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Assessment of some Vulnerability Parameters to the Urban Heat Island using Space based data

Case study, Tanta , Egypt

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Brief overview for Climate Change impacts in Egypt

Egypt - Climate Change Concerns

- As the home of one of the oldest civilizations on the planet, Egypt's concern about global climate change and its consequences on sustainable development.
- Egypt is a signatory to the 1995 United Nations Framework Convention on Climate Change (UNFCCC).

Impacts of climate change in Egypt

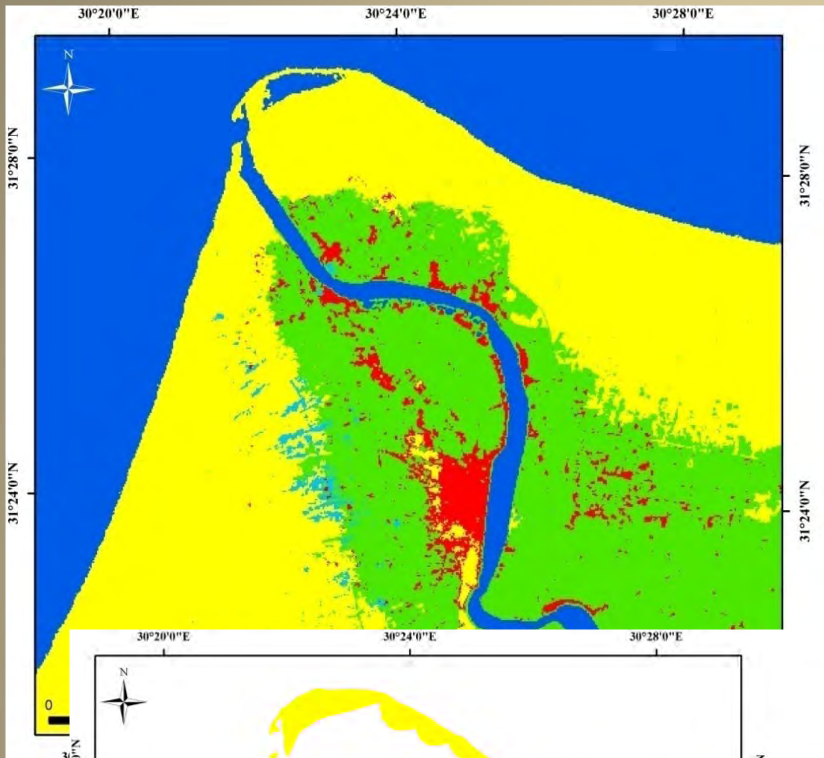
- Egypt is **vulnerable to climate change impacts** in vital areas threatening the **sustainability of its natural and socioeconomic systems**.
- **The rise in sea level** threatens Egypt’s long coastal stretch on the Mediterranean and the Red Sea with potential damages to tourism industry, a major contributor to the Gross Domestic Product (GDP), as well as impacts on the entire ecosystem.
- Climatic changes will also **impact agricultural productivity** and fisheries, thus influencing the country's food supply.
- **Rise in temperature and heat waves** threat the public health and affects activity and productivity.

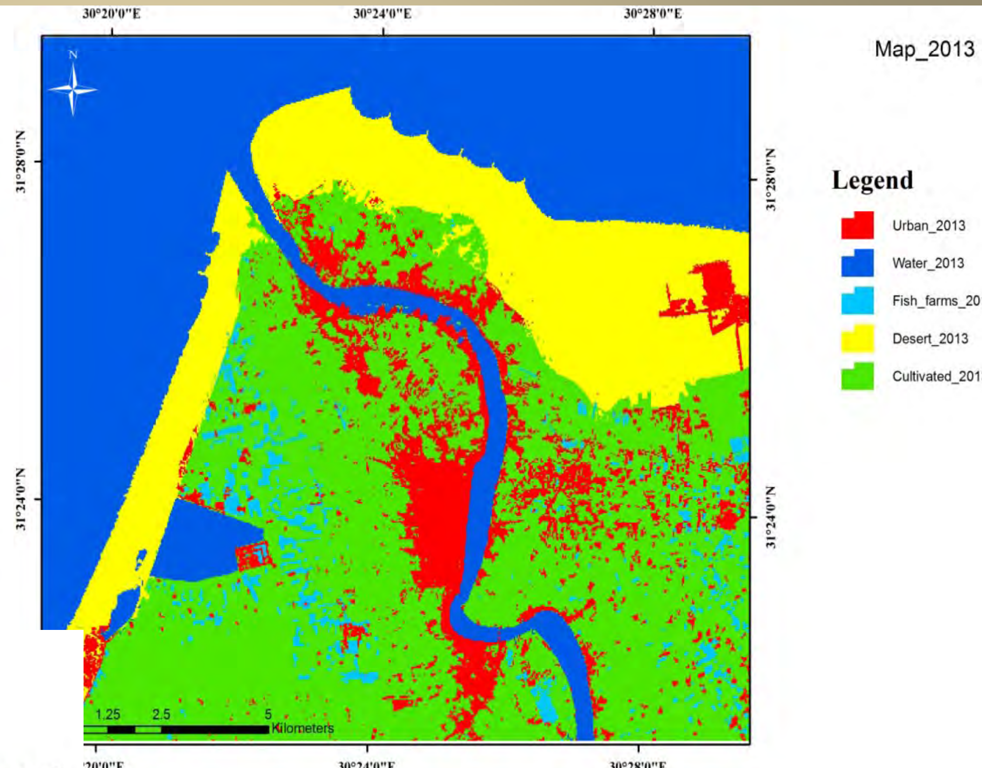
Scenario Sea level Rise and Nile Delta

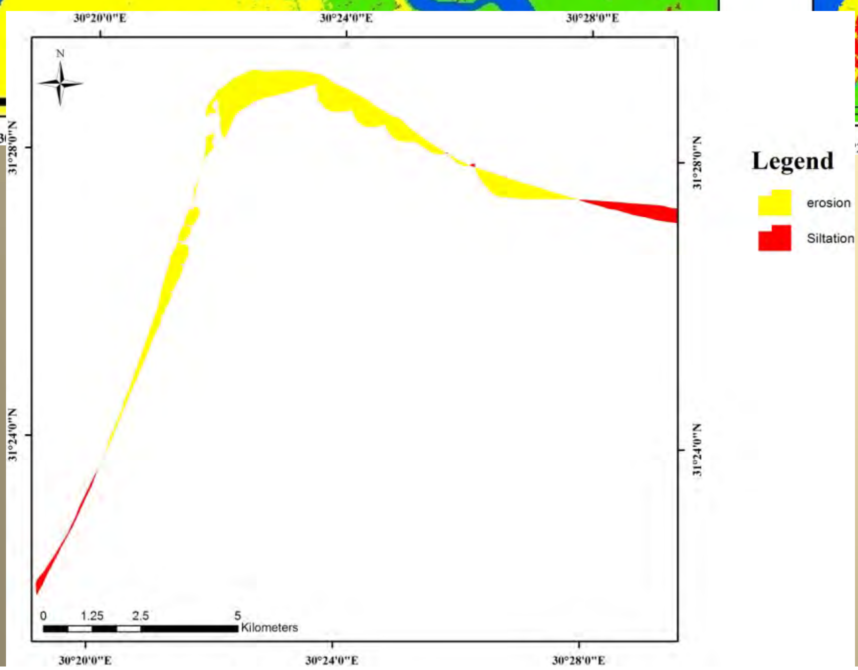
Rising sea level would destroy weak parts of the sand belt, which is essential for the protection of lagoons and the low-lying reclaimed lands. The impacts would be very serious: 1/3 of Egypt's fish catches are made in the lagoons. Sea level rise would change the water quality and affect most fresh water fish. Valuable agricultural land would be inundated. Vital, low-lying cities in Alexandria and Port Said would be threatened. Recreational tourism beach facilities would be endangered and essential groundwater would be salinated. Dykes and protective measurements would prevent the worst flooding up to a 50 cm sea level rise.It would cause serious groundwater salination.

Sources :Otto Simonett, UNDP/GRID Geneva, G.Sestini, Florence

Shoreline Erosion







Rosetta shoreline

Accretion	0.93 sq.km
Erosion	5.63 sq.km

Water Shortage

Egypt's water supply is primarily dependent on the second largest river in the world, the Nile.

The mean annual rainfall in Egypt varies from a maximum of 180 mm/year on the north coast, which extends for a distance of 1000 km, then decreases to an average of 20 mm near the city of Cairo, and diminishes to as little as 2 mm close to the city of Aswan in upper Egypt (Egyptian Environmental Affairs Authority, EEAA).

Adaptations

Water management is one of the most important adaptation actions. Adaptation options include measures to improve rain-harvesting techniques, increasing extraction of ground water, recharging groundwater, water recycling water, water desalination, and water conservation , reducing evaporation (through transportation canals and reservoirs)

Global rise in temperature and green gas effects on Soil and Crops

Vulnerability of crops to changes in pest infestation and plant diseases is another potential impact of climate variability. (EEAA)

Increases the risk of land degradation and desertification.

Decreases in crop yield in Egypt. Major crops like wheat and rice will be affected.

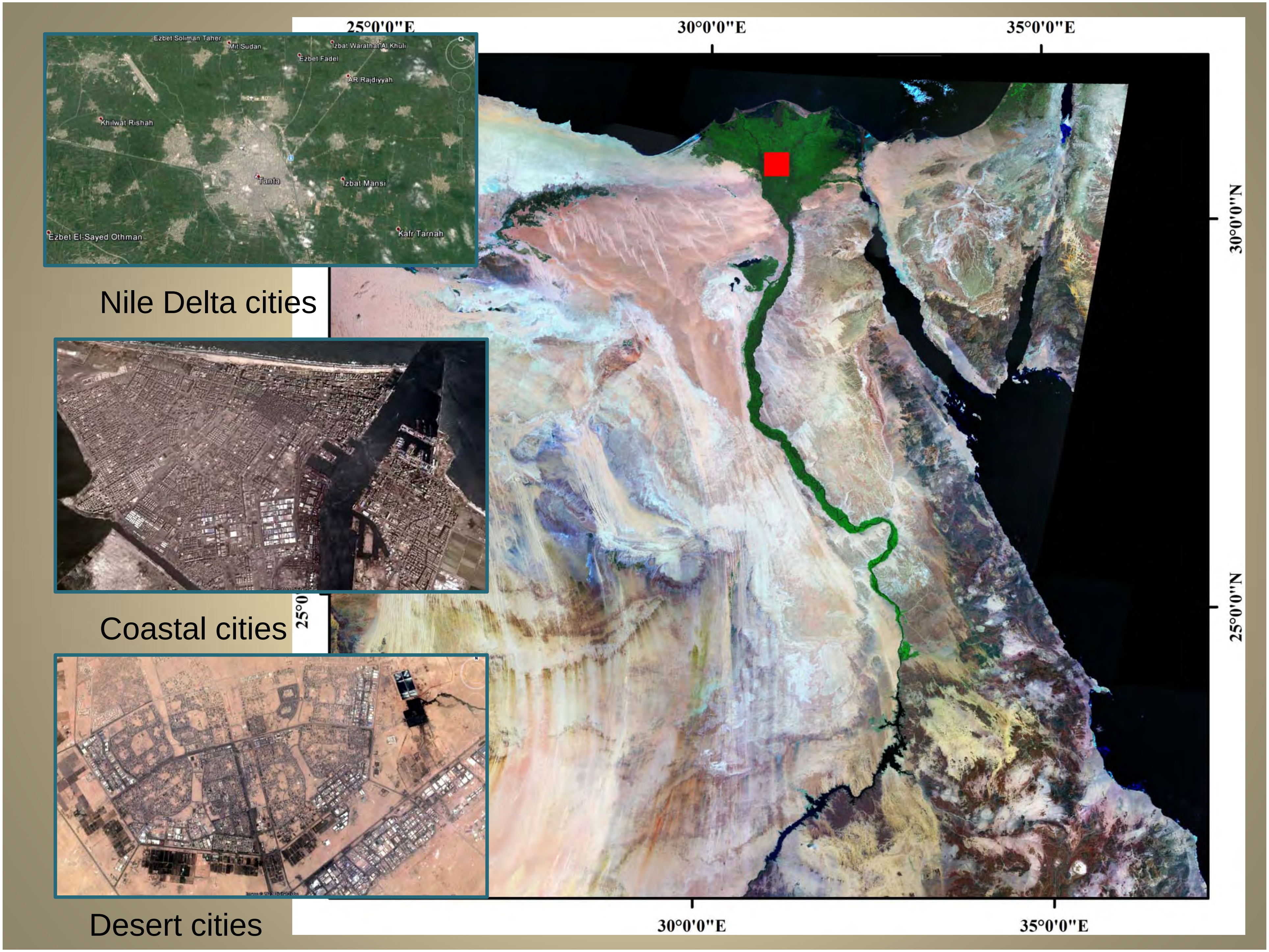
Red Sea coral reefs

are among the most spectacular in the world, a high level of biodiversity with over 1,000 named species and many more yet to be identified. They are considered among the most sensitive ecosystems to long-term climate change. (EEAA)

a) Healthy coral reef   b) Bleached coral reef.

Corals are especially **sensitive to variation in sea surface temperatures**, and when physiologically stressed, corals may lose symbiotic algae, which supply nutrients and colors. In this stage, corals appear white and are referred to as bleached

Egyptian Cities and Climate Change Vulnerability


25°0'0"E
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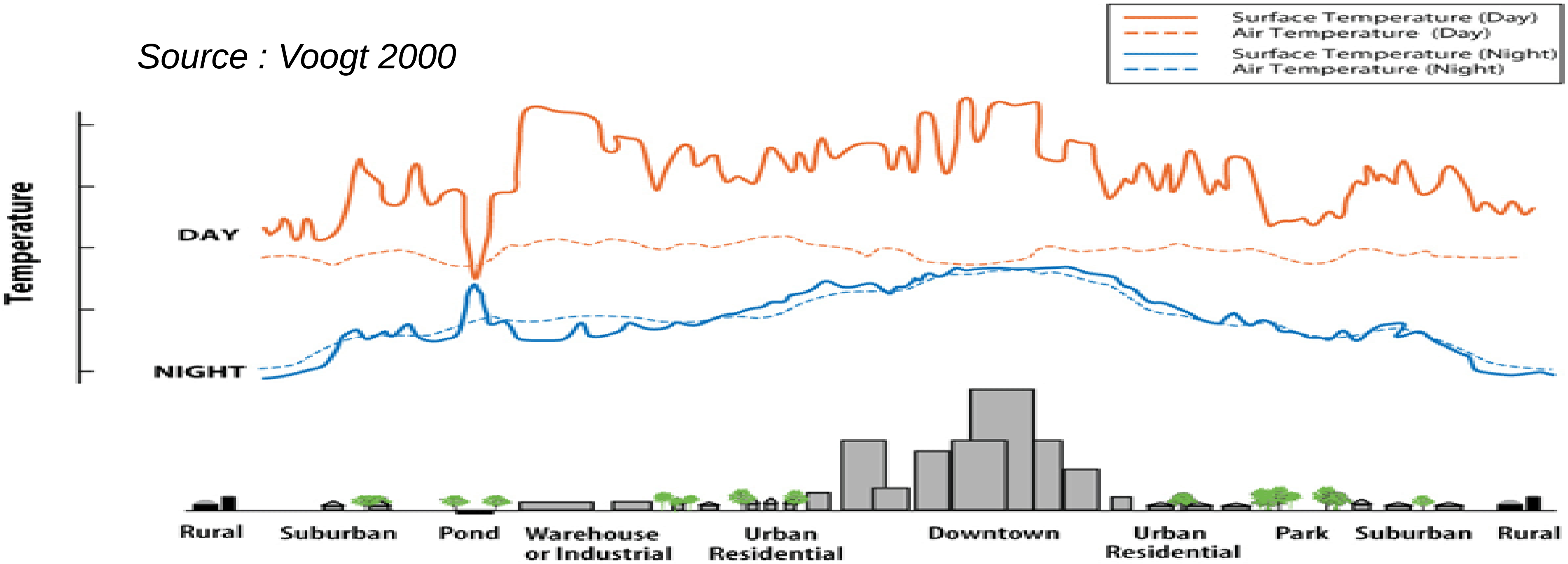
Ezbet Soliman Taher
Mit Sudan
Izbat Warathat Al Khuli
Ezbet Fadel
AR Rajdiyyah
Khilwat Rishah
Tanta
Izbat Mansi
Ezbet El-Sayed Othman
Kafr Tarnah
Nile Delta cities
Coastal cities
Desert cities

Urban Heat Islands on Cities

An urban heat island refers to the excess warmth of the urban atmosphere compared to the non-urbanized surroundings. The annual mean air temperature of a city with 1 million people or more can be (1–3°C) warmer than its surroundings. In the evening, the difference can be as high as (12°C).

Source : Voogt 2000



Why is the urban environment vulnerable to UHI

- Most greenhouse gas emissions that contribute to global climate change come from urban areas. These emissions therefore contribute to both local and global scale weather and climate modification. Further urbanization will increase emissions originating from cities. Investigation of the larger scale impacts of urban emissions is seen as an important area of future research.

- It is therefore important to study urban climates not only to the local environment but also to the state of the environment for the planet as a whole.

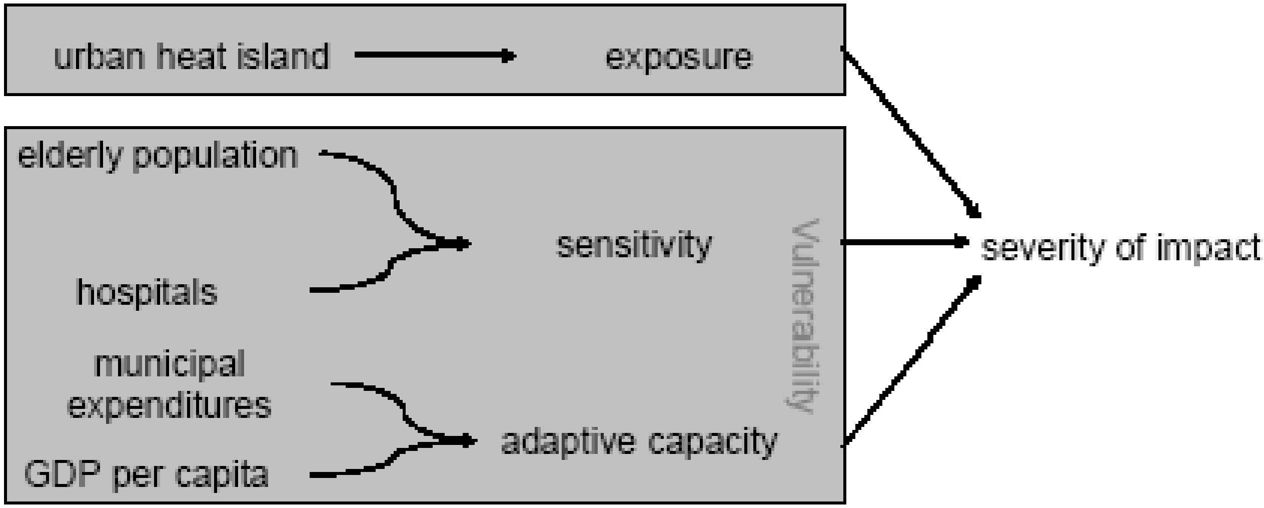
Why Do We Care About Heat Islands?

- ***Increased energy consumption*****:** Higher temperatures in summer increase energy demand for cooling and add pressure to the electricity grid during peak periods of demand.
- ***Elevated emissions of air pollutants and greenhouse gases***: Increasing energy demand generally results in greater emissions of air pollutants and greenhouse gas emissions from power plants. Higher air temperatures also promote the formation of ground-level ozone.
- ***Compromised human health and comfort*****: Hyperthermia** is elevated body temperature due to failed thermoregulation that occurs when a body produces or absorbs more heat than it dissipates. Extreme temperature elevation then becomes a medical emergency requiring immediate treatment to prevent disability or death. Respiratory difficulties, heat cramps and exhaustion, non-fatal heat stroke, and heat-related mortality.
- ***Impaired water quality*****:** Rapid temperature changes can be stressful to aquatic ecosystems.

Climate Change Vulnerability and Impacts on Cities

- Some cities are <u>vulnerable to climate change impacts</u>. Particular vulnerabilities can be :
- **To environmental exposure** (storm, sea level rise and land subsidence, flooding, drought)
- **Socio-economic sensitivity** (population, assets threatened).
- **Inverse adaptive capacity**, that is, its inability to adapt.

Severity of the Impacts



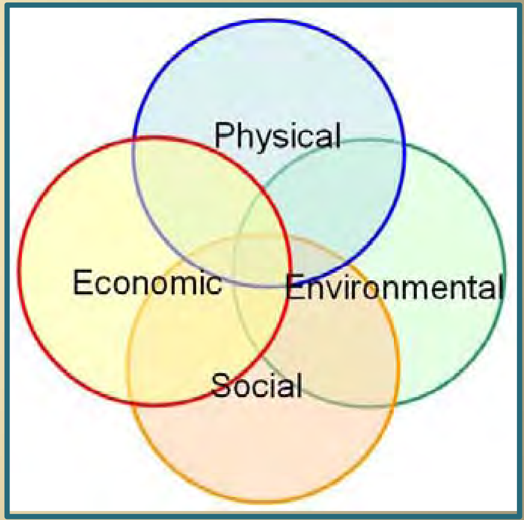
Source: Own illustration.

<u>Exposure</u> and **<u>vulnerability</u>** both influence **the severity of impacts** of urban heat islands. Vulnerability of urban population is determined by sensitivity (response of the system) and <u>adaptive capacity</u> (possible adjustments).

Vulnerability

Vulnerability = (Exposure) + (Resistance) + Resilience

Exposure: at risk property and population;
Resistance: Measures taken to prevent, avoid or reduce loss;
Resilience: Ability to recover or achieve desired post-disaster state.



- **Multi-dimensional (**e.g. **physical,** social, **economic, environmental**, institutional, and **human factors define vulnerability**);

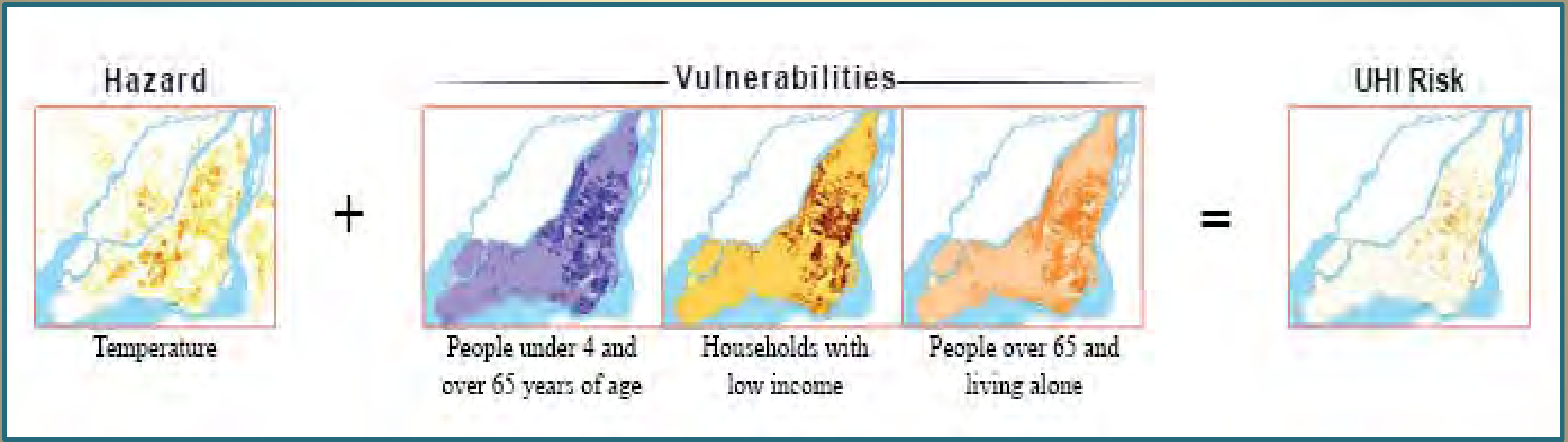
- **Dynamic (vulnerability changes over time).**

- **Scale-dependent can be** expressed at **different scales** from human to household to community to country **resolution;**

- **Site-specific (each location might need its own approach)**

UHI – Risk Levels

(Hazard, vulnerability and risk indices)



Source : Chee F Chan, Julia Lebedeva, José Otero, and Gregory Richardson (2007)

UHI Vulnerability Concepts

- Exposure : is influenced by :

  (1) The extent of the urban heat island in a given city

  (2) climate change (heat waves).

- Sensitivity : is differentiated into :

  (1) sensitivity of the population (poverty, age,)

  (2) medical coping potential (availability of hospital care) *WHO 2004.*

- Adaptive Capacity: is differentiated into :

  (1) adaptive capacity of the urban system.

  (2) adaptive capacity of the population.

Parameters affecting the Urban Climate

- **Albedo of a surface** is defined as its hemispherical and wave-length integrated reflectivity.

- **Anthropogenic heating** affects the near surface air temperature and participates in creating the UHI. (temperature scanning tools and in-situ data)

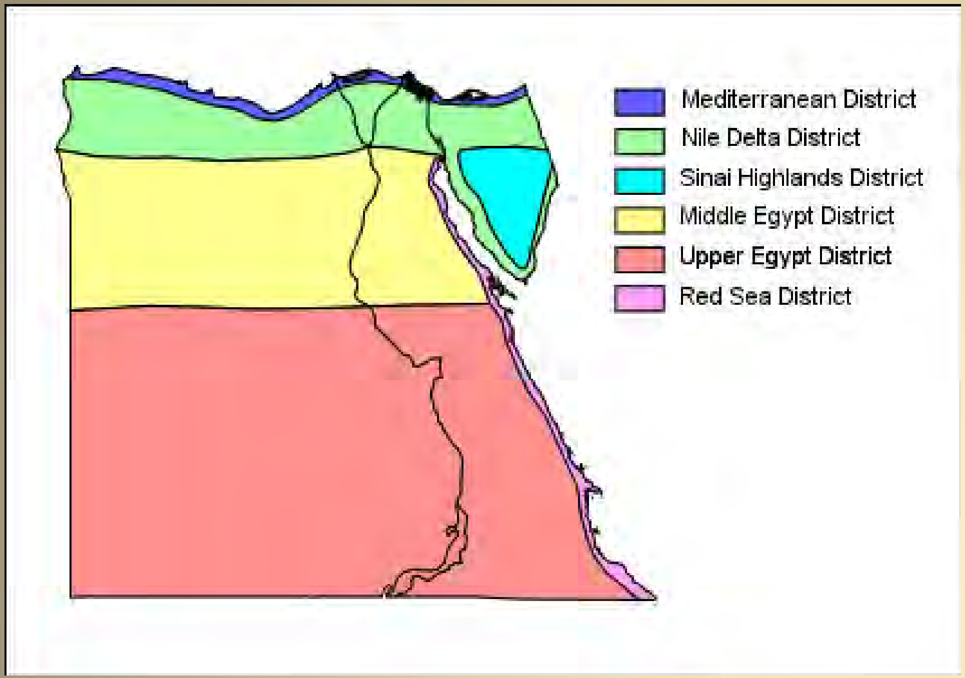
- **Evapotranspiration from plants**, soil is a moderator of near-surface climate.

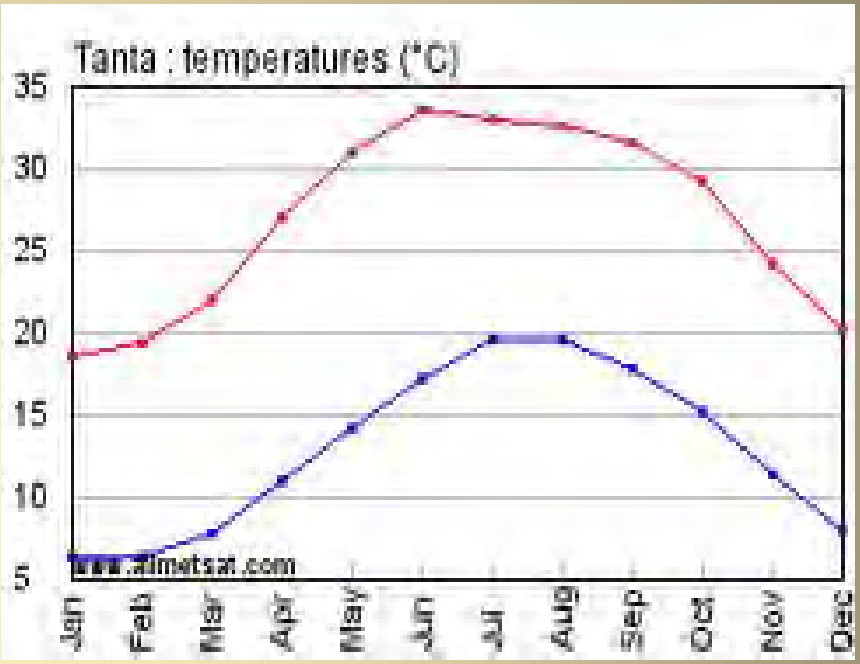
Assessment the UHI in Tanta City

Tanta city

- Tanta is located 94 km north to Cairo. Average area 1,942 km^2.
- Egypt's fifth largest populated area, with an estimated 450,000 inhabitants (2005). Population density 150 person/Acre.
- The city can be considered both as an industrial city as well as an agricultural centre. Among its industries cotton ginning, petroleum refining, flour milling, wool spinning, cottonseed oil extracting, tobacco products and processed food.
- The industrial zone lies in the south eastern part of the city. (area 76,132 sq.km)

Temperature

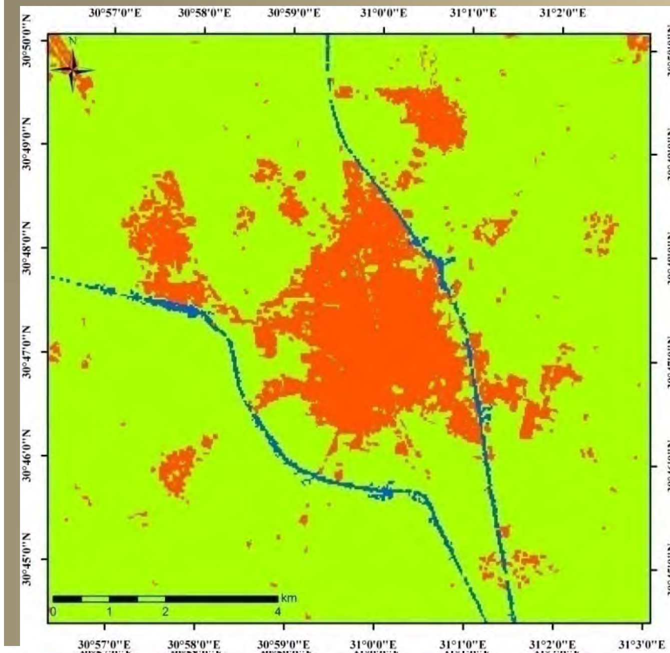




Temperature -Tanta city

F (C)	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Max	66 (19)	69 (21)	75 (24)	83 (28)	90 (32)	94 (34)	96 (35)	95 (35)	90 (32)	86 (30)	75 (24)	69 (21)
Min	47 (9)	49 (9)	52 (11)	57 (14)	63 (17)	64 (18)	71 (22)	71(22)	68 (20)	64 (18)	57 (14)	51 (10)

Landsat TM data were used for change Detection of Urban Growth Tanta Region

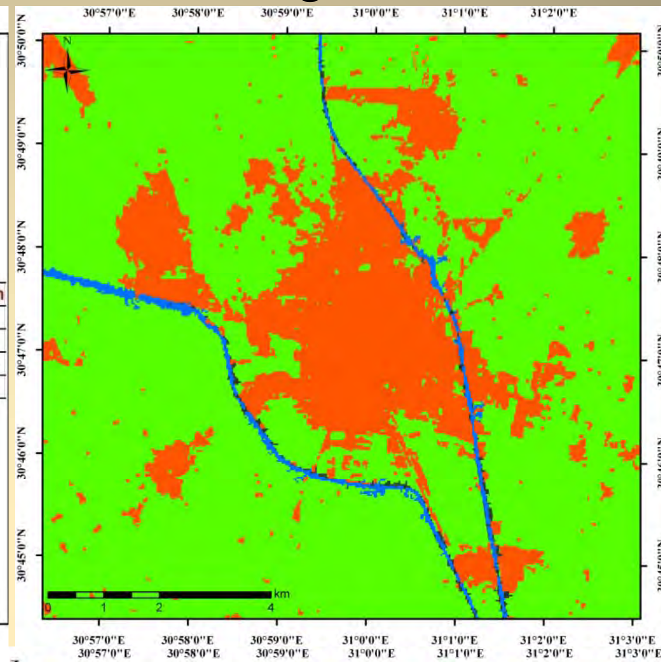


Class _1984

Legend

- Canal_1984
- Urban_1984
- Cultivated_1984

Legend	Area (km2)	Feddan
Canal	1.70	408
Urban	16.90	4055
Cultivated	95.14	22834
SUM	113.74	27297

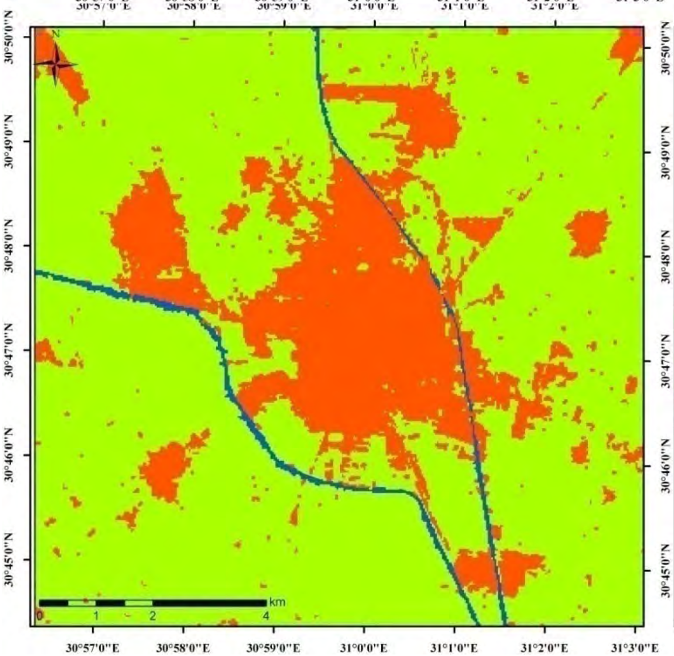


Class _1990

Legend

- Canal_1984
- Urban_1990
- Cultivated_1990

Legend	Area (km2)	Feddan
Canal	1.88	451
Urban	24.76	5943
Cultivated	87.24	20937
SUM	113.88	27331

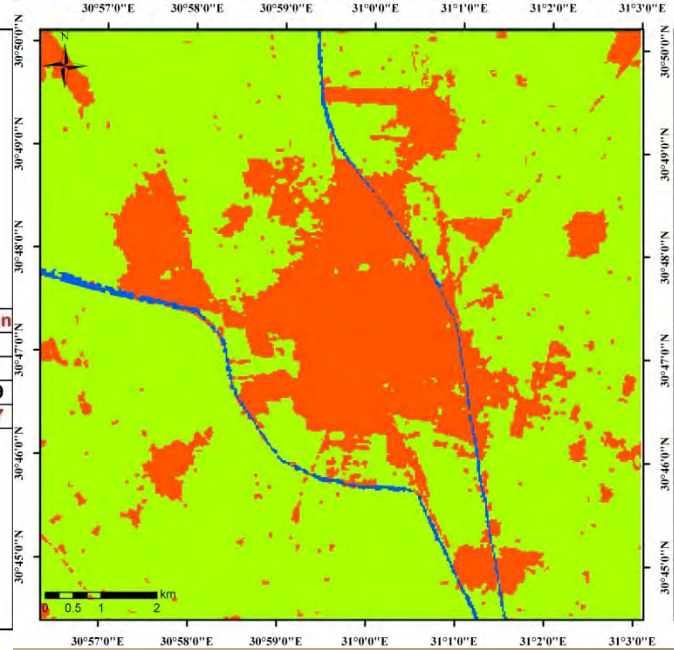


Class _1998

Legend

- Canal_1998
- Urban_1998
- Cultivated_1998

Legend	Area (km2)	Feddan
Canal	1.65	395
Urban	25.72	6172
Cultivated	86.37	20729
SUM	113.74	27297



Class _2005

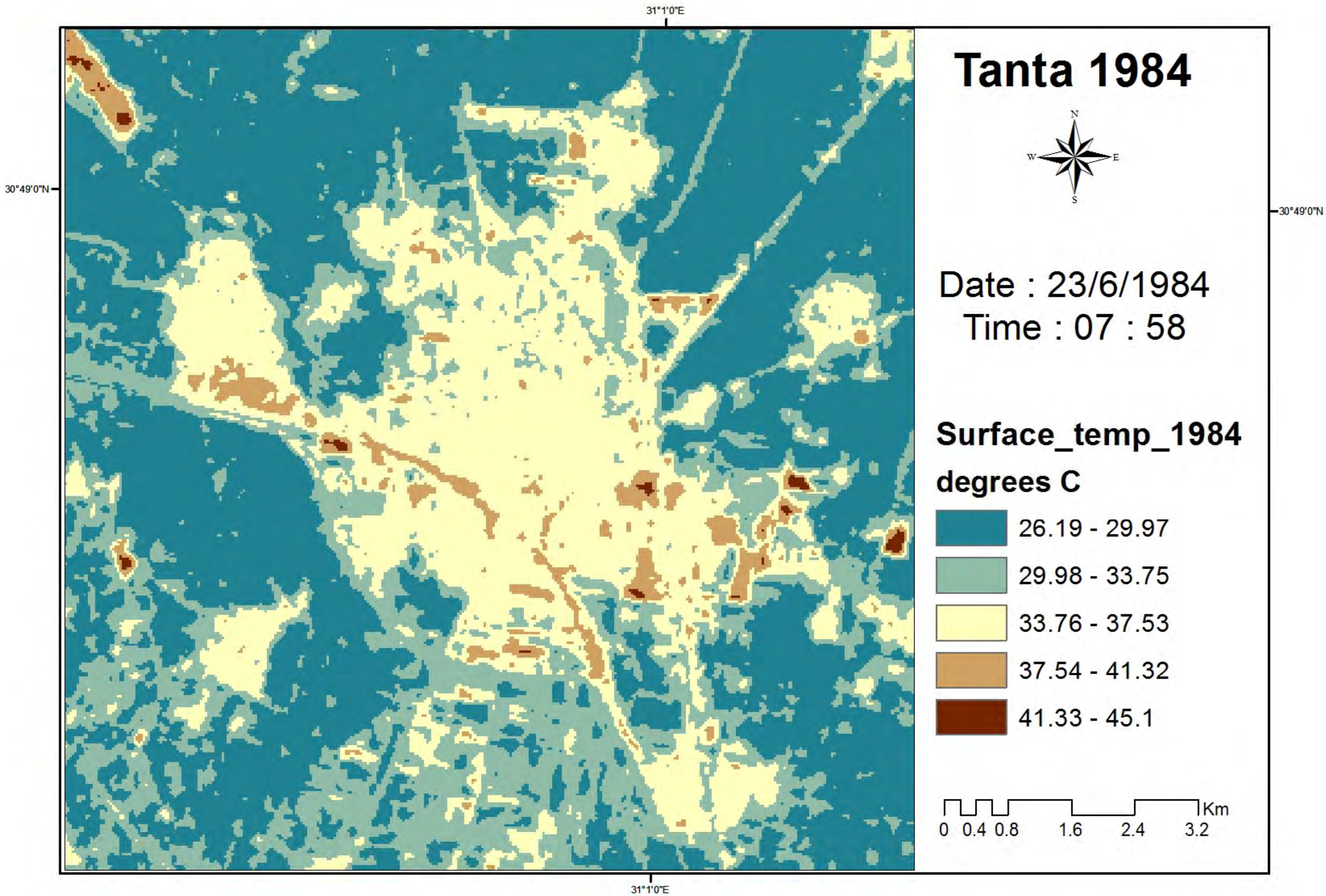
Legend

- Canal_2005
- Urban_2005
- Cultivated_2005

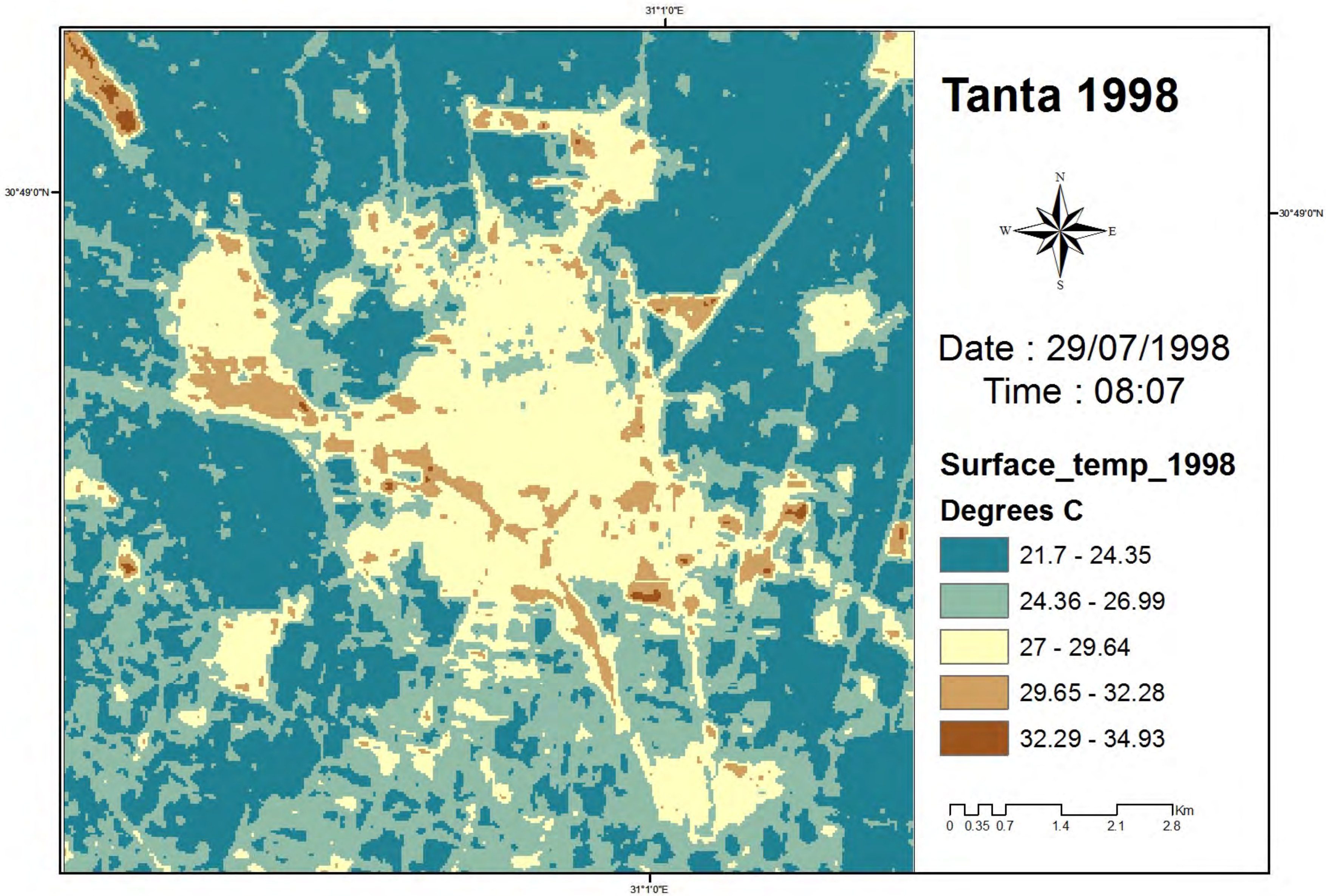
Legend	Area (km2)	Feddan
Canal	1.20	288
Urban	27.70	6647
Cultivated	84.85	20363
SUM	113.74	27299

Detection of the Heat Islands in Tanta Region using Landsat TM, ETM thermal bands

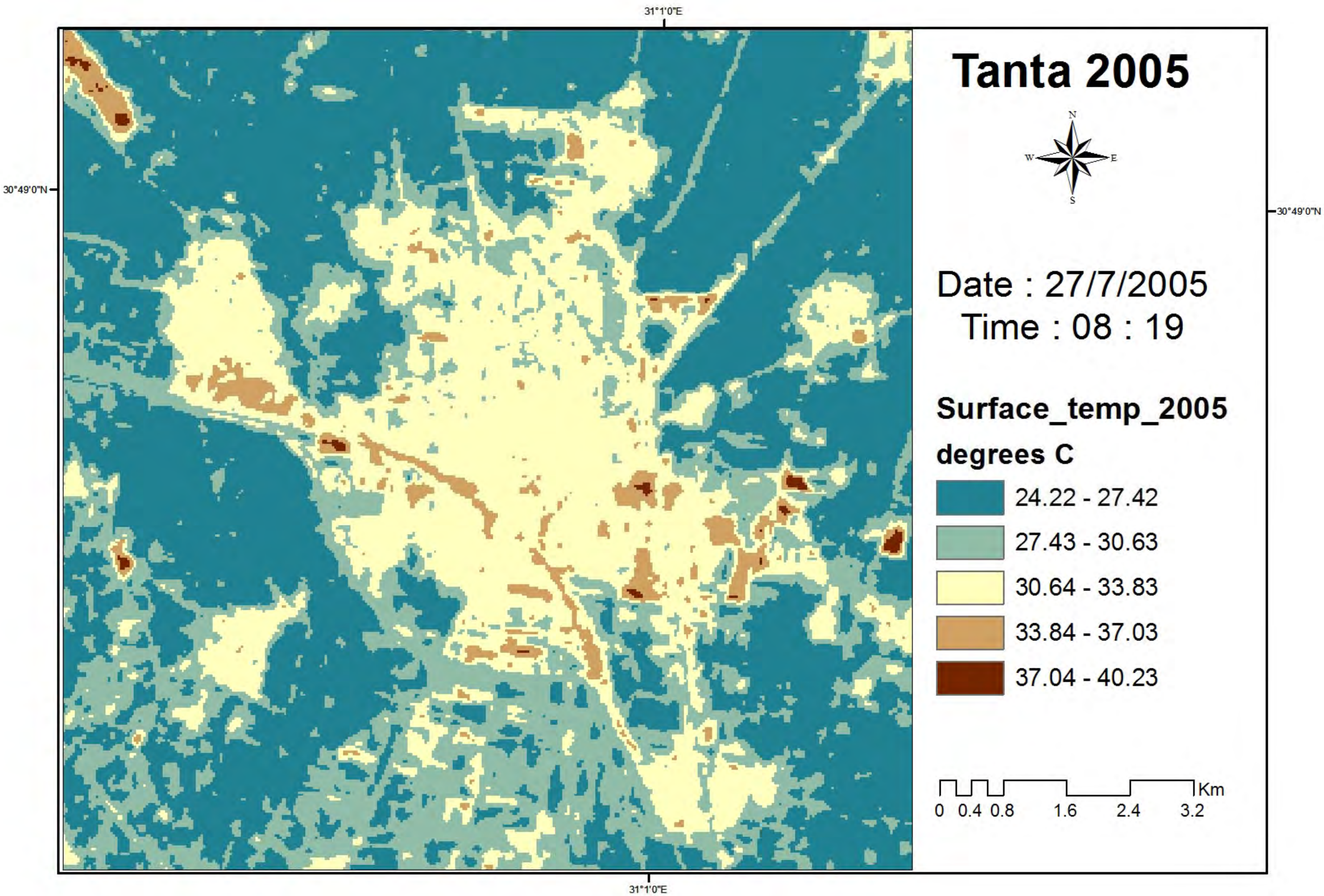
- **Surface Heat Measurements :**
- Some Satellite images (such as Landsat TM, ETM) provide a surface-based measurement that records energy (wave length in thermal bands) reflected and emitted from the land , including built-up areas, vegetation, bare ground, and water.
- Landsat TM, ETM thermal bands thermal infrared bands (10.4–12.5 μm) were used for mapping UHI for Tanta city.
- **The digital numbers (DN) were converted to radiance.**
- The **radiance was converted to surface temperature** using the Landsat specific estimate of the Planck curve



Temp difference reached average 4 degrees C with few scattered hotspots reached more than 11 degrees C.

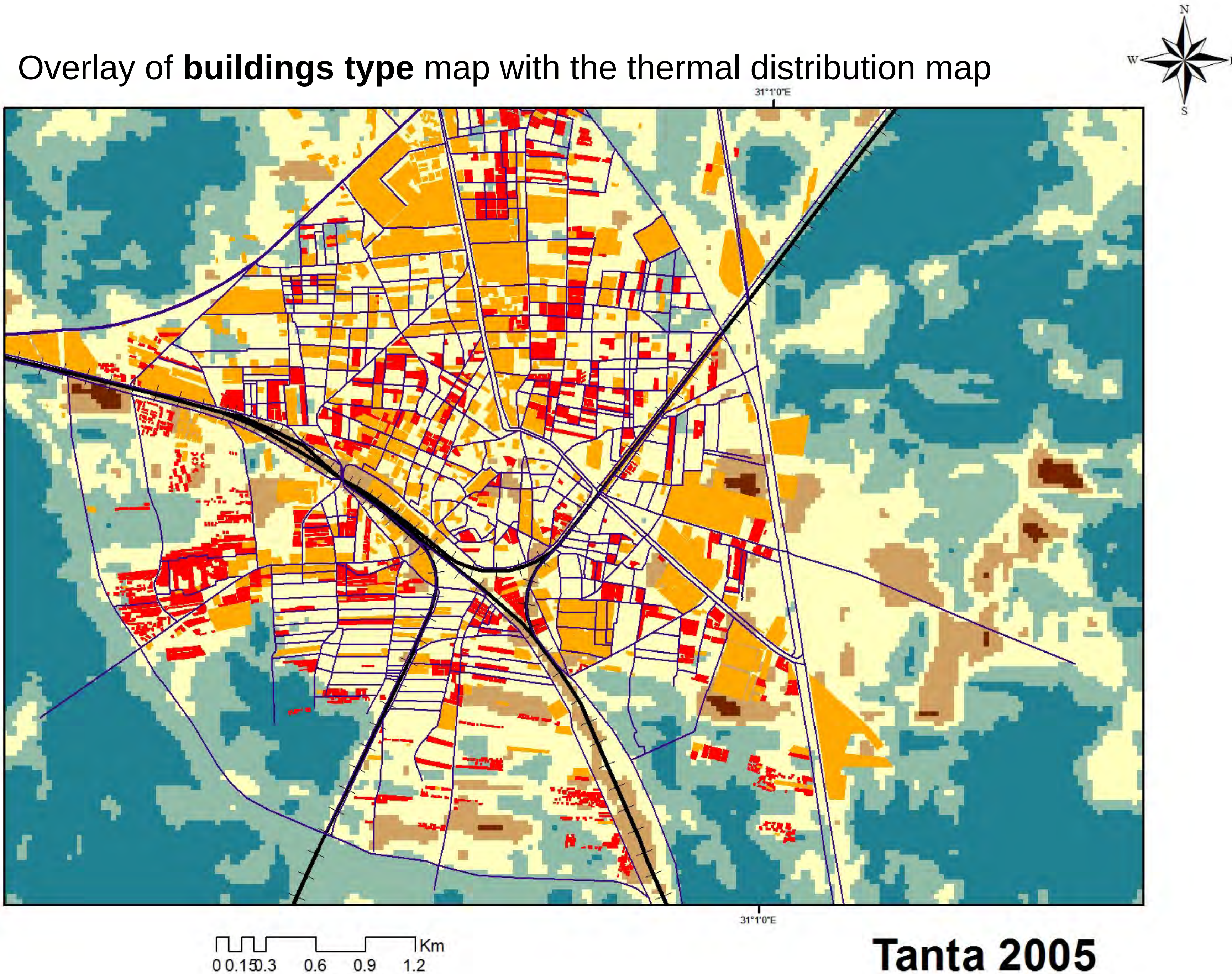


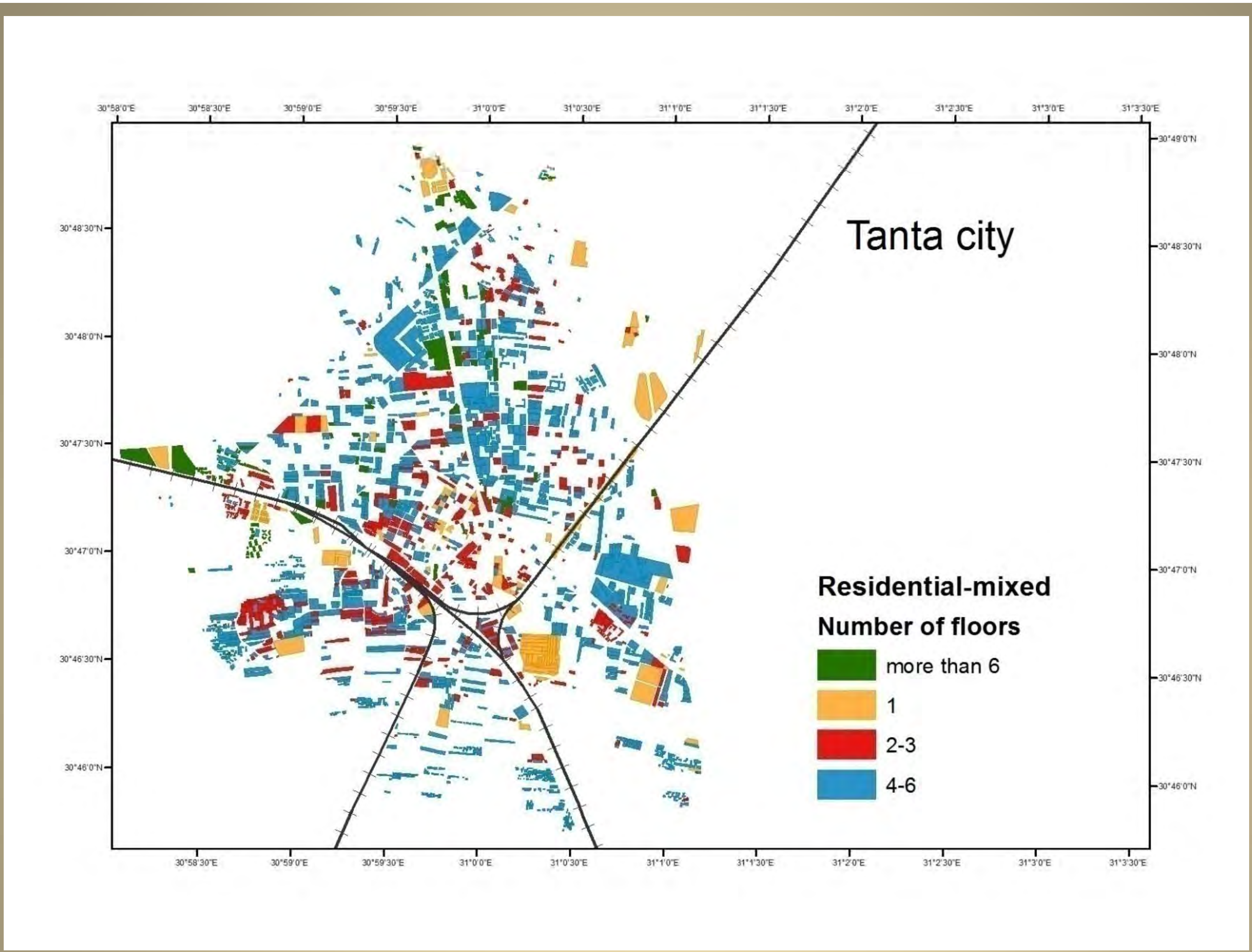
Difference in surface temperature is almost 3 degrees while hotspots reaching an increase of 7degrees C.



Difference in surface temperature is almost 3 degrees while hotspots reached almost 7 degrees C.

Overlay of **buildings type** map with the thermal distribution map





Roof geometry, **vegetation areas (%) and** variance in **building heights,** contribute to the urban surface temperature. **Hyperspectral images** can be used to identify urban material and emissivity.

Findings

- Some hotspots in the city were inspected through field investigations:
- The **industrial zone** and the **railway routes** have highest surface temperature reaching 34.93 degrees C in 1998 and reaching 37 degrees in 2005 in Summer early mornings.
- **Hotspots were detected over industrial zones** reaching max 45 degrees C in 1984 and 35 degrees C in 2005 in summer early morning.
- **Higher temperature** degrees were detected on **mixed building** (such as residential and garages, workshops) rather than pure residential buildings (field investigations).
- **The remote sensing data** provides not only a ***measure of the magnitude of surface temperatures*** of the entire metropolitan area, but also the ***spatial extent of the surface heat island*** effects.

Deriving some UHI Vulnerability Indicators and index in a City
RS and GIS

1. **Generic social vulnerability indicators**
   - Percentage of young children
   - Percentage of elderly people
   - Percentage of households living below poverty level.

2. **UHI specific social vulnerability indicators (GIS)**
   - people located in slums
   - people located in high density built-up areas.
   - people located in zones with little or no open green areas.
   - People in homes with poor facilities (quality of water, sewage, electricity)
   - Poor , low income people ; can not afford air conditions .

3. **UHI specific physical vulnerability indicators (RS)**
   - Buildings located in slum zones
   - Building located close to industrial zones, public garages, ..
   - High density buildings (several floors, narrow streets, ..)
   - Low Percentage or lack of green areas .
   - Percentage of open areas.
   - Percentage of asphalt roads and highways lacking trees and shades.

4. **Capacity indicators**
   - Awareness.
   - Government Programs for improvements of the environment in cities.
   - Improve health care.

Conclusion and Recommendation

Space Based Images Role in UHI

- **Space - based derived images** can help decision makers in developing compatible **strategies** (to reduce climate-related impacts / risk) i.e. **"climate risk management.**

- **Thermal remote sensing** is a base for measuring, mapping and analysis of UHI.
- **High resolution images** provide a great potentiality to examine, analyze and mange the urban environment.
- **Medium resolution** images provide a source for studying the geographical features, location parameters of a city, growth and changes over time .
- **Hyper-spectral images** can provide more information on roof building materials, emissivity, etc..)
- **Laser scanning** (LIDAR) data provide 3-D models which in turn help in understanding the urban fabric and geometry influencing urban climate.
- **In-Situ data and GIS spatial models** should be integrated with RS technology for **studying the vulnerability of a society and risk assessment**.

UHI Risk Mitigations and Resistance

Programs Adopted by the Egyptian Government

- Egypt has challenges and opportunities to reduce the heat island effect using some Strategies and Programs. Example of such programs are:
- Integrating the climate change issue in plans and programs (for example the UHI city possible reduction of impacts, programs and plans)
- Less buildings densities (urban fabric) in new cities.
- Adopting proper waste management systems (recycle solid waste, water treatments).
- Increasing trees and green areas.
- Improving public transportation systems and infrastructure.
- Switching to green energy plans (solar, wind,..)
- Increase public awareness about urban heat islands.
- Promote health care related to environment and heat waves.
- Local treatments for existing buildings such as green roofs, treated building materials (with less heat absorption , albedo, ..etc)

Researchers' needs

- In order to be able **to assess Vulnerability in urban areas**, we need to integrate demographic information (social status, economic status, political,…). We need to integrate information about exposure (elements at risk) e.g. the built-up environment *(types and conditions of the buildings, building densities, transportations systems, drainage systems, waste management system, 3-D city models)* with the information derived from remotely sensed data.

- Remote sensing provide a great potentiality to detect, quantify, compare, visualize and analyze hazards, vulnerability and risk. **Improvements in the spatial and spectral resolution** of current and next generation satellite-based sensors, (in more detailed representations of urban surfaces ,availability of low cost, high resolution portable thermal scanners) are expected to allow progress in the application **of urban thermal remote sensing.**

Environment *Photo by Bedaya NGO* البيئة