Delineating and Assessing Urban Green Infrastructure in Cities: Application of the Patch Matrix Model in Alexandria, Egypt

Esraa M. Abdel-Gawad, Hany M. Ayad, Dina M. Saadallah

(MSc. Candidate Esraa M. Abdel-Gawad, Faculty of Engineering Alexandria University, Alexandria, Egypt, Esraa.Gawad@alexu.edu.eg)
(Prof. Dr. Hany M. Ayad, Faculty of Engineering Alexandria University, Alexandria, Egypt, hany.m.ayad@alexu.edu.eg)
(Assoc. Prof. Dina M. Saadallah, Faculty of Engineering Alexandria University, Alexandria, Egypt, dina.saadallah@alexu.edu.eg)

1 ABSTRACT

Cities face crucial issues related to urbanisation, declining quality of life, inadequate infrastructure, and ecosystem degradation. Those issues have huge impacts on the health and wellbeing of communities. In response, the World Health Organisation (WHO) recommends granting each person in a city a minimum of 9 m2 of urban green spaces that are functional. Many cities face challenges to achieve this requirement due to limited green public areas and their under-exploration as green infrastructures. In Egypt, due to high urbanisation rate and increased densification, some cities, particularly large ones, are struggling to provide a proper share of open spaces per capita.

Exploring and promoting urban green spaces in cities could contribute to an improved quality of life (QOL) and ecosystem services. In this respect, “urban green infrastructure” (UGI) 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. This research focuses on green spaces as a main component of UGI in Alexandria, Egypt's second-largest city, through the application of the Patch Matrix Model (PMM). Since the 1980s, PMM has been a fundamental principle in landscape ecology, as it describes the horizontal landscape structure in a simple practical way by delineating homogeneous areas and by quantitatively assessing their spatial arrangement and diversity.

It is proposed to adopt PMM to classify and analyse UGI on an urban scale in Alexandria's Al Montazah district. Using remotely sensed data, Esri Sentinel-2 Land Cover maps, as well as existing local spatial information systems, delineation of existing and potential patches, corridors and matrices is performed. Homogenous areas of open spaces are analysed in terms of their shape, size, and functions. Linear spaces in the city are also investigated and the spatial arrangement of the PMM components is developed. Based on the implementation on a highly urbanised district, discussions extend to the potential and limitation of this approach for quantifying urban landscape patterns. The research results confirm the validity of PMM in delineating and providing scenarios for UGI development, and in proposing a tactic plan for city-scale interventions.

Keywords: Urbanization, Urban green spaces, Patch Matrix Model, Urban Green Infrastructure, Landscape ecology, Ecosystem

2 INTRODUCTION

According to the United Nations (UN) (2018), sixty-eight percent of earth’s population will be living in urban areas by 2050. Also, it is reported that in 2000, forty-seven percent lived in urban areas, which increased to fifty-five percent in 2018 with the fastest urbanisation rates experienced in Africa and Asia (United Nations, 2018). The global claim addressed is that urbanisation is a process that replaces vegetated areas, which provide shading, cooling, rainwater harvesting and infiltration functions, with built surfaces. Being a life itself, a single tree can have a great impact on a whole system of green spaces across the city.

Egypt, the third most populous country in Africa, is characterised by regional varieties of natural resources, labor force characteristics, and culture. Egypt, however, 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). According to the latest data by the World Bank, Egypt’s agricultural land areas represents 3.9% of total land area in 2018, while forest land areas represent 0% in 2020 after being 0.1% in 2015, which are low values compared to other countries, knowing that its urban population represents 43% of total population with annual growth of 2%. In this regard, 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 phasings out unsustainable projects by increasing public green spending as a percentage of public investments to 30%. Furthermore, Egypt also launched the Sustainable Development Strategy (SDS): Egypt Vision 2030 in 2016 aspiring to ensure quality of life (QOL) through sustainable projects and initiatives such as "Haya Karima" (Decent Life) initiative that started in 2020 (MPED, 2021).

Following the previous facts, addressed challenges need effective scenarios for green spaces across cities. On this matter, green spaces described by the term '(urban) green infrastructure' (UGI) is relatively new to academic literature, however the idea is long existing (Wito Van Oijstaeijen et al., 2020). UGI can be broadly defined as a strategically planned network of high quality natural and semi-natural areas with other environmental features, designed and managed to provide benefits from nature to people in both rural and urban settings. Additionally, it aims to enhance nature's ability to deliver valuable ecosystem goods and services, such as clean air or water. For example, permeable vegetated surfaces, green roofs, public parks, green walls, urban forests, green alleys and streets, and community gardens are all UGI elements that can exist in cities (Gill et al., 2009).

To understand UGI, there should be a recognition of its importance, classification approaches and evaluations methods. Consequently, the aim of this research is investigating compositions of UGI systems in an urban setting. The research mainly focuses on two broad objectives. Firstly, delineating UGI components by land use/cover and their categorisation in the city of Alexandria, Egypt. This requires a review and inspection of a variety of related tools or methods. Owing to existing literature, models can be analysed to be compared to each other and the most suitable model can be chosen to be adopted in the study area. This process introduces the second objective, focusing on the assessment of UGI in their local context based on principles of the chosen model: the patch matrix model, and the reason of its choice will be explained as the research proceeds.

3 LITERATURE REVIEW

Through its evolving over time, many approaches shaped UGI such as greenways or parkways as environmental features, 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 to facilitate a more inviting and interactive landscape that people could use as quotidian recreational spaces (Hall, 2002).

For the most part, principles of UGI have been supporting ideas of landscape ecology, which proposes that environments are made up of networks of ecological resources (Forman, 1995). Hence, Landscape ecology can provide the spatial framework that enables green space management. Plus, it can be proposed to consider ecosystem services (ES) to support UGI, rather than as a separate line of scholarly argument. In view of ES, common international classifications of ecosystem services are supporting, provisioning, regulating, and cultural ES, reflected on types of UGI. Moreover, landscape ecology theories and models offer choices for urban planning. In essence, landscape ecology encourages spatial relationship models, gathering of novel data on spatial dynamics, and investigating spatial scales (Pickett and Cadenasso 1995). Coupled with geographic sciences, rapid advancements in landscape ecology, and satellite imagery, predicting landscape change has become simpler over time (Turner, M. G., & Gardner, R. H., 2015).

In assessing the effects of landscape variability, spatial models have a significant impact. Most crucially, models should never be ends in themselves, but rather instruments for reaching a certain aim. In fact, models come in a variety of forms, and mathematical models are frequently used in landscape ecology. It is tremendously beneficial to compare different models before deciding which one is suitable in any case study (Turner, M. G., & Gardner, R. H., 2015).

This research tackles methods mentioned in gray literature, peer reviewed literature or books to compare and choose the most suitable one for adoption later. Wito Van Oijstaeijen et al. (2020) reviewed several assessment toolkits to support investments of UGI from an urban planning point of view, which has been a great aid in this research. Types of toolkits include webtools, spreadsheets, computer software or textual guides. This research investigates some models/ tools, groups them by types and compares their capabilities.

The first group of webtools include "Nature Value Explorer (NVE)", an application to support the quantification and valuation of ES (Vito et al., 2022). It evaluates cultural, and regulating ES in terms of denitrification, air quality and noise mitigation (Broekx, S., et al., 2013). The main advantages are its accessibility, and ease to combine results in GIS. On the other hand, it works on small local scales only and cannot include a district or a city, does not include all types of ES and was built for a certain case study whereas scenarios input in Egypt might differ. In addition there are: "Greenkeeper" to identify the value of a green space (Wito Van Oijstaeijen et al., 2020), "NEVO (Natural Environment Valuation Online tool)" to estimate the value of an area for delivering ES and biodiversity, "ORVal (Outdoor recreation valuation tool)" to predict the number of visits to greenspaces in England, and "Co$ting Nature" to allow scenarios understand the impact on ES delivery. The first three tools are not accessed in Egypt, while "Co$ting Nature" is limited to 1 km2 data entry.

Secondly, computer software like "Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST)", is used to map and value the goods and services from nature that sustain human life according to Stanford University definition. InVEST modelling approach focuses on carbon storage, sediment erosion, and pollination (Grafius, D. R., et al., 2016). Yet, it is limited to a certain scale and resolution with high expertise requirement. Also, "i-Tree eco" is a software by USDA Forest Service that uses field data from trees to quantify environmental effects on society (Wito Van Oijstaeijen et al., 2020). Additionally, "ARIES" is a software used in spatial mapping and quantification of ES, but it is time-consuming, and not independent of GIS as InVEST. These software are not inclusive to many aspects by which UGI can be fully described. A collaboration with another type of tools might be needed, which can be time consuming.

Thirdly, spreadsheets are found to be vital in some cases. For instance, "Green infrastructure valuation toolkit (GI-Val)" by The Mersey Forest, UK, establishes the value of green assets, using calculator Tools, and "Capital Asset Value of Amenity Trees (CAVAT)" by London Tree Officers Association (LTOA) helps decision-making when a publicly owned tree needs to be expressed in monetary terms (Wito Van Oijstaeijen et al., 2020). Their calculations are specific and requires high expertise in certain fields.

The fourth group includes textual guides or published documents. To name a few, "the mosaic model/ the Patch-Corridor-Matrix Model (PMM)" describes and understands the spatial configuration of landscapes (J. Ahern, 2007) in addition to "the MAES framework (mapping and assessment of ecosystems and their services)" (On Yi Liu & Alessio Russo, 2021). The MAES framework offers a linear structure of steps easy to comprehend and apply on ES limited by availability of data. Nevertheless, PMM is simple, compatible with GIS, understandable, requires moderate computational expertise, simplifies representations to mock conventional maps, and most importantly reflects how humans perceive landscapes. It is limited by the lack of established standards for classifications, ground truth of data, and the need for discrete boundaries of land uses (Lausch, A., et al., 2015). To sum up, 21 toolkits, 12 of which were mentioned above and summarised in figure (1), have been explored, where some limitations of each tool are mentioned in the previous paragraphs.

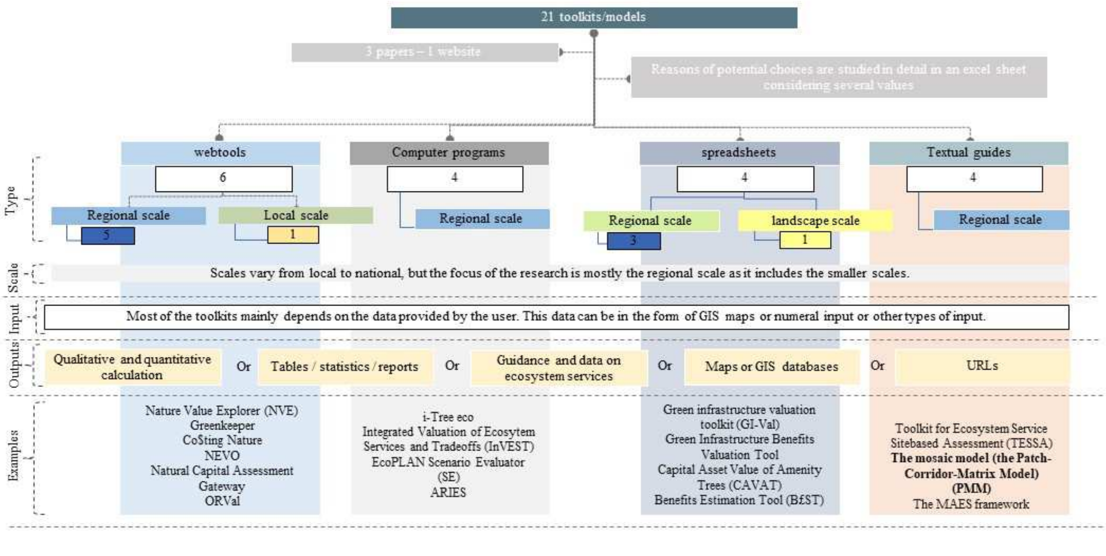

Fig. 1: Methods/Models/Toolkits investigated on the matter of UGI, ES, or landscape ecology (the researcher, July 2022).

The previous 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.

Moreover, it is preferred that a model offers ways to re-evaluate the input when proposing scenarios. It is found that 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. Furthermore, landscape structure is the spatial arrangement of landscape elements including patches, corridors, and the matrix itself. Quantitative analyses based on patches vary such as patch size distribution, and perimeter-to-area correlations. These quantitative metrics are used to assess how different or similar landscapes are by comparing them. Consequently, theses metrics play a vital role in landscape studies, which will be the approach adopted in this research (Turner, M. G., & Gardner, R. H., 2015).

4 METHODS AND TOOLS

Up to this point, PMM is selected to address how to delineate and assess UGI in Al Montazah District, Alexandria. The objective of landscape ecology goes beyond measuring patterns in the landscape, and spatial analysis is just one technique used to understand the relationships that make up landscapes. Describing and quantifying spatial patterns are required to emphasise such relationships (Turner, M. G., & Gardner, R. H., 2015). In this paper, the structure of the research, summarised in Figure (2), follows a linear flow of steps that each contributes to building the structure of the final results.

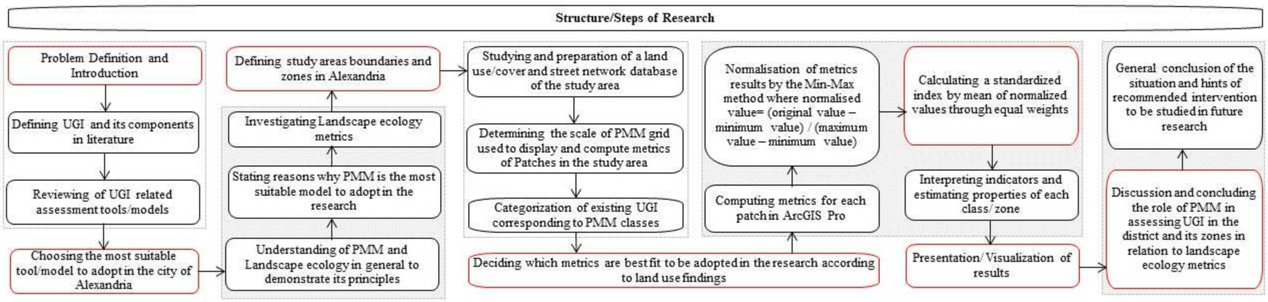

Fig. 2: Structure/steps of the research (the researcher, September 2022).

4.1 Study Area

The study area of Al Montazah District, one of Alexandria's far east districts, corresponds to about 53.83 km2. This district, like the city of Alexandria, has a long history of human developments and archaeological heritage from previous eras still in existence to the present date. Conventionally, the district has had access to a port whose development in recent years is currently a massive ongoing project.

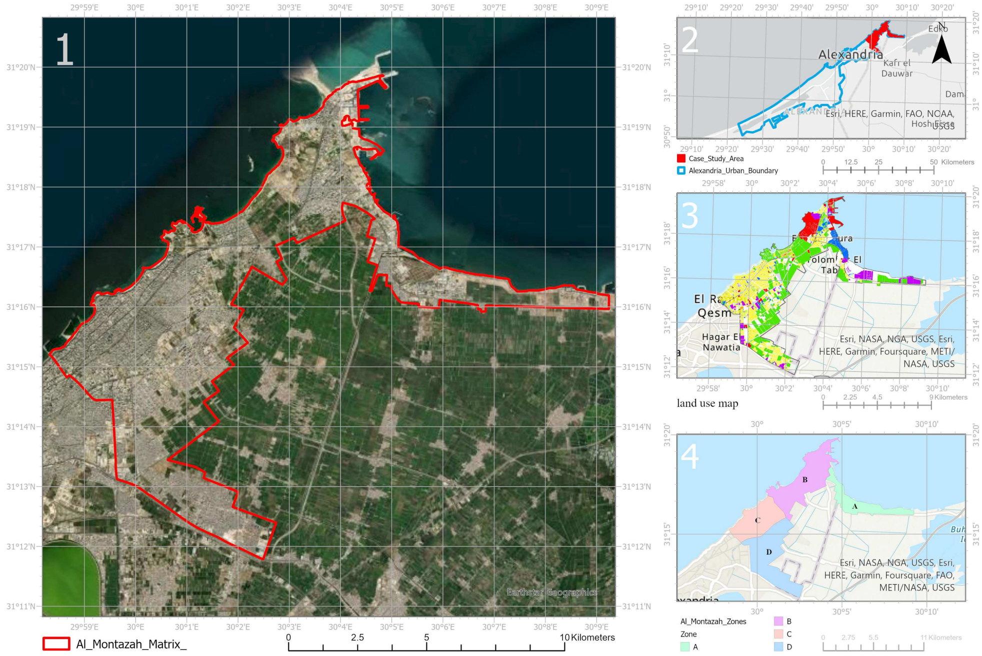

Fig. 3: Map 1: Al Montazah District study area boundary. Map 2: the location of the district in context of the city. Map 3: Al Montazah district land uses. Map 4: Zones of the district (The researcher via ArcGIS Pro, July 2022)

Obviously, the district features many beaches, some of which are accessed through the famous garden of Al Montazah palace, a national asset itself. As shown in maps in Figure (3), the expansion of this urban district to the south is threatening a lot of agricultural lands, which are gradually being invaded. As seen by land uses, residential blocks, parks or agriculture, administrations, and service exist descendingly. In this paper, the district will be conveyed as 4 zones as in map (4), where zone A represents the new extension of the district that contains many projects under construction. Abou-Qir area in zone B accesses the port and contains an important historical castle ruins. Zone C is a highly built-up residential zone. Likewise, Zone D is the expansion of the residential area in zone C, with some agricultural presence.

4.2 Utilisation of PMM in the research

Admittedly, Landscape ecology theories are valid for assessing UGI, as well as its concepts of degrees of connectivity, fragmentation, landscape function, dynamics, and sustainability (Wu, J., 2012). Customarily in landscape ecology, scales must be chosen based on the study's inquiry or goal. To reduce bias when calculating landscape metrics, the extent of the study landscape should be 2–5 times greater than landscape patches (Turner, M. G., & Gardner, R. H., 2015). This means that decreasing the size enhances the quantity of patches since more detail is resolved at the smaller scale. To apply this, the matrix is divided into grid cells of 100 m*100 m for presentation of UGI in the case study. Following their detection by land use, patches can be counted, and their areas and perimeters can be calculated. Accordingly, reporting of statistics on the patch level is more accurate. It is more helpful to report the number of patches as a density value: number of patches divided by landscape area.

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). Thus, selected metrics should be relatively independent of one another. Without considering their location on the landscape, metrics of landscape composition measure what is present and in what quantities. Overall, the metrics considered in this study are: perimeter area ratio (PAR), number of patches (NP), patch density (PD), total edges (TE), edges density (ED), patch richness density (PRD), the largest patch index (LPI), mean patch size (MPS), patch size standard deviation (PSSD), patch size coefficient of variation (PSCV), the gamma index (γ), patch shape index (PSI) and Fractal Dimension Index (FRAC). They are compared to each other in Table 1.

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	$FRAC=2\ln(.25P)/\ln(A)$	
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), $\gamma = L/3(V-2)$: L is the number of links and V is the number of nodes in the network.	

Table 1: Landscape ecology metrics considered in the research (Wu, J., 2012).

4.3 Delineating and assessing UGI in the Al Montazah study area

Adopting PMM, the research carried out its steps of classifications. This was performed by gathering land use/ cover information from local datasets. Forman and Gordon (1986) defined a patch as “a nonlinear surface area differing in appearance from its surroundings". Patches are valuable spatial abstractions depending on the study, and not treated as fixed components. In light of this, PMM enabled the categorisation of patches into 6 main classes, each including certain land uses, shown in Table (2) and represented in figure (4). These classes embrace: 1) environmental resource patches correspond to natural areas, or relatively permanent areas reflecting the normal heterogeneity of the environment. 2) constructed or built-up introduced patches dominate an aggregation of individuals or materials by human activities and will last if management regimes maintain them (Jacinta Fernandes et al., 2020). 3) planted introduced patches depend on green human activities such as gardens and site landscaping. 4) vegetation patches of any agriculture or forestry. 5) disturbance patches that result from acts of disturbance over any period such as areas used for cattle grazing. 6) remnant patches represent earlier life spans of other classes, managed to persist disturbance and are left as proof. In this regard, a mosaic can be obtained based on the mixture of these classes making up the whole matrix. Furthermore, the categorisation also included the corridors in the matrix by dividing them into 2 classes: built-up corridors such as roads, railways and pipelines and stream corridors responsible for carrying water flows along a linear form.

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.

Table 2: Patch class classification of Land use/ cover corresponding to UGI in Al Montazah District, Alexandria (The researcher, May 2022).

Once each metric is calculated on the patch level, they are compared to each other by representation on the class level to describe the matrix. Further steps are performed on these calculations to present findings on maps. Graduated scales in maps will be indicators of fragmentation, function, and richness of classes. These indicators will be speculated by a standardised 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. Besides, the connectivity in the matrix is described using the gamma index where its values range between 0 and 1, by considering intersections of corridors as nodes in this case.

5 RESULTS

Based on the findings, the output is represented through more than one outlook. One presentation of data in Figure (4) includes identification of classes in their spatial locations and arrangements. The compilation of this data is tallied and statistically compared to know insights into each zone of the district, and into each UGI class, for more in-deep perspectives. Eventually, reflecting landscape metrics findings on grid cells will disclose and facilitate the procedure of assessing the matrix. Just as important, the transformations in the district is described before analysing its components as follows. In many landscapes, changes usually occur in a gradual form, making effects more difficult to observe. However, signs of transformations can be determined on a timeline. Some processes may interfere with each other, but it is the cycle that builds the landscape. It can be seen in satellite images that changes to vegetation in the district is less abrupt than in built-up areas. Acts of perforations, fragmentation, shrinkage, and attrition occurred simultaneously since 1996. Meanwhile, dissections are observed more recently with new major projects in the last 4 years and are assumed to continue because of still ongoing infrastructure projects that may completely reshape the boundary of the matrix.

In accordance with available datasets, results of PMM classifications and metrics are concluded by values shown in Table (3). According to NP, vegetation and planted patches are the most dominant, as shown in Figure (4), which makes the matrix highly sensitive because they are affected by any interventions and require the most maintenance. Environmental resource patches are the least existing which shows scarcity in habitat areas, relatively permanent or reflecting normal heterogeneity of the environment which can be a disadvantage for the ecosystem.

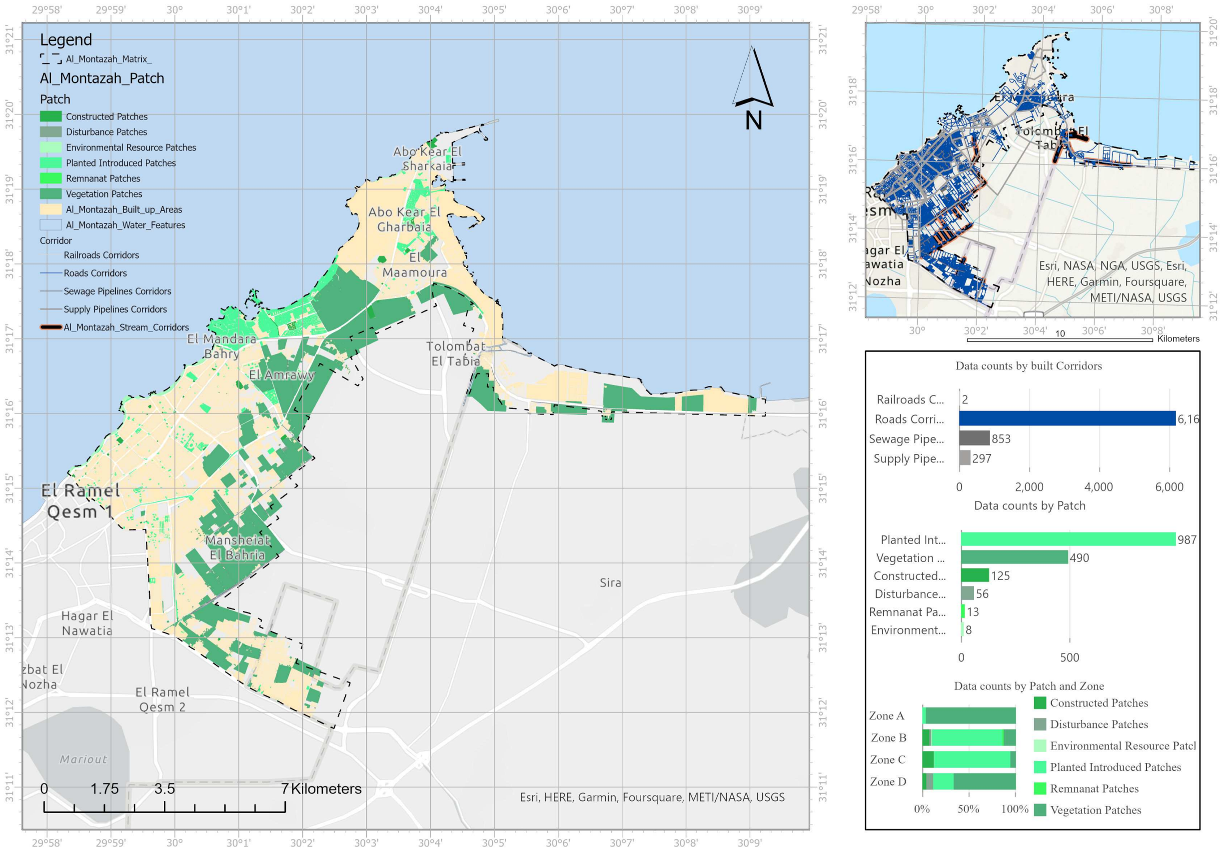

Fig. 4: Map 1: Distribution of patches in the district. Map 2: Distribution of Corridors in the district. Chart 1: Statistics of patches and corridors classifications according to PMM in Al Montazah district (The researcher via ArcGIS Pro, July 2022).

Furthermore, results by LPI, PSCV, PAR, PSI, and FRAC includes observations about the surface areas of patches, where large patches are supplemented with scattered small patches and some large patches exist solely, indicating a nearly optimum landscape. Also, large to small varieties of sizes are observed in all classes. Meanwhile, less convoluted shapes than smooth, and elongated to round shapes are the highest variability in environmental resource patches, and the lowest in remnant patches. The presence of more compact simple patches is observed in all classes, and it is effective in conserving internal resources because it minimises the exposed perimeter to outer effects. Remnant patches have some changes in shapes with few complexities. Conversely, environmental resource patches have the most changes in shapes because beaches depend on the natural curving of the Mediterranean Sea with more highly convoluted, plane-filling perimeter shapes. All in all, the matrix is not complex, extensive towards the sea, but limited towards southern agricultural lands, although that did not prevent past urban expansions. Spatial arrangements of patches and corridors can be seen in Figure (4). Arguably, data counts by patches and zones does not reflect a variety between zones as it is actually in the matrix because one class seems to always dominate a zone.

In order to further analyse the landscape, the gamma index helps to determine the level of connectivity in the landscape. Although its original use is applied to a bigger extent, it produced a logical output. In this case, the number of junctions where corridors intersect is around 27,539 nodes, while the number of links are around 5,542 direct links represented by built-up and stream corridors. By computing the index, its value was around 0.067, approaching zero. For this reason, it is a sign of low connectivity in the matrix, in spite of holding relatively high values in zone C and D respectively. When compared to the map, the low connectivity in the landscape is not shocking despite high concentrations of corridors in many areas. That is because most corridors do not serve UGI enough and roads are known to be highly traffic congested, lack greenery and suffer from poor infrastructure.

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

Table 3: Results of metrics calculations after normalisation and calculation of a standardised index (The researcher, September 2022).

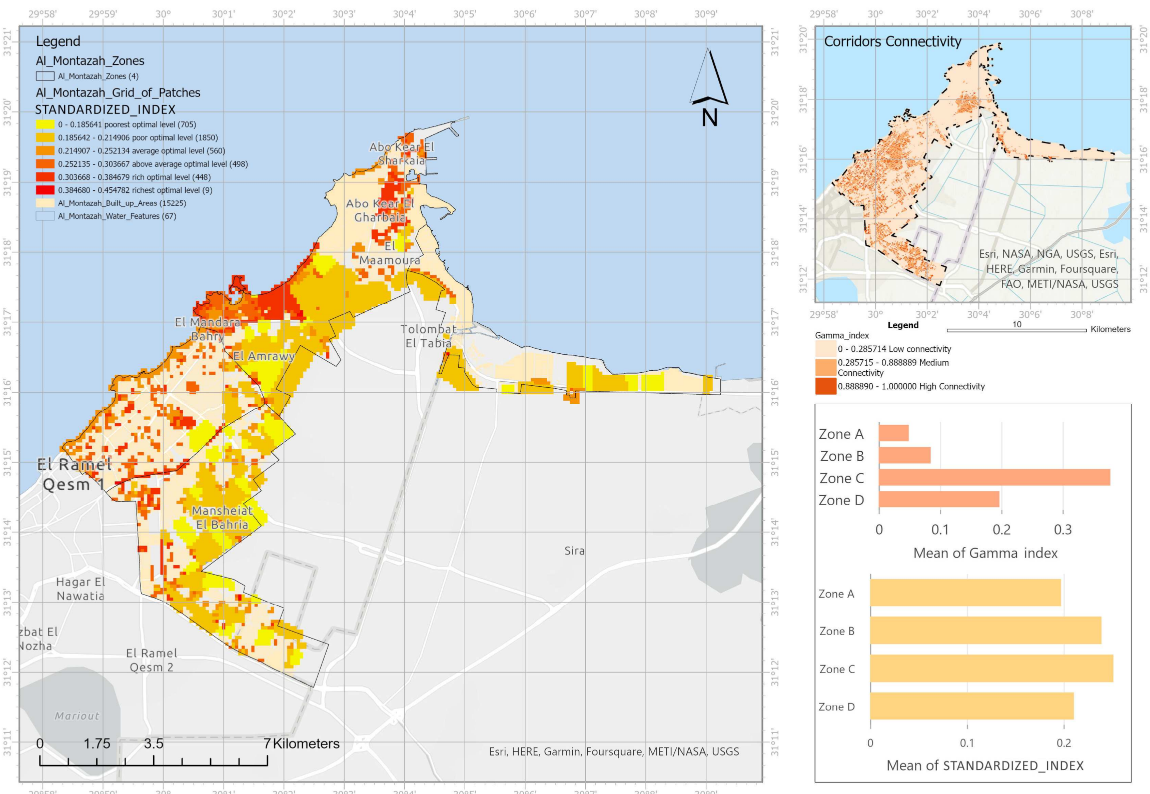

Fig. 5: Maps and charts showing results of graduation of standardized index for UGI patches, and graduation of the Gamma index corridors according to PMM in Al Montazah district zones (the researcher, July 2022).

To recapitulate, it can be said that the matrix is vulnerable because of the abundance and concentration of vegetation in the district zones. Additionally, it is not highly fragmented, and the distribution of this fragmentation among patches is valid, for the highest fragmented holds the least number of patches throughout the matrix: high fragmentation in remnant patches and lower fragmentation levels in other patches, concluded by PD. Moreover, corridors are concentrated more in the built-up residential zone C. It is also clear that most of UGI concentrations exist in zones B and D respectively. Despite being fragile, UGI represents 30.34% of the whole matrix, which makes the built-up areas the real triggers in the performance of the matrix and are dominating its personality.

6 DISCUSSIONS

Above all, landscape metrics are numerically related or correlated. In this research, the weights of metrics are proposed to be equal, and therefore effects of each metric are easily monitored. It is evidenced by scatter plots diagrams in Figure (6) that PSCV has the most impact on the value of the standardised index, especially in zone B. Also, FRAC is contributing more to the index than other metrics, considering that there are similarities in the effects caused by PD, ED, and LPI. 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.

To review, the percentage of patches that are considered the richest and more likely to be optimum represents 0.2% of the total patches, spread in all zones except zone A. Just as important, rich patches are more existing in the zones, around 11% of total patches. It is an advantage that highly valued patches are not concentrated in one zone; however, they obtain their values by being planted introduced patches only. Therefore, being rich does not mean there is a variety in the zone. On the contrary, 45.5% of the matrix are poor patches, seen in all zones, but the least in zone C. This percent consists mostly of vegetation patches that are not blending with heavy residential areas. Notwithstanding, most optimal patches are present in zone C followed by zone B. This may be due to the fact that gardens, squares, parking, and beaches in these zones are numerous, but occupy small areas. In addition, the national park of Al Montazah is a vital landmark of the city of Alexandria that exists in zone B and contributes to the richness of the district.

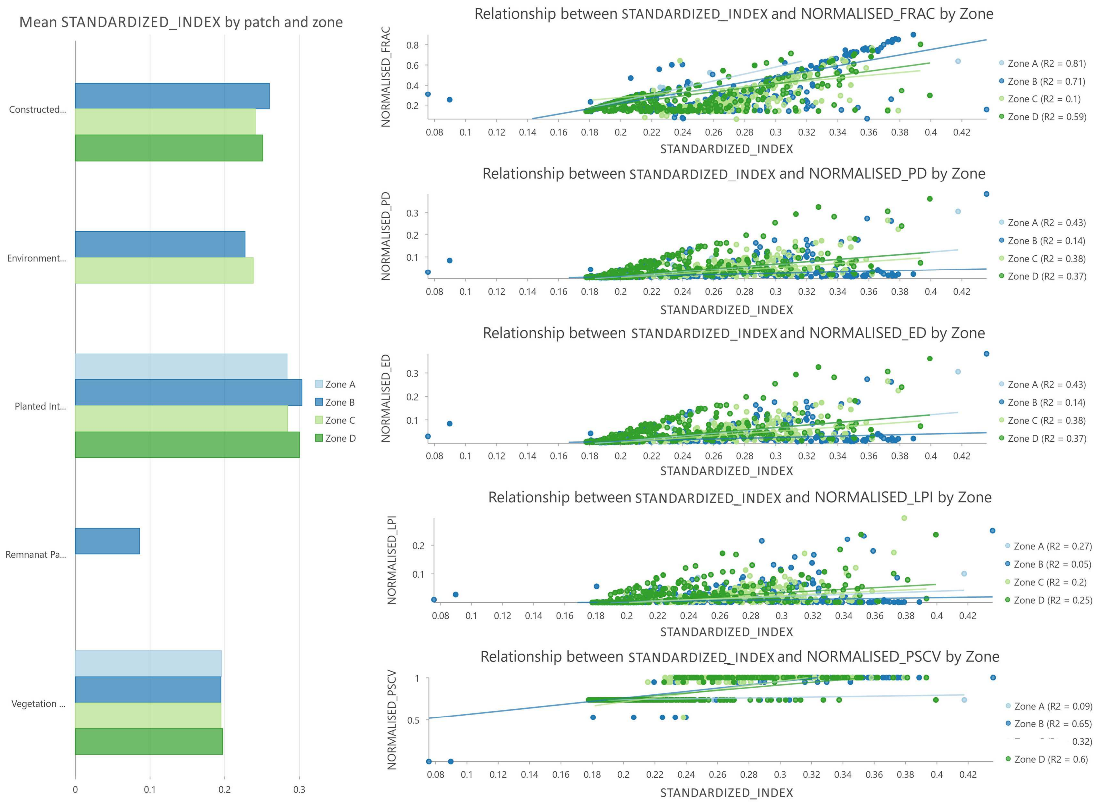

Fig. 6: Mean standardized index distribution by patch classes and zones and Scatter plots of relationships between metrics and the standardized index (The researcher, July 2022).

Without considering the quality of service these patches provide, the assessment is based on spatial properties. With this in mind, high positive correlations are found between the standardised index and all metrics especially PSCV, where their relationship is stronger and closer to forming straight lines as shown in Figure (6). The findings in this paper can summarise UGI in Al Montazah zones as moderately variable, and not very rich. Zone B, with its dominant park, is the richest by embracing all classes in variable amounts. In contrast, zone A is the poorest, due to its many construction sites and only embraces vegetations and planted open spaces that are not all open and usable by the public, unfortunately. Otherwise, there is no harm that environmental patches are limited to zone B and C due to their direct seafront, for this will encourage movement between zones. However, it is a disadvantage that they are limited to beaches and no other varieties.

The main challenge in interpreting existing data in the mosaic is not recognising intangible motivations that could not be evaluated through PMM alone. However, today's intensive industrial and logistic uses in the study area reflects an economic juxtaposition with natural conservation locations in the mosaic. Undoubtedly, UGI solutions at the local level will have implications to overcome any possible hazardous scenarios and contribute to obtaining balance between interests if possible.

7 CONCLUSION AND RECOMMENDATIONS

To wrap things up, the patch matrix model (PMM) is proved to be a useful tool for describing landscape pattern. On the whole, UGI was assessed based on analysing its components according to PMM, and landscape metrics. Results were validated by a standardised index, and correlations between this index and landscape metrics were discussed as indicators to guide green space planning. In short, UGI in Al Montazah district in Alexandria, Egypt is striving to be an optimum landscape according to the statistics attempted in this research. Accordingly, complexities could be solved through simple UGI solutions such as reviving zone B remnant patches as pilot projects, making use of stream corridors or linear patches to increase connectivity, and many other opportunities related to identifying hotspots for conservation strategies of existing landscape and its sustainable management. Further recommendations could be made upon the displayed results to localise action plans and suggestions in the district to enhance UGI and encourage keen NGOs or decision makers.

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