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Change in land-uses of Ramadi city and its influence on public transportation sustainability

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Abstract. The transportation system in the city of Ramadi, like other Iraqi cities, suffers from many problems for many reasons, notably, changing land uses there. Since the mid-nineties, the change from residential to commercial use was common in Ramadi, and the absence of successful and sustainable planning has exacerbated the problems more due to a large number of planning violations. Here lies the problem of the study, which is the negative impact of the change on the sustainability of urban transportation. In order to address such problems, there is a need for in-depth knowledge of the impact ratios and their reasons for resolving the various transportation changes under study, which is the sustainability of public transport for its significance, and it is deeply affected by changes in land uses. The aim of the study stems from impact standardization and its spatial location and analyzing it by using geographic information systems. The model can be adopted and circulated to the rest of the Iraqi cities in order to present a vision to address the negative impact resulting from the change in land uses and to achieve the goals of sustainable planning for the urban area.

1. Introduction

1.1 General

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, land value, diversity of land-uses, distance to the city center, traffic congestion, and other factors depending on the city and its land uses. Rapid development, increasing urban growth rate, and urban expansion of Ramadi City have led to many complex problems, such as deterioration of city center and random land-use expansion. Therefore, efforts are focused on sustainable urban planning to address issues in the land-use distribution system of the city.

Urban planning is done by studying the reality of the situation of the city and its land uses, which results in facts that can be used to assess and modify the master plan. This way, an optimum plan can be created with minimum errors and better flexibility in solving the plan's problems that can be encountered in the future by using different methods, the most important of which is the relationship between land-uses and transportation. A well-designed plan is comprehensive, integrate, real, flexible, and provides a balance between social and economic aspects. Planning is not only targeted to achieve specific goals but also to ensure a balance between social, economic, and environmental goals [1].

Public transportation is one of the essential techniques that significantly contribute to sustainable transportation in the presence of population growth and other defects in urban cities that lead to problems due to increased traffic volumes. Public transportation can reduce pollution, traffic accidents, and traffic congestion caused by private vehicles. Therefore, this study is conducted to evaluate the influence of changes in land-uses on public transportation sustainability and reveal its role, taking Ramadi city (the capital of Al Anbar Governorate) as a case study.



1.2 Research Problem

There are significant changes in land-uses of Ramadi city at the expense of other uses over a long time. The research problem is showing in terms of two points. The first point is the observed changes in land use in the study area. The second point is the changes in the performance of the transportation system in the study area and its factors.

1.3 Research Aim and Objectives

This research aims to study and analyze the influence of changes in land-uses on the public transportation of Ramadi city. To achieve this aim, the techniques for building the most proper mathematical model will be reviewed to choose the most appropriate one. The distance traveled by users to the public transportation facilities, obtained from a pre-designed questionnaire, will be adopted as a representative planning criterion.

1.4 Research Significance

Standard quantitative analysis is used instead of descriptive analysis by utilizing GIS and Geographically Weighted Regression (GWR), compared to statistical analysis methods, to accurately examine how the changes in land-uses affect public transportation.

1.5 Research Hypothesis

The area of changes in land-uses is directly proportional to the area served by public transportation.

1.6 Research Methodology

The quantitative analysis approach using GIS, GWR, and SPSS software is adopted in this research. The research methodology consists of two parts:

Part 1: Theoretical and conceptual framework that includes concepts related to changes in land-uses and definition of public transportation, weighted spatial analysis in GIS, and other concepts about variables influencing transportation sustainability.

Part 2: Analytical framework that includes an overview of the study area. It was divided into eight sectors, which is the number adopted by the municipality of Ramadi city. To assess the transportation service in the city, a community opinion questionnaire was used to obtain a descriptive representation of transportation in Ramadi City and its analysis using quantitative analysis methods and building and designing the model.

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 specify 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.

In conclusion, a planning model that describes and interprets the relationship was built, and solutions to problems resulted from changes in land-uses and their influence on public transportation were recommended.

2. Theoretical Framework

2.1 Basic Concepts

2.1.1 Changes in Land-uses

Regular study of land-uses of the city reveals its general structure, and it is not possible to understand the reality of the situation of the city and plan for future land-uses unless changes in its internal structure through successive stages are examined [2].

Urban land-uses are defined as "the spatial distribution of different city functions, including residential, commercial, industrial and recreational function, and how modern highways are designed based on fundamental criteria and specifications of the city, which are related to its size and social and economic importance. These functions occupy space in the form of use [3].

Many studies showed that the relationship between mobility and urbanism is one of the essential foundations of urban development. The mobility can be represented by some variables such as rate of generated trips, rate of attracted trips, public transportation orientation, trip length, trip cost, and others. Based on that, various types of changes in land-uses can be observed in most of the cities, the main of which are the change from agricultural land-use to residential land-use, and change from residential use to commercial use. Therefore, the uncontrolled change, change to commercial use, in particular, leads to trip attraction, and hence it is regarded as the most influencing factor on spatial instability of land-uses.

2.1.2 Sustainable Transportation

Sustainable transportation is defined as achieving mobility and accessibility necessary to meet development requirements without affecting the life quality of future generations. In such a way that the transportation is safe, healthy, inexpensive, and of limited pollution so that it fulfill current needs without damaging environmental consistency, in addition to promoting long-run economic growth [4].

In other definition, sustainable transportation is the transportation services that reflect the integration of social and environmental expenses in a manner that respects environmental capacity and balances between accessibility need, environmental quality, and consistency in the urban environment [5], as illustrated in Figure (1).

To achieve the best city plan (urban planning), the relationship between land-uses and transportation must be dynamic, not static. 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 [6] and other factors, such as a change in the behavior of road users and global technology development. This cannot be done unless comprehensive sustainability is adopted in all its aspects, whether social, environmental, or economic, i.e., adopting sustainable urban planning is one of the requirements of the principle of primary sustainable transportation.

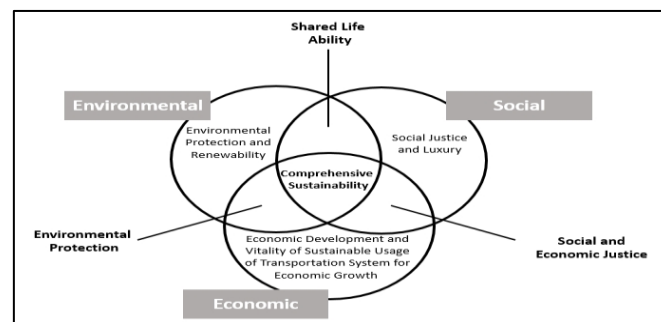


Figure 1. Comprehensive Sustainability Factors [7].

Transportation plan should include different transportation facilities that serve different modes of travel, such as public and private vehicles, bicycles, and pedestrians.

Since public transportation is very important, most countries carefully consider its planning and management based on cities' needs in terms of comfortability, cost, and the number of users who benefit from it. Therefore, significant investments are made to promote public transportation and encourage people to use it and give it the priority on other means of travel instead of private transportation. Providing public transportation routes could be better than constructing new roads and parking lots that cannot be accommodated by the city.

Consequently, the best practice to address the trend of using private cars is to activate public transportation service, considering the distance required by the user to access to the public transportation facility, which is the most important criterion of public transportation assessment.

Geographically Weighted Regression is a tool that helps researchers, policy, and decision-makers to project the effects of local geographical characteristics [8]. Accurate local indicators (indices) can be obtained by using the local (partial) model and unconventional transportation-land-uses models [9].

2.1.3 Geographically Weighted Regression

Building a model for the relationship between transportation and land-uses can provide values and weights for any required point in the study area. Based on that, the Geographically Weighted Regression was chosen to solve the problem of land-use changes and examine its influence on transportation, because it assigns weights to variables based on the variable's coordinates and adds it to the equation of total regression.

$$Y_i = \beta_0 + \beta_1 x_n \quad (1)$$

Where:

Y_i : Area of change in land-uses

x_n : Area served by public transportation

β_0 and β_1 : constant

$$Y_i = \beta_0(u_i, v_i) + \sum_{j=1} \beta_j(u_i, v_i)x_n \quad (2)$$

Where :

u_i and v_i : The Coordinates of Location

The results will be compared to simple linear regression using the statistical software SPSS that is used in almost all scientific research methodologies.

2.2 Mechanism of Land-uses Change

Land uses to refer to the social and economic relationships in the city described by various activities. Change in social and economic relationships creates a need to change activities; thus, change in land-uses [10].

Since urban land-uses reflect human activities in the city, which is influenced by unstable social and economic relationships, any change in the pattern of these relationships will be accompanied by a change in the events and activities, and a consequent change in land-uses [11].

"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 [12].

Planning land-uses must support features of the city that make it distinctive from other cities, whether it is a religious, heritage, historical, or a tourist city. The extensive change in human activities in any city will lead to a change and growth in land-uses by occupying new lands within boundaries of the city (in the center or suburbs) to satisfy residential needs and requirements.

The expansion in land-uses should be well-considered and consistent with urban and architectural planning. Otherwise, the change will be random and cause a significant contrast between uses and its random distribution and transportation planning, and eventually lead to many problems, such as traffic congestion and accidents at the expense of other areas. Random distribution of land uses of any Leads to lack of privacy, because of the lack of proper urban planning or lack of applying the necessary rules of the integrity of land- use distribution. 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 other areas that have not been considered when preparing the master plan of the city.

3. Applied Framework

3.1 Description of Study Area (Ramadi City)

Ramadi city is located in western Iraq and eastern Al Anbar Governorate. Its astronomical position is between (33°23') and (33°27') north latitudes and between (43°20') and (43°12') east longitude. It is the capital of Al Anbar Governorate and is divided into 8 sectors approved by Ramadi Municipality, as shown in Figure (2) [13]. Its total population is (271221) people in 2019, as estimated by Survey Censuses Division of Al Anbar Statistics Directorate. Data used in the analysis of the city was obtained from Ramadi Municipality, Al Anbar Governorate. The area of the built-up part of the city is about (6605) hectares. Table (1) illustrates the area of each sector.

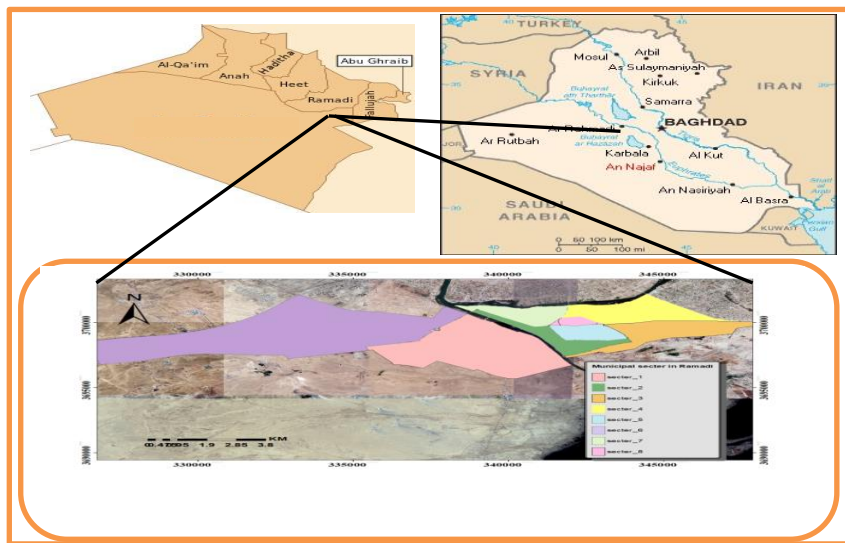


Figure 2. Geographical Location and sectors of Ramadi City

Table 1. Area and Population of sectors

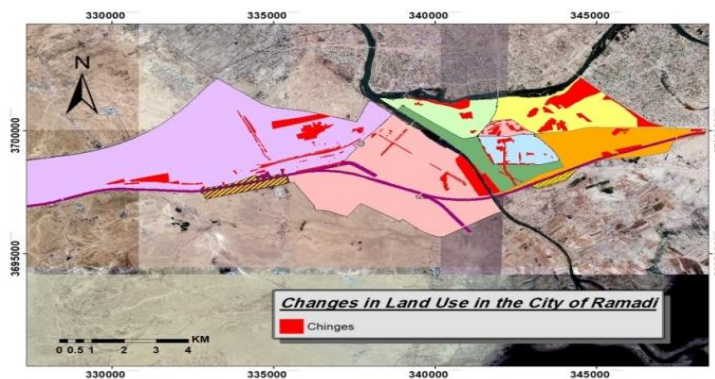
Sector codes	Sector	Area of Sector (Hectare)	Population
1	First	1580.16	61123
2	Second	326.39	40591
3	Third	611.13	33039
4	Fourth	616.5	29717
5	Fifth	232.1	38553
6	Sixth	2848.52	28202
7	Seventh	313.7	29565
8	Eighth	76.5	10431
Total		6605	271221

3.2 Changes in land-uses of Ramadi City

Field surveys were conducted to observe and determine the changes in land-uses of Ramadi city from 1993 to 2019, based on the master plan of 1993 and the master plan of 2012. The 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 land-uses' changes were observed as shown in Table (2). These changes represented around 8% of the area of the city, as illustrated in figure (3).

Table 2. Distribution of Changes in Land-uses of Ramadi City, 2019

Types of Land-uses Change	Area of Changes in Ramadi Sectors (Hectare)							
	1st	2nd	3rd	4th	5th	6th	7th	8th
Residential to Commercial	11.4	4.6	2	--	15.6	43.6	--	15.4
Orchards interspersed with houses to residential	--	--	--	97.2	--	--	--	--
Green to residential	8.6	--	11	5.6	--	65.2	--	--
Services to residential	--	--	5	--	--	--	--	--
Recreational to residential	57.2	16.8	--	--	--	--	--	--
Recreational to commercial	--	--	--	--	--	--	11.4	--
Green to industrial	--	--	2.45	--	--	--	--	--
Green to commercial	--	--	--	--	--	14.3	--	--
Green to roads	--	0.87	--	--	--	--	--	--
Parkings to commercial	--	--	--	--	--	--	--	0.01
Residential to educational	1.02	1.02	0.58	1	1.5	1.5	0.8	--
Roads to residential	--	--	--	--	--	39.8	--	--
Special to residential	--	--	--	--	--	65.2	--	--
Industrial to residential	--	--	--	19.6	--	--	--	--
Total	78.2	23.3	21.0	123.4	17.1	229.6	12.2	15.5

**Figure 3.** Change in land use in the city of Ramadi

From Table (2), it can be seen that the Sector No.6 has the largest area of change in land-uses because it is the largest by area and does not include a commercial center, which resulted in a change of residential use and green space to commercial use (about 57.9 hectares). On the other hand, particular use (military (the 8th Brigade)) was changed to residential use, with an area of change of about 65.2 hectares. Besides, there was an encroachment on transportation use (railway route) with an area of change of around (65.2) hectare.

This shift to residential use has led to a lack of educational use, which invoked a change in a part of residential use to educational use with an area of change of (1.5) hectare.

It is also clear from Table (2) that the smallest area of change of land-uses (15.5 hectares) was within the sector No.8, which is the center of Ramadi city. This is because there are a variety of activities in that Sector as it is a commercial center, People prefer to live away from the center. Therefore the prevailing change in this sector is from residential to other uses, with an area of change of approximately (15.4) hectares. Moreover, it can be observed from this table that the common type of

change, which was in Sector No.8, is from (orchards interspersed with houses) use to residential use that has an area of change of (97.2) hectares.

3.3 Public Transportation in Ramadi City

Public transportation is one of the important modes that significantly contribute to achieving sustainable transportation by reducing pollution, traffic accidents, and traffic congestion resulted from private vehicles with the expansion and population growth in urban cities, in addition to the emergence of many deficiencies in the cities that led to increasing problems due to increased traffic movement.

Public transportation is regarded as one of the most important means to transport people if large buses were used, whether the private or public sector owns it. "This mode of transportation is preferred because of its high absorptive capacity that significantly reduces traffic congestion, especially in rush hours. If it is provided continuously and affordably, it will encourage workers and visitors, of the central business district (CBD) in particular, to use this means of transportation, thereby reducing traffic congestion in the city.

It was found, through field surveys and daily observations in Ramadi city, that public vehicles in Ramadi city are limited to micro Buses (11-24) passengers that consisted of two lines, as shown in figure(4). The first line (Ramadi- Al Taamim) starts from Al Taamim's garage in the center of Ramadi city, heading towards Al Taamim and Al Khamsa Kilo districts. The total number of vehicles in this line is 30 vehicles. The second line (Ramadi – Al Sofiya) starts from Al Sofiya's garage (near the Directorate of Nationality in the center of Ramadi city) heading towards Al Sofiya district. The total number of vehicles in this line, mainly Hyundai minibuses (10-14) passengers, is approximately 40 vehicles.

In order to determine the area served by public transportation in Ramadi city, the Buffer Analysis in GIS was adopted. The buffer creates a polygon to a specified distance so that it becomes the precinct of the feature. Buffer can be created in GIS from the Proximity Tools group in the Analysis Tools group [14]. To assess the transportation service in the city, a community opinion questionnaire was used to obtain a descriptive representation of transportation in Ramadi City. The sample size was determined by applying Richard's equation to statistically represent the sample and obtain the best representation of the population. The reliability required for the sample is 0.05. A sample of 400 residents of Ramadi city was taken. According to Richard's equation, the required sample size is 384, given that the population of Ramadi is 271221. Therefore, a sample of 400 people was considered adequate. The questionnaire resulted in a critical variable, which is the distance required by individuals to access public transportation facilities. The questionnaire showed that 68% of participants take less than 375 m to access public transportation facilities, as illustrated in Table (3), therefor a buffer was created along the route of public transportation with an average distance of 370 m, as illustrated in figure (4) and the questionnaire that showed areas served by public transportation in all sectors of Ramadi city.

$$n = \frac{\left(\frac{Z}{d}\right)^2 \times (0.5)^2}{1 + \frac{1}{N} \left[\left(\frac{Z}{d}\right)^2 \times (0.5)^2 - 1\right]} \quad (3)$$

Where:

N: population size

Z: standard normal deviation at 95% confidence level = 1.96

d: percentage of error= 0.05

P: margin of errors= 0.5

In GIS, the Intersect analysis was used by intersecting the layer of sectors with the layer of buffer to find the area served by public transportation in each sector, as illustrated in Table (3).

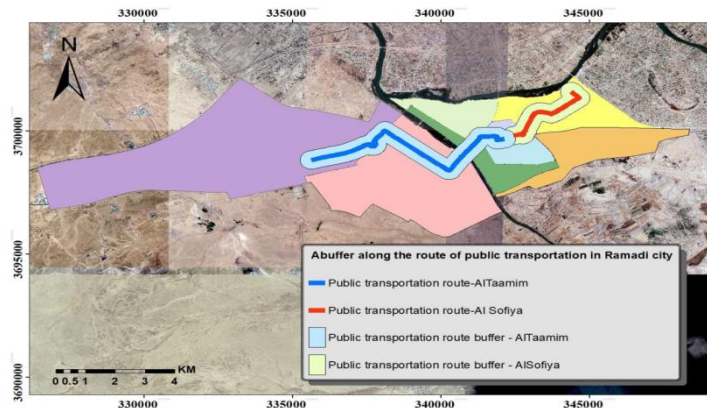


Figure 4. A buffer along the route of public transportation in Ramadi city

Table 3. area served by public transportation

Sector codes	Sector	Total area served by public transportation (hectare)
1	First	28.8
2	Second	48
3	Third	0.46
4	Fourth	224
5	Fifth	82.9
6	Sixth	203.5
7	Seventh	16.7
8	Eighth	60.3

3.4 Model Building and Design

The area of change in land-uses and the area served by public transportation is adopted as the dependent variable (Y) and the independent variable (X), respectively.

3.4.1 Statistical Model Building. The Bivariate (Pearson)

The correlation method was used to analyze the data in the statistical analysis software SPSS. Pearson's coefficient is the coefficient of correlation between two variables, between which the relationship is supposed to be linear. It is suggested to plot the correlation to make sure that the relationship is linear before using Pearson's coefficient. Source) The linear relationship between public transportation variable (X) and changes in the land-uses variable (Y) was tested, as illustrated in Figure (5). The degree of correlation (R^2 Linear) was 0.652, which indicates a moderate linear correlation.

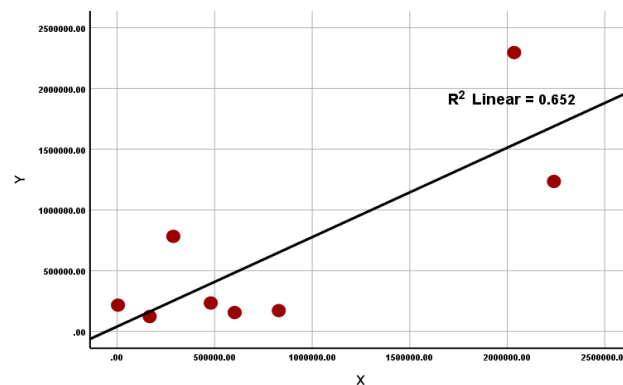


Figure 5. Linear correlation between public transportation and changes in land-uses

It was observed that the correlation coefficient between the two variables. R is 0.807, and the statistical significance is 0.015, as shown in Table (4). This indicates that the model is reliable according to the literature related to the statistical software, which states that if the statistical significance is less than 0.05, then the model is reliable.

Table 4. relationship between public transportation variable and area of changes in land-uses

		Y	X
Y	Pearson Correlation	1	.807*
	Sig. (2-tailed)		.015
	N	8	8
X	Pearson Correlation	.807*	1
	Sig. (2-tailed)	.015	
	N	8	8

*. Correlation is significant at the 0.05 level (2-tailed).

Linear Regression analysis in SPSS was used to develop a relationship between the dependent variable (Y, change in land-uses) and the independent variable (X, public transportation). Table (5) shows that the coefficient of determination $R^2=65\%$, which indicates the proportion of variance in the dependent variable. Table (6) shows a test of the significance of regression represented by $\text{sig.}=0.015$. Results indicate that the model is reliable.

Table 5. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.807a	.652	.594	492545.05413

a. Predictors: (Constant), X

Table 6. ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	2727329709901.	1	2727329709901.	11.24	.015b
Residual	1455603782116.9	6	242600630352.82		
Total	4182933492018.0	7			

Results in Table (7) were used to obtain equation (3).

Table 7. Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	39596.499	252233.214		.157	.880
X	.737	.220	.807	3.353	.015

$$Y_i = 39596.5 + 0.74 x_n \quad (3)$$

It can be seen from equation (3) that the change in land-uses is directly proportional to the area served by public transportation. This equation applies to all sectors of Ramadi city.

3.4.2 Model Building Using GWR

A relationship for each sector can be developed using GWR analysis, which makes it more accurate in interpreting the model than SPSS analysis that builds one relationship for the whole area of study and does not consider the spatial coordinate of the phenomenon. After interpreting results using GWR in GIS, it was observed that the determination coefficient between the two variable $R^2 = 0.79$, as shown in Figure (6). GWR is known for representing results spatially, i.e., it develops a relationship for each sector, as illustrated in Table (8), (9) and (10).

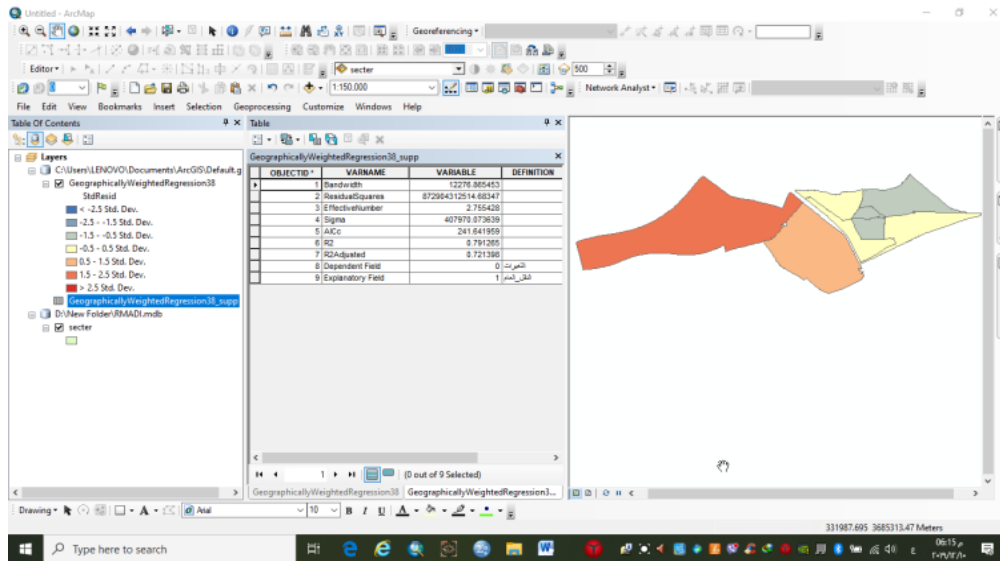


Figure 6. Spatial representation of the relationship between public transportation variable and area of changes in land uses.

Table 8. Geographically Weighted Regression

Sector	Observed y	Local R2	Con. number	Coefficient Interc	Coefficient X
1	782389	0.62	2.46	48030	0.71
2	233655	0.61	2.43	58134.4	0.66
3	216140	0.60	2.40	71237.6	0.59
4	1234401	0.61	2.41	66102.6	0.61
5	171360	0.61	2.43	61107	0.64
6	2296111	0.71	2.61	6917.8	0.88
7	122134	0.62	2.45	49797	0.68
8	155126	0.61	2.43	58857.7	0.64

Table 9. relationship for each sector

Sector	Model
First	Y= 48273.3 + 0.7X
Second	Y= 58372+0.66X
Third	Y= 71461.9+0.6X
Fourth	Y= 66335.6+0.6X
Fifth	Y= 61342.7+0.64X
Sixth	Y= 7190 + 0.87 X
Seventh	Y= 50046.4 + 0.68X
Eighth	Y 59097.5 +0.64X

Relationships developed using GWR are different from each other based on each sector, and they radically differ from relationships developed using SPSS. GWR analysis was adopted because it takes to account the spatial coordinates of the phenomenon, which plays a significant role in assessing and analyzing changes of land-uses with transportation in the city.

The strongest correlation obtained was for Sector No.6 with $R^2=71\%$ because of the changes in land-uses along with the residential use. While the weakest correlation obtained was for Sector No.3 with $R^2= 60\%$, since changes in land-uses in Sector No.3 were far away from the area served by public transportation, in addition to the unavailability of public transportation in this sector.

3.5 Results Interpretation and Discussion

The results of the analysis support the research hypothesis. That is, the changes in land-uses are directly proportional to public transportation, and that public transportation can achieve urban sustainability for any city. In order for urban planning to be sustainable should include accessibility of people to public transportation facilities, which requires a response from relevant directorates in the city by providing tools and facilities necessary to achieve this goal. By observing the route of public transportation in Ramadi City, it can be concluded that:

- 1- The public transportation service is not available in all sectors, especially Sector No.3 and 7. While in other sectors, many districts are far away from the route of public transportation.
- 2- The public transportation services inefficient because it serves only a small number of residents, which drives them to use private transportation that leads to increased traffic congestion and increases pollution levels in the city.
- 3- The users of public transportation need to travel long distances to access to the public transportation, compared to private transportation.
- 4- The patterns of land-uses along the route of public transportation are almost commercial uses that resulted from changes from other uses, which reinforces the importance of public transportation.
- 5- Sector 8 is the center of the city; the most common land use is commercial. People prefer to live away from the center. Therefore the prevailing change in this sector is from residential to other uses.

4. Conclusions and Recommendations

Based on this study results, the following can be concluded:

- Adopting GWR analysis gives more accurate results than other analysis methods in spatial analysis and representation of influences of changes in land-uses on public transportation. The reason is that it provides deeper insights into this phenomenon, which helps decision-makers in the city to give the public transportation service a higher priority to improve the public transportation system.
- The variety of land-uses along the route of public transportation contributes to providing direct access to work and shopping activities.
- The influence of change in land-uses on public transportation sustainability in Ramadi city is different, based on the eight sectors that constitute it.
- The privacy of the eighth zone, problems of changes in land uses and problems of transportation system were addressed differently and more carefully than other zones.

Based on the conclusions mentioned above, the following is recommended:

- 1- It is necessary to control changes in land-uses and road hierarchies inside cities to accurately project land-uses because they are trip generators that promote adequate public transportation. Therefore, it is essential to define the appropriate pattern that makes public transportation more attractive, whether in areas that will be developed in future or old areas that will be re-developed by applying sustainable urban development through public transportation, as public transportation is deemed the best choice for cities that experience adverse impacts of transportation service.

- 2- Public transportation routes in the city are proposed to serve more extensive areas of the city. It also recommended the increase in commercial and residential use in areas that cannot be served by public transportation affordably.
- 3- It is recommended to provide public transportation service by providing various trip destinations and reducing the distance required to access to public transportation facilities.

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