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IMPLEMENTATION OF BIT ERROR RATE (BER) BASED ON SOFTWARE DEFINED RADIO

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Abstract

Software defined radio (SDR) technology offers the resilience, efficient market hypothesis cost and less power consumption leading communications ahead, with widely reaching advantageousness accomplished by service providers and product advancers through to end users. Over a past couple of decades many Mobile communication standards have evolved and even today researches are going to develop new standards. Different standards of Mobile communication use different type of hardware circuitry. The existing mobile communication standards are primarily regional and not global. So efforts are going on to develop systems which can support multiple mobile communication standards using same hardware but swapping the software. The main aim of this paper is to present a scheme for Bit error rate (BER) in SDR. We do the source to sink transmission simulation by using Quadrature Amplitude Modulation, then, we compare the differences of BER versus SNR performances for input.

Keywords*: SDR; FPGA; DSP; BERT; SDR, Mat lab, Additive white Gaussian noise, quadrature amplitude modulation*.

استخدام معدل الخطأ بالنظام الثنائي على اساس البرمجة الراديوية المعرّفة

الخلاصة

إن تقنية البرمجة الراديوية المعرّفة تجعل المرونة وتقليل التكلفة وزيادة القدرة في قيادة الاتصالات نحو الامام بفائدة واسعة الوصول والتي يتم تحقيقها عن طريق موزعي الخدمة ومطوري المنتوج الى آخر مستخدم. العديد من معايير اتصالات الجولات عبر العقود المنصرمة قد تم انشائها ولحد يومنا هذا في حالة التطور بمعايير جديدة. تستخدم اتصالات الجوال معايير واجهزة ودوائر مختلفة. ان معايير اتصالات الجوال الموجودة مبدئيا تكون اغلبها محلية وليس عالمية. وان الجهود تستمر لتطوير الانظمة التي تدعم المعايير المتعددة والتي تستخدم نفس الأجهزة ولكن برمجة اخرى. ان الهدف الرئيسي من هذا البحث هو لتقديم نظام

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لمعدل خطأ النظام الثنائي في تقنية البرمجة الراديوية المعرّفة. يتم جعل محاكاة في الأرسال وذلك باستخدام التضمين السعوي التربيعي، وبعدها يتم على طلب التنقل لذا يسبب مستوى عالي من الازدحام .النمو مقارنة الفروقات الحاصلة في معدل النظام الثنائي نسبةً الى اداء معدل اشارة الخطأ. السكاني رافقه زياده في الكثافة السكانية من ٨٠ شخص /هكتار من الأرض الحضرية في عام ١٩٥٩ الى ١١٢,٩ شخص /هكتار في عام ٢٠١٤ وكذلك توجد فجوه مابين أسس النقل ونمو المساحات السكانيه .

الكلمات الدالة : *النمو الحضري ،النقل ،التحليل المكاني الزماني ، مؤشرات ،التحسس النائي ، خرائط*

1. Introduction

Urban growth is strongly related to transportation with reciprocal causes and effects. Causality, reciprocal effects, and reciprocal causes are apparent characteristics of urban growth and transportation relationship. However, the relationship could be inferred at four main interacted aspects: transportation infrastructure, travel demands, population and land use change [1]. Advances in transportation system have reduced the cost of commuting within urban areas and encouraged urban scattering. Equally, transportation infrastructure expansion has stimulated urban growth and land use changes [2].

At the same time, urban growth affects transportation. Urban growth patterns configure urban spatial structure and thus influence transportation. Urban growth not only increase travel demand [3] but also, cause infrastructure pressure and consequently traffic congestion [4]. Therefore, urban growth is strongly related to transportation with reciprocal causes and effects. Indicators can be used as an effective tool for quantifying and analyzing the spatial-temporal relationship between urban growth and transportation. Six indicators were developed to quantify the spatial-temporal urban growth and transportation situation; these are discussed below.

1.1. Transportation Infrastructure Expansion Index

The transportation infrastructure expansion index (TIEI) is designed to investigate the spatial temporal change of the transport system in Baqubah. It is calculated in terms of lengths of transportation infrastructure in kilometers and it is may be calculated as follows[5]:

$$TIEIt = (TIL_{l,t} - TIL_{l,t-1})/TIL_{l,t} \times 100 \quad (1)$$

where

TIEIt [%] is the transportation infrastructure expansion index;

$TIL_{l,t}$ and $TIL_{l,t-1}$ are the total transportation infrastructure length in kilometers at time t (current year) and time t−1 (former year).

1.2. Annual Urban Spatial Expansion Index

The urban spatial expansion index is imperative in describing the temporal change of an urban area in terms of its annual urban growth rate and annual growth area [5]. The annual urban spatial expansion index (AUSEI) has been adopted to discuss the temporal urban spatial growth of Baqubah and is calculated as follows:

$$AUSEIt = (Ut - Ut-1)/Ut/(Nt - Nt-1) \times 100 \quad (2)$$

where

AUSEIt [%] is the annual urban spatial expansion index; Ut and $Ut-1$ are the total urban areas of the study area in hectares at time t (current year) and time $t-1$ (former year); $N$is the total number of years from time t (current year) to time $t-1$ (former year).

1.3. Annual Land Use Change Index

Land use change is critical, not only in spatial temporal urban growth and transport analysis, but also in different global, regional and urban analyses. It reflects the dynamics of urban areas and is one of the driving forces of urban development [6]. Hence, a land use change index (LUCI) is considered to determine the land uses changes in Baqubah as follows:

$$ALUCIa,t=((LUa,t-LUa,t-1)/\ LUa,t\ )/(Nt-Nt-1)\times 100 \qquad (3)$$

where

ALUCIt [%] is the land use change index; LUa, and $LUa,-1$ are the total land area of land use class a in hectares at time t (current year) and time $t-1$ (former year); N is the total number of years from time t (current year) to time $t-1$ (former year).

1.4. Population Density Index

A population density index is critical in analyzing spatial temporal urban growth and transport analysis [6]. It reflects the pattern and characteristics of urban growth and efficiency of the transport system. Many urban studies have calculated population density as the total urban population to the total urban area. Accordingly, here a population density index (PDI) is implemented as follows:

$$PDIt=Pt/Ut \qquad (4)$$

where

PDIt [persons/ha] is the population density index; Pt is the total population at time t; and Ut is the total urban land in hectares at time t.

1.5. Road Density Index

The road density index reflects the densification of roads within the city, which can be compared with the total urban area and population. It also reflects the deficiencies in road infrastructure of such urban area. It can be expressed as the length of all roads per number of inhabitants and by the area of the city. The road density index (RDI) is designed to trace the change of road infrastructure over time at Baqubah and is as:

$$RDI\_At = RLt/UAt \qquad (5)$$

$$RDI\_CAPt= RLt/UPt \qquad (6)$$

Where

RDI_At [kilometers/ha] is the road density index per area and RDICAP[kilometers/person] is the road density index per capita; RLt is the total road length in kilometers at time t ; UAt is

the total urban area in hectares at time t; while UPt is the total urban population in the study area at time t.

1.6. Road Area Density Index

The road area density index is developed to investigate the spatial temporal relationship between urban growth and transport. It calculates the total area devoted to transport infrastructure in relation to the total urban area and similarly in relation to the urban population. It reflects the proportions of transport infrastructure of the total urban area and the total road space per person over time. The Road Area Density Index (RADI) is expressed as the proportion of the total road area (all road types) to the total urban area, as the total road area (all road types) to the total urban population, and as the total road area (all roads types) to the total urban residential area:

$$RADI\_At = Rat/UAt \times 100 \quad (7)$$

$$RADI\_CAPt = Rat/UPt \quad (8)$$

$$RADI\_RESt = Rat/URAt \quad (9)$$

where

RADIt [%] is the road area density index by urban area,

RADI_CAPt. [ha/person] is the road area density index per urban area. RADI_RESt[ha/ha] is the road area density index per residential land use area . RAt is the total road area in hectares at time ; $UAt$is the total urban area in hectares at time t; $UPt$is the total urban population in the study area at time t; and UAt is the total urban residential area in hectares at time t .

2. Input Data

This study utilizes a time series of maps and satellite images to quantify the spatial-temporal urban growth and transportation system situation from 1959 to 2014. Maps data of 1959, 1974, 1988 and 1994 are used for the period before 2004, as shown in Table (1). After 2004, Quick bird satellite image data of 2004, 2008 and GeoEye satellite image 2010 are used.

3. Study Region

The study region is Baqubah city. Baqubah is located at the east of Iraq with geographic coordinates [latitude (37° 25 50) to (37° 40 52) N, longitude (45° 16 39) to (47° 55 32) E] on both sides of river Diyala. Baqubah is the capital of Iraq's Diyala Governorate. The city is located some 50 km to the northeast of Baghdad, on the Diyala River. Baqubah served as a way station between Baghdad and Khorasan on the medieval Silk Road. The city of Baqubah growing cities evolution result of the improved economic and living conditions, which caused an increase in the ownership of vehicles, but the city, suffers from the old poor planning and lack of necessary studies and the crisis for modeling the movement of transport within the city. Figure (1) Shows location of the study region Baqubah city in Iraq.

Table 1. Data Maps of Baqubah City Different Time

Number	Year of Map	Scale of Map	Reference of Map
1	1959	1:25000	University of Baghdad(40)
2	1974	1:25000	University of Baghdad(40)
3	1988	1:25000	Directorate of urban planning and urban in Diyala
4	1990	1:1000000	General Authority of Survey
5	1994	1:25000	Center of Urban and Regional Planning for University of Baghdad
6	2000	1:50000	General Authority of Survey
7	2006	1:25000	Directorate of urban planning and urban in Diyala
8	2014	1:25000	Municipality of Baqubah

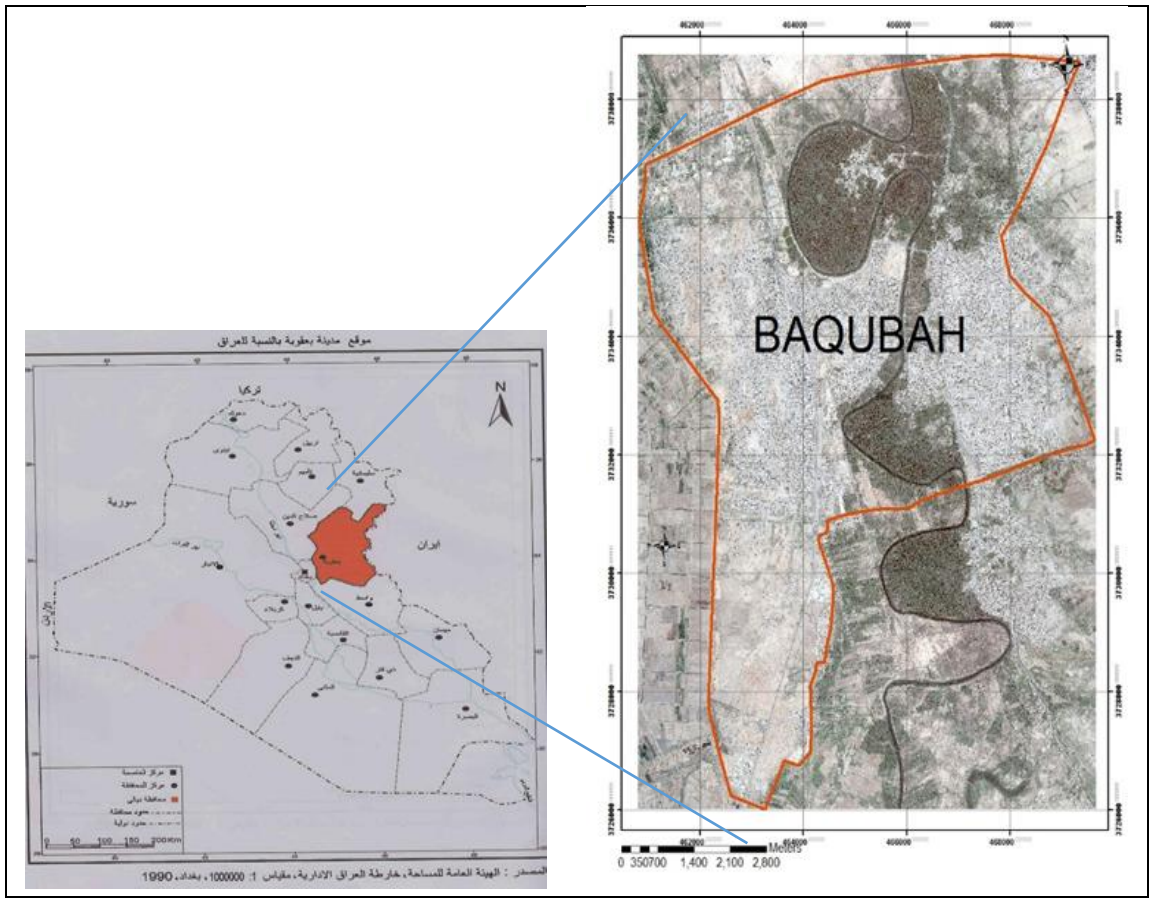


Figure 1. Location Study Area (Baqubah) from Iraq

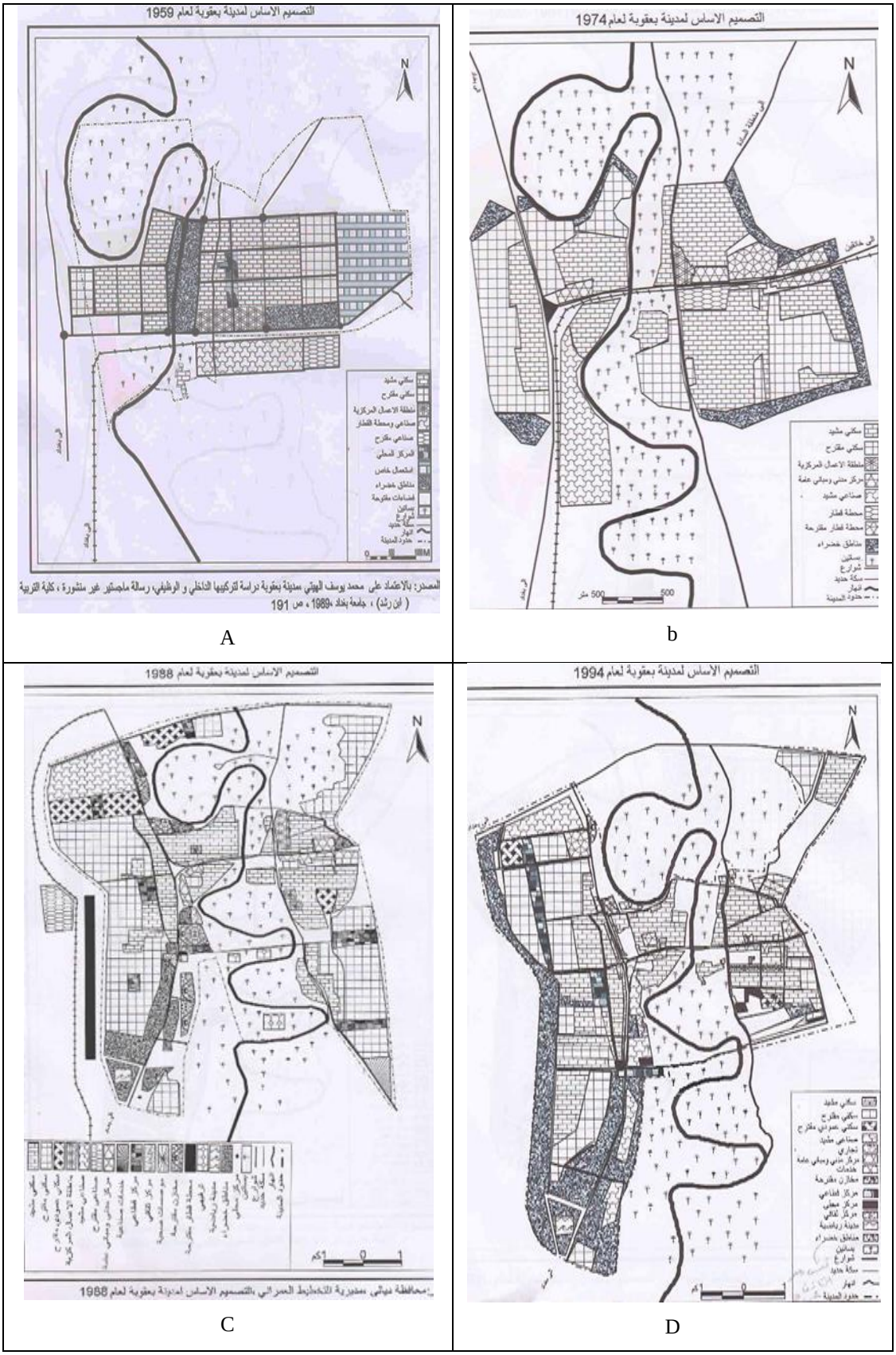


Figure 2. Master Plan of Baqubah City a-1959,b-1974,c-1988,and d-1994

4. Result and Discussion

4.1. Transportation Infrastructure Expansion Index

The results indicate that Baqubah suffered tremendous transportation infrastructure expansion from 1957 to 2014.By using equation (1), transportation infrastructure increased rapidly from 62 km to 178 km, with a change of 64.7% and an annual growth of 6.5% in 1977 to 1987 respectively as shown in Table (2). Most of the transportation infrastructure in Baqubah was constructed during that period. The transportation infrastructure was predominantly shaped by a linear grid pattern with satisfactory connectivity. The results are indicated in period 1997 to 2007 the slowly grew in that period and improved to 1.8% to 2014. Especially, the transportation infrastructure expansion in Baqubah has thus followed the proposed locations by Baqubah Municipality's master plans of 1959, 1974, 1988 and 1994 as shown in Figure (2).In relating population growth and transportation infrastructure expansion, three main gaps were clearly distinguished as shown in Figure (6). Initially, from the period of 1957 to 1977, the population grew rapidly and then the transportation infrastructure slowly expanded. From 1977 to 1987, the transportation infrastructure expansion rapidly increased in comparison with the steady decrease in population growth. In 2007, the transportation infrastructure expansion is decreased to the minimum value, and then grew slowly significantly to 2014.

Table 2. TIEI and Spatial-temporal Expansion of Baqubah Transportation Infrastructure from 1957 to 2014

Year	Road Length (km)	change LR	TIEI %	Annual LR %
1957	26	-------	------	-----
1977	62.8	36.8	58.6	2.9
1987	178	115.2	64.7	6.5
1997	288.6	110.6	38.3	3.8
2007	293	4.4	1.5	0.2
2010	302	9	3.0	1.0
2014	325	23	7.1	1.8

4.2. Annual Urban Spatial Expansion Index

Baqubah witnessed a dramatic spatial expansion through the period 1957-2014 are shown in Figure(3) and Table (3), also by using equation (2) to calculate the AUSEI. From 1957 to 1977, Baqubah urban area expanded slowly increase to a 566 ha with 3.4% annual growth rate. Subsequently, from 1977 to 1987, Baqubah witnessed a remarkably rapid increase in both population and urban mass; with 949 ha increase and the maximum annual growth rate 5.3% for all periods are shown in Figure (3) and Table (3), which was increased significantly by the country's oil boom. The spatial expansion in this period was affected by the rapid increase of transportation infrastructure. Two patterns of development can be distinguished outward expansion and sprawl development. From 1987 to 1997,and 1997 to 2007 , Baqubah experienced a tremendous urban expansion that matched with an economic slowdown, which

is reflected in the limited population growth, and spatial expansion the rate 2.2% are shown in Figure (3) and Table (3). A significant spatial expansion occurred in the west of Baqubah with a typical infill development pattern. On the other hand, sprawl and leap-frog development continued at the west and south fringes of Baqubah along with the transportation infrastructure. From 2007 to 2010, Baqubah is witnessed slowly increase annual growth rate about 2.6%because of the situation of in Iraq in this period. Lastly, from 2010 to 2014, Baqubah witnessed a significant infill development pattern at the east and south sides of Baqubah decreased the annual rate to 2.0% are shown in Figure (3) and Table (3). Figure (5) shows the relationship between urban spatial expansion and transportation infrastructure expansion in Baqubah from 1957 to 2014. First, the transportation infrastructure dramatically expanded, which may have stimulated the urban spatial expansion with a sprawl pattern from 1977 to 1987. From 1987 to 2007, both the transportation infrastructure expansion and urban spatial expansion rates decreased rapidly. Then, in the period from 2007 to 2014, the transportation infrastructure expansion and urban spatial expansion gradually increase. This expansion reflects the infill pattern of urban development. After 2007, the transportation infrastructure expanded slightly and the urban spatial expansion fell again because of the continuing sprawl at the fringes, which suggests that the spatial expansion is generated by the transportation infrastructure expansion.

Table 3. AUSEI and Spatial-temporal Expansion of Baqubah from 1957 to 2014

Year	Urban area (ha)	Spatial expansion(ha)	AUSEI %
1957	260	----------	------
1977	826	566	3.4
1987	1775	949	5.3
1997	2288.2	513.2	2.2
2007	2929	640.8	2.2
2010	3181.1	252.1	2.6
2014	3456	274.9	2.0

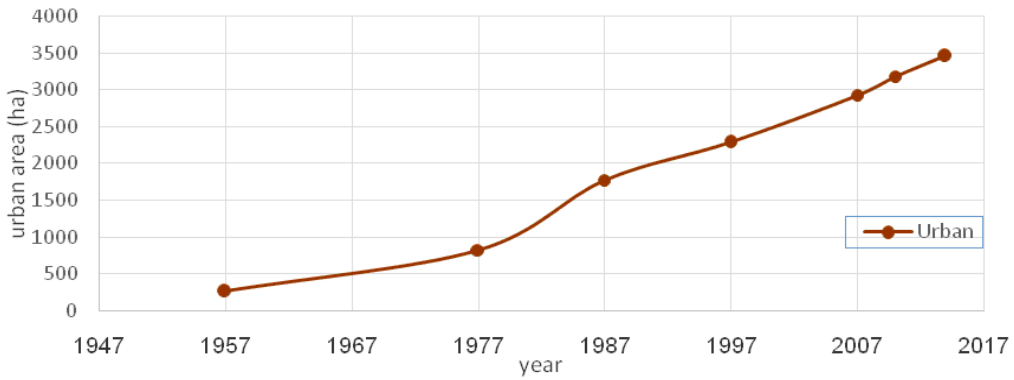


Figure 3. Urban Spatial Expansion between 1957 and 2014

4.3. Annual Land Use Change Index

Land use in Baqubah was changed from 1957 to 2014, four significant land use classes have rapidly and actively changed, residential, commercial, industrial and public places are shown in Figure (4) and Table (4). By using equation (3), residential development in Baqubah city has dramatically maximum rate increased 5.5% from1977 to1987 because the outside migration to the center of city. Commercial land use changed significantly and took place continually along main roads and Spatial-temporal analysis of urban growth and transportation significant secondary road intersections. Industrial land use, in contrast, changed significantly and followed up a planning scheme that took place in the locations that had been proposed by the master plans in 1977and 1987in the west of the city. The dynamics of urban growth in Baqubah changed as the city expanded, and hence, the city expanded through the emergence of informal settlements after 2003. Public places considerably changed, as shown in Figure (4), Table (4), and were developed in the locations proposed by the master plans of 1974, 1988, and 1994.Figure (5) shows the relationship between residential area growth and transportation infrastructure expansion in Baqubah from 1957 to 2014. The transportation infrastructure rapidly expanded and affected the dramatic growth and spread of residential areas from 1977 to 1987. Then, the transportation infrastructure expansion and residential area growth rates weakened rapidly from 1987 to 2007, when residential areas are consolidated and adjoined with existing residential areas. However, there was a gap between the transportation infrastructure expansion and residential area growth, with the latter leading. The ATIE rate declined broadly compared with the residential area growth rate. In the period from 1997 to 2007, there was a gap between transportation infrastructure expansion and residential area growth. Next, in the period 2007 to 2014, the ATIE rate decreased and the residential area growth rate increased. These trends reflect the minor interventions in transportation infrastructure after 2007 and the dispersed development of residential areas at the fringes.

Table 4. LUCI and Land use Change in Baqubah from 1957 to 2014

Year	Residential area (ha)	LUCI Res.	Commercial area (ha)	LUCI Com.	Industrial area (ha)	LUCI Ind.	Public area(ha)	LUCI pub.
1957	123	-----	23	-----	33	-----	65	----
1977	460	3.7	35	1.7	62	2.3	112	2.10
1987	1012	5.5	42	1.7	128	5.2	198	4.34
1997	1280	2.1	57	2.6	235	4.6	246	1.95
2007	1768	2.8	78	2.7	280	1.6	325	2.43
2010	1883	2.0	93	5.4	345	6.3	365	3.65
2014	2087	2.4	117	5.1	352	0.5	368	0.20

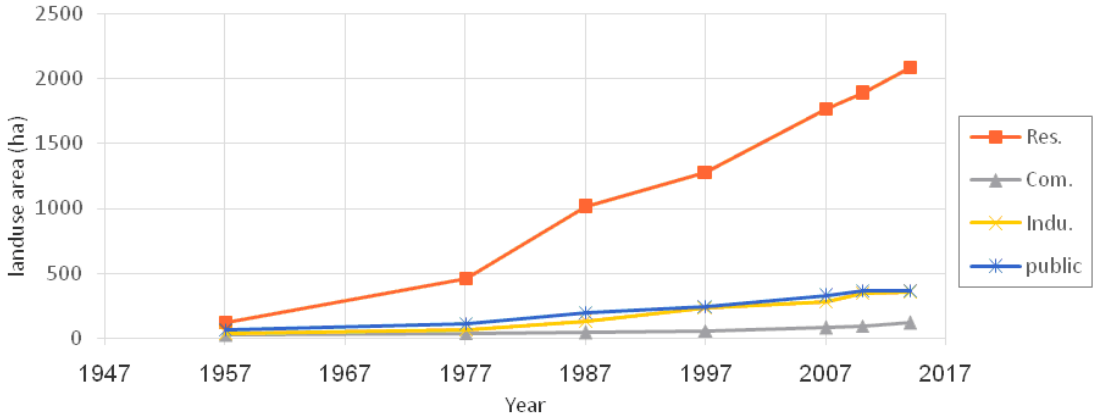


Figure 4. Land use Change between 1957 and 2014

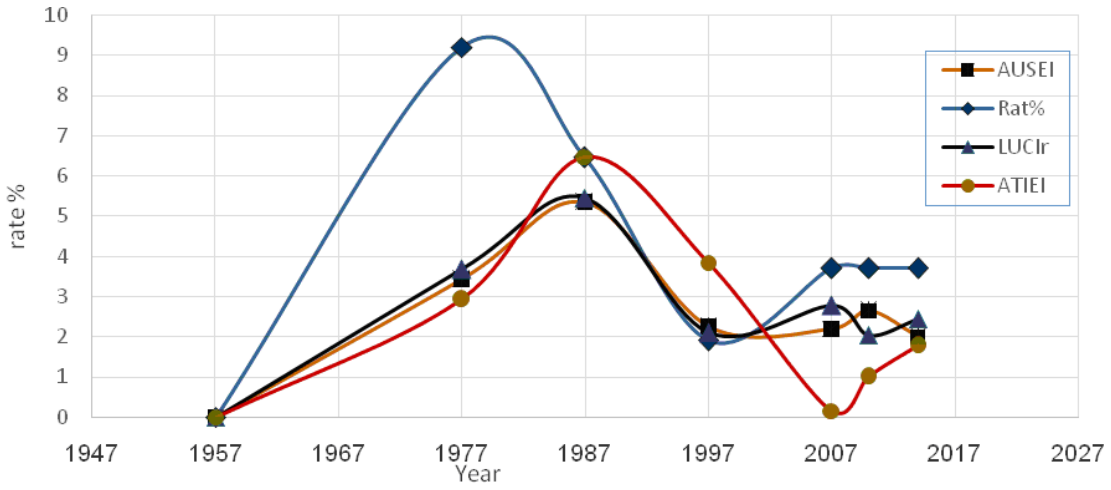


Figure 5. Relationship between Transportation Infrastructure and Urban Growth between 1957 and 2014

4.4. Population Density Change Index

Baqubah's population grew rapidly from 20790 (person) in 1957 to 390257 (person) in 2014 an increase of 18.77% of the total population in 1957 is shown in Figure (6) and Table (5). By using equation (4), the population growth was accompanied by a population density increase from 80 p/ha for urban land in 1957 to 112.9 p/ha in 2014. Many underlying factors have triggered population growth in Baqubah, including the following: local migration from villages and suburbs, external migration, rapid growth in the national Baqubah's population grew rapidly from 20790 (person) in 1957 to 390257 (person) in 2014 an increase of 18.77% of the total population in 1957 is shown in Figure (6) and Table (5). By using equation (4), the population growth was accompanied by a population density increase from 80 p/ha for urban land in 1957 to 112.9 p/ha in 2014. Many underlying factors have triggered population growth in Baqubah, including the following: local migration from villages and suburbs, external migration, rapid growth in the national economy and Baqubah's economy, and the natural increase in population.

Table (5): PDI and Population Growth from 1957 to 2014

Year	population	change	Rate %	Urban	PDI (P/ha)
1957	20790	-------	-------	260	80.0
1977	75489	54699	9.2	826	91.4
1987	144052	68563	6.46	1775	81.2
1997	194976	50924	1.9	2288.2	85.2
2007	302838	107862	3.7	2929	103.4
2010	331678	28840	3.7	3181.1	104.3
2014	390257	58579	3.7	3456	112.9

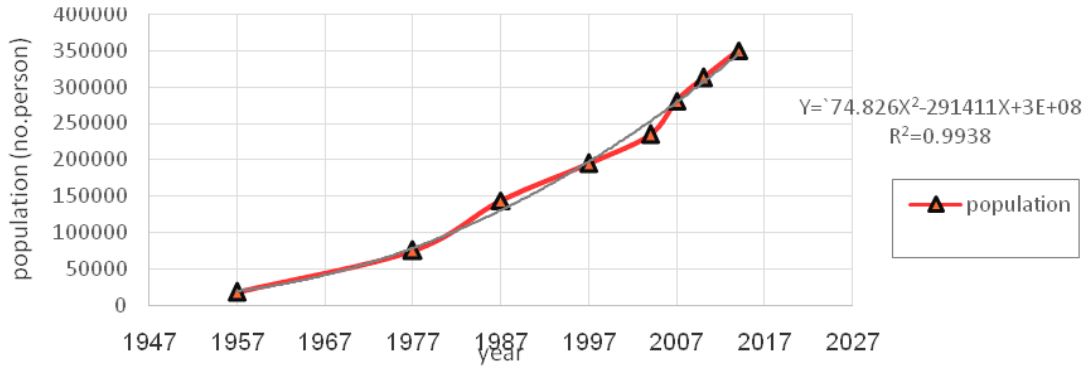


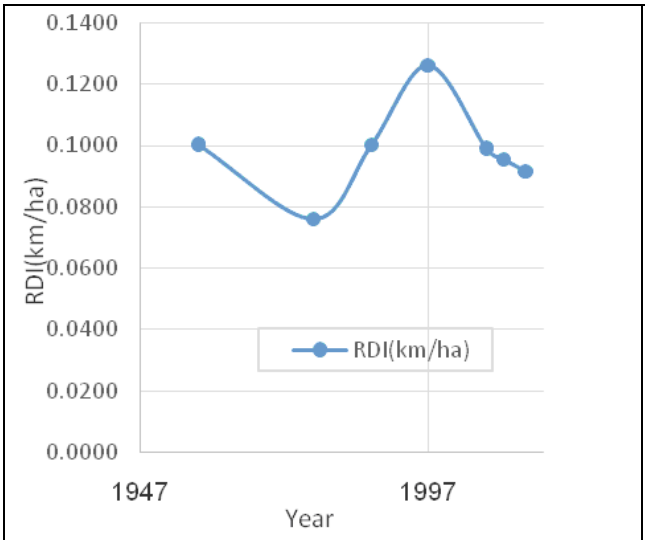
Figure 6. Population Growth between 1957 and 2014

4.5. Road Density Index

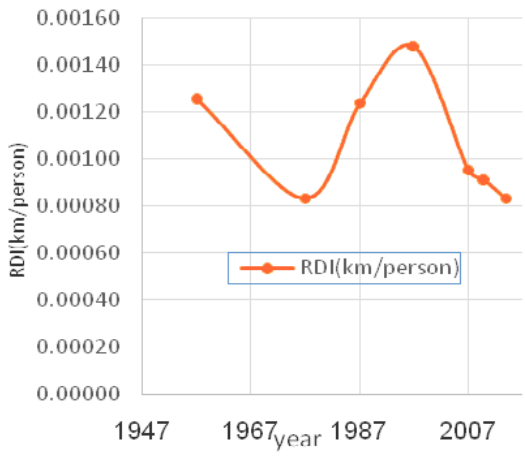
The road density index explains the densification of transportation infrastructure as has been explained in equation (5) and equation (6). The change in road density in Baqubah from the period of 1957 to 2014 are shown in Table (6) and Figure (7). The results indicate that road density in relation with the urban area changed from 0.1 km/ha in 1957 to 0.0917 km/ha in 2014. The most significant changes occurred between 1977 and 1997, when the road density increased from 0.076, 0.10 and 0.126 (km/ha) in 1977, 1987 and 1997respectively are shown in Table (6) and Figure (7).Thus, in this period greater accessibility to different land uses was provided. Conversely, the road density in comparison with the population of Baqubah was reduced from 0.00125 km/person in 1957 to 0.00083 km/person in 2014. Although, it slightly increased from 0.00083, 0.00124 and 0.00148 km/person in 1977, 1987 and 1997 respectively are shown in Table (6) and Figure (7), due to the rapid increase in transportation infrastructure at the time, it decreased considerably to 0.00095, 0.00091 and 0.00083 km/person in 2007 ,2010 and 2014 respectively are shown in Table (6) and Figure (7). This change reflects the rapid growth increase of Baqubah's population growth since 1977.On the basis of this indicator we can conclude that the speed of road infrastructure provision has not coincided with population growth. The population of Baqubah has grown rapidly, with a 6.46% average annual growth.

Table 6. Road Density Index of Baqubah from 1957 to 2014

Year	Road length (km)	Urban area (ha)	Population (person)	RDI (km/ha)	RDI (km/person)
1957	26	260	20790	0.1000	0.00125
1977	62.8	826	75489	0.0760	0.00083
1987	178	1775	144052	0.1003	0.00124
1997	288.6	2288.2	194976	0.1261	0.00148
2007	293	2929	302838	0.1000	0.00097
2010	302	3181.1	331678	0.0949	0.00091
2014	325	3456	390257	0.0940	0.00083



RDI (km/ha)



RDI (km/person)

Figure 7. Road Length Density Index between 1957 and 2014

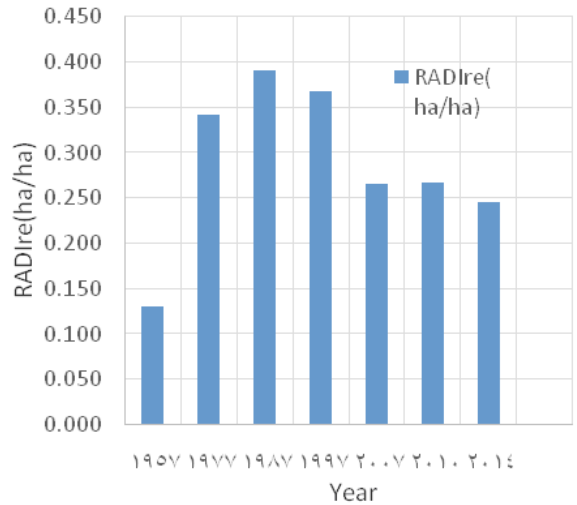
4.6. Road Area Density Index

The RADI was designed to explore the spatial-temporal relationship between urban growth and transportation (Equation 7, Equation 8 and Equation 9). The total area of transportation infrastructure is calculated based on the length of the quantified road types and with respect to the width of each road type. Table (7) and Figure (8) are shown the change in road area density in Baqubah from the period of 1957 to 2014.The total area devoted to transportation infrastructure (Equation 7) particularly increased from 6.2% in 1957 to 15% in 2014. The greatest increase occurred in 1987, where the total area devoted to transportation infrastructure increased to 22.3% from 19% in 1977. The change in the total area devoted to transportation infrastructure matched with the change in the total urban area of Baqubah as shown in Table (7); which indicates that the spatial expansion of Baqubah has been affected by transportation infrastructure expansion. The road area density in relation to the total residential area (Equation 8) also witnessed a dramatic change are shown in Table (7) and Figure (8). Although the road area density increased from 0.13 ha/ha in 1957 to 0.39 ha/ha in

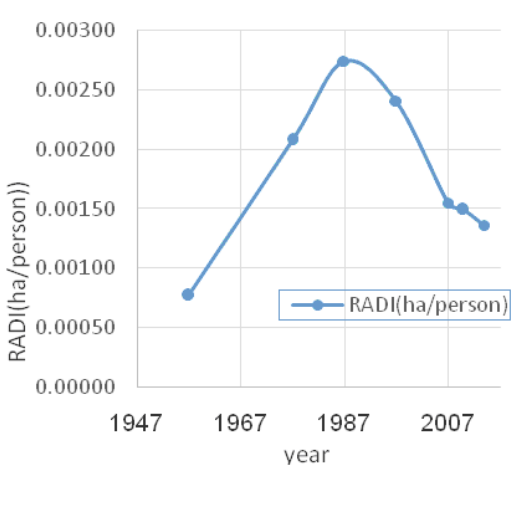
1987, it decreased to 0.367 ha/ha in 1997 and to 0.245 ha/ha in 2014. These Figures show that, although the transportation infrastructure has increased in absolute terms, it has decreased relative to the size of the urban developed area, because of the dramatic increase in residential area, which suggests that the expansion of the residential area was stimulated by the transportation infrastructure. In contrast, the road area density in comparison to the population has increased from 0.00077 ha/person in 1957 to 0.00274 ha/person in 1987(because of the rapid expansion of the transportation infrastructure). Although the road area density reduced from 0.00241 ha/person in 1997 to 0.00136 ha/person in 2014, are shown in Table (7) and Figure (8). These Figures reflect the gap between the rapid increase of Baqubah's population and the transportation infrastructure expansion, which reveals the increase of transportation infrastructure demand.

Table 7. Road Area Density Index (RADI)

Year	Road area (ha)	Urban area (ha)	RADI % (ha/ha)	Res. Area (ha)	RADI Res. (ha/ha)	population	RADI (ha/per)
1957	16	260	6.2	123	0.130	20790	0.00077
1977	157	826	19.0	460	0.341	75489	0.00208
1987	395	1775	22.3	1012	0.390	144052	0.00274
1997	470.2	2288.2	20.5	1280	0.367	194976	0.00241
2007	478	2929	16.3	1768	0.270	302838	0.00158
2010	495.1	3181.1	15.6	1883	0.263	331678	0.00149
2014	532	3456	15.4	2087	0.255	390257	0.00136



RADI residential (ha/ha)



RADI population (ha/person)

Figure 8. Road Area Density Index (RADI) between 1957 and 2014

5-Conclusion

1. The developed indicators provide significant information on the spatial-temporal relationship between urban growth and transportation.
2. Transportation and urban growth are strongly related. In fact, there is a reciprocal relationship between transportation and urban growth. Indicators can be used as an effective tool for quantifying and analysing the spatial-temporal relationship between urban growth and transportation. The AUSEI. From 1957 to 1977, Baqubah urban area expanded slowly increase to a 566 ha with 3.4% annual growth rate. Subsequently, from 1977 to 1987, Baqubah witnessed a remarkably rapid increase in both population and urban mass; with 949 ha increase and the maximum annual growth rate 5.3%
3. Six indicators were developed to quantify the spatial-temporal urban growth and transportation situation, applying spatial temporal analysis techniques from remote sensing and Geographic Information System.
4. Transportation infrastructure expansion strongly correlates with population growth, spatial expansion and land use change. From 1977 to 1987, the transportation infrastructure expansion rapidly increased in comparison with the steady decrease in population growth.
5. This study provides significant information for transportation and urban development policies. There was a gap between the transportation infrastructure expansion and residential area growth.
6. The population growth was accompanied by a population density increase from 80 p/ha for urban land in 1957 to 112.9 p/ha in 2014.
7. The road area density reduced from 0.00241 ha/person in 1997 to 0.00136 ha/person in 2014 and the road area density increased from 0.13 ha/ha in 1957 to 0.39 ha/ha in 1987, it decreased to 0.367 ha/ha in 1997 and to 0.245 ha/ha in 2014.

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