UNIVERSITI PUTRA MALAYSIA

MODELLING RAPID URBAN GROWTH OF KIRKUK CITY BASED ON ETHNICITY FACTORS USING GIS AND CELLULAR AUTOMATA-MARKOV

MAZEN ABDILWAHAB ABDULA

FRSB 2016 13

MODELLING RAPID URBAN GROWTH OF KIRKUK CITY BASED ON ETHNICITY FACTORS USING GIS AND CELLULAR AUTOMATA-MARKOV

By

MAZEN ABDILWAHAB ABDULA

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Doctor of Philosophy

November 2016

DEDICATION

I would like to dedicate this thesis to:

My parents, who would have appreciated seeing it if they were still alive.

To my family

Brothers and Sisters

All loyal friends

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the Degree of Doctor of Philosophy

MODELLING RAPID URBAN GROWTH OF KIRKUK CITY BASED ON ETHNICITY FACTORS USING GIS AND CELLULAR AUTOMATA-MARKOV

By

MAZEN ABDILWAHAB ABDULA

November 2016

Chairman : Mohd Johari Mohd Yusof, PhD
Faculty : Design and Architecture

During the past 90 years, Kirkuk City has grown rapidly due to the exploitation of its oil reserves. As a multi-ethnic city, the presence of oil has been a source of ethnic conflict among the Kurds, Arabs and Turkmen. Kirkuk has long been considered an ethnic powder keg waiting to explode. Each group's own distinctive historical narrative became increasingly politicised and antagonistic during the twentieth century. The Iraqi Government implemented an aggressive and extensive social engineering policy designed to manage potential political and security threats to the oilfields that had been established in Kirkuk. A new social policy of Arabisation was implemented; a preferential treatment policy which favoured the ethnic Arabs over non-Arabs.

However, while the ethnic Arabs benefitted from the affirmative action policy, the other ethnicities were expelled and this led to rising ethnic tension; planting a seed of antagonism towards ethnic Arabs and led to negative social relations between ethnic groups, which was augmented by residential segregation that divided the three major ethnic groups further.

Following the invasion of Iraq in 2003, the Kurds have become more politically powerful and an importuned force in the politics of the state, which in turn is even more important than the demographic issues in the powerful symbol of Kirkuk. As a reaction, another demographic change has occurred with informal rapid urban growth represented by many Kurdish returnees following the new Kurd government policy of Kurdification. The demographic change is a layered and multi-faceted social interaction that in many ways makes the resolution of Kirkuk's ethno-political tension difficult to achieve, particularly when this complex picture is coloured by the presence of immense quantities of oil reserves. This thesis used GIS and CA- Markov to examine Kirkuk City's urban growth, the factors that influenced its development, the impact of socio-political conflict represented by ethnic conflict on urban growth, the reshaping of the Master Plan and the pattern of settlement development of the city.

A model was developed to simulate the residential expansion based on ethno-political conflict areas for each ethnic group in order to answer the question: “Dose political transition based on ethnicity affect the shape of a city master plan?”. The findings of the study suggested that there are significant effects of ethno-political factors in urban growth and planning, as well as future trends. However, the effect of the other physical, environmental and socio economic factors were not strong as a determinant of social interaction and integration, and other non-spatial factors were more important. The ethno-political factors shaped the city’s Master Plan toward the north–eastern side of the city even though it was not recommended in the previous Master Plan. The findings visualised the shape of the future Master Plan based on ethnicity. According to all the above-mentioned factors, if the status of Kirkuk governorate is not settled politically, Kirkuk City’s planning pattern will continue to be heterogeneous. The findings have important policy implications to avoid the segregation of the society of Kirkuk City and will assist policy makers and urban planners to consider the trends in urban growth expansion and give the advantages and consequences for each ethnic scenario.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

PEMODELAN PERKEMBANGAN KAWASAN BANDAR DI BANDAR KIRKUK BERDASARKAN FAKTOR ETNIK MENGGUNAKAN GIS DAN CELLULAR AUTOMATA-MARKOV

Oleh

MAZEN ABDILWAHAB ABDULA

November 2016

Pengerusi : Mohd Johari Mohd Yusof, PhD
Fakulti : Rekabentuk dan Senibina

Dalam tempoh 90 puluh tahun ini, Bandar Kirkuk telah berkembang dengan pesat disebabkan eksploitasi rizab minyak. Sebagai sebuah bandar multi-etnik, penemuan minyak telah menjadi sebab berlakunya konflik etnik dalam kalangan orang Kurd, Arab dan Turkmen. Kirkuk telah lama dianggap sebagai kawasan campuran pelbagai etnik yang akan mencetus perkelahian. Sejarah setiap kumpulan etnik ini telah dipolitikkan dan diapikan semasa abad ke-20. Kerajaan Iraq telah telah melaksanakan dasar pengendalian sosial yang agresif dan meluas yang bertujuan untuk membendung kemungkinan ancaman berbentuk politik dan ancaman keselamatan kepada telaga minyak yang telah ditubuhkan di Kirkuk. Polisi sosial baru peng-Arab-an telah dilaksanakan; polisi pilih kasih yang melebihkan kepentingan orang Arab etnik berbanding kepentingan etnik bukan Arab.

Walau bagaimanapun, semasa orang Arab etnik mendapat kelebihan daripada polisi tindakan afirmatif itu, etnik-etnik lain telah diusir dan ini membawa kepada meningkatnya ketegangan hubungan etnik; menanam benih permusuhan terhadap orang Arab etnik dan membawa kepada hubungan sosial yang negatif antara kumpulan-kumpulan etnik yang bertambah lagi disebabkan oleh pengasingan kawasan kediaman yang membahagikan tiga kumpulan etnik utama itu.

Berikutan serangan ke atas Iraq pada tahun 2003, Orang Kurd telah mendapat kuasa politik yang lebih kuat dan mempunyai kuasa mendesak dalam politik negara ini, isu ini ini menjadi lebih penting daripada isu demografi dalam simbol kekuasaan Kirkuk. Berikutan ini, satu lagi perubahan demografi telah berlaku iaitu pertumbuhan bandar tidak rasmi yang pesat disebabkan kepulangan orang Kurd berikutan polisi baru peng-Kurd-an oleh kerajaan Kurd. Perubahan demografi ini adalah interaksi sosial yang berlapis dan berbagai yang, dalam banyak cara, membuatkan resolusi ketegangan etno-politik di Kirkuk sukar dicapai, terutamanya bila gambaran kompleks ini ditambah lagi dengan kehadiran rizab minyak yang mewah. Tesis ini menggunakan GIS dan CA- Markov untuk memeriksa perkembangan Bandar Kirkuk; faktor-faktor

yang mempengaruhi perkembangannya; kesan konflik sosio-politik, yang diwakili oleh konflik etnik, ke atas perkembangan bandar; pembentukan semula Pelan Induk; dan corak penempatan pembangunan bandar ini. Satu model telah dibina menggunakan ca-markov sebagai simulasi perkembangan kawasan kediaman berdasarkan kawasan konflik etno-politik untuk setiap kumpulan etnik untuk menjawab soalan berikut: "Adakah Peralihan Politik Yang Berdasarkan Etnik Akan Memberi Kesan Kepada Bentuk Pelan Induk Sesebuah Bandar?" Hasil kajian menunjukkan kemungkinan yang faktor etno-politik memberikan kesan yang besar untuk perkembangan dan perancangan bandar, termasuklah trend masa depan. Walau bagaimanapun, kesan daripada faktor fizikal, persekitaran, dan sosio-ekonomi adalah tidak sekuat sebagai penentu interaksi sosial dan integrasi, dan faktor bukan-ruang adalah lebih penting. Faktor etno-politik membentuk Pelan Induk kawasan Timur Laut bandar walaupun ini tidak digalakkan dalam Pelan Induk sebelum ini. Penemuan ini menggambarkan bentuk Pelan Induk masa hadapan yang berdasarkan etnik. Menurut semua faktor yang disebut di atas, jika status pentadbiran Kirkuk tidak dapat diselesaikan secara politik, corak perancangan Bandar Kirkuk akan terus dipengaruhi kebudayaan beraneka ragam. Hasil kajian mempunyai implikasi polisi yang penting untuk mengelakkan pengasingan masyarakat di Bandar Kirkuk, dan akan membantu pembuat dasar dan perancang bandar untuk mempertimbangkan trend perkembangan bandar dan menunjukkan kelebihan dan konsekuens untuk setiap senario etnik.

ACKNOWLEDGEMENTS

I wish to express my gratitude to all those who have given me assistance, help and support during the completion of my PhD in Design and Architecture Faculty, University Putra Malaysia.

I acknowledge a deep sense of gratitude to Dr. Mohd Johari Mohd Yusof, my supervisor, and my committee members, Dr Noordin Bin Ahmad, Dr Shamsul Abu Bakar and Dr Najat Qader Omer who have always spread their helping hands during my PhD study periods. Their guidance and kindness shown to me during and at the completion of my present work is much appreciated. I have a deep sense of gratitude to my previous supervisor, Dr Kamaria Dola (Allah bless her soul). This thesis would never have been accomplished in this shape without their selfless contributions in various aspects. My appreciation is extended to all good friends of mine for their valuable support in GIS work and to librarian, Ms Siobhan Roulston, for her diligent assistance in text arrangements.

This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Mohd Johari Mohd Yusof, PhD
Senior Lecturer
Faculty of Design and Architecture
Universiti Putra Malaysia
(Chairman)

Noordin Bin Ahmad, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Shamsul Abu Bakar, PhD
Senior Lecturer
Faculty of Design and Architecture
Universiti Putra Malaysia
(Member)

Najat Qader Omer,PhD
Senior Lecturer
Faculty of Engineering
Universiti of Kirkuk, Kirkuk, Iraq
(Member)

ROBIAH BINTI YUNUS, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software

Signature: _____ Date: _____

Name and Matric No: Mazen A. Abdula / GS23945

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) were adhered to.

Signature: _____
Name of Chairman of Supervisory Committee: Dr. Mohd Johari Mohd Yusof

Signature: _____
Name of Member of Supervisory Committee: Associate Professor Dr. Noordin Bin Ahmad

Signature: _____
Name of Member of Supervisory Committee: Dr. Shamsul Abu Bakar

Signature: _____
Name of Member of Supervisory Committee: Dr. Najat Qader Omer

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

KPC	Kirkuk Province Council
DEM	Digital Elevation Model
CA	Cellular Automata
IDPs	Internal Displaced Persons
MCE	Multi-Criteria Evaluation
GIS	Geographical Information System
RS	Remote Sensing
MCET	Multi-Criteria Evaluation Technology
ILO	International Labour Organisation
MDGs	Millennium Development Goals
EGM	Expert Group Meeting
LU	Land Use
AHP	Analytic Hierarchy Process
PSS	Planning Support System
MOLA	Multi-Objective Land Allocation
WLC	Weighted Linear Combination
RC	Ratio Consistency
TM	Thematic Mapper
ETM	Enhance Thematic Mapper
USGS	United States Geological Survey
SRTM	Shuttle Radar Topography Mission
EROS	Earth Resources Observation Systems
DTED	Digital Terrain Elevation Data
UTM	Universal Transverse Mercator
GCS	Geographic Coordinate System
ESA	Environmental Sensitive Area
MLC	Maximum Likelihood Classification
DN	Digital Number

ASCII	American Standard Code for Information Interchange
RMS	Root Mean Squared RMS
RGF	Raster Group files
FCUS	Future Conceptual Urban Structure (FCUS)

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Several problems and issues have developed from the recently experienced political, economic and demographic changes; these changes are totally different from those of the past. The structures and sizes of numerous cities around the world have been changed due to demographic changes, with suburban areas experiencing environmental and social problems which previously only affected urban areas.

There is a relationship between political, economic and historical circumstances with regards to urban reality and the problems surrounding it. This reality is seen at varying levels in both developed and under developed societies of the world. However, these relationships and differences prove that urban problems have their causes and as such, urban development is a result of the interactions between urban problems and these relationships and differences. Urban development is the intricate net which consists of environmental, human, social, economic and administrative problems. Just like any other process, the factors that influence urban change are related to the appearance in urbanisation. As a reaction, the relationship between these factors has resulted in many constructional, residential and planning problems.

According to Weber and Puissant (2003), the standard of living of urban dwellers has been lowered as a result of rapid global urbanisation. The increase of urban populations can be linked to globalisation even though this urbanisation is experienced at different levels across countries around the world. It is projected that the transformation in population size and spatial distribution will continue to grow in the future because of unending urbanisation and increases in population size; with this, it is predicted that the global urban population will rise in the future to 2.5 billion by 2050, especially in Asia and Africa. Also, another report by the United Nations (2014), projected global urban growth to increase by 66%. By 2050, this will amount to a world urban population of 6.4 billion out of 8.9 billion total world population. This implies that only 2.5 billion of the world population will not be living in urban areas (World Urbanisation Prospects 2005, 2006 and 2007; Revised 2008; Revised 2012). This increase in urban population according to the United Nations is caused by rural-urban migration, which in turn results in a change of natural land for urban use caused by spatial distribution of human settlements (United Nations, 2014).

Some of the negative impacts of such rapid urban growth are motorised transport, increased rate of energy consumption, pollution (noise, air and water), relative loss of rich agricultural land, and damaged or destroyed biological ecosystem diversity. Even though researchers and policy makers view this negative impact as a symbol that shows the economic strength of the affected region, they also view it as a sign of

environmental and ecological degradation. Thus, it is important for the stakeholders in this field of study to take note of the changes caused by urban dynamics so as to know how to plan and manage the situation (Knox, 1993; Turner et al., 1993).

Other negative impacts include ethnic conflict, an important determinant of the political, economic and social development of many nations and localities. It is widely believed that ethnic conflict leads to political instability, poor quality of institutions, badly designed economic policy and disappointing economic performance, all of which, in one way or another, impact the urban development and the lifestyle of the population. (Alesina, Devleeschauwer, Easterly, & Kurlat, 2003)

In related literature, early examples such as Canning and Fay (1993) and Mauro (1995), have discussed the effects of ethnic fragmentation on government activities and quality of institutions. La Porta et al. (1999), in a broad empirical study of the determinants of the quality of government, are of the opinion that ethnic fractionalisation matters, even though variables related to legal origins may be more important. There is ample literature indicating that in more ethnically fragmented communities, the provision of public goods is less efficient, participation in social activities and trust is lower, and economic success, measured by growth of city size, falls short of expectations. Evidence that trust does not travel well across racial lines is also supported by Glaeser, Laibson, Scheinkman, & Soutter (2000) and Alesina, Devleeschauwer, Easterly & Kurlat (2003).

Multi-temporal images can be used to see continuous urban growth especially in cases where undeveloped areas convert to partly developed, and then to fully developed, within a given period of time. The common process of urbanisation is expansion from downtown to suburbs and gradually to urban areas with different rates of growth in various directions. Some areas experience directional growth compared to other locations due to popular attractions found within the areas (Al-Kheder, 2006).

There are major urban growth factors that determine the process of urbanisation and expansion are physical, environmental and socio-economic factors (Clarke, 1997). Every geometric attribute which directly affects the process of development in a negative or positive way is referred to as a physical variable. One possible factor could be elevation, highlighted using a Digital Elevation Model (DEM) alongside the structure of land use.

Socio-economic factors are the second category that affects urban growth such as population distribution. The greater the distance from a city centre to the suburbs, the lesser the growth of the population. Another factor which mainly affects infrastructures such as road networks is often affected by origin-destination trip behaviours of travellers. Other socio-economic factors include crime rates, population density, income level, political aspects and ethnic diversity (Al-Kheder, 2006). The intricate nature of the process of urban growth is greatly affected by these growth factors.

Researchers have continued to show growing interest in modelling the process of urbanisation with a specific focus on examining the dynamics of intricate urban systems and investigating how the environment and lifestyle are affected by urban growth. In order to implement realistic dynamic modelling, there is a need to use ample techniques and methodologies of urban modelling. For this reason, there are some analytical models that have been designed based on the physical attributes of a city and the relationship between city size, economic status, and ethnic distribution (Yang & Lo, 2003).

The main function of these models is to facilitate the understanding of urban growth and the pattern of this growth based on ethnicity, rather than to project urban development that may occur in the future (Yang & Lo, 2003). In recent times, new intelligent techniques of urban modelling have been developed due to various reasons. Firstly, intelligent models enhance interpretation which mathematical models are unable to do because they are developed through the use of simple and understandable rules of transition. Secondly, intelligent models are more suitable for urban modelling because the spatial nature of an urban modelling process contains a two-dimensional grid derived from imagery alongside its related factors; hence urban growth can be fitted into these intelligent models. An example is the Cellular Automata (CA) model which is well-suited to such a process. Thirdly, intelligent models are a better option because they enhance visualisation more effectively than conventional urban models, thereby reducing modelling errors while enhancing urban modelling efficiency. The introduction of these intelligent models facilitates the understanding of the spatial effect of urban growth through the use of dynamic modelling techniques as well as detecting temporal variations (Allen & Lu, 2003). Cellular Automata-based intelligent models are designed to simplify the intricate process of urbanisation while maintaining accuracy.

The use of intelligent techniques and automata-based intelligent models provide the framework for the discovery of cross-cutting policy issues that bridge different types of cities, or cities at a particular location on the analytical continuum. The distillation of such insights broadens the relevance of this research for practitioners and policy-makers. The key urban ethnic conditions that are affected by planning policies can be visualised and described in terms of how they may facilitate or impede the movement towards peaceful co-existence between all ethnic groups.

1.2 Problem Statement

The main problem is the constant change in Iraq's urban development situation which is reminiscent of the experiences in other developing countries. This problem is not improving due to constant wars and economic and political instability that have been experienced in Iraq over the past three decades. The effects of these problems are seen in the living standards and intellectual and cultural changes occurring in Iraq. There are additional obstacles associated with planning caused by natural and man-made demographic factors. One serious problem is the emergence of illegal urban growth based on ethnicity caused by the racial policy of the previous government. This policy

saw unorganised city growth and the failure of Kirkuk City's Master Plan to meet the development needs of the rapidly growing population.

Political transition that has led to difficult living conditions is one of the causes of unrestrained urban sprawl in the city, which in turn continues to cause environmental and socio-economic problems, one of which is the growing tension between the ethnic groups. This problem has become more frightening than ever before due to lack of administrative discipline and legal authority.

There is rapid urban growth caused by ethnic conflict in Kirkuk City, which is a large city in northern Iraq. This area is the study location of this research. It is characterised by political transformation, ethnic diversity and varying patterns of social interaction, all of which make decision-making difficult especially with the presence of oil in large quantities. After the Second World War, ethnic conflicts were severe due to the presence of oil (Stansgield, 2009). This condition has made Kirkuk City a complex city with different ethnic groups fighting for resources and power because of its oil wealth.

The inconsistencies in the city's Master Plan which were caused by political changes, have led to unexpected and undesirable urban growth. This urban growth is also the result of poor and unorganised urban planning which influences the future structure of the city. As a result of these urban problems, a Master Plan was developed for the U.S. government by Pell Frischmann Consultancy. According to the US government's Iraq Transition Assistance Office, the project is an "extremely high priority" and will enable the US to "effectively empower the Kirkuk government" (Stewart, 2007).

However, this proposal failed to gain ground for the following reasons:

- The ethnic conflicts in KPC (Kirkuk Province Council);
- Failure of the planning processes to incorporate adequate local input (Knights, 2010); and
- Conflict of interest between authorised political parties.

Most of the objections centred on improper settlements built around the city which were intended to facilitate the permanent resettlement of Internal Displaced Persons (IDP) through infrastructure provision. This rejected Master Plan proposal instead focused on urban renewal in many of the peripheral areas where Kurdish IDPs had already been settled (Knights, 2010).

There were two stages of ethnic conflicts that led to rapid population growth in Kirkuk City. The first was the policy of Arabisation (Stansgield, 2009) which came as a result of the fight over the resources in the area. In order to control the resources, more Arabs were allowed to occupy the city, thereby leading to the expulsion of indigenes. A large

number of Arabs were permitted to come to settle there; they were given jobs, security (Letayf, 2011) and open green land which they converted to residential areas thereby leading to the destruction of green lands (Kamona, 2009). The unbalanced Arab population increase which was the result of this Arabisation policy, led to the revival of the city's original Master Plan which was designed by Greek company, Doxyaids, in 1975 for the Ministry of Municipalities of Iraq and facilitated by political involvement (Frischmann, 2007).

Kurdisation policy was the second stage that promoted population increase in Kirkuk City. As a reaction to Arabisation after the political transition in 2003, thousands of Kurds returned to Kirkuk City. This resulted in increased informal settlements in the city which in turn negatively affected the Master Plan. Due to this increase in population, the available infrastructure and services were unable to meet the needs of these new informal settlements. This disorganised spatial development led to the urgent need to combine cooperative action to deal with social problems by providing technical and social infrastructure (Dwyer, 1975).Conflict of interest also played a role in the failure of the city's Master Plan which occurred due to non-stop escalation of this problem. This type of problem also continued to grow because, as mentioned earlier, these informal settlements had their own rules and regulations peculiar only to them (Dwyer, 1975).

It is crucial to realise that the future of Iraq hinges on finding a solution to the problem of Kirkuk City's status with a formula that is mutually acceptable to all ethnic parties. It must be accepted that any attempt by the Kurds to impose a solution by forcibly annexing Kirkuk for the Kurdistan region risks plunging northern Iraq into an indefinite period of violence and ethnic upheaval. Equally crucial is the fact that any effort to force an unacceptable solution on the Kurds will inevitably produce a similar undesirable outcome (Romano & Romano, 2007; Stansgield, 2009).

Although a number of studies have been carried out, there is a knowledge gap that exists regarding spatial ethnical development as most of these studies have been descriptive rather than exploratory. To fill this gap, the current study investigates the phenomenon of rapid urban growth based on ethnic conflict and methods of controlling and modelling the spatial phenomenon so as to better understand development issues based on ethnic conflict. This will in turn provide understanding and highlight how theoretical and conceptual understanding can make sense out of what appears to be a confusing issue. Also, the study intends to examine the factors that have the strongest impact on abnormal urban growth, investigate urban growth mechanism, urban processes and their effects while attempting to visualise the appearance of the city when it is well-organised and planned.

1.3 Research Questions

The following research questions are formulated:

1. What are the common factors that influence urban sprawl in Kirkuk City?
2. Does the distribution of socio-ethnic groups influence the trend of Kirkuk City's development and the reshaping of its appearance?
3. What are the future patterns of Kirkuk City's growth that are influenced by socio-political factors?

1.4 Research Objectives

General objective is aim at examining Kirkuk city's urban growth and the factors that influence its development. It investigates the impact of socio-political conflict represented by ethnic conflict on urban growth and settlement development of Kirkuk City. A model is developed to simulate the residential areas for each ethnic group with an approach that will bring about better understanding of the dynamics of urban growth based on ethnicity. To achieve the stated aims, there are three main research objectives:

1. To identify the factors that influence urban growth in Kirkuk city.
2. To compare and analyse the previous and current Master Plans of Kirkuk City that were affected by socio-political factors; and
3. To develop a spatial model and simulate the future expansion of Kirkuk City on the basis of socio-political factors and ethno-political conflicts.

1.5 Significance of the Study

Despite the fact that a number of studies have been conducted, most of them were descriptive and lacking in explanatory features. Thus, this study brings to light how future spatial urban growth based on ethnic conflict can be simulated and projected in line with the social and ethno-political factors that influence this development. So as to enable policy, decision makers and city managers are able to monitor a city's performance over time while planning and managing urban growth based on the patterns of ethnic growth.

From a theoretical perspective, it is hoped that the findings of this study will make a meaningful contribution to the growing body of literature regarding the studied phenomenon. This research also serves as a contribution to the existing body of academic and professional knowledge in the field of social urban planning by highlighting the pattern of urban expansion on the basis of ethnic group distribution and the political interface of the Master Plan. This study also evaluates, assesses and investigates the non-predictable factors such as future political decisions and changes with the uncertainty of social instability that may impact growth of the city and reshape the Master Plan. It is also hoped that this study will facilitate the reproduction of the monitored development in order to help decision makers and city planners and managers to understand the suitable methods to be used for future master plans, thus

avoiding the mistakes and shortcomings of past Master Plans. In addition, the study reveals the unpleasant degrading effects of patterns of abnormal growth within the city of Kirkuk. A multi-ethnic city is a far more complex project that requires its managers to have and effectively use available information to manage the city and guide it along the best path to achieve its development aims.

This study will be of tremendous help to policy and decision makers in the area of urban planning and management as the work develops a model that will help solve the problems related to social urban growth. Finally, it serves as reference material for general purpose research and student researchers.

1.6 Scope of the Research

This study focused on modelling urban growth based on ethnicity and in line with the changes that occurred in Kirkuk City's Master Plan through the use of combined CA-Markov approach and alongside Multi-Criteria Evaluation (MCE). The principles of transition rules were derived by using a detailed qualitative survey. In order to achieve this, decision makers from various fields were asked to participate in the study by providing their most preferred methods of weighting in creating suitability maps; weights obtained from this survey were used in the derivation of transition rules.

A simulation of Kirkuk City's ethnicities in 1984 and 2000 was carried out to obtain images for 2016 for each ethnic group. The same procedure was followed using images from 2000 and 2013 to predict ethnic distribution for 2026. This model was used to visualise the shape of Kirkuk City and to project the future urban development trend of the growth change according to ethnic distribution until 2026. For accuracy, Kappa Methods were used to validate the model.

1.7 Outline of the Thesis

This thesis has five chapters consisting of the following elements:

Chapter One contains an introduction of the research, background of the study, problem statement, research objectives, research questions, scope of the study, significance of the study and an outline of the entire thesis.

Chapter Two presents a review of theoretical and methodological literature related and relevant to this study. An overview of land-use planning, ethnicity and its effects on the economy and institutions, theories of modelling, an explanation of the concept of Cellular Automata and its use in urban modelling are all contained in the literature review. In addition, the use of Multi-Criteria Evaluation (MCE), Geographical Information System (GIS) and Remote Sensing (RS) in urban planning are also discussed in this chapter. Finally, methods of combining CA models with MCE are presented in the conclusion of the chapter.

Chapter Three contains preparation of data for modelling the study area. In this chapter, short descriptions of natural and socio-economic and socio-political factors that influence urban development in Kirkuk City are presented.

Chapter Four shows the ethnic factors responsible for urban growth and how they can be represented in Cellular Automata. It also presents the classification of transition rules through maps of suitability. Modelling based on user interface and design of database is also discussed here. Finally, definitions of MCET and CA-Markov models of urban expansion alongside its components are given in this chapter.

Chapter Five, the final chapter of this work, contains the conclusion, contributions of the study, suggestions for further related research and some of the limitations of this study.

REFERENCES

Abbott, J. (2002). An analysis of informal settlement upgrading and critique of existing methodological approaches. *Habitat International*, *26*(3), 303–315. http://doi.org/10.1016/S0197-3975(01)00049-2

Abdullah, S. A., & Nakagoshi, N. (2006). Changes in landscape spatial pattern in the highly developing state of Selangor, peninsular Malaysia. *Landscape and Urban Planning*, *77*, 263–275.

Abebe, F. K. (2011). *Modelling Informal Settelment Growth in Dar es Salaam, Tanzania*. Universityof Twente.

Agarwal, C., Green, G. M., Grove, J. M., Evans, T. P., & Schweik, C. M. (2002). A review and assessment of land-use change models: dynamics of space, time, and human choice. (F. S. U.S. Department of Agriculture Northeastern Research Station, Ed.). Retrieved from www.geog.ucsb.edu/~kclarke/ucime/Helens-Sem/seminar2001/Land_Use_Draft_9.pdf

Ahmad, A., & Quegan, S. (2012). Analysis of Maximum Likelihood Classification on Multispectral Data. *Applied Mathematical Sciences*, *6*(129), 6425–6436. http://doi.org/10.12988/ams.2013.34214

Alan Gilbert. (2007). The Return of the Slum: Does Language Matter? *International Journal of Urban and Regional Research*, *31*(4).

Alesina, A. A., Devleeschauwer, A., Easterly, W., & Kurlat, S. (2003). Fractionalization. *Journal of Economic Growth*, *8*(2), 155–194. http://doi.org/10.1023/a:1024471506938

Algers, S., Eliasson, J., & Mattsson, L.-G. (2005). Is it time to use activity-based urban transport models? A discussion of planning needs and modelling possibilities. *The Annals of Regional Science*, *39*(4), 767–789. http://doi.org/10.1007/s00168-005-0016-8

Al-Hadithi, T. S., Shabila, N. R., Al-Tawil, N. G., & Othman, S. M. (2010). Demographic transition and potential for development: the case of Iraqi Kurdistan. *Eastern Mediterranean Health Journal = La Revue de Sante de La Mediterranee Orientale = Al-Majallah Al-Sihhiyah Li-Sharq Al-Mutawassit*, *16*(10), 1098–1102.

S. Al-kheder, J. Wang and J. Shan,(2008) "Fuzzy Inference Guided Cellular Automata Urban-Growth Modelling Using Multi-Temporal Satellite Images," *International Journal of Geographical Information Science*, Vol. 22, No. 11-12, pp. 1271-1293. doi:10.1080/13658810701617292

Allen, J., & Lu, K. (2003). Modeling and Prediction of Future Urban Growth in the Charleston Region of South Carolina: a GIS-based Integrated Approach. *Ecology and Society*, *8*(2), [online]: http://www.ecologyandsociety.org. http://doi.org/2

Anderson, A. E., Ellis, B. J., & Weiss, J. A. (2007). Verification, validation and sensitivity studies in computational biomechanics. *Computer Methods in Biomechanics and Biomedical Engineering*, *10*(3), 171–184.

Anderson,Liam and Stansfield, G. (2009). *Crisis In Kirkuk/ The Ethnopolitics of Conflict and Compromise*. Philadelphia: University of Pennsylvania Press.

Andersson, C., Lindgren, K., Rasmussen, S., & White, R. (2002). Urban growth simulation from "first principles." *Physical Review E - Statistical, Nonlinear, and Soft Matter Physics*, *66*(2), 1–9. http://doi.org/10.1103/PhysRevE.66.026204

Araya, Y. H., & Cabral, P. (2010). Analysis and Modeling of Urban Land Cover Change in Setúbal and Sesimbra, Portugal. *Remote Sensing*, *2*(6), 1549–1563.

Arsanjani, J. J., Helbich, M., Kainz, W., & Boloorani, A. D. (2012). Integration of logistic regression, Markov chain and cellular automata models to simulate urban expansion. *International Journal of Applied Earth Observation and Geoinformation*, *21*(1), 265–275. http://doi.org/10.1016/j.jag.2011.12.014

Barredo, J. I., & Demicheli, L. (2003). Urban sustainability in developing countries' megacities: modelling and predicting future urban growth in Lagos. *Cities*, *20*(5), 297–310.

Barredo, J. I., Kasanko, M., McCormick, N., & Lavalle, C. (2003). Modelling dynamic spatial processes: simulation of urban future scenarios through cellular automata. *Landscape and Urban Planning*, *64*(3), 145–160.

Batty, M. (2007). *Cities and complexity: understanding cities with cellular automata, agent-based models, and fractals*. The MIT press.

Batty, M. (2009). Urban Modeling. *International Encyclopedia of Human Geography*, 51–58. http://doi.org/http://dx.doi.org/10.1016/B978-008044910-4.01092-0

Batty, M., & Xie, Y. (1997). Possible urban automata. *Environment and Planning B: Planning and Design*, *24*, 175–192. http://doi.org/10.1068/b240175

Bollens, S. a. (2008). Governing Polarized Cities. *Sewyer Seminar*, (Bollens 2007), 1–27. Retrieved from http://www.polisci.upenn.edu/ppec/sawyer/Speakers/Speakers' Publications/Bollens Governing Polarized Cities.pdf

Bollens, S. a. (2009). Comparative Research on Urban Political Conflict: Policy Amidst Polarization. *The Open Urban Studies Journal*, *2*, 1–17. http://doi.org/10.2174/1874942900902010001

Brahimipour, A. E., Aadat, M. S., & Arshchin, A. F. (2016). Prediction of Urban Growth through Cellular Automata-Markov*, Bulletin de la Société Royale des Sciences de Liège*, Vol. 85, 2016, p. 824 - 839.

Brown, D. G., Robinson, D., Riolo, R., & Rand, W. (2005). Spatial Process and Data Models: Toward Integration of Agent-Based Models and GIS. *Journal of Geographic Systems*. Retrieved from http://www.cscs.umich.edu/sluce/publications/jgs_abmgis.pdf

Cao, K. (2013). Modern urban planning theoriesSunShiwenModern urban planning theoriesBeijing: China Architecture and Building Press, 2007. 618pp. ¥128.00 (hbk) ISBN 978-7-112-07681-9. *Planning Theory*, *12*(3), 321–323. http://doi.org/10.1177/1473095212451042

Central Organization for Statistica and Information Technology , The World Bank, K. R. S. O. (2007). *Iraq Household Socio-Economic Survey Ihses — 2007*. *Iraq*.

Christer Anderstig & Lars-Goran Mattsson. (1991). An integrated model of residential and employment location in a metropolitan region. *Regional Science Association International*.

Clarke, K. C., Hoppen, S., & Gaydos, L. J. (1997). A self-modifying cellular automaton model of historical urbanization in the San Francisco Bay area. *Environmental and Planning B*, *24*, 247–261.

Cohen, B. (2006). Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. *Technology in Society*, *28*(1-2), 63–80. http://doi.org/10.1016/j.techsoc.2005.10.005

Collins, C., & Wolff, S. (2008). Creating political space to resolve inter-communal tensions in Kirkuk , Submission to the USIP Competition "Case Studies in Peacebuilding. Iraq, 1–6.

Couclelis, H. (2005). " Where has the future gone?" Rethinking the role of integrated land-use models in spatial planning. *Environment and Planning A*, *37*(8), 1353.

D. Lu, & Weng, Q. (2007). A survey of image classification methods and techniques for improving classification performance International Journal of Remote Sensing. *International Journal of Remote Sensing*, *8*(5), 823–870. http://doi.org/10.1080/01431160600746456

Deep, S., & Saklani, A. (2014). Urban sprawl modeling using cellular automata. *The Egyptian Journal of Remote Sensing and Space Science*, *17*(2), 179–187. http://doi.org/10.1016/j.ejrs.2014.07.001

Dubovyk, O., Sliuzas, R., & Flacke, J. (2011). Spatio-temporal modelling of informal settlement development in Sancaktepe district, Istanbul, Turkey. *ISPRS Journal of Photogrammetry and Remote Sensing*, *66*(2), 235–246. http://doi.org/10.1016/j.isprsjprs.2010.10.002

Durand-Lasserve, A., & Selod, H. (2009). The formalization of urban land tenure in developing countries. In *Urban Land Markets* (pp. 101–132). Springer.

Dwyer, D. J. (1975). *People and Housing in Third World Cities: perspectives on the problem of spontaneous settlements*. Published by Longman Group Limited, London and New York, 1975.

Eastman, J. R. (2009). *IDRISI Taiga: Guide to GIS and Image Processing*. Worcester: Clark Labs, Clark University.

Eldefrawi, S. (2013). " Impact of Physical Structure of Informal Settlements on the Social Integration of Residents ." Paper presented at the International RC21 Conference 2013

Elizabethh Ferris, K. S. (2008). The Future Of Kirkuk : The Referendum And Its PotentiaL. *University of Bern. Brookings Institution.*

Eric J. Miller, Bilal Farooq, D. W. (2010). Microsimulating Urban Spatial Dynamics: Historical Validation Tests Using the ILUTE Model System. *Igarss 2014*, (1), 1–5. http://doi.org/10.1007/s13398-014-0173-7.2

Eşbah, H., Erdogan, M. A., & Tanriöver, A. A. (2011). Cellular automata-Markov chain and landscape metrics for landscape planning. *Az.Itu.Edu.Tr*, *8*(2), 63–79. Retrieved from http://www.az.itu.edu.tr/azv8no2web/08-esbah-erdogan-tanriover-08-02.pdf

Etessami, K., Kwiatkowska, M., Vardi, M., & Yannakakis, M. (2007). Multi-objective model checking of Markov decision processes. *Tools and Algorithms for the Construction and Analysis of Systems*, 50–65.

Ewing, R. H. (2008). Characteristics, causes, and effects of sprawl: A literature review. *Urban Ecology: An International Perspective on the Interaction Between Humans and Nature*, *21*(2), 519–535. http://doi.org/10.1007/978-0-387-73412-5_34

Ewing, R., Schieber, R. a., & Zegeer, C. V. (2003). Urban Sprawl as a Risk Factor in Motor Vehicle Occupant and Pedestrian Fatalities. *American Journal of Public Health*, *93*(9), 1541–1545. http://doi.org/10.2105/AJPH.93.9.1541

Flötteröd, G., Chen, Y., & Nagel, K. (2012). Behavioral Calibration and Analysis of a Large-Scale Travel Microsimulation. *Networks and Spatial Economics*, *12*(4), 481–502. http://doi.org/10.1007/s11067-011-9164-9

Forsell, N., Wikström, P., Garcia, F., Sabbadin, R., Blennow, K., & Eriksson, L. O. (2011). Management of the risk of wind damage in forestry: a graph-based Markov decision process approach. *Annals of Operations Research*, 1–18.

Franz, G., Maier, G., & Schröck, P. (2005). Urban Sprawl How useful is this concept ? *ERSA Conference Papers ersa06p105, European Regional Science Association.*, 1–29.

Frischmann, P. (2009). *Kirkuk Masterplan Final Report A11975/Aaa/11-07/R01 December 2009*.Iraq

Frumkin, H. (2002). Urban sprawl and public health. *Public Health Reports*, *117*(3), 201–217. http://doi.org/10.1016/S0033-3549(04)50155-3

Galster, G., Hanson, R., Ratcliffe, M. R., Wolman, H., Coleman, S., & Freihage, J. (2001). Wrestling Sprawl to the Ground: Defining and measuring an elusive concept. *Housing Policy Debate*, *12*(4), 681–717. http://doi.org/10.1080/10511482.2001.9521426

Galster, G., Hanson, R., Ratcliffe, M. R., Wolman, H., Coleman, S., & Freihage, J. (2001). Wrestling sprawl to the ground: defining and measuring an elusive concept. *Housing Policy Debate*, *12*(4), 681–717.

Gang Chen &Congcong Wu & Jingsong Ma &Yingxia. (2010). An integrated approach of Multi-Criteria Suitability Evaluation and Cellular Automata modeling for urban growth simulation. *IEEE*.

Glaeser, E. L., Laibson, D. I., Scheinkman, J. a., & Soutter, C. L. (2000). Measuring Trust*. *Quarterly Journal of Economics*, *115*(3), 811–846. http://doi.org/10.1162/003355300554926

Guan, D. J., Li, H. F., Inohae, T., Su, W., Nagaie, T., & Hokao, K. (2011). Modeling urban land use change by the integration of cellular automaton and Markov model. *Ecological Modelling*, *222*(20), 3761–3772.

Gül, A., Gezer, A., & Kane, B. (2006). Multi-criteria analysis for locating new urban forests: An example from Isparta, Turkey. *Urban Forestry & Urban Greening*, *5*(2), 57–71.

Gwilliam, K. (2013). Cities on the move - Ten years after. *Research in Transportation Economics*, *40*(1), 3–18. http://doi.org/10.1016/j.retrec.2012.06.032

Habitat, U. N. (2009). Planning sustainable cities: Global Report on Human Settlements. 2009. *Nairobi: UN Habitat*.

Hanham, R., & Spiker, J. S. (2005). Urban sprawl detection using satellite imagery and geographically weighted regression. *Geo-Spatial Technologies in Urban Environments*, (2002), 137–151. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-77957296031&partnerID=40&md5=31a6d33b3e01e9388f54ce19d44306e3

Hart, K. (1973). Informal Income Urban Ghana Opportunities and. *The Journal of Modern African Studies*, *11*(1), 61–89.

Hasse, J. (2002). Is It Sprawl Or Smart Growth? Adozen Geospatial Indices Of Urban Sprawl. Rowan University

Hasse, J. (2004). Accessibility as a Spatial Indicator of Sprawl, (2000), 108–115. Rowan University.

Henninger, H. B., Reese, S. P., Anderson, A. E., & Weiss, J. A. (2010). Validation of computational models in biomechanics. *J. Engineering in Medicine*, *224*.

Herold, M., Couclelis, H., & Clarke, K. C. (2005). The role of spatial metrics in the analysis and modeling of urban land use change. *Computers, Environment and Urban Systems*, *29*(4), 369–399. http://doi.org/10.1016/j.compenvurbsys.2003.12.001

Herold, M., Menz, G., & Clarke, K. C. (2001). Remote sensing and urban growth models–demands and perspectives. In *Symposium on remote sensing of urban areas*.

Hill, A., & Lindner, C. (2010). Modelling informal urban growth under rapid urbanisation.Technishe University, Durtmund

Houet, T., & Hubert-Moy, L. (2006). Modelling and projecting land-use and land-cover changes with a Cellular Automaton in considering landscape trajectories: An improvement for simulation of plausible future states. *EARSeL eProceedings*, *5*(1), 63–76.

Huang, J., Wu, Y., Gao, T., Zhan, Y., & Cui, W. (2015). An Integrated Approach based on Markov Chain and Cellular Automata to Simulation of Urban Land Use Changes, *775*(2), 769–775.Applied Mathmatic &Information Science ,An International Journal 9,No,2 http://dx.doi.org/10.12785/amis/090225

Human Rights Watch. (2004). Claims in Conflict Reversing Ethnic Cleansing in Northern Iraq, *16*(4).United Nation

Human Rights Watch. (2015). *World Report 2015*. United Nation http://doi.org/10.5860/CHOICE.44-6612

International/Doxiadis Associtates-Consultants. (1975). *Kirkuk Master Plan Report Prepared for the Ministry of Municiplites of the Government of Repaplic of Iraq*.

Irwin, E. G., & Geoghegan, J. (2001). Theory, data, methods: Developing spatially explicit economic models of land use change. *Agriculture, Ecosystems and Environment*, *85*(1–3), 7–23. http://doi.org/http://dx.doi.org/10.1016/S0167-8809(01)00200-6

Itzhak Benenson & Paul M.Torrens. (2004). *Geosimulation Aotomate - Based Modeling Of Urban Phenomena*. John Wiley & Sons.

Jankowski, P., Andrienko, N., & Andrienko, G. (2001). Map-centred exploratory approach to multiple criteria spatial decision making. *International Journal of Geographical Information Science*, *15*(2), 101–127.

Jantz, C. a, Goetz, S. J., & Shelley, M. K. (2004). Using the SLEUTH urban growth model to simulate the impacts of future policy scenarios on urban land use in the Baltimore -- Washington metropolitan area. *Environment and Planning B: Planning and Design*, *31*(2), 251–271. http://doi.org/10.1068/b2983

Jenerette, G. D., & Wu, J. (2001). Analysis and simulation of land-use change in the central Arizona-Phoenix region, USA. *Landscape Ecology*, *16*(7), 611–626.

Jiangquan Hu & Zhihong Tao & Jing Chen ; Zongmiao Kou. (2010). An evaluating indicator for urban sprawl simulation and prediction. *International Conference .Beijing*.

Joan Serras, Melanie Bosredon, R. H. & M. B. (2014). Urban Planning and Big Data: Taking LUTi Models to the Next Level. *Nrdic Center for Spatial Development*, (1).

Jokar Arsanjani, J., Helbich, M., Kainz, W., & Darvishi Bloorani, A. (2012). Integration of logistic regression, Markov chain and cellular automata models to simulate urban expansion. *International Journal of Applied Earth Observation and Geoinformation*.

Jokar Arsanjani, J., Kainz, W., & Mousivand, A. J. (2011). Tracking dynamic land-use change using spatially explicit Markov Chain based on cellular automata: the case of Tehran. *International Journal of Image and Data Fusion*, *2*(4), 329–345.

Jonsson, R. D. (2008). Analysing sustainability in a land-use and transport system. *Journal of Transport Geography*, *16*(1), 28–41. http://doi.org/10.1016/j.jtrangeo.2007.02.006

Jørgensen, S. E., & Bendoricchio, G. (2001). *Fundamentals of ecological modelling* (Vol. 21). Elsevier Science.

Kamusoko, C., Aniya, M., Adi, B., & Manjoro, M. (2009). Rural sustainability under threat in Zimbabwe – Simulation of future land use/cover changes in the Bindura district based on the Markov-cellular automata model. *Applied Geography*, *29*, 435–447.

Kanbur, R. (2009). Conceptualising informality: Regulation and Enforcement. *Indian Journal of Labour Economics*, *52*(1), 1–12.

Kanchan Chandra. (2006). What Is Ethnic Identity And Does It Matter? *Annual Review of Political Science*, *9: 397-424*. http://doi.org/10.1017/CBO9781107415324.004

Katzman, K. (2013). Iraq : Politics , Governance , and Human Rights. *Congressional Research Service* 7-5700 www.crs.gov RS21968

Kirkuk Provincial Government. (2007). Strategy Framework for Growth and Development 2007-2012 Kirkuk Province.USAID

Klosterman, R. E. (1999). The What if? Collaborative planning support system. *Environment and Planning B*, *26*, 393–408.

Klosterman, R. E. (2008). *A New Tool for a New Planning: The What if?™ Planning Support System*. *Planning Support Systems for Cities and Regions* (Vol. 17). http://doi.org/10.1177/0739456X9701700105

Klosterman, R. E., & Pettit, C. J. (2005). An update on planning support systems. *Environment and Planning B: Planning and Design*, *32*(4), 477–484. http://doi.org/10.1068/b3204ed

Knights, A. A. and M. (2010). Kirkuk In Transition Confedence Building In Northern Iraq. *The Washington Institute For Near East PolicY* (Vol. 102).

Koomen, E., Rietveld, P., & Nijs, T. de. (2008). Modelling land-use change for spatial planning support. *Annals of Regional Science*, *42*, 1–10.

Koomen, E., & Stillwell, J. (2007). Modelling land-use change: Theories and methods. In E. Koomen, J. Stillwell, A. Bakema, & H. J. Scholten (Eds.), *Modelling Land-Use Change: Progress and Applications* (Vol. 90). Springer.

Ladak, D. G. (2003). *Iraq ' s Refugee and IDP Crisis : Human Toll and Implications*. *The Midddle East Institutie Washington,DC*.

Larry Hanauer, L. E. M. (2012b). Resolving Kirkuk Lessons Learned from Settlements of Earlier Ethno-Territorial Conflicts. *National Defense Research Institute National RAND*. Retrieved from http://www.rand.org

Lee, D. B. (1979). Urban Models. *Transportation*. http://doi.org/10.1007/978-3-540-70508-6

Letayf, P. (2011). An Ethnic Tug-of War? the Struggle Over the Status of Kirkuk. *NIMEP.iNSIGHTS, the Institute for Global Ladership.Tufts University*.

Li, X., & Yeh, A. G.-O. (2000). Modelling sustainable urban development by the integration of constrained cellular automata and GIS. *International Journal of Geographical Information Science*, *14*(2), 131–152. http://doi.org/10.1080/136588100240886

Lindenstrauss, G., & Eran, O. (2014). The Kurdish Awakening and the Implications for Israel. *Strategic Assessment*, *17*(1), 83–93.

Liu, H., & Zhou, Q. (2005). Developing urban growth predictions from spatial indicators based on multi-temporal images. *Computers, Environment and Urban Systems*, *29*(5), 580–594. http://doi.org/10.1016/j.compenvurbsys.2005.01.004

Logofet, D. O. (2008). Convexity in projection matrices: Projection to a calibration problem. *Ecological Modelling*, *216*(2), 217–228.

Logofet, D. O., & Korotkov, V. N. (2002). “Hybrid” optimisation: a heuristic solution to the Markov-chain calibration problem. *Ecological Modelling*, *151*(1), 51–61.

Long, H., Tang, G., Li, X., & Heilig, G. K. (2007). Socio-economic driving forces of land-use change in Kunshan, the Yangtze River Delta economic area of China. *Journal of Environmental Management*, *83*(3), 351–64. http://doi.org/10.1016/j.jenvman.2006.04.003

Maithani, S. (2010). Cellular Automata Based Model of Urban Spatial Growth. *Journal of the Indian Society of Remote Sensing*, *38*(4), 604–610.

Malczewski, J. (1999). *GIS and multicriteria decision analysis*. New York: Wiley.

Martellozzo, F., & Clarke, K. C. (2011). Measuring urban sprawl, coalescence, and dispersal: a case study of Pordenone, Italy. *Environment and Planning B: Planning and Design*, *38*(6), 1085–1104. http://doi.org/10.1068/b36090

Massam, B. H. (1988). Multi-criteria decision making (MCDM) techniques in planning. *Progress in Planning*, *30*, 1–84.

Mhangara, P. (2011). *Land Use/Cover Change Modelling and Land Degradation Assessment in the Keiskamma Catchment Using Remote Sensing and GIS*. *Faculty of Science*. Nelson Mandela Metropolitan University, Port Elizabeth, South Africa.

Miller, E., & Salvini, P. (2001). The integrated land use, transportation, environment (ILUTE) microsimulation modelling system: Description & current status. *Travel Behaviour Research: The Leading Edge*, (Sections 9), 711–724. Retrieved from http://www.civ.utoronto.ca/sect/traeng/ilute/downloads/conference_papers/miller-salvini_iatbr-00.pdf

Mirkatouli, J., Hosseini, A., & Neshat, A. (2015). Analysis of land use and land cover spatial pattern based on Markov chains modelling. *City, Territory and Architecture*, *2*(1), 4. http://doi.org/10.1186/s40410-015-0023-8

Mitsova, D., Shuster, W., & Wang, X. (2011). A cellular automata model of land cover change to integrate urban growth with open space conservation. *Landscape and Urban Planning*, *99*, 141–153.

Mitullah, W. V., & Wachira, I. N. (2003). Informal Labour in the Construction Industry in Kenya: A Case Study of Nairobi, (May), 1–70.

Mohamed Al-shalabi, , Lawal Billa, Biswajeet Pradhan, Shattri Mansor, A. A. A. A.-S. (2013). Modelling urban growth evolution and land-use changes using GIS based cellular automata and SLEUTH models: the case of Sana’a metropolitan city, Yemen. *Environmental Earth Sciences*, *70*(1).

Mokadi, E. (2011). *Modeling the Future Impact of Cincinnati's Proposed Streetcar on Urban Land Use Changes*. *College of Design, Art, Architecture, and Planning, School of Planning*. University of Cincinnati, Cincinnati, USA.

Mondal, P., & Southworth, J. (2010). Evaluation of conservation interventions using a cellular automata-Markov model. *Forest Ecology and Management*, *260*, 1716–1725.

Moreno, N., Wang, F., & Marceau, D. J. (2009). Implementation of a dynamic neighborhood in a land-use vector-based cellular automata model. *Computers, Environment and Urban Systems*, *33*(1), 44–54. http://doi.org/10.1016/j.compenvurbsys.2008.09.008

Munroe, D. K., Croissant, C., & York, A. M. (2005). Land use policy and landscape fragmentation in an urbanizing region: Assessing the impact of zoning. *Applied Geography*, *25*(2), 121–141. http://doi.org/10.1016/j.apgeog.2005.03.004

Musaoglu, N., Tanik, A., & Kocabas, V. (2005). Identification of land-cover changes through image processing and associated impacts on water reservoir conditions. *Environmental Management*, *35*(2), 220–30. http://doi.org/10.1007/s00267-003-0270-4

Nations, U. (2010). World Population Prospects: The 2010 Revision. Population Division, Department of Economic and Social Affairs, United Nations New York, NY, USA.

Noor, N.M & Hashim, M. (2010). Urban Sprawl Processes Joining Cellular Automata, GIS and Remote Sensing Data: Simulation of Details Un-authorized Development. *IEEE*.

Nyerges, T. L., & Jankowski, P. (2009). *Regional and urban GIS: a decision support approach*. The Guilford Press.

Omar, N. Q., Ahamad, M. S. S., Wan Hussin, W. M. A., Samat, N., & Binti Ahmad, S. Z. (2014). Markov CA, Multi Regression, and Multiple Decision Making for Modeling Historical Changes in Kirkuk City, Iraq. *Journal of the Indian Society of Remote Sensing*, *42*(1), 165–178. http://doi.org/10.1007/s12524-013-0311-2

Paegelow, M., & Olmedo, M. (2005). Possibilities and limits of prospective GIS land cover modelling—a compared case study: Garrotxes (France) and Alta Alpujarra Granadina (Spain). *International Journal of Geographical Information Science*, *19*(6), 697–722. http://doi.org/10.1080/13658810500076443

Páez. (2005). Spatial statistics for urban analysis: A review of techniques with examples. *GeoJournal*, *61*(1), 53. http://doi.org/10.1007/sGEJO-004-0877-x

Park, B. (2014). *Turkey-Kurdish Regional Government Relations After the U.S. Withdrawal From Iraq: Putting the Kurds on the Map?*

Park, M., Kim, Y., Lee, H., Han, S., Hwang, S., & Choi, M. J. (2013). Modeling the dynamics of urban development project: Focusing on self-sufficient city development. *Mathematical and Computer Modelling*, *57*(9-10), 2082–2093. http://doi.org/10.1016/j.mcm.2011.05.058

Park, S., Jeon, S., Kim, S., & Choi, C. (2011). Prediction and comparison of urban growth by land suitability index mapping using GIS and RS in South Korea. *Landscape and Urban Planning*, *99*(2), 104–114. http://doi.org/10.1016/j.landurbplan.2010.09.001

Paul M. Torrens &David O'Sullivan. (2000). Cities, cells, and complexity: developing a research agenda for urban geocomputation. *5th International Conference on GeoComputation,*.

Perera, N. (2006). *Urban Theory and the Urban Experience Encountering the City*. *International Journal of Urban and Regional Research* (Vol. 30). http://doi.org/10.1111/j.1468-2427.2006.00673_6.x

Phua, M.-H., & Minowa, M. (2005). A GIS-based multi-criteria decision making approach to forest conservation planning at a landscape scale: a case study in the Kinabalu Area, Sabah, Malaysia. *Landscape and Urban Planning*, *71*(2), 207–222.

Poelmans, L., & Van Rompaey, A. (2010). Complexity and performance of urban expansion models. *Computers, Environment and Urban Systems*, *34*(1), 17–27. http://doi.org/10.1016/j.compenvurbsys.2009.06.001

Pontius Jr., R. G., & Schneider, L. C. (2001). Land-cover change model validation by and {ROC} method for the {Ipswitch Watershed, Massachusetts, USA}. *Agric. Ecosyst. Environ.*, *85*, 239–248.

Pontius, R. G., Boersma, W., Castella, J. C., Clarke, K., de Nijs, T., Dietzel, C., … Verburg, P. H. (2008). Comparing the input, output, and validation maps for several models of land change. *The Annals of Regional Science*, *42*(1), 11–37.

Pontius, R. G., & Chen, H. (2006). GEOMOD Modeling. Retrieved from http://www.clarku.edu/%7Erpontius/pontius_chen_2006_idrisi.pdf

Pontius, R. G., & Chen, H. (2008). Land change modeling with GEOMOD. *Clark University, Worcester*.

Pontius, R. G., & Malanson, J. (2005). Comparison of the structure and accuracy of two land change models. *International Journal of Geographical Information Science*, *19*(2), 243–265.

Pontius, R. G., & Millones, M. (2011). Death to Kappa: birth of quantity disagreement and allocation disagreement for accuracy assessment. *International Journal of Remote Sensing*, *32*(15), 4407–4429.

Pual Waddell. (2002). UrbanSim MOdeling Urban Development For Land use Transportaion and Environment Planning. *APA Journal*, *68*(3).

Quil Lawrence. (2008). *Invisible Nation: How the Kurds' Quest for Statehood Is Shaping Iraq and the Middle East*.

Qureshi, M. E., Harrison, S. R., & Wegener, M. K. (1999). Validation of multicriteria analysis models. *Agricultural Systems*, *62*, 105±116.

Romano, D. (2007). The Future of Kirkuk. *Ethnopolitics*, *6*(2), 265–283. http://doi.org/http://dx.1080/17449050701345033

Sack, R. D. (1986). *Human territoriality Its theory and history*. Cambridge University Press.

Samat, N. (2007). *Integrating GIS and celular automata spatial model in evaluating urban growth: prospects and challenges*. Universiti Teknologi Malaysia, Faculty of Built Environment.

Samat, N. (2009). Integrating GIS and CA-MARKOV Model in evaluating urban spatial growth. *Malaysian Journal of Environmental Management*, *10*(1), 83–100.

Sang, L., Zhang, C., Yang, J., Zhu, D., & Yun, W. (2011). Simulation of land use spatial pattern of towns and villages based on CA–Markov model. *Mathematical and Computer Modelling*, *54*(3-4), 938–943.

Santé, I., García, A. M., Miranda, D., & Crecente, R. (2010). Cellular automata models for the simulation of real-world urban processes: A review and analysis. *Landscape and Urban Planning*, *96*(2), 108–122.

Santé, I., García, A. M., Miranda, D., & Crecente, R. (2010). Cellular automata models for the simulation of real-world urban processes: A review and analysis. *Landscape and Urban Planning*, *96*(2), 108–122.

Seto, K. C., & Kaufmann, R. K. (2003). Modeling the Drivers of Urban Land Use Change in the Pearl River Delta, China: Integrating Remote Sensing with Socioeconomic Data. *Land Economics*, *79*(1), 106–121. http://doi.org/10.3368/le.79.1.106

Shafizadeh Moghadam, H., & Helbich, M. (2013). Spatiotemporal urbanization processes in the megacity of Mumbai, India: A Markov chains-cellular automata urban growth model. *Applied Geography*, *40*, 140–149. http://doi.org/10.1016/j.apgeog.2013.01.009

Shekhar S. (2013). Slum Modelling by using Ontology and Geoinformatics: Case study of Gulbarga. *International Journal of Geoinformatics*.

Silva, E. ., & Clarke, K. . (2002). Calibration of the SLEUTH urban growth model for Lisbon and Porto, Portugal. *Computers, Environment and Urban Systems*, *26*(6), 525–552. http://doi.org/10.1016/S0198-9715(01)00014-X

Silva, E. a., Ahern, J., & Wileden, J. (2008). Strategies for landscape ecology: An application using cellular automata models. *Progress in Planning*, *70*(4), 133–177. http://doi.org/10.1016/j.progress.2008.05.002

Silva, E., & Wu, N. (2012). Surveying Models in Urban Land Studies. *Journal of Planning Literature*, *27*(2), 139–152. http://doi.org/10.1177/0885412211430477

Soitm. (2013). Summary of confiscation of the land and demographic changes of the Iraqi Turkmen region *. *Turkman Human Right Research Foundation*..

Stevens, D., & Dragicevic, S. (2007). A GIS-based irregular cellular automata model of land-use change. *Environment and Planning B: Planning and Design*, *34*(4), 708–724. http://doi.org/10.1068/b32098

Stewart, | By Dan. (2007). UK firms to masterplan war-torn Iraqi city 2007. Retrieved from http://www.building.co.uk/uk-firms-to-masterplan-war-torn-iraqi-city/3094755.article

Straatman, B., White, R., & Engelen, G. (2004). Towards an automatic calibration procedure for constrained cellular automata. *Computers, Environment and Urban Systems*, *28*(1-2), 149–170. http://doi.org/10.1016/S0198-9715(02)00068-6

Sui, D. Z., & Zeng, H. (2001). Modeling the dynamics of landscape structure in Asia's emerging desakota regions: a case study in Shenzhen. *Landscape and Urban Planning*, *53*(1-4), 37–52.

Sun, H., Forsythe, W., & Waters, N. (2007). Modeling urban land use change and urban sprawl: Calgary, Alberta, Canada. *Networks and Spatial Economics*, *7*(4), 353–376.

Talabany, N. (2007). Who Own Home. *Middle East Quarterly*, 90. Retrieved from http://www.meforum.org/1075/who-owns-kirkuk-the-kurdish-case

Tayyebi, A., Perry, P. C., & Tayyebi, A. H. (2014). Predicting the expansion of an urban boundary using spatial logistic regression and hybrid raster–vector routines with remote sensing and GIS. *International Journal of Geographical Information Science*, *28*(4), 639–659. http://doi.org/10.1080/13658816.2013.845892

Torrens, P. (2003). Automata-based models of urban systems. In P. A. Longley & M. Batty (Eds.), *Advanced Spatial Analysis* (pp. 61–81). Redlands, CA: ESRI press.

Triantakonstantis, D. (2012). Urban growth prediction: a review of computational models and human perceptions. *Journal of Geographic Information System*, *04*(December), 555–587. http://doi.org/10.4236/jgis.2012.46060

Triantakonstantis, D., Stathakis, D., & Area, a S. (2015). Urban Growth Prediction in Athens , Greece , Using Artificial Neural Networks, *9*(3), 217–221.

Tsai-chu Wu & Bo-yi Hong. (2010). Simulation of Urban Land Development and Land Use Change Employing GIS with Cellular Automata. *IEEE*.

Un. (2010). Planning Sustainable Cities. Global Report On Human Settlements , United Nations Human Settlements Programme, United Nations

Un-Habitat. (2003). *The Challenge of Slums - Global Report on Human Settlements*. *London Earthscan*. http://doi.org/http://dx.doi.org/10.1108/meq.2004.15.3.337.3

UN-Habitat. (2012a). *Evaluation of the UN-Habitat Urban Programme in Iraq 2004-2012*. Retrieved from http://www.unhabitat.org/pmss/listItemDetails.aspx?publicationID=3512

UN-Habitat. (2012b). *The state of arab cities 2012 challenges of urban transition*.

Unicef. (2012). Children in an Urban World. *The State of World's Children 2012*, 107. Retrieved from http://www.unicef.org/sowc2012/pdfs/SOWC 2012-Main Report_EN_13Mar2012.pdf

Union European. (2008). Iraq : Kurdish challenges, *European Union's Institute for Security Studies, Paris,* (79), 1–24.

United Nations, H. (2012). *I ' m a City Changer in Africa*. Retrieved from WWW.UNHABITAT.ORG

United Nations, H. (2014). *World Urbanization Prospects*. *Demographic Research* (Vol. 12). United Nations, Department of Economic and Social Affairs, Population Division (2014). http://doi.org/10.4054/DemRes.2005.12.9

Varol, T. (2014). Rethinking past , today and future of Kirkuk and its black gold 1. *European Journal of Research on Education*, *2013*(2147-6284), 12–16.

Vaz, E. (2015). Predicting Urban Growth of the Greater Toronto Area - Coupling a Markov Cellular Automata with Document Meta-Analysis. *Journal of Environmental Informatics*, *25*(2), 71–80. http://doi.org/10.3808/jei.201500299

Verburg, P. H., Kok, K., Pontius Jr, R. G., & Veldkamp, A. T. (2006). Modeling Land-Use and Land-Cover Change. In E. F. Lambin & H. Geist (Eds.), *Land-Use and Land-Cover Change Local Processes and Global Impacts*. Berlin, Germany: Springer-Verlag.

Waddell, P., Ulfarsson, G. F., Franklin, J. P., & Lobb, J. (2007). Incorporating land use in metropolitan transportation planning. *Transportation Research Part A: Policy and Practice*, *41*(5), 382–410. http://doi.org/10.1016/j.tra.2006.09.008

Wang, L., Hu, H., Zheng, X., Deng, J., & Ning, G. (2010). Study on LUCC Based on Vector Date Source Using the CA_Markov Model: A Case Study of Changping District, Beijing, China. In *2010 International Conference on Multimedia Technology (ICMT)* (pp. 1–4). Ningbo, China: IEEE.

Wang, S. Q., Zheng, X. Q., & Zang, X. B. (2012). Accuracy assessments of land use change simulation based on Markov-cellular automata model. *Procedia Environmental Sciences*, *13*, 1238–1245.

Ward, D. P., Murray, a. T., & Phinn, S. R. (2000). A stochastically constrained cellular model of urban growth. *Computers, Environment and Urban Systems*, *24*, 539–558. http://doi.org/10.1016/S0198-9715(00)00008-9

Ward, D. P., Murray, A. T., & Phinn, S. R. (2003). Integrating spatial optimization and cellular automata for evaluating urban change. *The Annals of Regional Science*, *37*(1), 131–148.

Weerakoon, K. (2002). Integration of GIS based suitability analysis and multicriteria evaluation for urban land use planning; contribution from the Analytic Hierarchy Process. *3rd Asian Conference on Remote Sensing. Asian Association on Remote Sensing, Nepal*, (October).

Wegener, M. (2004). Overview of land-use transport models. *Transport Geography and Spatial Systems*, 127–146. http://doi.org/10.1007/s10654-011-9614-1

White, R., & Engelen, G. (2000). High-resolution integrated modeling of spatial dynamics of urban and regional systems. *Computers, Environment, and Urban Systems*, *24*, 383–400.

Wierzbicki, A. P., & Hillier, F. S. (2010). The Need for and Possible Methods of Objective Ranking. In M. Ehrgott, J. R. Figueira, & S. Greco (Eds.), *Trends in Multiple Criteria Decision Analysis* (1st , p. 462).

Wolff, S. (2010a). Governing (in) Kirkuk: Resolving the status of a disputed territory in post-American Iraq. *International Affairs*, *86*(6), 1361–1379. http://doi.org/10.1111/j.1468-2346.2010.00948.x

Wolff, S. (2010b). Governing (in) Kirkuk: resolving the status of a disputed territory in post- American Iraq. *International Affairs*, *86*(6), 1361–1379.

Wu, F., & Webster, C. J. (1998). Simulation of land development through the integration of cellular automata and multicriteria evaluation. *Environment and Planning B-Planning & Design*, *25*(1), 103–126. http://doi.org/Doi 10.1068/B250103

Xia Li & Anthony Gar-On Yeh. (2000). Modelling sustainable urban development by the integration of constrained cellular automata and GIS. *International Journal of Geographical Information Science*, *14*(2).

Xia Lia & Anthony Gar-On Yehb. (2004). Data mining of cellular automata's transition rules. *International Journal of Geographical Information Science*, *18*(8).

Yang, X., Zheng, X. Q., & Lv, L. N. (2012). A spatiotemporal model of land use change based on ant colony optimization, Markov chain and cellular automata. *Ecological Modelling*, *233*, 11–19.

Ye, B., & Bai, Z. (2008). Simulating land use/cover changes of Nenjiang county based on CA-Markov model. In D. Li (Ed.), *Computer And Computing Technologies In Agriculture, Volume I* (pp. 321–329).

Yeh, A. G. O., & Li, X. (2001). A constrained CA model for the simulation and planning of sustainable urban forms by using GIS. *Environment and Planning B: Planning and Design*, *28*(5), 733–753.

Yeh, G.-O., & Li, X. (2000). A Constrained CA Model for the Simulation and Planning of Sustainable Urban Forms by Using GIS. *Environment and Planning B-Planning & Design*.

Yu, J., Chen, Y., & Wu, J. P. (2009). Cellular automata and GIS based landuse suitability simulation for irrigated agriculture. In *18th World IMACS / MODSIM Congress*. Cairns, Australia.

Yue, W., Liu, Y., & Fan, P. (2013). Measuring urban sprawl and its drivers in large Chinese cities: The case of Hangzhou. *Land Use Policy*, *31*, 358–370. http://doi.org/10.1016/j.landusepol.2012.07.018

Zhang, Q., Ban, Y., Liu, J., & Hu, Y. (2011). Simulation and analysis of urban growth scenarios for the Greater Shanghai Area, China. *Computers, Environment and Urban Systems*, *35*, 126–139.

Zhang, X., Kang, T., Wang, H., & Sun, Y. (2010). Analysis on spatial structure of landuse change based on remote sensing and geographical information system. *International Journal of Applied Earth Observation and Geoinformation*, *12*, S145–S150. http://doi.org/10.1016/j.jag.2010.04.011