Changes in Land Use and Its Impact on the Hierarchy of Roads in Ramadi City

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Abstract. Well-consideration should be given to the change in land use since it has a significant impact on the hierarchy of roads in terms of traffic congestion, traffic accidents, and low efficiency of roads as they serve traffic volumes higher than what has been planned for the master plans of cities. Therefore, this research investigates the impact of change in land uses on the hierarchy of roads in Ramadi city by utilizing Geographically Weighted Regression (GWR) in the Geographic Information System (GIS) to analyze the relationship between changes in land uses and road class according to the functional classification system of Ramadi city. The GWR analysis method was adopted because it provides an accurate description of the study area and takes into account the spatial dimension of the phenomenon. It was concluded that all classes of roads (major arterial, minor arterial, collector, and local roads) have a linear relationship with changes in land uses. Moreover, results show that the secondary arterial roads are the most affected by changes in land uses while the local roads are uselessly affected.

1. Introduction
1.1 General
Modernity and development of transportation networks are deemed as a crucial measure to define the extent of city development as it is closely linked to the daily life of residents. The ease, safety, and less possible time and effort at which goods and commodities access to all parts of the city are the most important elements of the link between land uses and transportation. Accessibility is also a very important contributor to economic and productivity growth that can be achieved by integrated planning. It is recognized that roads alone cannot be a goal, but are constructed to serve mobility generated by local land uses based on location or type of activity they serve [1]. Transportation planning can be linked to land uses planning with the concept of an Integrated Transportation Planning concept that balances the needs of the two processes. That is, it takes to account planning, developing, and operating transportation activities as well as investing on transportation by exploiting current and future lands and planning of resources and environment. The problem statement was there are changes in land uses of Ramadi city without considering the hierarchy of roads according to the functional classification of roads of Ramadi city.

1.2 Aim of Study
The main aim of this study is to find a relationship between changes in land uses and hierarchy of roads in Ramadi city (major arterial, minor arterial, collector, and local roads).

1.3 Significance of Study
The major significance of this study is to employing the geographically weighted regression (GWR) analysis method in GIS to accurately examine the significance of the relationship between change in land uses and the hierarchy of roads.

1.4 Hypothesis
There is a relationship between changes in land uses and classes of roads (major arterial, minor arterial, collector, and local roads).

1.5 Methodology
This study adopted the quantitative analysis approach using GIS and SPSS software and it has consisted of two parts:

- Theoretical and conceptual framework that includes concepts of changes in land used and definition of a hierarchy of roads as well.
- Analytical framework that includes an overview of the study area and its analysis using quantitative analysis methods as well as building and designing the model. In conclusion, a planning model that describes and interprets the relationship was built.

Data was collected from different resources, such as aerial photographs of the study area that were obtained from the concerned official directorate, field surveys to identify changes in land-uses of Ramadi city in coordination with the division of Town Planning in Ramadi city municipality, in addition to data from pertinent literature.

2. Background
2.1 Basic Concepts
2.1.1 Changes in Land Uses
The change in land use is a shift that occurs in the type of land use in the temporal and spatial dimensions [2]. These changes result in problems in the region, which are caused. To not enter the element of estimation or prediction, which leads to the necessity of preparing stages for its treatment in time and by specifying what is required for the development of the region in all economic and social directions

Different activities generate different patterns of land-uses, in which more than one activity may exist. The most significant factors that affect changes in land-uses are the density of population, diversity of land-uses, hierarchy of roads, distance to the city center, traffic congestion, and other factors depending on the city and its land-uses. A city can be regarded as an urban center developed due to agglomeration of residents in a specific area, thus a set of functions and special land uses is generated, which may change and develop depending on residents’ needs.

Several studies have found that the relationship between mobility and urbanism is one of the most important foundations of urban development. It also showed that the flow of mobility is accompanied by a flow of capital investment, which results in changes in land-use because of accessibility [3]. Change in land uses is a transformation that takes place in the spatial and temporal dimensions of a given type of land use [4].

2.1.2 Hierarchy of Roads
It can be observed in all planning theories, whether old or recent, urban or regional, that hierarchy is one of the important foundations that they were built upon. The hierarchy of roads depends on the anticipated traffic volume, which in turn influences the number and width of traffic lanes, design speed, car ownership, and their development. It also depends on the anticipated development of land uses. The emergence of transportation issues, e.g., traffic accidents and congestion, has created a necessity to adopt the hierarchy of streets of the city, i.e., classifying streets according to the functional significance to create a balance between traffic and land uses. The functional classification system of roads in Iraq uses the road width as a classification criterion, as listed below [6]:

- Major Arterial Roads (Width of roads is more than 40 meters)
- Minor Arterial Roads (The width of the roads is between 40 and 25 meters)
- Collector Roads (Width of roads is from 25 meters to 16 meters)
- Local Roads (The width of the roads is less than 16 meters)
The hierarchy of roads provides a perspective for every traffic issue based on destination centers, whether it was educational, health, recreational, or social. The streets are designed to accommodate a certain number of vehicles, but over time they become insufficient to accommodate the increasing number of vehicles due to population growth and the people's desire to own private vehicles, which exceeds the design limit for these roads and unaccounted changes in land uses, and thus the occurrence of traffic congestion.

2.2 Mechanism of Change in Land Uses
Planning land uses must promote the features of a city that make it distinctive from other cities, regardless of being a religious, heritage, historic, or a tourist city. Since urban land uses are a reflection of human activities in the city, these activities are governed by unstable social and economic relationships. Besides, the increase in population has resulted in loose population distribution and density in the city, which leads again to a re-distribution and a change in land-uses to adapt to the new trend of residents' needs in terms of quantity and quality [7]. The extensive change in human activities in any city will lead to a change and growth in land uses by occupying new lands within the boundaries of the city (in the center or suburbs) to satisfy residential needs and requirements. Deviation of land-uses from what has been planned for in the master plan of the city may be one of the reasons for the deficiency of new roads; roads that serve extra areas that have not been considered when preparing the master plan of the city.

3. Methodology & Data Collection
3.1 A Case Study: (Ramadi City)
It can be seen from Figure (1) that Ramadi city is located in southeastern Al Anbar Governorate. Its astronomical position is between (33°23') and (33°27') north latitudes, and between (43°20') and (43°12') east longitude. Ramadi is the center and administrative capital of Al Anbar Governorate that has an area of 138288 square kilometers, while the area of the built-up part of Ramadi is about (7191) hectares [5].

3.2 Changes in Land Uses in Ramadi City
Field surveys were conducted to observe and determine changes in land-uses of Ramadi city from 1993 to 2019, based on the master plan of 1993 and the master plan of 2012. A field survey was carried out from October 5 to November 3, 2019, in the eight sectors of Ramadi in coordination with Ramadi Municipality. Fourteen types of changes in land use, which represent about 8% of the area of the city, were observed. The distribution of these changes is demonstrated in Table (1) and Figure (2). From Table (1), it can be seen that change from orchards interspersed with houses to residential use comes at the top of all change. This is one of the most pronounced changes affecting transportation planning with an area of approximately 97.2 hectares (about 1.35% of the area of the city). Change from residential to commercial comes second with an area of 92.6 hectares (about 1.3% of the area of the city), which leads to additional trips generated per day.

What also stands out in the table is the area of change in land use from parking to commercial. Although the area is small (about 0.09 hectares), the location of change is important because it is in the city center (within the marketplace) that already has traffic congestions. The reason why this change is significant is that the parking was changed to a shopping mall, which attracts more trips and is linked to the distant main streets by narrow streets.
Figure 1. Location and Sectors of Ramadi City
Figure 2. Changes in Land Uses in Ramadi City From 1993 to 2019

Table 1. Distribution of Changes in Land-uses of Ramadi City

| Types of Land-uses Change                                      | Sector 1 | Sector 2 | Sector 3 | Sector 4 | Sector 5 | Sector 6 | Sector 7 | Sector 8 | Total |
|---------------------------------------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| Residential to Commercial Orchards interspersed with houses to residential | 11.4     | 4.6      | 2        | --       | 15.6     | 43.6     | --       | 15.4     | 92.6  |
| Green to residential                                          | --       | --       | --       | 97.2     | --       | --       | --       | --       | 97.2  |
| Services to residential                                      | 8.6      | --       | 11       | 5.6      | --       | 65.2     | --       | --       | 90.4  |
| Recreational to residential                                   | --       | --       | 5        | --       | --       | --       | --       | --       | 5     |
| Recreational to commercial                                    | 57.2     | 16.8     | --       | --       | --       | --       | --       | --       | 74    |
| Green to industrial                                           | --       | --       | --       | --       | --       | --       | 11.4     | --       | 11.4  |
| Green to commercial                                           | --       | --       | 2.45     | --       | --       | --       | --       | --       | 2.45  |
| Green to commercial                                           | --       | --       | --       | --       | --       | --       | --       | 14.3     | 14.3  |
| Green to roads                                                | --       | 0.87     | --       | --       | --       | --       | --       | --       | 0.87  |
| Parking to commercial                                         | --       | --       | --       | --       | --       | --       | --       | --       | 0.09  |
| Residential to educational                                    | 1.02     | 1.02     | 0.58     | 1        | 1.5      | 1.5      | 0.8      | --       | 7.42  |
| Roads to residential                                          | --       | --       | --       | --       | 39.8     | --       | --       | --       | 39.8  |
| Special to residential                                        | --       | --       | --       | --       | 65.2     | --       | --       | --       | 65.2  |
| Industrial to residential                                     | --       | --       | --       | 19.6     | --       | --       | --       | --       | 19.6  |
| Total                                                         | 78.22    | 23.29    | 21.03    | 123.4    | 17.1     | 229.6    | 12.2     | 15.49    |       |

Author, based on field surveys.

3.3 Hierarchy of Roads in Ramadi City

Functional classification was used to classify the roads of Ramadi city. As illustrated in Figure (4), roads are classified into major arterials, minor arterials, collectors, and local roads. Data on the length and width of roads in the form of a GIS file was obtained from the Municipality of Ramadi. Spatial analysis was performed using the Intersect tool in GIS. This tool calculates the area of overlapping portions between two or more layers of a feature. Areas are calculated and arranged in an Attribute table. The intersect tool can be found in Overlay Tools within the Analysis Tools group, as shown in Figure (3) [8].
Table (2) shows areas of roads in the eight sectors of Ramadi arranged based on its functional classification.

| No. | Sector | Local Roads (Hectare) | Collector Roads (Hectare) | Minor Arterials (Hectare) | Major Arterials (Hectare) |
|-----|--------|------------------------|---------------------------|---------------------------|---------------------------|
| 1   | Sector 1 | 135.82                 | 56.56                     | 12.9                      | 211.26                    |
| 2   | Sector 2 | 44.21                  | 17                        | 10.14                     | 29                        |
| 3   | Sector 3 | 66.04                  | 20.15                     | 12.39                     | 163.35                    |
| 4   | Sector 4 | 45.5                   | 22.63                     | 49                        | 122                       |
| 5   | Sector 5 | 31.12                  | 11.62                     | 8.6                       | 80                        |
| 6   | Sector 6 | 254.7                  | 126.67                    | 94.73                     | 3333.17                   |
| 7   | Sector 7 | 29.52                  | 4.17                      | 4.87                      | 51.71                     |
| 8   | Sector 8 | 10                     | 7.6                       | 8.34                      | .00                       |
|     | Total   | 616.91                 | 4.266                     | 97.200                    | 32.3910                   |

4. Analysis and Results

4.1 Model Building

In this study, three steps were involved in model building. First, statistical analysis was performed using Pearson’s Bivariate Correlation method in SPSS. A significant relationship was observed between changes in land uses and all classes of roads with a Significance of less than 0.05 as shown in Scatter/Dot plots from Simple Scatter in SPSS, as

Figure 3. Analysis Tools Application

Figure 4. Hierarchy of Roads in Ramadi City
shown in Figure (5). Second, the linearity of the relationship between the four classes of roads and changes in land uses (Table 4). This indicates the reliability of the model according to SPSS literature. The area of change in land uses and the area of roads are detailed in Table (3).

### Table 3. Area of change in land uses and area of roads

| Local (X4)(m²) | Collector (X3)(m²) | Arterial (minor) (X2)(m²) | Arterial (major) (X1)(m²) | Area of Change in land uses (Y)(m²) |
|----------------|--------------------|---------------------------|---------------------------|-----------------------------------|
| 135.82         | 56.56              | 12.9                      | 211.26                    | 78.22                             |
| 44.21          | 17                 | 10.14                     | 29                        | 23.29                             |
| 66.04          | 20.15              | 12.39                     | 163.35                    | 21.03                             |
| 45.5           | 22.63              | 49                        | 122                       | 123.4                             |
| 31.12          | 11.62              | 8.6                       | 0.00                      | 17.1                              |
| 254.7          | 126.67             | 94.73                     | 3333.17                   | 229.6                             |
| 29.52          | 4.17               | 4.87                      | 51.71                     | 12.2                              |
| 10             | 7.6                | 8.34                      | 0.00                      | 15.49                             |

### Table 4. Correlations

|          | Y | X1  | X2  | X3  | X4  |
|----------|---|-----|-----|-----|-----|
| **Correlations** |   |     |     |     |     |
| Y Pearson Correlation | 1 | .878** | .974** | .907** | .867** |
| Sig. (2-tailed) | .004 | .002 | .002 | .002 | .002 |
| N | 8 | 8 | 8 | 8 | 8 |
| X1 Pearson Correlation | .878** | 1 | .903** | .939** | .910** |
| Sig. (2-tailed) | .004 | .002 | .001 | .002 | .002 |
| N | 8 | 8 | 8 | 8 | 8 |
| X2 Pearson Correlation | .974** | .903** | 1 | .858** | .805* |
| Sig. (2-tailed) | .002 | .006 | .006 | .016 | .016 |
| N | 8 | 8 | 8 | 8 | 8 |
| X3 Pearson Correlation | .907** | .939** | .858** | 1 | .990** |
| Sig. (2-tailed) | .002 | .001 | .006 | .000 | .000 |
| N | 8 | 8 | 8 | 8 | 8 |
| X4 Pearson Correlation | .867** | .910** | .805* | .990** | 1 |
| Sig. (2-tailed) | .005 | .002 | .016 | .000 | .000 |
| N | 8 | 8 | 8 | 8 | 8 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).
The linear relationship between the two variables, i.e., the hierarchy of roads (X) and changes in land use (Y), has a coefficient of determination, $R^2$, of higher than 0.75, which indicates a very significant linear relationship.

Now moving to the third step in which the GWR analysis, a tool that helps researchers and policy and decision-makers to project the effects of local characteristics [8], was used. Building a model that correlates transportation to land uses can assign values and weights for any required point in the study area. Based on that, the GWR was selected to solve the problem of changes in land uses and examine its impact on transportation. GWR assigns weights to the variables based on the variable’s coordinates as shown in the following total regression equation:

$$Y_i = \beta_0 + \beta_1 x_n$$  \hspace{1cm} (1)

Where:
- $Y_i$: Area of change in land uses
- $X_n$: Area of roads

Location coordinates can be calculated using the following equation:
\[ y_i = \beta_0 (u_i, v_i) + \sum_{j=1}^{n} \beta_j (u_i, v_i)x_{nj} \]  

(2)

The model of Ramadi city includes four transportation variables. A model was built for each class of roads in the study area.

4.2 Major Arterial Roads

Data on the area of roads (in the study area) variable was processed using a set of GWR tools. It was the first input to the software and then analyzed. The variable was statistically described by the coefficient of determination (R2 = 0.77) and Adjusted R Square (Adjusted R2 = 0.73) as demonstrated in Figure (6). Table (5) shows the results of the analysis, while Table (6) shows the mathematical relationship between the area of major arterial roads and the area of changes in land uses.

![Table 5. Results of Analysis of Relationship between Area of Major Roads and Area of Change in Land Uses](image)

**Figure 6.** Relationship between Area of Major Roads and Area of Change in Land Uses (Author, based on (GIS))

**Table 5.** Results of Analysis of Relationship between Area of Major Roads and Area of Change in Land Uses

| Sector | Condition Number | Coefficient Interc | Coefficient X1 | Residual |
|--------|------------------|--------------------|----------------|---------|
| 1      | 1.551            | 36.389             | 0.058885       | 29.41   |
| 2      | 1.550            | 36.393             | 0.058887       | -14.727 |
| 3      | 1.550            | 36.397             | 0.058889       | -24.406 |
| 4      | 1.549            | 36.397             | 0.058888       | 79.854  |
| 5      | 1.550            | 36.394             | 0.058887       | -19.254 |
| 6      | 1.553            | 36.383             | 0.058881       | -3.031  |
| 7      | 1.551            | 36.393             | 0.058886       | -26.917 |
| 8      | 1.550            | 36.394             | 0.058887       | -20.884 |
Table 6. Mathematical Relationship between Area of Major Arterial Roads and Area of Changes in Land Uses

| Sector No. | Equation       |
|-----------|---------------|
| Sector1   | \( Y = 36.4 + 0.06X_1 \) |
| Sector2   | \( Y = 36.39 + 0.06X_1 \) |
| Sector3   | \( Y = 36.4 + 0.06X_1 \) |
| Sector4   | \( Y = 36.4 + 0.06X_1 \) |
| Sector5   | \( Y = 36.39 + 0.06X_1 \) |
| Sector6   | \( Y = 36.38 + 0.06X_1 \) |
| Sector7   | \( Y = 36.39 + 0.06X_1 \) |
| Sector8   | \( Y = 36.39 + 0.06X_1 \) |

4.3 Minor Arterial Roads

This variable was statistically described by the coefficient of determination (R²=0.94) and the adjusted R square (Adjusted R² = 0.94) as demonstrated in Figure (7). Table (7) shows the results of the analysis, while Table (8) shows the mathematical relationship between the area of minor arterial roads and the area of changes in land uses.

Figure 7. Relationship between Area of Minor Roads and Area of Change in Land Uses (Author, based on GIS)

Table 7. Results of Analysis of Relationship between Area of Minor Roads and Area of Change in Land Uses

| Sector | Condition Number | Coefficient X1 | Coefficient X2 | Residual |
|--------|------------------|----------------|----------------|---------|
| 1      | 2.169            | 5.07           | 2.393          | 42.291  |
| 2      | 2.169            | 5.061          | 2.394          | -5.964  |
| 3      | 2.169            | 5.047          | 2.394          | -13.1   |
| 4      | 2.169            | 5.048          | 2.394          | 1.158   |
| 5      | 2.169            | 5.057          | 2.394          | -8.504  |
| 6      | 2.169            | 5.093          | 2.393          | -2.170  |
| 7      | 2.169            | 5.062          | 2.393          | -4.175  |
| 8      | 2.169            | 5.057          | 2.393          | -9.511  |
Table 8. Mathematical Relationship between Area of Minor Roads and Area of Changes in Land Uses

| Sector No. | Equation          |
|------------|-------------------|
| Sector1    | \(Y = 5.07 + 2.39X^2\) |
| Sector2    | \(Y = 5.06 + 2.39X^2\) |
| Sector3    | \(Y = 5.05 + 2.39X^2\) |
| Sector4    | \(Y = 5.05 + 2.39X^2\) |
| Sector5    | \(Y = 5.06 + 2.39X^2\) |
| Sector6    | \(Y = 5.09 + 2.39X^2\) |
| Sector7    | \(Y = 5.06 + 2.39X^2\) |
| Sector8    | \(Y = 5.06 + 2.39X^2\) |

4.4 Collector Roads

This variable was statistically described by the coefficient of determination \(R^2 = 0.82\) and the adjusted \(R^2\) (Adjusted \(R^2 = 0.79\)) as demonstrated in Figure (8). Table (9) shows the results of the analysis, while Table (10) shows the mathematical relationship between the area of collector roads and the area of changes in land uses.

![Figure 8](image)

Figure 8. Relationship between Area of Collector Roads and Area of Change in Land Uses (Author, based on GIS)

Table 9. Results of Analysis of Relationship between Area of Collector Roads and Area of Change in Land Uses

| Sector | Condition Number | Coefficient Interc | Coefficient X3 | Residual |
|--------|------------------|--------------------|----------------|---------|
| 1      | 2.191            | 8.2852             | 1.7081         | -26.66  |
| 2      | 2.190            | 8.2958             | 1.708          | -14     |
| 3      | 2.190            | 8.3096             | 1.7078         | -21.11  |
| 4      | 2.190            | 8.3104             | 1.7078         | 76.49   |
| 5      | 2.1901           | 8.2997             | 1.7079         | -10.98  |
| 6      | 2.193            | 8.264              | 1.7083         | 4.94    |
| 7      | 2.191            | 8.296              | 1.7080         | -2.89   |
| 8      | 2.191            | 8.301              | 1.7079         | -5.77   |
Table 10. Mathematical Relationship between Area of Collector Roads and Area of Changes in Land Uses

| Sector No. | Equation        |
|------------|----------------|
| Sector1    | Y = 8.28 + 1.71X3 |
| Sector2    | Y = 8.29 + 1.71X3 |
| Sector3    | Y = 8.31 + 1.71X3 |
| Sector4    | Y = 8.31 + 1.71X3 |
| Sector5    | Y = 8.3 + 1.71X3 |
| Sector6    | Y = 8.26 + 1.71X3 |
| Sector7    | Y = 8.3 + 1.71X3 |
| Sector8    | Y = 8.3 + 1.71X3 |

4.5 Local Roads

This variable was statistically described by the coefficient of determination (R²=0.75) and the adjusted R square (Adjusted R² = 0.71) as demonstrated in Figure (9). Table (11) shows the results of the analysis, while Table (12) shows the mathematical relationship between the area of local roads and the area of changes in land uses.

Figure 9. Relationship between Hierarchy of Roads and Area of Change in Land Uses (Author, based on GIS)

Table 11. Results of Analysis of Relationship between Hierarchy Roads and Area of Change in Land Uses

| Sector | Condition Number | Coefficient Interc | Coefficient X4 | Residual   |
|--------|------------------|--------------------|----------------|------------|
| 1      | 2.4417           | 1.5154             | 0.8254         | -35.382    |
| 2      | 2.4416           | 1.5343             | 0.825          | -14.646    |
| 3      | 2.4413           | 1.5603             | 0.8249         | -34.419    |
| 4      | 2.4413           | 1.5590             | 0.8249         | 84.344     |
| 5      | 2.4411           | 1.5411             | 0.8251         | -10.071    |
| 6      | 2.442            | 1.4713             | 0.8259         | 17.772     |
| 7      | 2.441            | 1.5322             | 0.8252         | -13.374    |
| 8      | 2.441            | 1.5421             | 0.8251         | 5.716      |
Table 12. Mathematical Relationship between Area Roads and Area of Changes in Land Uses

| Sector No. | Equation |
|------------|----------|
| Sector 1   | Y = 1.51 + 0.83X  |
| Sector 2   | Y = 1.53 + 0.82X  |
| Sector 3   | Y = 1.56 + 0.83X  |
| Sector 4   | Y = 1.56 + 0.83X  |
| Sector 5   | Y = 1.54 + 0.83X  |
| Sector 6   | Y = 1.47 + 0.83X  |
| Sector 7   | Y = 1.53 + 0.83X  |
| Sector 8   | Y = 1.54 + 0.83X  |

5. Discussion

To accurately describe the problem of this study, the results of each variable were analyzed using GWR and spatially represented by calculating the standard deviation (Std. Dev.) values, which were ranging between negative and positive values and did not show a unified gradient [9].

5.1 Major Arterial Roads

The relationship between the area of major arterial roads variable and area of changes in land uses variable can be spatially represented by standard deviation values shown in Figure 10.

Spatial representation of the relationship between the area of major arterial roads and area of changes in land uses. It can be seen that for Sector 2, the standard deviation values ranged between -0.5 and +0.5. That is, the relationship is significantly negative and positive, i.e., there is a small change in land uses along the arterial roads (Sittin Street). It is worthy to mention that the area of arterial roads in this sector was small, while there were changes distant from major roads.

It can also be observed that in Sector 1 the standard deviation ranged between -1.5 and +0.5, i.e., the relationship is significantly positive as there are changes along Al Taamim street, despite that the area of arterial roads in the Sector 1 is large.

In addition, the standard deviation of Sector 4 ranged between +2.5 and +1.5. That is, the relationship is positive, but this class of roads sector has a lower impact in this sector.

Regarding Sector 3, 5, 6, 7, and 8, the standard deviation range between -0.5 and -1.5. This indicates that the relationship is significantly negative as there are changes in land uses in Sector 5 and Sector 8, although this class of roads does not exist in both sectors.
5.2 Minor Arterial Roads
The relationship between the area of minor arterial roads and the area of changes in land uses can be spatially represented by standard deviation values shown in Figure (11). The relationship was positive in some areas and negative in others.

![Figure 11. Spatial Representation of Relationship between Area of Minor Arterial Roads and Area of Changes in Land Uses](image)

It can be seen that the standard deviation of Sector 1 ranged between 1.5 and 2.5, i.e., the relationship is positive, but the impact of minor roads on changes in land uses in this sector is lower than that of the other sectors. This is because the area of changes in land uses linked to minor arterial roads is small, such as Al Taamim street (city corner), while the area of minor arterial roads is small, as illustrated in Figure (10).

As regards to Sector 2, 4, 6, and 7, the standard deviation values ranged between -0.5 and +0.5. This indicates that there is a significant positive relationship in some areas but negative in other areas. This is because that most of changes in land uses were distributed near or around the minor arterial roads, such as the change around Arbaeen Street, Omar Bin Abdul Aziz Street, and the vicinity of the general parking garage in Sector 4.

Moreover, for Sector 3 and 8, the standard deviation values ranged between -0.5 and -1.5, which is an indication of a significantly negative relationship as changes in land uses were very evident, although the area of minor arterial roads was limited.

5.3 Collector Roads
The relationship between the area of collector roads variable and area of changes in land uses variable can be spatially represented by standard deviation values shown in Figure (12). The relationship was positive in some areas and negative in others.
Figure 12. Spatial Representation of Relationship between Area of Collector Roads and Area of Changes in Land Uses

It can be seen that the standard deviation of Sector 4 ranged between 1.5 and 2.5, i.e., the relationship is positive, but the impact of collector roads on changes in land uses in this sector is lower than that on the other sectors. This is because most of changes in land uses in this sector were distributed along different classes of roads, such as Arbaeen Street, Sittin Street, and the vicinity of the general parking garage as shown in Figure (12).

It can also be seen that the standard deviation values of Sector 2, 5, 6, and 8 were ranging between -0.5 and +0.5. This means that the relationship is significantly positive in some areas and negative in other areas. This is because, most of the changes in land uses were distributed around collector roads, e.g., Al Mustawaa Street in Sector 5 and Al Khadami Street in Sector 6.

Regarding Sector 1 and 3, the standard deviation values ranged between -0.5 and -1.5, which indicates a significantly negative relationship as changes in land uses along collector roads in both sectors were very small, although the area of this class of roads was evident.

5.4 Local Roads

The relationship between the area of collector roads variable and area of changes in land uses variable can be spatially represented by standard deviation values shown in Figure (13). The relationship was positive in some areas and negative in others.

Figure 13. Spatial Representation of Relationship between Area of Local Roads and Area of Changes in Land Uses

It can be seen that the standard deviation of Sector 4 ranged between 1.5 and 2.5, i.e., the relationship is positive, but the impact of local roads on changes in land uses in this sector is lower than that in the other sectors.

It can be also seen that the standard deviation values of Sector 2, 5, 7, and 8 were ranging between -0.5 and +0.5. That is, the relationship is significantly positive in some areas and negative in other areas. This is because there are changes in land uses (commercial) in Sector 5 and they were distributed near or around local roads. Whilst in Sector 8, most of the changes (commercial) were along local roads.

Besides, for Sector 1 and 3, the standard deviation values ranged between -0.5 and -1.5, which indicates a significantly negative relationship as changes in land uses along this class of roads was small, although both sectors have the largest area of this class of roads.
6. Conclusions and Recommendations
Results analysis and interpretation lead to the conclusion and recommendations:

6.1 Conclusions
- All road classes (major arterial, minor arterial, collector, and local) exhibited a significant relationship (Sig. less than 0.05) with changes in land uses.
- All road classes (major arterial, minor arterial, collector, and local) showed a linear relationship with changes in land uses.
- Minor arterial roads have the most significant relationship with an Adjusted R Square of 0.94.
- Local roads have the lowest impact on changes in land uses.

6.2 Recommendation
- Since land uses are trip generators and in order to properly protect them, random changes in land use must be controlled by competent authorities represented by the Municipality of Ramadi.
- It is recommended to adopt GWR analysis when examining and representing spatial phenomena related to traffic and transportation planning in cities.
- It is also recommended to consider the hierarchy of roads if changes in land uses were introduced when updating the master plans of cities.
- This case study could be generalized and applied to other Iraqi cities.

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