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Research paper



Spatial-temporal assessment and characterizing urban sprawl for the city of Sulaymaniah-Iraq from 1925-2018

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Abstract

Urbanization changes urban landscapes and results in environmental and ecological exhaustion. The dramatic growth of urbanization has been the main controversial concern of many studies due to the passive impacts on the city-built environment. Measuring and characterizing urban sprawl are the main focus of this study. A sequential growth of the city of Sulaymaniah in Iraq has been investigated through quantifying and analyzing the spatial-temporal expansion of the city from 1925 -2018. The study method deviates from triangular method by combining three different approaches; Remote Sensing/GIS, qualitative analysis, and literature review. The study results reveal that Sulaymaniah experienced a tremendous urban pressure especially after 2003, as a result of rapid population growth caused by the enormous migration from other cities of Iraq and neighboring countries, many urban areas have experienced exhaustion of social amenities in the concerned communities. The study findings show that the urban chaos and uncontrolled growth have been an irreversible phenomenon in the structure of the city, likewise, a significance damages have appeared environmentally and ecologically. The outcomes of this study could be a reference point for experts and planners in structuring the new urban growth policies and tools for driving the foreseeable urbanization process which is required in coordinating the future development.

Keywords: *Urbanization; Urban Sprawl; Spatiotemporal Analysis; Sulaymaniah, Iraq.*

1. Introduction

In recent years, the cities are growing very rapidly due to the socio-economic development and industrial revolution [1]. The rapid urbanization and growth of the urban areas have led to urban sprawl. Therefore the sprawled areas have been suffered from various complex problems such as unplanned urban development, socio-economic segregation, land consumption, non-efficiency in the infrastructure provision, and car dependency [2]. Thus, measuring and defining urban sprawl issues requires a deep understanding of the physical dimensions regarding the process of urban development and sprawl [3], as well as assessing its elements such as population, gross domestic products, and public facilities [4]. Therefore, the new urban cores in less dense areas are considered as the starting point of future urban development. The analysis of the indicators of urban sprawl and their integration to the core of the systems of territorial planning, allows the spaces which should be considered as a priority to be protected [5 – 6]. In fact, through the indicators of urban sprawl and consistent assessment of the situation, it is possible to understand the dynamics of landscape capacities of peri-urban areas around urban agglomerations and then reform the planning instruments [7–8]. However, the process of accelerating growth in many cities of developing countries has a significant impact on the urban landscape of these cities. Those problems seriously threaten human environment as well as socio-economic sustainable development [9]. In the view of this, the science-based and effective control of urban growth have become an important component of the city planning that must be considered in urban managing and policy design measures.

Urban sprawl is a multi-dimensional growth mode, precise its definition is tough [10 – 13]. Urban sprawl is defined as the expansion process of a land along the main road toward the suburb area that characterized by disorder pattern, non-organized functions, and low density. Squires, Habibi and Asadi [14 – 15] pointed out that urban sprawl is the growth of metropolis, urban space, car dependency, and low density which are main features of the sprawl. Mills [16] defined the urban sprawl as spread of excessive suburbanization in the economist city. Furthermore, waste of resource due to unplanned and unbalance urban expansion [2].

Urban growth varieties identification is a necessary aspect of urban expansion feature [17 – 18]. Consequently, various urban growth issues have been studied from the initial step using qualitative methodology [19 – 21]. According to the scholars, urban growth can be categorized into three types: outlying expansion, infilling, and edge-expansion [22 – 24]. The urban sprawl study is taking the city as a whole object, based on the overall macroscopic scale rather than micro scale level such as blocks or streets. The urban spatial expansion process characterized by gradual dynamic growth. Since, it is bottom-up process that composed at the local level by the spatial development of land use pattern [25].

Analysis of urban growth can be conducted from the different perspectives such as physically, politically, economically, socially, and environmentally with different results [26]. Accordingly, urban sprawl and growth are considered as a complex process, associated with various socio-economic, ecological, and physical aspects accompanying by spatial, temporal, and legislations influences. Special complexities of urban sprawl are reflecting the associating physical characteristics with a certain location that cannot be similar to another location. The spatial restriction has more control, where the area specified by restricted topography like mountains, forests, and coastal area [6]. In addition, temporal measures also complex the process of urban sprawl. The alteration of the cities

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over time with different indicators contribute to urban sprawl complexity [26 –27]. The process of decision making also associated with the urban sprawl dynamics, which starts from the individual's choices till to government decisions. Therefore, it is very necessary to understand the process of urban sprawl as a whole regarding each time, place, and system, rather than narrow it to a singular perspective [28]. It means considering all the spatial, temporal, and policy decision will provide a comprehensive assessment of the whole issues regarding the growth progression, as well as support the predications of the future growth and preventing the repetition of the previous mistakes. Thus, time and space are the two basic urban growth elements.

2. Urban growth in Iraq and Sulaymaniah

Urbanization in Iraq engenders several social, economic, and environmental challenges. Since, the urban growth process has been continued without clear strategy [26 – 29]. However, numerous ineffective attempts have been commenced in order to manage the urban area through organizing the growth, nonetheless the rapid growth of population has put the facilities and infrastructure of some cities under pressure [30].

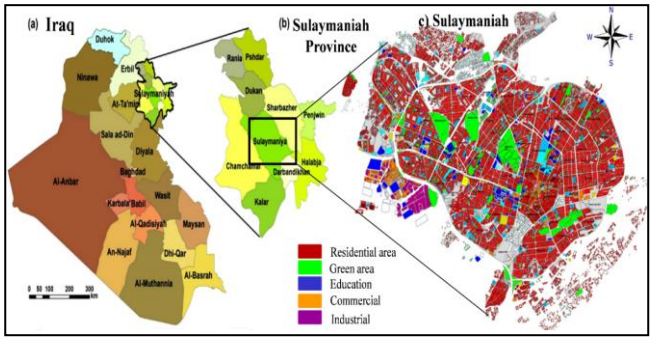


Fig. 1: Map Of Iraq (Left) And Sulaymaniah (Right).

In the cities of Iraq, urban growth has been rapid and unpredictable, particularly in the Kurdistan region because of a significant alteration in the political and economic system in 1991[31]. Therefore, the Kurdish cities have been facing a big challenge in acclimatizing the changes. The economic reforms after the political events of early 1990s have substantial effects on the northern cities of Iraq. The Kurds manage to maintain their own government in 1999, concentrating the oil investments in the region has restructured the economic sectors significantly [32]. The strategy of oil and gas pursuing has provided the capability of fiscal independent of Kurdistan region, since many foreign companies have complemented this opportunity to establish their direct investments [31].

Moreover, cities in Iraq and Sulaymaniah in particular has practiced very fast growth in the developing world [33]. Sulaymaniah is one of the cities in Kurdistan region locating in the northern part of Iraq as shown in Figure 1. It has experienced an obvious alteration due to the mentioned events and factors, besides the economic prosperity. In addition, Sulaymaniah has witnessed unexpected population explosion, as a result of the two type of migrations; first is immigration phenomenon from the other cities of Iraq which suffer from the unsecured circumstance of the war, and the second is rural-urban migration.

The substantial differences in the rural and urban condition, since the rural area specified by the lack of service and drastic way of life push the people to immigrate toward the urban area. Whereas, the attractive condition of the city and urban area with more job opportunities, service provision pull the rural community to live and settle in the city [34].

Therefore, numerous issues have been arisen such us; unplanned development and growth, socio-economic segregation, land consumption, non-efficiency in the infrastructure provision, and car dependency. Besides, the informal settlements have specified as a group of residences, where the families are illegally inhabiting the land on which they are settled, where there is no formal layout plan and the land is either non-serviced or minimally serviced [35 – 36]. Hence, the peripheral settlements are merged into the inner city due to the urban development expansion [37]. Consequently, these settlements appear inconsistent with the surrounding areas and neighbourhoods. Since, they do not follow any planning guidelines therefore, they are likely to be quite troubled to an urban development process that is based upon the building of city development plans [35].

3. Methodology and materials

3.1. Research model

This study method deviates from triangular method which is combining three different approaches of using qualitative approach [38 – 40], Remote Sensing/GIS mapping [3], [41 – 42], and literature review [43 – 47] as instruments of quantifying and analysing urban sprawl and city structure. Those three methods have been linked in a matrix model of confidence level in term of reliability of the results, based on the degree of findings consistency from the three methods [48 – 50]; the level of confidence has assigned in order to obtain trustworthy research outcomes.

A qualitative approach via verbal protocols involving 17 experts' interviewees among whom are university professors and senior municipal council officials in Sulaymaniah city, were interviewed to achieve the research objectives, integrated by spatiotemporal analysis of the growth process in different stages using Remote sensing/GIS tools to produce maps regarding each stage. Correspondingly, aside of this research is carrying out extensive documents review and review of historical maps at the very early stages, have been included.

A qualitative approach was conducted to meet the objectives of the study. In deep face to face interviews with the planners, experts in the municipality, master plan committee, as well as, professors of the universities especially, those who have participated in directing Sulaymaniah master plan. Further, the urban development stages have been analysed through detecting the dynamic change of the study area by using Remote Sensing/GIS mapping, in order to validate the size, numbers, density of growth scattered, and reveal that how the driving forces are reliable and the urban pattern has been changed during different growth phases. Also, various sources have been involved in collecting data including master plans of different years, historical documents and maps, official reports and documents followed by field observation and survey.

As a side of the study is historical growth investigation. Thus, the literature review as well as the site observation are crucial source that carrying out extensive documents review and review of policy tools and measures such as master plans, development plans, urban boundaries, zoning ordinances, subdivision regulations, infrastructure investment, and development fees are the basic means to achieve a fully understanding of the urban growth management process which provide intensive idea and insight about the study themes. The Figure 2 is illustrating the main concept of the study method and objectives.

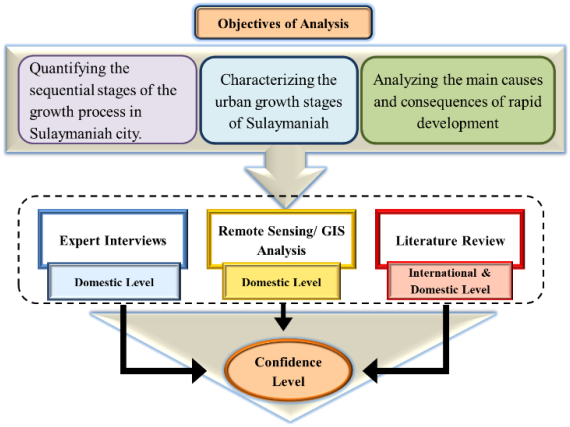


Fig. 2: Methodological Framework and Analysis Scales.

3.2. Confidence level

In order to obtain the objectives of the study through reliable results and findings, the confidence level that structured by Jacobs [48] was followed, which depends Mastrandrea [50] on the IPCC Fifth Assessment Report and Millennium Ecosystem Assessment [49]. The multiple evidences and agreements have been used to assess the confidence of the finding's validity. The combination evidence followed the matrix model structure from Jacobs and Mastrandrea [48], [50]. Their model decides on the parameters with higher level of confidence as the most powerful variable that affecting the final findings and results of the study. Simply, the parameters with higher evidence are the most considerable one in the findings. In this study the number of the methods that provide intended information used as the criterion decision to evaluate the level of confidence. Thus, if all the three methods are supporting the evidence then it refers to higher grade of evidence. While if two from the three methods promote the evidence then consider as medium level of evidence and weak or limited evidence if the evidential information provided from only one method, as in the Table 1.

Table 1: Evidence Levels for Findings

Level of Evidence	Explanation
High evidence	All three methods can provide information
Medium evidence	Any two from all methods can provide information
Low evidence	Any one from all methods can provide information

The second part of the matrix model is the agreement level. Each method in the study has a different level of agreement. Thus, high agreement refers to the case of agreement confirmation from all or more than 60% for interviewees and at least two sources of literature review. If the interviewees agreement range is between 25%-60% supported by one or two references and the information confirmed by remote sensing analysis then the state is defined as medium agreement. Finally, the lowest grade of agreement is referring to interviewee's agreement of less than 25%, equal rejection and confirmation from review of literature and the remote sensing provide non-supported argument, as in the Table 2.

Table 2: Agreement Level for Findings from Interviews, Remote Sensing/GIS and Literature Review

Agreement level symbol	Clarification
High agreement Symbol ***	Statement was confirmed within one method -for interviews:>60% of interviewees confirmed -for literature: more than two sources confirmed -for RS: not applicable (only one location)
Medium agreement Symbol **	Statement was confirmed but limited data within one method -for interviews: 25–60% of interviewees confirmed - for literature: one or two sources confirmed - for RS: confirmed
Low agreement Symbol *	Confirmation and rejection within one method - for interviews: < 25% of interviewees confirmed - for literature: confirmation and rejection balanced -for RS: rejection
Symbol --	No data or no evidence

In the Table 3 that shows the confidence level, there are four classifications of the level of confidence, starting from the highest level which is named very high, high, medium, low and very low respectively, each of them has its confidence degree as follow;

a) Very high: The statement refers to availability of enough data in all three methods and high degree of consistency and accordance between the three methods, thus, robust evidence in three methods supported the hypothesis.
b) High: The term refers to statuses; first, if there is medium evidence (two of the methods provide data) with high accordance between both results. Second, if there is enough data from all three methods, but their results diverging or having slightly accordance.
c) Medium: The limited data provided from all three methods with high accordance of the result or the data provided by at least two of the three methods.
d) Low: If two of the methods provide contradictory results.
e) Very low: Only one of the methods provides limited data that consider as idle argument evidence. See the Table 3:

Table 3: Combinations between Degree of Agreements and Evidence Levels for Finding, Sources: [48 – 50].

Level of Confidence	Limited evidence	Medium evidence	Robust evidence
High Agreement	Medium	High	Very High
Medium Agreement	Low	Medium	High
Low Agreement	Very Low	Low	Medium

4. Findings and discussion

The main procedures in this study involve three prime stages. First is quantifying and analyzing the sequential stages of urban growth process in Sulaymaniah through a Remote sensing / GIS mapping. That has been used in defining the spatiotemporal analysis of planning concept in different stages of urbanization process. The GIS/Remote Sensing has considered as the best tool in scheming the area, direction, and extent of urban growth. In addition, GIS/Remote Sensing maps is very useful tool to specified the various stages features of the city growth. Whereas assigned as the second study objective. Hence, the maps have been generated by digitizing the growth area and new development outside the city boundary as well as the infill growth within the city regarding each stage of development from 1925 to 2018 depending on the high-resolution data and maps from Digital Globe Vie Google Earth. Despite, the very early development phases maps are not available in the Google earth. The study depends upon the simulation of the old maps and AutoCAD tool to generate the maps that can be reliable in the study analysis. Then, the analyzes process in this study has been classified in to eight phases of growth involving; 1925, 1973, 1980, 1990, 2003, 2007, 2013, and 2018. In addition, these phases have been investigated regarding to various indicators involving area, size, trend of growth, pattern, growth driving forces, growth challenges, cause, and effects.

The second part of the study is characterizing the sequential phases of growth process. Thus, the qualitative method based in-depth interviews, GIS/Remote Sensing and literature review have been conducted in the purpose of fulfilment of the second and third research objective. The third part of the study, involves the determination of urban sprawl driving forces. Hence, in the second and third part of this study, the literature review has been used beside the two other methods. Consequently, more reliable findings in the study have been obtained due to the confidence level assessment.

4.1. Stages of urban expansion in Sulaymaniah

The interpretation of classified growth stages, which have been shown in the Figure 4, shows that the first phases in 1925 the city corpus of Sulaymaniah was situated in the south-east of today's city. The shape was longitudinal, pointing towards the north, from a south-west to a north-east direction, located on a fairly plain plateau. The results demonstrate that the urban form looks compact and dense. Additionally, the size of the developed city was 14590 ha.

In the second growth phases in 1973, nearly 50 years later, the study results prove that the city corpus has grown more or less in ring form to the east, west, and north. The extensions to the south are less in size than in the north. Moreover, the study reveals that west and south areas of development, are not connected to the urban extension ring. The interpretation of the findings reveal that the borders of the developed areas did not show a homogeneous form, they start looking irregular in the shape. In 50 years, the city corpus has increased to 31580 ha, that more than 100% growth.

Regarding the third phase which was seven years later, in 1980. The study investigations have recorded another large increase in the corpus of the city of Sulaymaniah. Again, the city has grown more or less in ring form. The urban extensions are predominantly towards the north and the east, and to a lesser extent towards the south. The findings from the study show that the shape of the city borders are quite irregular showing bulges that penetrate outwards the city boundary. The area occupied by the city amounts now to 84150 ha, this amounts to nearly three times the size of 1973.

Ten years later, in 1990, the findings have identified a considerable increase in size of urban area. The urban extension occurs predominantly in north-western direction, but not in a consistent form rather in islands. Some of them in the south and west, more or less disconnected to the actual city corpus for the first time. Urban development occurs in western direction outside the official demarcation of the city of Sulaymaniah. The overall area occupied by urban development amounts to 217390 ha out of this 5780 ha are located outside the city demarcation. This shape of the city corpus is about 2.5 times bigger than the area in 1980.

The study findings regarding the 2003 phases, have shown that the growth pattern in character and form are very different from the development in the previous decades. The urban development spreads predominantly in western direction hereby the wadi in north-south direction gets also filled with development which is mostly commercial land use. The road to Kirkuk city in the west, seems to attract the development, which occurs in scattered form, like islands. The ring road around Sulaymaniah has lost its function as a city boundary. The overall developed urban area was 389120 ha, out of that 45820 ha are located outside the official demarcation of the city.

The findings about 2007 stages, have recorded that the growth at that time has strengthened the development trend which had occurred in the 2003 map.

The study results have recorded a large amount of scattered development islands in the western direction along the Kirkuk road but also in the north, south-west and south-east. The extensions in the north and in the south-east have started reaching into the feet of the mountains creating considerable ecological problems. The overall developed urban area was 585800 ha inside the city and 132040 ha outside the official demarcation of the city. Obviously, the city growth will continue due to the population trends and the economic developments in the future.

It can be understood from the study results, that the main areas of development are; the districts outside the ring road in the north and south-east, along the entrance road of the city and the airport.

Thus, the city growth was continued due to the population trends and the economic developments in 2013 to reach 963150 ha toward the main entrance road of the city especially in the west and south –east. The main areas of development were; the districts outside the ring road in the north and south-east, the municipalities of two districts, Bakrajo and Raparin and the area around the airport.

Finally, in this study the last phase of growth is in 2018. The city area raised to 1335250 ha, 472650 ha in both inside and outside the city, respectively. Meanwhile, the interpretation of the findings shows that the rate of the city growth from 2013 to 2018, per years decelerated comparing to the previous years.

Both inside and outside city area regarding each phases of growth, have been presented in Figure 3. Furthermore, the whole growth stages and phases of expansion have been shown in the Figure 4.

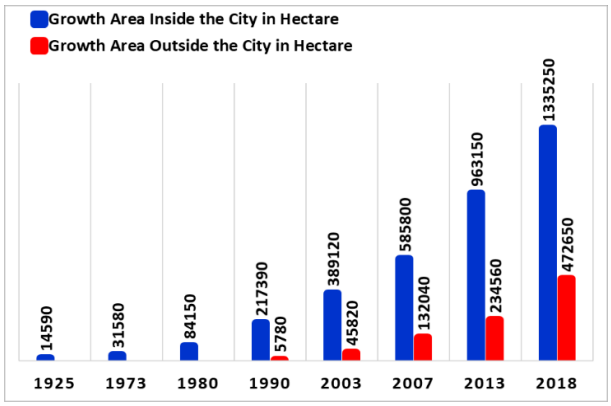


Fig. 3: Growth Area in both Outside and Inside Sulaymaniah City.

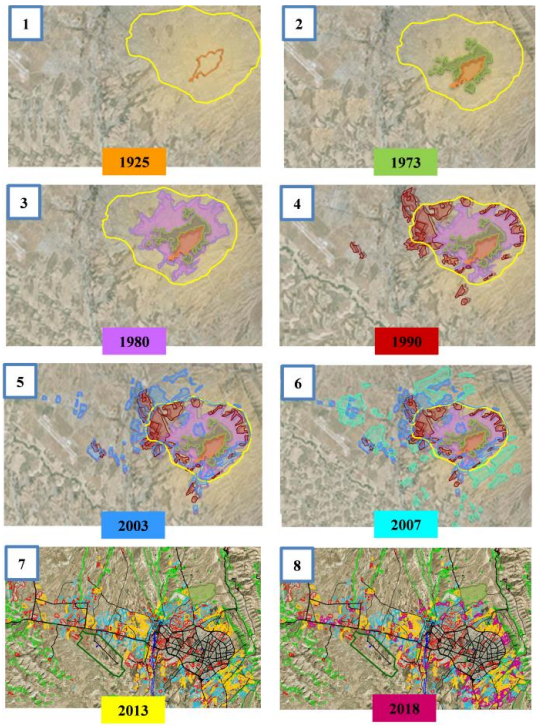


Fig. 4: Sulaymaniah Growth Stages from Year of 1925 to 2018.

4.2. Characterizing and analysing the development phases

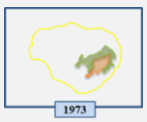
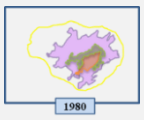
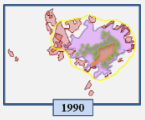
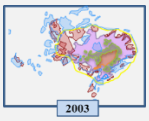
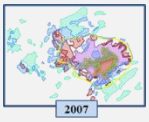
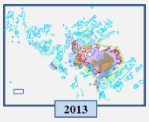
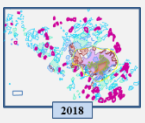
The city development has divided into eight phases from 1925 to 2018, emphasizing on specification of city development phases, due to the significant change that the city has faced over the whole growth process. A qualitative method based on interviews, has been conducted with the planners and experts in the municipality and master plan committee. As well as, professors in the universities especially, those who participated in directing Sulaymaniah master plan. In total, 17 in- depth interviews have been conducted in this study, whereas 7 from the respondents are experts in the municipality and master plan committee, 6 are academic professors in the university of Sulaymaniah and 4 in Sulaymaniah polytechnic university. Each interview took one to one and half hour. The questions of the interview have structure in the purpose of obtaining a clear understanding of urban growth process. The majority of the respondents belong to the planning department in the municipality of Sulaymaniah, which is the institution for urban and rural development management.

The interviews have started with an overview to the study, then the respondents were requested to present their understanding of urban growth process in the study area. Accordingly, the different phases

of development process, the deep specification regarding each stage, how pattern of development has been transferring during the urbanization process, driving forces for urban growth and challenges for urban development managements, were the main key determinants of the interview investigations. Further questions have addressed regarding managing the future urban development. The study has focused on individual interview rather than on group discussion as it was impossible to gather all the respondents at the same time [51]. The purpose of employment in-depth interview is to obtain a comprehensive information about the whole process of urbanization, moreover to provide an opportunity to the respondents to express their experience and knowledge with the themes under debate. Open-ended questions have been applied in order to gain deeper insights concerning the spatial development process. The interview content has been transcribed and analyzed through data coding and analyzing, 14 codes have been assigned, for instance the urban growth pattern, driving forces for urban development and the managements challenges. The process of analyzing consists the qualitative analysis through managing, classifying and shaping the qualitative data.

In addition, many official documents and maps have been provided from the planning department in the municipality of Sulaymaniah, in order to support the literature section of this study. As well as, various sources have been involved in collecting data including different years master plan, historical documents, maps, official reports and documents followed by field observation and survey. Since, limited publications are available in databases like Science Direct and Google Scholar about the city of Sulaymaniah, but in total, 65 references were assigned as relevant sources for the study focus. Further, the urban development stages have been analyzed through detecting the dynamic change of the study area in order to validate size, areas, and direction of growth scattered. Moreover, the investigation on driving forces and urban pattern during different growth phases, have been revealed. Each phase has been analyzed based on the area, growth direction, pattern characteristics, and driving force of the growth which has been classified into static and dynamic forces, as illustrated in the Table 4.

Table 4: Characterizing the Growth Phases in Sulaymaniah City

Phases	Indicators	Specifications
 1925	Area	14590 ha
	Growth direction	South-east of today's city and directing from south-west to north east.
	Growth characteristics	Longitudinal shape, compact and dense urban form, organic structure and pattern.
Driver forces	Dynamic powers: Social and cultural criteria, art, custom and identity. Static powers: Topography and geography.	
 1973	Area	31580 ha (more than 100% of 1925 area)
	Growth direction	City growth toward the west, north and east.
	Growth characteristics	Ring form, enclaves, nonhomogeneous and irregular.
Driver forces	Dynamic powers: Religion, social relationship and historical background. Static Powers: Topography, geography and climate.	
 1980	Area	84150 ha (three times of 1973 area).
	Growth direction	North and west.
	Growth characteristics	Ring form, irregular and bulges penetrate outwards.
Driver forces	Dynamic powers: Historical background and building regulations. Static powers: Development plan, topography and geography.	
 1990	Area	217390 ha (inside the city) - 5780 ha outside the city (tow times bigger than 1980 area).
	Growth direction	North and west.
	Growth characteristics	Western direction developed outside the official city demarcation, not consist form, island form and disconnected to the city.
Driver forces	Dynamic powers: Political decision, regulation and social relationship. Static powers: Law enforcement, development plan and development control.	
 2003	Area	389120 ha (inside the city) - 45820 ha (outside the city).
	Growth direction	West with along Kirkuk road.
	Growth characteristics	Different from the previous development, mostly commercial Scattered form and city boundary (60 M road) invade.
Driver forces	Dynamic powers: Autonomy, political event and regulations. Static powers: Resources, infrastructure, power, technology and topography.	
 2007	Area	585800 ha (inside the city) - 132040 ha (outside the city).
	Growth direction	Western direction along Kirkuk road, north direction, south-west and South-east.
	Growth characteristics	Large amount of scattered development islands, extension in the north and south east reaching the mountains.
Driver forces	Dynamic powers: Technology, autonomy, political event, migration and population explosion. Static powers: Resources, infrastructure, power, technology, mountain and ecological problems.	
 2013	Area	963150 ha (inside the city) - 234560 ha (outside the city).
	Growth direction	Western direction, infill growth in the west, south and south east.
	Growth characteristics	Infill growth, expanding the existence and slower than previous growth.
Driver forces	Dynamic powers: Unequal distribution of public amenities, technology, autonomy, migration, political, conflict, investment and city safety. Static powers: Topography, development plan, resource and power constraints.	
 2018	Area	1335250 ha (inside the city) - 472650 ha (outside the city).
	Growth direction	Western direction but dispersal form and infill growth around the city boundary.
	Growth characteristics	Dispersal patch of growth and higher density around the boundary of th city.
Driver forces	Dynamic powers: Commercial activities. economic reforms, political autonomy, free Press and improved political relations. Static powers: Financial crisis, lack of resource and environmental degradation.	

4.3. Driving forces of urban sprawl

The study findings show that the economic growth is a main driving force of urban sprawl. More than 60% of the respondents and more than two sources [30 – 32] confirmed this outcome. The interpretation of the results prove that the urban growth and especially sprawl occur due to a variety of reasons with various level of influence depending on the city and country that occurs in. Accordingly, the

previous studies [2], [13], [21], [52 – 55] have been assigned 24 reasons behind urban growth, for instance; economic growth, population explosion, transportation, demand for more living space, unsuccessful urban management, lack of planning policy implementation, weak strategies regarding the urban development, single-family home and so on have been classified.

In addition, the findings from both interviews and literature analysis indicate that the population explosion because of migration from rural to urban area and from other cities in Iraq toward Sulaymaniah, have considered as a significant reason of sprawl. In addition, increasing of housing demand and basic infrastructure necessitates, push the city to expand toward the peripheral area. Besides, oil and gas industry were identified as a powerful driver of urban sprawl. This fact was confirmed by less than 60% of the interview, while more than two sources have approved the statement [31 – 32], [47]. In general, the political reform has considered as a main reason of other driving forces of sprawl such as oil and gas investments, migration and economic prosperity, the statement has confirmed by 60% of the interviews and more than two sources. A part of the sprawl drivers has been backed to the transportation, new roads provision as a response to the increased number of cars, has led to the urban sprawl. Therefore, transportation has a low level of confidence as a driving force of urban sprawl in Sulaymaniah.

However, the level of influences of these driving forces varies based on the time, country and system, each economic, political, social and other urban measures has different impacts in accelerating, driving, constraining and restricting the urban growth or urbanization process. Therefore, in this study the driving forces of urban growth have been classified into four main parts;

a) Economic growth; The location of the urban growth is usually affected by the profit and economical value of the certain area [56]. Whereas the market mechanism accompanying higher income and higher living standards that affect the form of urban growth. Accordingly, housing demand rises as the number of working persons increases due to the expansion of the economic bases that leads to higher income per capita [2], in turn the city passes through a very rapid growth process either in form of urban sprawl or urban expansion.

b) Population and urbanization; Raising in the population occurs due to rural-urban migration or natural population growth. United Nations Division (UNPD) has declared that more than half of population growth in the world, has occurred in the urban area since 2010. It is predicted to increase in 2050 to reach 70%. Recently, developing and semi-developed countries are challenging the rural-urban migration, movement of people from rural to urban areas and cities represents the common form of migration. Therefore, the urban expansion has been affected by the inner migration phenomenon and generates the urban sprawl. Accordingly, urbanization has been known as the agglomeration of people in the specific area [57]. It is important to understand that urbanization is not attached to population but is more related to the economic and physical development [58]. Meanwhile, the urbanization process in developing and semi-developed countries comes from the push factors associated with the rural area and the pull factors of cities [59], because of the regional inequity. Whereas, industrialization, development, and modernization are supposed to gain urbanization not agglomeration of people and imbalance between urban and rural area [60].

c) Transportation technology; Both public and private transportation are important indicators that drive the process of urban growth and urbanization in the cities [61]. Roads and highways are the main accelerators of urban growth and urban sprawl [62 – 63]. Transportation system also affecting the location and direction of the new urbanized area whether in the periphery area or along the main roads of the city [62], [64].

d) Government policy and control; In both regional and local level, the urban growth management tools have a significant effect on the urbanization and urban growth process. Decisions about new projects, policy implementation of urban growth, regulations and law enforcements, are all forces which drive and accelerate the urban growth in the cities [19], [34], [65]. Therefore, urban sprawl is usually accompanying by poor planning policy, lack of law enforcement, and inefficient urban managing tools [2].

4.4. Challenges for urban planning managements

The experts have assigned several challenges for urban planning management. Conferring to the review of literature and knowledge from interviewees, poor law enforcement, nonefficiency of master plan, lack of planning management tools, and governmental decentralization are identified as the main challenges in managing the urban growth of Sulaymaniah. The respondents have insisted on nonefficiency of Sulaymaniah master plan, poor law enforcement, and lack of policy implementation, as factors that have increased the urban chaos. Thus, the informal settlements have appeared especially in the boundary area of the city [36]. However, the statements confirmation from the literature review and respondents were diverse. Conferring to the study results,the government decentralization has shown the lowest level of confidence as there is no evidence from GIS/Remote sensing to prove the statement. While the government decentralization was denoted by the respondents as a main challenge of urban growth managements and there was only one source of literature support the statement [31]. Accordingly, the interviewees have stated that the weak urban growth managements are due to the poor law enforcement. Therefore, they have recommended an improvement of the existing policy as well as developing new planning policies in order to tackle the current issues.

4.5. Discussion of findings from the three approaches

The study findings are based on a combination of the results from the three methods in the study. Quantifying, analyzing and determining the urban growth process and its driving forces in Sulaymaniah are the main objectives in this research. The advantage of a combination the three methods is the ability of comparing the results obtained from each method with the rest, then assessing the findings based on a confidence level. Hence, the GIS/Remote sensing has been used in the spatiotemporal analysis. While the qualitative analysis and literature review have been used in describing the main driving forces, specification, and management challenges of urban growth process. Then the matrix table of confidence level has combined and linked all the results from the three methods.

The study results, from the three approaches, have proven that there is a notable development in Sulaymaniah area, especially from 2003 to 2007, the city thrice its area during this period. The urban sprawl is the main growth pattern of development, this fact is confirmed by [36, 55]. Suburbanization also has confirmed by the three methods as an urban pattern of development. While, peri-urbanization, gentrification and counter urbanization have less confirmation according to the study findings. Therefore, it can be interpreted that the urban sprawl considered as a complex process associated with various socio-economic, ecological and physical aspects, accompanying by spatial, temporal and legislations influences. Consequently, it is very necessary to understand the process of urban sprawl as a whole progression and regarding each period. It means considering all the spatial, temporal and policy decision, will provide a comprehensive assessment of the entire issues regarding the urban development.

Concerning, the driving forces of urban sprawl, the study findings reveal that the economic growth is a main driving force of urban sprawl. The statement has confirmed with a very high level of confidence followed by population explosion and political reform. It is because of rural-urban migration and people movements from other cities of Iraq toward Sulaymaniah, due to the unstable political events of these cities. Transportation had lower measure as a driving force of urban sprawl. It can be understood from the study outcomes that the growth process in Sulaymaniah can be driven by different forces like political, economic, social, and demographic, with different results. Therefore, the Table 5 clarifies the aspects that have been considered in this study in analyzing the urban sprawl and its driving forces.

In addition, temporal measures also complex the process of urban sprawl, the alteration of the cities over time with different indicators contribute to urban sprawl complexity. Different planning strategies and growth managements guidelines, decrease the management efficiency. Thus, time and space are considering as the two basic urban growth indicators, subsequently changing the rate of the city growth depends on time and location of expanded area beyond the city boundaries.

Table 5: Confidence of Findings of Pattern of Urban Growth, Driving Forces of Urban Growth and Challenges for Urban Planning Managements

Analyzed themes	Keywords	Inter-view	GIS/RS analysis	Litera-ture	Confi-dence
Pattern of urban growth	Urban sprawl	***	***	***	Very high
	Suburbanization	**	***	*	High
	Peri-urbanization	*	**	*	Me-dium
	Gentrification	*	*	--	Low
	counter urbanization	*	--	*	Low
Driving forces of ur-ban growth	Economic growth	***	**	***	Very high
	Population growth	***	--	**	High
	Political reform	***	--	***	High
	Oil and gas Industry	**	*	***	Me-dium
	Transportation	*	--	*	Low
	Nonefficiency of master plan	***	**	***	Very high
Challenges for urban planning manage-ments	Poor law enforcement	***	**	**	High
	Lack of planning manage-ment tools	***	--	***	High
	Governmental decentrali-zation	***	--	**	Me-dium

5. Conclusion

The rapid urban expansion of the city of Sulaymaniah has been observed in this study, especially from 2003 to 2007. This led to numerous significant changes in the structure of the city, as a result of urban sprawl which has taken place in all directions and particularly along the main roads in the city entrances. According to the study findings, the economic prosperity due to the oil and gas industry after the region autonomous, is the main driving force that accelerated the rapid urbanization after 2003. In addition, the population explosion because of the migration toward Sulaymaniah city has a substantial impact on urban sprawl. Nonetheless, Sulaymaniah has developed without clear planning strategy, regulations and policies are fabricated after the urban growth constructed. Perhaps the most significant finding of this study was deteriorating of master plan, since it has failed to control and regulate urban growth in the city.

It can be understood from the study results, the different era of city management are taking undesirable impacts on the city because of various measures and strategies. Non-consistency of urban management due to the different urban planning policies and different measures products from different period of time resulting instability of master plan and managements tools. As a result, the city expansion involving the economic, social and political developments cannot be adapted successfully, especially, in the absence of flexible urban management system. Thus, in the edge of the expanded cities, the villages have grappled with the urban area, created village inside the city. Consequently, the traditional system of the rural area cannot adapt the new urbanization.

As the urbanization is continuing to grow, then wider extension should be expected that accompanying with numerous problems including longer commuting, car dependency, environmental deterioration, non-efficiency of land resource and larger scale of infrastructure and facilities. Moreover, environmental disruptions involving open space reduction, green area damages and wildlife habitats fragmentation are assigned as a result of rapid urban development.

In conclusion, great efforts to improve law enforcement and growth strategy are required, reform the urban growth policies and tools should be considered seriously. As well as, the expectation of the future growth and preventing the repetition of the previous mistakes, are essential steps in controlling the urban growth. However, cities with strong economic development are "trending towards more compact" rather than "trending towards more disperse". This indicates that city like Sulaymaniah with high levels of economic scope, should be encouraged to adopt compact growth modes rather than disperse growth.

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References

[1] S. García-Ayllón, "Rapid development as a factor of imbalance in urban growth of cities in Latin America: A perspective based on territorial indicators," Habitat International, vol. 58, pp. 127–142, 2016. https://doi.org/10.1016/j.habitatint.2016.10.005.

[2] B. Bhatta, "Causes and Consequences of Urban Growth and Sprawl," in *Analysis of Urban Growth and Sprawl from Remote Sensing Data*, Berlin, Heidelberg: Springer Berlin Heidelberg, 2010, pp. 17–36.

[3] Abu Ghurah, Kamarudin, and Abd Wahab, "Assessment of urban growth and sprawl using GIS and remote sensing techniques in South Ghor region, Al-Karak, Jordan.," *International Journal of Engineering and Technology*, vol. 7, no. 14, pp. 5–11, 2018. https://www.sciencepubco.com/index.php/ijet/article/view/16853/7270.

[4] Y. Sun, S. Zhao, and W. Qu, "Quantifying spatiotemporal patterns of urban expansion in three capital cities in Northeast China over the past three decades using satellite data sets," *Environmental Earth Sciences*, vol. 73, no. 11, pp. 1–15, 2015. https://doi.org/10.1007/s12665-014-3901-6.

[5] N. Abhishek, M. Jenamani, and B. Mahanty, "Urban growth in Indian cities: Are the driving forces really changing?" *Habitat International*, vol. 69, pp. 48–57, 2017. https://doi.org/10.1016/j.habitatint.2017.08.002.

[6] K. Lal, D. Kumar, and A. Kumar, "Spatio-temporal landscape modeling of urban growth patterns in Dhanbad Urban Agglomeration, India using geoinformatics techniques," *Egyptian Journal of Remote Sensing & Space Science*, vol. 20, no. 1, pp. 91–102, 2017. https://doi.org/10.1016/j.ejrs.2017.01.003.

[7] A. González, A. Donnelly, M. Jones, N. Chrysoulakis, and M. Lopes, "A decision-support system for sustainable urban metabolism in Europe," *Environmental Impact Assessment Review*, vol. 38, pp. 109–119, 2013. https://doi.org/10.1016/j.eiar.2012.06.007.

[8] E. T. Umaru, W. T. Aiyejina, N. T. A. Abdrazack, and A. M. Ajagbe, "The Impact of Non-Residential Tertiary Institutions on Housing in Lagos: A Case Study of Lagos State University," 2012. http://eprints.covenantuniversity.edu.ng/id/eprint/4975.

[9] R. F. M. Ameen and M. Mourshed, "Urban environmental challenges in developing countries—A stakeholder perspective," *Habitat International*, vol. 64, pp. 1–10, Jun. 2017. https://doi.org/10.1016/j.habitatint.2017.04.002.

[10] J. S. Desalvo and Q. Su, "The determinants of urban sprawl: theory and estimation," *International Journal of Urban Sciences*, pp. 1–17, 2018.

[11] R. Goetzke, *Modeling Urban Sprawl*. 2014. https://link.springer.com/chapter/10.1007/978-94-007-7969-3_14.

[12] J. Gong, Z. Hu, W. Chen, Y. Liu, and J. Wang, "Urban expansion dynamics and modes in metropolitan Guangzhou, China," *Land Use Policy*, vol. 72, pp. 100–109, 2018. https://doi.org/10.1016/j.landusepol.2017.12.025.

[13] T. J. Nechyba and R. P. Walsh, "Urban Sprawl," *Journal of Economic Perspectives*, vol. 18, no. 4, pp. 177–200, 2004. https://www.jstor.org/stable/3216798?seq=1#page_scan_tab_contents. https://doi.org/10.1257/0895330042632681.

[14] S. Habibi and N. Asadi, "Causes, Results and Methods of Controlling Urban Sprawl," *Procedia Engineering*, vol. 21, pp. 133–141, 2011.

[15] G. D. Squires, "Urban Sprawl: Causes, Consequences, and Policy Responses," *Externalities*, 2002. http://webarchive.urban.org/publications/210460.html. https://doi.org/10.1016/j.proeng.2011.11.1996.

[16] E. S. Mills, "Urban sprawl causes, consequences and policy responses: Gregory D. Squires, editor. Washington, D.C.: Urban Institute Press, 2002," *Regional Science & Urban Economics*, vol. 33, no. 2, pp. 251–252, 2003. https://doi.org/10.1016/S0166-0462(02)00061-3.

[17] Z. Chen, Y. Liu, A. Stein, and L. Jiao, "Characterization and spatial modeling of urban sprawl in the Wuhan Metropolitan Area, China," *International Journal of Applied Earth Observations & Geoinformation*, vol. 34, no. 1, pp. 10–24, 2015. https://doi.org/10.1016/j.jag.2014.06.012.

[18] E. I. Hennig, C. Schwick, T. Soukup, E. Orlitová, F. Kienast, and J. A. G. Jaeger, "Multi-scale analysis of urban sprawl in Europe: Towards a European de-sprawling strategy ☆," *Land Use Policy*, vol. 49, pp. 483–498, 2015. https://doi.org/10.1016/j.landusepol.2015.08.001.

[19] J. A. Alnsour, "Managing urban growth in the city of Amman, Jordan," *Cities*, vol. 50, pp. 93–99, 2016. https://doi.org/10.1016/j.cities.2015.08.011.

[20] E. E. Duncan, S. E. Eluwa, and A. A. Musibau, "Urbanization and 3D City Moelling for Developing Countries: A Comparative Study," *Electronic Journal of Information Systems in Developing Countries*, vol. 54, no. 1, pp. 1–20, 2012. https://doi.org/10.1002/j.1681-4835.2012.tb00384.x.

[21] T. Osman, P. Divigalpitiya, and T. Arima, "Driving factors of urban sprawl in Giza Governorate of Greater Cairo Metropolitan Region using AHP method," *Land Use Policy*, vol. 58, pp. 21–31, 2016.http:// www.mdpi.com/journal/environments. https://doi.org/10.1016/j.landusepol.2016.07.013.

[22] Y. Shi, X. Sun, X. Zhu, L. I. Yangfan, and L. Mei, "Characterizing growth types and analyzing growth density distribution in response to urban growth patterns in peri-urban areas of Lianyungang City," *Landscape & Urban Planning*, vol. 98, no. 2, pp. 425–433, 2010.

[23] C. Sun, Z. Wu, Z. Lv, N. Yao, and J. Wei, "Quantifying different types of urban growth and the change dynamic in Guangzhou using multi-temporal remote sensing data," *International Journal of Applied Earth Observation & Geoinformation*, vol. 21, no. 1, pp. 409–417, 2013. https://doi.org/10.1016/j.jag.2011.12.012.

[24] F. M. Xi *et al.*, "[Spatiotemporal pattern of urban growth and its driving forces in urban agglomeration of central Liaoning Province, China]," *Ying yong sheng tai xue bao = The journal of applied ecology / Zhongguo sheng tai xue xue hui, Zhongguo ke xue yuan Shenyang ying yong sheng tai yan jiu suo zhu ban*, vol. 21, no. 3, p. 707, 2010.

[25] R. Tan, Y. Liu, K. Zhou, L. Jiao, and T. Wei, "A game-theory based agent-cellular model for use in urban growth simulation: A case study of the rapidly urbanizing Wuhan area of central China," *Computers Environment & Urban Systems*, vol. 49, pp. 15–29, 2015. https://doi.org/10.1016/j.compenvurbsys.2014.09.001.

[26] S. Jarah, B. Zhou, R. Abdullah, Y. Lu, and W. Yu, "Urbanization and Urban Sprawl Issues in City Structure: A Case of the Sulaymaniah Iraqi Kurdistan Region," Sustainability, vol. 11, no. 2, p. 485, Jan. 2019. https://doi.org/10.3390/su11020485.

[27] G. Galster, "Wrestling Sprawl to the Ground: Defining and Measuring an Elusive Concept," *Housing Policy Debate*, vol. 12, no. 4, pp. 681–717, 2001. https://doi.org/10.1080/10511482.2001.9521426.

[28] Z. Tao, J. Liu, and X. Deng, "Spatial patterns of urban land expansion of super-cities of China in 1990s," in *IEEE International Geoscience & Remote Sensing Symposium*, 2004. https://doi.org/10.1109/IGARSS.2004.1370369.

[29] S. F. Mahmud, "Urban Policy in Iraq For The Period 1970-2012, Evaluation Study," *Journal of Advanced Social Research*, 2014.

[30] L. A. N. Raouf, "Housing and social segregation in Iraq," pp. 368–382, 2010.

[31] G. Stansfield, "The unravelling of the post-First World War state system? The Kurdistan Region of Iraq and the transformation of the Middle East," *International Affairs*, vol. 89, no. 2, pp. 259–282, Mar. 2013.

[32] M. M. Gunter, "Arab–Kurdish Relations and the Future of Iraq," *Third World Quarterly*, vol. 32, no. 9, pp. 1623–1635, Oct. 2011. https://doi.org/10.1080/01436597.2011.618649.

[33] J. J. Arsanjani, M. Helbich, and E. D. N. Vaz, "Spatiotemporal simulation of urban growth patterns using agent-based modeling: The case of Tehran," *Cities*, vol. 32, no. 32, pp. 33–42, 2013. https://doi.org/10.1016/j.cities.2013.01.005.

[34] L. R. Phillips, "A comparative study of growth management effectiveness and urban sprawl in two thoroughbred landscapes in the U.S," *Applied Geography*, vol. 65, pp. 58–69, 2015. https://doi.org/10.1016/j.apgeog.2015.09.002.

[35] J. Abbott and D. Douglas, "The use of longitudinal spatial analyses of informal settlements in urban development planning," *Development Southern Africa*, vol. 20, no. 1, pp. 3–19, 2003. http://www.tandfonline.com/doi/abs/10.1080/03768835022000019301. https://doi.org/10.1080/0376883502200001930 1.

[36] Kayfi Akram Mawlan, Norazmawati Md Sani, Kausar Hj Ali, and Abdul Gaphar Othman, "SPATIAL_INTEGRATION_OF_INFORMAL_SETTLEMENTS_IN_THE_URBAN_FABRIC_CASE_STUDY_OF_ERBIL_CITY_IRAQ," 2013.

[37] R. Salvia, P. Serra, I. Zambon, M. Cecchini, and L. Salvati, "In-Between Sprawl and Neo-Rurality: Sparse Settlements and the Evolution of Socio-Demographic Local Context in a Mediterranean Region," *Sustainability*, vol. 10, no. 10, p. 3670, Oct. 2018.

[38] J. W. Creswell, "Research design: Qualitative, quantitative, and mixed methods approach (3rd ed.).," *Manual Therapy*, vol. 16, no. 1, p. 103, 2011. https://doi.org/10.1016/j.math.2010.09.003.

[39] T. Damianakis and M. R. Woodford, "Qualitative research with small connected communities: generating new knowledge while upholding research ethics," *Qual Health Res*, vol. 22, no. 5, pp. 708–718, 2012. https://doi.org/10.1177/1049732311431444.

[40] J. Miles Matthew B. |Huberman. A. Michael|Saldana, "Qualitative Data Analysis: A Methods Sourcebook. Third Edition." *Sage Publications Ltd*, 2014.

[41] M. Herold, N. C. Goldstein, and K. C. Clarke, "The spatiotemporal form of urban growth: measurement, analysis and modeling," *Remote Sensing of Environment*, vol. 86, no. 3, pp. 286–302, Aug. 2003. https://doi.org/10.1016/S0034-4257(03)00075-0.

[42] F. Mu and L. Zuo, "Spatial and temporal dynamic of urban sprawl in West China: a case study of Chongqing, China," in *Geoinformatics & Joint Conference on Gis & Built Environment: Geo-simulation & Virtual Gis Environments*, 2008. https://doi.org/10.1117/12.812558.

[43] B. M. Burke, "Book Review: Who Sprawls Most? How Growth Patterns Differ Across the U.S. William Fulton, Rolf Pendall, Mai Nguyen, and Alicia Harrison. Washington, DC: The Brookings Institution, July 2001 (www.brook.edu/urban/fulton%2d pendall.htm)," *Population & Environment*, vol. 23, no. 4, pp. 428–434, 2002. https://doi.org/10.1023/A:1014580904160.

[44] D. Conradson, "[Book review] Dear M. and Flusty, S. 2002: The spaces of postmodernity: readings in human geography.," 2004.

[45] Y. S. Lincoln and E. E. Guba, "RESEARCH, EVALUATION, AND POLICY ANALYSIS: HEURISTICS FOR DISCIPLINED INQUIRY," *Review of Policy Research*, vol. 5, no. 3, pp. 546–565, 2010. https://doi.org/10.1111/j.1541-1338.1986.tb00429.x.

[46] Morris, "History of Urban Form before the Industrial Revolution by A. E. J. Morris," *Review of Architecture & Building Science*, vol. 56, no. 3, p. 340, 2012.

[47] C. Sabr, "A STUDY ON THE URBAN FORM OF ERBIL CITY (THE CAPITAL OF KURDISTAN REGION) AS AN EXAMPLE OF HISTORICAL AND FAST-GROWING CITY," *Humanities and Social Sciences Review*, pp. 325–340, 2014.

[48] S. Jacobs, B. Burkhard, T. V. Daele, J. Staes, and A. Schneiders, "'The Matrix Reloaded': A review of expert knowledge use for mapping ecosystem services," *Ecological Modelling*, vol. 295, pp. 21–30, 2015.

[49] Ma, "Ecosystems and human well-being: Synthesis," Millennium Ecosystem Assessment (MA), Washington, DC: Island Press/World. Resources Institute. 2005.

[50] M. D. Mastrandrea *et al.*, "The IPCC AR5 guidance note on consistent treatment of uncertainties: a common approach across the working groups," *Climatic Change*, vol. 108, no. 4, pp. 675–691, Oct. 2011. https://doi.org/10.1007/s10584-011-0178-6.

[51] R. Potter, "Urbanisation and Planning in the Third World: Spatial Perceptions and Public Participation," *New York New York St*, vol. 76, no. 3, p. 340, 2010. https://doi.org/10.2307/214160.

[52] L. Chen, C. Ren, B. Zhang, Z. Wang, and M. Liu, "Quantifying Urban Land Sprawl and its Driving Forces in Northeast China from 1990 to 2015," *Sustainability*, vol. 10, no. 2, p. 188, Jan. 2018. 10, 188.

[53] X. Z. Deng, J. Y. Zhan, R. Chen, and Ieee, "The patterns and driving forces of urban sprawl in China," in *IEEE International Geoscience & Remote Sensing Symposium*, 2005.

[54] P. N. Glendening, "Book: Urban Sprawl and Public Health: Designing, Planning, and Building for Healthy Communities," *Journal of Industrial Ecology*, vol. 11, no. 2, pp. 151–153, 2010. https://doi.org/10.1162/jie.2007.1260.

[55] H. A. H. Kahachi and A. J. Jafer, "Urban sprawl on agricultural land in Iraq-The factors and impacts A study of Karkh area in the city of Baghdad," *International Journal of Environment & Water*, vol. 4, no.

2, pp. 69–76, 2015. https://www.researchgate.net/profile/Hussaen_Kahachi.
[56] E. Stam, P. Gibcus, J. Telussa, and E. W. Garnsey, "Employment Growth of New Firms," *Ssrn Electronic Journal*, 2008. https://doi.org/10.2139/ssrn.1923081.
[57] S. K. Goodall, "Rural-to-urban Migration and Urbanization in Leh, Ladakh," *Mountain Research & Development*, vol. 34, no. Aug 2004, pp. 220–227, 2016.
[58] D. Harvey, "Rural psychologists' network," *Australian Journal of Rural Health*, vol. 8, no. 3, p. 173, 2000. https://doi.org/10.1046/j.1440-1584.2000.00310.x.
[59] R. Jedwab, L. Christiaensen, and M. Gindelsky, "Demography, urbanization and development: Rural push, urban pull and … urban push? ☆," *Journal of Urban Economics*, vol. 98, 2015. https://doi.org/10.1016/j.jue.2015.09.002.
[60] L. Y. He and X. C. Wen, "Population growth, interest rate, and housing tax in the transitional China," *Physica A Statistical Mechanics & Its Applications*, vol. 469, 2016. https://doi.org/10.1016/j.physa.2016.11.057.
[61] M. M. Maya, "Transportation Planning and the Prevention of Urban Sprawl," *New York University Law Review*, vol. 83, no. 3, pp. 879–910, 2008. https://doi.org/10.1111/j.1540-5893.2008.00347_6.x.
[62] Q. Cai, Z. Wang, and L. Xiao, "The Effect of Transportation and Housing Subsidies on Urban Sprawl," *Journal of Systems Science & Information*, no. 3, 2018. http://www.cnki.com.cn/Article/CJFDTotal-JSSI201803003.htm.
[63] S. Hamidi and R. Ewing, "Is Sprawl Affordable for Americans? Exploring the Association Between Housing and Transportation Affordability and Urban Sprawl," *Transportation Research Record Journal of the Transportation Research Board*, vol. 2500, pp. 75–79, 2016. https://doi.org/10.3141/2500-09.
[64] C. Wang and X. Jing, "Study on the Implementation Effect of Land Use Planning in Changzhi," *Journal of Taiyuan Normal University*, 2015. http://www.en.cnki.com.cn/Article_en/CJFDTotal-SJYX201504021.htm.
[65] M. G. Boarnet, R. B. Mclaughlin, and J. I. Carruthers, "Does state growth management change the pattern of urban growth? Evidence from Florida ☆," *Regional Science & Urban Economics*, vol. 41, no. 3, pp. 236–252, 2011. https://doi.org/10.1016/j.regsciurbeco.2010.12.004.