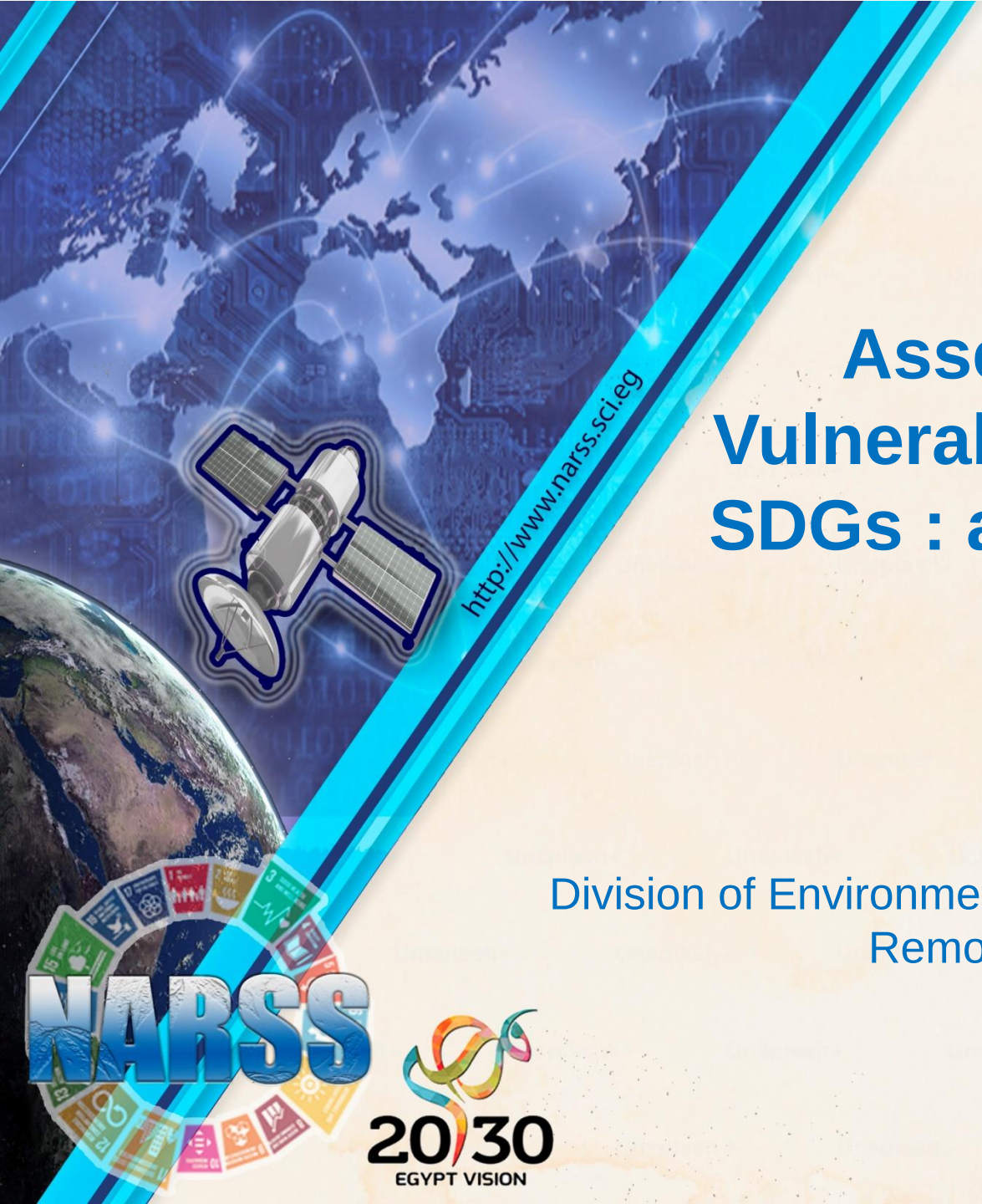
جمهورية مصر العربية
وزارة التعليم العالي والبحث العلمي
الهيئة القومية للاستشعار من البعد وعلوم الفضاء
National Authority for Remote Sensing and Space Sciences



Assessment of Environmental Vulnerability in cities in the light of UN SDGs : applications on some Egyptian Cities

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The world is steadily becoming urban.

50 percent of the world's population will be dwelling in cities between 2000 and 2030. All the growth of the world’s population is expected to be absorbed by the urban areas of less developed regions. (UN, 2018)

Urban Vulnerability

- Since urban vulnerability to disasters is after all a function of human behavior, **there is a need for** a better understanding to :
- (a) Explain what **constitutes an urban vulnerability**.
- (b) Identify vulnerabilities **using assessment tools.**

Questions

- The presentation addresses 3 questions:
- **What ??**

What is meant by environmental vulnerability in cities?

- **Why ??**

Why ..what are the causes of such vulnerability to

- **How** ??

How can we measure, monitor and improve EV ?

- **Introduction**

Vulnerability and Capacity of cities

- **Vulnerability**

  A set of conditions and processes resulting from physical, social, economical and environmental factors, which increase the susceptibility a community to the impact of hazards and lowers its adaptation and resilience.

- **Capacities**

  A set of Positive factors, that increase the ability of people and their society to cope with hazards. *ie.* factors that increase their resilience, or reduce their susceptibility to the impact of hazards.

- Risk = Hazard * Vulnerability
-

Vulnerability (is crucial for Disaster Risk Management in Cities UNDRR)

- Disaster risk assessments include the identification of hazards such as their location, frequency, intensity and probability. The analysis of **exposure and Vulnerability,** including the physical, social, health, environmental and economic dimensions and the evaluation of effectiveness of coping capabilities with respect to likely risk scenarios.

Environmental Vulnerability in Cities : symptoms and causes

- ***Rapid and uncontrolled Urban growth*** due to rapid increase in population resulted in **inadequate housing** and growth of ***slums.***

- **High population density resulted in Inadequate or *insufficient habitats, infrastructure / services* .**

- **Cities are Centers of industrial activities** which cause ***pollution of air, water and health impacts*.**

- **Poor Waste management result in deteriora**tion of ***air, water*** ,and health impacts***.***

- **Illiteracy and Poverty *and lack of job s* in cities lead to *illegal activities and violence.***

The main Goals of this study are:

•To conduct and explore **RS & GIS models in construction of spatial indicators** to explore and map some relative environmental vulnerability factors leading to degradation in traditional Egyptian cities through some applications.

To identify and point out the relative needs among different city wards for allocation of service and utilities.

To provide guidelines for priorities of allocating resources and funds to promote the city resilience.

To follow and comply with some guidelines of the UN Habitat Sustainable Development Goals (SDG 11).

Urban Sustainable Development Goals (USDGs) based on UN 2030 Agenda

- **Urban Sustainable Development Goals (USDG)** are part of the United Nations 2030 Agenda for Sustainable Development.

- **Goal11s addresses sustainable cities** and communities as follows:
- “**make cities and human settlements inclusive, safe , resilient and sustainable”.**
- It includes a series of 11 targets, each with politically negotiated indicators”.

SUSTAINABLE DEVELOPMENT GOALS

2015

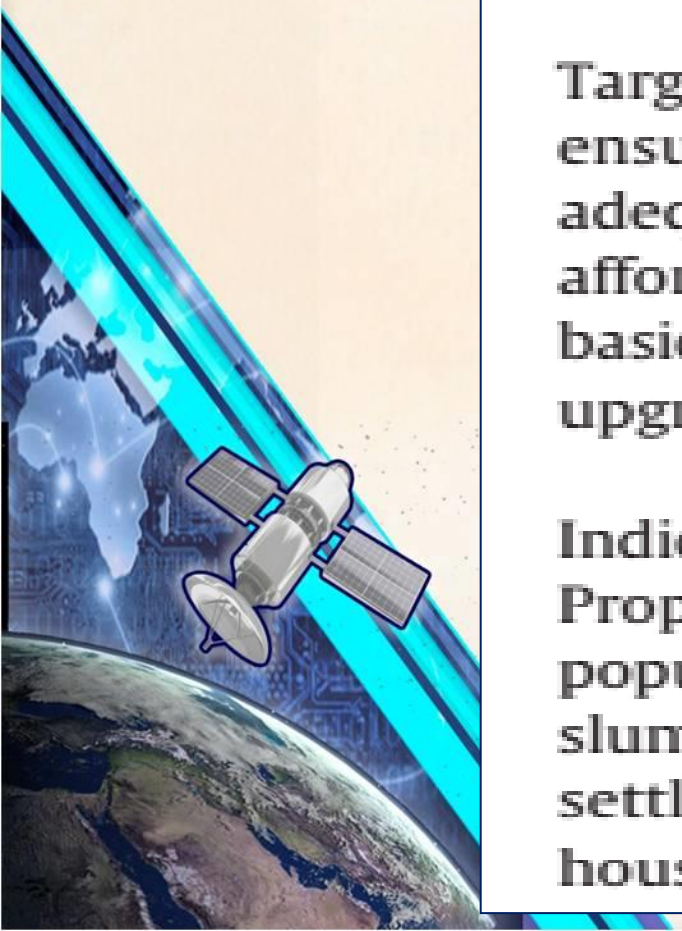
1. No Poverty
2. Zero hunger
3. Good health and well being
4. Quality education
5. Gender equality
6. Clean water and sanitation
7. Clean energy
8. Descent work and economic growth
9. Industry, innovation and infrastructure
10. Reduced inequalities
11. **Sustainable cities and communities**
12. Responsible consumption and production
13. Climate action
14. Life below water
15. Life on land
16. Peace, justice and strong institutions
17. Partnerships for the goals

NARSS

20/30 EGYPT VISION

USDG Targets vs Challenges

USDG 11
SDG 11: Make cities inclusive, safe, resilient and sustainable. Target 11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums Indicator 11.1.1 Proportion of urban population living in slums, informal settlements or inadequate housing



Sustainable Development Goal 11 and other urban indicators require spatial data for reporting.

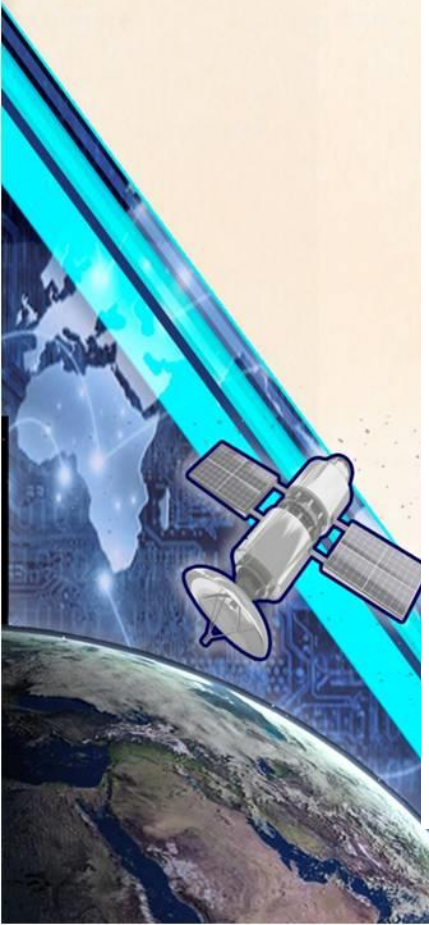
The Indicators System

- The word for *indicator* in Arabic also means "***pointer".***
- No policies without indicators, no indicators without policies.

- A set of indicators may be established to permit evaluation of the objectives or policies .(UNCHS, 1995 and World Bank/UNCHS, 1991).

- ***key indicators***, are regarded as the minimum data requirement to monitor the most important issues.

- ***Extensive indicators***, are intended to permit a more comprehensive evaluation of particular sectors.



Indicator-based indices and GIS

- Indicator-based indices can be used to measure sustainability and/or vulnerability /degradation….

- Assessment of city's vulnerability index necessitate integration of **remote sensing data**, spatial **GIS models**, in addition to surveys and **demographic census data to create SPATIAL indices.**

Perception of City Vulnerability Index (CVI)

- **The City Vulnerability Index (CVI)** is a single (combined) measure of the level of degradation. (it points out the needs for improvement) in cities based on the urban environmental conditions (natural, shelter, economic and social dimensions).

- CVI is usually calculated by aggregation of sub-indices derived for **natural environment**, **infrastructure**, **social** ,**economic, shelter** criteria.

Geospatial Tools in Vulnerability Assessment of urban communities (vulnerability index)

- Satellite data has been widely used in vulnerability assessment of the natural environment in cities such as detection of urban heat islands, city growth / sprawl, flash flood hazards, dust storms and many others.

- A growing area of research is the use GIS to construct a **vulnerability index for urban communities** and services.

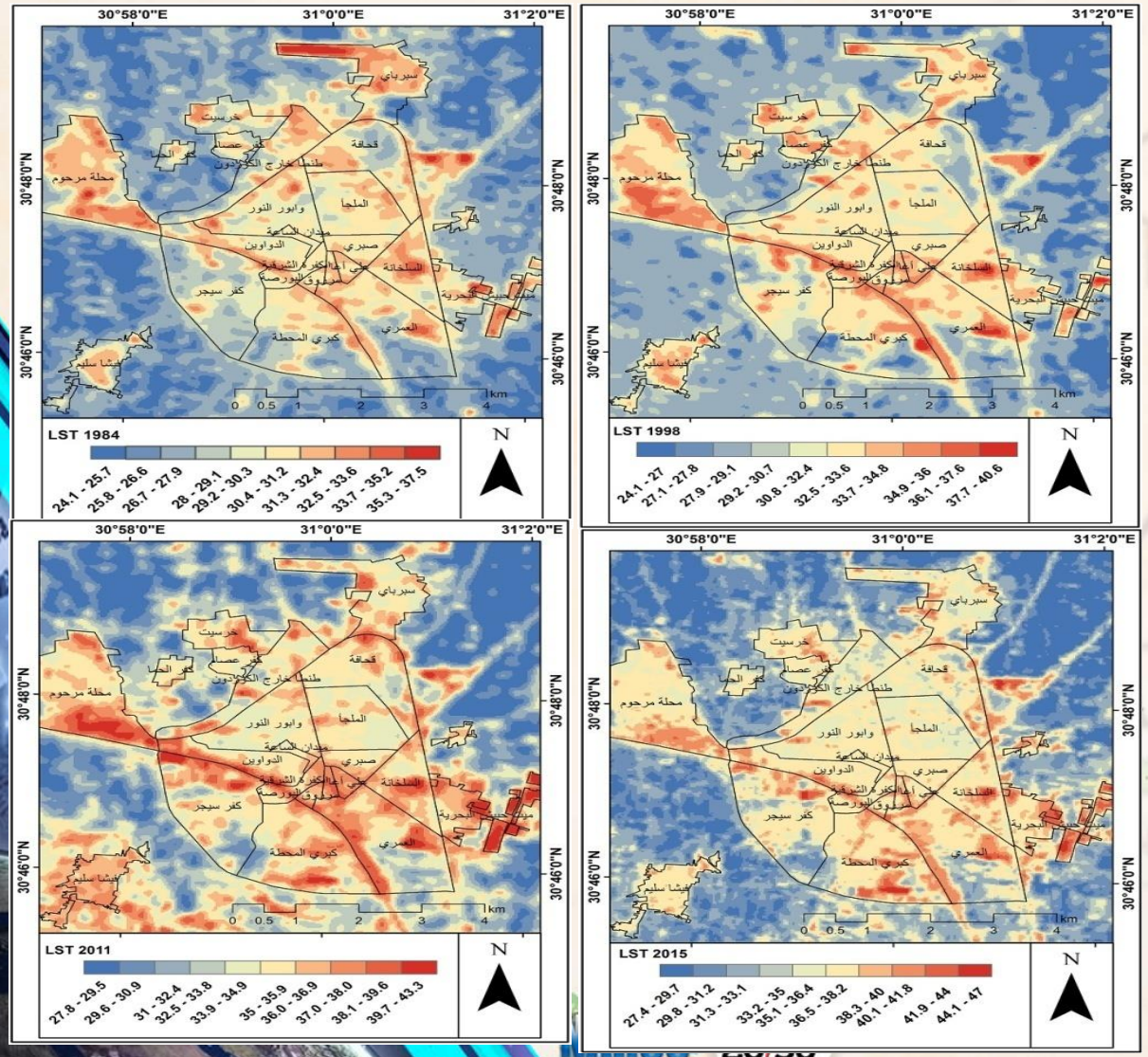
Indices based on Satellite and image processing (RS)

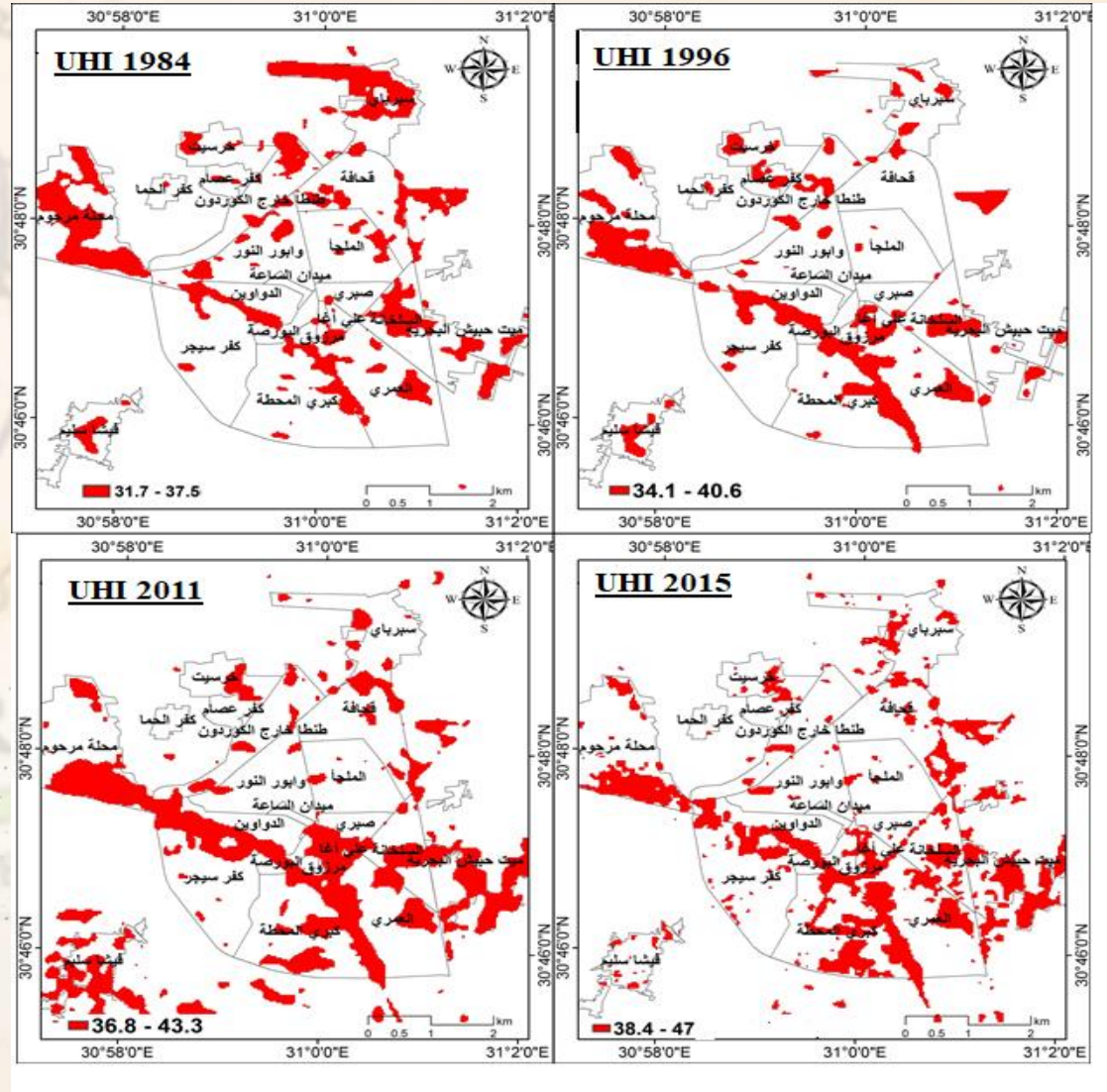
Examples of some applications (NARSS)

APPLICATION 1

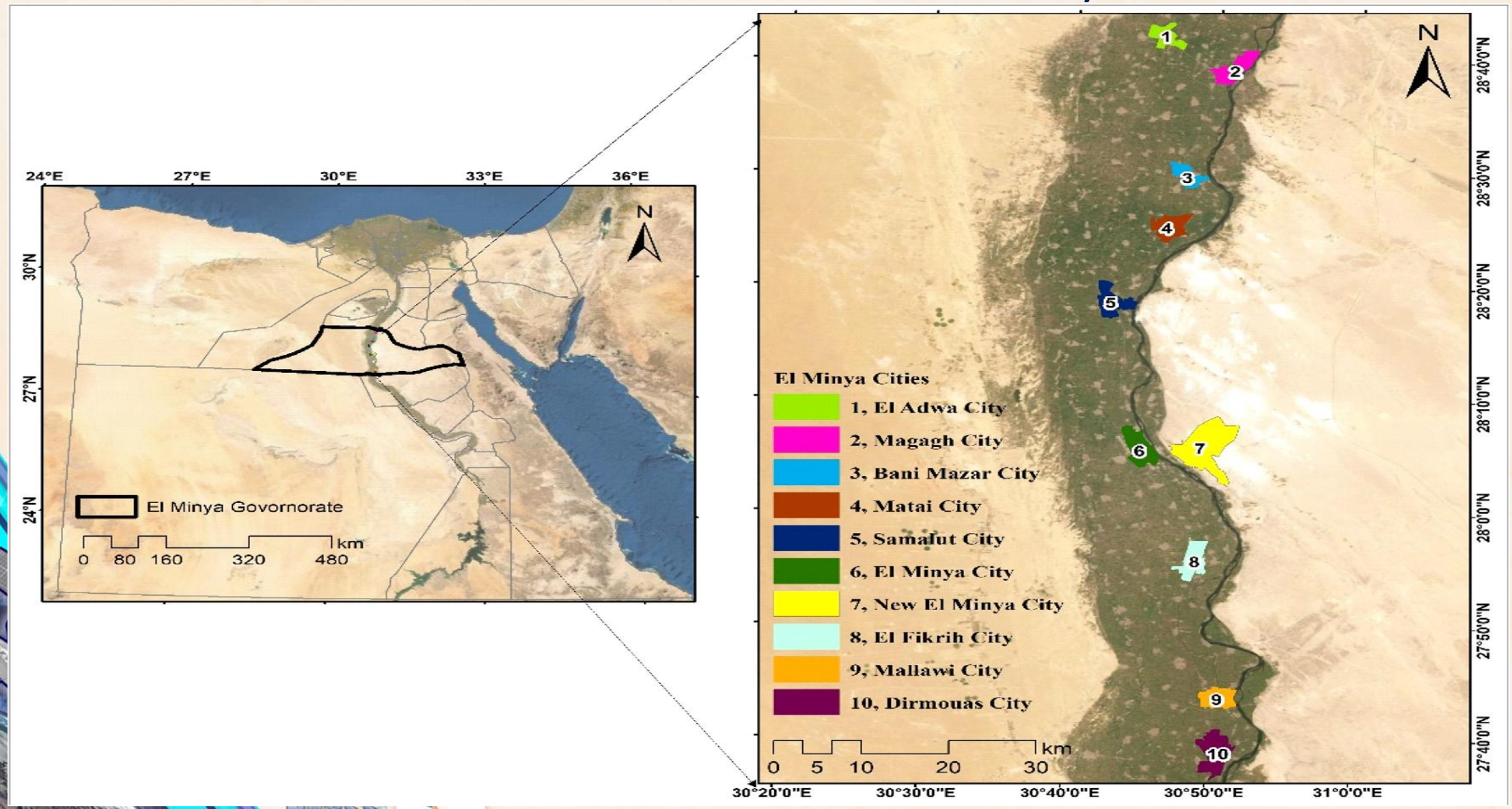
Detection of Urban Heat Islands in Cities

Detection of changes in LST and UHI over Tanta City from multi-temporal satellite data Landsat ETM+ an example of deterioration of the natural environment in cities (*contributor of a city vulnerability index*)

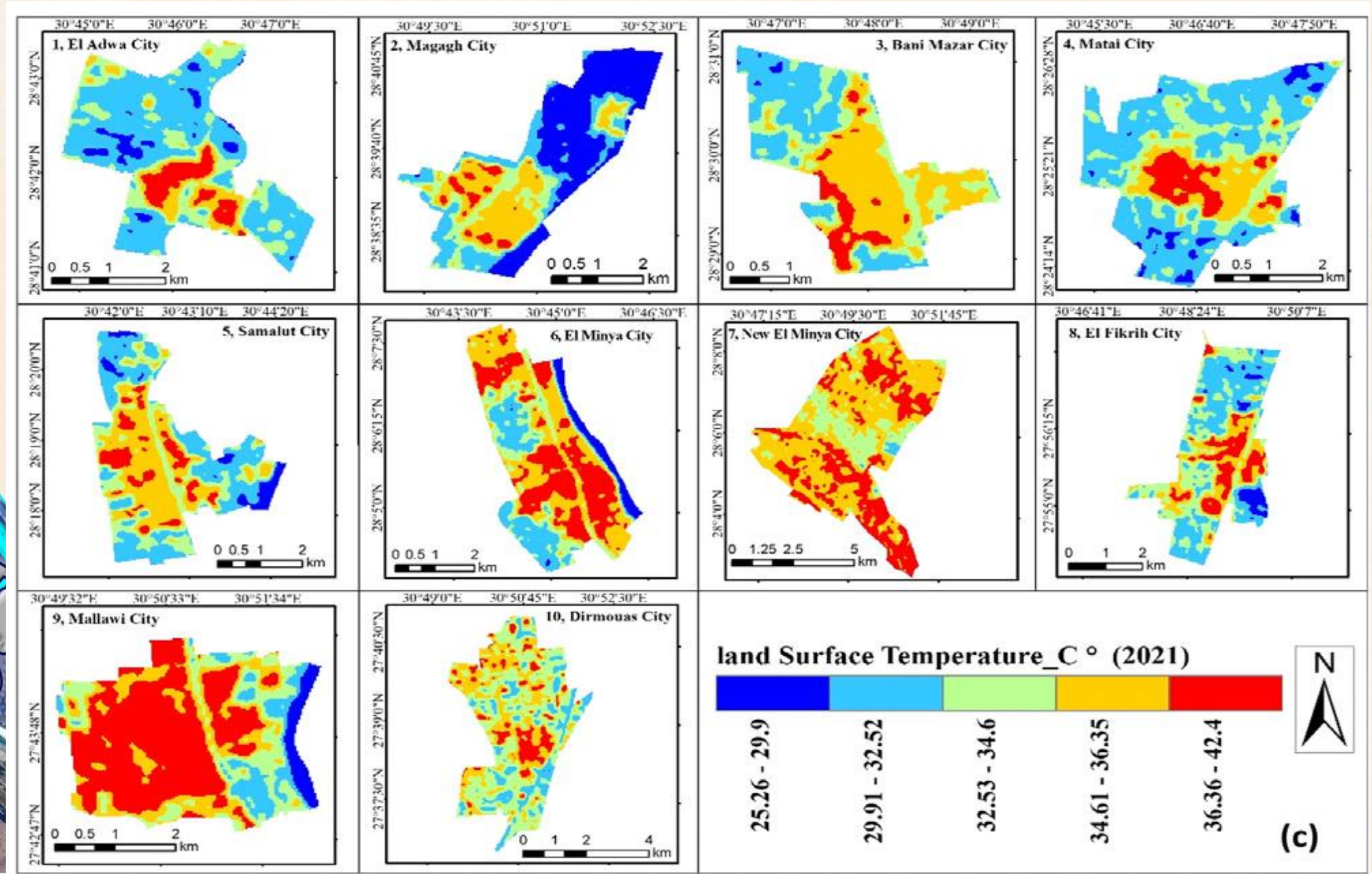




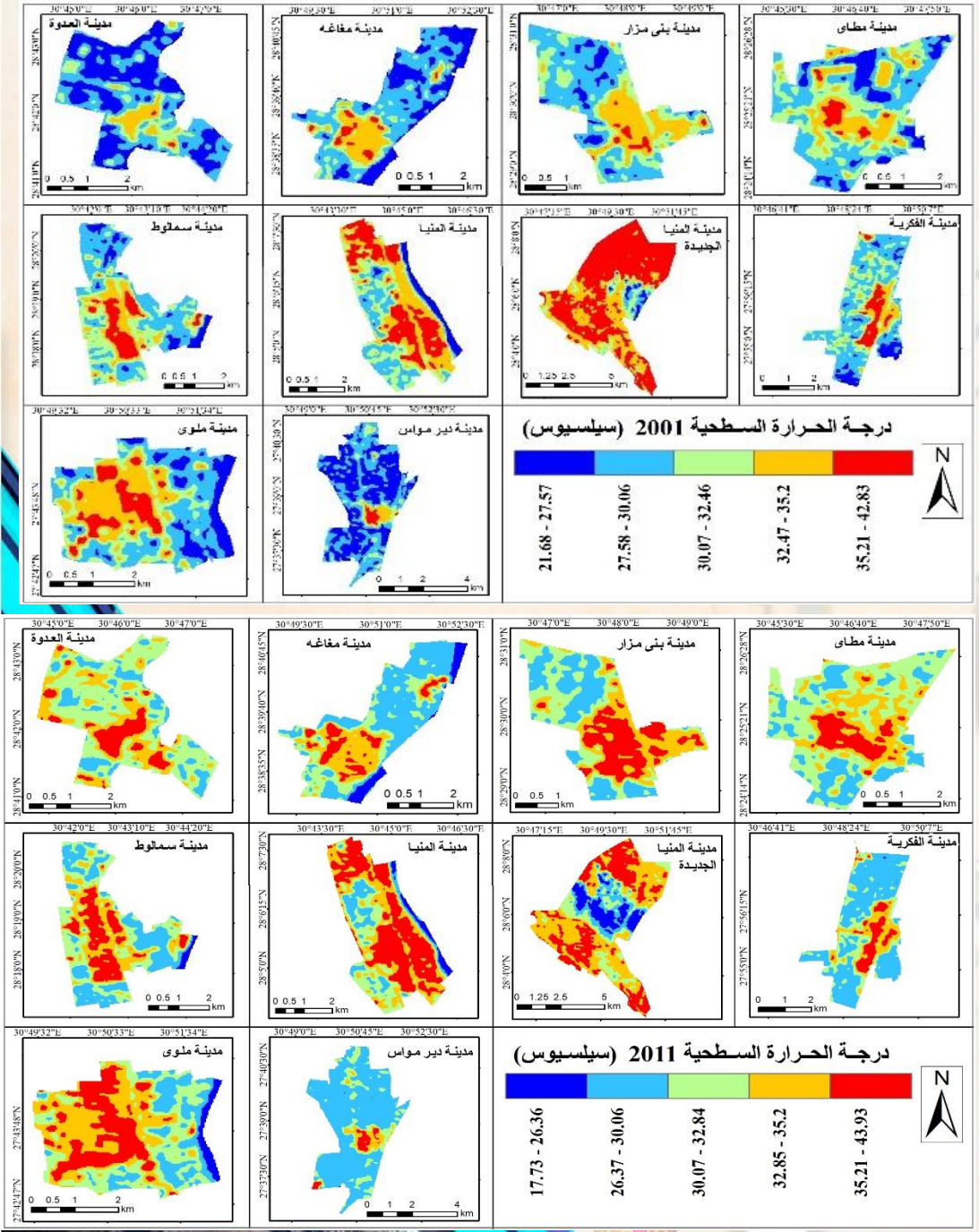
Urban Heat Islands in cities of El-Minya

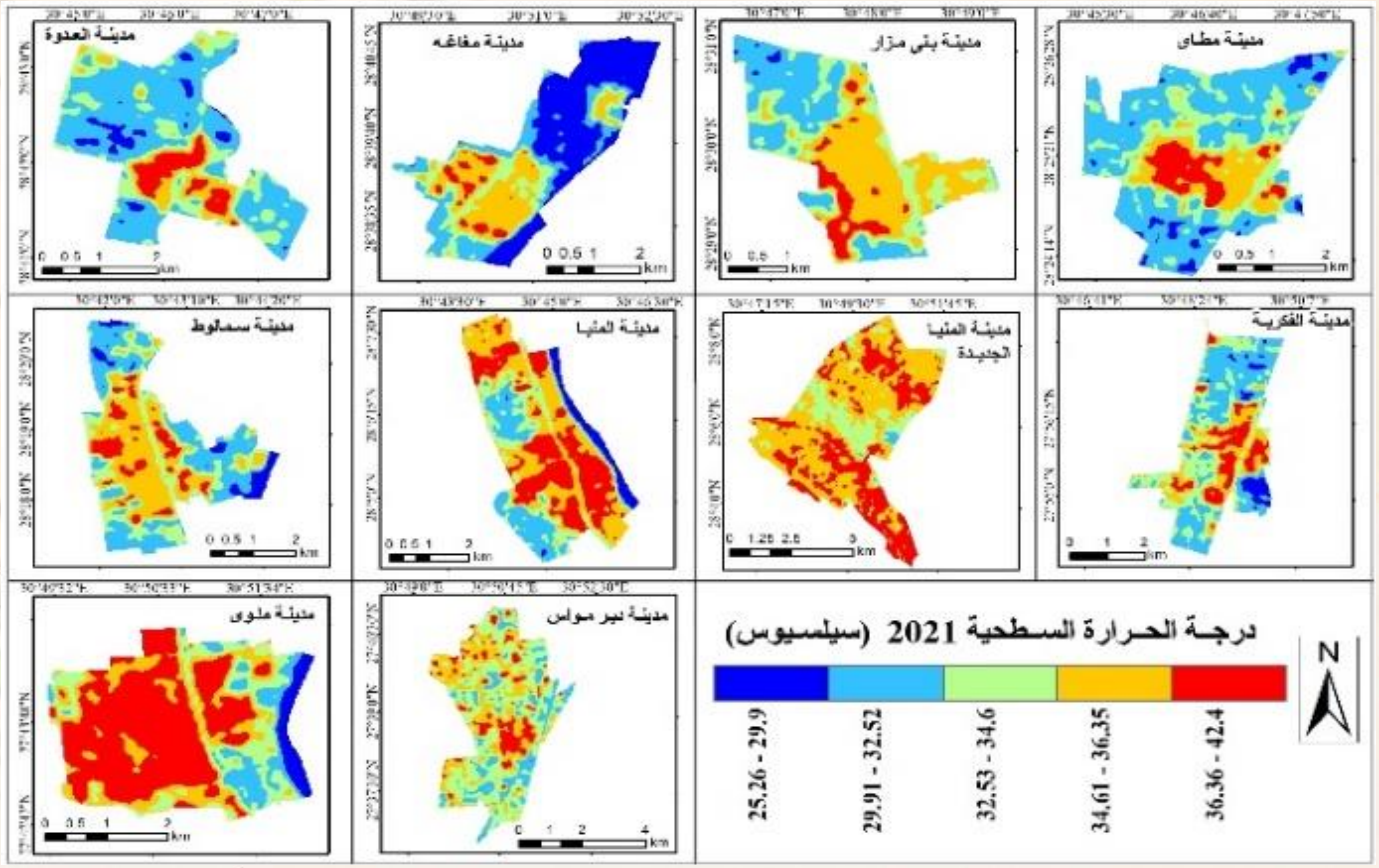


Urban Heat Islands in cities of El-Minya 2021

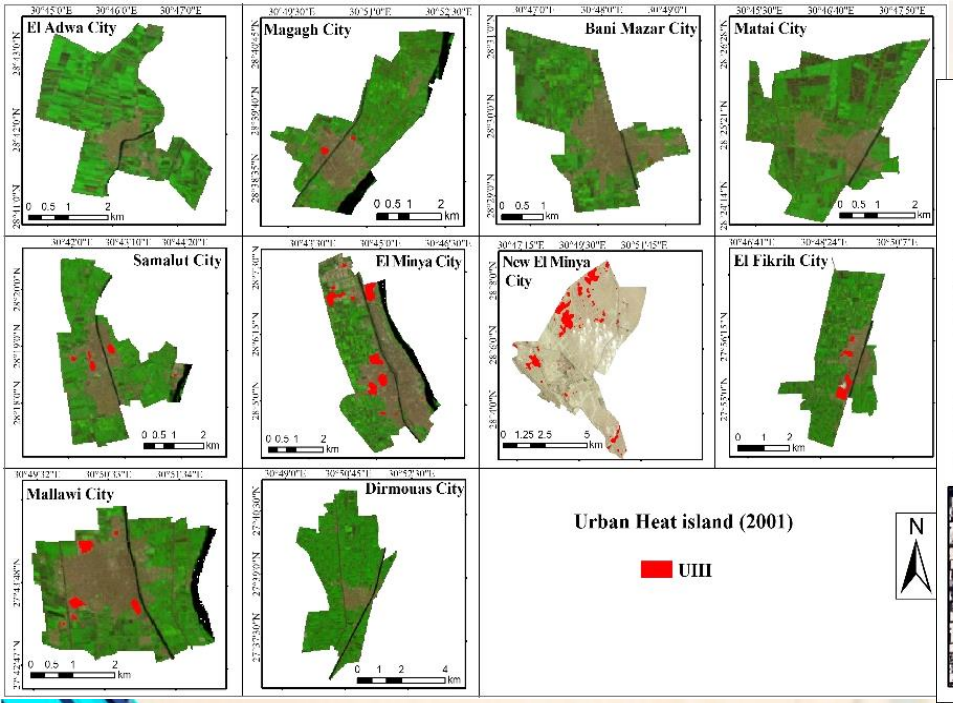


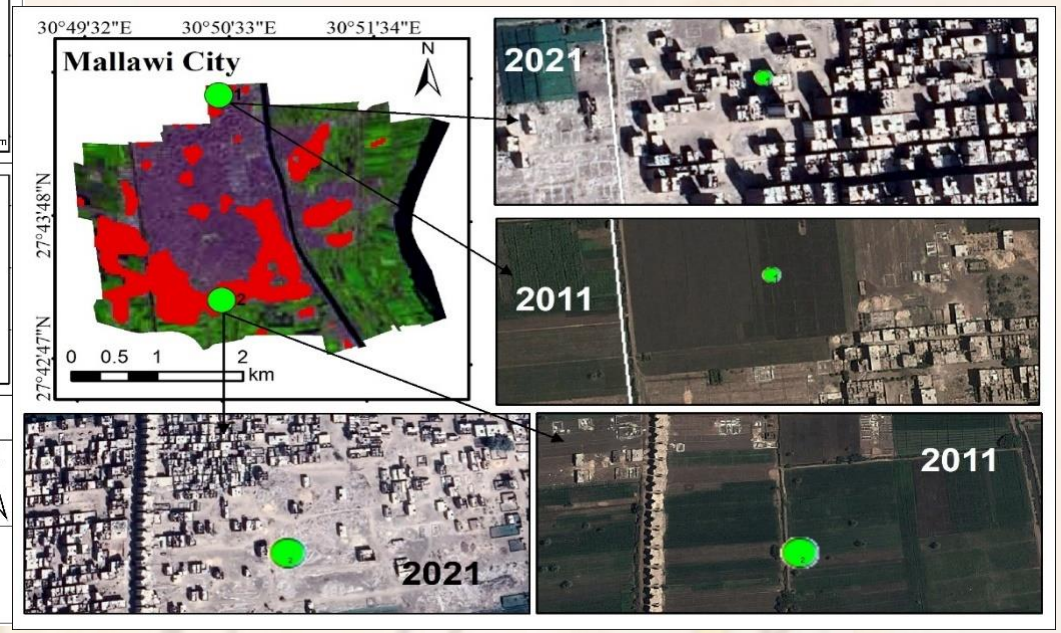
الاثار البيئية الناجمة عن االعمران
(دراسة حالة: LST الحرارة السطحية (2001 – 2021)

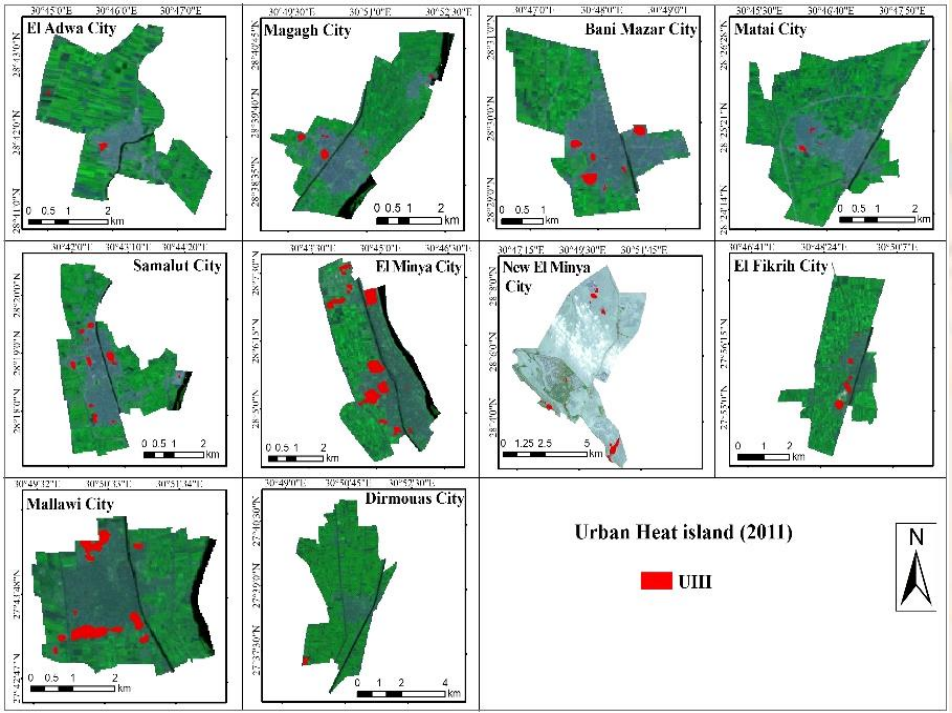


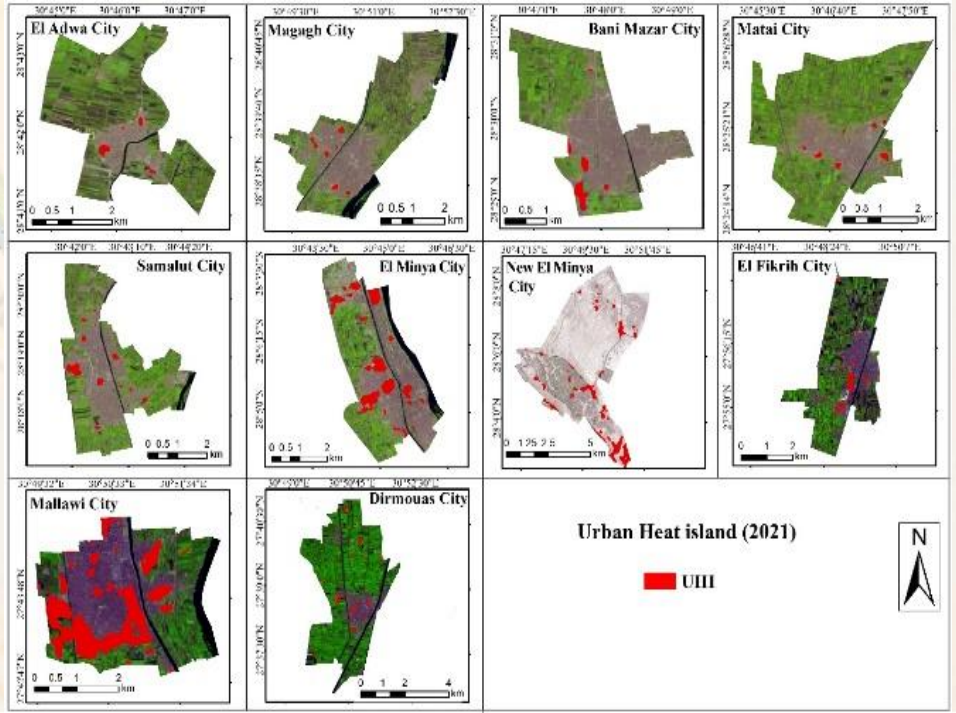


1. تحديد مناطق الجزر الحرارية لمدن محافظة المنيا 1. Urban Heat Islands





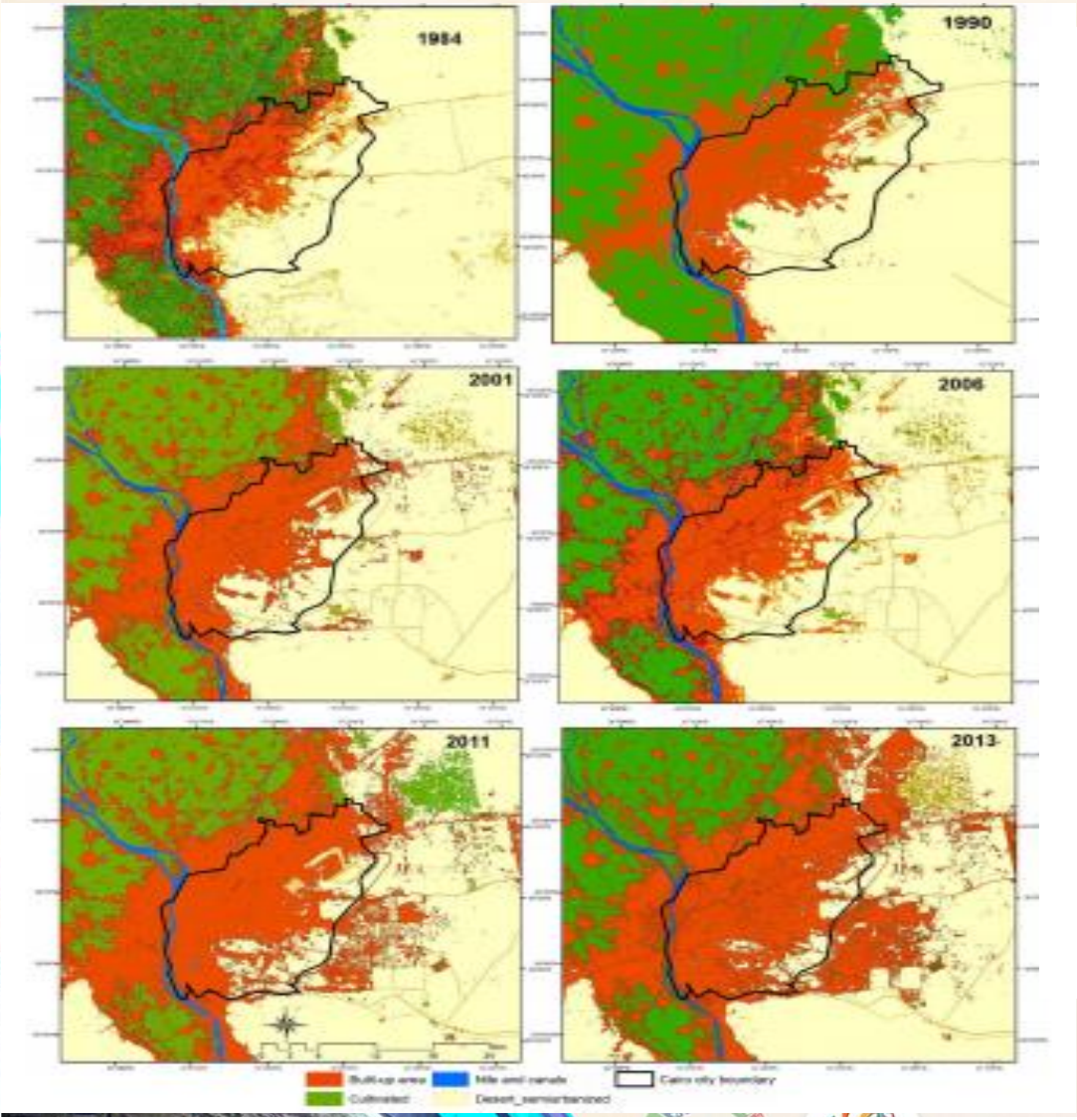


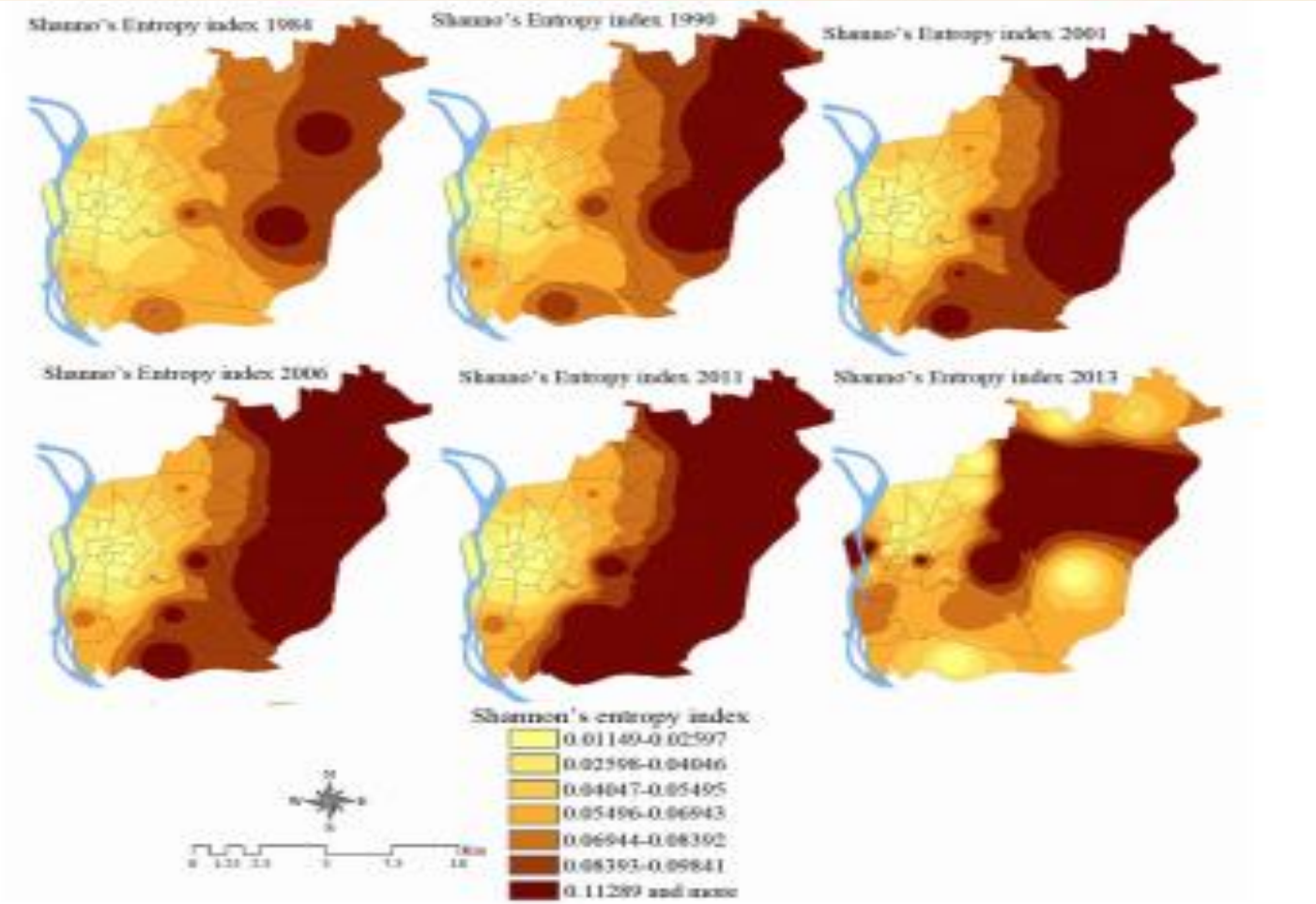


Application 2

- Detection and measuring urban sprawl (**Shanon's entropy index**)

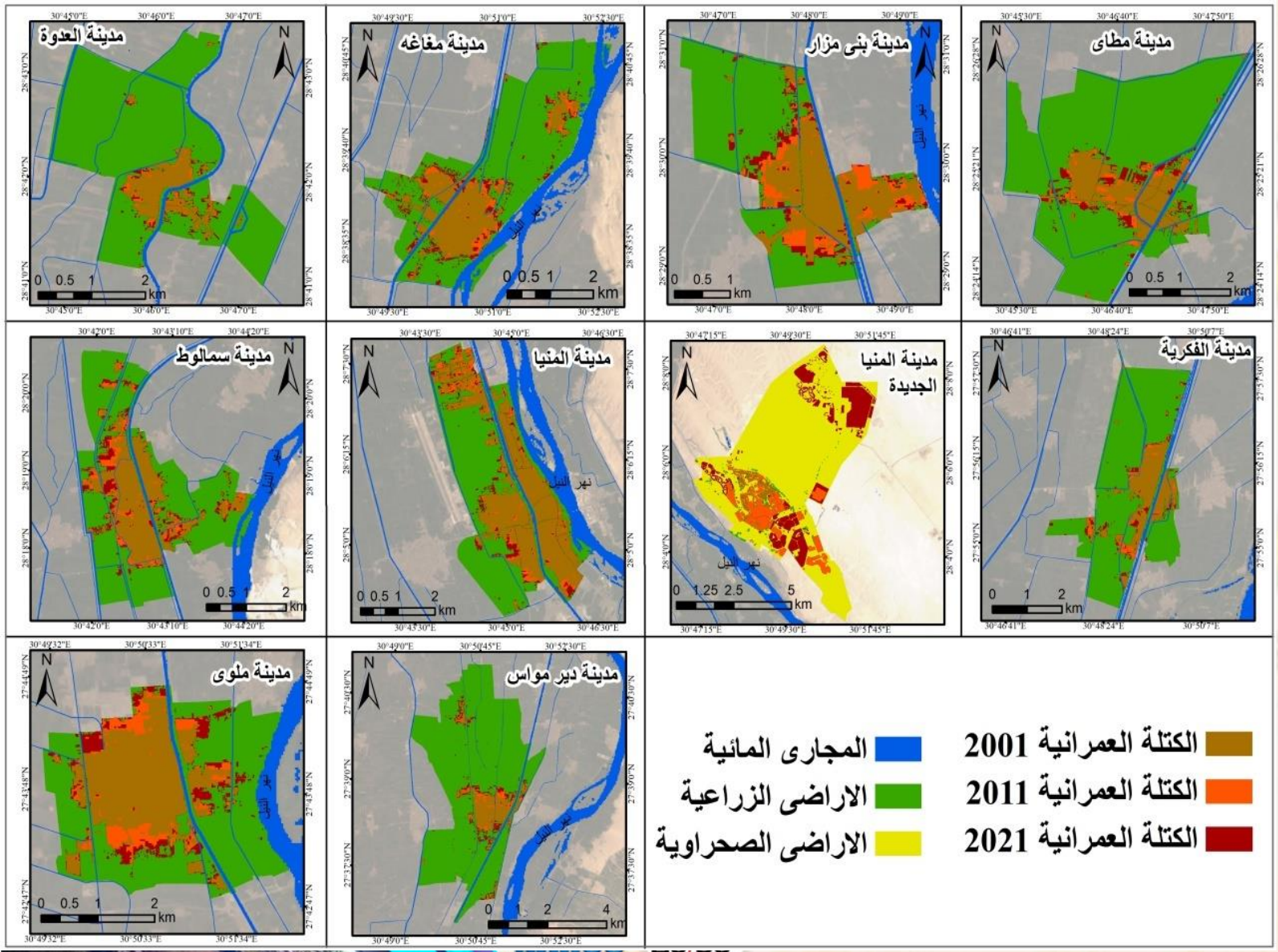
<u>Urban Sprawl</u> Index based on Landsat TM, ETM satellite data
an example of an uncontrolled urban growth in <u>Cairo</u>(contributor of *a city vulnerability index*)

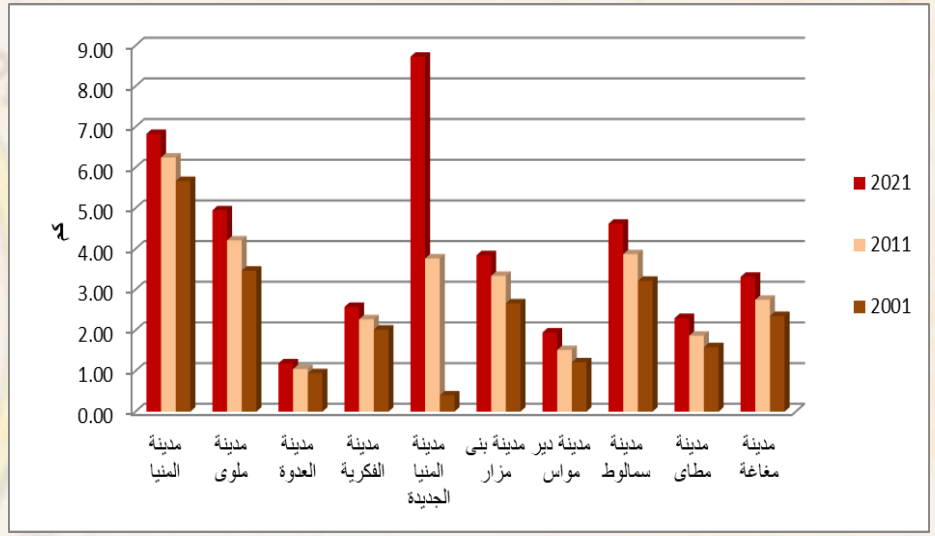




LULC changes and urban growth-sprawl of Cairo city (1984-2013)

الكتلة العمرانية لحضر لمحافظة المنيا أعوام 2001 و2011 و2021





Construction of Spatial Indices based on Remote Sensing , Spatial Multicriteria Evaluation SMCE – GIS models and Statistical data

UN Habitat urban Indicators to measure Cities Performance (Utilities, housing and demographic situations) 2004

Table 1. List of Habitat Agenda Indicators

Chapter/ Habitat Agenda goals	Indicators
1. Shelter	
Promote the right to adequate housing	Key indicator 1: durable structures Key indicator 2: overcrowding check-list 1: right to adequate housing extensive indicator 1: housing price and rent-to-income
Provide security of tenure	Key indicator 3: secure tenure extensive indicator 2: authorized housing extensive indicator 3: evictions
Provide equal access to credit	check-list 2: housing finance
Provide equal access to land	extensive indicator 4: land price -to-income
Promote access to basic services	Key indicator 4: access to safe water Key indicator 5: access to improved sanitation Key indicator 6: connection to services
2. Social development and eradication of poverty	
Provide equal opportunities for a safe and healthy life	Key indicator 7: under-five mortality Key indicator 8: homicides check-list 3: urban violence extensive indicator 5: HIV prevalence
Promote social integration and support disadvantaged groups	Key indicator 9: poor households
Promote gender equality in human settlements development	Key indicator 10: literacy rates check-list 4: gender inclusion extensive indicator 6: school enrolment extensive indicator 7: women councilors

UN Habitat urban Indicators to measure Cities Performance

3. Environmental Management	
Promote geographically-balanced settlement structures	Key indicator 11: urban population growth Key indicator 12: planned settlements
Manage supply and demand for water in an effective manner	Key indicator 13: price of water extensive indicator 8: water consumption
Reduce urban pollution	Key indicator 14: wastewater treated Key indicator 15: solid waste disposal extensive indicator 9: regular solid waste collection
Prevent disasters and rebuild settlements	check-list 5: disaster prevention and mitigation instruments extensive indicator 10: houses in hazardous locations
Promote effective and environmentally sound transportation systems	Key indicator 16: travel time extensive indicators 11: transport modes
Support mechanisms to prepare and implement local environmental plans and local Agenda 21 initiatives	check-list 6: local environmental plans
4. Economic Development	
Strengthen small and micro-enterprises, particularly those developed by women	Key indicator 17: informal employment
Encourage public-private sector partnership and stimulate productive employment	Key indicator 18: city product Key indicator 19: unemployment

Why do we start by conducting city vulnerability assessment ??

- To diagnose weakness and needs for better adaptation and resilience in a city.
- The target is :
- To move from a vulnerable city situation to a more resilient prosperous one *i.e* improve the quality of life for the citizens.

GOAL 11 and The City Prosperity Initiative

CPI DIMENSIONS

- Productivity
- Infrastructure
- Quality Of Life
- Equity and Social Inclusion
- Environmental Sustainability
- Governance and Legislation

SDG WITH URBAN BASED TARGETS

8.1.1 City product per capita
8.2.1 Growth rate per employment
8.3.1 Informal employment
8.5.2 Unemployment rate
9.2.1 Manifacturing employment

3.6.1 Traffic fatalities
6.1.1 Access to improved water
6.2.1 Access to improved sanitation
7.1.1 Access to electricity
9.c.1 Mobile network coverage
17.8.1 Internet access

15.1.2 Forest (green areas) as a percentage of total land area
16.1.1 Homicide rate
16.1.3 Population subjected to violence

1.1.1 Poverty rate
5.5.1 Women in local government
8.5.1 Gender wage gap
8.6.1 Youth unemployment
10.1.1 Growth rate 40%

3.9.1 Population exposed to outdoor air pollution
6.3.1 Waste water treatment
7.2.1 Share of renewable energy
12.5.1 Solid waste recycling share

9.a.1 Investement capacity
16.6.1 Local expenditure efficiency
17.17.1 Public-private partenrship

City Development Index CDI

- The **CDI** is the composite index that is composed of five sub-indices such as

  City Product

  Infrastructure

  Waste

  Health

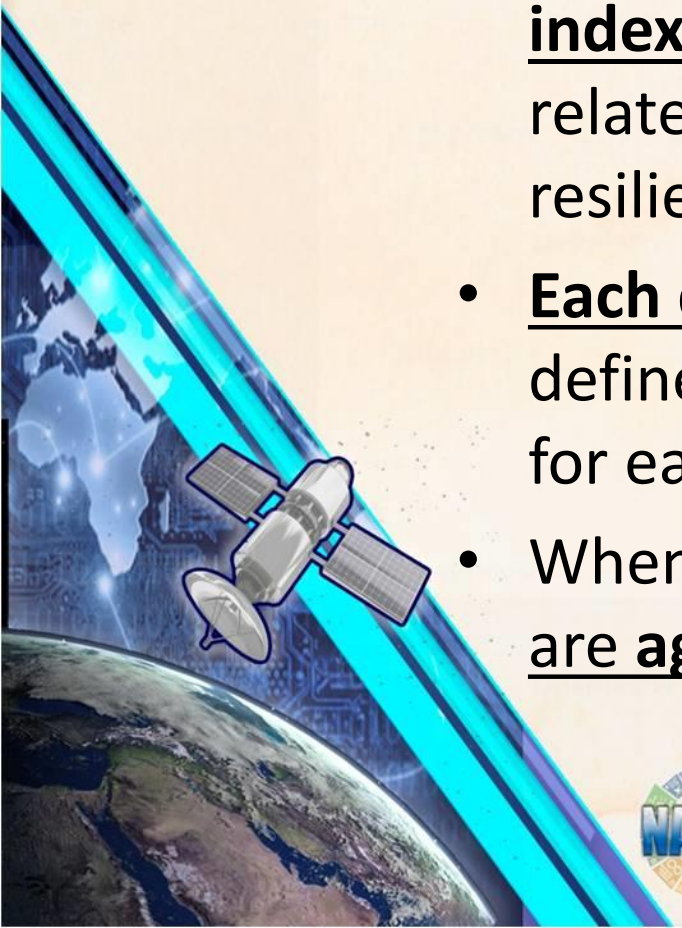
  Education (UN-Habitat, **2001**).

- The City Development Index (CDI) is originally created for evaluating city sustainability (UN Habitat, 2006).

Creation of City Vulnerability index

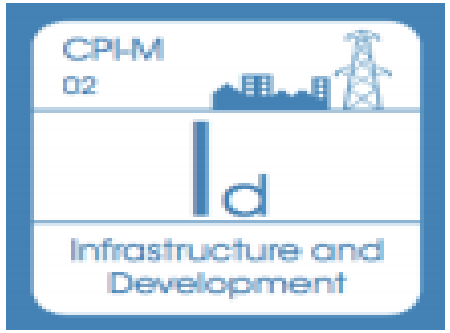
(based on CDI)

- The City Vulnerability Index (CPI) is defined as :a **multi-dimensional index.** It is determined based on a collection of factors or dimensions related to conceptualizations of a vulnerable/ poverty and low resilience.
- **Each dimension (factor) is composed of sub-dimensions**, which are defined from a group of variables (or indicators) that are measured for each city.
- When sub-dimensions are made-up by two or more indicators, they are **aggregated into one single value.**



Indicators (sub-indices)

INFRASTRUCTURE



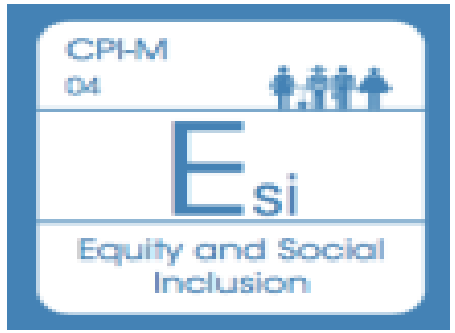
1. Housing Infrastructure
- Improved Shelter
- Access To Improved Water

2. Social Infrastructure
- Physicians Density

3. ICT
- Internet Access

4. Urban Mobility
- Traffic Fatalities

EQUITY AND SOCIAL INCLUSION



1. Economic Equity
- Gini Coefficient
- Poverty Rate

2. Social Inclusion
- Slum Households
- Youth Unemployment

3. Gender Inclusion
- Equitable Secondary School Enrolment

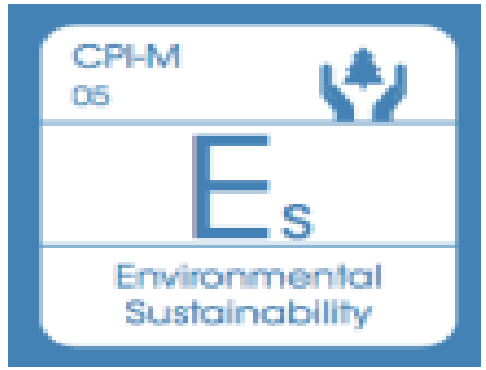
QUALITY OF LIFE

1. Health
- Life Expectancy at birth
- Under-Five Mortality Rate

2. Education
- Literacy Rate
- Mean Years of Schooling

3. Safety and Security
- Homicide Rate

ENVIRONMENTAL SUSTAINABILITY



1. Air Quality
- PM2.5 Concentration

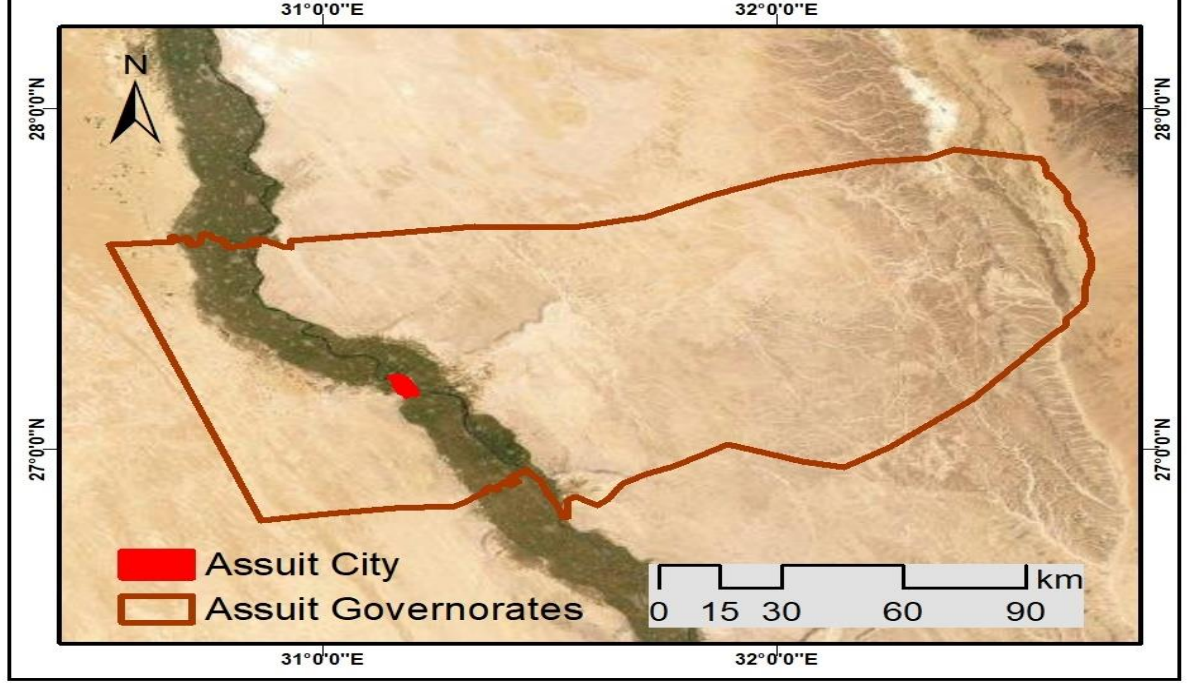
2. Waste Management
- Waste Water Treatment

3. Energy
- Share of Renewable Energy
- CO2 Emissions

Example : Modeling a City Vulnerability Index for Assiout City (CVI)

- We constructed a **CVI** for Assiout city to assess and compare the **needs** among the different city wards.
- The index is modeled based on selected environmental, social and economic dimensions following the guidelines of the UN Habitat urban indicators -SDGs.
- **The constructed City Vulnerability Index (CVI)** is a measure of the level of degradation based on the selected dimensions (factors). It **points out the needs for improvement visualized in city maps**).

- CVI index and its sub-indices act as guideline for improving the city resilience, and can guide the allocation of funds .


31°0'0"E
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28°0'0"N
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N
Assuit City
Assuit Governorates
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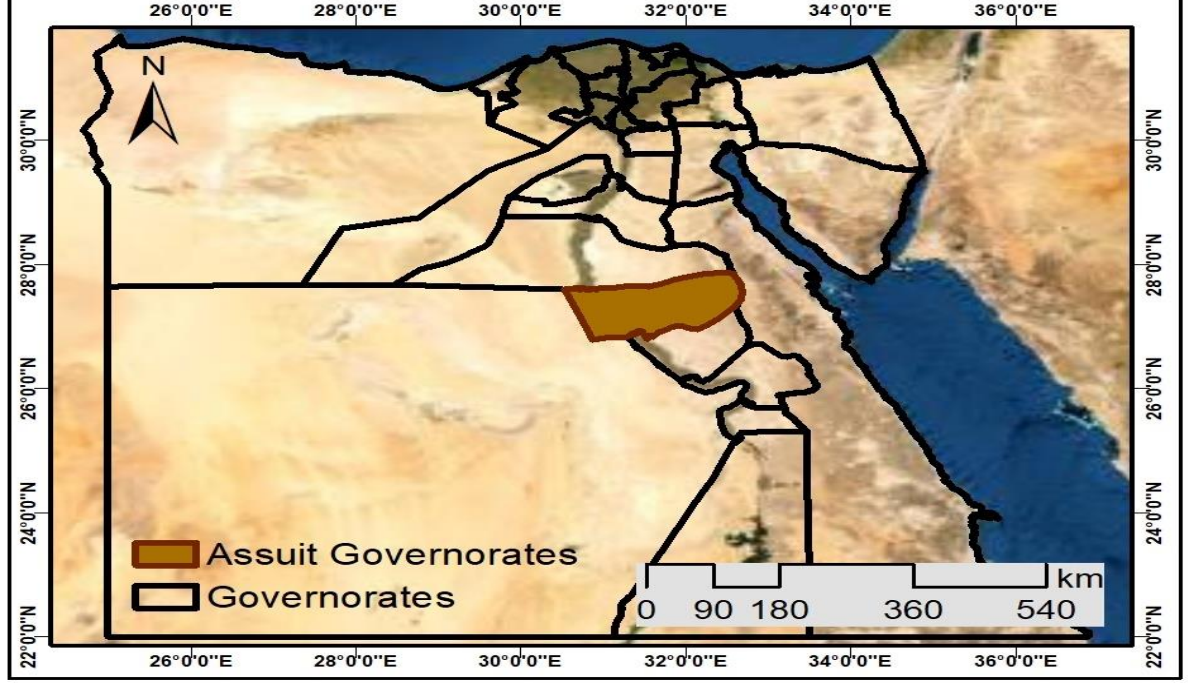
km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Assuit Governorates
Governorates
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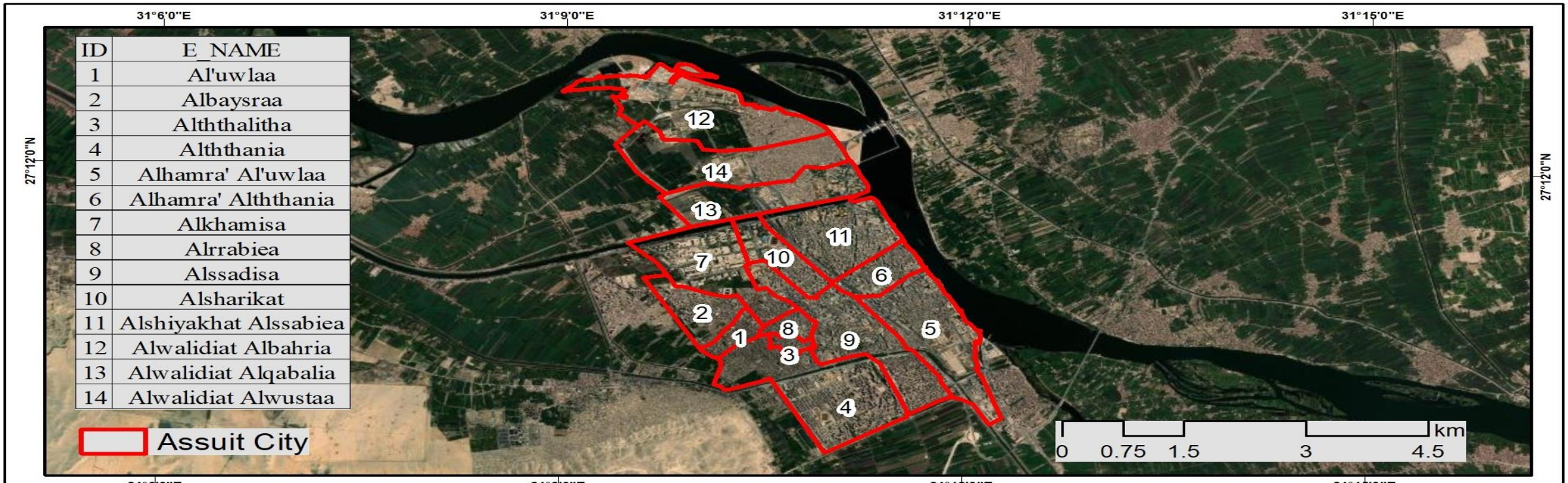
km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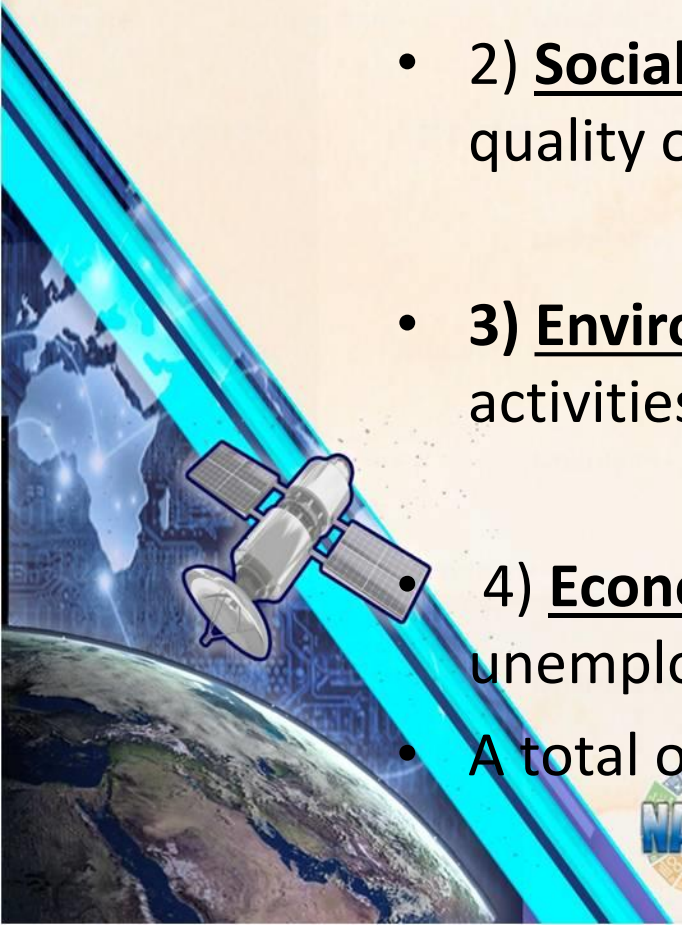
1 Al'uwlaa
2 Albaysraa
3 Alththalitha
4 Alththania
5 Alhamra' Al'uwlaa
6 Alhamra' Alththania
7 Alkhamisa
8 Alrrabiea
9 Alssadisa
10 Alsharikat
11 Alshiyakhat Alssabiea
12 Alwalidiat Albahria
13 Alwalidiat Alqabalia
14 Alwalidiat Alwustaa
Assuit City
0 0.75 1.5 3 4.5
km

Assiout City Vulnerability model

- Assiout **city vulnerability model** has been developed based on UN-HABITAT urban indicators in four dimensions:
- 1) **Shelter indicator** (habitat quality, overcrowding , service connectivity,…).
- 2) **Social indicator** (rate of illiteracy, school enrolment, social status,age and quality of society,…).
- **3) Environmental indicators** that relate to the degradation caused by human activities (pollution, high voltage pressure areas, and population density,..).
- 4) **Economic indicator** (Land price, utilities and road density, unemployment,..).
- A total of thirteen sub-indicators have been established for analysis.



PS: Indicator number (x) is taken after the UN indicator coding. No numbering

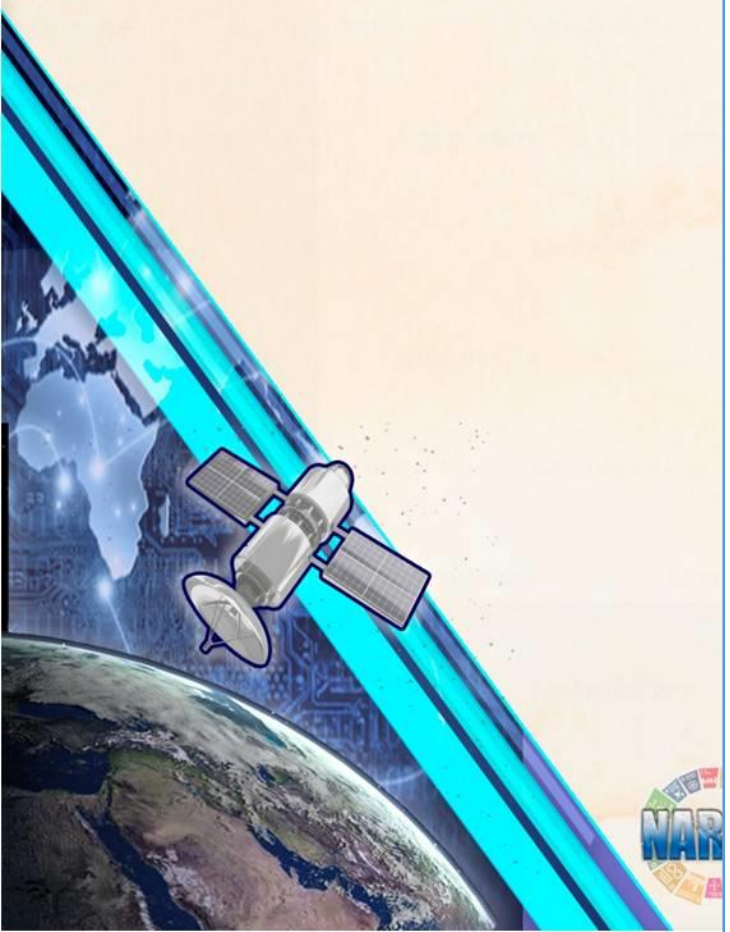
Table ( )Types of Urban Indicators of Vulnerability

1. ShelterDegradation	2. Social Degradation	3. Environmental Degradation	4. Economic Degradation	5. GovernanceDegradation
indicator (1): Habitat Quality ▪ Unsuitable habitat ▪ Quality of buildings ▪ Type of building use ➢ Governmental Buildings	indicator (10): Rate of illiteracy	indicator (11): urban population growth ▪ Population growth ▪ Population density ▪ Vacant land ratio	indicator (20): Average price of residential land	No Data Available
indicator (2): overcrowding ▪ Overcrowding ▪ Average size of the family	indicator (6): school enrolment (ratio) ▪ primary education ▪ Mid education ▪ high education	indicator: Pollution ▪ Air pollution ▪ Soil pollution ▪ Noise ▪ Water pollution	indicator :Utilities ▪ Roads	
Indicator (6): connection to services(Poor Services) ▪ No Sanitation ▪ No Water network ▪ NoElectricity network ▪ Natural Gasnetwork	indicator: Social status ▪ Single Ratio ▪ Divorced Ratio	indicator: High voltage pressure areas	indicator : ▪ Road density	
	indicator :Quality of society ▪ Under age Ratio ▪ Old age Ratio			

Source: after Urban Indicators Guidelines ,2004.

Source: after Urban Indicators Guidelines -2004(SAULE JÚNIOR and CARDOSO, 2004).
PS: Indicator number (x) is taken after the UN indicator coding. No numbering indicates that proxy indicator is created by the researchers.

Data Sources



Data	Source
▪ Assiout administrative boundary ▪ Pollution ▪ High voltage pressure areas ▪ Road density ▪ Utilities	General Organization for Physical Planning (GOPP, 2007)
▪ Habitat Quality ▪ Overcrowding ▪ Connection to services ▪ School enrolment. ▪ Illiteracy rates. ▪ Urban population growth. ▪ Urban density. ▪ Social status ▪ Quality of society ▪ Urban population growth ▪ Average price of residential	(CAPMAS, 2015)

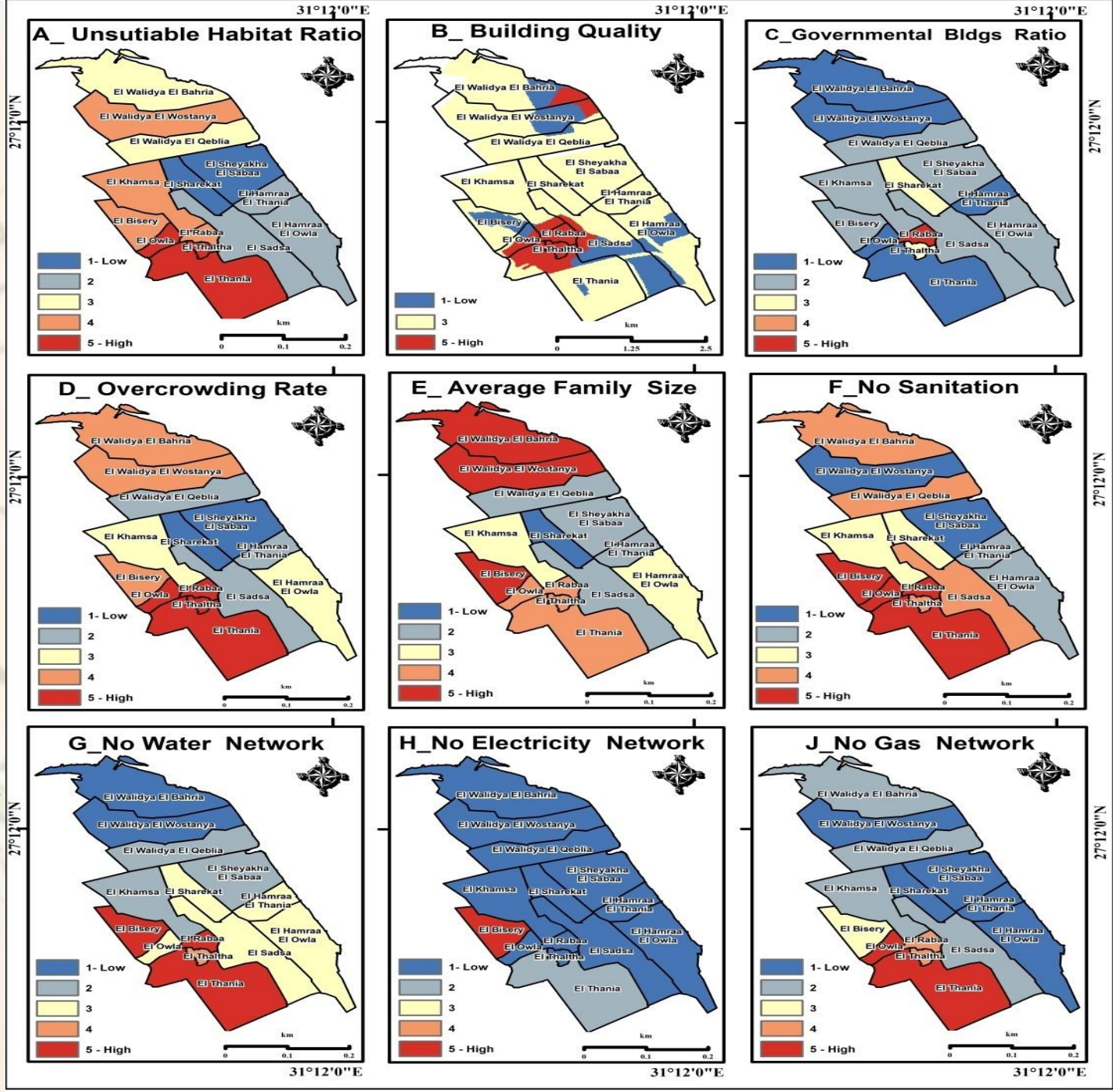
Results

Factors for **Shelter** Vulnerability

Standardized sub-indicators maps for

<u>Shelter status /vulnerability index</u>

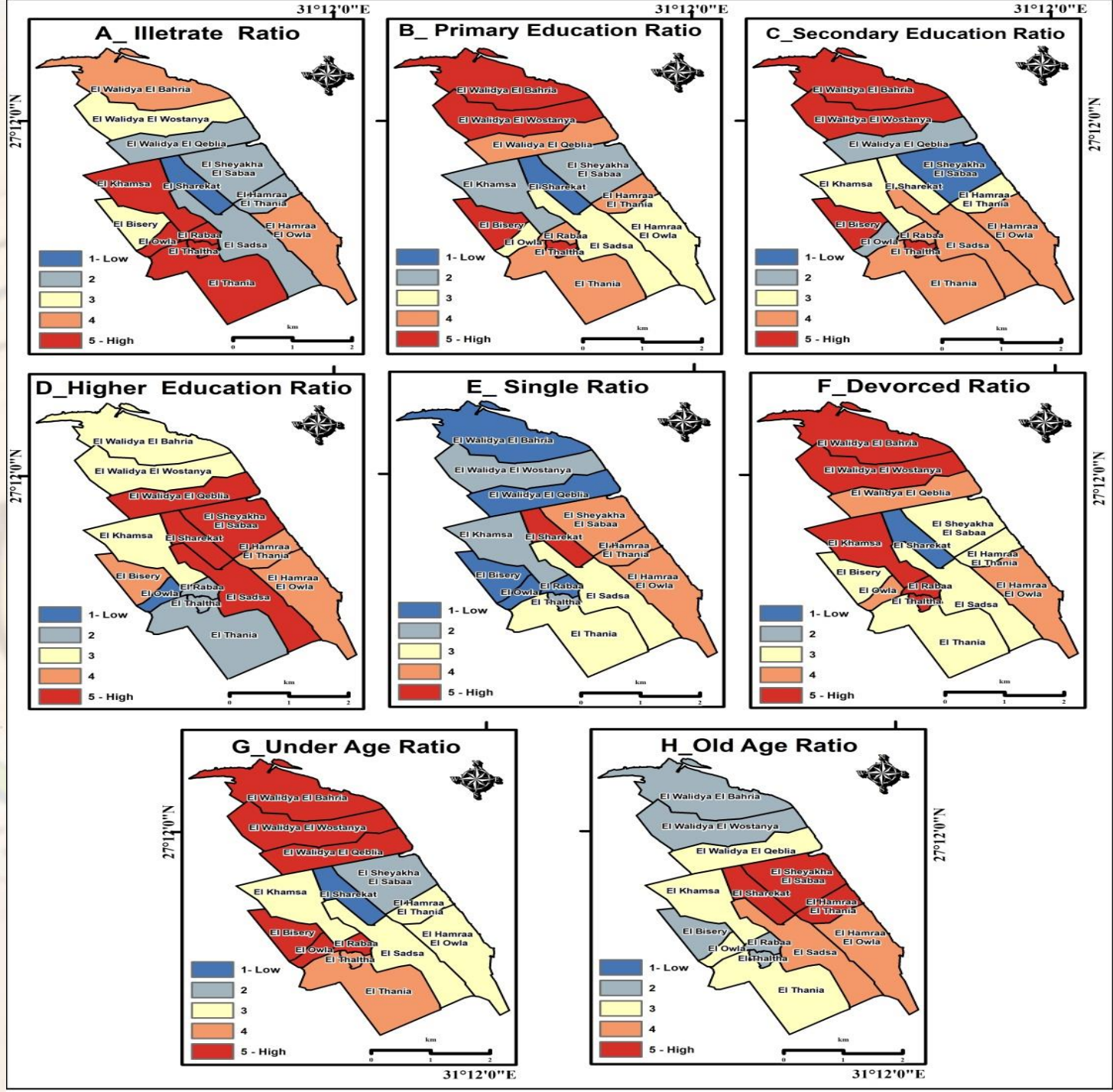
(A) Unsuitable habitat
(B) Quality of buildings.
(C) Governmental Buildings
(D) Overcrowding ratio
(E) Average size of the family
(F) No Sanitation.
(G) No Water network
(H) No Electricity network.
(J) Natural Gas network.



Factors for **Social** Vulnerability

Standardized sub-indicators maps for **Social status/ vulnerability index**:

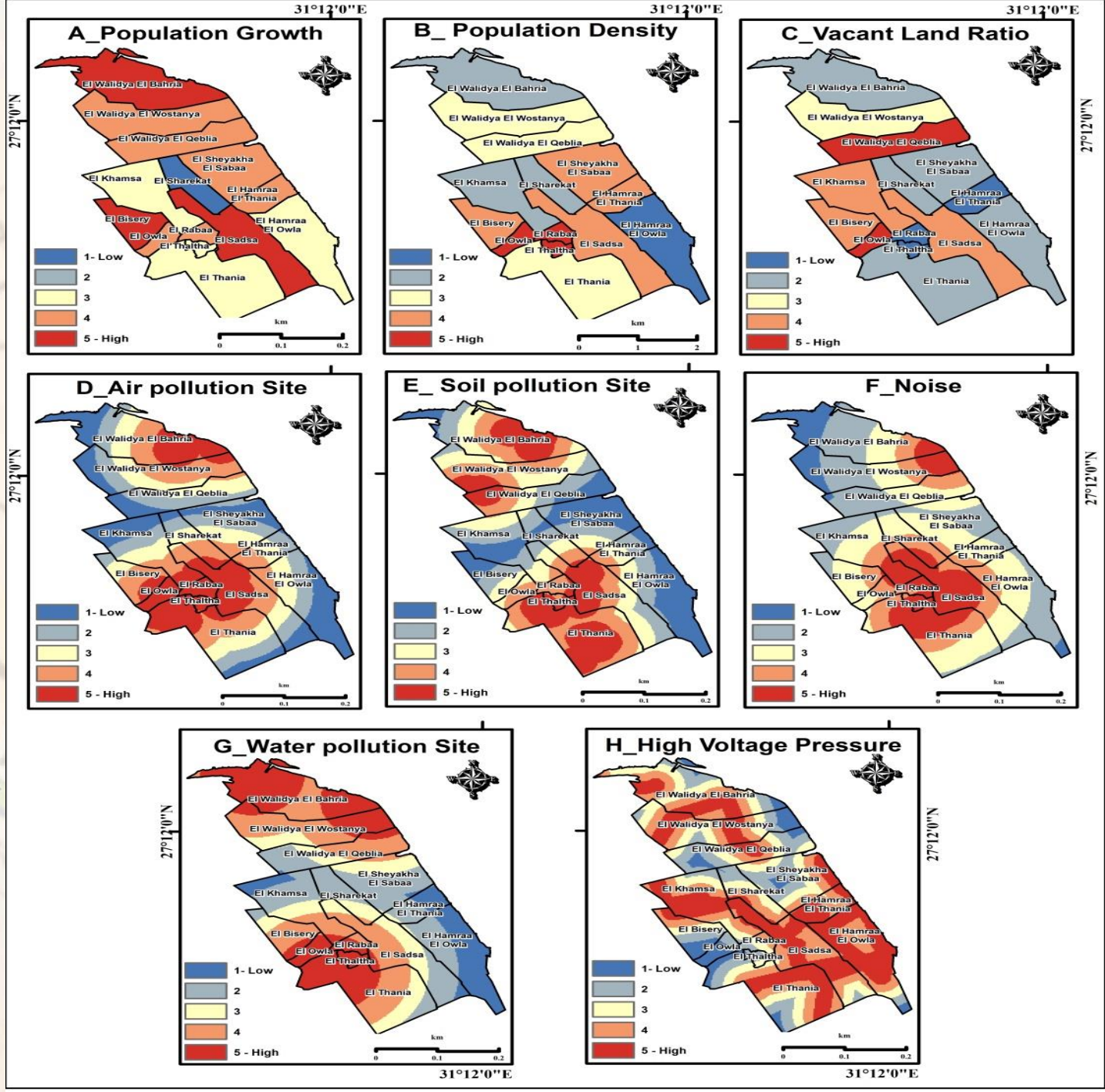
(A) Rate of illiteracy
(B) primary education Ratio
(C) secondary education Ratio
(D) higher education Ratio
(E) Single Ratio.
(F) Divorced Ratio.
(G) Under age Ratio;
(H) Old age Ratio.



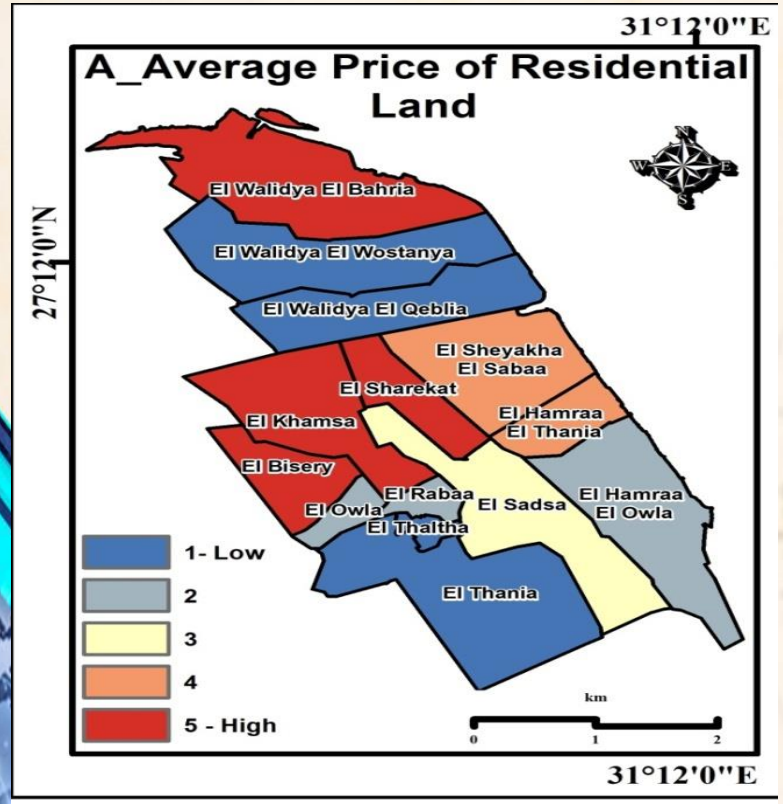
Factors for **Environmental** Vulnerability

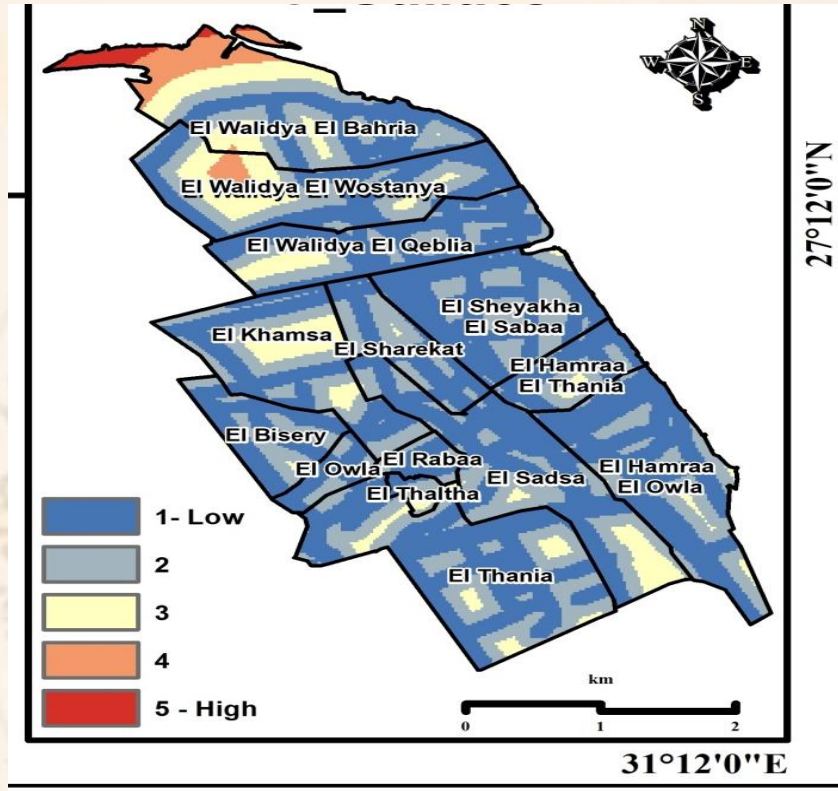
Standardized sub-indicators maps for **Environmental degradation** :

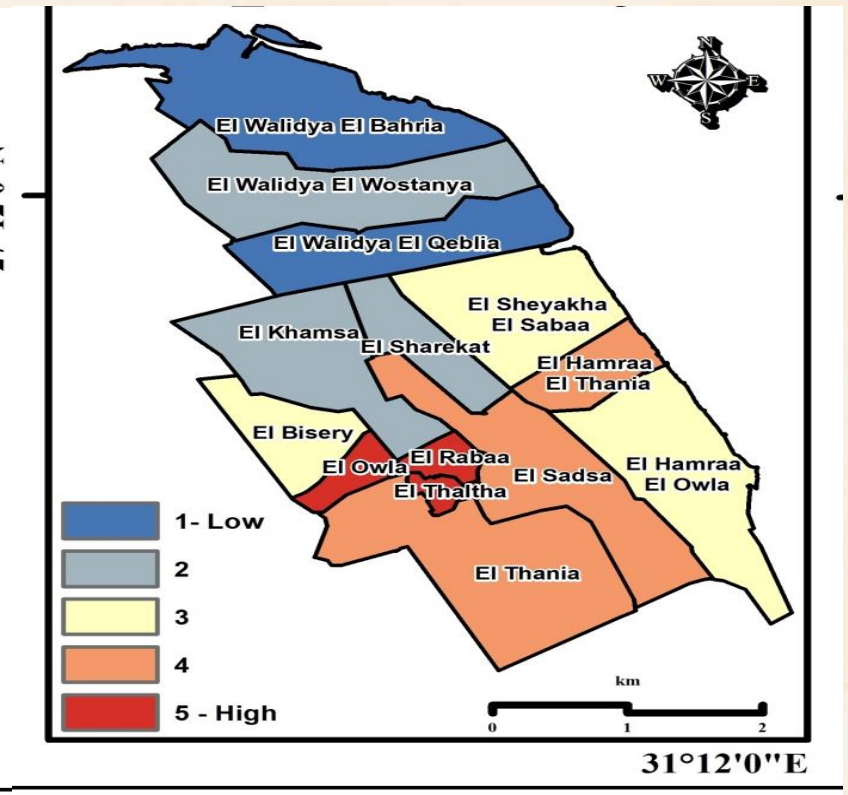
A) Population growth
B) Population density
(C) Vacant land ratio
(D) Air pollution
(E) Soil pollution
(F) Noise
(G) Water pollution
(H) High voltage pressure areas.



Factors for Economic Vulnerability







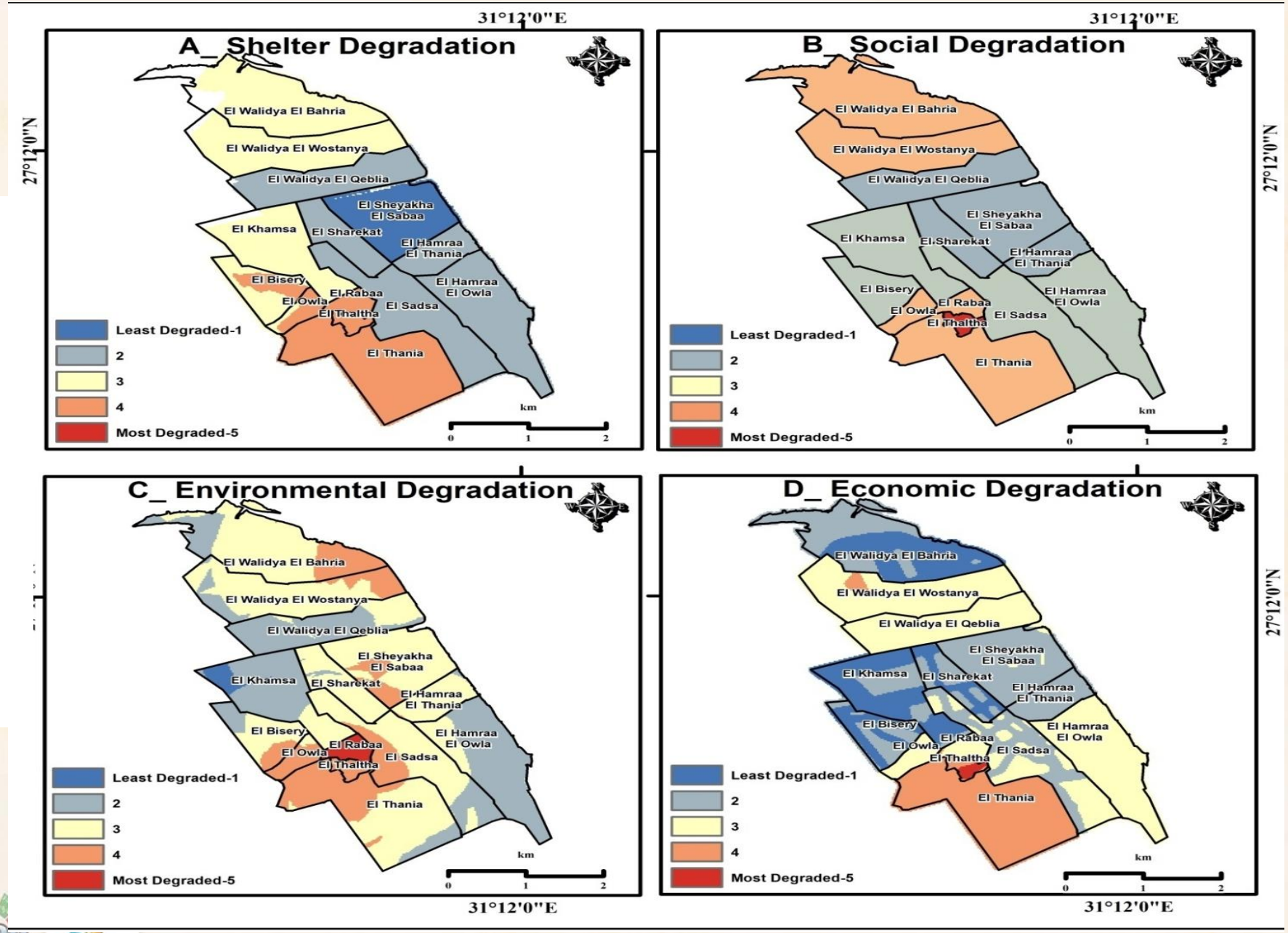
Standardized factor maps for **Economic vulnerability** :

a) Average price of residential land,
b) Road density,
c) Availability to main utilities.

Env. Degradation **scenarios**

Combined index maps for vulnerability & Environmental degradation.

A) **Shelter**
B) **Social**
C) **Environmental**
D) **Economic**.



Findings

- **In the Shelter scenario** : **most degraded areas are located in the South-west** of the city including districts (El Thaltha , El Owla , El Thania and El Rabaa) and parts of El Walidya El Wostanya. This results caused by slums like Arab el- balad and Arbeen **, poor connection to services** and **overcrowding**.

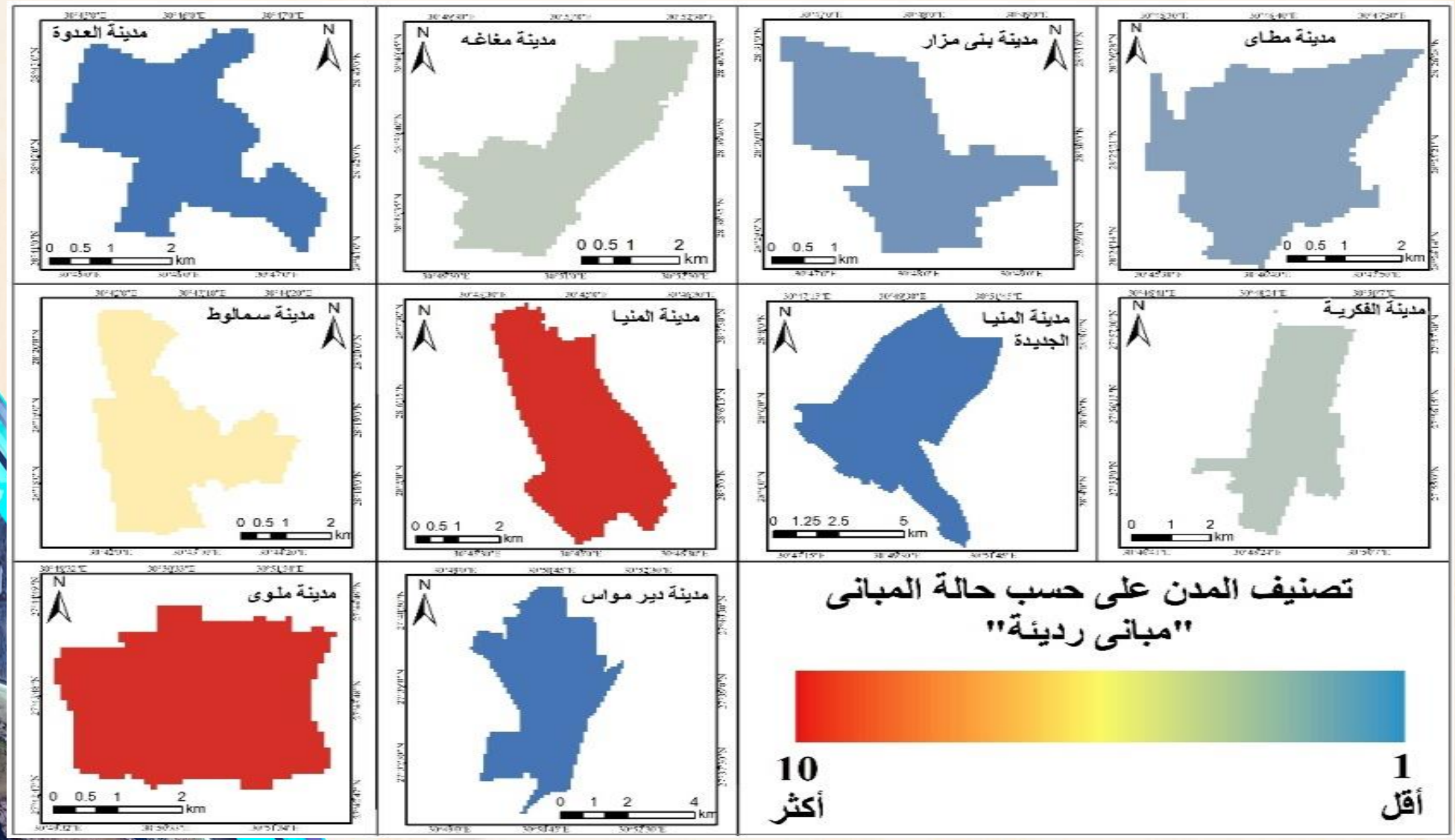
- **The Social scenario :** degradation is concentrated in **the south-west of the city** including some districts: (El Thaltha and El Walidya El Wostanya district) **in the north zone.** The degradation is due to **high ratio of illiteracy, dependency ratio (age), and divorce**.

- **The Environmental scenario :** most degraded sites were found in the **south-west** of the city in (El Thaltha, El Owla , El Thania and El Rabaa), some zones **scattered on the northern parts** of (El Walidya El Wostanya district). The main cause is caused by **humans activities** in the city : **pollution sources**, **high voltage pressure areas**, and **intensive informal commercial and industrial activities**.

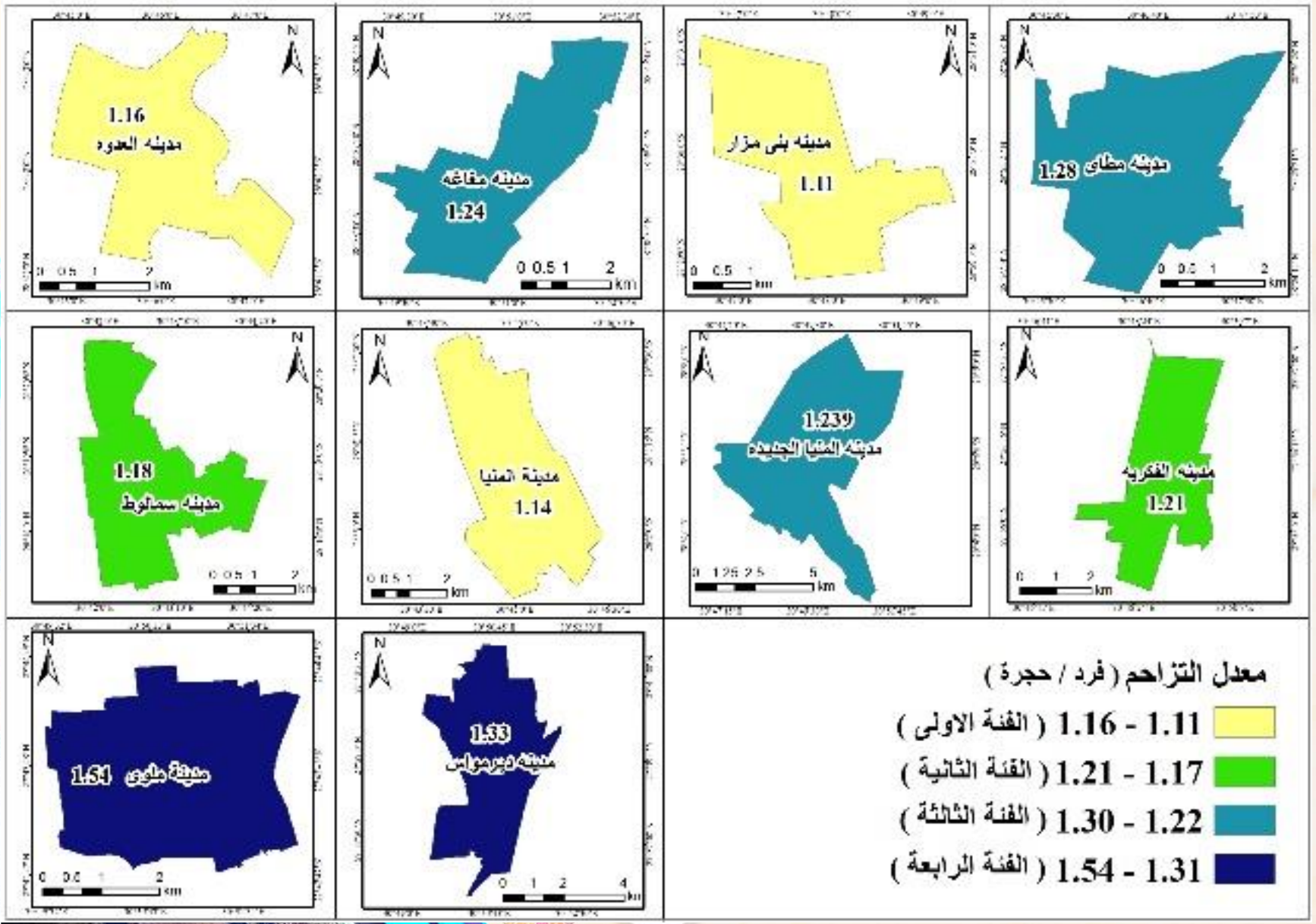
Application 3

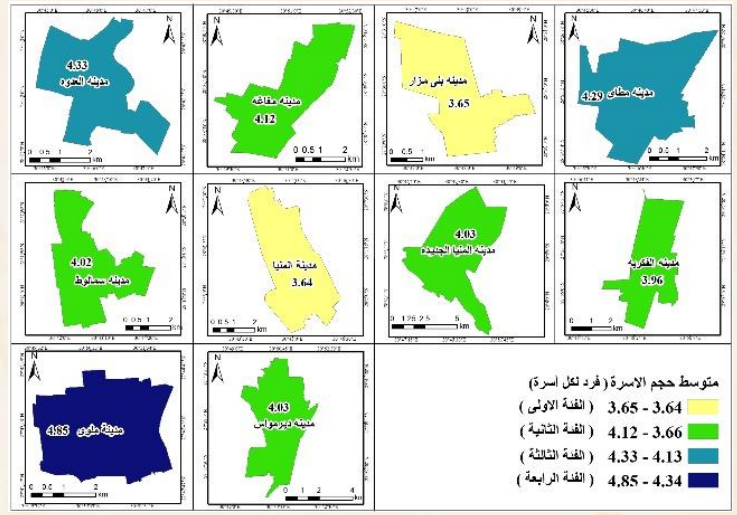
Measuring and Comparing the Environmental Vulnerability for 10 cities in El-Menya Governorate

تصنيف المدن طبقا لحالة المباني



معدل التزاحم بالمسكن





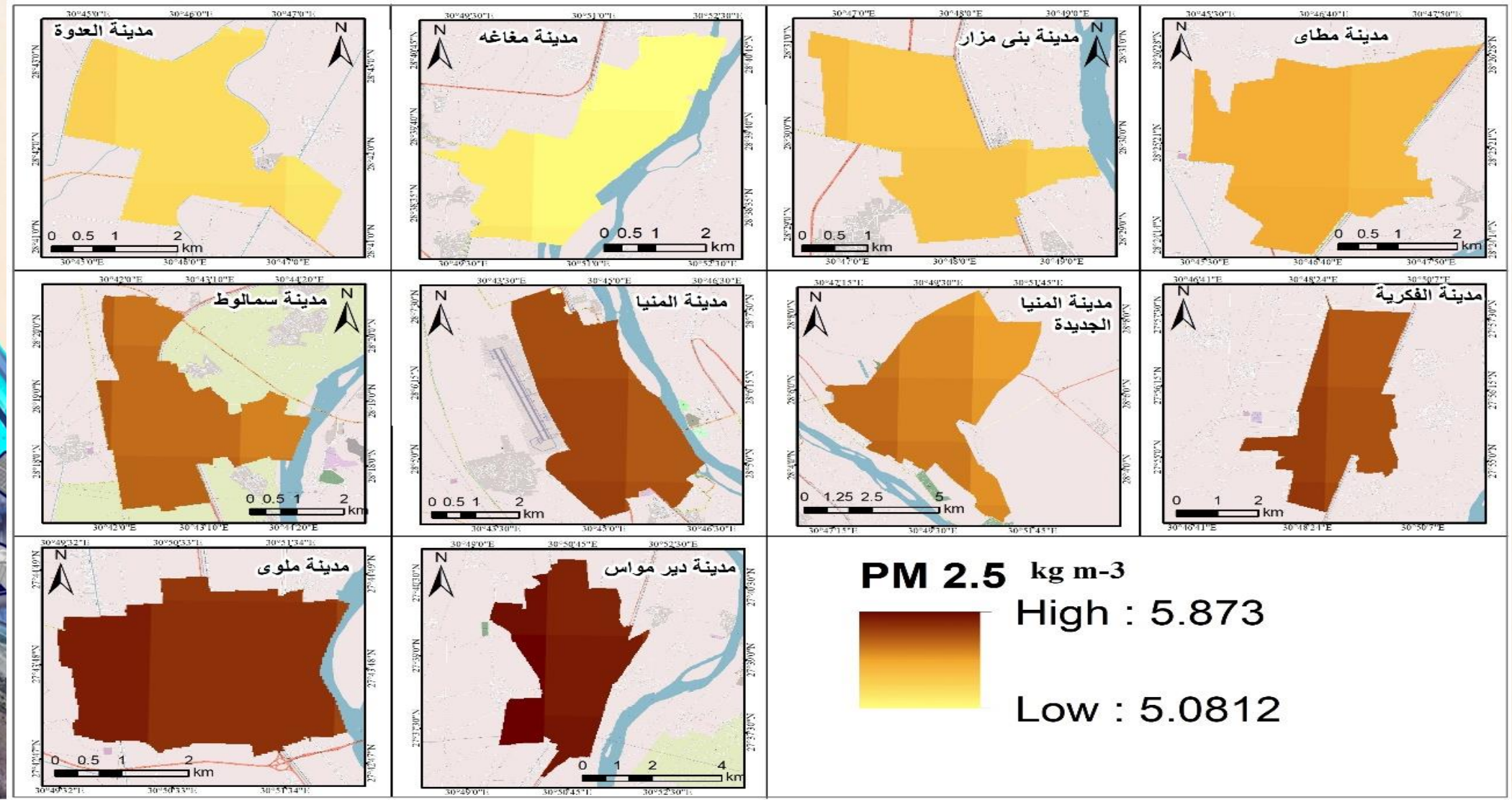
متوسط حجم الاسرة

الهدف (11.6) **تقليل التأثيرات البيئية للمدن**

المؤشر 11.6.1 الخاص بإدارة النفايات الصلبة يُعرف بأنة نسبة النفايات الصلبة الحضرية التي يتم جمعها بانتظام مع تصريف نهائي كافٍ من إجمالي النفايات الصلبة الحضرية الناتجة عن المدن. ويقيس حصة تلك النفايات الصلبة المتولدة في المدن.

	العدوه	الفكريه	المنيا	المنيا_الجديده	بنى_مزار	ديرمواس	سمالوط	مطاى	مغاغه	ملوى
متعهد جمع القمامة	10	7	1	9	4	8	3	6	5	2
إلقاء فى صندوق القمامة	9	6	1	10	4	8	3	7	5	2
التخلص من القمامة بالحرق	1	5	6	2	9	4	7	3	8	10
إلقاء القمامة في ترعه مصرف	2	8	5	1	6	9	10	7	3	4
إلقاؤها القمامة في الشارع	2	6	9	1	7	3	4	5	8	10
متوسط طرق التخلص من المخلفات الصلبة	4.8	6.4	4.4	4.6	6	6.4	5.4	5.6	5.8	5.6

المؤشر11.6.2 الخاص بتلوث الهواء في المناطق الحضرية يُعرف بأنة متوسط المستويات السنوية للجسيمات الدقيقة العالقة (مثل $PM_{2.5}$ وPM_{10}) في المدن. ويقيس هذا المؤشر نسبة التعرض المرجح للسكان للتلوث المحيط بجسيمات $PM_{2.5}$؛ أي تركيزات الجسيمات العالقة التي يقل قطرها عن 2.5 ميكرون



Features of Urban Vulnerability and Deterioration

- In most cities, vegetation was replaced with concrete, asphalt, and other surfaces.
- Urban environmental problems are mostly : inadequate infrastructure : water supply, wastewater, solid waste, energy, traffic,
- Natural environment : loss of green spaces, urban sprawl, UHI , pollution of soil, air , water , noise, etc..
- Socio-economic : citizens' illiteracy, poverty , unemployment deteriorated health, high rates of crimes -homicides, etc..
- All these problems are particularly serious in developing countries causing a vulnerable – deteriorated urban environment.

Conclusion

Remote Sensing data, Census data, Sptatial data and GIS multi-criteria models were integrated to create **Spatial Indices** to assess **city vulnerability and degradation** and their causal **factors.**

- Spatial Dimensions and Indices provide **a diagnosis** and **a comparison of environmental situations ; an anatomical vision** of the cities.

- The Environmental assessments of cities may include : Sprawl of slums, overcrowding , habitat quality, population densities, dependency ratios, illiteracy , poor connection to services , and polluted areas.
- **CVI reflects a city's degradation, poverty and needs as well as vulnerability.**
- Such studies provide a **DSS for improving a city resilience.**

Importance of Assessment of the CVI

- Results of such studies are guidelines for environmentalists /planners, city managers for :

- 1. Setting priorities of the environmental issues among various cities (comparing the indices).

- 2. Setting priorities of the hot environmental issues in the city various sectors.

- 3. Setting plans for improving a city's resilience in the 3 pillars of sustainability (natural – socio-economic – technical).

Recommendations

- Government need to maintain a firm control on Rapid and unplanned urbanization, population movement and concentrations are needed to decrease disaster vulnerability, particularly of low-income urban dwellers.
- Some of the strategies and tools that are part of a vulnerability analysis that can be an integral part of the management; include :
- Risk analysis and assessment for cities
- Urban hazard mapping for Mitigation
- Long term strategic urban planning/zoning
- Environmental Impact Assessment
- Environmental Management Systems

Thank you