimates for each image within the specified period is sum up to obtain the total water surface area for the Spring-Summer periods of 2022 and 2023.

# Task 2: Comparative Analysis.

## **Objective:**

To compare the water surface areas calculated for the Spring-Summer periods of 2022 and 2023.

## **Methodology:**

- Calculate Statistics:** Statistical measures are computed, including mean, variance, minimum, maximum, and histogram of the water areas for the periods of interest.
- Visualize Results:** The water area time series for 2022 and 2023 is visualized using bar charts, and a combined line chart was created to facilitate comparison.

# CODE OUTPUT AND MAP

Google Earth Engine

Search places and datasets...

fair-circuit-424701-i6

Scripts Docs Assets

New Script Get Link Save Run Reset Apps

Filter methods...

- ee.Algorithms
- ee.Array
- ee.Blob
- ee.Classifier
- ee.Clusterer
- ee.ConfusionMatrix
- ee.Date
- ee.DateRange
- ee.Dictionary
- ee.ErrorMargin
- ee.Feature

```
96  series: {
97    0: {color: 'blue', lineWidth: 2},
98    1: {color: 'cyan', lineWidth: 2}
99  },
100 legend: {position: 'bottom'}
101 });
102
103 // Print the charts to the console.
104 print(chart2022);
105 print(chart2023);
106 print(chartCombined);
107
108 // Visualize results on the map.
109 Map.centerObject(aoi, 10); // Center map on AOI.
110 var waterVisParams = {palette: ['000000', '00FFFF'], min:
111 Map.addLayer(s2_2022.median().select('Water'), waterVisPar
112 Map.addLayer(s2_2023.median().select('Water'), waterVisPar
113 |
```

Inspector Console Tasks

Statistics for 2022:

- Object (5 properties)
  - Water\_histogram: Object (4 properties)
    - Water\_max: 4093.9104766845703
    - Water\_mean: 87.02789317406808
    - Water\_min: 0
    - Water\_variance: 226961.96795137477

Statistics for 2023:

- Object (5 properties)
  - Water\_histogram: Object (4 properties)
    - Water\_max: 3177.4386978149414
    - Water\_mean: 74.13040024770348
    - Water\_min: 0
    - Water\_variance: 143579.612861498

The screenshot shows the Google Earth Engine interface. The top navigation bar includes 'Google Earth Engine', a search bar, and a user profile 'fair-circuit-424701-i6'. Below the navigation is a toolbar with 'Scripts', 'Docs', and 'Assets' tabs, followed by buttons for 'New Script', 'Get Link', 'Save', 'Run', 'Reset', 'Apps', and settings. A sidebar on the left lists various Earth Engine modules. The main area contains a script editor with code for visualizing water data from 2022 and 2023. To the right is an 'Inspector' panel displaying statistical data for both years, and a 'Console' panel showing the execution results. At the bottom, there are two map viewers showing regions around Asti and Mantua, with various roads and geographical features labeled.

# CODE OUTPUT AND MAP

Google Earth Engine



Search places and datasets...



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Scripts Docs Assets

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Examples

RS\_Assignment\_Muhammad Asad...

Get Link

Save

Run

Reset

Apps



```
62 var stats_2022 = computeStats(s2_2022);
63 var stats_2023 = computeStats(s2_2023);
64
65 // Print statistics to the console.
66 print('Statistics for 2022:', stats_2022);
67 print('Statistics for 2023:', stats_2023);
68
69 // Function to normalize water area to fit within the range 1 to 100.
70 var normalizeWaterArea = function(image, maxArea) {
71   return image.multiply(100).divide(ee.Image.constant(maxArea));
72 }
73
74 // Function to compute and plot histograms.
75 var computeAndPlotHistograms = function(imageCollection, year, color) {
76   // Sum water masks over the entire period.
77   var waterSum = imageCollection.map(function(image) {
78     return image.multiply(ee.Image.pixelArea());
79   }).sum();
80
81   // Get the maximum water area for normalization.
82   var maxArea = waterSum.reduceRegion({
83     reducer: ee.Reducer.max(),
84     geometry: aoi,
85     scale: 10,
86     maxPixels: 1e10
87   }).get('Water');
88
89   // Convert maxArea to an ee.Image to use in the divide operation.
90   var maxAreaImage = ee.Image.constant(maxArea);
91
92   // Normalize the water area.
93   var normalizedWaterSum = waterSum.multiply(100).divide(maxAreaImage);
94
95
```

Inspector

Console

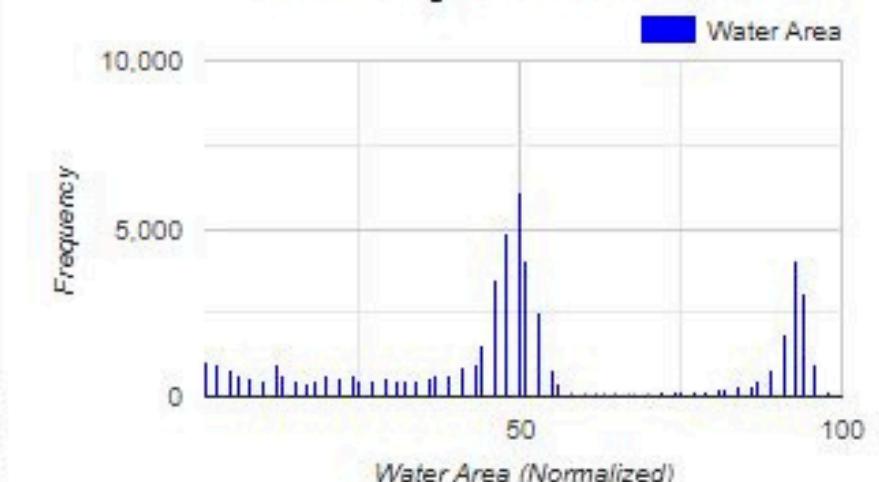
Tasks

Total Water Area in 2022 (m<sup>2</sup>):

JSON

114728046.34217355

Normalized Histogram of Water Area in 2022



Total Water Area in 2023 (m<sup>2</sup>):

JSON

97725403.7159273

Normalized Histogram of Water Area in 2023



# CODE OUTPUT AND MAP

Google Earth Engine Search places and datasets... fair-circuit-424701-i6

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Examples

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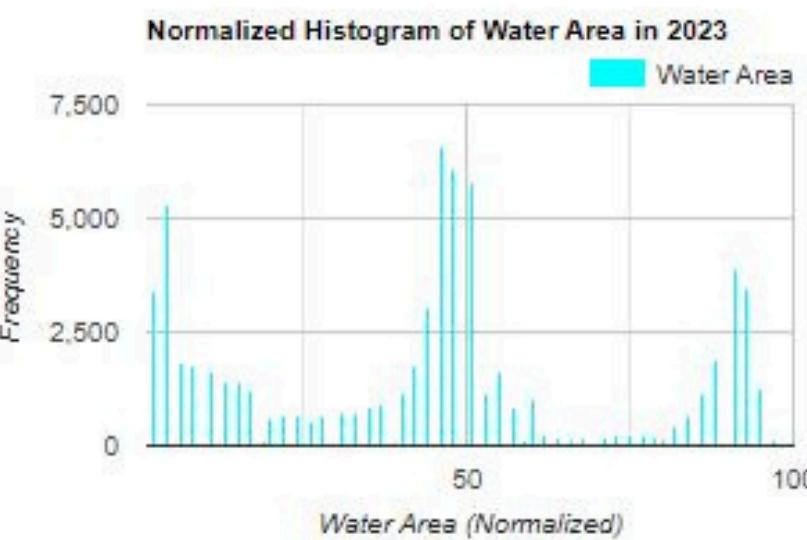
Get Link Save Run Reset Apps ⚙️

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```

Inspector Console Tasks

97725403.7159273

Normalized Histogram of Water Area in 2023



A histogram showing the normalized frequency of water areas in 2023. The x-axis is 'Water Area (Normalized)' ranging from 0 to 100. The y-axis is 'Frequency' ranging from 0 to 7,500. The distribution is highly skewed, with most values between 0 and 50, and several sharp peaks reaching up to 7,500.

Water Area in 2022



A bar chart showing the total water area in 2022 for each month. The y-axis is 'Water Area (m²)' ranging from 0 to 4,000,000. The x-axis is 'Date' showing months from January to December. The bars show significant seasonal variation, with peaks in March, April, and May, and a notable low point in August.

5:59 PM 6/16/2024

# CODE OUTPUT AND MAP

Google Earth Engine

Search places and datasets...

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Inspector Console Tasks

0 20 20 20 20 20 20 20 20 20 Date

Water Area in 2023

waterArea

6,000,000

4,000,000

2,000,000

0

Water Area (m<sup>2</sup>)

Date

Comparison of Water Area (2022 vs 2023)

waterArea

6,000,000

4,000,000

2,000,000

0

Water Area (m<sup>2</sup>)

Date

Script Editor

Owner (1)  
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Reader  
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Archive  
No accessible repositories. Click Refresh to check again.

Examples

```
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63 var stats_2023 = computeStats(s2_2023);
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65 // Print statistics to the console.
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94
95 }
```

# STATISTICAL ANALYSIS

Statistics for 2022:

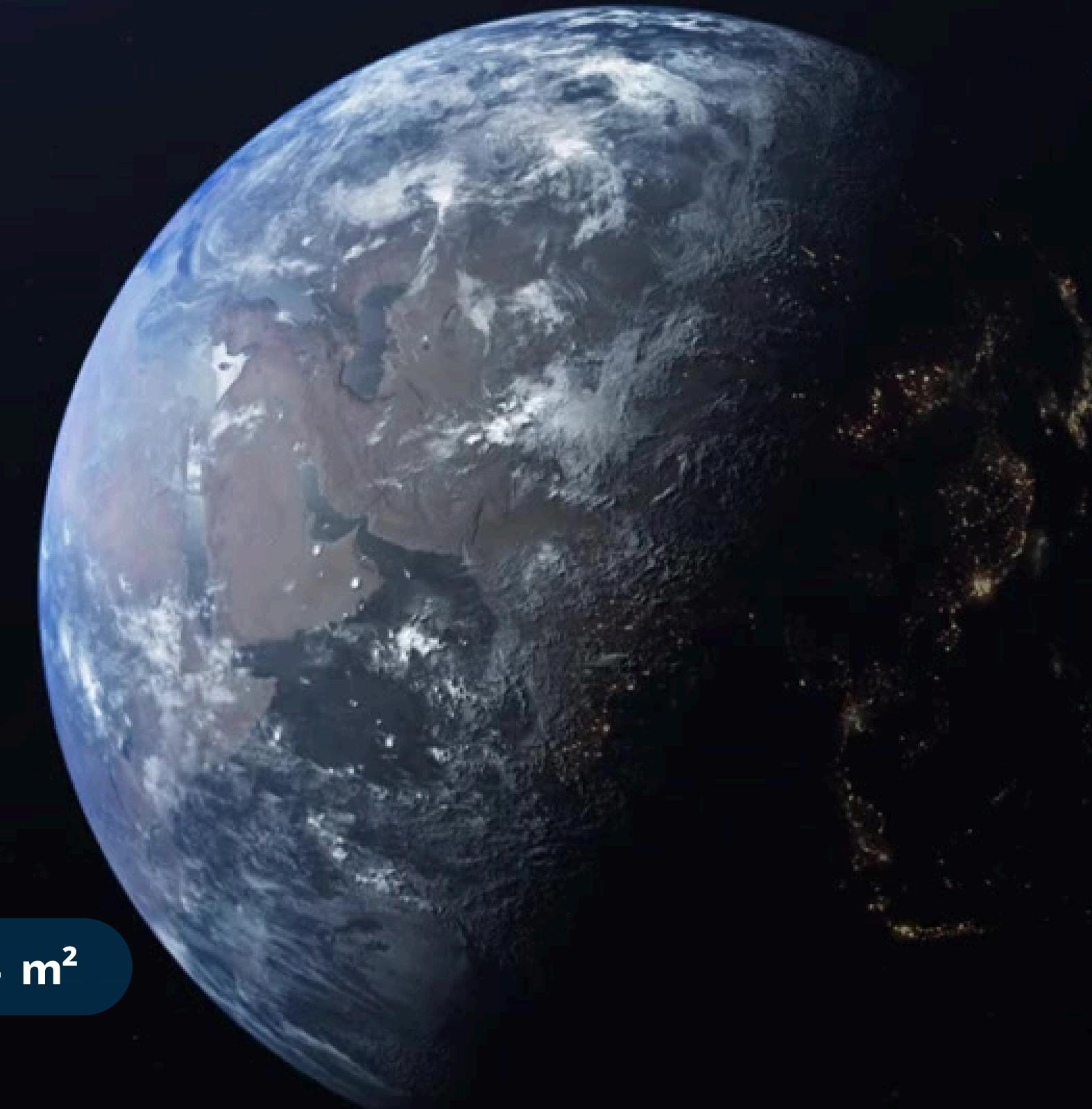
Maximum Water Area: **4093.91 m<sup>2</sup>**

Mean Water Area: **87.03 m<sup>2</sup>**

Minimum Water Area: **0 m<sup>2</sup>**

Variance in Water Area: **226961.97 m<sup>2</sup>**

Total Water Area in 2022: **114728046.34 m<sup>2</sup>**



# STATISTICAL ANALYSIS

Statistics for 2023:

Maximum Water Area:  $3177.44 \text{ m}^2$

Mean Water Area:  $74.13 \text{ m}^2$

Minimum Water Area:  $0 \text{ m}^2$

Variance in Water Area:  $143579.61 \text{ m}^2$

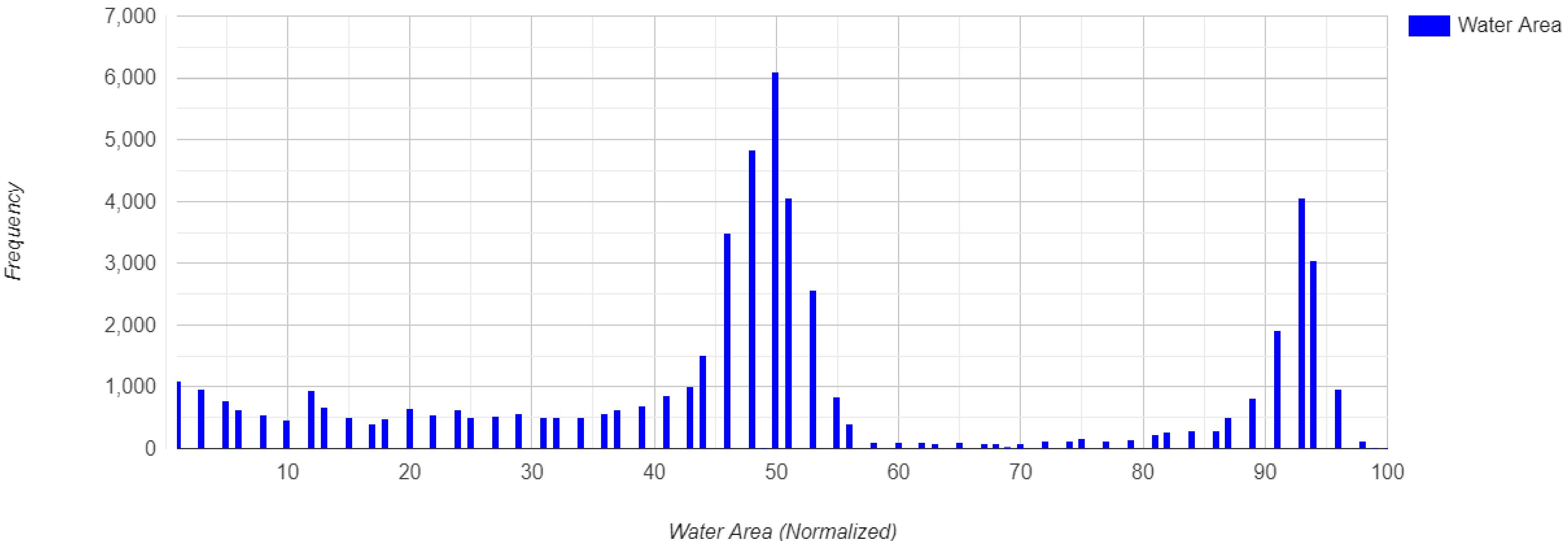
Total Water Area in 2023:  $97725403.71 \text{ m}^2$



# HISTOGRAMS

YEAR 2022:

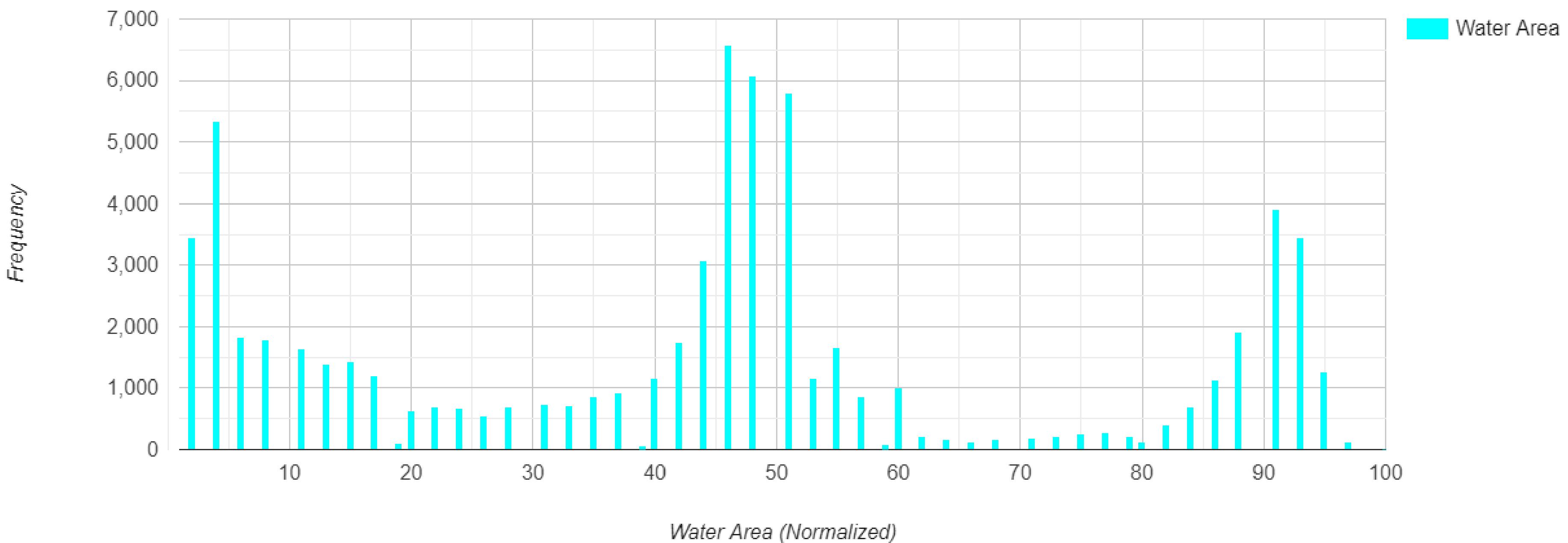
Normalized Histogram of Water Area in 2022



# HISTOGRAMS

**YEAR 2023:**

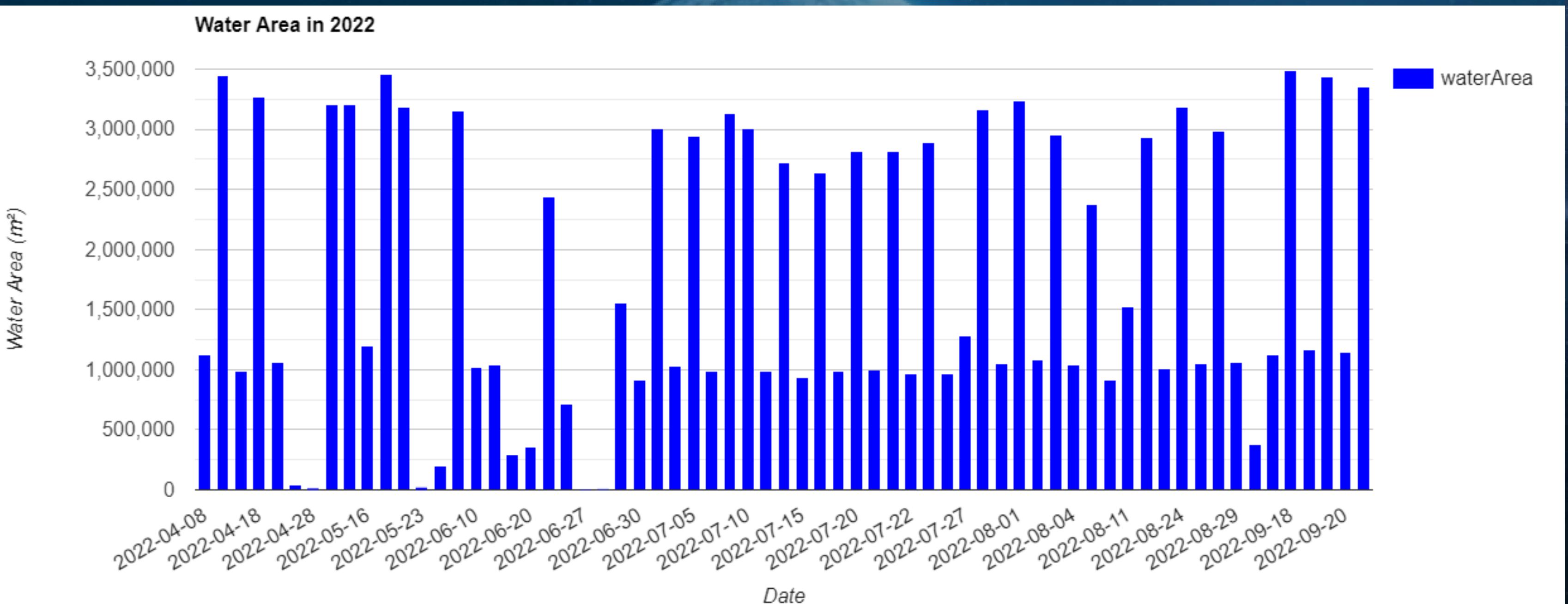
Normalized Histogram of Water Area in 2023



# RESULTS AND COMPARISON

## Overview of Water Extents in 2022

The 2022 saw a significant variation in the water level of the Po River south of Cremona. In MAY the level of water is further increased. However, in JULY we have seen drop water levels.

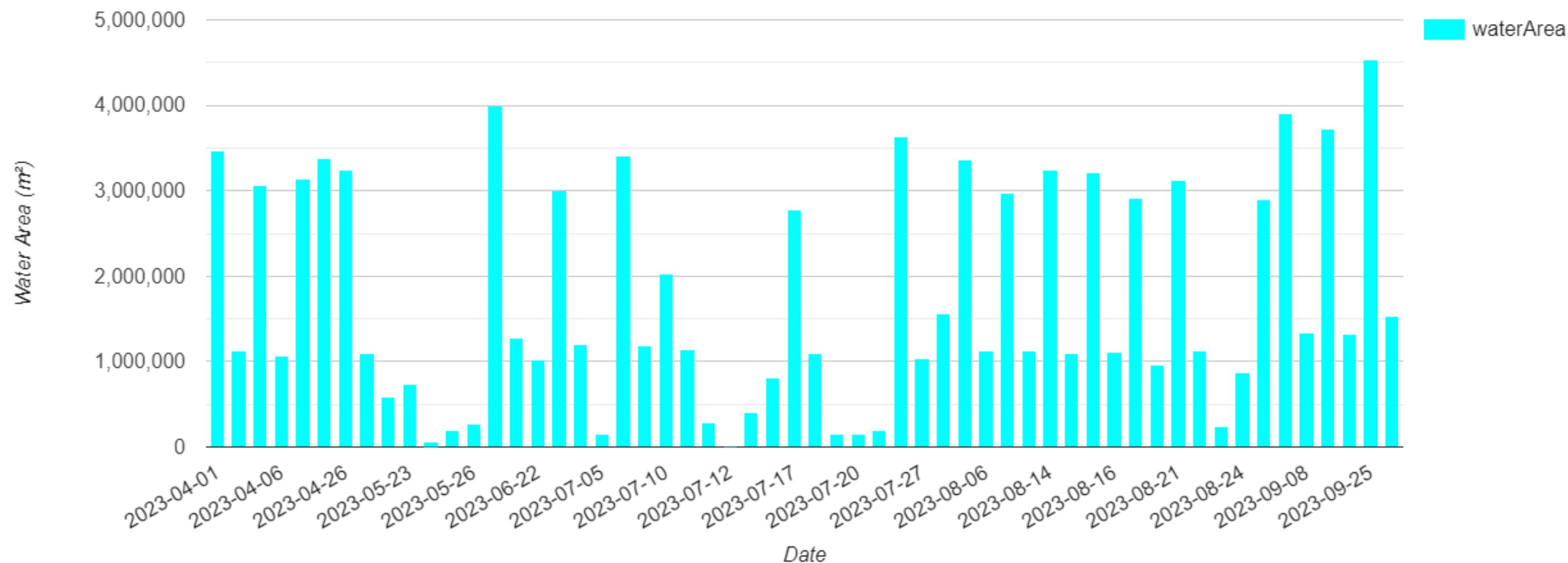


# RESULTS AND COMPARISON

## Overview of Water Extents in 2023

The analysis of the Po River's water extents in 2023 has differences compared to 2022.

In MAY it has higher water levels due rainfall and/or snowmelt. These variations show how climate influences affect rivers and emphasize the value of continuous monitoring.

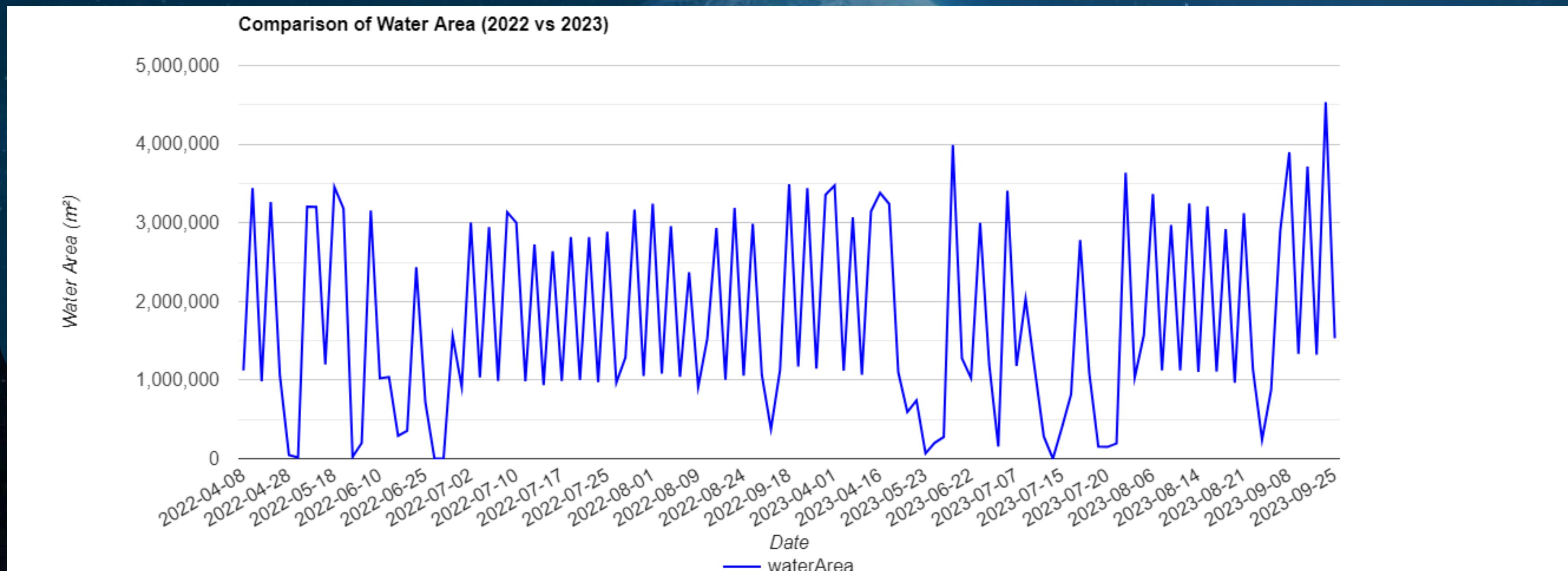


# RESULTS AND COMPARISON

## 2022 vs 2023 Water Extents

The Po River's water extents in 2022 and 2023 are contrasted in this graph. The differences in total water surface levels, as well as changes in maximum and minimum values, are highlighted.

These metrics help in understanding the trends observed in these two years.



# CONCLUSION

This research created an effective way to evaluate water resources using Sentinel-2 photos. A comparison between 2022 and 2023 showed that the Po River's water availability may fall, showing the importance of careful water management and observation.

