# Environmental Change of the Dead Sea and its Surrounding Areas

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Fall 2020

Final Project LARP 743

# Introduction

The Dead Sea is shrinking and it has enormous implications for the region surrounding it. The Jordan River and Galilee to the North flow south and feed the Dead Sea with fresh water. Throughout the years, Syrian, Jordanian and Israeli governments have created networks that siphon off this fresh water flow up stream to help irrigate and feed other areas of the country. As a result, the Dead Sea has lost its primary water source. The shrinking of the sea creates a groundwater level drop which leaves behind sinkholes that can swallow everything in its path, dangerous for humans and the land.

Additionally, the growing tourism industry surrounding the Dead Sea, primarily in the southern area, creates greater need for fresh water and infrastructure support. The receding water has caused resort areas to play catch up in trying to get close to the water but avoid the sinkholes.

The Dead Sea lies between Israel and Jordan and partially within the West Bank. The receding coastline is therefore a political and environmental justice issue as individuals in power causing the catastrophe hurt those most vulnerable who live near the water body itself. As one can see there are many policy issues at stake. My project sets out to explore and validate the environmental, economic and political implications of the Dead Sea's shrinkage.

# Outline

Introduction:

Section 1: Examining the features of the Dead Sea

1.1-1.3: Observing the surface area of the water

It is well known that the Dead Sea is shrinking and we will examine if satellite imagery around surface water will tell the same story. We use two different datasets to display this information.

1.4-1.5: Looking at the Normalized Difference Vegetation Index (NDVI)

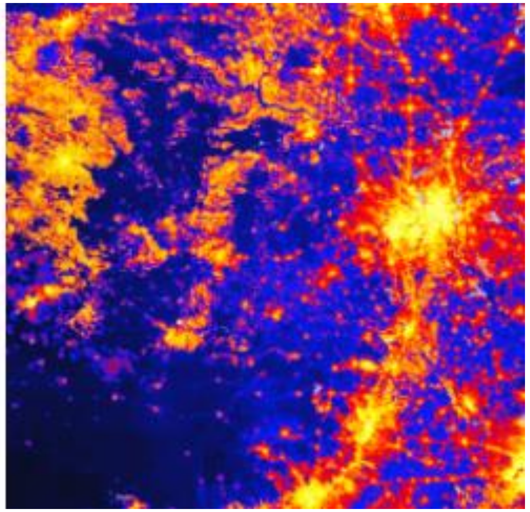
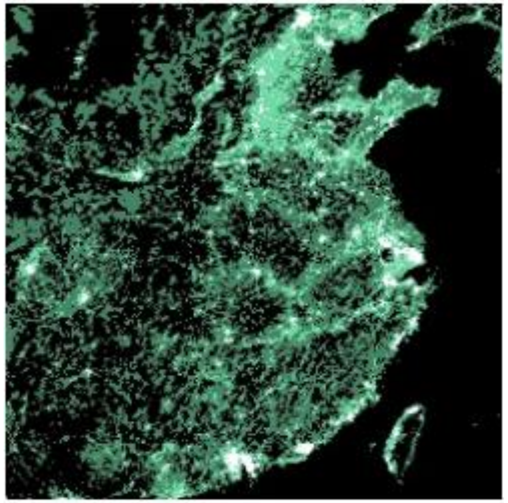
Our objective is to understand where the Dead Sea might be losing or gaining in vegetation. Contrary to popular belief, there is an agricultural industry around the Dead Sea that is partially dependent on the water from the sea itself. Thus examining the NDVI in the buffer area around the Dead Sea might explain the impact the Dead Sea's shrinking has on local development.

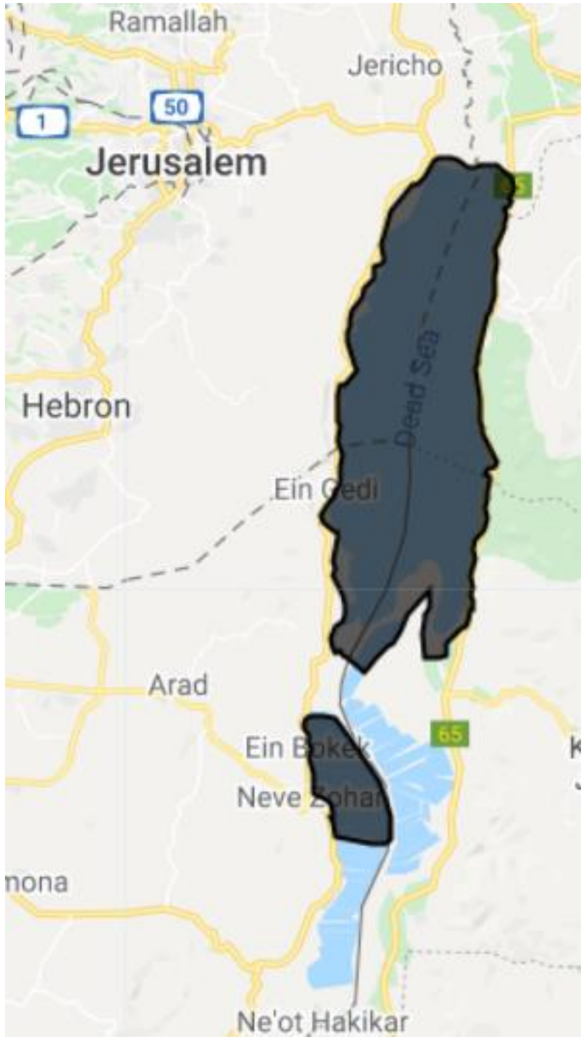
# Outline Continued

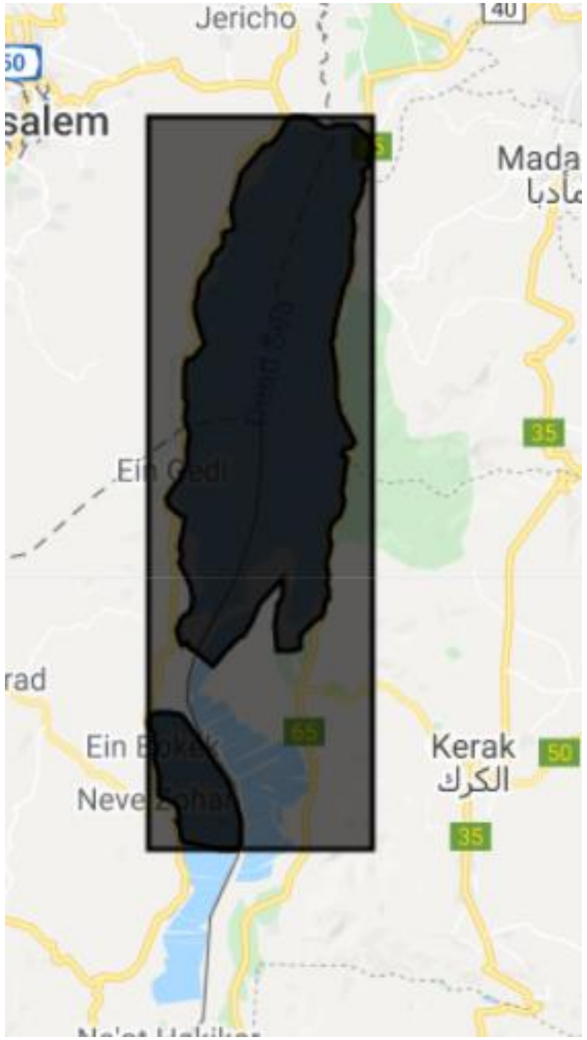
Section 2: Examining the symbiotic impact on areas around the Dead Sea through a few datasets:

2.1: Global Human Settlement Layers
2.2: Degree of Urbanization
2.3: Human Modification
2.4: Night-time lighting

Conclusion: Environmental and Political Ramifications of the Dead Sea and surrounding areas

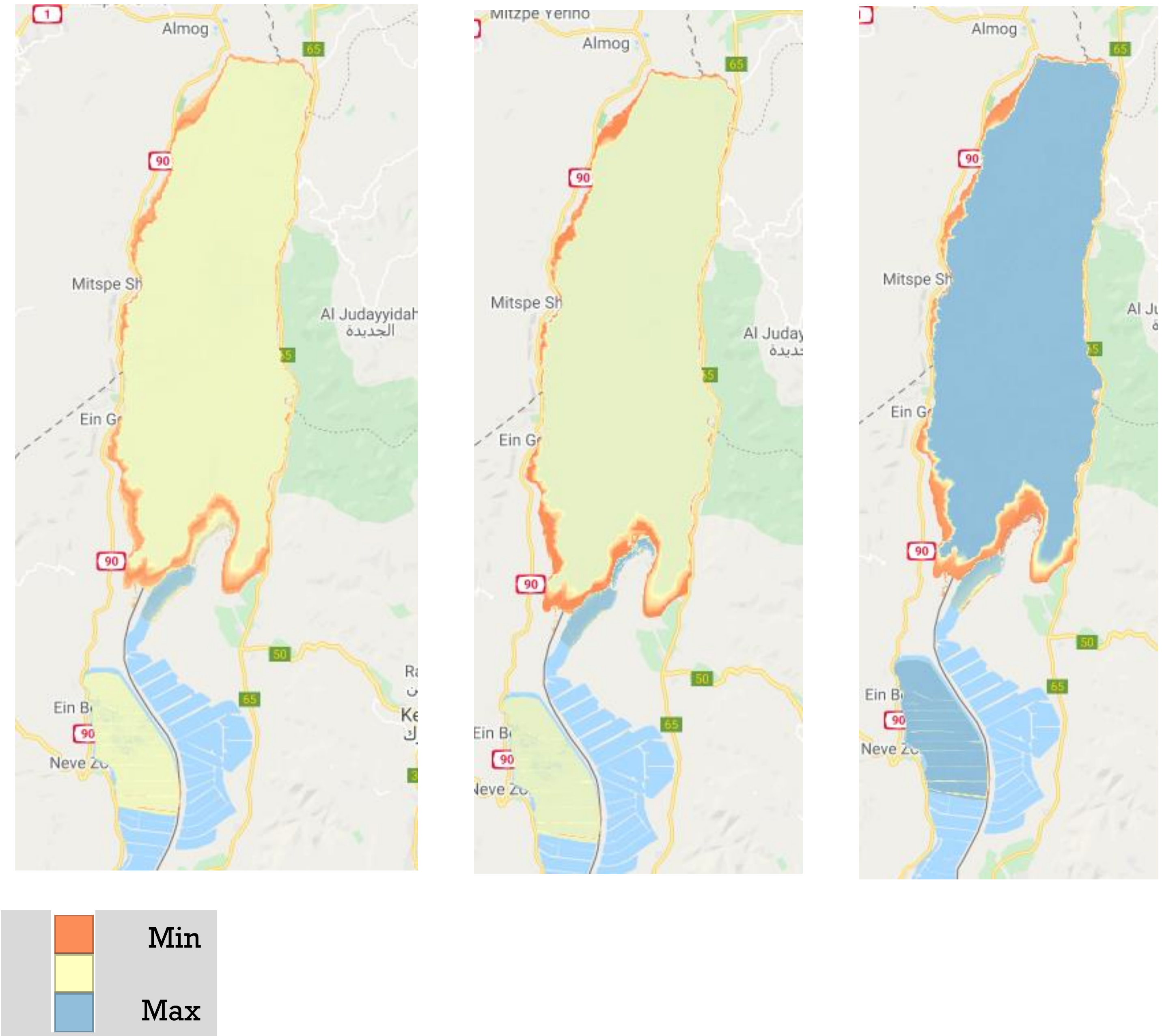

# Study Area

The Dead Sea and its surrounding area is at the following latitude and longitude ((35.3, 31.7), (35.5, 31.7), (35.35, 31.1), (35.5, 31.1)).

It is well known as the lowest point on Earth with an elevation at 1400 ft below sea level.

The study area was created from the Global Lakes and Wetlands Database from the WWF

# Step 1.1: Surface Water Area




First, we examine a dataset that contains maps on surface water change between 1984-2019. As such, we can see a considerable change across a 35 year span. Importantly, we point out the loss of surface water around the western and southern edge of the area across all images.

Left: Surface water absolute change, negative change around the edges

Middle: Normalized change in occurrence

Right: The frequency of present water

Dataset: JRC Global Surface Water Mapping Layers, v1.2

# Step 1.2: Surface Water Area By Specific Years

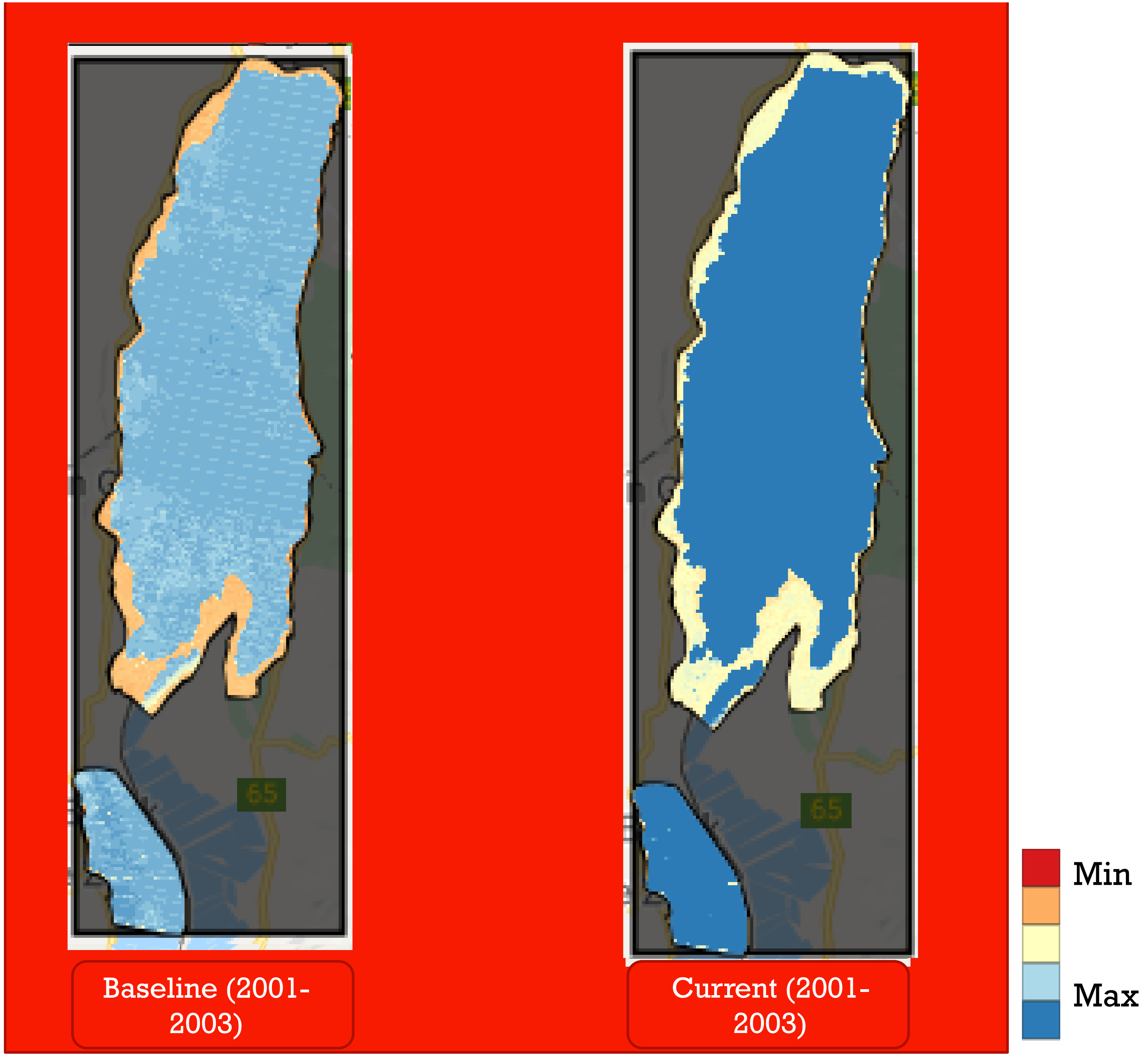
Next, we use an image collection to filter for the specific time span of interest. Here we see the surface water change filtered from 2001-2003 and 2017-2019.

Takeaway: It appears that the pixels of the surface area increased from the Baseline to Current pictures.

Left: Surface water change from 2001-2003

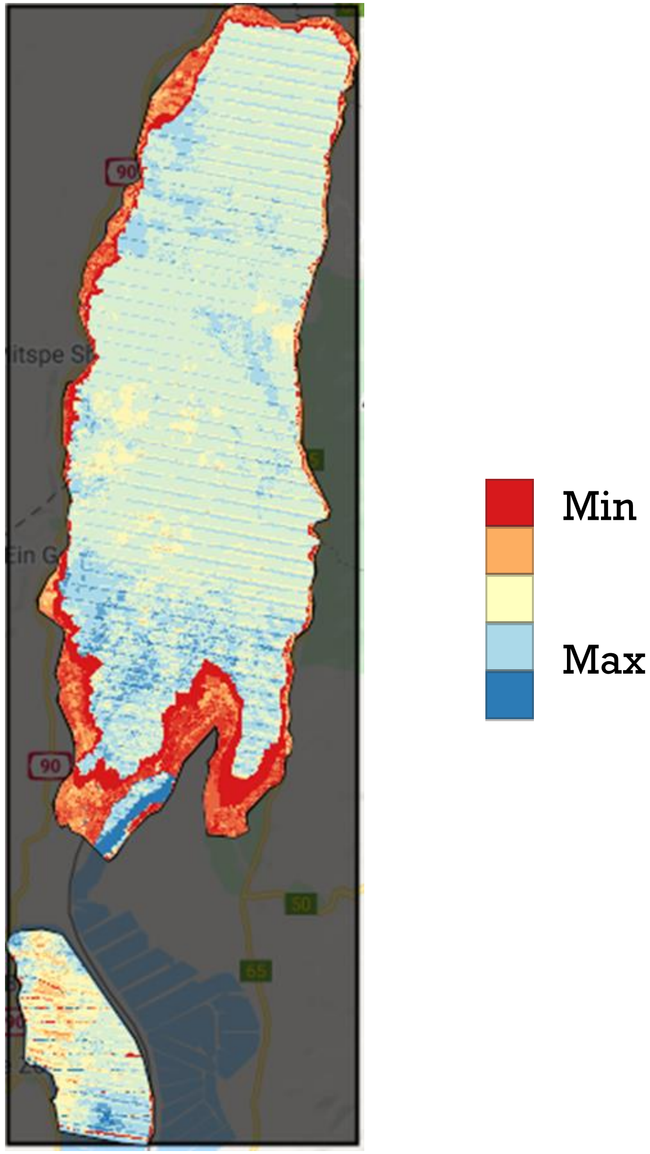
Right: Surface water change from 2017-2019

Dataset:
JRC Monthly Water History, v1.2



# Step 1.3: Difference in Surface Water Area

Next we subtract the current image from the baseline image featured in the last slide. The image on the right is the result which shows areas that lost surface water in red and areas that gained water in blue. As we can see there is significant variation between 2001 and 2019. The red areas of surface water loss especially in the southern end of the lake will continue to remain significant.




Difference

957170236.9237471
Surface Water Area of Baseline (2001-2003) JSON

1276248940.7785795
Surface Water Area of Current (2017-2019) JSON

33.335627409427254
Percentage change in Surface Water Area JSON

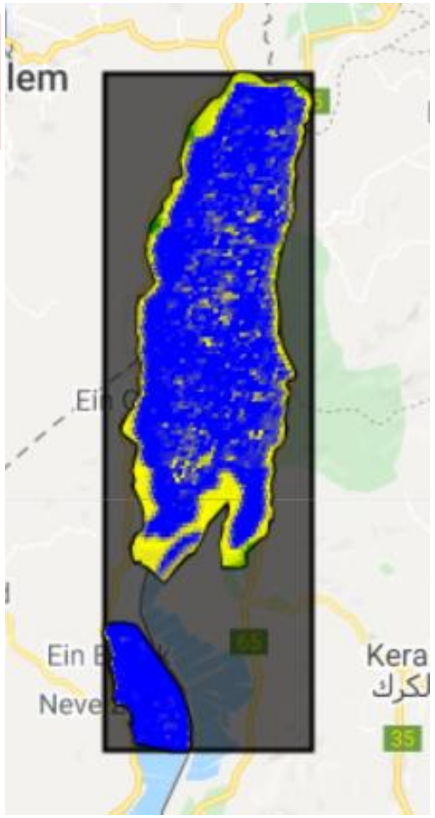
319078703.8548324
Difference in Surface Water Area JSON

In addition to visualizing the loss of water through color, our script calculates the loss of surface area in square meters. While the difference image makes it apparent that there is a loss near the southern border the numbers suggest an overall increase in surface water area over time (33%) which requires more investigating.

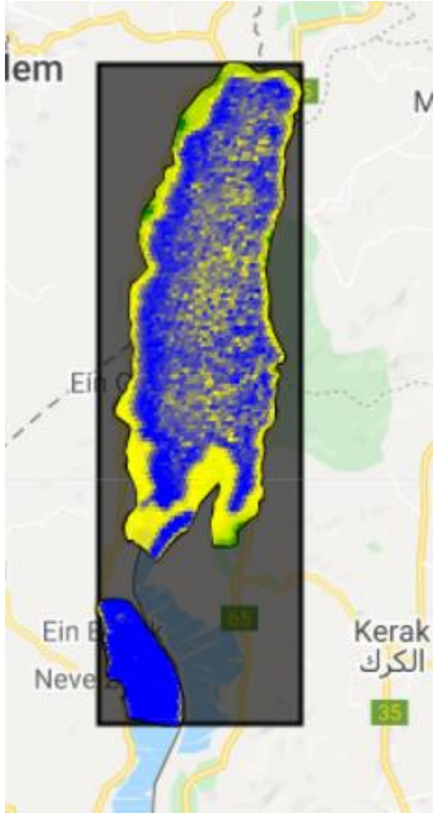
The increase issue is perhaps tied to the initial data collection. To resolve this, I tried to take different summary statistics and each time saw the current area was higher than the baseline. In a future project, I would try masking out the no data in both images.

# Section 1.4: NDVI of the Dead Sea

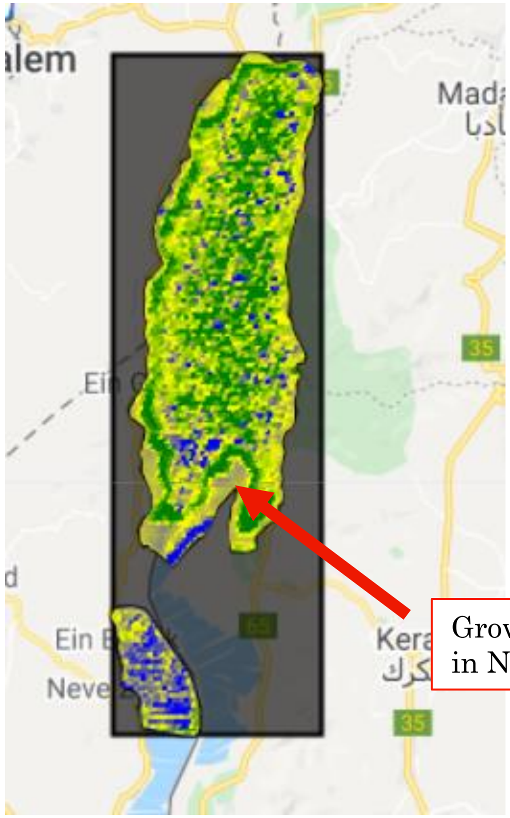
2001-2003



2017-2019



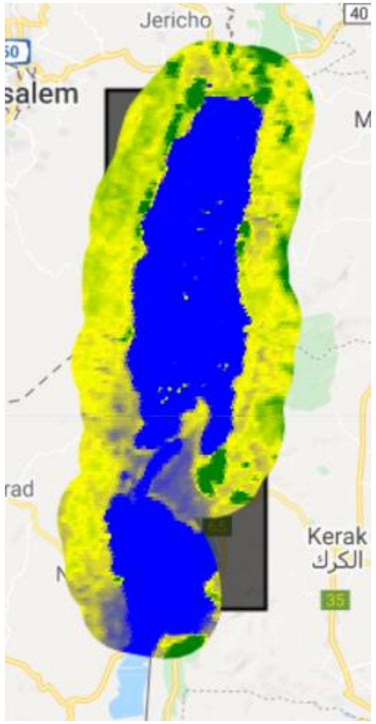

Difference in NDVI

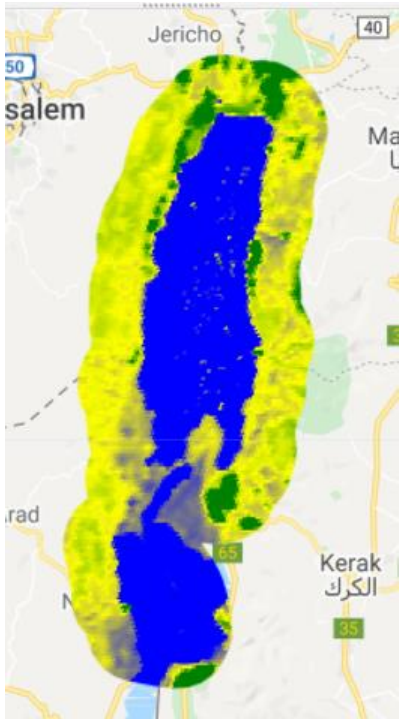


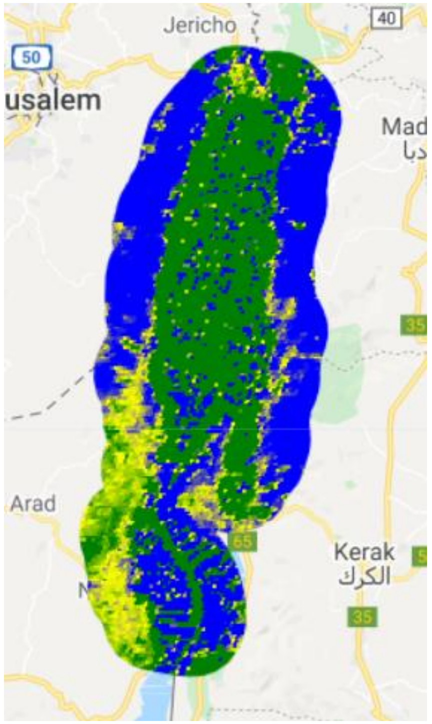
Growth in NDVI

Presented here is a visualization of the Dead Sea's NDVI in 2001-2003, 2017-2019 and the difference in change between those years. The values range from a min of -.08 in blue to a maximum of .267 in green (with yellow as a middle value). We can see that indeed the NDVI value has grown from the baseline year to the current year. In the difference image, it appears the Dead Sea has gained in NDVI value especially around the southern edges. This southern area will continue to be where the greatest change occurs across our datasets.

# Section 1.5: NDVI of the area around Dead Sea




Left: NDVI in 2001-2003 (min: .05, max: .17)

Middle: NDVI in 2017-2019(min: .05, max: .17)

Right: The Difference in the images (min: -.0008, max: .009)

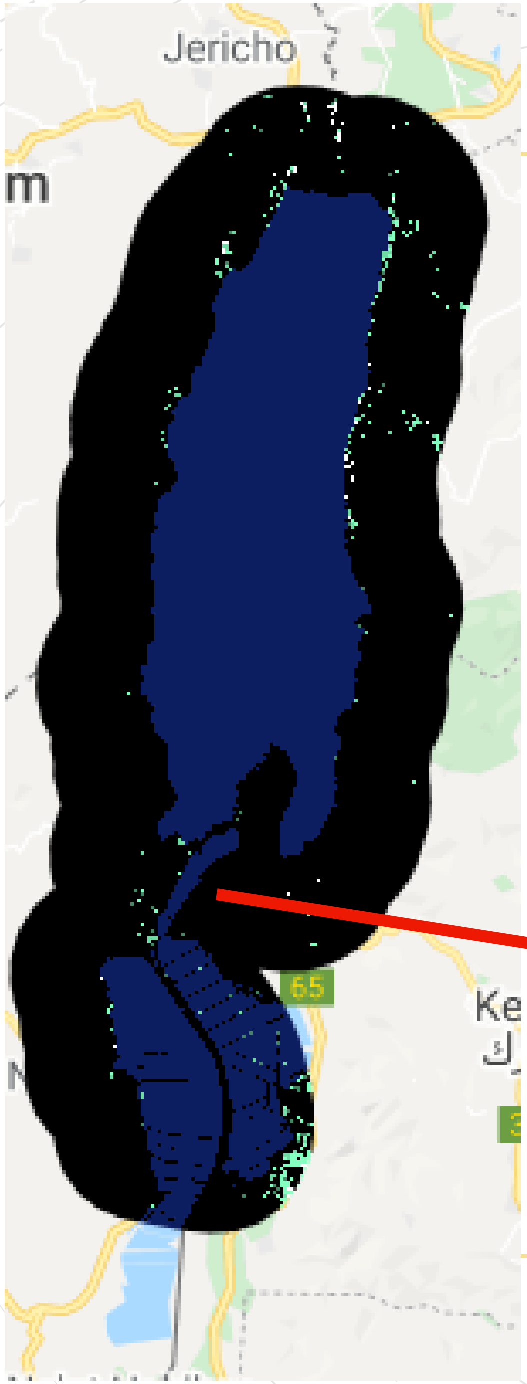
Range(Min: Blue, Yellow, Max: Green)

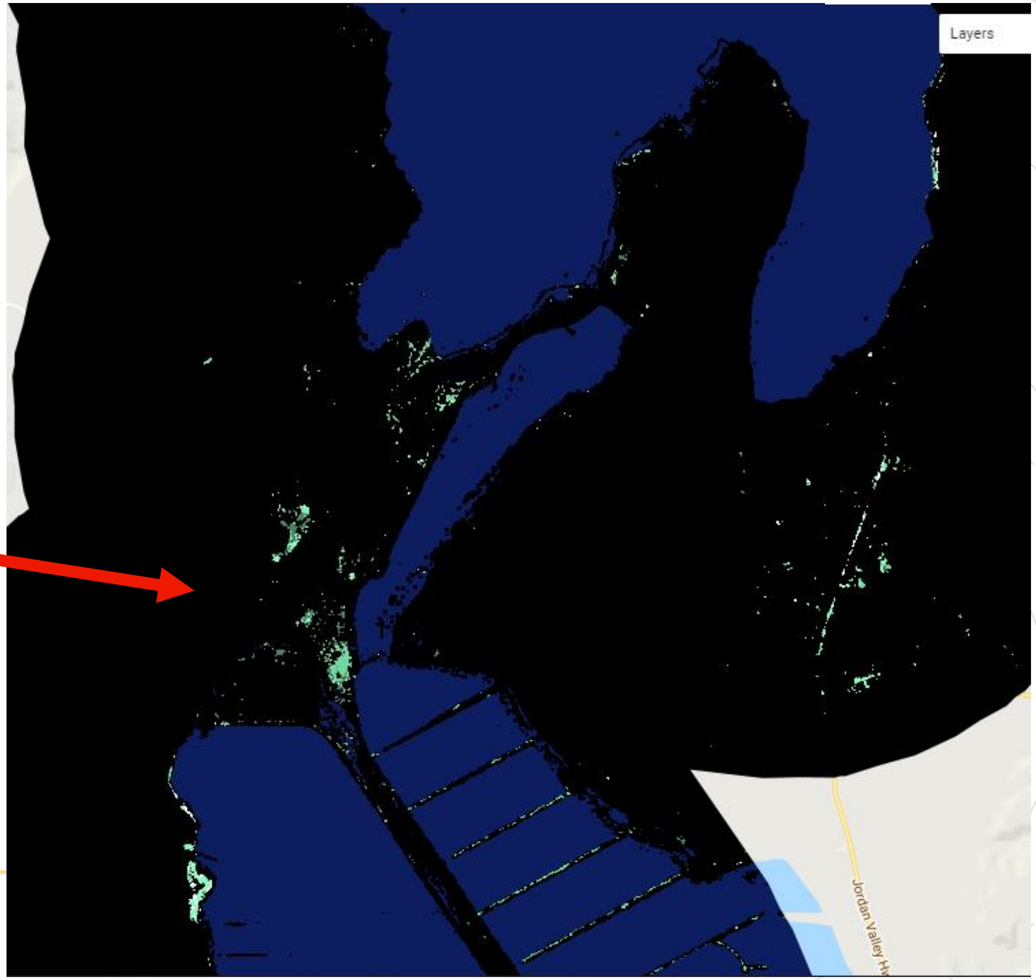
Next, we examine the NDVI of the buffer zone around the Dead Sea which was set to 7000 meters (approximately 4.3 miles). In the first two images, we see a slight increase in green values which represent the maximum amount. In the difference image, we see the relatively small decrease in NDVI with some more major increase in NDVI around the Southwestern quadrant. This quadrant is where most of the development and resort areas are. The tourist site, Masada is located here as well as the resort town Ein Bokek and one kibbutz, Ein Gedi, has made their living from growing dates in this area.

# Section 2: Man-Made Development

In this section, we examine a few different datasets to see if there is a connection between the Dead Sea's shrinking and the location of development. The Dead Sea is host to a few different resorts like Ein Bokek featured above. The picture on the left also shows Kibbutz Ein Gedi which as you can see is an oasis of greenery amidst a desert. Some of this water comes from natural spring water but some is also irrigated from water taken from the Dead Sea which is a cause of its shrinkage.

# Step 2.1: Human Settlement



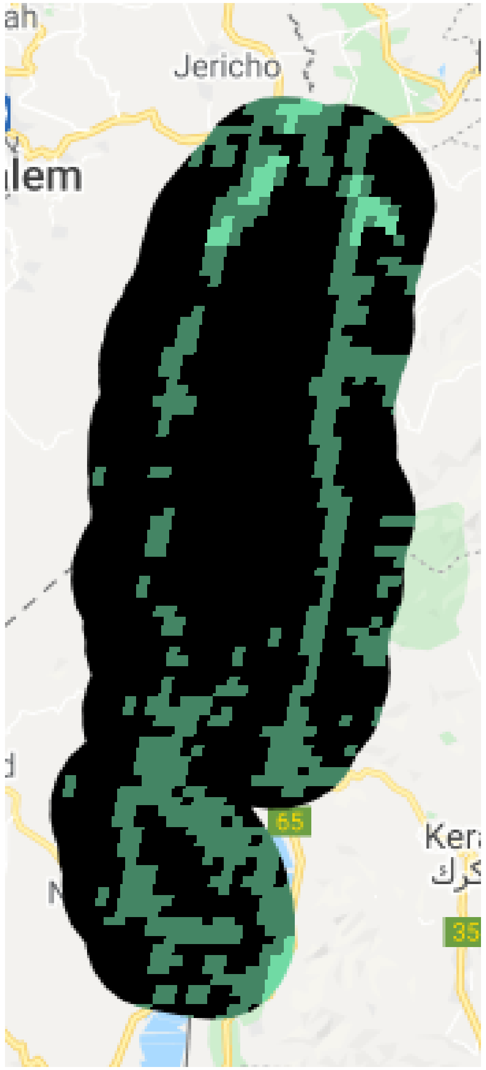

Using the dataset of Global Human Settlement Layers, we first examine the area of built up presence over time. We see that most of the older development exists in the North and Northeastern area. Additionally, there seems to be a lot of settlement from 1975-1990 in the southeastern quadrant.

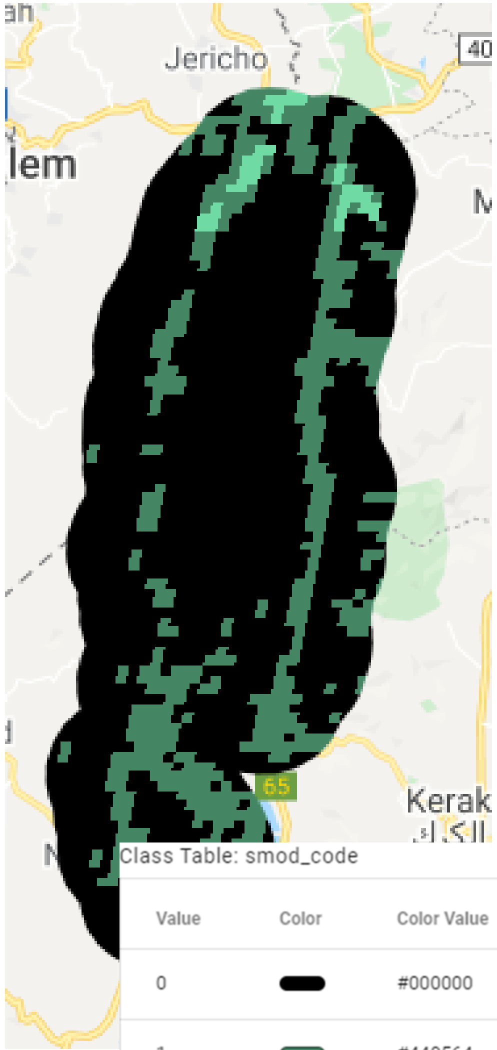
The area we are most concerned about does appear to have development from more recent epochs.

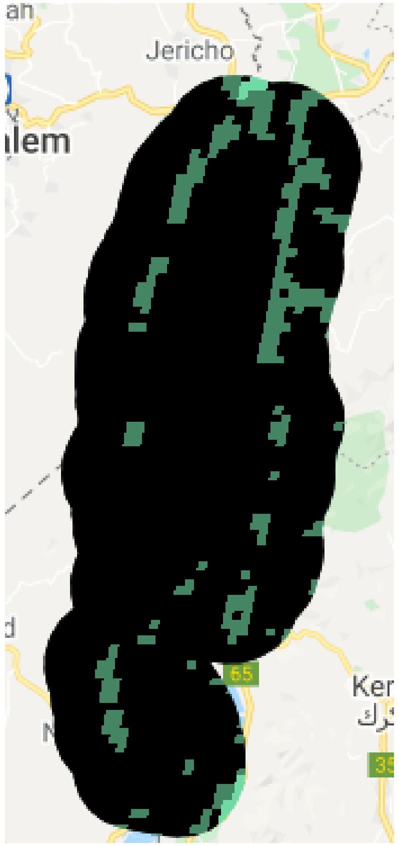
Class Table: built

| Value | Color | Color Value | Description |
|---|---|---|---|
| 1 | | #0c1d60 | Water surface |
| 2 | | #000000 | Land no built-up in any epoch |
| 3 | | #448564 | Built-up from 2000 to 2014 epochs |
| 4 | | #70daa4 | Built-up from 1990 to 2000 epochs |
| 5 | | #83ffbf | Built-up from 1975 to 1990 epochs |
| 6 | | #ffffff | built-up up to 1975 epoch |

# Step 2.2: Degree of Urbanization




Class Table: smod_code

| Value | Color | Color Value | Description |
|---|---|---|---|
| 0 | | #000000 | Inhabited areas |
| 1 | | #448564 | RUR (rural grid cells) |
| 2 | | #70daa4 | LDC (low density clusters) |
| 3 | | #ffffff | HDC (high density clusters) |

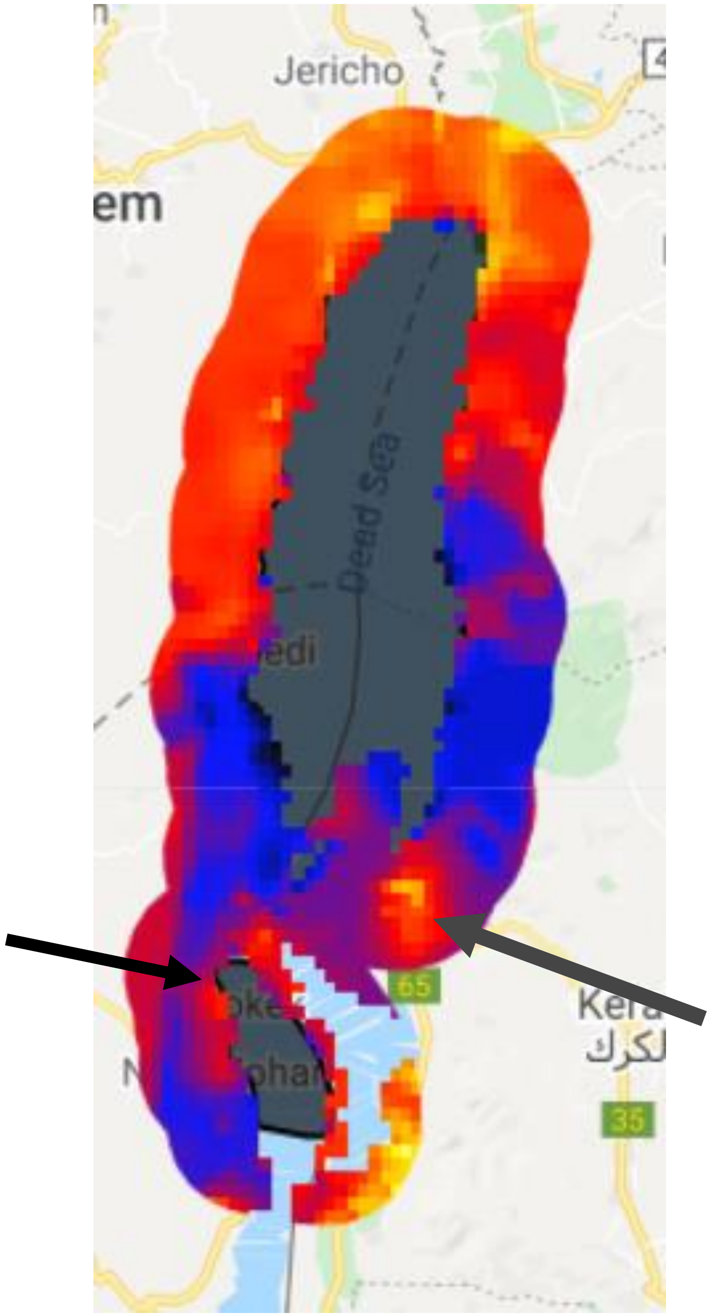
In this slide, we examine a dataset that shows human settlement by population clusters. We filtered for our dates of study 2000 and 2014 (this was the last date) to see if any change occurred within this 15 period but cannot see anything visually. For comparison, we've provided the map from 1975. We see the growth of development in the southwest and high density clusters in the north.

Left: Degree of Urbanization in 2000

Middle: Degree of Urbanization in 2014

Right: Degree of Urbanization in 1975

Dataset: Global Human Settlement Layers, Settlement Grid 1975-1990-2000-2014

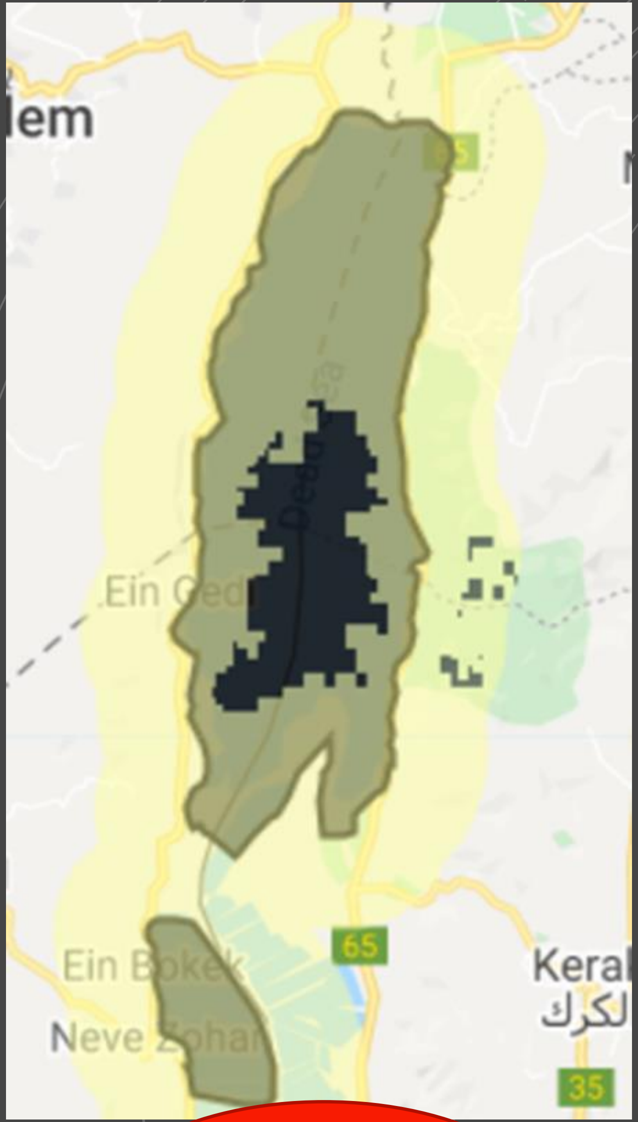



# Step 2.3: Human Modification

We also used a dataset that observes human modification of the Earth. We added this buffer layer to the Dead Sea and observed the strongest areas of modification. The values for human modification go from 0 to 1 and dark blue to a bright yellow. Interestingly, the greatest amount of human modification has occurred in the northern half of the Dead Sea. There also seems to be major spots of human modification in the south very near to where the shrinking is at its highest. This helps prove the connection between man made development and the environmental issues of the Dead Sea.

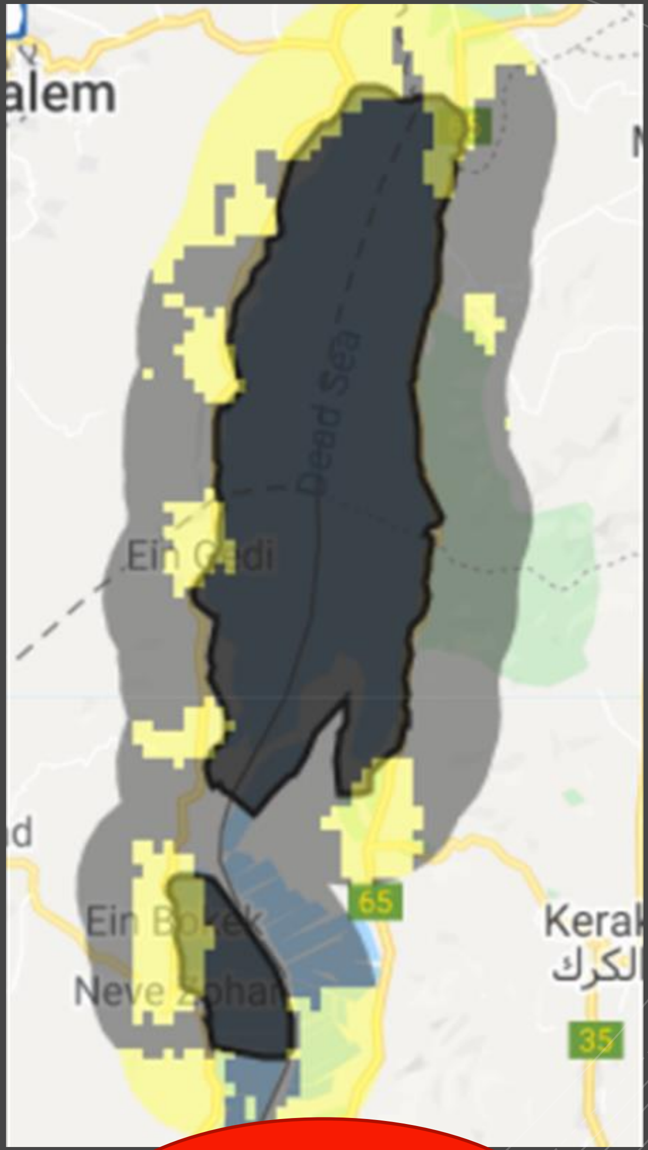
Dataset: CSP gHM: Global Human Modification

# Step 2.4: Nighttime Lighting




Sometimes Lit

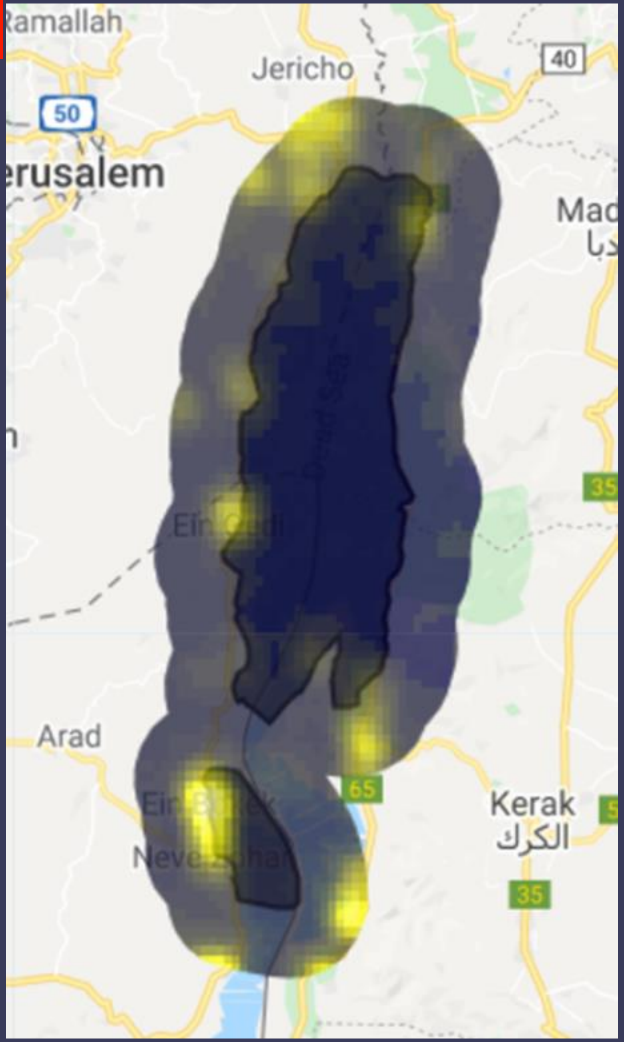
In addition to datasets that explicitly look at development and population growth, nighttime lighting is often used as a proxy to show where people and places are. Here we use nighttime lighting to show the areas occupied around the Dead Sea. The lights present on the water are perhaps lights emitted from boats. The always lit image shows examples of where lighting is the most steady. This layer is consistent with the other layers documenting regions that are more heavily populated.



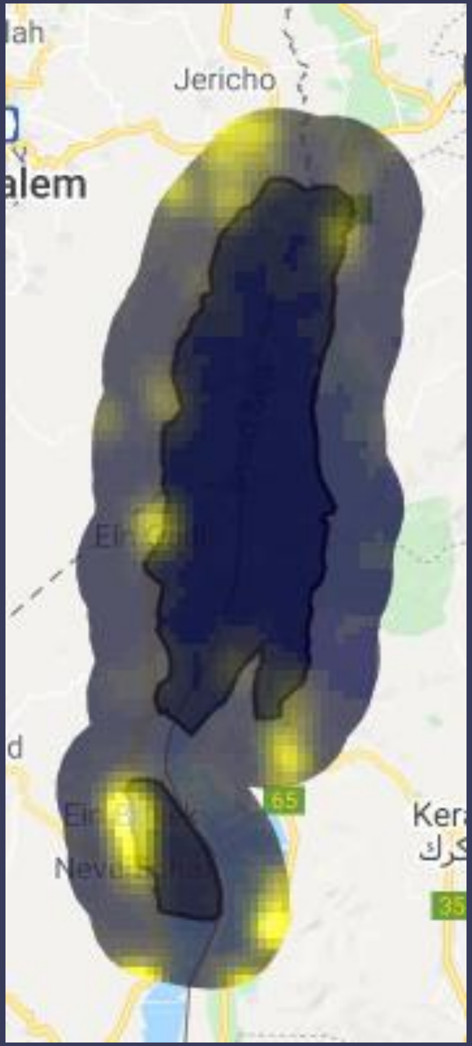

Always Lit

# Step 2.4: Nighttime Lighting

We used another dataset specifically of a 2000 satellite to see the persistent lighting in this year and then to see the persistent lighting in 2013 (the last year available) to see if any thing has changed within our study period. It does not appear to be the case.




2000




2013

# Conclusion

This project has demonstrated the environmental degradation occurring in and around the Dead Sea through the exploration of various datasets around surface water area, NDVI, human settlement patterns, human modification, and nighttime lighting imagery. As it relates to the Dead Sea, the same areas which are experiencing loss of water are gaining in vegetation and are areas in which human growth patterns occurred.

In order to move forward in saving the Dead Sea from further shrinking, more effort is needed to regulate the allocation of fresh water from the Jordan River to the Dead Sea as well as water usage around the Dead Sea area itself. This requires a joint political effort between Jordan and Israel in addition to an economic development strategy to replace the necessary limits placed on the agricultural and tourism industries which have the greatest share of the economy in this region.

Hopefully, the region can unite to plan for the future of this great and unique area of the world.

# For Future Research

Future research on the area of the Dead Sea would focus on the speed and direction of development. It might study where the Dead Sea shoreline and water area would be in 5 to 10 years from now and how that would affect the development surrounding it.

Additionally, I know the receding of saline lakes is a global issue so I would examine a few other lakes to see if there were similar spatial or temporal patterns among all these areas. The findings could further our understanding on ways to stop the shrinkage of the lakes.

# References

**Background Literature:**

- https://www.smithsonianmag.com/science-nature/the-dying-of-the-dead-sea-70079351/#:~:text=The%20Dead%20Sea%20is%20shrinking,earth%20above%20collapses%20without%20warning.
- https://www.nbcnews.com/news/world/dead-sea-dying-1-5-billion-plan-aims-resurrect-it-n926066
- https://phys.org/news/2017-09-dead-seaenvironmental-edge-extremes.html
- https://www.haaretz.com/israel-news/.premium.MAGAZINE-the-drop-dead-beauty-of-the-dead-sea-environmental-disaster-1.8511194
- https://blog.nationalgeographic.org/2013/02/22/the-middle-east-lost-a-dead-sea-size-amount-of-water-in-7-years/

- Datasets used:
- Global Lakes and Wetlands: https://www.worldwildlife.org/pages/global-lakes-and-wetlands-database
- Global Surface Water Mapping: https://developers.google.com/earth-engine/datasets/catalog/JRC_GSW1_2_GlobalSurfaceWater
- JRC Monthly Water History: https://developers.google.com/earth-engine/datasets/catalog/JRC_GSW1_2_MonthlyHistory
- MODIS Vegetation Indices: https://developers.google.com/earth-engine/datasets/catalog/MODIS_006_MOD13A1
- Global Human Settlement Layers: https://developers.google.com/earth-engine/datasets/catalog/JRC_GHSL_P2016_BUILT_LDSMT_GLOBE_V1
- Global Human Settlement Urbanization: https://developers.google.com/earth-engine/datasets/catalog/JRC_GHSL_P2016_SMOD_POP_GLOBE_V1
- Global Human Modification: https://developers.google.com/earth-engine/datasets/catalog/CSP_HM_GlobalHumanModification
- Nighttime Lights: https://developers.google.com/earth-engine/datasets/catalog/NOAA_DMSP-OLS_NIGHTTIME_LIGHTS

Special thanks to TC and Dana for their kind patience and help throughout this project!

# Full Code:  the code can be accessed here

FinalProj.7

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```
//Tova Perlman
//LARP Final Project
//Environmental Change of the Dead Sea and its Surrounding Areas

//Step 1: Get Study Area
//Load Feature Collection of the Global Waters

var deadseaother= ee.FeatureCollection('users/tovaperlman/GLWD-level1');

//Filter for the specific two GLWD_ID's that cover the Dead Sea
var deadseaother = deadseaother.filter(ee.Filter.inList('GLWD_ID',[2342,244])).union();
//Extract the first element
var DSElement = deadseaother.first();
var DSFeature = ee.Feature(DSElement);
//Create a geometry from the element
var DS= DSFeature.geometry();

// Centering our study area
Map.centerObject(deadseaother, 9);
//Adding a layer specific to the dead sea
Map.addLayer(deadseaother,{},'Dead Sea');
print(deadseaother);

//Create a separate layer that has a bounding box around the Dead Sea
var Bounding_Box= DS.bounds();
print(Bounding_Box, 'Bounding Box');
Map.addLayer(DS.bounds(),{},'Bounding Box');

//Create a layer for just the buffer zone
var buffer= DSFeature.geometry().buffer(7000)

//Find the Area of the Dead Sea
var area = deadseaother.geometry().area();  //.multiply(ee.Image.pixelArea())
print("Area of Dead Sea in Sq Meters", area);

//Step 2: Examining Global Surface Water from 1984 to 2019 using an image
var surfacewater = ee.Image('JRC/GSW1_2/GlobalSurfaceWater').clip(deadseaother.geometry());
```

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```
//Step 2: Examining Global Surface Water from 1984 to 2019 using an image
var surfacewater = ee.Image('JRC/GSW1_2/GlobalSurfaceWater').clip(deadseaother.geometry());

print(surfacewater,'surfacewater')

//Select the band of interest, in this case Absolute Change
var abs_change=surfacewater.select('change_abs');
Map.addLayer(abs_change,{min:-100, max:75, palette:["#fc8d59","#ffffbf","#91bfdb" ]},"Surface water abs_change");
print(abs_change, 'abs_change')

//Now displaying the normalized change in occurrence
var change_norm=surfacewater.select('change_norm');
Map.addLayer(change_norm,{min:-100, max: 65, palette:["#fc8d59","#ffffbf","#91bfdb"]},"Surface water change_norm");
var change_percent= ee.Number(change_norm.multiply(100))
print(change_percent, 'change_norm')

//This band displays the frequency of present water
var occurrence=surfacewater.select('occurrence');
Map.addLayer(occurrence,{min:-.5, max:100, palette:["#fc8d59","#ffffbf","#91bfdb"]},"Surface water occurrence");
print(occurrence, 'occurrence')


//Step 3: Examinining Global Water Surface Area Change for our study years 2001-2003 and 2017-2019 using an image collection
var waterorno= ee.ImageCollection("JRC/GSW1_2/MonthlyHistory")

print(waterorno)

//Creating the baseline
//Filter the date range of interest using a date filter- filtering between 2001-2003
var waterorno_dateofint=waterorno.filterDate('2001-01-01','2003-12-31');

 //Take pixel-wise mean of all the images in the collection
 var waterorno_mean=waterorno_dateofint.mean();
 var waterorno_final=waterorno_mean;

 //Clip data to region of interest // Make sure it is the geometry object
 // Multiply by ee.Image to get the sq meters of each pixel area
```

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```
 //Clip data to region of interest // Make sure it is the geometry object
 // Multiply by ee.Image to get the sq meters of each pixel area
var waterorno_DeadSea_Baseline = waterorno_final.clip(deadseaother.geometry()).multiply(ee.Image.pixelArea());
//print(ee.Number(waterorno_DeadSea_Baseline), "Baseline for Water Surface Area");

 //Add data to map to visualize it; add visualization properties
 Map.addLayer(waterorno_DeadSea_Baseline,{min:10000, max:100000, palette:["#d7191c", "#fdae61","#ffffbf","#abd9e9","#2c7bb6"]},"Water Area_Baseline");

//Create layer for current year
 //Filter the date range of interest using a date filter- filtering to 2017-2019
 var waterorno_datecurrent=waterorno.filterDate('2017-01-01','2019-12-31');

//Take pixel-wise mean of all the images in the collection for dates of interest
 var waterorno_mean2=waterorno_datecurrent.mean();
 var waterorno_final2=waterorno_mean2;

 //Clip data to region of interest
 var waterorno_DeadSea_Current=waterorno_final2.clip(deadseaother.geometry()).multiply(ee.Image.pixelArea());
 //print(waterorno_DeadSea_Current);

 //Add data to map to visualize it; add visualization properties
 Map.addLayer(waterorno_DeadSea_Current,{min:10000, max:100000, palette:["#d7191c", "#fdae61","#ffffbf","#abd9e9","#2c7bb6"]},"Water Area_Current");

// //Now subtracting the current image from the old image in order to see where there have been gains or losses in water surface area
 var waterorno_DeadSea_Difference = waterorno_DeadSea_Current.subtract(waterorno_DeadSea_Baseline)
 Map.addLayer(waterorno_DeadSea_Difference,{min:15000, max:40000, palette:["#d7191c", "#fdae61","#ffffbf","#abd9e9","#2c7bb6"]},"Water Area_Difference");

//Step 3.2: Use Reduce Region to get Spatial Sum of Area for current and baseline

//Reduce region to get sum
function DeadSea_mean2(feature){
  //Calculate spatial sum value for each area
  var reduced3= waterorno_DeadSea_Baseline.reduceRegion({reducer:ee.Reducer.sum(), geometry: feature.geometry(), scale:500})
  var reduced4= waterorno_DeadSea_Current.reduceRegion({reducer:ee.Reducer.sum(), geometry: feature.geometry(), scale:500})

  //Add the calculated sum value as a property for each area
  return feature.set({'waterorno_base':reduced3.get('water'),'waterorno_curr':reduced4.get('water')})
}

//Map the function over the Dead Sea area
var Reduced2=deadseaother.map(DeadSea_mean2);
print(Reduced2, "Reduced2")

//Get and print out the Baseline Area and the Current Area values
print(ee.Feature(Reduced2.first()).get("waterorno_base"), "Surface Water Area of Baseline (2001-2003)");
print(ee.Feature(Reduced2.first()).get("waterorno_curr"), "Surface Water Area of Current (2017-2019)");

//Naming them baseline and current for calculations of the difference and percentage change
var waterorno_Base = ee.Feature(Reduced2.first()).get("waterorno_base")
var waterorno_Curr = ee.Feature(Reduced2.first()).get("waterorno_curr")
```

**FinalProj.7**

```
// //Now we find the percentage of area change and difference in surface water area
var waterorno_percentage = (ee.Number(waterorno_Curr).subtract(ee.Number(waterorno_Base))).divide(waterorno_Base).multiply(100)
var waterorno_Difference3 = (ee.Number(waterorno_Curr).subtract(ee.Number(waterorno_Base)))
print(waterorno_percentage, "Percentage change difference in Surface Water Area") //
print(waterorno_Difference3, "Difference in Surface Water Area") //


// //Step 4: Calculating NDVI of the Dead Sea and its buffer

//Load MODIS image collection from the Earth Engine archive
var MODIS=ee.ImageCollection('MODIS/006/MOD13A1');

//print image collection to check structure of dataset
print(MODIS);

//Select the band of interest, in this case: NDVI
var NDVI=MODIS.select('NDVI')


//Creating the baseline
//Filter the date range of interest using a date filter
var NDVI_dateofint=NDVI.filterDate('2001-01-01','2003-12-31');

//Take pixel-wise mean of all the images in the collection
var NDVI_mean=NDVI_dateofint.mean();

//Multiply each pixel by scaling factor to get the NDVI values
var NDVI_final =NDVI_mean.multiply(0.0001);

//Clip data to region of interest // Make sure it is the geometry object
var NDVI_DeadSea_Baseline = NDVI_final.clip(deadseaother.geometry());
//print(NDVI_DeadSea_Baseline);

//Add data to map to visualize it; add visualization properties
Map.addLayer(NDVI_DeadSea_Baseline,{min:-.08, max:.267, palette:['blue','yellow','green']},"NDVI_DeadSea_Baseline");

//Create layer for current year
//Filter the date range of interest using a date filter- filtering to 2017-2019
var NDVI_datecurrent=NDVI.filterDate('2017-01-01','2019-12-31');

//Take pixel-wise mean of all the images in the collection
var NDVI_mean2=NDVI_datecurrent.mean();

//Multiply each pixel by scaling factor to get the NDVI values
var NDVI_final2=NDVI_mean2.multiply(0.0001);

//Clip data to region of interest
var NDVI_DeadSea_Current=NDVI_final2.clip(deadseaother.geometry());
print(NDVI_DeadSea_Current);
```

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```
//Add data to map to visualize it; add visualization properties
Map.addLayer(NDVI_DeadSea_Current,{min:-.08, max:.267, palette:['blue','yellow','green']},"NDVI_DeadSea_Current");

//Now subtracting the current image from the old image
var NDVI_DeadSea_Difference = NDVI_DeadSea_Current.subtract(NDVI_DeadSea_Baseline);
Map.addLayer(NDVI_DeadSea_Difference,{min:-.05, max:.1, palette:['blue','yellow','green']},"NDVI_DeadSea_Difference");


//Step 4.2: Reduce Region to get Mean

//Create a function for reduce region to get mean
function DeadSea_mean(feature){
  //Calculate spatial mean value of NDVI for each sub-area
  var reduced1= NDVI_DeadSea_Baseline.reduceRegion({reducer:ee.Reducer.mean(), geometry: feature.geometry(), scale:500})
  var reduced2= NDVI_DeadSea_Current.reduceRegion({reducer:ee.Reducer.mean(), geometry: feature.geometry(), scale:500})

  //Add the calculated NDVI value as a property for each sub-area
  return feature.set({'NDVI_base':reduced1.get('NDVI'),'NDVI_curr':reduced2.get('NDVI')})
}

//Map the function over each the area
var Reduced=deadseaother.map(DeadSea_mean);
print(Reduced,"Reduced")

//Get and print out the Baseline Area and the Current Area
var NDVI_Base = ee.Feature(Reduced.first()).get("NDVI_base")
var NDVI_Curr = ee.Feature(Reduced.first()).get("NDVI_curr")
print(NDVI_Base, "Area of Baseline NDVI (2001-2003)");
print(NDVI_Curr, "Area of Current NDVI (2017-2019)");


//Now we find the NDVI percentage change and difference
var NDVI_percentage = (ee.Number(NDVI_Curr).subtract(ee.Number(NDVI_Base))).divide(NDVI_Base).multiply(100)
var NDVI_Difference3 = (ee.Number(NDVI_Curr).subtract(ee.Number(NDVI_Base)))
print(NDVI_percentage, "NDVI Percentage") //large percentage, doesnt mean anything
print(NDVI_Difference3, "NDVI Difference") //not a large difference


//Showing a Histogram to see the distribution of the NDVI
// Load a the NDVI final image.
var image = NDVI_final;

// Define the region over Dead Sea.
var region = deadseaother.geometry();

// Pre-define some customization options.
var options = {
  title: 'Dead Sea Histogram of NDVI',
  fontSize: 20,
  hAxis: {title: 'NDVI'},
  vAxis: {title: 'Mean of NDVI'},
```

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```
  vAxis: {title: 'Mean of NDVI'},
};

// Make the histogram, set the options.
var histogram = ui.Chart.image.histogram(image, region, 30)
    .setOptions(options);

// Display the histogram.
print(histogram); //fairly skewed toward reduction in NDVI, few pixels for where this is an increase


//Step 5: Calculate NDVI of the buffer zone of 7000 m around the Dead Sea

//Clip data to buffer region of interest
var NDVI_BB_Baseline = NDVI_final.clip(buffer);
print(NDVI_BB_Baseline, "NDVI_BB_Baseline");

//Add data to map to visualize it; add visualization properties
Map.addLayer(NDVI_BB_Baseline,{min:.05, max:.17, palette:['blue','yellow','green']},"NDVI_Buffer_Baseline");


//Clip data to region of interest
var NDVI_BB_Current=NDVI_final2.clip(buffer);
print(NDVI_BB_Current, "NDVI_BB_Current");

//Add data to map to visualize it; add visualization properties
Map.addLayer(NDVI_BB_Current,{min:.05, max:.17, palette:['blue','yellow','green']},"NDVI_Buffer_Current");

//Now subtracting the current image from the old image
var BB_difference = NDVI_BB_Current.subtract(NDVI_BB_Baseline);
Map.addLayer(BB_difference,{min:-.0008, max:.009, palette:['blue','yellow','green']},"NDVI_Buffer_Difference");
print(BB_difference);


//Section 2: Man-Made Development


//Step 6: Examining Man-Made Development in the region using Global Human Settlement Layers Dataset
//Built Environment dataset- This is an image, that means its static
var dataset = ee.Image('JRC/GHSL/P2016/BUILT_LDSMT_GLOBE_V1');
var dataset= dataset.clip(buffer);
var builtUpMultitemporal = dataset.select('built')

var visParams = {
  min: 1.0,
  max: 6.0,
  palette: ['0c1d60', '000000', '448564', '70daa4', '83ffbf', 'ffffff'],
};

Map.addLayer(builtUpMultitemporal, visParams, 'Built-Up Multitemporal');

//Step 7: Examining Degree of Urbanization in study years
```

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```
//Step 7: Examining Degree of Urbanization in study years
//Image Collection: GHSL: Global Human Settlement Layers, Settlement Grid 1975-1990-2000-2014

//Step 7.1: First examining for year 2000
var settlementinit= ee.ImageCollection("JRC/GHSL/P2016/SMOD_POP_GLOBE_V1")
.filterDate('2000-01-01','2000-12-31')
.map(function(image){return image.clip(buffer)}); // Clipping to buffer zone
print(settlementinit, 'settlement');
var visParams = {
  min: 0.0,
  max: 3.0,
  palette: ['000000', '448564', '70daa4', 'ffffff'],
};
Map.addLayer(settlementinit, visParams,'Degree of Urbanization Initial (2000)');

//Step 7.2: Then examining for year 2013
var settlement_current = ee.ImageCollection('JRC/GHSL/P2016/SMOD_POP_GLOBE_V1')
  .filter(ee.Filter.date('2013-01-01', '2013-12-31'))
  .map(function(image){return image.clip(buffer)}); // Clipping to buffer zone

var visParams = {
  min: 0.0,
  max: 3.0,
  palette: ['000000', '448564', '70daa4', 'ffffff'],
};
Map.addLayer(settlement_current, visParams, 'Degree of Urbanization Current (2013)');

// Step 7.3: Then creating a reference map from the earliest year of 1975
var settlement_1975 = ee.ImageCollection('JRC/GHSL/P2016/SMOD_POP_GLOBE_V1')
  .filter(ee.Filter.date('1975-01-01', '1975-12-31'))
  .map(function(image){return image.clip(buffer)});

var visParams = {
  min: 0.0,
  max: 3.0,
  palette: ['000000', '448564', '70daa4', 'ffffff'],
};

Map.addLayer(settlement_1975, visParams, 'Degree of Urbanization 1975');

//Step 8: Global Human Modification
// Using the Global Human Modification Dataset and clipping to the buffer to see where the largest modification has been
var modification = ee.ImageCollection('CSP/HM/GlobalHumanModification').select('gHM')
.map(function(image){return image.clip(buffer)}) ; //clipping to buffer
var visualization = {
  //bands: ['gHM'],
  min: 0.0,
  max: 1.0,
  palette: ['0c0c0c', '071aff', 'ff0000', 'ffbd03', 'fbff05', 'fffdfd']
};
```

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};

Map.addLayer(modification, visualization, 'Human modification');

//Step 9: Night Time Lighting- Temporal collection- Usage as proxy of development

//Step 9.1: Getting the image collection (This code influenced by examples from class)
var NightLightIMAGES    = ee.ImageCollection('NOAA/DMSP-OLS/NIGHTTIME_LIGHTS')
.select('stable_lights')
.map(function(image){return image.clip(buffer)});

// //Step 9.2: Getting the sometimes and always light bands using .or and .and
var SometimesLightIMAGE = NightLightIMAGES.or();
var AlwaysLightIMAGE    = NightLightIMAGES.and();
print( NightLightIMAGES );
Map.centerObject(deadseaother, 9);

//Step 9.3 Adding the layers to the map
Map.addLayer( SometimesLightIMAGE, {min: 0, max: 1, palette: ['000000','ffff99'], opacity:0.5}, 'Sometimes Lit');
Map.addLayer( AlwaysLightIMAGE,    {min: 0, max: 1, palette: ['333333','ffff55'], opacity:0.5}, 'Always Lit');

//Step 9.4: Visualizing the persistent lighting from the 2000 dataset

var Nighttime2000   = ee.Image( 'NOAA/DMSP-OLS/NIGHTTIME_LIGHTS/F152000' ).clip(buffer);  // Night Lighting in 2000
var alllighting   = Nighttime2000.expression( 'b(0)' );                          // Band 0: All Lighting
var stablelighting    = Nighttime2000.expression( 'b("stable_lights")' );        // Band 1: Persistent Lighting
var Differencelighting = Nighttime2000.expression( 'b(0) - b(1)' ); // Shows the inconsistent lighting, it is the All lighting-Persistent lighting
print( Nighttime2000, alllighting, stablelighting, Differencelighting );
Map.centerObject(deadseaother, 9);
Map.addLayer( alllighting,   {min: 0, max: 63, palette: ['000044','ffff00','ffffff'], opacity:0.5}, 'All Lighting 2000'  );
Map.addLayer( stablelighting,    {min: 0, max: 63, palette: ['000044','ffff00','ffffff'], opacity:0.5}, 'Persistent Lighting 2000'  );
Map.addLayer( Differencelighting, {min: 0, max: 15, palette: ['ffffff','777777','ff0000'], opacity:0.9}, 'Difference Image 2000');

//Step 9.5: Visualizing the persistent lighting from the 2013 dataset

var Nighttime2013   = ee.Image( 'NOAA/DMSP-OLS/NIGHTTIME_LIGHTS/F182013' ).clip(buffer);  // Night Lighting in 2013
var alllighting   = Nighttime2013.expression( 'b(0)' );                          // Band 0: All Lighting
var stablelighting    = Nighttime2013.expression( 'b("stable_lights")' );        // Band 1: Persistent Lighting
var Differencelighting = Nighttime2013.expression( 'b(0) - b(1)' ); // Shows the inconsistent lighting, it is the All lighting-Persistent lighting
print( Nighttime2013, alllighting, stablelighting, Differencelighting );
Map.centerObject(deadseaother, 9);
Map.addLayer( alllighting,   {min: 0, max: 63, palette: ['000044','ffff00','ffffff'], opacity:0.5}, 'All Lighting 2013'  );
Map.addLayer( stablelighting,    {min: 0, max: 63, palette: ['000044','ffff00','ffffff'], opacity:0.5}, 'Persistent Lighting 2013'  );
Map.addLayer( Differencelighting, {min: 0, max: 15, palette: ['ffffff','777777','ff0000'], opacity:0.9}, 'Difference Image 2013');

//Step 9.6: Using the earliest year, 1992, as a reference image
var Nighttime1992   = ee.Image( 'NOAA/DMSP-OLS/NIGHTTIME_LIGHTS/F101992' ).clip(buffer);  // Night Lighting in 1992
var alllighting   = Nighttime1992.expression( 'b(0)' );                          // Band 0: All Lighting
var stablelighting    = Nighttime1992.expression( 'b("stable_lights")' );        // Band 1: Persistent Lighting
var Differencelighting = Nighttime1992.expression( 'b(0) - b(1)' ); // Shows the inconsistent lighting, it is the All lighting-Persistent lighting
print( Nighttime1992, alllighting, stablelighting, Differencelighting );
Map.centerObject(deadseaother, 9);
Map.addLayer( alllighting,   {min: 0, max: 63, palette: ['000044','ffff00','ffffff'], opacity:0.5}, 'All Lighting 1992'  );
Map.addLayer( stablelighting,    {min: 0, max: 63, palette: ['000044','ffff00','ffffff'], opacity:0.5}, 'Persistent Lighting 1992'  );
Map.addLayer( Differencelighting, {min: 0, max: 15, palette: ['ffffff','777777','ff0000'], opacity:0.9}, 'Difference Image 1992');


//The End !
```