Urban Heat Island assessment.

Introduction

Objectives.

1. The primary objective of this is to get the effects of the war in Palestine on urban heat in Gaza Strip.
2. Other objectives include;
   a. Assess urban heat islands and LST trends in Gaza strip.
   b. Assess and interpret the urban heat intensity of Gaza.
   c. Compare the urban heat means of the 3 major urban areas in gaza.
   d. Generate urban heat risk ad vulnerability maps.
   e. Make a comparison between urban heat, landuse and land cover, urban heat risk and urban heat vulnerability.

Methodology

1. Extract daytime surface temperature from Band 10 of landsat 8/9 imagery.
2. Extract nighttime surface temperature from LST 1km night of Modis aqua.
3. Merge the two datasets to get a mean day and night land surface temperature.
4. Get the mean temperatures for the 3 urban (Delineated using degurba) areas in Gaza, these include Gaza, An_Nusayrat and Khan_Yunis.
5. Get the Urban Heat Island intensity of Gaza Strip using the following formulat:
   a. $LST\ UHI = LSTurban - LSTrural$
6. Get the urban heat risk and vulnerability maps.
7. Get the different in land surface temperature (LST), of the affected areas, before the war, and after the war.

Urban Heat islands in Gaza Palestine

Assessment of urban heat in Palestine brought in a new dimension urban heat island that was not previously foreseen, during the beginning of the study. However, this unforeseen predicament, which involved landcover, and their different heat absorption rates was going to be a major factor in assessing urban heat islands in Gaza.

The major point of focus for this analysis is the effects of the war in Gaza on urban heat islands. Among the main focus points were the mean LST, and the effects of the change of landcover from built up to bare land due to the distraction of built up area by the war.

Hypothesis.

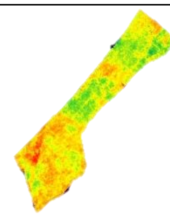
1. The sandy landcover will exhibit the highest levels of land surface temperatures during the day but will exhibit lower levels at night. However, there will be a radical decrease between the day and night temperatures. For urban areas, although the day LST will be below that of bare sandy areas, there will me minimal change between the day and night LST values.
2. The destruction of buildings, trees and other green items will results in increased daytime LST on those affected regions during the day.
3. The urban center with the least green cover in Gaza will have the highest LST values.

Findings.

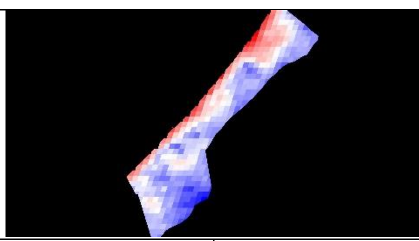
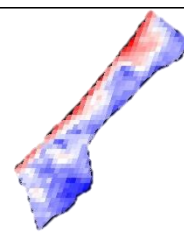
1. Sentinel Image

Pre_war start_date = '2022-12-01' end_date = '2023-04-30'	***Pre_war*** Start date = '2023-12-01' End date = '2024-04-30'
	

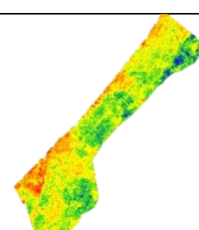
2. LST day time
    a. Band B10 of Landsat 8 and 9 imagery, transformed to degrees Celsius.

			
Minimum value:	21.02	Minimum value:	21.14
Maximum value:	36.07	Maximum value:	36.98
Mean value:	27.91	mean value:	29.32

3. LST night time
    a. Band LST_Night_1km, transformed to degrees Celsius.

			
Minimum value:	8.67	Minimum value:	8.30
Maximum value:	15.25	Maximum value:	15.94
mean value:	11.19	mean value:	11.47

4. Mean between day and night time LST
    a. This leverages the high spatial resolution of Landsat to capture temperature variations in vegetation, urban and bareland landcovers, while capitalizing on the frequent MODIS acquisitions to account for the rapid heating and cooling cycles in arid environments.

			
Minimum value:	16.65	Minimum value:	17.23
Maximum value:	23.96	Maximum value:	24.11
Mean value:	19.55	Mean value:	20.40

5. Comparison of LST in affected areas (pixels), before and during the war.

Minimum value:	22.73	Minimum value:	22.56
Maximum value:	34.85	Maximum value:	36.17
Mean value:	26.77	Mean value:	28.71

6. Urban Heat Island Intensity
    a. During the day

Urban mean value (Day):	27.55	Urban mean value (Day):	28.98
Rural mean value (Day):	27.25	Rural mean value (Day):	29.44
LST UHI (Day):	0.29	LST UHI (Day):	-0.461

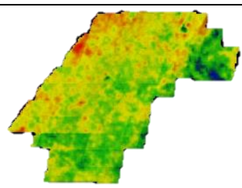
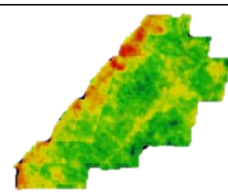
    b. At night

Urban mean value (Night):	11.56	Urban mean value (Night):	11.79
Rural mean value (Night):	10.22	Rural mean value (Night):	10.85
LST UHI (Night):	1.35	LST UHI (Night):	0.94

    c. Using mean of day and night

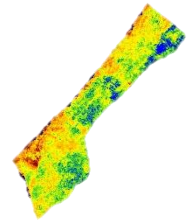
Urban mean value (Mean):	19.55	Urban mean value:	20.39
Rural mean value (Mean):	18.73	Rural mean value:	
LST UHI (Mean):	0.82	LST UHI	

7. Comparison between mean day and night Gaza, An_Nusayrat and Khan_Yunis LST.

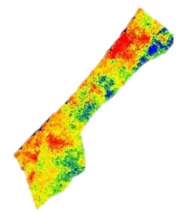
	Gaza	An_Nusayrat	Khan_Yunis
During War			

	Gaza	An-Nusayrat	Khan-Yunis		Gaza	An_Nusayrat	Khan_Yunis
Min value:	16.74	17.29	17.36	Min value:	17.38	17.80	17.61
Max value:	23.06	23.79	23.53	Max value:	23.64	23.80	24.00
Mean value:	19.27	19.37	19.81	Mean value:	20.27	20.02	20.59

8. Urban heat risk areas map
    a. The urban heat risk area map takes into consideration the mean day and night temperatures extracted, ndvi, bsi and ndwi at the time of interest.
        i. LST (Land Surface Temperature):
            1. Index: Measures the surface temperature of the land.
            2. Weight: Given a weight of 1 due to its direct correlation with urban heat.
        ii. NDVI (Normalized Difference Vegetation Index):
            1. Index: Indicates the presence and health of vegetation.
            2. Weight: Assigned a weight of -0.2 to account for its cooling effect in urban areas.
        iii. NDWI (Normalized Difference Water Index):
            1. Index: Identifies the presence of water bodies.
            2. Weight: Given a weight of -0.1 as water bodies contribute to cooling.
        iv. BSI (Built-up Area Index):
            1. Index: Identifies built-up areas.
            2. Weight: Assigned a weight of 0.3 due to the heat-absorbing nature of urban structures.

<table>
<tr><td></td><td></td></tr>
<tr><td colspan="2">- To assess levels of vulnerability, the dataset can be normalized to a scale of 0-1, then classified. The area per class would indicate the level of risk Gaza strip has had.</td></tr>
</table>

9. Urban heat index

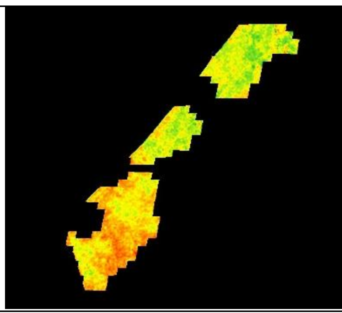
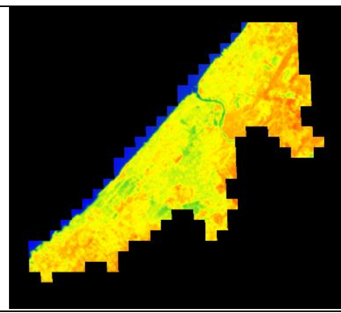
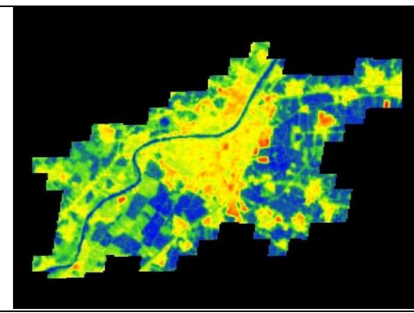
<table>
<tr><td></td><td></td></tr>
<tr><td colspan="2">- To assess levels of vulnerability, the dataset can be normalized to a scale of 0-1, then classified. The population within these classes would indicate the level of vulnerability within the area.</td></tr>
</table>

Comparison between Gaza Strip, Rabat, and Nairobi.

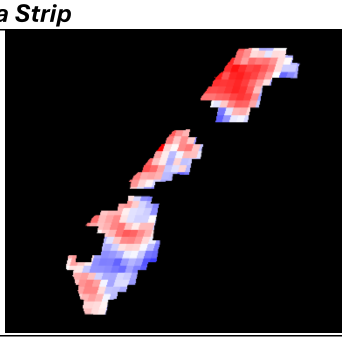
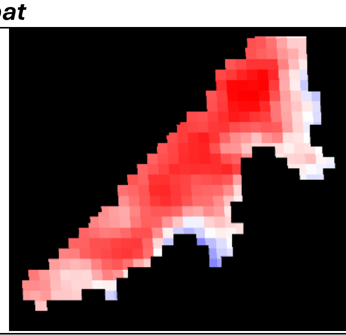
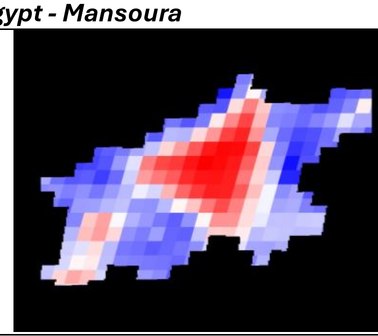
start_date = '2023-07-01'

end_date = '2023-09-30'

1. **Land Surface Temperature daytime.**
   a. This includes the thermal bands of landsat 9/8.

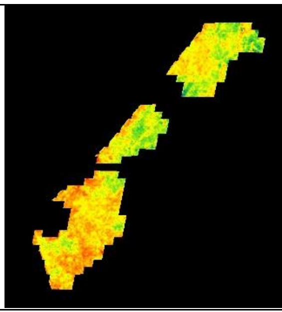
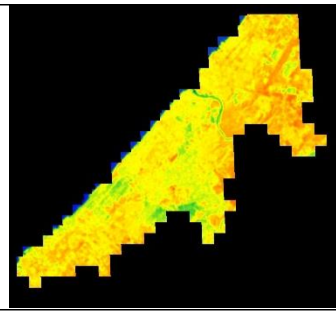
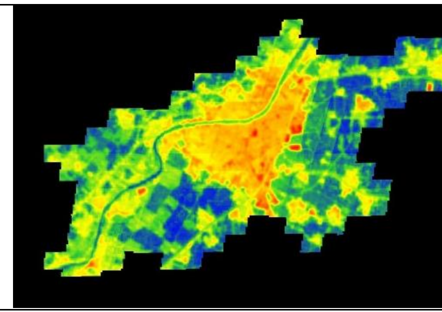
Gaza Strip	***Rabat***	***Egypt - Mansoura***
		
		
Minimum value: 32.64 **Maximum value**: 53.60 **mean value**: 44.57 **Urban mean value**: 43.82 **Rural mean value**: 44.85 **UHI Intensity**: -1.03	**LST Minimum value**: 22.32 **LST Maximum value**: 61.76 **LST mean value**: 39.04 **Urban mean value**: 42.36 **Rural mean value**: 42.24 **UHI Intensity**: 0.12	**Minimum value:** 30.35 **Maximum value:** 51.58 **mean value:** 36.06 **Urban mean value:** 37.08 **Rural mean value:** 34.02 **UHI Intensity:** 3.07

2. **Land Surface Temperature at nighttime.**
   a. This includes the nighttime thermal bands of Modis aqua.

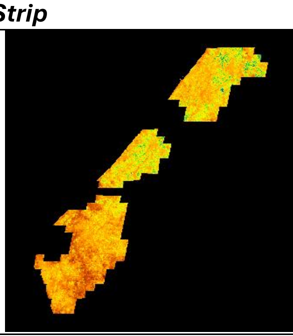
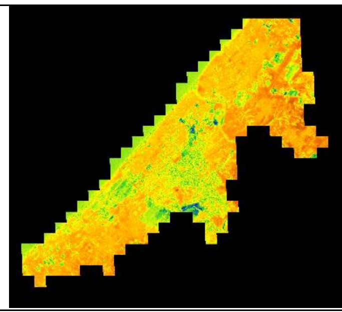
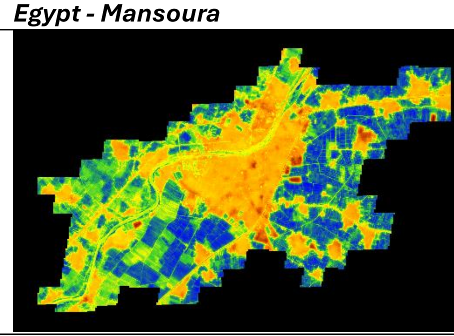
Gaza Strip	***Rabat***	***Egypt - Mansoura***
		
Minimum value: 19.95 **Maximum value**: 26.28 **mean value:** 23.09	**Minimum value**: 14.14 **Maximum value**: 20.81 **mean value**: 16.98	**Minimum value**: 19.61 **Maximum value**: 26.28 **mean value**: 21.58

3. **Combination between Landsat and Modis LST.**

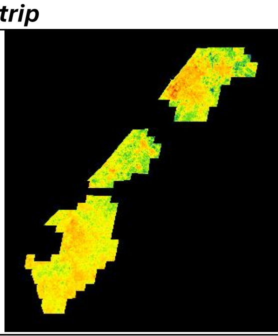
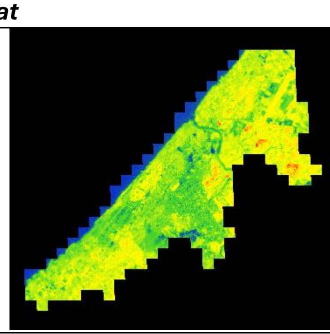
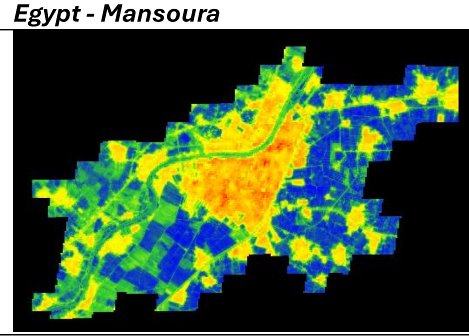
Gaza Strip	***Rabat***	***Egypt - Mansoura***

		
Minimum value: 28.65 **Maximum value:** 38.10 **Mean value:** 33.83	**Minimum value**: 20.76 **Maximum value**: 40.06 **Mean value**: 33.11	**Minimum value:** 25.50 **Maximum value:** 37.71 **Mean value:** 28.82

4. **Urban Heat Vulnerable Areas.**
    a. This involves combining the LST, NDVI, NDWI, and BSI layers using a weighted overlay approach. This involves assigning weights or scores to each index based on its contribution to urban heat vulnerability. Areas with high LST, low NDVI, low NDWI, and high BSI typically indicate higher vulnerability to urban heat.

Gaza Strip	***Rabat***	***Egypt - Mansoura***
		
Vulnerability index: 0.66 (Without pop)	**Vulnerability index:** 0.56 (Without pop)	**Vulnerability index:** 0.31 (Without pop)

5. **Urban Heat Vulnerability index.**
    a. **This involves merging the Urban Heat Vulnerable Areas map to the population dataset, to get areas with high urban heat potential with the highest population.**

Gaza Strip	***Rabat***	***Egypt - Mansoura***
		
Vulnerability index: 0.49 (With pop)	**Vulnerability index:** 0.45 (With pop)	**Vulnerability index:** 0.24 (With pop)

Discussion

The urban heat analysis highlights the urban heat islands and vulnerability in the two regions. Due to the nature of the land cover present in the two regions, higher values in temperature can be observed on the sandy and bare land, as sand absorbs more heat than the built up area, vegetation and water. However, Urban Heat Islands can be observed in the built up area, which go hand to hand with the general characteristics of urban heat islands, such as roofs with higher reflectance, low to no vegetation cover, and no presence of water features. Modis is also used to show the Surface thermal inertia characteristics of various materials. It can be clearly seen, how, although sand has a high heat absorption rate, it also has a high heat dispersion rate, unlike the built up and asphalt surfaces, whose difference between day and night is minimal. Areas with higher values, both day and night, exhibit areas with a higher heat index.

The resulting UHVI (Urban Heat Vulnerability Index) is a single raster layer or map that classifies the study area into different levels of urban heat vulnerability, such as low, moderate, high, or very high vulnerability. Areas with higher UHVI values typically indicate a combination of higher surface temperatures, lower vegetation cover, less water availability, a higher proportion of built-up surfaces, and higher population densities, making them more vulnerable to the adverse effects of urban heat.

The UHVI can be used by urban planners, policymakers, and stakeholders to identify and prioritize areas for targeted interventions, such as increasing green spaces, implementing cool roof strategies, improving urban ventilation, or implementing heat adaptation measures for vulnerable populations. It provides a spatial representation of urban heat vulnerability, enabling informed decision-making and resource allocation to mitigate the impacts of urban heat islands and improve resilience to extreme heat events.