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Spatial Monitoring and Classifying of Urban Deterioration in the Egyptian Cities Using Geographic Information System (GIS) Approach: A Case Study of Mansoura City, Egypt

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Abstract The phenomenon of urban deterioration in Egyptian urbanization is considered as one of the challenges facing sustainable urban development. This is due to many reasons, foremost of which is the reliance of authorities on traditional and inadequate monitoring and classifying tools. Despite the growing number of these areas, few attempts were made to spatially monitor and classify the degree of deterioration of these areas through comprehensive indicators. In order to control this phenomenon, the process of monitoring and classifying these areas is considered as the first step. Therefore, this paper aims to propose a model to monitor and classify urban deterioration using geographic information systems (GIS) approach. The city of Mansoura, which is one of the largest medium-sized cities in Egypt, has been chosen as the case study. Geospatial data were gathered according to the year 2021. The results of the study show four different categories of urban deterioration and its priority to upgrade the quality of life for the people living in these areas. The findings also uncover some of the urban characteristics of these categories which contribute to raising the efficiency of urban management in Mansoura city.

Keywords Urban Decay, Urban Deterioration, Urban Change, MCDM, AHP Method, Indicators of Urban Deterioration, Geographic Information System Models

1. Introduction

As a consequence of rapid urbanization and socio-economic transformation in developing countries during the past four decades, several signs of urban deterioration have occurred, which presented negative impacts on many urban, environmental, and social aspects [1].

Without exception, Egypt suffers from deteriorated areas which have become a distinctive feature of Egyptian cities [1]. Deteriorated areas have spatially occupied significant parts of these cities i.e., accounting for over 70% of the total built environment [2]. Because of the phenomenon's huge scale and diversity of its dimensions and features [3], it has become one of Egypt government's top planning objectives [4], which are aimed at providing a better quality of life for the population and achieving sustainable urban development [5].

Many of the attempts submitted by those authorities in particular the main planning bodies in the city (the Informal Settlements Development Fund (ISDF), and the Authority of Urban Planning) dealing with the phenomena aimed to identify and monitor urban deterioration by only focusing on the urban/physical dimension without addressing and ignoring social, economic and environmental aspects that these areas suffer from [6].

In addition, it concentrated only in the Informal (unplanned) urban areas and not the overall urban built areas of the city with its diverse characteristics [4,7,8]. All the fore-mentioned indicate the existence of shortcomings in the administrative aspects to control this phenomenon [7].

The research adopted the definition of deteriorated urban areas that manifests all social, environmental, economic, and administrative aspects that contribute to the physical urban decay [5,8,9]. These areas have witnessed a lack of services, facilities, high population densities, lack of green spaces, and an increase in the number of standards/law violations. They also suffer from high crime rates and spread of informal activities. Furthermore, they suffer from a low level of income (high poverty rates), widespread unemployment, poor natural environment quality and a high level of pollution.

The technology used in monitoring is one of the most important factors for accurate identification of these areas, which were not widely available in the government's attempts presented [10], where the process of monitoring the deteriorated areas was carried out through a subjective manual field survey based on personal opinions; which takes a lot of efforts, time and costs [10-13].

Despite using satellite-based remote sensing techniques in monitoring the deteriorated areas, those authorities relied on a limited number of urban/physical indicators, such as the pattern of the irregular street network and the type of compactness of urban fabric [11,12]. This resulted in a poor accuracy in detecting these areas.

In order to control this phenomenon, multi-dimensional (comprehensive) monitoring and classification indicators (urban, demographic, social, economic, environmental, governance, and administrative) are considered a great priority. Because these indicators help in dealing with the complex manifestation of the phenomena.

This also helps to achieve the sustainable development Goals (SDG) [13-16], especially Goal No. 1, which is concerned with the eradication of poverty that is one of the main drivers of urban deterioration [5,7] and Goal No. 6 which focuses on providing clean water and sanitation. Finally comes to Goal No. 11, which insists on making cities and human settlements be: inclusive, safe, resilient, and sustainable [15].

The research conducted the study in the entire city of Mansoura as one of the capital cities of the governorates in Delta, Egypt, using indicators based on data gathered in the year 2016-2017 and it is updated to the year 2021 as shown in the methodology section.

Multi-Criteria Analysis (MCA) tool is used in integration with ArcGIS which is considered as the most common tool for dealing with multi-criteria phenomena for determining and classifying the degree of deterioration [17-21]. This tool helps to pair with other systems and methods such as Decision-Making Systems (DSS) and Multi-Criteria Decision-Making method (MCDM), which contribute to the "synergistic effect" to reach the efficiency and quality of analysis and spatial monitoring of the deteriorated areas [19-21].

The research results help to determine the size and distribution of these deteriorated areas and their characteristics, which in turn help in raising the efficiency of the urban management of the city.

2. Materials and Methods

The Research Methodology is divided into the following four main steps as shown in Figure 1. The first step is the definition of the study area. The second step outlines the selection criteria of indicators for measuring urban deterioration. The third step is getting the weight for each indicator through the use of Saatys pairwise comparison of the Analytic Hierarchy Process (AHP) [22]. The final step is the spatial analysis that was conducted through the use of the weighted overlay tool for all indicators by using ESRI ArcGIS software to identify the deteriorated areas at the entire city level in order to classify them according to their degree of deterioration.

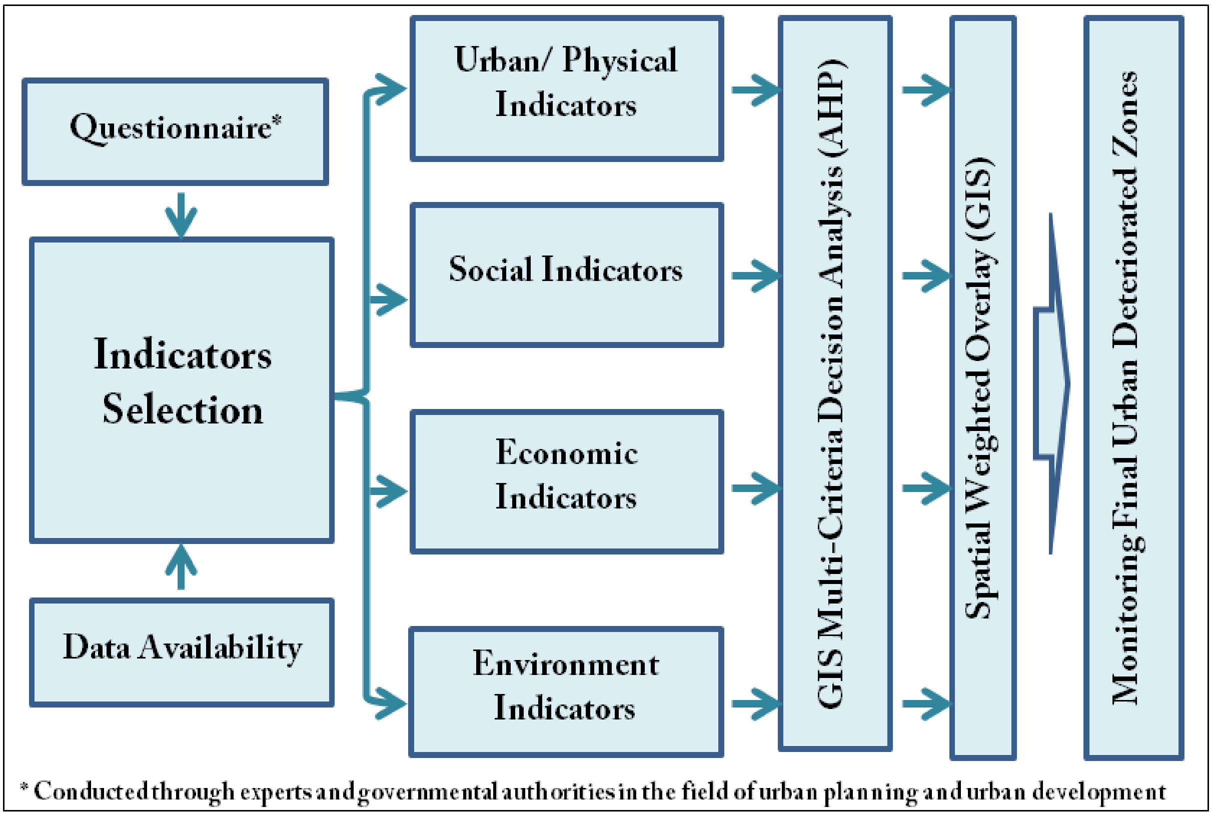


Figure 1. The research methodology

2.1. Study Area

The city of Mansoura which is the capital of Dakahlia Governorate is one of Egypt's Delta cities. The city is located at the intersection of a latitude of 31° 03′00″N and a longitude of 31° 23′00 E at an altitude of 15 m above the sea level. The city is also distinguished by its location on the eastern side of the Nile River as shown in Figure 2. It is divided administratively into two districts; the first district includes 5 Sheikha (an administrative boundary unit that is roughly equivalent to US census blocks) and 7 Sheikha units in the second district. Mansoura is the second-largest city in the Delta, with a population of 543,402 according to the 2017 population data from the Central Agency for Public Mobilization and Statistics (CAPMAS) [23] with an area of 17.5 km^2. It is also considered as one of the most attractive cities in the Nile Delta. Over the past 25 years, the city has undergone massive urban growth, where the population increased by 1.46 times during the period from 1996 to 2017 [23,24]. Consequently, a lot of pressures have occurred on the city's urban areas, resulting in the formation of numerous deteriorated areas.

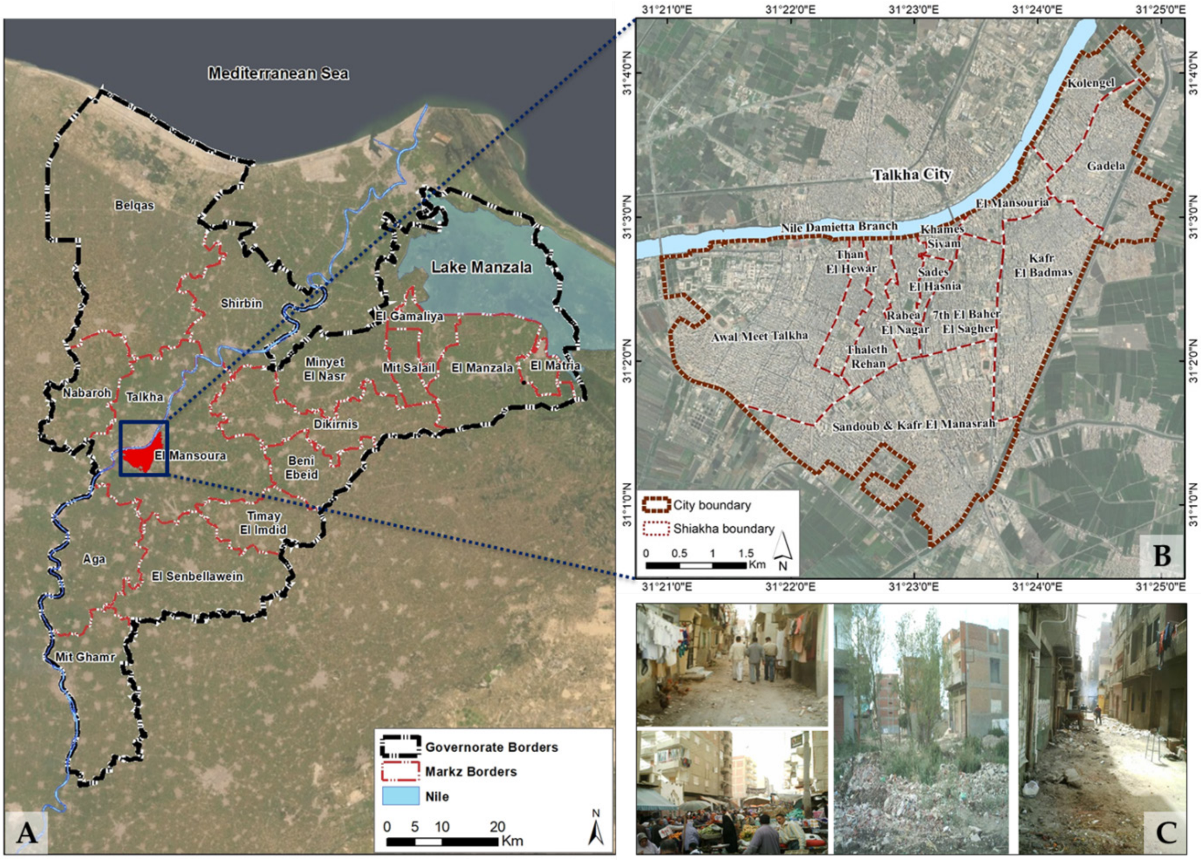


Figure 2. The study area of (A) the Nile Delta region, (B) Base map in Mansoura city, and (C) Urban deterioration manifestations in Mansoura city.

2.2. Data Sources

Many primary, secondary, and statistics data were relied upon, as shown in Table 1. The first of which is the Egyptian government agencies. The research used a geographic database collected from the Strategic Plan of Mansoura City 2027 that was issued by the General Authority for Urban Planning (GOPP) in 2016 [25], especially for the urban/physical data such as (Building structure condition, heights, services, etc.).

Data on social and economic aspects were also collected through the CAPMAS in 2017 [23] and the Crisis Management Center in the Cabinet of Ministers [26] for some indicators such as the overcrowding rate, crime, unemployment, and rates of informal/unplanned activities, etc.).

Secondly, in order to deal with unavailable data from the reports and statistical books, a field survey was conducted in 2021 by a team of urban planners with expertise ranging from 5-10 years for the purpose of updating and auditing the collected data.

2.3. Selection of Indicators

Urban Deterioration is a complex issue due to its multiple dimensions and manifestations [3,7,27]. Therefore, the research depends on a set of multiple indicators that include different sectors (urban, demographic, social, economic, environmental, governance, and administrative), which were used in many previous studies, which dealt with urban decay locally and globally [3,5,7,8,25,27-44].

A List of 25 indicators were presented to a purposive sample of a group of urban planning experts in the form of a questionnaire, in order to select and rank the most important and suitable indicators for Egyptian cities based on a Five-point Likert scale. Then, we obtained the average value of the AHP scale for each individual indicator as an input for the Pairwise Comparison Matrix (PCM) that calculates the relative compared weight of the indicators. The group of experts contains the following participants: (4) Officials from the Urban Planning Department in the Egyptian governorates, (6) Officials from the Urban Monitoring Department in the GOPP, (7) Officials from the Slum Development Unit ISDF, (2) Experts from international organizations interested in monitoring the development of the degraded areas, and (6) Consultants in the field of urban planning and development.

After the exclusion of indicators with unavailable data, the final list included 15 indicators that are divided into four groups representing urban, population and social, economic, and environmental indicators as shown in Table 2, as well as governance indicators that are embedded in the main mentioned groups.

Table 1. The description of data and its sources (Material descriptions)

Data Type	Date	Format	Scale/Level	Derived Data	Source Of Data
Geodatabase and Report Of the Strategic Plan of Mansoura city	2016	Geospatial database, JPEG, PDF	1:2000	Deterioration indicators and related data	General Organization for Physical Planning (GOPP)
Population censuses and statistics	2017	Excel Sheets, PDF	Shiakha	Socio and Economic Status	Central Agency for Public Mobilization and Statistics (CAPMAS)
Site visit & Survey	2021	JPEG	Zones	Deterioration indicators and related data	Authors

Table 2. Material descriptions (Indicators descriptions and their weights)

Sector		Indicators	Data representation method	Measurement/ units	Deterioration level			Source	Weight
					Low (Score = 1)	Moderate (Score = 2)	High (Score = 3)		
Urban/Physical Indicators	Buildings	Building structural condition	Hexagonal shape	structural condition	Good	Average	Poor	[3,8,25 ,30]	13.90%
		Building law Violations Percentage	Hexagonal shape	%	<30	30-60	>60	[8,25,31]	4.60%
	Services	School proximity.	Multi buffer	Distance in meters	<500	500-1000	>1000	[29-30]	7.20%
		Hospital proximity.	Multi buffer	Distance in meters	<500	500-1000	>1000	[29-30]	7.20%
	Infrastructure	Street condition	Hexagonal shape	Paving condition	Paved	-	Unpaved	[25,29]	8.50%
		Efficiency and quality of infrastructure networks (Water, electricity, sewage)	Hexagonal shape	Infrastructure networks quality	Good	Average	Poor	[5,28]	11.30%
Social Indicators		Population density	Administrative boundaries	Persons/km^2	<20000	20000-40000	> 40000	[28,29 ,31]	13.80%
		Crime rate	Administrative boundaries	%	<10	10-20	>20	[35-38]	3.60%
		poverty rate	Administrative boundaries	%	<5	5-10	>10	[7,35-38, 42]	3.80%
		Overcrowding rate	Administrative boundaries	Person/Room	<2	2-3	>3	[28,32]	2.30%
Economic Indicators		Percentage of informal economic activities	Hexagonal shape	%	<10	10-20	>20	[28,35-37]	3.10%
		Unemployment Rate	Administrative boundaries	%	<5	5-10	>10	[24,28,32, 36,41]	2.80%
Environment Indicators		Accessibility to Ventilation & Daylight	Hexagonal shape	Building height/Street width	<1.5	1.5-2	>2	[31,33]	4.90%
		Proximity and distance from sources of pollution	Multi buffer	Distance in meters	>100	50-100	<50	[33,39]	7.90%
		Per capita green area	Hexagonal shape	m^2/persons	>10	5-10	<5	[34,39,40, 43, 44]	5.10%

2.4. Measuring Indicators of Urban Deterioration

Measuring the degree of deterioration in the city relied on different benchmarks [30,31,40-44]. The main benchmark is the local urban planning law no. 119 of the year 2008 that determined the maximum of ratio of building height to street widths and measuring the minimum distance of proximity to the educational services and healthcare. In some indicators, we contextualized international organization standards and benchmarks such as Un-Habitat, ILO, and the World Bank, etc. to be applicable in Egypt such as the population densities by using the aforementioned local law that used the maximum value of densities of 20000 persons/km^2. Also, regarding the (Per capita green area), the research considered the minimum value of 5m^2/person as it is used in different research projects in the Egyptian context [43,44].

Other indicator benchmarks are determined according to the minimum and maximum existing surveyed value from the city such as the (percentage of informal economic activities, poverty rate, etc.). Therefore, the minimum the value of these indicators is, the higher quality of life in these areas will be.

Three classes were determined according to the minimum and maximum benchmarks for each indicator. These classes are normalized to obtain values of (1 to3) to be used in the final weighted overlay tool in the model.

2.5. Weights of the Indicators

The monitoring process includes a large and different set of indicators, which differ in their degree of importance. Therefore, it was necessary to use a model to measure the different weights of each indicator. The research adopted the AHP model using of Saaty methodology [22,45] by building Pair-wise Comparison Matrices (PCMs) using expert questionnaire results to assign the weight value of each and classify them according to their impacts on monitoring urban deterioration.

According to Saaty, the indicators are arranged from 1 to 9 for the PCM elements, where a value of (1) indicates that the criteria are of equal importance and a value of (9) is the highest relative importance.

Accordingly, AHP was conducted in 6 steps, as described below:

1- The relative importance of each parameter was determined on the basis of the pairwise significance scale. This step is called Prioritization as shown in Table 3.

Table 3. Pairwise comparison importance scale

Scale	Description	Reciprocals*
1	Elements i and j have equal importance j	1
3	Element i is slightly more important than element j	1/3
5	Element i is more important than element j	1/5
7	Element i is much more important than element j	1/7
9	Element i is very much more important than element j	1/9

* Reciprocals are used if element i has a lower value than element j.

2- The Pair-wise Comparison Matrix (PCM) of (15*15) cells are created to represent the urban deterioration indicators shown in Table 3, where the element in the row is indicated with the symbol (i) and the element in the column is indicated with the symbol (j). In addition, the value of the importance of each element is determined by other elements (property of reciprocity) according to equation (1) as shown in Table A1.

$$(a_{i,j} = 1/a_{i,j}) \quad (1)$$

3- The matrix was standardized using the following mathematical equation (1):

$$\frac{a_{i,j}}{\sum_{i,j=1}^{n} a_{i,j}} \quad (2)$$

4- The Normalized Value for each parameter of the paired comparisons with the weighted values in the last column of the standard matrix to obtain the eigenvector that represents the consistency index (CI).

5- CI is applied to check the pairwise comparison matrix using the following mathematical equation (3):

$$CI = \frac{(\lambda \max - n)}{n-1} \quad (3)$$

Where (CI) is the consistency index, (n) is the number of weak indices being compared, and (Lambda Max) is the value of the eigenvector matrix.

6- The consistency Ratio (CR) that Saaty has developed to check the consistency of the paired comparisons [45,46].

The (CR) is the ratio of (CI) over the random index (RI) [46,47], which has constant values, as shown in Table 4, where this is expressed mathematically using equation (4):

$$CR = \frac{CI}{RI} \quad (4)$$

Where the value of CR was calculated to equal 3.5% i.e. (0.035), which is less than 10% (0.1) [45,46], which indicates the consistency of the double comparison matrix.

Table 4. RI (c) based on the order of the PCM [46,47]

No. of Indicators	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI (random index)	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.53	1.56	1.57	1.59

2.6. Spatial Data Analysis

These indicators were used by converting it to geospatial maps using three main methods to represent the data for monitoring the deteriorated areas in the city as shown in Table 2.

1- Hexagonal Shape: The city was divided into (438) hexagonal cells with dimensions of 200*200 m, as an analytical unit. These dimensions were selected in accordance with the average lengths of residential blocks in the Mansoura city. In addition, the hexagonal shape has the advantage of having equal diameters, and therefore, it was chosen as one of the best geometrical shapes to express the phenomena [48-50]. This also helps to increase the accuracy of the spatial monitoring of urban elements, by measuring the percentage of concentration of those elements within each cell, like most urban indicators as shown in Table 2.
2- Multi Buffer: It is used to express proximity and distance from specific elements as shown in Table 2.
3- Administrative Boundaries: They are used to express data at the level of administrative boundaries (Sheikh unit) in social, economic, and environmental indicators as shown in Table 2.

The urban deterioration areas in Mansoura city were calculated using equation (5) [33,51] where (f) stands for urban deterioration index, (n) is the total number of indicators, (w_f) is the relative weight of the indicator, and (S_f) express the indicator value:

$$.weighted\ ranking = \sum_{f=1}^{n} w_f * S_f \qquad (5)$$

Then, multiply each indicator by its corresponding weight and add it into an integrated model through the weighted overlay sum function to reach the classification of the degraded areas according to the previous classification, then, it is normalized to a scale of (0-100%) [28,52,53].

In order to make the results more useful, four categories were determined that make the phenomenon classifiable according to the intensity of the deterioration values.

These categories are manually pointed in a scale of 0-100% as mentioned in the result section, table 5.

Accordingly, the produced raster data were classified, by the weighted overlay tool in the ArcGIS, into these categories according to the indicators of deterioration. They were as follow: from (1) to (4), where (1) very low deterioration- (2) low Moderate deterioration- (3) Moderate/ High- (4) very high/severe deterioration. This would help deal with different levels of deterioration and to adopt a suitable policy in dealing with the phenomenon [54,55].

2.7. Testing the Credibility of the Model

The credibility of the model is tested by comparing the final model results of the locations of the deteriorated areas with those results detected by the Dakahlia Governorate. In addition, a random manual selection of one of each resulted categories of deteriorated areas are chosen to evaluate the degree of deterioration qualitatively with the areas resulted in the proposed model by a team of 3 urban planners.

3. Results

The set of spatial maps for each indicator was extracted at the level of the entire city. A map of the deteriorated areas with their four basic classifications i.e. (Very low – Low – Moderate/High – Very High deterioration) was drawn in Figure 3H which was based on the predetermined weights for each indicator using AHP as shown in Table 2. After that, a normalizing step has been done for these indicators and their overlay is stratified, as described in the methodology section.

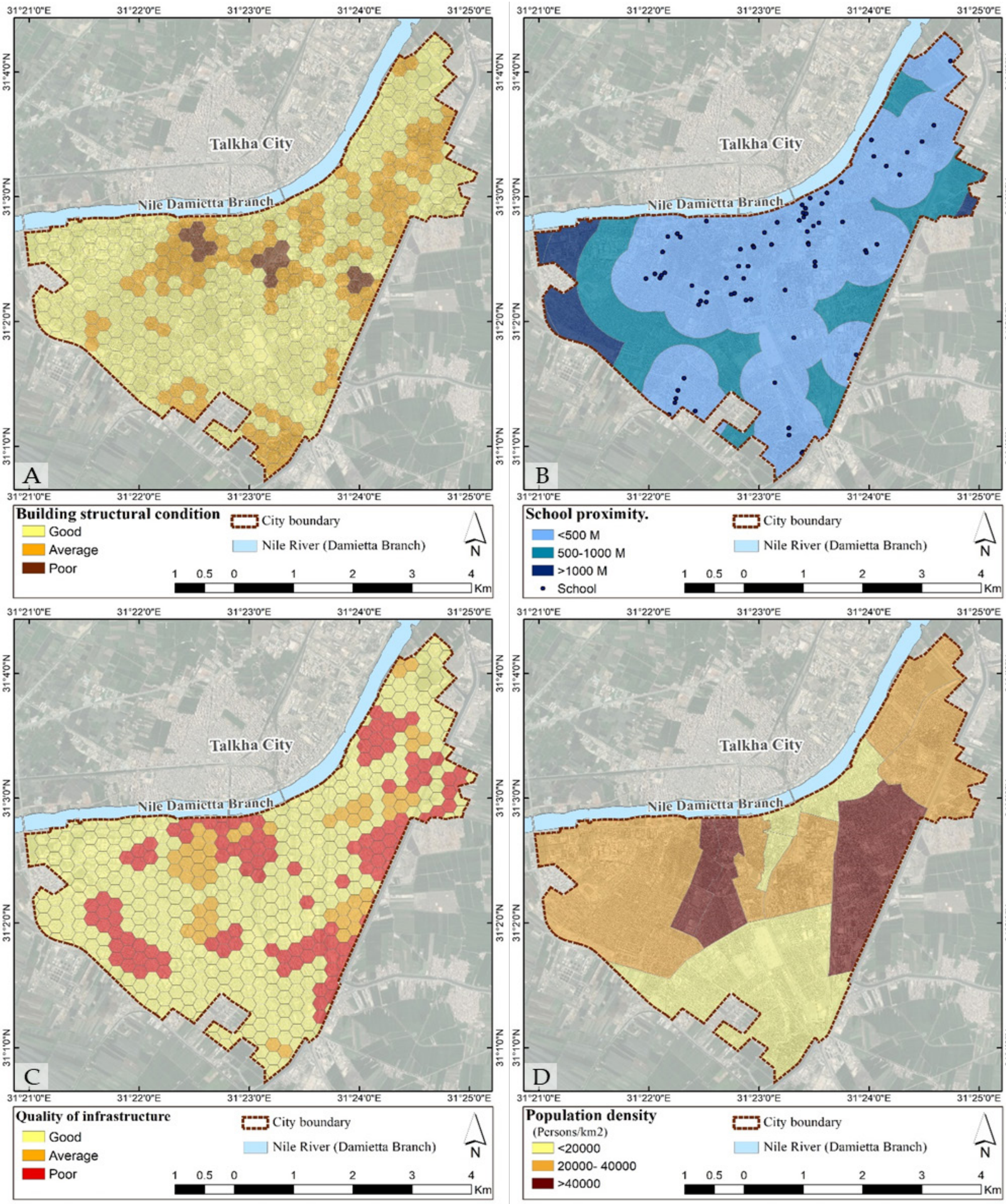
Based on the previous steps, the results revealed a prevalence of deteriorated areas in the city of Mansoura as shown in Table 5, where the city urban areas that suffer from deterioration are classified as follows:

1. Very low deterioration, i.e., less than 30% (percentage of deterioration), which represents an area of 2.1 km^2 which is equal to 12% of the city's total urban area.
2. The low deterioration i.e., ranges from 30-50% (percentage of deterioration), which represents an area of 5.1 km^2 which is equal to 29.1% of the city's total urban area.
3. Moderate/High deterioration i.e., ranges from 50-80% (percentage of deterioration), which is considered as the prevailing pattern in the city. It represents an area of 8.6 km^2 which is equal to 49.1% of the city's total urban area, i.e., about half of the city's area.
4. Very High deterioration, more than 80% (percentage of deterioration), which represents an area of 1.7 km^2 which is equal to 9.8% of the city's total area.

Accordingly, the low-deteriorated areas which represent a percentage close to a third of the urban areas can be considered as “transitional” or we can describe it as areas subject to a series of transformations to become a moderate or high deteriorated areas if the trend continues. The moderate/high deteriorated areas exceeded half of the current urban built areas, which indicates a critical need to control the spread of these areas in the future.

Table 5. Levels of Urban deterioration in the city of Mansoura

Deterioration level	General characteristics	Percentage of deterioration	Area Km^2	%
Very Low	Planned areas with few manifestations of deterioration	<30%	2.1	12.00%
Low	Areas on the way to deterioration	30-50%	5.1	29.10%
Moderate/High	Deteriorated areas	50-80%	8.6	49.10%
Very High	Severely deteriorated areas	>80%	1.7	9.80%
Total built area of the city			17.5	100.00%



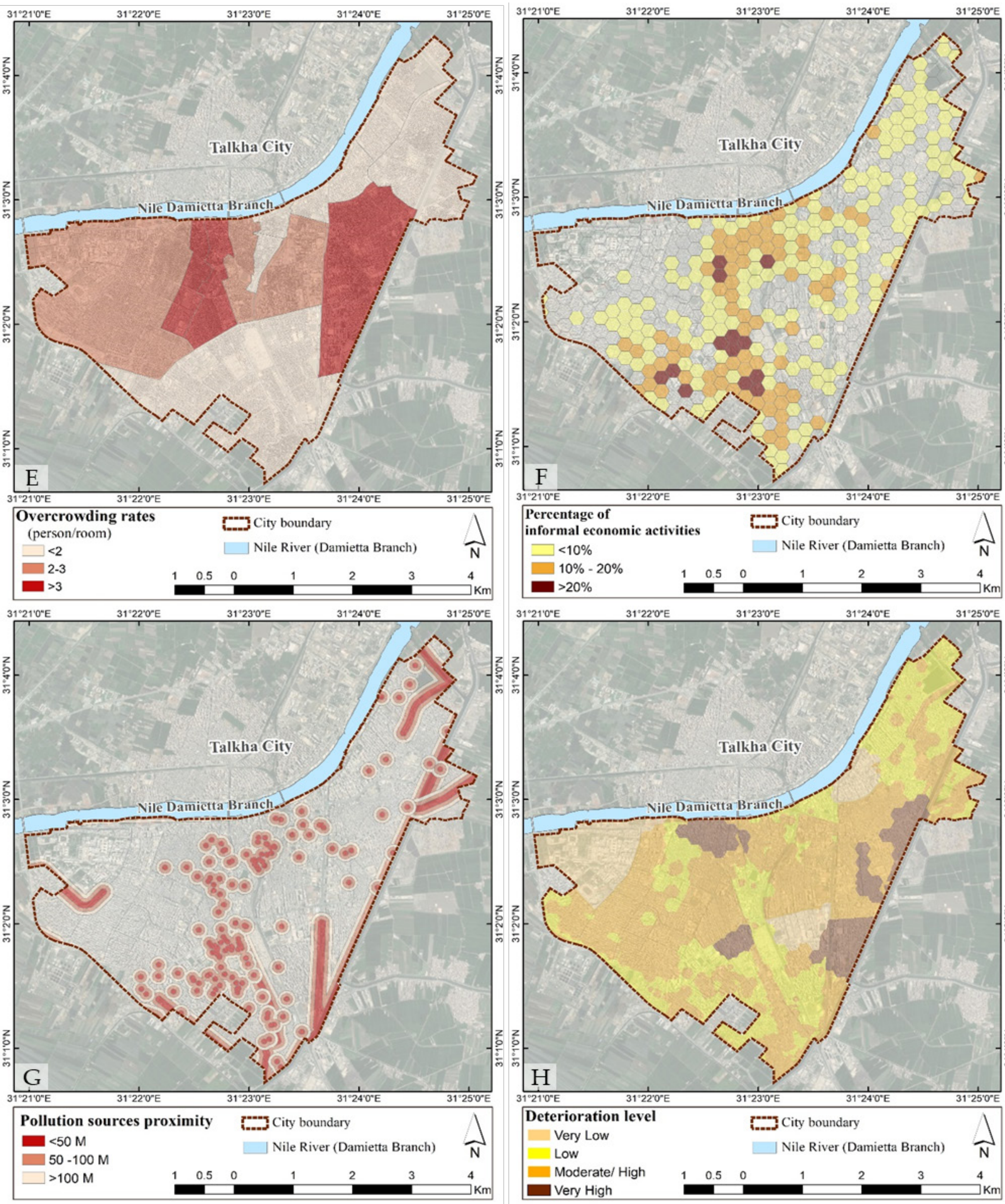


Figure 3. Samples of output maps (A) Building structural condition, (B) School proximity, (C) Efficiency and quality of infrastructure networks (Water, electricity, sewage), (D) Population density, (E) Overcrowding rates, (F) Percentage of informal economic activities, (G) Proximity and distance from sources of pollution, (H) Final map of the deteriorated areas.

By observing the spatial distribution of the deteriorated areas in the city and the type of urban pattern (planned – unplanned/informal) for these four classifications, we can state the following notices:

- The very low and low deteriorated areas represent most of the planned areas, which suffer from some minor manifestations of deterioration.
- The Moderate/high deteriorated areas, contained a mixture of planned and unplanned areas, and are distributed widely in a sporadic pattern throughout the city.
- The Very high deteriorated areas are mostly unplanned, nearly half of them are located on the outskirts/city periphery of the city, and the rest are

located in the heart of the city at the historic city center on the river.

Having stated that, these four categories and their related distribution patterns can contribute significantly to the decision-making process to include these areas in urban development plans and to arrange priorities of planning intervention accordingly, that the higher the level of the deteriorated areas the shorter-term strategies are needed.

4. Discussion

Through the concluded classification of the city of Mansoura, it becomes clear and quantified that urban deterioration is a major feature of the city, which is consistent with studies that described most of Egyptian mid-sized cities [56].

Despite the inclusion of unplanned areas within the classification of moderate/high deterioration areas, a significant part of these unplanned areas are located in the very low and low deterioration areas, which confirms that the unplanned areas are diversified and cannot be unified [5,7,8,9,54].

In 2018, the Dakahlia Governorate monitored 14 deteriorated areas inside the city of Mansoura [57], with a total area of 3.9 km^2, representing 22.3% of the city, as shown in Figure 4.

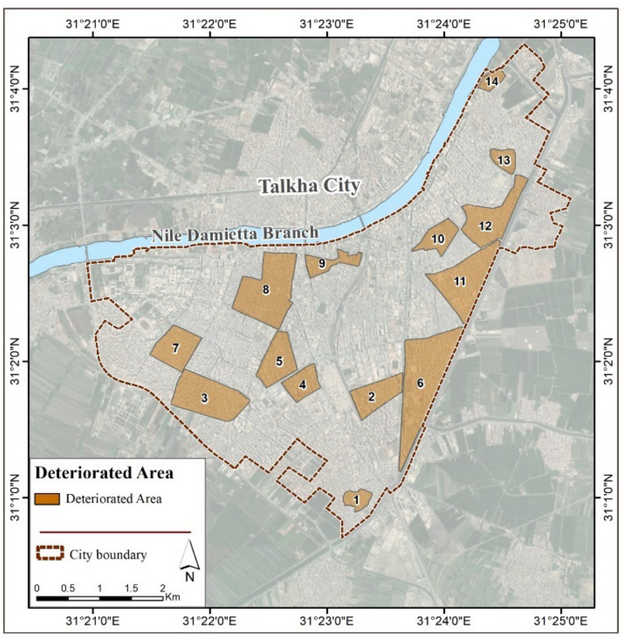


Figure 4. Deteriorated areas were monitored by Dakahlia Governorate

The model results reveal that the area of moderate/high and very high category is 10.3 km^2 which represents 58.9% of the total city area, as shown in Table 5.

By comparing the model detected areas with the areas specified by the Dakahlia Governorate, it was found that the former contains all of the authority detected areas and exceeds its total sizes of areas. This can be explained by several reasons, the most important of which is the research's use of comprehensive indicators to measure and monitor deterioration, while the administrative authorities relied on limited indicators (urban only). Also, this might be due to the research used recent data obtained in the year of 2021. This specific comparison in Mansoura city is almost the same as those results produced by Khaef and Zebardast [5] who used comprehensive indicators rather than using three urban indicators only in Tehran city.

All the authority-detected areas are containing in the model output. This confirms the validity and comprehensiveness of the model.

It was concluded that environmental and social dimensions represent a significant weight compared to the rest of the dimensions, especially in the moderate/high level category of the deteriorated areas.

The results show that aging was not the main cause of deterioration as a greater part of the old city center (56%) is not deteriorated. This can be due to the social attachment to these areas [9] or due to governmental regeneration projects, as these interpretations need to be verified in further research.

5. Conclusion

This paper concentrated on the accurate spatial monitoring of urban deteriorated areas and their classification according to a set of comprehensive indicators, which contain different sectors of sustainable development (urban, social, economic, and environmental) through the use of geographical information systems (GIS) and a Multi-Criteria Analysis (MCA).

This step provided a starting point for understanding the different characteristics of the deteriorated areas and their different patterns by classifying them according to the degree of deterioration, which can be generalized to the Egyptian cities.

In the city of Mansoura, the deteriorated areas were monitored and classified into the following four basic classifications: (Very low - Low - Moderate/High - Very High deterioration) with the percentages of 12.00%, 29.10%, 49.10%, 9.80%, respectively. This classification helps to provide different intervention strategies for each and to avoid dealing with the phenomena as one type regardless of its characteristics.

Also, the model concluded that areas exceeded the areas specified by the governorate by threefold, which helps to undertake the phenomenon of deterioration in a comprehensive manner and to achieve sustainability to improve the quality of life.

Additionally, the model can be considered as a tool for predicting areas that may be on the way to deterioration, which helps in taking precautionary measures to limit the increase of urban deterioration at the city level.

This study is considered as a part of the ongoing studies to identify, monitor, and classify deteriorated areas through the application of various/comprehensive variables. However, the study did not address the forces or factors leading to urban deterioration with its various patterns, nor the effects resulting from it, which might be the focus of future research in the Egyptian cities.

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Conflicts of Interest

The authors declare that there is no conflict of interest.

Appendix

Table A1: The Pairwise Comparison Matrix (PCM)

Ind.*	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A	1	8	4	4	2	2	1	3	3	5	7	6	4	2	4
B	0.12	1	0.25	0.25	0.2	0.14	0.12	0.2	0.2	0.33	0.5	0.5	0.33	0.17	0.25
C	0.25	4	1	1	2	0.33	0.25	2	2	3	4	4	1	0.5	1
D	0.25	4	1	1	2	0.33	0.25	2	2	3	4	4	1	2	1
E	0.33	5	0.5	0.5	1	0.5	0.5	3	3	4	5	4	3	2	3
F	0.5	7	3	3	2	1	0.5	4	4	5	6	5	3	2	2
G	1	8	4	4	3	2	1	3	3	5	7	6	4	2	4
H	0.33	5	0.5	0.5	0.33	0.25	0.2	1	0.9	2	3	2	0.5	0.33	0.5
I	0.33	5	0.5	0.5	0.33	0.25	0.2	0.9	1	2	3	2	0.5	0.33	0.5
J	0.2	3	0.33	0.33	0.25	0.2	0.17	0.5	0.5	1	2	1	0.33	0.25	0.33
K	0.14	2	0.25	0.25	0.2	0.17	0.14	0.33	0.33	0.5	1	0.5	0.33	0.25	0.33
L	0.17	2	0.25	0.25	0.25	0.2	0.17	0.5	0.5	1	2	1	0.5	0.25	0.5
M	0.25	3	1	1	0.33	0.33	0.25	2	2	3	3	2	1	0.5	1
N	0.5	6	2	0.5	0.5	0.5	0.5	3	3	4	4	4	2	1	2
O	0.25	4	1	1	0.33	0.5	0.25	2	2	3	3	2	1	0.5	1

***.** (A) Building structural condition, (B) Building law Violations Percentage, (C) School proximity, (D) Hospital proximity, (E) Street condition, (F) Efficiency and quality of infrastructure networks (Water, electricity, sewage), (G) Population density, (H) Crime rate, (I) Poverty rate, (J) Overcrowding rate, (K) Percentage of informal economic activities, (L) Unemployment Rate, (M) Accessibility to Ventilation & Daylight, (N) Proximity and distance from sources of pollution, (O) Per capita green area.

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