A presentation for REAL CORP 2022 conference

DELINEATING AND ASSESSING URBAN GREEN INFRASTRUCTURE IN CITIES:

Application of the Patch Matrix Model in Alexandria, Egypt

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PROBLEM DEFINITION

Being a life itself, a single tree can have **a great impact** on a whole system all across the city.

However, Urbanization has Consequences on the natural environment:

- loss of natural areas
- fragmentation of open spaces
- degradation of water resources
- decreased ability for nature to respond to change
- and increased costs of public services (Benedict and McMahon 2002).

The World Health Organization (WHO) recommendation: granting each person in a city a minimum of 9 m2 of urban green spaces that are functional.

Therefore, Exploring and promoting urban green spaces in cities could contribute to an improved quality of life (QOL) and ecosystem services.

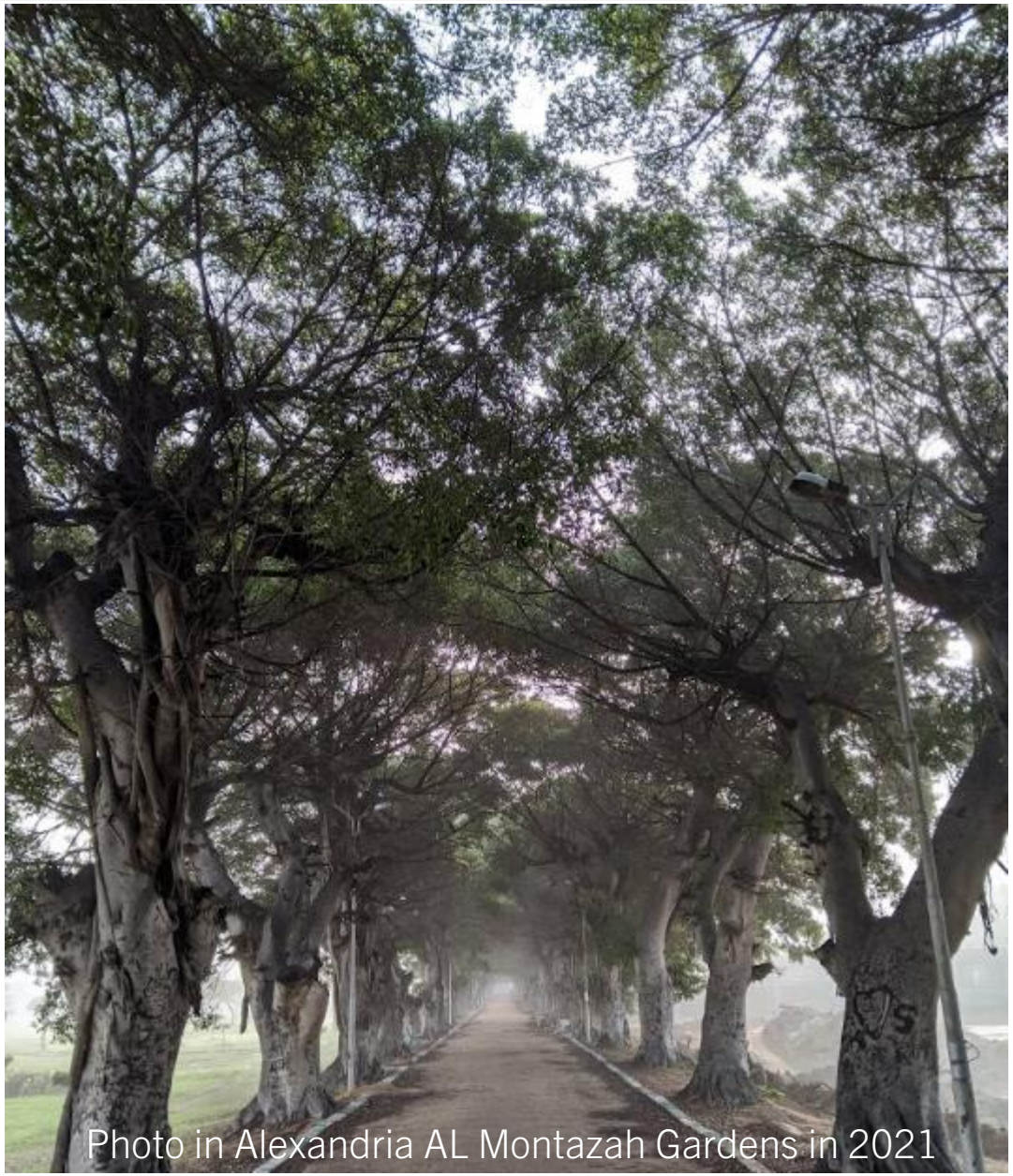


Photo in Alexandria AL Montazah Gardens in 2021

RESEARCH QUESTION

Urban Green Infrastructure responds to such issues by offering opportunities that attempt to preserve values and functions of ecosystems, as well as solutions to support biodiversity and urban healthy environments.

In this regard, the research attempts to answer two main questions:

Why is Urban Green Infrastructure (UGI) Important, and how to delineate it?

How to assess UGI in order to implement more UGI in the city?

Answered by Landscape Ecology Principles

landscape ecology theories and models offer choices for urban planning

It is found that the Patch Matrix Model (PMM) is a flexible model to adopt due to its classification methods, instructions and metrics that formulate a dataset of cells assigned to categories of patches, and their functions.

RESEARCH AIM

This research focuses on green spaces as a main component of UGI.

Consequently, the aim of this research is developing an adopted model to investigate UGI systems in an urban setting.

The research mainly focuses on two broad objectives.

- Firstly, delineating UGI categorisations in the city of Alexandria, Egypt through a review of existing literature, and models that can be analysed to be compared to each other.
- The second objective, focusing on the quantitative assessment of UGI in their local context based on principles of the chosen model: the patch matrix model.

CONTEXT OF THE RESEARCH

African green infrastructure: a complicated issue that has been troubled by previous **environmental injustice** and is still understood to be essential to long-term sustainability (Anderson, Okereke, Rudd, & Parnell, 2013).

Egypt, the third most populous country in Africa, is suffering from **severe desertification**, **land degradation**, and **drought** as a result of both natural and human-caused factors, such as **climate change, sea level rise**, improper **management** of resources, **overgrazing**, and **rapid urban growth** (MPED, 2021).

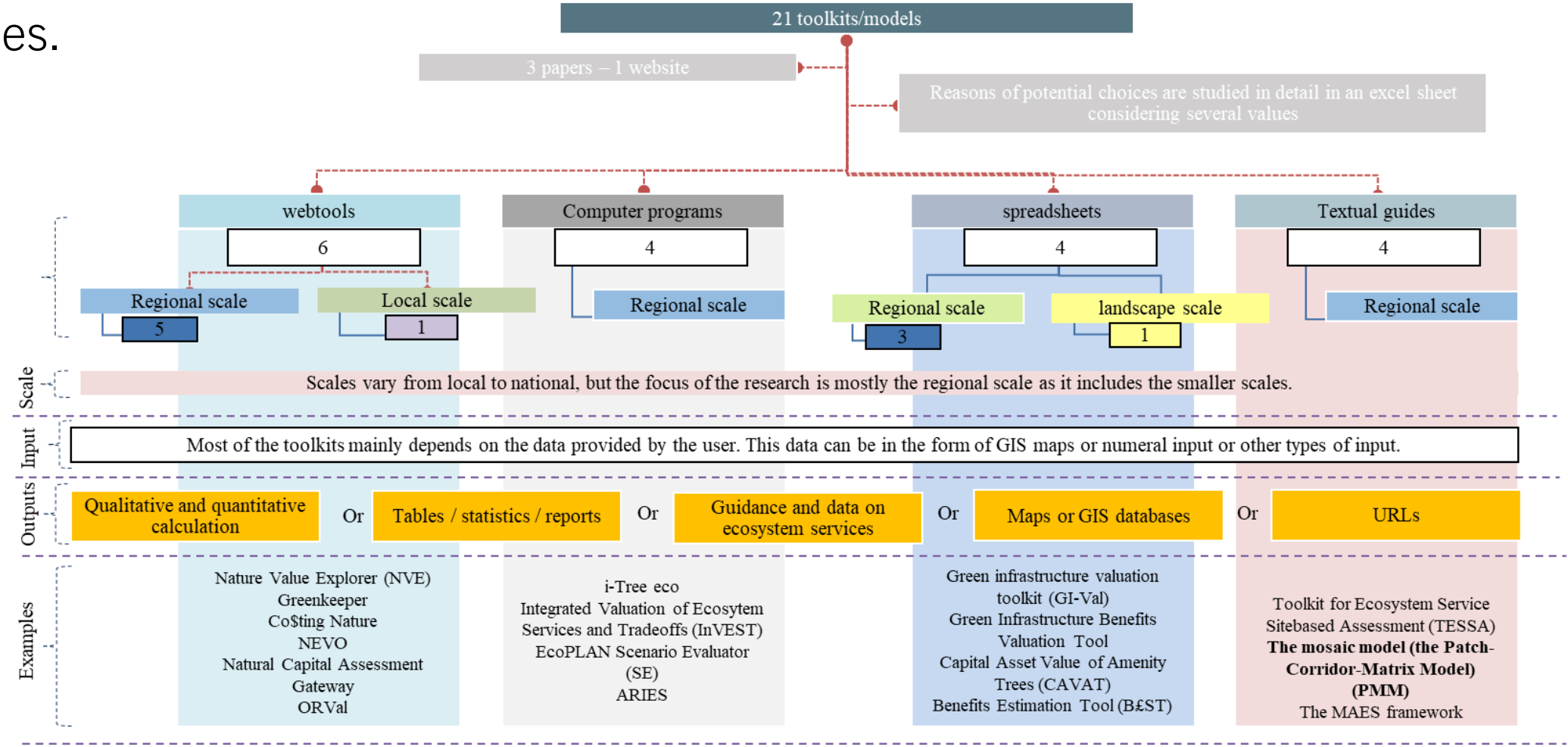
Recently, since launching **the Sustainable Development Strategy** (SDS), Green initiatives in Egypt made up 691 projects in the 2020–2021 investment plan, accounting for around 14% of all public investments. The plan prioritises **green projects** and gradually phasing out unsustainable projects by increasing **public green spending** as a percentage of public investments to 30% (MPED, 2021).

URBAN GREEN INFRASTRUCTURE IN LITERATURE

- Through its evolving over time, many approaches shaped UGI such as **greenways or parkways**, developed first in the USA, and promoted by the work of **Frederick Law Olmsted** through his 1870s famous **Boston's Emerald Necklace system of parks.**
- Later, **Ebenezer Howard** initiated **the garden cities movement** in Europe (Fábos, 2004).
- Subsequently, similar examples assure the roles of UGI as **recreational spaces** (Hall, 2002).
- The following review aims to choose **a suitable approach for analysing a district in Alexandria, Egypt.**
- The **decision** is based on how approaches define UGI in urban settings, what the output is and how it is displayed.
- It is preferred that a model offers ways to re-evaluate the input **when proposing scenarios later.**
- It is found that **Quantitative analyses** based on PMM patches vary and these quantitative metrics are used to assess how different or similar landscapes are by comparing them. Consequently, these play **a vital role** in landscape studies (Turner, M. G., & Gardner, R. H., 2015).

UGI ASSESSMENT METHODS

This research investigates some models/ tools, groups them by types and compares their capabilities.



UTILIZATION OF PMM IN THE RESEARCH

Forman and Gordon (1986) defined **a patch** as “a nonlinear surface area differing in appearance from its surroundings”.

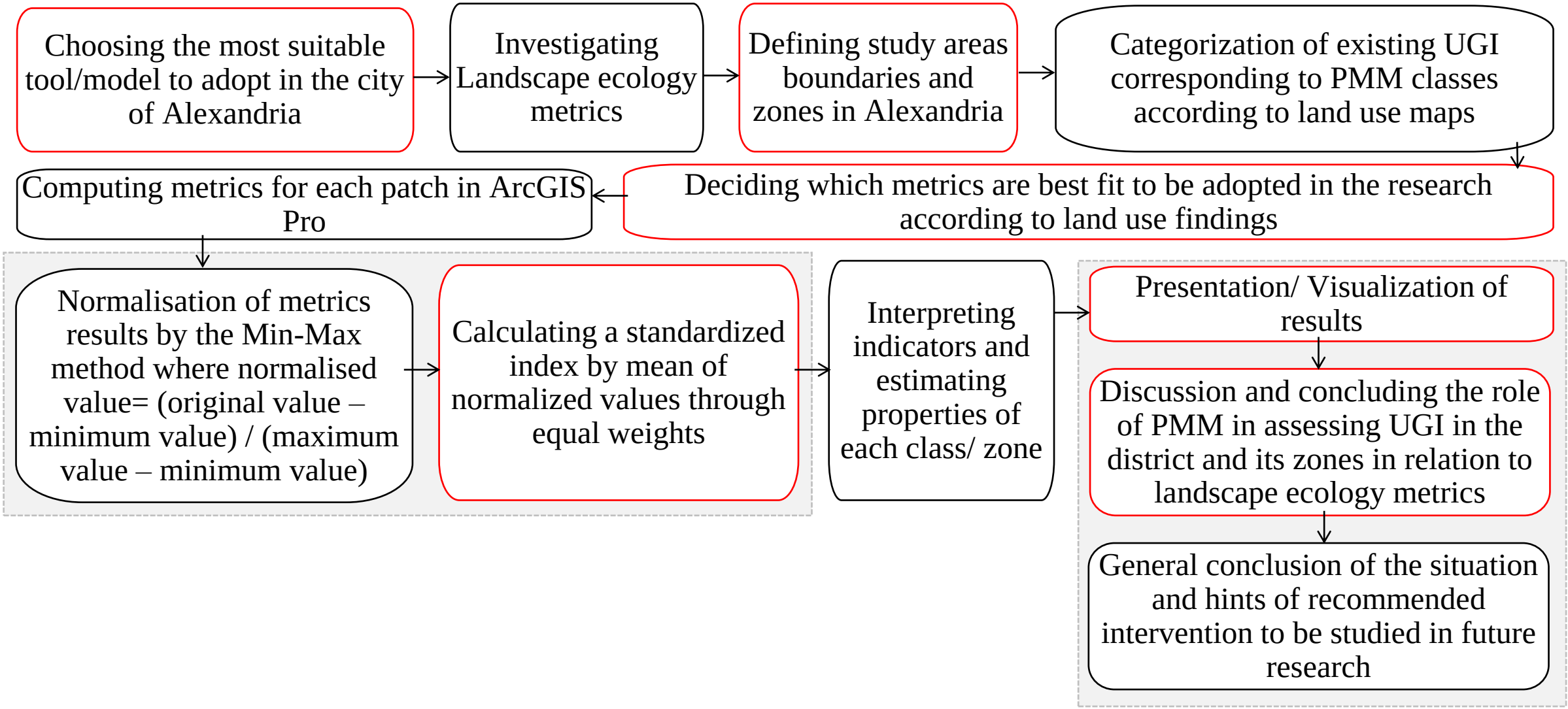
Admittedly, Landscape ecology theories are **valid** for assessing UGI, and it concepts (Wu, J., 2012).

Traditionally, there is **no formula** to figure out how many and which metrics are required to describe a landscape, **yet one sole metric is inadequate** (Turner, M. G., & Gardner, R. H., 2015).

Scale according to PMM

- Customarily, scales must be chosen based on the study's **goal**. The **extent** of the study should be 2–5 times greater than landscape patches (Turner, M. G., & Gardner, R. H., 2015).

RESEARCH METHODOLOGY



UTILIZATION OF PMM IN THE RESEARCH

Qualitative categorizations

Patch class	Land use/ cover of UGI elements associated with the patch class in Al Montazah District, Alexandria
Environmental resource patches	Beaches and sandy waterfronts, lagoon areas.
Constructed or built-up introduced patches	Cemeteries, swimming pools, Playgrounds, parking spaces, infrastructure facilities such as water supply or sewage stations, squares.
Planted introduced patches	Parks, gardens, green spaces, plantations, or nurseries.
Vegetation patches	Agricultural lands.
Disturbance patches	Farms and grazing fields.
Remnant Patches	Abandoned farms and fields.

Quantitative calculations

Metric	Description	Choice of a metric in case of duplication
PAR	PAR = P/A: P is perimeter of a patch, and A is area of the patch.	FRAC reflects shape complexity overcoming limitations of other metrics, so it will be the one computed in the research.
PSI	PSI = $p/2\sqrt{A\pi}$	
FRAC	FRAC=2ln(.25P)/ln(A)	
NP	The total number of patches in the landscape.	PD represents the density; therefore, it will be computed.
PD	The number of patches per square kilometer (i.e., 100 ha).	
TE	The sum of the lengths of all edge segments (unit: meter).	ED represents the density; therefore, it will be computed.
ED	The total length of all edge segments per hectare for the class or landscape of consideration (unit: m/ha).	
PRD	The number of patch types per square kilometer (or 100 ha).	PRD is not informative on the patch level
LPI	The ratio of the area of the largest patch to the total area of the landscape (unit: percentage).	
MPS	The average area of all patches in the landscape (unit: ha).	PSCV is the metric that will be computed as it embraces MPS and PSSD within itself.
PSSD	The standard deviation of patch size in the entire landscape (unit: ha).	
PSCV	The standard deviation of patch size divided by mean patch size for the entire landscape (unit: percentage).	
γ	The Gamma index of network connectivity (0-1), γ= L/3(V-2): L is the number of links and V is the number of nodes in the network.	

ALEXANDRIA'S CASE STUDY

- The city of Alexandria has displayed its beauty throughout ages.

Egypt Delta and Coast, Google Earth, 2022

- Like many **Mediterranean** cities, it is struggling to support a population that is **expanding quickly**, and higher living standards.

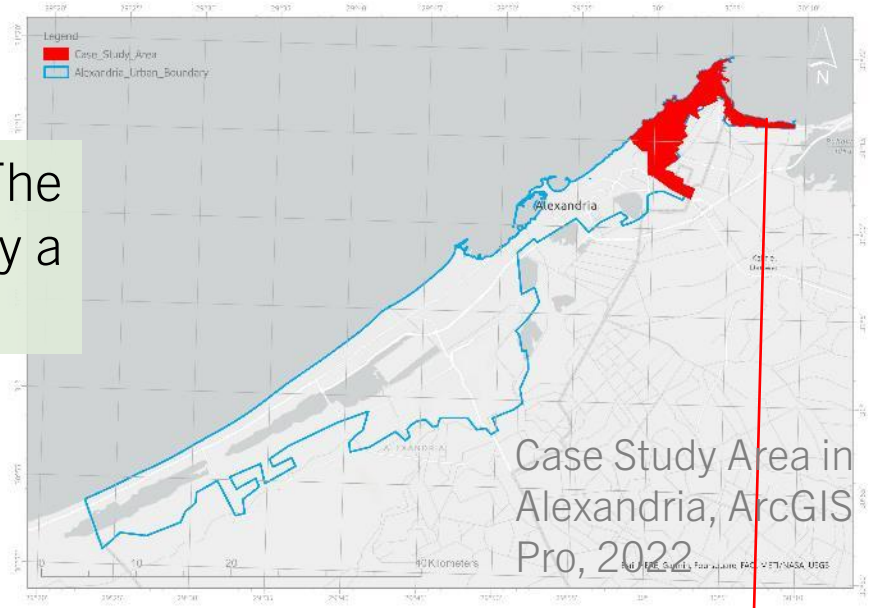
Alexandria Governorate, Google Earth, 2022

- However, with unauthorized urban growth, UGI is **at risk** (Barthel, Davidson, & Sudarskis, 2017).

ALEXANDRIA'S CASE STUDY

- One of Alexandria's far east districts: about 53.83 km^2. The district has had access to a port which development is currently a massive ongoing project in recent years.

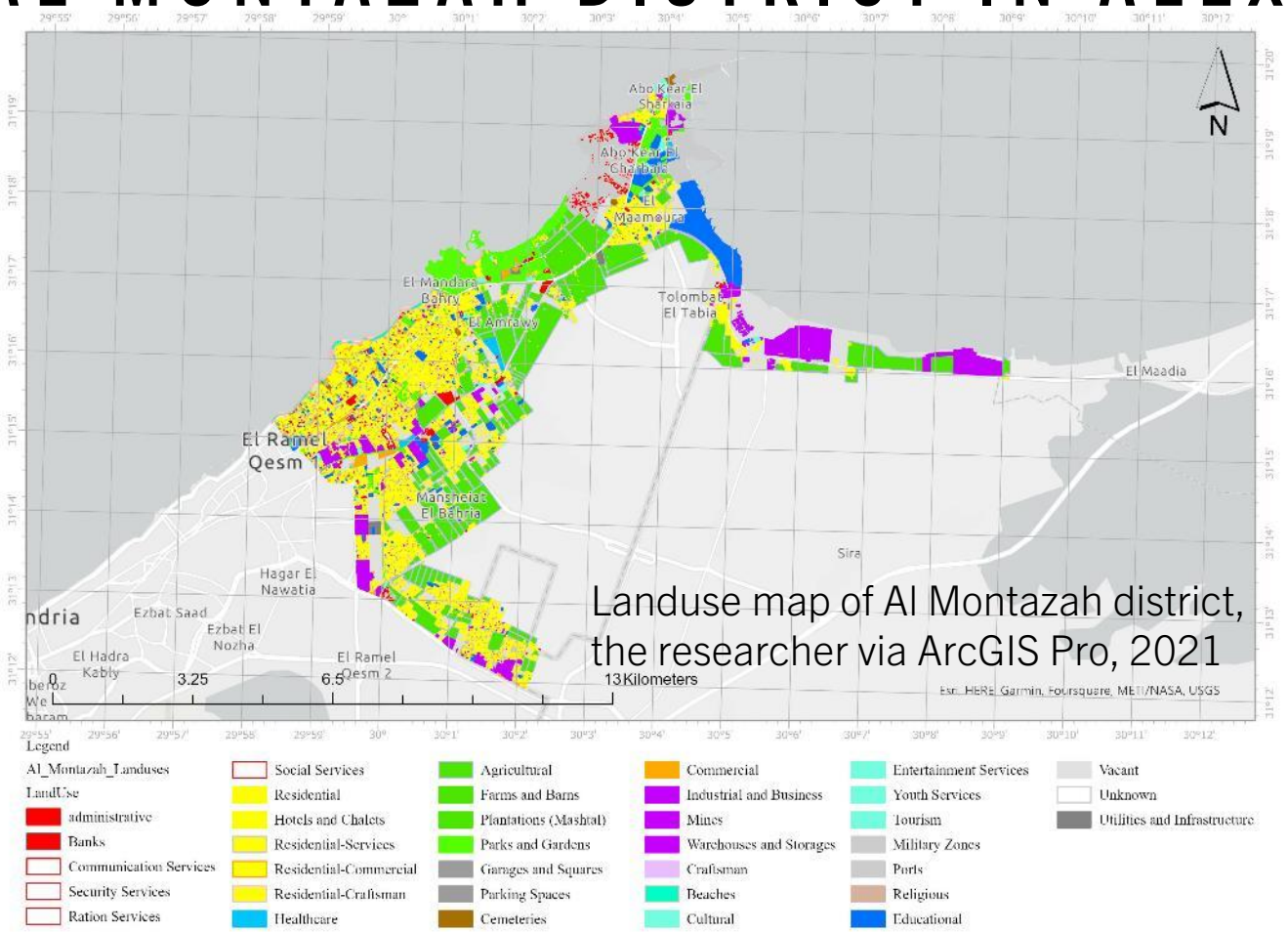
Photo in Alexandria AL Montazah Gardens in 2021



Case Study Area in Alexandria, ArcGIS Pro, 2022

Al Montazah District Alexandria, ArcGIS Pro, 2022

AL MONTAZAH DISTRICT IN ALEXANDRIA



Landuse map of Al Montazah district, the researcher via ArcGIS Pro, 2021

Photos in Al Montazah gardens, 2021

Obviously, the district features many beaches, mostly accessed through **the famous garden of Al Montazah palace.**

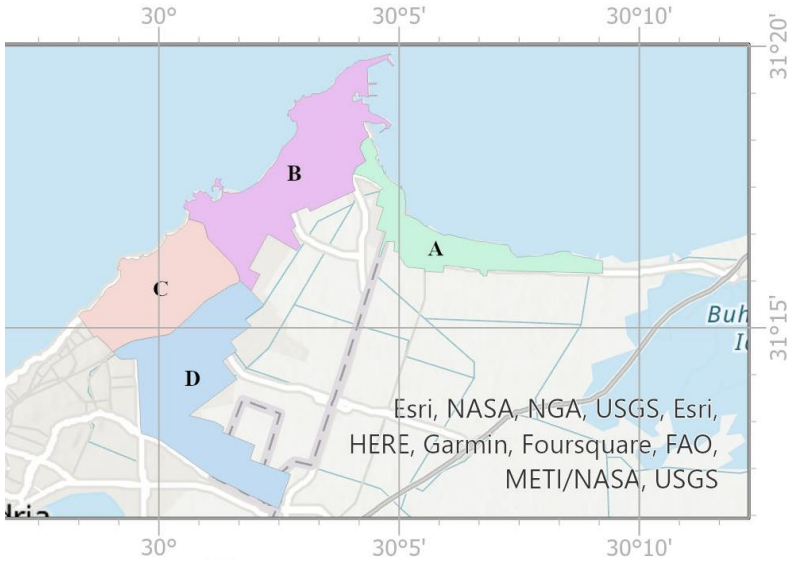
THE PREVIOUS FINDINGS CONTRIBUTED TO THE RESULTS THROUGH:

1. Producing visualized maps.
2. Formulating statistical graphs.
3. Concluding meanings behind them.
4. and by introducing recommendations.

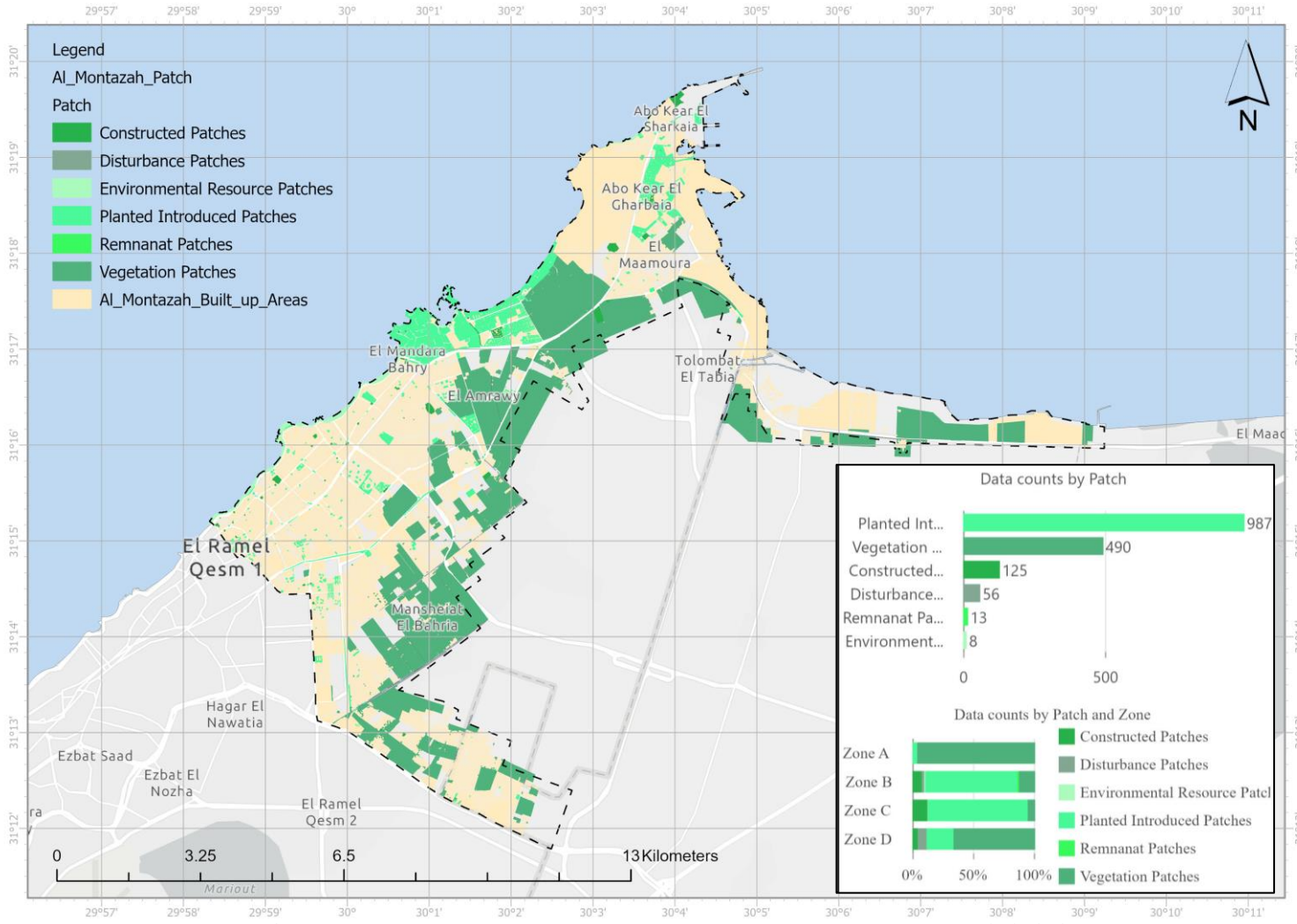
RESULTS AND DISCUSSIONS

In this paper, the district will be conveyed as 4 zones

It can be said that the matrix is vulnerable because of the abundance and concentration of vegetation as shown.



Zones, the researcher 2022.

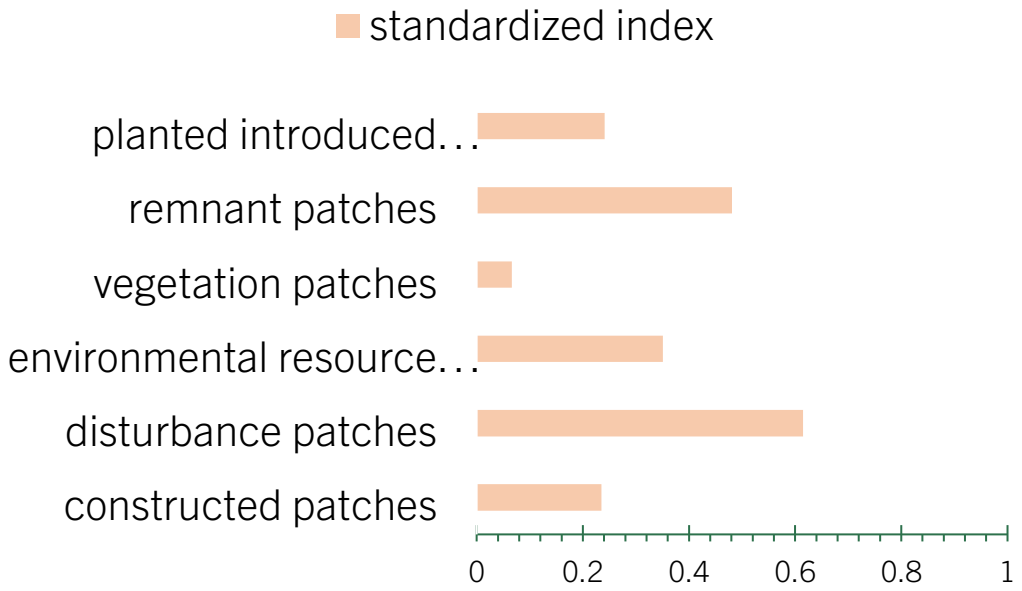


Distribution of patches in the district, the researcher, 2022

RESULTS AND DISCUSSIONS

The indicators will be speculated by a standardized index combining all normalised values of the 5 chosen metrics ranging from 0 to 1, 1 being the highest.

This index will be responsible for showing how optimal the landscape is and where.

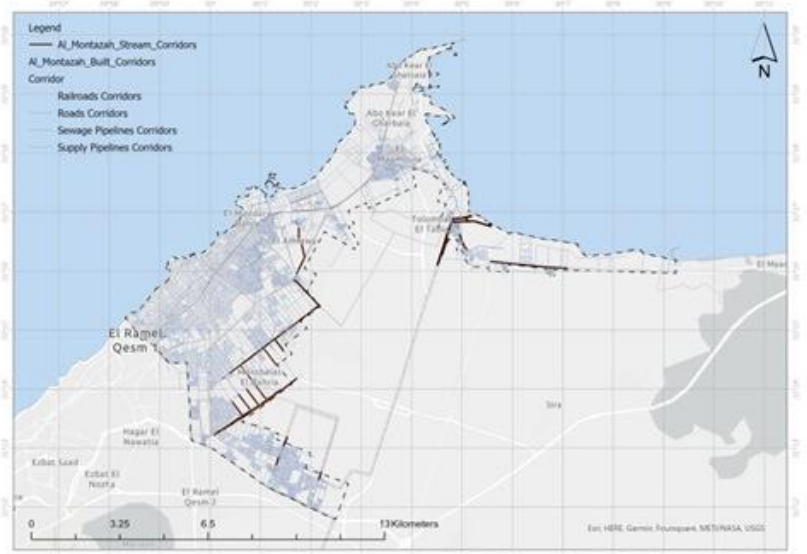


Normalised Values	patches					
	Constructed	Disturbance	Environmental Resource	Vegetation	Remnant	Planted Introduced
PAR	0.120	0.050	0.000	0.492	0.005	1.000
PSI	0.041	0.036	0.222	0.041	0.050	0.073
FRAC	0.250	0.250	0.500	0.250	0.308	0.327
NP	0.120	0.049	0.000	0.492	0.005	1.000
PD	0.330	0.906	0.000	0.008	1.000	0.273
TE	0.077	0.017	0.061	0.839	0.000	1.000
ED	0.419	0.754	0.228	0.000	1.000	0.566
PRD	0.035	0.210	0.027	0.000	1.000	0.003
LPI	0.142	0.165	1.000	0.035	0.097	0.000
MPS	0.033	0.002	1.000	0.670	0.000	0.043
PSSD	0.052	0.486	1.000	0.860	0.000	0.071
PSCV	0.034	1.000	0.028	0.039	0.000	0.038
standardization index	**0.235**	**0.615**	**0.351**	**0.066**	**0.481**	**0.241**

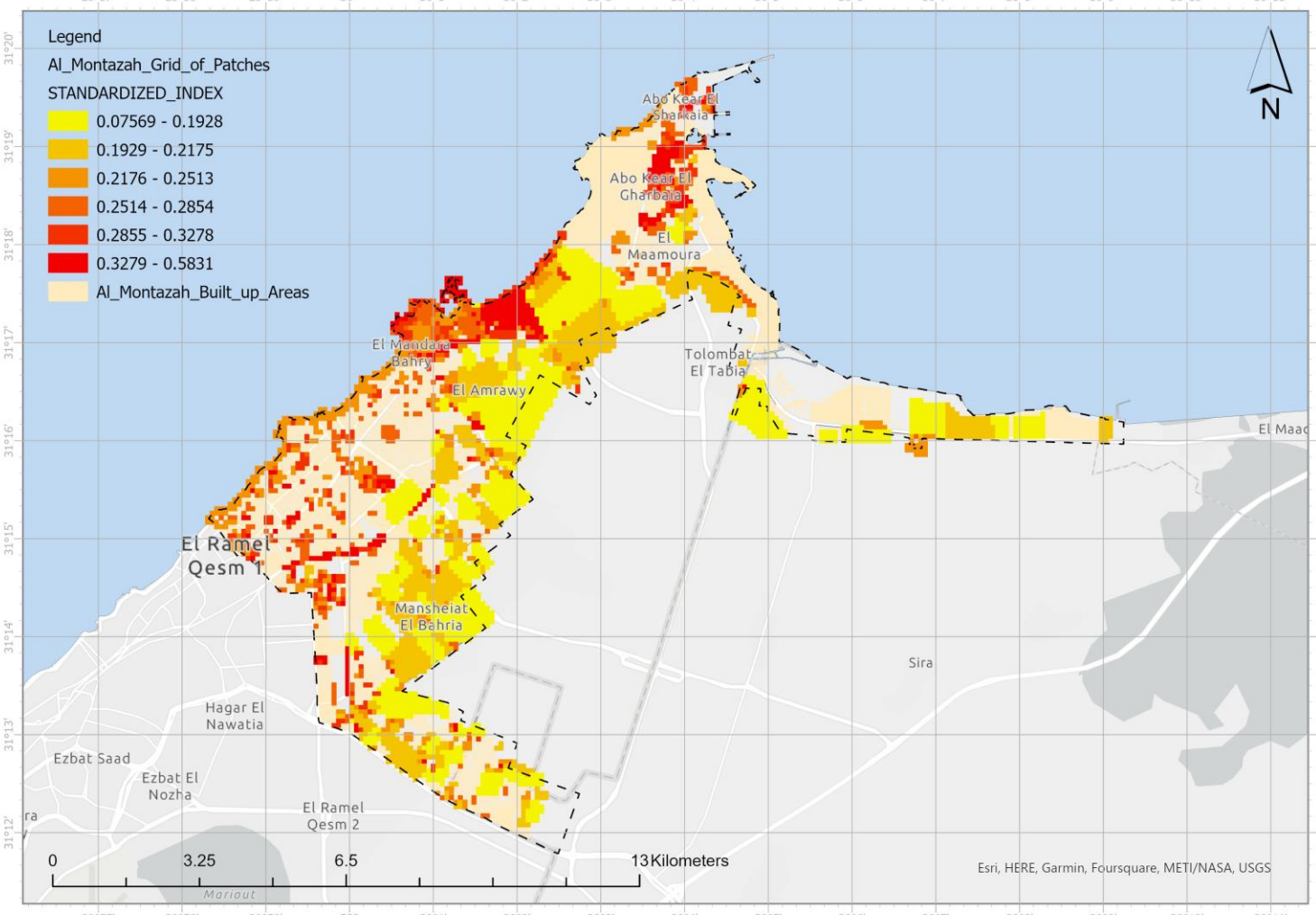
RESULTS AND DISCUSSIONS

Corridors are also mapped to monitor their concentrations.

The findings can summarize UGI in Al Montazah as moderately variable, and not very rich.



Corridors in the district, the researcher, 2022.



Standardized index of patches in the district, the researcher 2022.

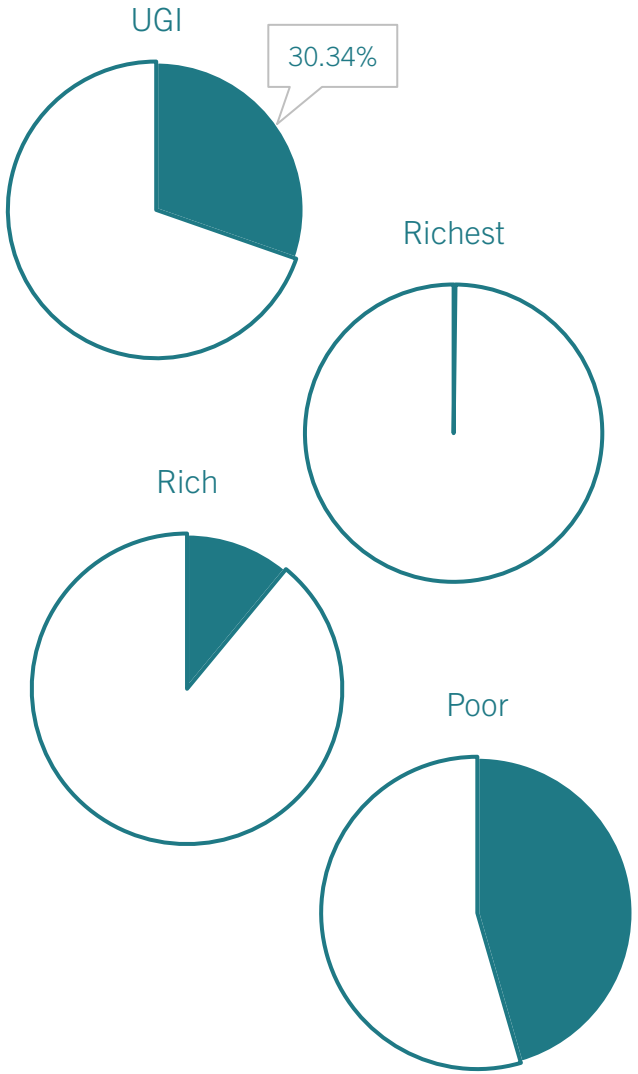
RESULTS AND DISCUSSIONS

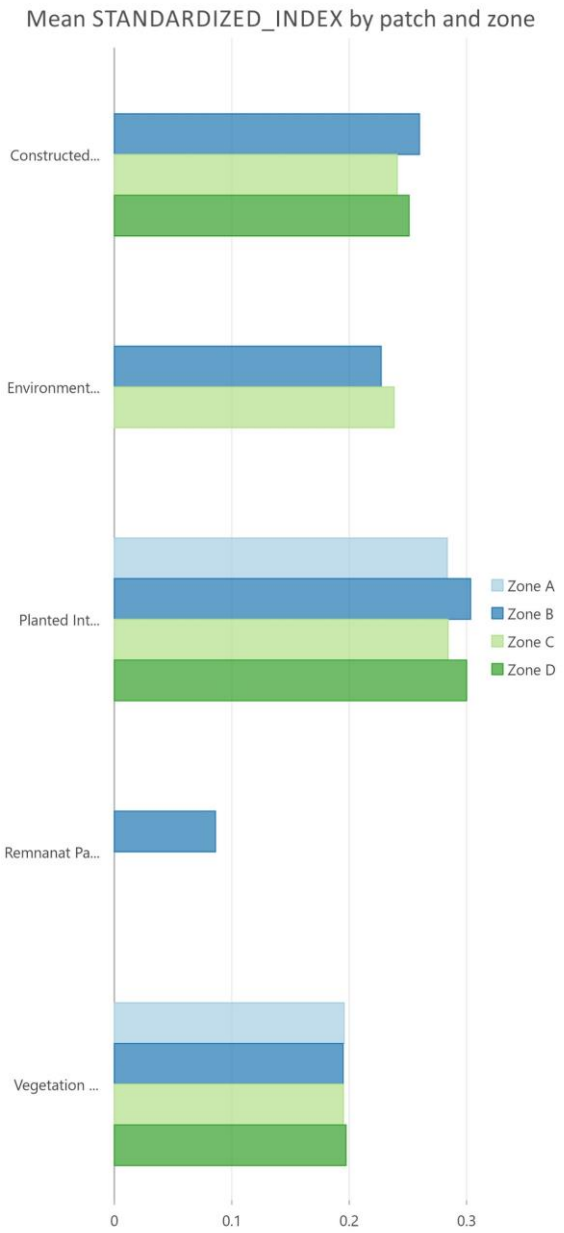
Despite being fragile, UGI represents 30.34% of the whole matrix.

All in all, the matrix is not complex, extensive towards sea, but limited towards southern agricultural lands.

It is not highly fragmented, and the distribution of fragmentation is valid, for the highest fragmented holds the least number of patches.

- 0.2% of the total patches are considered the **richest**, spread in all zones except zone A.
- **Rich** patches are around 11% of total patches.
- 45.5% of the matrix are **poor** patches, seen in all zones, but the least in zone C.



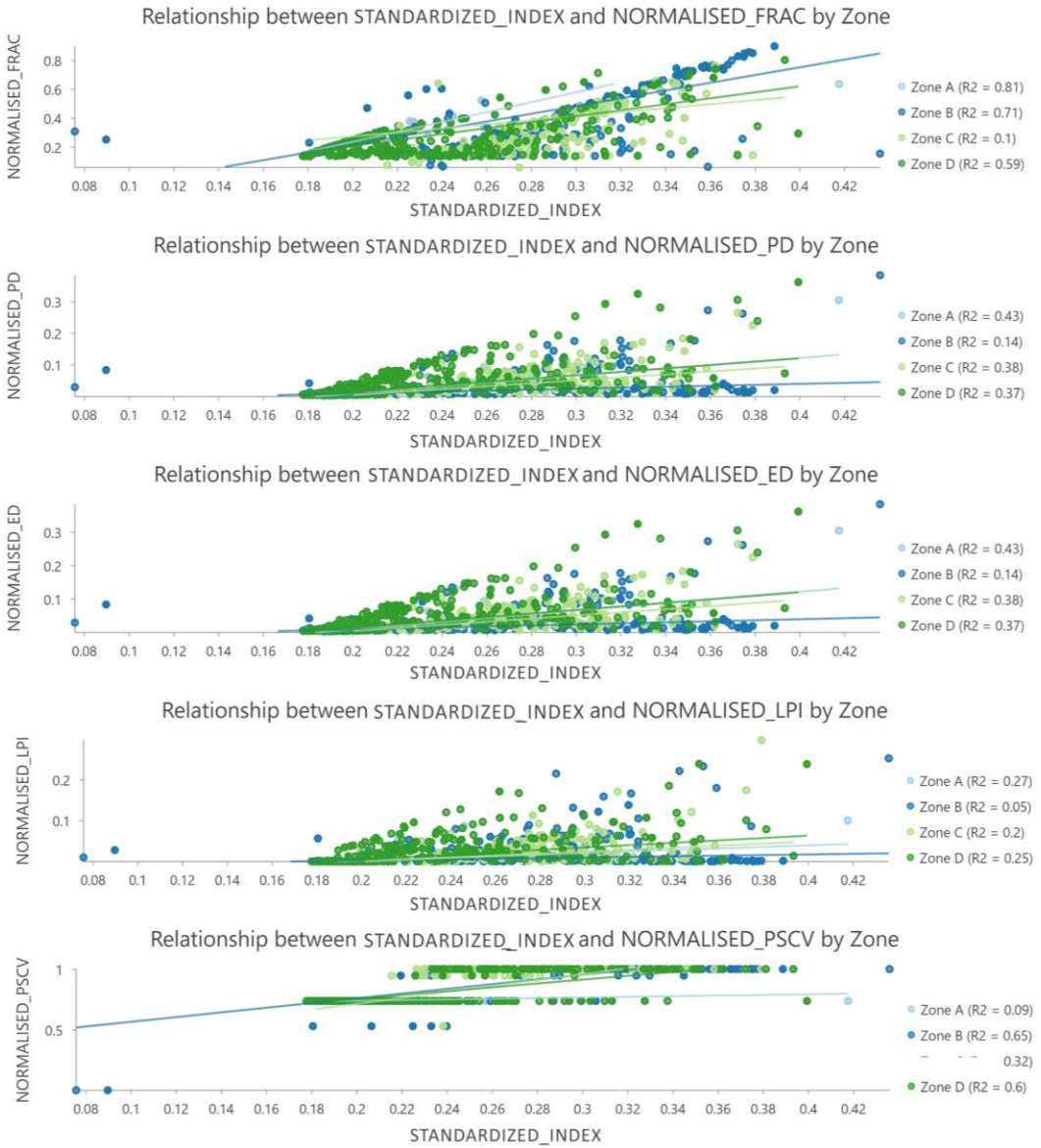


RESULTS AND DISCUSSIONS

Above all, landscape metrics are numerically related or correlated.

It is evidenced by scatter plots diagrams that PSCV has the most impact on the value of the standardized index, especially in zone B. Also, FRAC is **more contributing** to the index than other metrics

Putting it all together, relationships prove that areas of patches are a crucial factor in this assessment, since area is an essential parameter in the calculations.



CONCLUSION

The patch matrix model (PMM) is proved to be a useful tool through landscape metrics.

The research objectives were to adopt PMM in a framework applied in cities for the purpose of evaluating its city green open spaces.

Results were validated by a standardized index, and correlations between this index and landscape metrics were discussed to guide green space assessment.

In conclusion, UGI in Al Montazah district in Alexandria is striving to be an optimum landscape.

This is a continuous study that will proceed to develop and subjected to application in different contexts.

- Accordingly, complexities could be solved through simple UGI solutions such as reviving remnant patches as pilot projects, making use of stream corridors to increase connectivity, and other opportunities for conservation strategies.
- Future recommendations could be made upon the displayed results to localize action plans and suggestions in the district to enhance UGI and encourage keen NGOs or decision makers.

THANK YOU