Research papers

The relationship between traffic congestion and land uses: A case study of Al-Kut city, Iraq

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Abstract Traffic congestion is one of the major problems that contemporary cities need to address. Decision makers in cities, interested in finding appropriate strategic solutions to a very complex problem, are faced with an ever greater headache each year. The solutions available should not cost billions of dollars or lead to the construction of bridges or tunnels that move the problem from one place to another, thereby creating new

bottlenecks. Individuals who drive in these congested areas often sit for long periods in traffic, and this leads to physical and emotional stress as well as decreased performance and productivity. This study constructed a mathematical model that illustrates the relationship between traffic congestion and the distribution of land use in the city of Al-Kut, demonstrating that land use planning can have a significant impact on congestion levels in the near and long term.

Keywords: *land use, transport, congestion, traffic, city of Al Kut*

INTRODUCTION

It has become evident in planning studies that transport and traffic in cities cannot be planned in isolation from land use planning. At the same time, it is not possible to plan land uses in isolation from transport, due to the nature of the overlap and spatial relations between them in terms of planning patterns of street networks and their components. Therefore, it is possible to do away with the creation of many expensive roads through proper planning and the appropriate location of land use.[1] Land use and transport are complementary to each other where traffic movement is considered an effect of urban land use. If we organise the land use for a particular city, then we can forecast the traffic movement on the network and the mode of spatial and temporal traffic distribution. If the use of the land has changed or the transport has moved, there will definitely be potential for predicting the shape and magnitude of movement change.[2] Traffic congestion and delays are the direct result of the operational performance of neighbouring links, which in turn are significantly affected by land use developments.[3]

The power of the relationship between land use and transport is evident by the fact that land use is the generator of traffic and transport in the city. Traffic patterns also reflect any land use changes for different activity trips. The city's transport system changes with changing land use. According to transport theory, the effect of the land use change on traffic can be guesstimated.[4] In recent studies, the relationship between urban form and trip patterns has become a significant consideration for planners and decision makers. Urban traffic depends on the location of the activities that supply the services.[5] It is a problem of spatial distribution. Knowledge of the characteristics of spatial organisation of cities is the main answer to the question about the interaction between city structure and trip patterns.

Researchers have suggested that the change in urban form is the most crucial indicator of the demand for urban transport, which in turn reduces congestion and consumption of fuel and improves the quality of the environment. Recent studies have focused on reducing the number of trips by encouraging efficient land use and with well-designed, well-managed transport systems. The transport system leads to land use for transport (transport network) and the processing of traffic on the transport network;[6] this results in traffic congestion and the horizontal movement of passengers on the transport network. This network includes roads, the capacity of each road and intersection, the safe and legal speed of each road, the cost of public and private transport, the time spent for a trip, the cost of parking, and many others factors. In order to ensure good interaction among the transport network, transport planning should be planned. Transport planning is the process

of information development to assist in decision making for urban transport development and management. Transport can have a significant impact on mobility, economic development, environmental quality, government funding and quality of life. Proper planning is required to help provide quality transport services at a cost with less impact on the environment and to improve economic activity.

A lack of transport planning can lead to severe traffic congestion, slowing economic growth, negative environmental impact, wasted public money and wasted energy.[7] The transport development framework is directly related to the development of land uses as part of the long-term plan. The transport planning process follows the steps and begins the process by organising the study and main tasks by defining the main solutions to the problem.[8] Access to an efficient transport system is an ongoing planning task to meet the requirements of the movement of people and goods at a level that matches the development process. Therefore, appropriate planning of the transport network and the development of possible alternatives to the optimal alternative is a continuous process that evolves with the development of the city. Transport planning should be adjustable and continuous, reflecting what is changing in the city.

- Urban areas include tightly packed residents and the direction and development of public transport;
- New developments include the creation of roads and roads associated with different villages and village centres' uses;
- Remote rural areas include the creation of villages and provide essential processing services and transport services. The many models used in planning provide a means to test theories and to develop information about urban system behaviour.

Iacono *et al*. reviewed the most frequent frameworks for transport modelling and land use change. These models focus attention on the role of accessibility in location choices. They have introduced an approach for understanding this connection and its effects on the urban structure.[9] Public transport projects require a long period to be completed (in terms of study, design and implementation). K. Joh conducted a case study in the south bay area of Los Angeles to investigate relationships between land use and travel behaviour. The results indicated that mixed-use neighbourhoods promote walking trips rather than reducing automobile trips and have an effect on traffic systems.[10] Yan Ou *et al*. investigated the impacts of land use on traffic systems through computational experiments based on TransWorld, a computational platform for artificial transport systems[11] (see also Yan-Li Wang,[12] Li-Ya,[13] Cervero and Kang,[14] Zheng[15] and Farhan *et al*.[16]).

This research aims to find solutions for traffic congestion problems through a deeper understanding of the relationship between traffic and land uses to address congestion problems in Al-Kut city which have been exacerbated.

METHODOLOGY

The study area

Al-kut city is located in the centre of Iraq and is the capital of Wasit province. It is located between latitude 32°1′ and 33°30′ northern and longitude 46°20′ and 44°30′ eastern.[17] The area of the province is 17,153 sq. km, while Al-Kut city has a built-up area of 45 sq. km. It has an important location on the Tigris river, which passes through the middle of the city and divides it into two equal halves

that are connected by Al-Kut barrage.[18] Also, there are many other rivers that branch out from the city, such as the Gharraf and Dujaili.[19] In terms of spatial location and its relation to neighbouring areas, Al-Kut city is connected to Baghdad, which is approximately 180km to the north. The limits of spatial research are the municipal boundaries of Al-Kut, which are shown in the basic planning map of the city. The temporal boundaries of the research are the study of the cross-section of Al-Kut city for 2010.

Building analytical factors: Fragmentation of study area (adjacent analysis)

For the purpose of adopting quantitative analytical methods and producing clear results that reflect the reality of the case study, this study considered dividing the study area into a group of partial elements (cells) in order to reach a spatial division and to calculate the values of the indicators adopted in the research by dividing Al-Kut city into a network of cells. A square-shaped cell network has been adopted along the length of one cell. This length is chosen because it includes most of the area of the central region as any interaction that cannot be segmented in practice. It is also an economic, social and psychological necessity, because all life is present in it. The results are shown in Figures 1 and 2.

The neighbourhood function is carried out by dividing the study area into smaller parts of the survey. These parts are regular or irregular according to the nature of the study and according to the spatial classification of the land use. Geographic information systems (GIS) are concerned with the methods of dealing with contiguous areas and their relation to the geographical phenomenon and

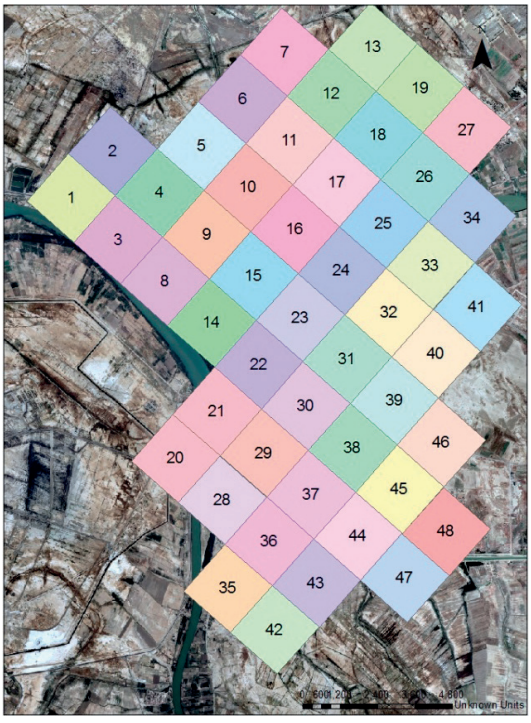

Figure 1: Building the cell network to analyse the neighbourhoods in the city of Al-Kut

Source: Authors

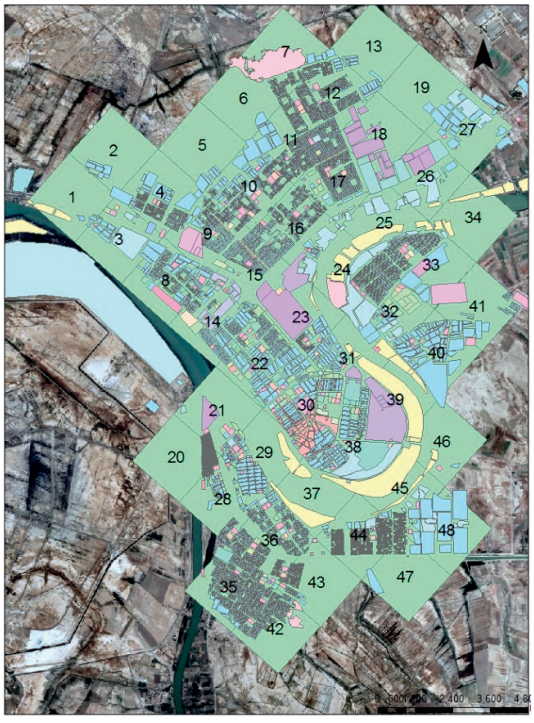

Figure 2: The intersection of the cell network to analyse the juxtaposition with land use

Source: Authors

conducting spatial measurements and analysis. There are many functions that can be accomplished using this function, including:

- Spatial measurements, the most important of which are longitudinal measurements between two phenomena or area spaces;
- Spatial search for information, such as areas of concentration of population or places of traffic congestion or counting of those who frequented commercial centres.

DERIVATION OF LAND USE INFORMATION

For the purpose of building information on land use, the research relied on a set of basic functions of GIS analyses in order to derive values that were adopted as indicators of research, as follows:

Analytical function (overlay intersection)

Through the intersection of the cell network with all layers of other land use for the purpose of deriving the values of the parts of these factors for each cell of the study area, thus obtaining the second generation of derivative information to be used for later analysis. The advantage of using this function is that the output of the intersection of the two layers is stored in a new layer separate from the two basic layers.

Dissolve analysis function

This analysis was adopted for the unification of adjacent spatial phenomena through the adoption of a component of the database related to spatial phenomena as an element of integration, by integrating them adopting the analysis of juxtaposition as a basis for such integration, and to obtain information to be adopted in statistical analysis. The spatial distribution and the construction of the network metadatabase of transport and movement by giving weights to these phenomena and scattering them on the network of cells; the utility of this division to compare these parts of the study area and calculate the values of their variables and to know the ratios of each type of land use within this cell.

Traffic surveys

A site survey was conducted for all areas of Al-Kut city and the main congestion areas were identified during different times of day. The weight of a cell from the network of land use cells is given according to the conditions of the congestion survey. The lowest values ranged from ten to the highest value 95, as shown in Figure 3 and the table of total values shown in the model's legend.

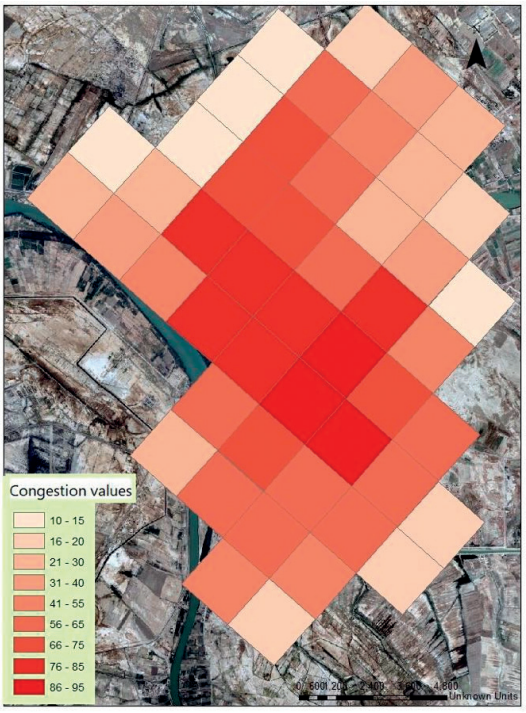

Figure 3: The amount of congestion on the cell network to analyse the juxtaposition

Source: Authors

RESULTS: MODEL BUILDING AND ANALYSIS

The mathematical model of the traffic congestion in the urban road network in Al-Kut city with other variables has been constructed according to the relationship shown in equation 1 below:

$$Y = 35.520 + 0.074\ X1 + 0.289\ X2 + 0.195\ X3 - 0.333\ X4 + 0.174\ X5 + 0.441\ X6 \ldots \text{Eq 1}$$

Where:

Y is the severity of the traffic congestion and was measured according to the comparative values (10–95 per cent). These values are dependent on the location of residential neighbourhoods in the city;
X1 represents the commercial use area of the studied area;
X2 represents the administrative usage area of the studied area;
X3 represents the residential use area of the studied area;
X4 represents the health use area of the studied area;
X5 represents the industrial use area of the studied area;
X6 represents the educational use area of the studied area.

The results of the model, according to the analysis of the program of statistical analysis of social studies (SPSS) for the first stage, expressed all the variables used in the model and this is evident through the analysis of test (t), where the results indicate the significance when comparing the middle of the sample taken with the middle of the community crossing neighbourhoods of the residential district is divided in the city, as previously explained. In the ANOVA phase (Table 3), the results indicate that the model has accepted the alternative hypothesis, which expresses a strong correlation between the independent variables and the variable of the model. This is equivalent to the analysis and testing (F), where the calculated F value is much larger than its numerical value expresses the possibility of adopting this model and its results. The sample of the analytical model (model summary) shows that the value of determination coefficient indicates that its value is (R = 0.74) and that the value of the square of determination coefficient is (R2 = 0.55) and its value indicates that it is morally acceptable and has a good interpretation of the variables of land use area used within the independent variables of the form. It reflects that the traffic congestion experienced by the city is due to the interaction of diversity in the land use located in the city, which in turn causes severe traffic congestion. This requires taking into account these variables in addition to others that represent the network movement variables and road users' behaviour.

The details of the data used in the model, the details of the model, its results and the results of the test, and the integrated statistical program (SPSS) are listed in Tables 1–4.

Table 1: The details of the data used in the model

Number	Congestion	Com.	Gov.	Heal	House_1	Indu.	Educ.
1	25	0	8738	7620	73522	0	0
2	10	0	8738	131859	115547	0	0
3	35	0	1964	0	218419	0	10918
4	30	0	0	0	392653	0	18177
5	15	0	0	0	127248	0	0
6	10	0	0	0	138667	0	0

Table 2: Model summary

Model	R	R square	Adjusted R square	Sta. error of the estimate
1	0.741(a)	0.550	0.484	18.488

Predictors: (constant), Educ., Indu., Hous_1, Heal, Gov., Com.

Table 3: ANOVA (b)

Model	Sum. of squares	df	Mean square	F	Sig.
Regression	17110.801	6	2851.800	8.343	.000(a)
Residual	14014.199	41	341.810		
Total	31125.000	47			

a Predictors: (constant), Educ., Indu., Hous_1, Heal, Gov., Com.

b Dependent variable: Congestion

Table 4: Standardised and unstandardised coefficients (a)

Model	Unstandardised coefficients		Standardised coefficients	t	Sig.
	B	Std. error	Beta		
(constant)	35.520	4.140		8.579	.000
Com	3.10E-005	.000	.074	.564	.576
Gov	.000	.000	.289	2.354	.023
Heal	.000	.000	-.332	-3.028	.004
Hous_1	8.03E-006	.000	.195	1.825	.075
Indu	4.90E-005	.000	.174	1.621	.113
Educ	.000	.000	.441	3.416	.001

a Dependent variable: Congestion

CONCLUSIONS

Land use has an important role in the relationship between traffic in the city and the problem of traffic congestion. Addressing the problem of traffic congestion requires in-depth surveying and data preparation for the use of modern technologies, including GIS. The model used has given significant results and can be adopted and tested for other Iraqi cities. The hypothesis of this study was proved, ie the relationship between traffic congestion and land use in the city and the adoption of GIS technology to facilitate the process of analysis and evaluation of the problem. The study recommends the adoption of the proposed model by local government, as well as the use of spatial analysis in urban planning to solve traffic problems in Iraqi cities.

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