Exercise 1: Create a heat risk index

How can I print an exercise to PDF format?

Software requirements

- ArcGIS Pro 3.2
- ArcGIS Online
- Spatial Analyst extension

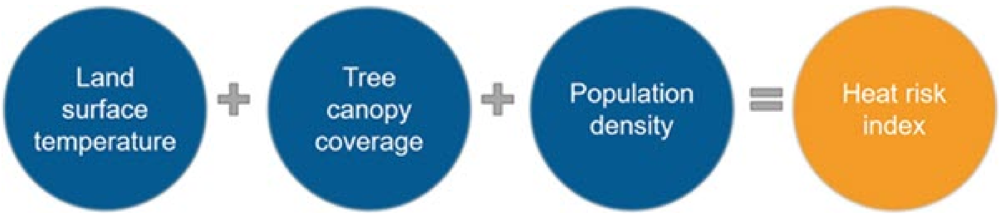
Introduction

Extreme heat is the climate-related hazard that people around the world are experiencing most. Not only are temperatures rising, but the number of hot days is also increasing. We are seeing progressively more heat waves across the globe and observing the effects of these heat waves on our cities, ecosystems, and food production.

As a result of climate change, urban heat islands (UHIs) are becoming more prevalent. In a UHI, the temperature of an urban area, like a city, is higher than that of the surrounding rural areas. Structures like buildings and roads absorb and re-emit the sun's heat more than natural landscapes like forests and water bodies do. Because urban areas have higher concentrations of these heat-trapping structures and forested areas are limited, pockets of heat can surround the urban areas, creating UHIs.

Reducing the effects of climate change requires creating strategic and localized adaptation plans. The first step in developing a localized adaptation plan for extreme heat is creating a heat risk index (HRI). An HRI identifies the areas within a community that should be prioritized in the adaptation plan.

The input variables that are chosen will depend on the spatial analysis question that is being asked. The HRI in this exercise combines three input variables: land surface temperature, tree canopy coverage, and population density.



The heat risk index (HRI) in this exercise will be the result of three input variables: land surface temperature, tree canopy coverage, and population density.

Scenario

Imagine the following scenario: The city of Athens, Greece, has been experiencing extreme heat for many years. The city is working with its Chief Heat Officer to create innovative adaptation plans to battle the effects of this extreme heat. As a GIS analyst for Athens, you have been asked to create a heat risk index (HRI) that prioritizes areas for tree planting as part of an adaptation plan to help cool the city. You will work through all the necessary steps to prepare and combine your data to create an HRI for Athens, Greece.

Note: The exercises in this course include View Result links. Click these links to confirm that your results match what is expected.

Estimated completion time in minutes: 120 minutes

Expand all steps

Collapse all steps

- Step 1: Add data to an ArcGIS Pro project

The inputs for your HRI will be derived from multiple data sources, including ArcGIS Living Atlas of the World. You will derive your first input variable, land surface temperature, from data found in ArcGIS Living Atlas of the World.

In this step, you will create a new ArcGIS Pro project to add the data.

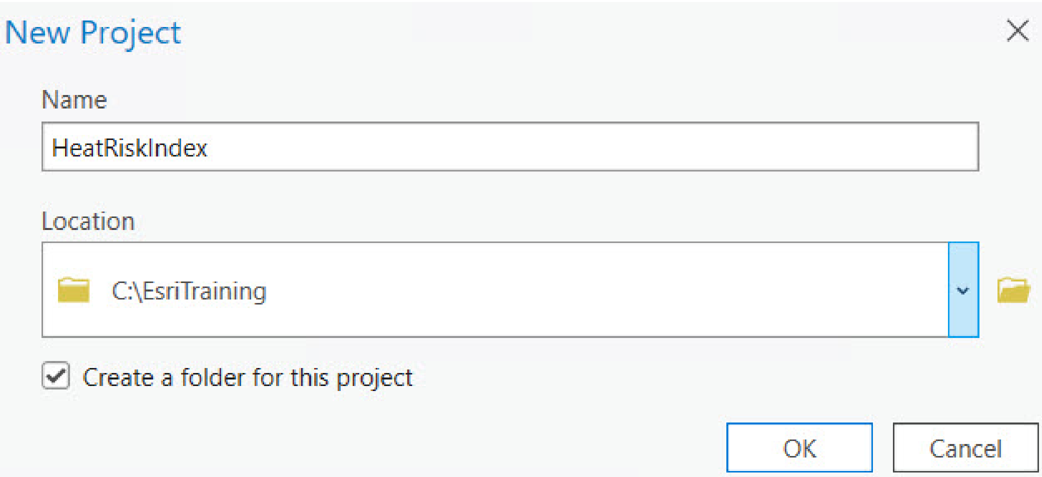
a Start ArcGIS Pro.

b If necessary, sign in to ArcGIS Pro using your course ArcGIS account username (ending in _CLIM) and password.

c Under New Project, click Map.

d In the New Project dialog box, for Name, type **HeatRiskIndex**.

e For Location, browse to and select your EsriTraining folder.



*Step 1e***: Add data to an ArcGIS Pro project.*

f Click OK.

A map opens to a default view of North America.

The first input variable for your HRI is land surface temperature. You will derive land surface temperature from the Multispectral Landsat imagery layer found in ArcGIS Living Atlas of the World.

g On the ribbon, click the Map tab and, in the Layer group, click the Add Data icon.

h From Living Atlas, add the Multispectral Landsat imagery layer.

- Hint

  - In the Add Data dialog box, under Portal, click Living Atlas.
  - In the Search Living Atlas field, type **Multispectral Landsat** and press Enter.
  - Select the Multispectral Landsat imagery layer and click OK.

The Multispectral Landsat imagery layer includes Landsat GLS, Landsat 8, and Landsat 9 imagery. The layer is time-enabled and updated daily with new imagery. To learn more, you can review the metadata on the layer's item page in ArcGIS Online.

You have created a new ArcGIS Pro project and added data from ArcGIS Living Atlas of the World for your first input variable.

- Step 2: Set a study area

To create a localized HRI, you must define the study area. Your analysis focuses on the city of Athens, Greece, which is a sprawling urban area; therefore, your study area will also include the urban neighborhoods that surround Athens.

In this step, you will set the study area to Athens and the surrounding urban areas. First, you will add a layer from ArcGIS Living Atlas that includes postcode boundaries for Greece with total population count per postcode.

a From ArcGIS Living Atlas, add the Greece Postcodes3 Boundaries feature layer.

*Step 2a***: Set a study area.*

The layer is added to your map. However, you will need to zoom to the layer to view it.

b Turn off the Multispectral Landsat layer.

c Zoom to the GRC_Postcodes3 layer.

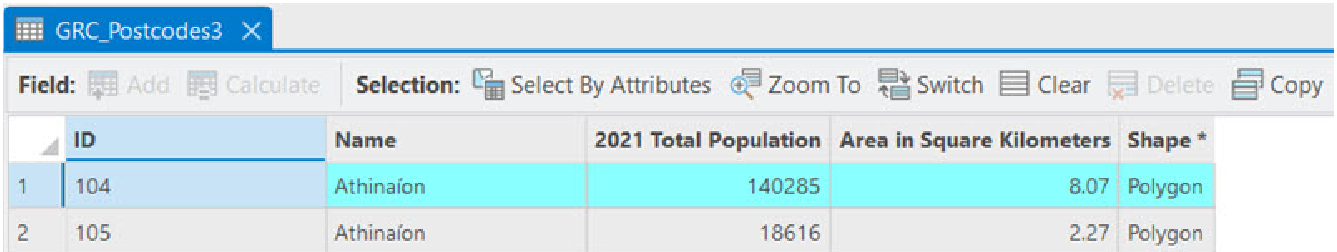
- Hint

  Right-click GRC_Postcodes3 and choose Zoom To Layer.

The Greece Postcodes3 Boundaries layer includes the postcode boundaries for all of Greece. To set your study area to Athens, you will select specific postcodes in the attribute table.

d For the GRC_PostCodes3 layer, open the attribute table.

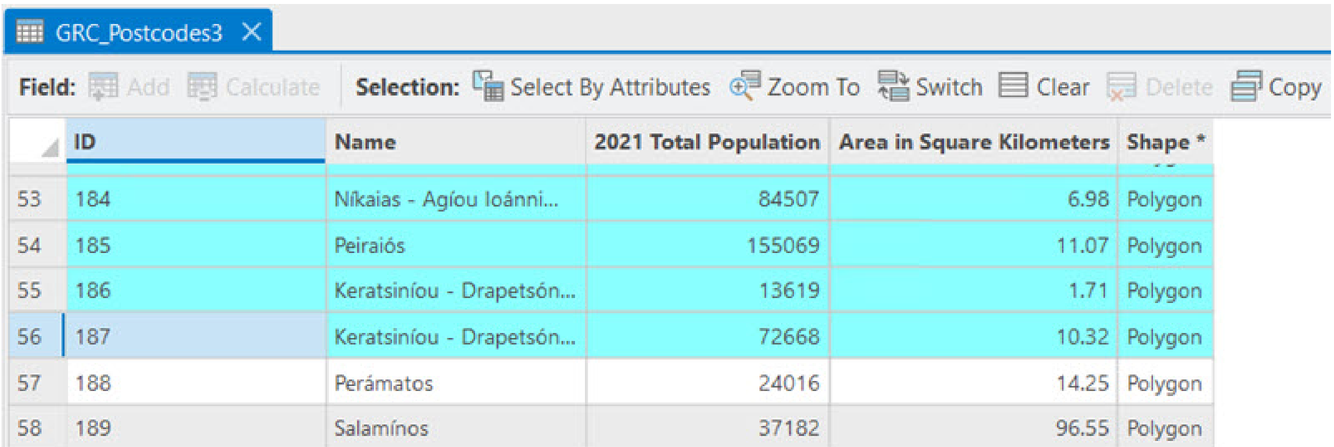
e In the attribute table, click the number 1 to select the first row.



*Step 2e***: Set a study area.*

f Scroll down to row 56.

g Press Shift on your keyboard and click the number 56.



*Step 2g***: Set a study area.*

You have selected 56 postcodes in the Athens area.

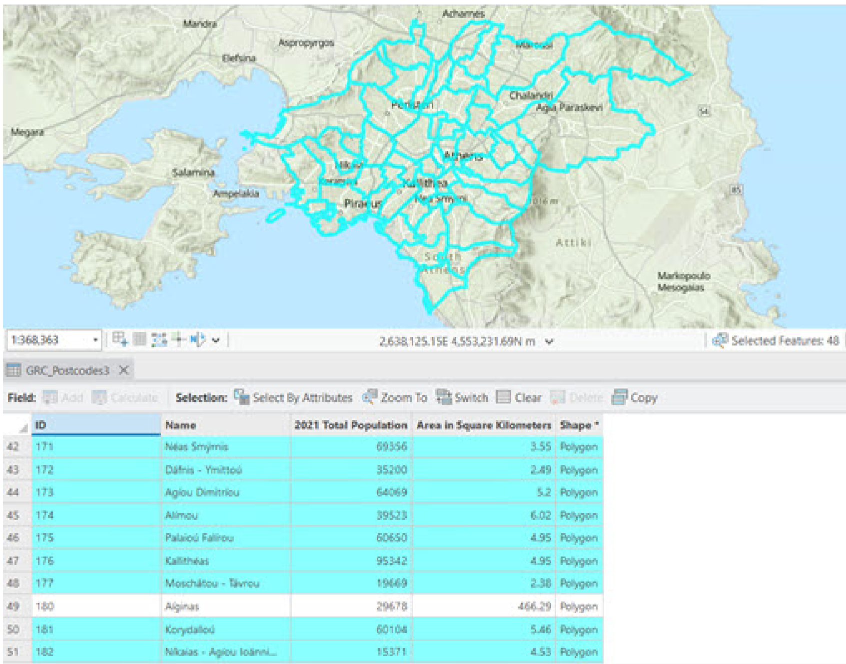
h At the top of the table, click the Zoom To button to show the selected postcodes on the map.

There are 7 postcodes that you do not want to include in your study area because they cover areas like national parks and surrounding islands that could skew your HRI. You will remove these 7 postcodes now.

i Unselect the rows listed in the following table by pressing and holding Ctrl on your keyboard and clicking each row number in the attribute table.

Row number	ID	Name
18	133	Fylis
21	136	Acharnon
26	145	Kifisias
27	146	Kifisias
39	165	Glyfadas
40	166	Glyfadas
49	180	Aiginas

j Click the Zoom To button again.



*Step 2j***: Set a study area.*

The selection in your map has updated to show only the 49 postcodes that you want to include in your HRI.

You will now copy the selected features to create a new layer with only the postcodes necessary for your study area.

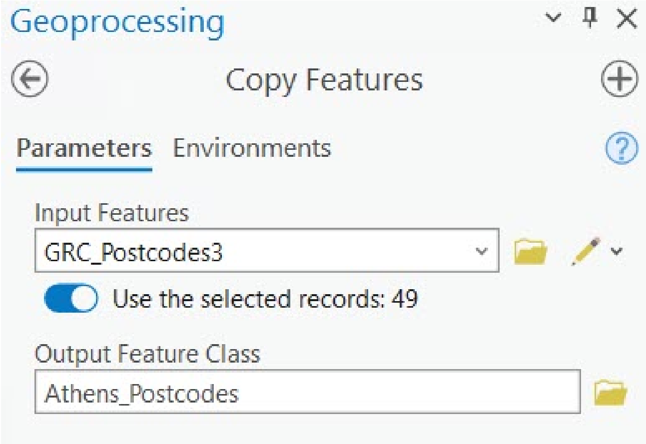
k In the Geoprocessing pane, search for and open the **Copy Features** (Data Management Tools) tool.

- Hint

    To open the Geoprocessing pane, click the Analysis tab and, in the Geoprocessing group, click Tools.

l For Input Features, click the down arrow and choose GRC_Postcodes3.

m For Output Feature Class, type **Athens_Postcodes**.



*Step 2m***: Set a study area.*

n Click Run.

o Close the attribute table and turn off the GRC_Postcodes3 layer.

*Step 2o***: Set a study area.*

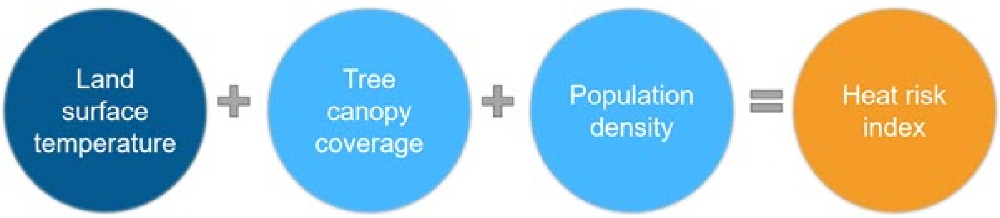
You have created a new layer that defines the study area for your HRI by selecting the postcodes that pertain to Athens and its surrounding urban areas.

p Turn off the Athens_Postcodes layer.

q Save your project.

- Step 3: Configure layer properties

The first input variable for your HRI is land surface temperature. To derive land surface temperature, you must configure the layer to ensure that the appropriate properties are set.



You will derive land surface temperature from the Multispectral Landsat imagery layer that you added to your project. The Multispectral Landsat imagery layer contains decades of information for many visualization types. To select the correct visualization for land surface temperature, you must configure the processing template, the mosaic operator, and a definition query in the layer properties.

In this step, you will configure these layer properties to select the land surface temperature data from the Multispectral Landsat imagery layer.

a Turn on the Multispectral Landsat layer.

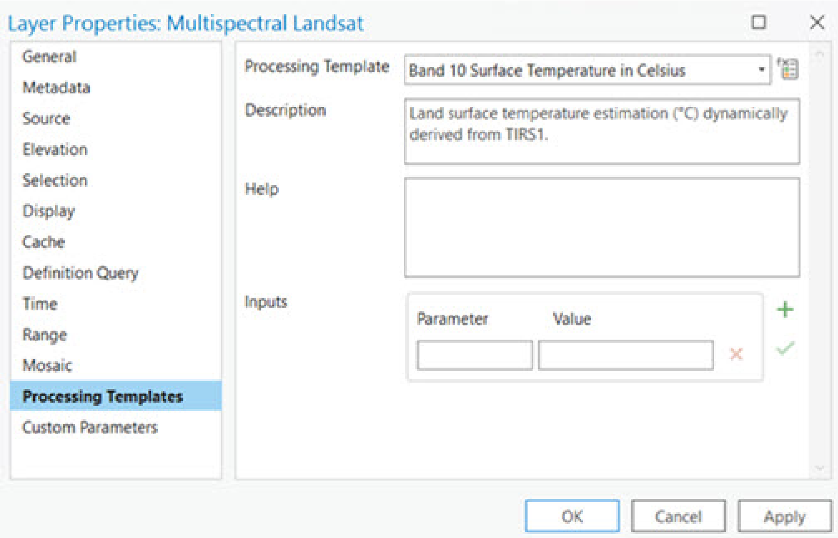
The Multispectral Landsat layer contains imagery of thermal energy that is emitted from the earth's surface in two distinct bands. By using processing templates in the layer properties, you can convert the thermal imagery of the land surface into images that approximate surface temperature in either degrees Celsius or degrees Fahrenheit.

You will select the processing template that identifies land surface temperature in degrees Celsius.

b Right-click Multispectral Landsat and choose Properties.

c In the Layer Properties dialog box, click the Processing Templates tab.

d For Processing Template, click the down arrow and choose Band 10 Surface Temperature In Celsius.



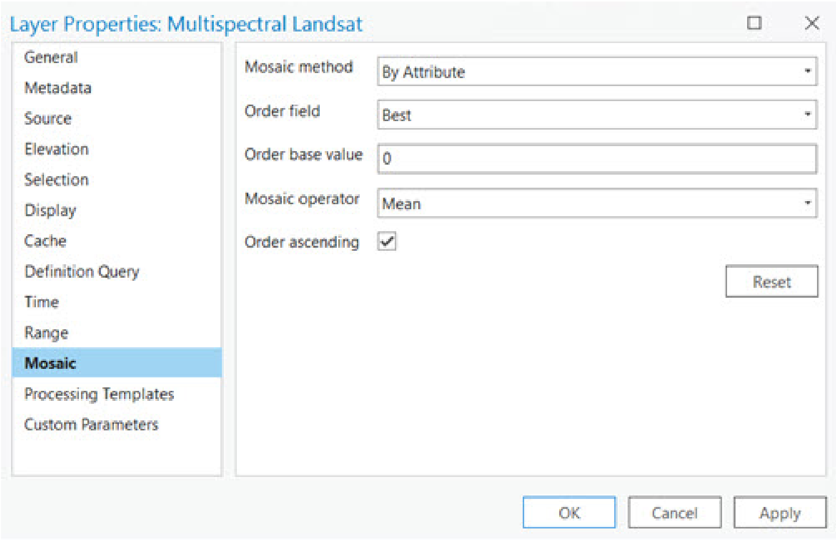
*Step 3d***: Configure layer properties.*

You have selected the processing template that identifies land surface temperature in degrees Celsius.

Layers that are made up of cells, such as imagery layers, may include overlapping cells. The mosaic operator allows you to define how these overlapping cells are resolved. In this case, you will set the mosaic operator to Mean, which will provide the average land surface temperature for overlapping cells.

e Click the Mosaic tab.

f For Mosaic Operator, click the down arrow and choose Mean.



*Step 3f***: Configure layer properties.*

Imagery layers may also contain images that are not necessary for deriving land surface temperature. In this case, the Multispectral Landsat imagery layer specifically contains clouds and cloud shadows, which could interfere with your analysis. Using a definition query to filter out these cloudy images would improve the overall quality of your analysis.

You will create a definition query that filters out all images with more than 5-percent cloud cover.

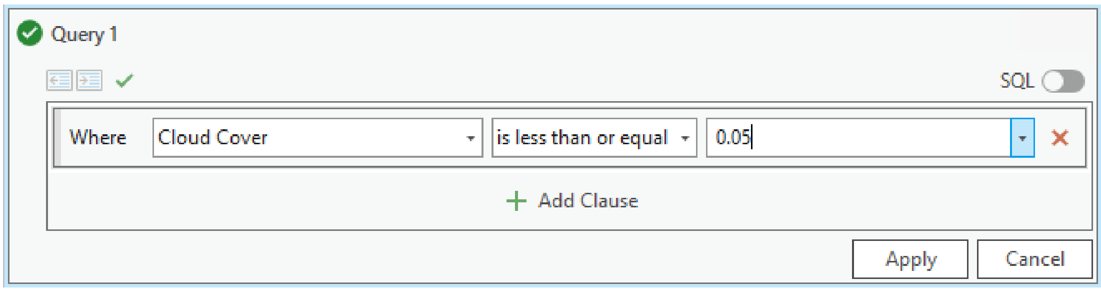
g Click the Definition Query tab.

h Point to Query 1, and then click the Remove Definition Query button.

i In the Remove Definition Query dialog box, click Yes.

j Click New Definition Query.

k Write a query that reads `Where Cloud Cover Is Less Than Or Equal To 0.05`.



*Step 3k***: Configure layer properties.*

l In the Query 1 box, click Apply.

m In the Layer Properties dialog box, click Apply, and then click OK.

Note: It may take a moment for the query to be applied.

You will change the symbology of the Multispectral Landsat layer to visualize the results of the configured layer properties.

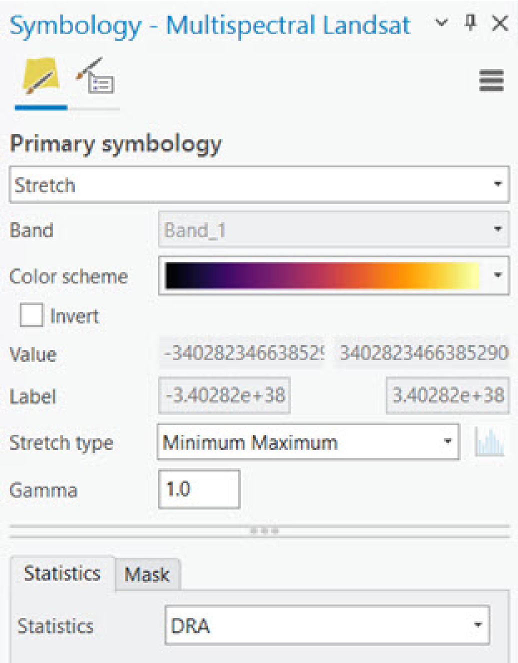
n Open the Symbology pane for the Multispectral Landsat layer.

- Hint

Right-click Multispectral Landsat and choose Symbology.

o In the Symbology pane, set the following parameters:

- Color Scheme: Inferno
- Stretch Type: Minimum Maximum
- Statistics: DRA



*Step 3o***: Configure layer properties.*

Note: Due to the global coverage of the layer and the changes that you made to the layer properties, it may take a couple of minutes for the symbology to render in the map.

You have symbolized the layer to visualize the land surface temperature input variable. Areas with cooler temperatures are shown in dark purple and areas with hotter temperatures are shown in orange and yellow.

p Save your project.

You have configured the layer properties of the Multispectral Landsat imagery layer to select and symbolize the first input variable for your HRI, land surface temperature.

- Step 4: Define the study area for the land surface temperature input variable

To be used as an input variable, the extent of the land surface temperature layer must match the study area of the heat risk index. In your case, the Multispectral Landsat imagery layer covers the entire globe but you need it to cover only Athens.

In this step, you will create, from the Multispectral Landsat imagery layer, a new layer that focuses on your study area of Athens.

a Zoom to the Athens_Postcodes layer.

You will use the map extent of the Athens_Postcodes layer to set the study area for the Multispectral Landsat imagery layer.

b Open the Multispectral Landsat attribute table.

Note: It may take a couple of minutes for the attribute table to load because the Multispectral Landsat imagery layer contains a large amount of data.

c At the bottom of the attribute table, click the Filter By Extent button to show records only for the current map extent in the attribute table.

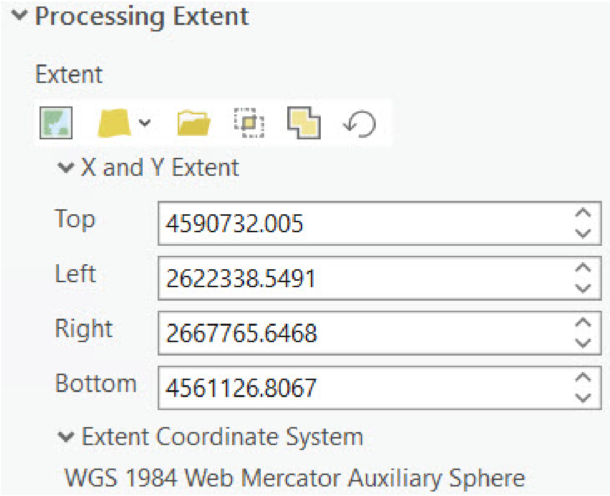
You have set the map extent and filtered the data in the attribute table and are now ready to copy the Multispectral Landsat imagery layer to create a new layer that is focused on Athens.

d Open the **Copy Raster** (Data Management Tools) tool.

First, you will adjust the tool's environments to set the processing extent and, thereby, clip the raster output to the Athens_Postcodes boundary.

e In the Geoprocessing pane, click the Environments tab.

f In the Processing Extent section, click the Extent By Layer down arrow and choose AthensPostcodes.



*Step 4f***: Define the study area for the land surface temperature input variable.*

You will now complete the tool parameters to create a copy of the Multispectral Landsat layer.

g Click the Parameters tab.

h For Input Raster, choose Multispectral Landsat.

You want to save your output as a TIFF file. However, TIFF files cannot not be stored in a file geodatabase, so you need to create a project folder to store the TIFF file.

You will create a folder for the output file location and give the output raster dataset a name that ends in .tif.

i For Output Raster Dataset, click the Browse button .

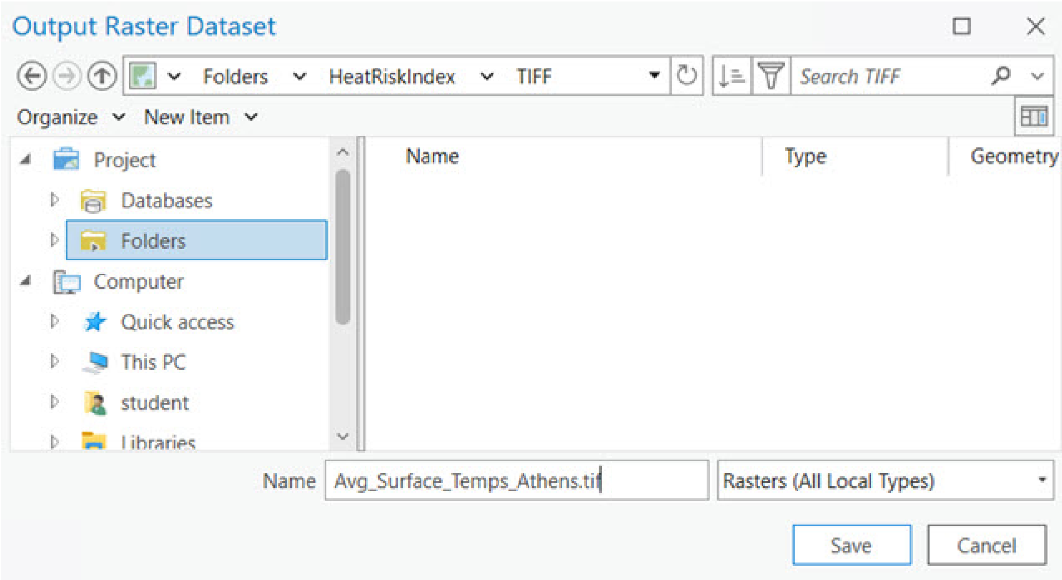
j In the Output Raster Dataset dialog box, under Project, click Folders.

k Double-click HeatRiskIndex.

l At the top left of the dialog box, click New Item and choose Folder.

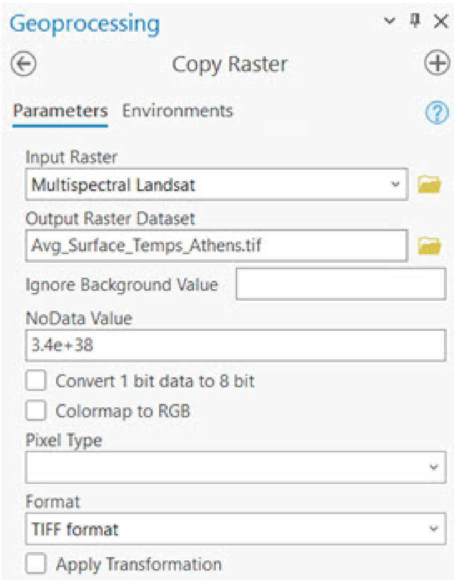
m Name the folder **TIFF** and click Open.

n For Name, type **Avg_Surface_Temps_Athens.tif**



*Step 4n***: Define the study area for the land surface temperature input variable.*

o Click Save.



*Step 4o***: Define the study area for the land surface temperature input variable.*

You are now ready to run the Copy Raster tool to create a new layer that limits the Multispectral Landsat layer to your study area.

p Click Run.

Avg_Surface_Temps_Athens.tif is added to the Contents pane.

> Note: The tool ran but with a warning that your processing template will not be saved to the new layer. You may disregard this warning.

q Close the attribute table and turn off the Multispectral Landsat layer.

r Save your project.

You have used the the Multispectral Landsat imagery layer to create a new TIFF layer that focuses on the study area of Athens.

- Step 5: Summarize temperature values in a table

The final step in deriving the land surface temperature input variable is to summarize all the temperature values in each area to determine the maximum, or hottest, average temperature value in degrees Celsius.

In this step, you will use the Zonal Statistics As Table tool to create a summary table of the temperature values in each postcode polygon for Athens.

a Open the **Zonal Statistics As Table** (Spatial Analyst Tools) tool.

The input dataset defines the zones that the table will use. The zone field is the field in the attribute table that will be used to identify the individual zones, or postcodes, in this case.

b For Input Raster Or Feature Zone Data, choose Athens_Postcodes.

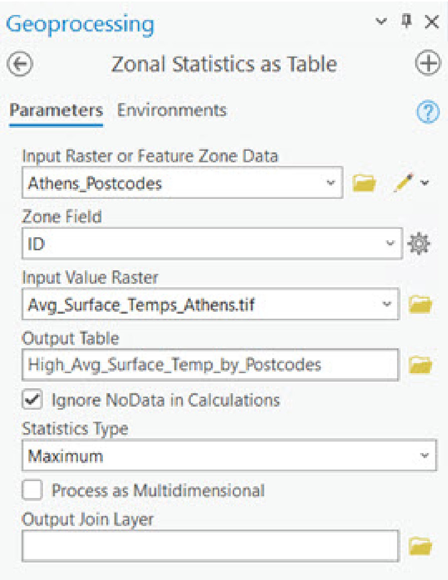
c For Zone Field, confirm that ID is selected.

The input value raster is the raster layer that contains the values that you want to use, average land surface temperature in degrees Celsius, in this case. You want to determine the hottest average temperature for each postcode, so you will set the Statistics Type to maximum.

d For Input Value Raster, choose Avg_Surface_Temps_Athens.tif

e For Output Table, type **High_Avg_Surface_Temp_by_Postcodes**.

f For Statistics Type, choose Maximum.



*Step 5f***: Summarize temperature values in a table.*

g Click Run.

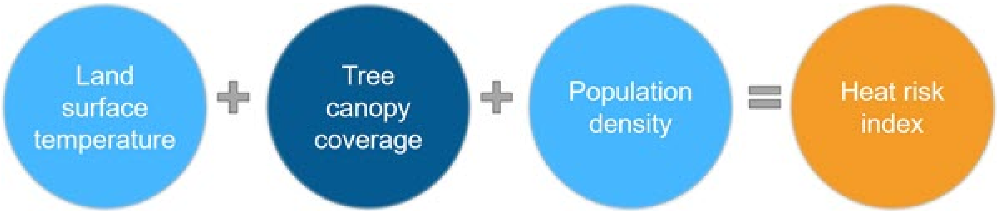
The High_Avg_Surface_Temp_by_Postcodes table is added to the Contents pane in the the Standalone Tables section.

h Save your project.

You have derived your first input variable, land surface temperature, by creating a table that summarizes the temperature values in each postcode polygon for Athens.

- Step 6: Identify tree canopy coverage

The second input variable in your HRI is tree canopy coverage. To be derived from a layer, the tree canopy data must be isolated and the amount of coverage for the area calculated.



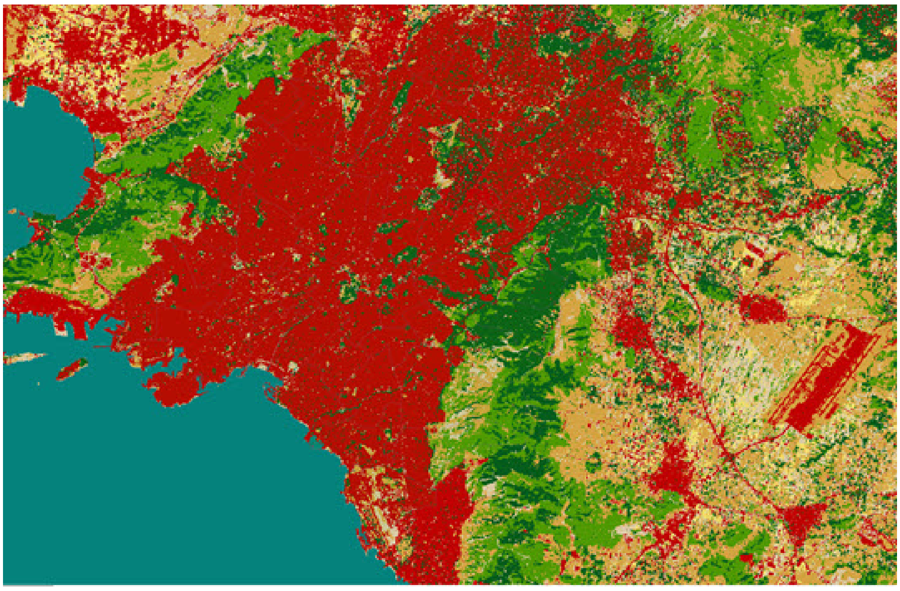
You will add an ArcGIS Living Atlas layer that shows global land cover categorized as 11 different land cover classes, including tree cover. You will use the Tree Cover class to isolate the cells in the raster layer classified as tree cover, which will be used to calculate tree canopy coverage.

In this step, you will identify tree canopy coverage from an ArcGIS Living Atlas layer.

a Turn off the Avg_Surface_Temps_Athens.tif layer.

b From ArcGIS Living Atlas, add the European Space Agency WorldCover 2020 Land Cover layer.

This layer is a baseline land cover map of the world from the WorldCover Consortium and European Space Agency for the year 2020. To learn more, you may review its item page in ArcGIS Online.



*Step 6b***: Identify tree canopy coverage.*

The Tree Cover class includes all geographic areas that are dominated by trees with a cover of 10 percent or more.

By adding this layer, you can already see that most of Athens and its surrounding area is dominated by the Built-up class, which is symbolized in red on the map. The Built-up class includes land that is covered by buildings, roads, and other human-made structures, such as railroads. Both residential and industrial buildings are included in this class.

You will isolate the cells in your study area using a raster function. Raster functions are operations that apply processing directly to the cells of imagery and raster datasets. With a raster function, you can decide whether to only apply an operation to the dataset or to create a new layer, like a geoprocessing tool would. The Remap raster function allows you to group cell values and then assign the group a new value.

You will use the Remap raster function to calculate lack of tree canopy.

c On the ribbon, click the Imagery tab and, in the Analysis group, click Raster Functions.

d In the Raster Functions pane, scroll down and expand Reclass.

e Click Remap to open the Remap raster function.

The item page of the land cover layer indicates that tree cover cells have a value of 10. You will remap the values in the layer so that tree cover cells have a value of "1" and everything else has a value of "0." The Remap raster function output will display as a new layer in the Contents pane.

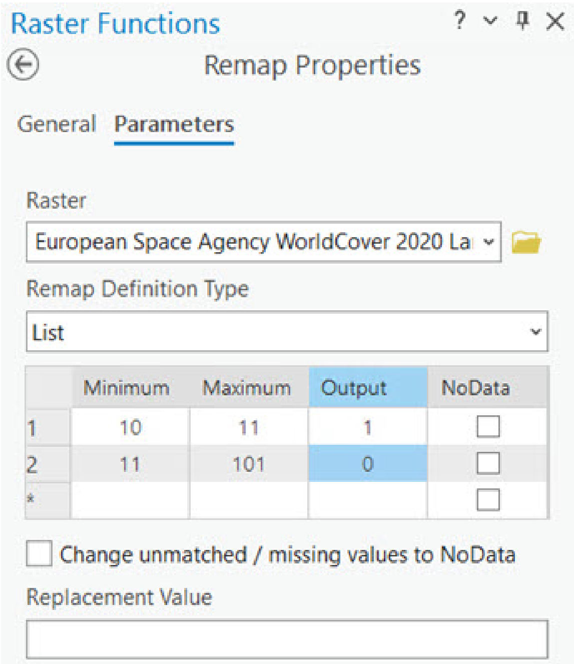
f In the Remap Properties pane, for Raster, choose European Space Agency WorldCover 2020 Land Cover.

g For Remap Definition Type, confirm that List is selected.

h Complete the Remap table, using the following table as a guide:

	Minimum	Maximum	Output
1	10	11	1
2	11	101	0

i Leave the NoData boxes unchecked.



*Step 6i***: Identify tree canopy coverage.*

j Click Create New Layer.

A new layer is added to Contents pane that symbolizes tree cover cells as 1 and everything else as 0.

k Turn off the European Space Agency WorldCover 2020 Land Cover layer.

l Save your project.

You have added land cover data from ArcGIS Living Atlas and used it to identify tree canopy coverage.

- Step 7: Calculate tree canopy coverage

The European Space Agency WorldCover 2020 Land Cover layer that you added covers the entire globe; therefore, the output of your Remap raster function includes tree canopy coverage for the entire globe as well.

In this step, you will create a new tree canopy coverage layer specific to your study area so that you can calculate only the amount of tree canopy coverage for Athens.

First, you will define your study area by creating a copy of the Remap_European Space Agency WorldCover 2020 Land Cover layer using the Athens_Postcodes layer as the extent. This will result a layer that you can use to calculate tree canopy coverage for Athens only.

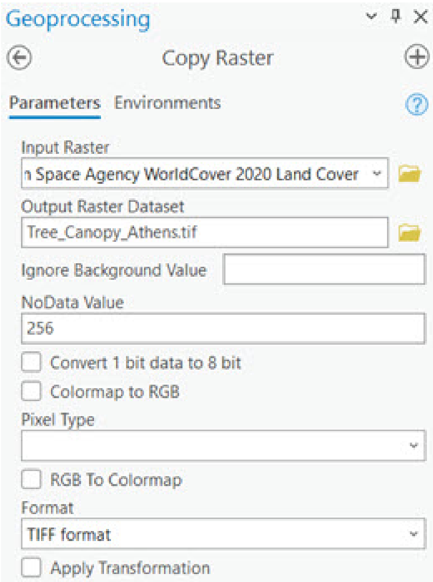
a Open the **Copy Raster** (Data Management Tools) tool.

b On the Environments tab, set the Processing Extent to AthensPostcodes.

c On the Parameters tab, for Input Raster, choose Remap_European Space Agency WorldCover 2020 Land Cover.

d For Output Raster Dataset, browse to the TIFF folder.

e For Name, type **Tree_Canopy_Athens.tif**, and then click Save.



*Step 7e***: Calculate tree canopy coverage.*

f Click Run.

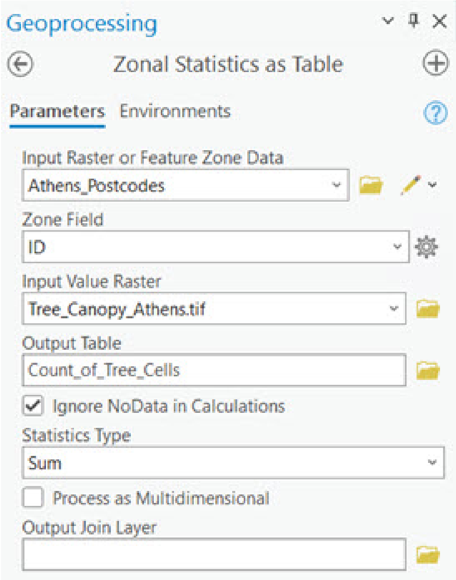
g Turn off the Remap_European Space Agency WorldCover 2020 Land Cover layer.

Now that you have a defined study area for your tree cover data, you can use the Zonal Statistics As Table tool to create a table with the count of the number of tree cover cells in each postcode polygon.

h Open the **Zonal Statistics As Table** (Spatial Analyst Tools) tool.

i In the Geoprocessing pane, set or confirm the following parameters:

- Input Raster Or Feature Zone Data: Athens_Postcodes
- Zone Field: ID
- Input Value Raster: Tree_Canopy_Athens.tif
- Output Table: **Count_of_Tree_Cells**
- Statistics Type: Sum



*Step 7i***: Calculate tree canopy coverage.*

j Click Run.

The Count_of_Tree_Cells table is added to the Contents pane in the Standalone Tables section.

k Open the Count_Of_Tree_Cells table.

- Hint

Right-click Count_Of_Tree_Cells and choose Open.

A Sum field was added to the table because you selected Sum as the statistics type. The Sum field is the total count of the number of tree cover cells in each census polygon.

l Save your project.

You have created a new layer for your second HRI input variable, tree canopy coverage. Using this new layer, you have calculated the amount of tree cover for each postcode in the Athens study area.

- Step 8: Calculate tree canopy coverage as a percentage

In an HRI, the tree canopy coverage input variable is presented as two percentages for the study area: percent tree cover and percent lacking tree cover. Now that you have a table that identifies the total number of tree cover cells in each postcode in your study area, you can calculate these two percentages.

In this step, you will calculate two percentage fields to finalize the tree canopy coverage input variable for your Athens HRI.

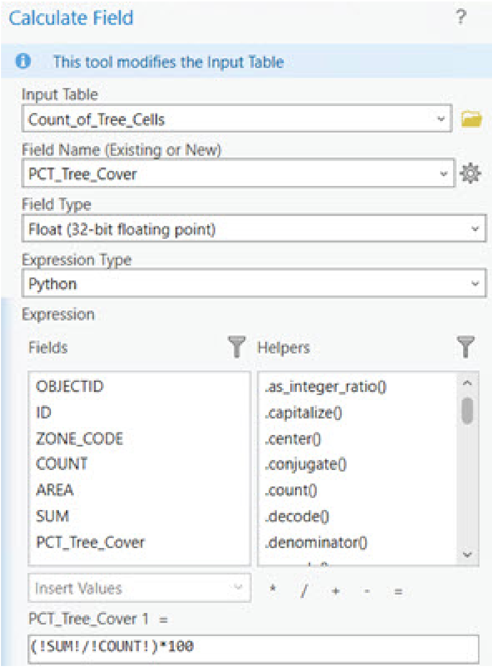
a In the attribute table, click Calculate to open the Calculate Field tool.

First, you will use the Count and Sum fields to calculate the percentage of tree canopy cover for each postcode. The formula for this calculation is the sum of the tree canopy cover cells divided by the total count of cells, multiplied by 100. The results will be calculated as a fractional value, so you will select the Float field type, which allows up to six decimal places.

b In the Calculate Field dialog box, for Field Name (Existing Or New), type **PCT_Tree_Cover**.

c For Field Type, choose Float (32-bit Floating Point).

d For PCT_Tree_Cover =, type `(!SUM!/!COUNT!)*100`



*Step 8d***: Calculate tree canopy coverage as a percentage.*

e Click Apply.

PCT_Tree_Cover
5.053872
22.68789
9.864513
13.98572
2.542614
10.23138
30.85604
19.73435

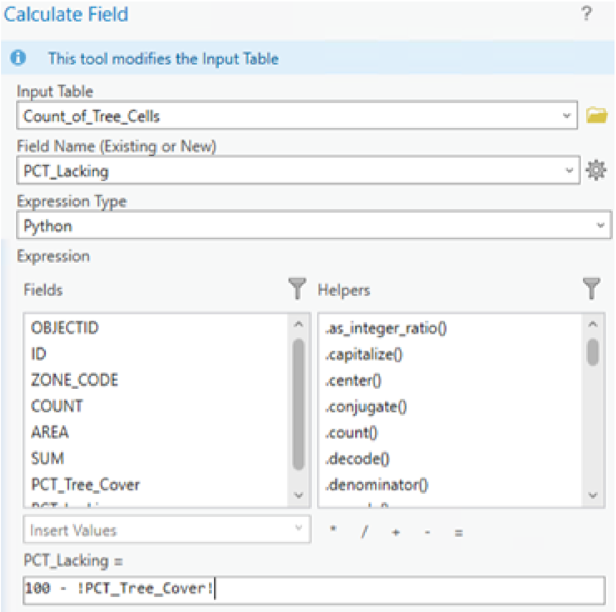
*Step 8e***: Calculate tree canopy coverage as a percentage.*

A new field, PCT_Tree_Cover, is added to the attribute table and shows the percent tree canopy coverage for each Athens postcode.

You will now calculate the percent lacking tree canopy coverage for each postcode.

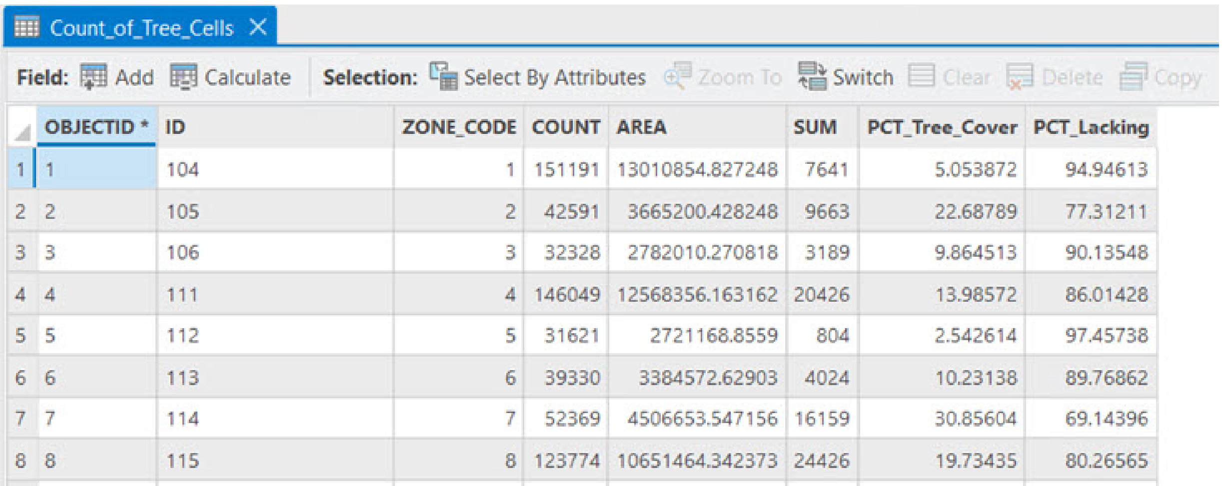
f In the Calculate Field dialog box, for Field Name, delete PCT_Tree_Cover and type **PCT_Lacking**.

g For PCT_Lacking =, delete the previous formula and type **`100 - !PCT_Tree_Cover!`**



*Step 8g***: Calculate tree canopy coverage as a percentage.*

h Click Apply, and then click OK to close the tool.



	OBJECTID *	ID	ZONE_CODE	COUNT	AREA	SUM	PCT_Tree_Cover	PCT_Lacking
1	1	104	1	151191	13010854.827248	7641	5.053872	94.94613
2	2	105	2	42591	3665200.428248	9663	22.68789	77.31211
3	3	106	3	32328	2782010.270818	3189	9.864513	90.13548
4	4	111	4	146049	12568356.163162	20426	13.98572	86.01428
5	5	112	5	31621	2721168.8559	804	2.542614	97.45738
6	6	113	6	39330	3384572.62903	4024	10.23138	89.76862
7	7	114	7	52369	4506653.547156	16159	30.85604	69.14396
8	8	115	8	123774	10651464.342373	24426	19.73435	80.26565

*Step 8h***: Calculate tree canopy coverage as a percentage.*

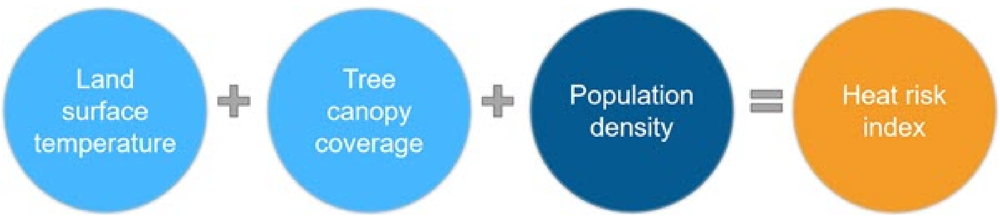
You have calculated the percent tree cover and the percent lacking tree cover for each postcode in your Athens study area.

i Close the table and save your project.

You are now done preparing the second input variable for your HRI, tree canopy coverage.

- Step 9: Calculate population density

The third input variable for your HRI is population density, which identifies the areas with the most people. This information will help the city prioritize densely populated areas in its adaptation plan.



In this step, you will calculate population density for each postcode in Athens using the Athens_Postcodes layer.

a Turn off the Tree_Canopy_Athens.tif layer.

b Open the Athens_Postcodes attribute table.

The attribute table contains two fields that you can use to calculate population density: 2021 Total Population and Area In Square Kilometers. These fields were already included in the Greece Postcodes3 Boundaries layer from ArcGIS Living Atlas that you used to create your study area. The formula for calculating population density is total population divided by area of a polygon (postcode, in this case).

You will use the 2021 Total Population field and the Area In Square Kilometers field to create a new field in the attribute table that calculates population density.

c Open the Calculate Field tool.

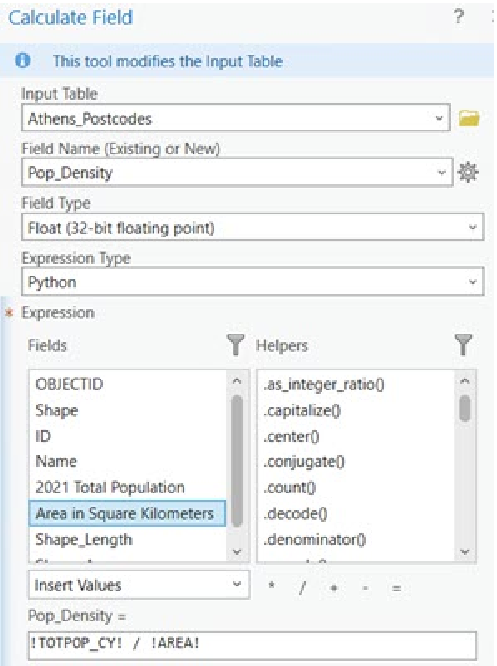
d For Field Name, type **Pop_Density**.

e For Field Type, choose Float (32-bit Floating Point).

f For Expression, from the Fields list, double-click 2021 Total Population to add it to your expression.

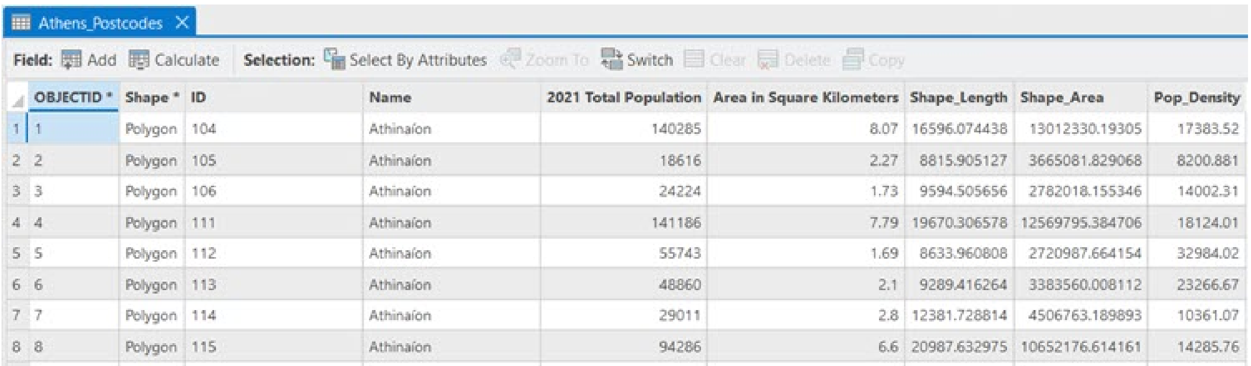
g To the right of the Insert Values field, click the Divide (/) symbol.

h From the Fields list, double-click Area In Square Kilometers.



*Step 9h***: Calculate population density.*

i Click Apply, and then click OK.



	OBJECTID *	Shape *	ID	Name	2021 Total Population	Area in Square Kilometers	Shape_Length	Shape_Area	Pop_Density
1	1	Polygon	104	Athinaíon	140285	8.07	16596.074438	13012330.19305	17383.52
2	2	Polygon	105	Athinaíon	18616	2.27	8815.905127	3665081.829068	8200.881
3	3	Polygon	106	Athinaíon	24224	1.73	9594.505656	2782018.155346	14002.31
4	4	Polygon	111	Athinaíon	141186	7.79	19670.306578	12569795.384706	18124.01
5	5	Polygon	112	Athinaíon	55743	1.69	8633.960808	2720987.664154	32984.02
6	6	Polygon	113	Athinaíon	48860	2.1	9289.416264	3383560.008112	23266.67
7	7	Polygon	114	Athinaíon	29011	2.8	12381.728814	4506763.189893	10361.07
8	8	Polygon	115	Athinaíon	94286	6.6	20987.632975	10652176.614161	14285.76

*Step 9i***: Calculate population density.*

You have used the Athens_Postcodes layer to calculate the third input variable for your HRI, population density, for each postcode in the study area.

j Save your project.

- Step 10: Combine the input variables

After the input variables have been prepared, they can be combined to create the HRI.

You have derived the three input variables for your HRI; however, the data values are currently stored in three separate tables. You need to join the standalone tables to the Athens_Postcodes layer.

In this step, you will combine the three input variables to create the HRI for Athens. First, you will use the Join Field tool to transfer the PCT_Lacking field from the Count_Of_Tree_Cells table to the Athens_Postcodes layer.

a Open the **Join Field** (Data Management Tools) tool.

b For Input Table, choose Athens_Postcodes.

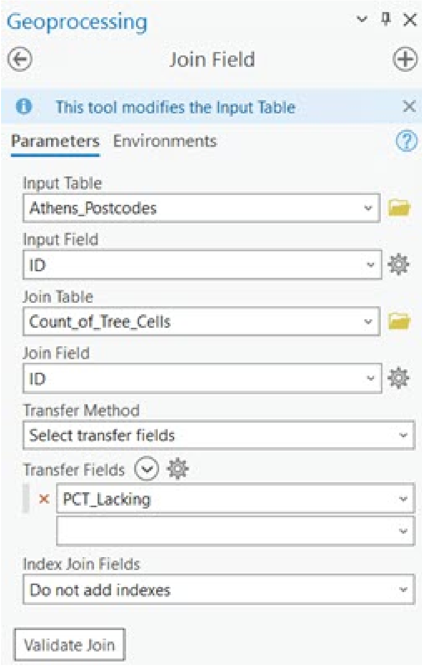
c For Input Field, choose ID.

d For Join Table, choose Count_Of_Tree_Cells.

e For Join Field, choose ID.

You will select the field in the Count_Of_Tree_Cells table that you want to transfer to the Athens_Postcodes layer.

f For Transfer Fields, choose PCT_Lacking.



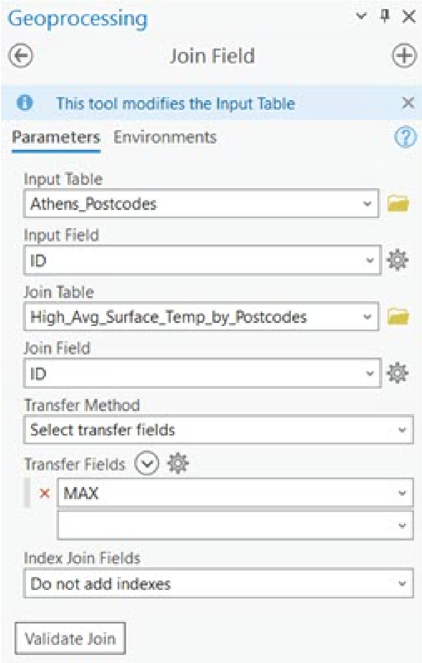
*Step 10f***: Combine the input variables.*

g Click Run.

h At the end of the Athens_Postcodes attribute table, notice that the PCT_Lacking field has been added.

Next, you will add the land surface temperature input variable to the Athens_Postcodes attribute table.

i Join the High_Avg_Surface_Temp_By_Postcodes table using ID as the join field and MAX as the transfer field.



*Step 10i***: Combine the input variables.*

j Click Run.

The MAX field has been added to the Athens_Postcodes attribute table. This field represents the highest average surface temperatures for each postcode.

All three input variables that you derived for your HRI are now stored in the Athens_Postcodes attribute table. However, the input variables use different units of measurement and must be standardized before being combined. You will use the Standardize Field geoprocessing tool to standardize the units for the three input variables.

k Open the **Standardize Field** (Data Management Tools) tool.

l For Input Table, choose Athens_Postcodes.

You will use the minimum-maximum standardization method to standardize the input variables and create a 5-point scale where 1 represents areas with the lowest heat risk index and 5 represents areas with the highest heat risk index.

m For Standardization Method, choose Minimum-Maximum.

n For Minimum Value, type **1**.

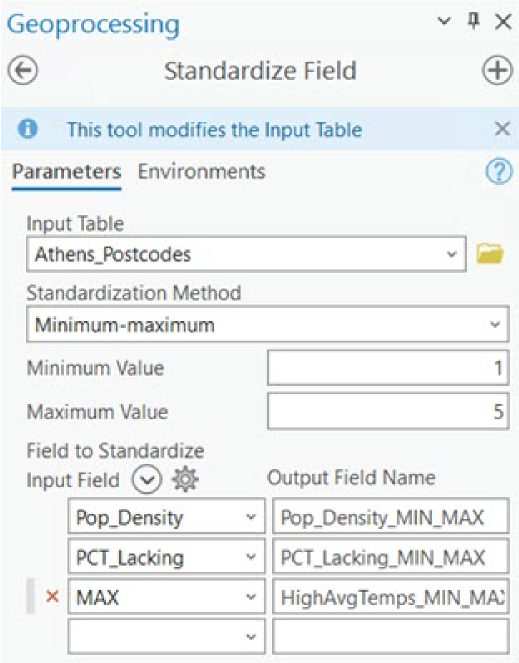
o For Maximum Value, type **5**.

p In the Field To Standardize section, for Input Field, click the down arrow and check your three input variables.

- Hint

  Pop_Density, PCT_Lacking, and MAX

q For MAX, change Output Field Name to **HighAvgTemps_MIN_MAX** to avoid confusion.



*Step 10q***: Combine the input variables.*

r Click Run.

You have created three new fields in the Athens_Postcodes attribute table to standardize the input variables on a scale from 1 to 5.

Your three input variables have now been combined to create an HRI for Athens where 1 represents areas with the lowest heat risk index and 5 represents areas with the highest heat risk index based on each input variable.

s Close the attribute table and save your project.

- Step 11: Visualize the heat risk index

After the three input variables have been combined to create the HRI, the HRI can be visualized on a map. To visualize the HRI for Athens, you need to adjust the Athens_Postcodes symbology to reflect the standardized scale that you created.

In this step, you will use an Arcade expression to adjust the Athens_Postcodes symbology to visualize the HRI for Athens. Arcade is a lightweight expression language used to create custom content in ArcGIS applications. Like other expression languages, Arcade can perform mathematical calculations, format text or symbology, and evaluate logical statements. The Arcade language was designed for use solely within ArcGIS.

a Turn on the Athens_Postcodes layer.

b Right-Click Athens_Postcodes and choose Symbology to open the Symbology pane.

c For Primary Symbology, click the down arrow and choose Unclassed Colors.

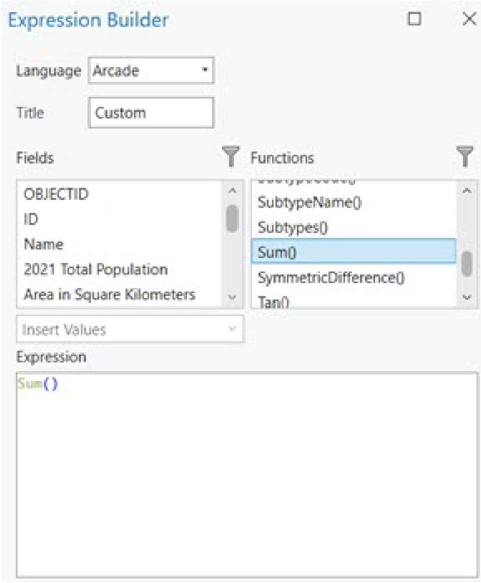
d Next to Field, click the Set An Expression button .

You will use the Expression Builder to write the Arcade expression that will symbolize your map of Athens based on a sum of the HRI values for each input variable.

e Under Expression, delete the existing text.

f Under Functions, scroll down until you locate Sum().

g Double-click Sum() to add it to your expression.



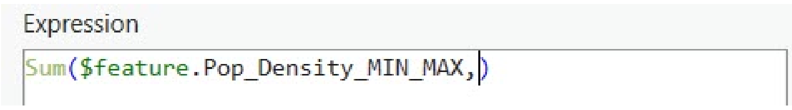
*Step 11g***: Visualize the heat risk index.*

You will use the Sum Arcade function to sum the HRI values for the three input variables.

h After `Sum`, click between the parentheses to continue writing your expression.

i From the Fields list, double-click Pop_Density_MIN_MAX.

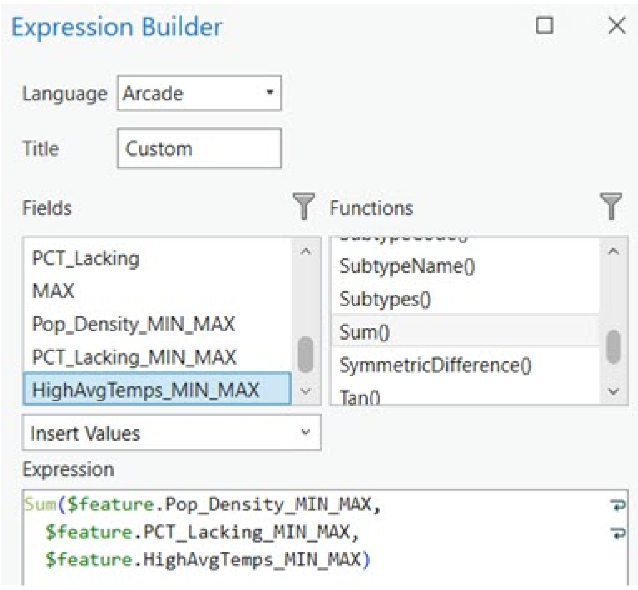
j Type a comma after the word `MAX`, as shown in the following graphic.



k From the Fields list, double-click PCT_Lacking_MIN_MAX.

l Again, type a comma after the word `MAX`.

m From the Fields list, double-click HighAvgTemps_MIN_MAX.



*Step 11m***: Visualize the heat risk index.*

Your final expression should read:

```
Sum($feature.Pop_Density_MIN_MAX,
        $feature.PCT_Lacking_MIN_MAX,
```

```
    $feature.HighAvgTemps_MIN_MAX)
```

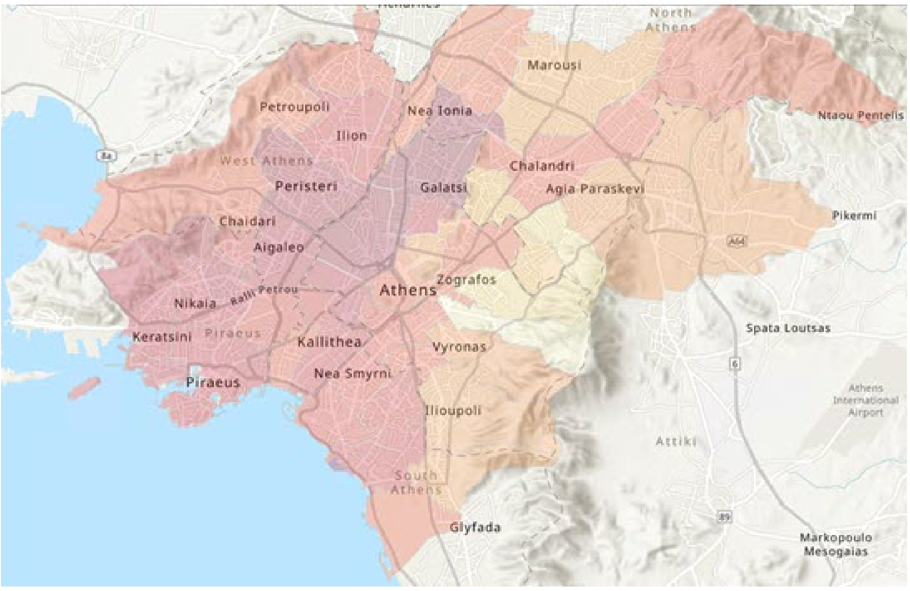
n Click OK to apply the expression.

You will now choose a color scheme that better visualizes the results.

o For Color Scheme, select Yellow-Orange-Red (Continuous).

- Hint

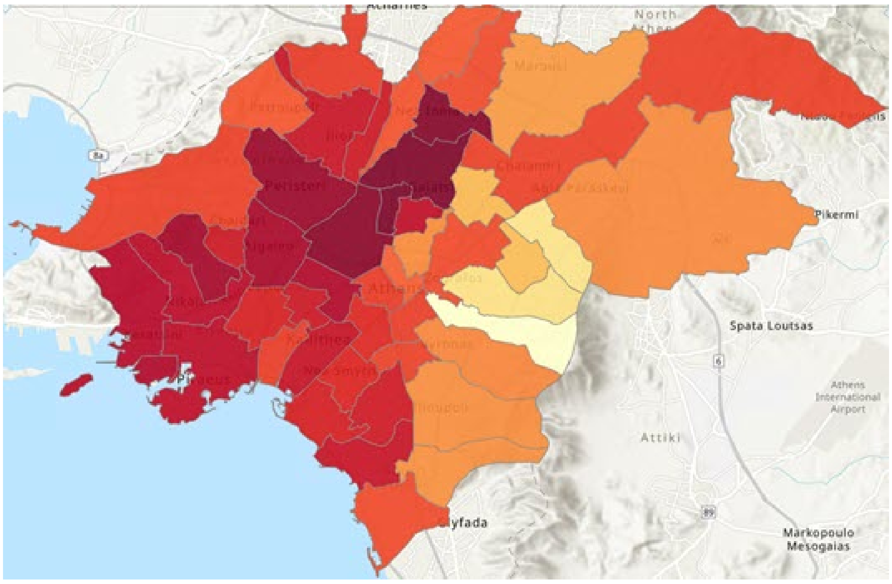
  Check Show Names to see the name of each color scheme.



*Step 11o***: Visualize the heat risk index.*

To make the symbology easier to see on the map, you will change the visual effects of the Athens_Postcodes layer.

p On the ribbon, click the Feature Layer tab and, in the Effects group, set Transparency to **10.0**%.



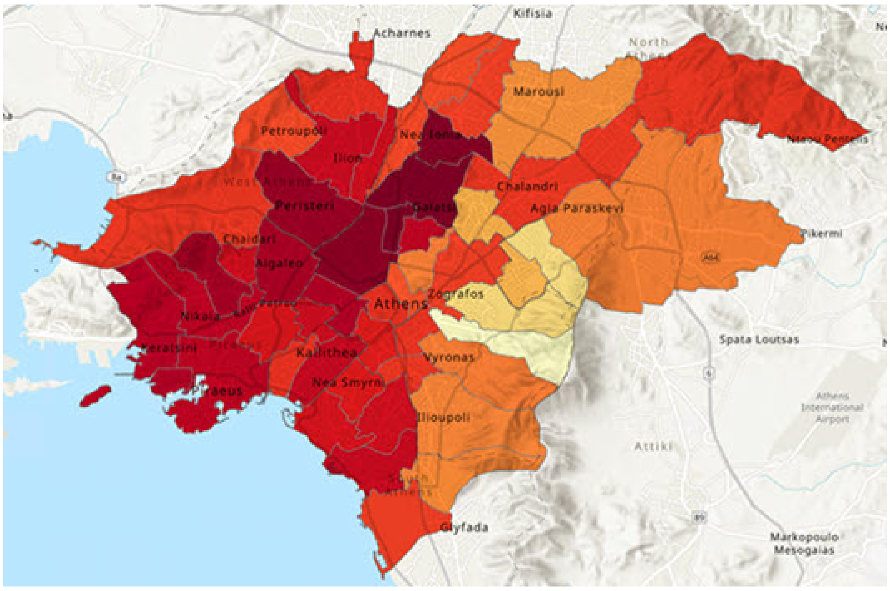
*Step 11p***: Visualize the heat risk index.*

Although transparency is a commonly used visual effect, ArcGIS Pro offers additional visual effects for layers and features, such as blending modes. Layer blending draws the entire layer and blends it with the content underneath, such as a basemap. Blending ensures that the labels on the basemap remain visible.

You will use the multiply layer blend effect.

q Set Transparency to **0**%.

r For Layer Blend, click the down arrow and choose Multiply.



*Step 11r***: Visualize the heat risk index.*

Your final map symbolizes postcodes with a higher HRI value in darker shades of red; these postcodes would benefit the most from the addition of trees. Postcodes with lower HRI values are symbolized in lighter shades of yellow and orange.

s Save your project.

You have used data from ArcGIS Living Atlas to derive three input variables to create a heat risk index for Athens, Greece. You have visualized your results on a map to highlight the postcodes that are hotter, have fewer trees to protect against extreme heat, and have more residents. The Chief Heat Officer and the city of Athens can use the resulting intervention-focused map as a planning tool to prioritize areas for tree planting.

- Step 12: Share your map

Heat risk indices can be shared with the stakeholders involved in implementing adaptation plans for extreme heat.

Your map is ready for sharing with community leaders to help them prioritize the postcodes that would benefit most from tree planting. In this step, you will share your HRI map to ArcGIS Online as a web map.

The only layers that need to be included in the web map are the Athens_Postcodes layer and the basemaps; therefore, you will remove the layers that you do not need before sharing.

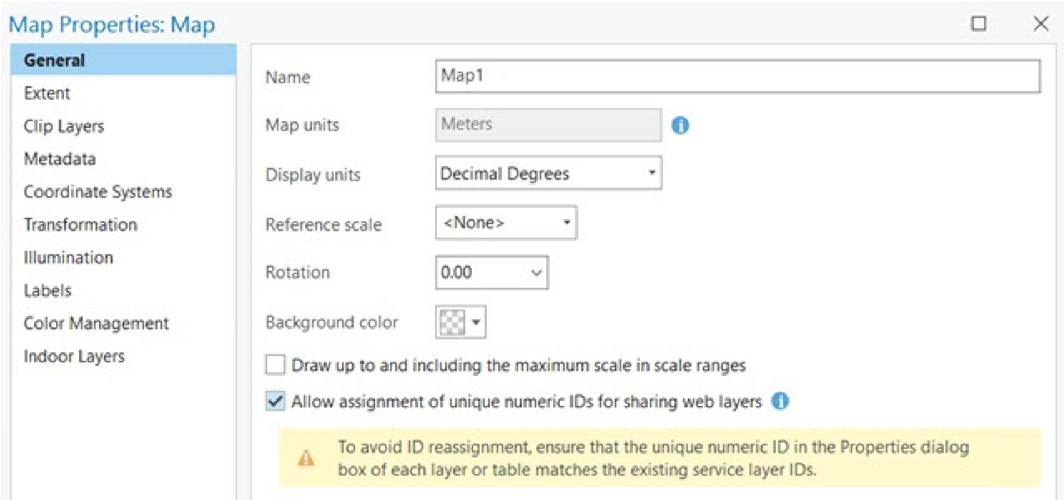
a In the Contents pane, remove all the layers *except* for the Athens_Postcodes layer and the basemap layers.

Note: If you did not want to remove the layers, you could instead create a new map and copy and paste the Athens_Postcodes layer to the new map.

You will adjust the map properties to allow assignment of unique numeric IDs for sharing web layers. This step can prevent warnings or errors when analyzing your map for sharing.

b In the Contents pane, right-click Map and choose Properties.

c On the General tab, check the box for Allow Assignment Of Unique Numeric IDs For Sharing Web Layers.



*Step 12c***: Share your map.*

d Click Apply, and then click OK.

e Share your map as a web map using the following parameters:

- Name: **Athens Heat Risk Index_<your first and last name>**
- Summary: **A heat risk index for postcodes in Athens, Greece, and the surrounding urban areas.**
- Tags: **Athens, Climate change, Heat risk, Adaptation plan**.
- Share With: Everyone

- Hint

To share your map as web map, click the Share tab on the ribbon and, in the Share As group, click Web Map.

f Analyze and share your map.

You shared your HRI map to ArcGIS Online as a web map. Community leaders could now access the map and use it to prioritize postcodes for the adaptation plan of planting trees to help keep Athens communities cooler.

g If you plan to complete the optional stretch goal, keep ArcGIS Pro open; otherwise, save your project and exit ArcGIS Pro.

- Step 13: Stretch goal (optional)

ArcGIS offers the opportunity to enrich data with demographic variables, like median age or household income, through its GeoEnrichment service. Enriching your data can add geographic context and insights to your data and enhance your spatial analysis.

Working through a spatial analysis, like creating a heat risk index, is an iterative process: you can add more data, switch data, or even enrich your data to refine the analysis and gather more information about your study area.

In this course, you have learned that vulnerable populations are disproportionately affected by climate change. With this in mind, in this stretch goal, you will be enriching the Athens_Postcodes layer to incorporate vulnerable populations into your heat risk index. Generally, the populations that are most vulnerable to extreme heat are older adults, young children, unhoused people, and outdoor workers.

Identifying vulnerable populations while creating adaptation plans will result in more equitable solutions.

a Review the following resources to learn more about GeoEnrichment in ArcGIS:

- Esri Location Data: Demographics

- Esri Demographics Help: What is Esri Demographics data
- ArcGIS Pro Help: Enrich Layer (Analysis).
- Esri Demographics Help: Greece

b Using what you learned in these resources, enrich your Athens_Postcodes layer to include available demographics for groups that are vulnerable to extreme heat.

c Recalculate your heat risk index.

d Share your workflow and results as a map in the forum using the tag **#StretchSection5**.