UNIVERSITI PUTRA MALAYSIA

A GEOSPATIAL APPROACH IN MODELING URBAN LAND DEVELOPMENT AND REDEVELOPMENT OF BANDAR ABBAS, IRAN

MOHSEN DADRAS

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A GEOSPATIAL APPROACH IN MODELING URBAN LAND DEVELOPMENT AND REDEVELOPMENT OF BANDAR ABBAS, IRAN

By

MOHSEN DADRAS

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

March 2015

Objective of this study is to arrive at a better understanding of spatio-temporal dynamics of urban growth through integration of mathematical and statistical models and remote sensing data, and the techniques of GIS. Bandar Abbas is the study area of this research. Bandar Abbas has been facing many problems such as decayed urban district, unbalance and interaction of uses, restrictions of lands suitable for development, and physical limitation in urban sprawl due to the irregular growth, increasing migration of population and the lack of planning in urban management. The remote sensing data were used to calculate the urban sprawl and changes in land use. The results indicate that from 1956-2012, the urban area has increased from 403.77 hectares to 4959.59 hectares and the population of the city has grown to more than 30 times in the past six decades. The sprawl of the urban boundary of Bandar Abbas is determined by using the aerial photos and satellite images of 5 periods in over 56 years in this study. The analysis of remote sensing data in the 60-year period show that more than 50 percent of the urban area in Bandar Abbas city in decayed areas is scattered. The criteria and sub-criteria effective in urban development and redevelopment were determined based on experts' opinions, model of Pathway Analysis and creation of statistical database based on questionnaires. According to the main objective of the study, a novel method is used for identification of suitable land for development and redevelopment in urban areas. Using the results obtained in this study, a novel method to identify the following effective criteria and sub-criteria, determine the suitable land for urban development and redevelopment, provide planning and land management solution based on smart growth model and taking into account the actual conditions existing in parallel developed and presented.

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of philosophy

A GEOSPATIAL APPROACH IN MODELING URBAN LAND DEVELOPMENT AND REDEVELOPMENT OF BANDAR ABBAS, IRAN

By

MOHSEN DADRAS

March 2015

Chairman: Associate Professor Helmi Zulhaidi bin Mohd Shafri, PhD

Faculty: Engineering

In general, the objective of this study is to arrive at a better understanding of spatio-temporal dynamics of urban growth through integration of mathematical and statistical models and data remote sensing (RS), and the techniques of GIS. Bandar Abbas is the study area of this research. Bandar Abbas has been facing many problems such as decayed urban district, unbalance and interaction of uses, restrictions of lands suitable for development, and physical limitation in urban sprawl due to the irregular growth, increasing migration of population and the lack of planning in urban management.

The remote sensing data were used to calculate the urban sprawl and changes in land use. The results indicate that from 1956-2012, the urban area has increased from 403.77 hectares to 4959.59 hectares and the population of the city has grown to more than 30 times in the past six decades. The sprawl of the urban boundary of Bandar Abbas is determined by using the aerial photos and satellite images of 5 periods in over 56 years in this study. The comparison of the results obtained from the analysis of the master plan show that in terms of the pattern of land-use changes in the fundamental changes over the past 60 years has been created. However, such comparison indicates that the current situation is a continuation of the past and the irregularity of urban growth from a lack of appropriate allocation of land use and lack of knowledge about the land use changes over the past years. The first objective of the research and results obtained from the use of spatial data with high spatial resolution are upgraded and the master plan of land use is refined to identify the finer land use changes.

Then, in order to identify the process of urban sprawl over time, the official boundary of Bandar Abbas was divided which is placed in a circular area in 32 geographical directions. The statistical models of Pearson chi-square and the Shannon's entropy were used to calculate the degree-of-freedom and degree-of-sprawl used in the analysis of urban growth. The results of the analysis show that Bandar Abbas enjoys high degree-of-freedom and degree-of-sprawl and negative value of degree-of-goodness.

The second objective of the study was to analyze the pattern and process of urban growth over the past 60 years. To achieve the second objective of the study, the remote sensing data with high spatial resolution are used in order to extract the built-up areas. Further, the use of statistical models and its analysis to identify more precisely the pattern and process of urban growth in the past 60 years are also utilized. The analysis of remote sensing data in the 60-year period show that more than 50 percent of the urban area in Bandar Abbas city in decayed areas is scattered.

The criteria and sub-criteria effective in urban development and redevelopment were determined based on experts' opinions, model of Pathway Analysis and creation of statistical database based on questionnaires. The analysis is performed by entering the intended variables and to use the mathematical and statistical formula and GIS tools. The qualitative and quantitative models such as Analytical Hierarchy Process (AHP), Fuzzy AHP, Frequency Ratio, Weighting index, and Weighting factor are used in this study for identification of lands suitable for development and redevelopment. TOPSIS model is used as an ideal solution to identify and prioritize appropriate lands identified. Then, the models of smart growth (TND, RCD and SD) and Smart Code are applied for the planning of lands identified.

The correlation between the 1300 points sampled and field observations show that the Fuzzy AHP model has the most significant correlation (R^2= 0.822) with the reality. Eastern and southern neighborhoods of the city have a great potential for urban development. Based on the models used in identifying suitable land for urban redevelopment, Frequency Ratio model has the most significant correlation (R^2= 0.918) with the reality. The central, southern and southwestern areas adjacent to Bandar Abbas have great potential for urban redevelopment.

For third and fourth objective of the study, a novel method is used for identification of suitable land for development and redevelopment in urban areas. Using the results obtained in this study, a novel method to identify the following effective criteria and sub-criteria, determine the suitable land for urban development and redevelopment, provide planning and land management solution based on smart growth model and taking into account the actual conditions existing in parallel developed and presented.

Abstrak thesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENDEKATAN GEOSPATIAL DALAM PEMODELAN PEMBANGUNAN TANAH BANDAR DAN PEMBANGUNAN SEMULA BANDAR ABBAS, IRAN

Oleh

MOHSEN DADRAS

Mac 2015

Pengerusi: Profesor Madya Helmi Zulhaidi bin Mohd Shafri, PhD

Fakulti: Kejuruteraan

Secara umumnya, objektif kajian ini adalah untuk mendapatkan pemahaman yang lebih baik tentang dinamik spatio-temporal dalam pertumbuhan bandar melalui integrasi model matematik dan statistik dan data penderiaan jauh (RS), dan teknik GIS. Kawasan kajian dalam penyelidikan ini adalah Bandar Abbas. Disebabkan oleh pertumbuhan yang tidak teratur, peningkatan penghijrahan penduduk dan kurangnya perancangan dalam pengurusan bandar, Bandar Abbas telah menghadapi banyak masalah dalam beberapa dekad kebelakangan ini seperti kemerosotan bandar, keseimbangan dan interaksi kegunaan, sekatan tanah yang sesuai untuk pembangunan, dan penularan fizikal terhad di bandar.

Untuk mengira terkapar bandar dan perubahan dalam penggunaan tanah, data remote sensing telah digunakan. Keputusan menunjukkan bahawa dalam tempoh 1956-2012, kawasan bandar telah meningkat daripada 403.77 hektar kepada 4959.59 hektar, dan penduduk bandar telah berkembang kepada lebih daripada 30 kali dalam tempoh enam dekad yang lalu. Dalam kajian ini, gambar-gambar dari udara dan imej satelit dalam 5 tempoh, lebih 56 tahun telah digunakan untuk menentukan sempadan penularan bandar di Bandar Abbas. Bandingkan keputusan yang diperolehi daripada analisis paln induk menunjukkan bahawa dari segi corak guna tanah perubahan dalam perubahan asas dalam tempoh 60 tahun yang lalu telah dijadikan. Walau bagaimanapun, dengan membandingkan keputusan yang diperolehi dengan pelan induk yang menunjukkan bahawa keadaan semasa adalah sebenarnya kesinambungan masa lalu dan ketidakteraturan pertumbuhan bandar dari kekurangan peruntukan yang sesuai penggunaan tanah dan kekurangan pengetahuan tentang perubahan penggunaan tanah ke atas tahun yang lalu. Malah, Objektif pertama kajian dan sumbangan hasil daripada penggunaan data spatial dengan resolusi spatial tinggi telah dinaik taraf dan memperbaiki pelan induk penggunaan tanah dan mengenalpasti lebih halus adalah penggunaan tanah perubahan.

Kemudian, untuk mengenalpasti proses penularan Bandar dari masa ke masa, sempadan rasmi Bandar Abbas dibahagikan kepada 32 arah geografi dan diletakkan di kawasan bulatan. Model statistik Pearson chi-square dan entropi Shannon ini telah digunakan untuk mengira darjah kebebasan dan darjah penularan yang digunakan dalam analisis pertumbuhan bandar. Keputusan analisis menunjukkan bahawa Bandar Abbas menikmati darjah kebebasan yang

tinggi dan darjah penularan dan nilai negatif darjah kebaikan. Objektif kedua kajian ini adalah untuk menganalisis corak dan proses pertumbuhan bandar sejak 60 tahun yang lalu. Menurut hasil, kedua penyelidikan sumbangan objektif menggunakan data penderiaan jauh dengan resolusi spatial tinggi untuk mengekstrak kawasan binaan, penggunaan model statistik dan analisis untuk mengenal pasti dengan lebih tepat corak dan proses pertumbuhan bandar di 60 masa lalu tahun. Analisis data remote sensing dalam tempoh 60 tahun yang menunjukkan bahawa lebih daripada 50 peratus daripada kawasan bandar di bandar Bandar Abbas di kawasan reput bertaburan.

Kriteria dan sub-kriteria yang berkesan dalam pembangunan bandar dan pembangunan semula telah ditentukan berdasarkan pendapat pakar-pakar, model Analisis Laluan dan penciptaan pangkalan data statistik berdasarkan kepada soal selidik dengan memasukkan pembolehubah yang dimaksudkan bagi menjalankan analisis menggunakan formula matematik dan statistik dan alat GIS. Model-model kualitatif dan kuantitatif digunakan dalam kajian ini untuk mengenal pasti tanah-tanah yang sesuai untuk pembangunan dan pembangunan semula termasuk Proses Hierarki Analisis (AHP), Fuzzy AHP, Nisbah Frekuensi, indeks Pemberat, dan faktor Pemberat. Model TOPSIS telah digunakan sebagai satu penyelesaian yang ideal untuk mengenal pasti dan memberi keutamaan kepada tanah-tanah yang sesuai. Seterusnya, model pertumbuhan pintar (TND, RCD dan SD) dan Kod Pintar digunakan bagi perancangan tanah yang dikenal pasti.

Hubungan antara 1300 titik sampel dan pemerhatian di lapangan menunjukkan bahawa model AHP Fuzzy mempunyai korelasi yang paling penting (R^2 = 0.822) dengan realiti. Kawasan timur dan selatan bandar mempunyai potensi yang besar untuk pembangunan bandar. Berdasarkan model yang digunakan dalam mengenal pasti tanah yang sesuai untuk pembangunan semula bandar, model Nisbah Kekerapan mempunyai korelasi yang paling penting (R^2 = 0.918) dengan realiti. Kejiranan di Bandar tengah, selatan dan selatan-barat Bandar Abbas mempunyai potensi yang besar untuk pembangunan semula bandar. Menurut ketiga-alik objektif dan hasil carian dicapai, Sumbangan utama di bahagian kajian membentangkan kaedah baru untuk mengenal pasti tanah yang sesuai untuk pembangunan dan pembangunan semula di kawasan bandar. Dengan menggunakan keputusan yang diperolehi dalam kajian ini, satu kaedah baru untuk mengenal pasti kriteria berikut berkesan dan sub-kriteria, menentukan tanah yang sesuai untuk pembangunan bandar dan pembangunan semula, menyediakan perancangan dan penyelesaian pengurusan tanah berdasarkan model pertumbuhan pintar dan mengambil kira keadaan sebenar sedia ada selari dibangunkan dan dibentangkan.

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I certify that a Thesis Examination Committee has met on 2 March 2015 to conduct the final examination of Mohsen Dadras on his thesis entitled "A Geospatial Approach in Modeling Urban Land Development and Redevelopment of Bandar Abbas, Iran" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

Hussain bin Hamid, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Shattri bin Mansor, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Abd. Rahman bin Ramli, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Ramesh P.Singh, PhD
Professor
Chapman University
United States
(External Examiner)

ZULKARNAIN ZAINAL, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 15 April 2015

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

Helmi Z.M. Shafri, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

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

Biswajeet Pradhan, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

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Professor and Dean
School of Graduate Studies
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Signature: _____
Name of Chairman of Supervisory Committee: Dr. Helmi Zulhaidi Mohd Shafri
Associate Professor
Department of Civil Engineering
Faculty of Engineering
Universiti Putra Malaysia
43400 UPM Serdang, Selangor Darul Ehsan

Signature: _____
Name of Member of Supervisory Committee: Prof. Madya Dr. Biswajeet Pradhan
Jabatan Kejuruteraan Awam
Fakulti Kejuruteraan
Universiti Putra Malaysia
43400 Serdang, Selangor

Signature: _____
Name of Member of Supervisory Committee: Dr Noordin Ahmad
Jabatan Kejuruteraan Awam
Fakulti Kejuruteraan
Universiti Putra Malaysia

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AHP	Analytical Hierarchy Process
APA	American Planning Association
ASTER	Advanced Space borne Thermal Emission and Reflection Radiometer
DA	Discriminant Analysis
DEM	Digital Elevation Model
et al.	et alia
etc.	et cetera
ETM+	Landsat Enhanced Thematic Mapper Plus
FR	Frequency Ratio
FAHP	Fuzzy AHP
GIS	Geography Information System
ha	hectare
HS	High Suitable
HUS	High Unsuitable
IMU	Inertial Measurement Unit
IRS	Indian Remote Sensing
Km	kilometer
LD	Land Development
LRD	Land Redevelopment
LUC	Land Use Change
LULU	Land Use Land Cover
LUCD	Land Use Change Detection
MCDM	Multi Criteria Decision Making
M	meter
M	Moderate
PA	Pathway Analysis
PSO	Port and Shipping Organization
RCD	Regional Center District
RS	Remote Sensing
SD	Special District
SG	Smart Growth
S	Suitable
TFN	Triangular Fuzzy Number
TND	Traditional Neighborhood Center
TOPSIS	The Technique for Order of Preference by Similarity to Ideal Solution
US	Unsuitable
VHS	Very High Suitable
VHUS	Very High Unsuitable
Wf	Weighting factor
Wi	Weighting index

CHAPTER I

INTRODUCTION

1.1 Introduction

In developing countries, population growth has increased the demand for land use appropriate for residence and providing suitable infrastructure. On the other hand, this process is deemed a necessity in maintaining the sustainable development of urban land in the cities facing restrictions in the land-use appropriate for development. Therefore, a variety of aspects have to be investigated in urban development, including items such as: changes in land use in past and present, urban expansion, identifying land suitable for the development and redevelopment and urban planning and management. The process of urbanization in history has always been dependent on several factors such as environmental and ecological, physical, economic, social, cultural, political and structural ones. In the present century, due to the advances in technology, several factors have been effective in the process of urban growth and development, such as landscapes, the development of infrastructure and appropriate access in urban communities (Knox, 1994).

The process of urbanization has always occurred along with physical expansion of cities and changes in landscapes and urban uses. In the last few decades, given the city's population increase, expansion of cities and changes in landscapes and uses have been observed to had speeded up in developed and developing countries. Total area of the construction in cities with a population of more than 100000 in 1990 has increased by one-third of the extent of the period 1990-2000 and this growth has occurred almost equally in industrial and developing countries (Angel et al., 2005). Countries of India, China and South Africa have had the highest rate of growth of urban land expansion in the past two decades and the North America has had the highest change in the total amount of the urban expanse from 1970 up to 2012 (United Nations, 2012). In the year 2012, the urban population rate had been 52% (3.6 billion), whilst it had been 13% in 1900 (United Nations, 2012).

Changes in the population are deemed as a basic and important factor in the process of formation and spatial expansion of cities, especially in developing countries. In the industrial and developed countries wherein population growth is more or less stabilized, the spatial growth of cities has occurred quickly. Factors influencing the occurrence of this phenomenon, one can primarily mention the increased citizens' demand for private vehicles and the economic growth of urban communities due to the changes brought about by industrialization in these communities (Clarke et al., 1997).

Land development is conversion of raw land into construction ready housing, commercial, educational, green space, sport or industrial building sites. Land development process involves improvements that have indefinite life, such as draining, dredging, excavating, filling, grading, paving, etc. Land development refers to altering the landscape in any number of ways such as: Changing landforms from a natural or semi-natural state for a purpose such as agriculture or housing, Subdividing real estate into lots, typically for the purpose of building homes,

Developing property or changing its purpose, for example by converting an unused factory complex into condominium. Also, the improvement of legislation in the land development process is very efficient and leads to the sustainable development of urban areas (Spitz and Moreno, 1996; Blasius and Friedrichs, 2007; Lehman, 2007; Firman, 2009; Gong et al., 2014; Long et al., 2012; Long and Liu, 2012).

Variations on redevelopment include: Urban infill on vacant parcels that have no existing activity, but were previously developed, especially on Brownfield land, such as the redevelopment of an industrial site into a mixed-use development (Grete Swensen, 2012; American Planning Accosssiation, 2009). Constructing with a denser land usage, such as the redevelopment of a block of townhouses into a large apartment building. Adaptive reuse, where older structures which have outlived their uses are converted into new ones, such as an industrial mill into housing lofts. Redevelopment projects can be small or large ranging from a single building to entire new neighborhoods or "new town in town" projects.

Redevelopment also refers to region and district statutes which give cities and counties the authority to establish redevelopment agencies and give the agencies the authority to attack problems of urban decay (Grete Swensen, 2012; Ghamami et al., 2010; Andalib, 2010; Adhvaryu, 2011). The fundamental tools of a redevelopment agency include the authority to acquire real property, the power of eminent domain, to develop and sell property without bidding and the authority and obligation to relocate persons who have interests in the property acquired by the agency. The financing of such operations might come from borrowing from federal or state governments and selling bonds and from Tax Increment Financing (Grete Swensen, 2012; American Planning Accosssiation, 2009).

Other terms sometimes used to describe redevelopment include urban renewal (urban revitalization). While efforts described as urban revitalization often involve redevelopment, they do not always involve redevelopment as they do not always involve the demolition of any existing structures but may instead describe the rehabilitation of existing buildings or other neighborhood improvement initiatives (Wang et al., 2011; Wang et al., 2013; Pearsall et al., 2014; Loures, 2015; Wang et al., 2013).

It is very necessary from different aspects to review the process of use changes and urban landscape, pattern of urban growth and urban expansion. At first, the continuous or discontinuous spatial growth of cities, when considered on a global scale, has a significant impact on the performance of the earth system from different aspects (Lambin et al., 2001; Foley et al., 2005).

The size and complexity of urban growth has significantly increased. This process is very impressive and tangible in developing countries and has caused many environmental problems such as deforestation, desertification, soil erosion, the destruction of plant and animal habitats, being exposed to or the extinction of plant and animal communities, climate changes, the loss of healthy water sources and several other items (Seto and Fragkias, 2005; Yu and Ng, 2007).

In the second stage, changes in prospects and the spatial growth of cities can have some negative impacts on urbanization, which may prevent the sustainable development of urban systems. For example, some topics such as: traffic congestion, air and water quality deterioration, poverty, crime and unemployment are closely related to the urban sprawl and the aforementioned factors will certainly have a direct impact on sustainable urban development. Thirdly, the spatial growth of cities and prospect changes, as discussed above, are the results of the process of urban development and urbanization. Monitoring, modeling and planning of urban growth can definitely provide useful and practical insight in the process of urbanization. In other words, the measurement and analysis of urban patterns may be considered as an effective way in understanding the factors involved in the formation and the rise of urban phenomena which eventually results in the analysis of the process of urban growth and dynamism (e.g., Clarke et al., 1997; Dietzel et al., 2005; Seto and Fragkias, 2005; Hu and Lo, 2007; Serra et al., 2008).

In the fourth stage, the irregular growth of cities and construction of incompatible uses leads to stagnation of development and reduction of the quality of residence in urban areas. Another very important item is the reduction and loss of land suitable for development in urban areas. The irregular growth of cities in developing countries without taking into account the sustainable development and the loss of suitable urban development plans, today has reduced lands suitable for physical and structural development in cities. The less developed regions, without paying attention to their physical structure, are approaching disintegration in the passage of time. This process causes numerous problems in economic, social, security and development aspects in the future, and today this problem is deemed one of the serious obstacles to development in large cities.

However, the complexity of urban systems is considered as a fundamental challenge in urban growth studies, prospect changes, and land uses. As stated above, the process of urbanization and its development can be affected by several factors such as social, political, economic, cultural and physical.

The spatial dimensions of the cities may witness a variety of growths in the passing of time and place. Monitoring of urban growth and its modeling, using Remote Sensing (RS) data and Geographic Information System (GIS), can be helpful in better understanding the process of spatial changes of cities in different time periods and various places.

Due to the interaction between local communities and the effects of globalization, urban systems are rapidly changing and becoming more complex (Seto and Fragkias, 2005). In addition, access to a model specifying the effects of the feedback of urban sprawl during the process of urbanization is very difficult. The duration of this effect, since it is dependent on a variety of factors and criteria, makes too much complex and extensive the simulation and estimation of existing reality (Liu et al, 2007). For example, the environmental degradation caused by urban sprawl may change the behavior of human populations and the policies of using the land, and because of its non-linearity and feedback of the effects; it complicates the simulation of the causal relationship of the phenomena and effective criteria towards each other. In addition, connecting and bringing together the human communities living around the cities such as villages and residential settlements, given the physical expansion of cities, increase effective criteria and more complicate measurement of urban development (Clarke et

al., 1997). Of examples of these criteria, one can mention: impacts of nation, culture, religion and lifestyle upon the spatial growth of the city.

Due to the complexity of the process of urbanization, an integrated approach to the use of remote sensing data, geographic information system and qualitative and quantitative models can be helpful in describing the patterns of growth, identifying effective parameters and criteria in the urban development and redevelopment and finally urban ultimately planning and determining the development plan in urban areas. It also provides us with a clearer understanding of the spatial and temporal dynamics of the growth of urban areas.

Remote sensing data such as aerial photos and satellite images, given their cost-effectiveness and accuracy, play a significant role in collecting information on land cover and doing studies on the process of urban growth using the manual interpretation or auto classifieds (Golubiewski and Hussein, 2007). Classification is an optimal method, but sometimes due to the complex and heterogeneous structures such as urban land use, the process of classification can be a bit difficult. Essentially, the parameters of the accuracy of collecting data, the type of sensor, the quality of the images, time of collecting, spectral wavelength of taking photos, and the type of images in term of colorful and black-and-white have a significant role in the process of interpretation and classification of images.

Geographic information system (GIS) is an organized collection of computer hardware and software, geographic information, and specialists designed and developed for collecting, saving, updating, processing, analyzing and presenting all geographic information. The application of GIS in urban studies has a lot of variety. Modeling of urban land uses, forecasting, supply and demand in housing, determining the optimal path for vehicles, determining and identifying the urban boundary, finding locations for development, planning events, urban crisis management, and planning for land uses are instances of its applications in urban planning.

The rapid increase in population, shortage of land suitable for housing and identifying lands suitable for urban development makes obvious an ever-increasing need to plan in all aspects of life. Urban communities and the city are no exceptions to this planning and management. Considering that the population of developing countries is largely scatted in urban areas and all around the country, the exact and all-inclusive management of the lives of human communities and issues related to it seems essential. Investigation of various aspects of urban planning and management and decision-making in relation to it requires having information on the historical background and current status, and predicting conditions of urban environments.

Creation of the geodatabase of attribute and spatial data for urban studies is very essential. The diversity and extent of the accuracy of the information and the collection of data associated with urban issues for the use of analytical models are very important. Geodatabase of spatial data in urban studies includes remote sensing data (aerial photos, satellite images), GPS data, topographic maps, land use and cover maps, cadaster maps and etc. The attribute information is based on field information, population census, attribute data of urban land uses and land cover, environmental, cultural, economic, social, political, and etc.

Several statistical and mathematical models are used in the field of urban studies and investigation and identification of lands suitable for development and redevelopment in the urban areas. Some of the examples of the models mentioned, which have been used in this study are: Analytical Hierarchy Process (AHP), Fuzzy AHP, Fuzzy TOPSIS, Frequency Ratio (FR), Weighting index (Wi), and Weighting factor (Wf). Also the models used for investigating the process of changes in land-use and urban growth include: Land Use Change Detection, Pearson's Chi-square, Shannon's Entropy and Degree-of-Goodness. In the following, the models of Smart Growth (SG) and Smart Code (SC) can be used in planning the land uses identified.

The basis of the models of urban land identification for development and redevelopment is the opinions of certified experts and the creation of a statistical database is based on a questionnaire; which makes their analysis and study possible by entering the intended variables and the use of mathematical and statistical relationships and tools of GIS. Another advantage of using these models is increasing the accuracy and reducing the computational error in the urban analyses. But, this essential point is worth mentioning that the type of the data and the accuracy of collecting play a significant role in determining the level of accuracy and precision of the results achieved.

This essential point should be mentioned that the use of remote sensing data, GIS and combining them with quantitative and qualitative models can be very useful for urban growth studies and land-use changes. Spatial analysis based on various criteria and parameters, the use of GIS techniques in studying patterns of urban growth and development as well as the identification and estimation of urban land use changes at various time intervals extracted by using remote sensing data, are very efficient and useful in the urban development studies and its planning. In addition, the GIS-based spatial analysis can clearly indicate spatial-temporal patterns and the analysis of the process of urban growth based on urban growth patterns observed in the passing of time is possible. So, the integration of quantitative and qualitative models with remote sensing and GIS is very efficient and useful improving detection of urban land use change. Identification and determination of the spatial growth of the city and presentation of development plans based on the identification of the lands which can be used for development and redevelopment and smart growth.

1.2 Problem Statement

The irregular growth of cities and non-monitoring of construction and creation of urban land uses has largely reduced the capability of development in urban areas. This problem and identification of the factors affecting it are deemed as a fundamental problem for managers and urban planners. On the other hand, the irregular growth of city diminishes quality of citizens' residence, services, access and increases urban vulnerability. Another fundamental problem caused by the phenomenon of irregular growth is a destruction of lands suitable for development and redevelopment on the level of cities. Urban boundaries face different limitations in development in the passing of time due to their expansion in different parts and ways such as: natural, topography, and structural. Hence, it highly increases the demand to use the suitable lands inside the city and in open space in the city boundary. In most cases, the lack of suitable land for development in cities, causes all kinds of business brokers, rents, and

mismanagements. Here, a master urban plan which is indispensable is very necessary and it would prevent any kinds of irregular growth and suitable urban land wastage to some extent.

Urban planning in Iran and Bandar Abbas faces several urban growth challenges. Structure of urban planning in Iran is formed based on trans-regional scale development plans, master plan and structure plan. The Ministry of Roads and Urban Development runs such projects. This organization delegates the projects' responsibility to licensed consultant companies. In this study, land use mechanism and urban growth procedure is considered based on standard per capita. Master and structure plans provide applied maps of land use and methodology to urban managers and planners which are used for implementation of development plans in the future. Moreover, the mentioned plans determine the trend of land development in future, population growth rate based urban growth pattern, and standard per capita area needed for each use. In addition, urban development plans determine the boundary between developed and non-developed regions. All irregular and unauthorized constructions as well as fringing areas have been formed in non-developed regions. However, these boundaries and constraints regarding division of regions are not aptly implemented. Almost in all Iranian cities, urban expansion has occurred beyond the boundaries determined by development and master plans. The first master plan for Bandar Abbas city was prepared by Dr. Adibi Consultant Company in 1967. In this plan, 2.3% population growth with a population density equaling to 100 people in each Hectare was predicted. According to prediction of 1967 master plan, the Bandar Abbas city area was supposed to reach 1250 in 1987. Political, social and economic processes played an important role in excessive growth of Bandar Abbas city during the 20 years' time span (1967-1987). The second master plan for Bandar Abbas was provided in 1984. As there were unutilized spaces between built-up regions, the urban growth was predicted in these regions. Furthermore, excessive growth of city boundaries and development of fringing areas were restricted in mentioned master plan. In other words, in this plan urban growth in empty spaces between urban lands were considered as a priority. Yet, urban boundaries grew toward North and North east due to lack of supervision and improper implementation of issues predicted in master plan. The last master plan for Bandar Abbas city was prepared by Sharmand Consultant Company in 2005. Unfortunately, the plan suffers from several shortcomings and it has not been passed by council of architecture and urban development (Appendix 8, 9, and 10).

To sum up, excessive migration to the city, growth of fringing area, lack of reconstruction in old regions of the city, imperfect execution of master plans and lack of supervision on administrative process are the main reasons which have avoided realization of predictions performed by master plans in Bandar Abbas city. Moreover, the political, economic and social evolutions have also played an important role in the growth of Bandar Abbas city in recent decades.

The Master and Structure plans that have been done over the past 60 years in the city of Bandar Abbas have no compatibility with the existing reality. The parameters such as per capita, density, household size and access in the design and layout are not correctly predicted. The function defined for localities and regions based on criteria (such as: cultural and historic, ecological and environmental, physical, economic, social, structural and accessibility) did not affect the current situation and the lack of comprehensive and structure plans has high incompatibility with the fact that are present. Functions defined for urban areas of Bandar Abbas in the past years are not appropriate due to lack of implementation of the comprehensive and structure plans and its incompatibility with the status quo. Factors causing irregular growth

and development are fundamental problems in the sustainable development of the city of Bandar Abbas and hence it will be raised. Other disadvantages of the master and structure plans have been carried out. It can be used to detect failed and decay predictions based on the useful life of the urban uses terms and the standards mentioned. Over time, these factors will accelerate the deterioration of the urban pattern. Hence, the importance of the land redevelopment is more than ever and it is necessary to solve this problem (Appendix 8, 9, and 10).

Locate in the coastal range; the city of Bandar Abbas has had a linear growth and development due to its placement during the past years and since its formation. A large portion of open land suitable for the development has been dedicated to urban land uses. The main obstacle of physical expansion of urban boundary is natural disasters such as: the rocky cliffs and rugged highlands with high slope on the North and the beach in the South. On the East and West of the city, due to the establishment of the military uses such as the airport and the air force in the East, military waterfront, and residential and office complex of Navy in the West and the railway line in the North-West the sprawl of the city is limited (Figure 3.2).

Another effect of irregular growth of Bandar Abbas is the lack of development plan based on the existing facts. Despite being reviewed and modified in different periods, the master plan of the city of Bandar Abbas unfortunately does not have the required executive power being inconsistent with the urban realities. On the other hand, regulatory and executive organizations, such as the organizations of roads and urbanization and municipalities have no monitoring of the implementation of the master plans made during the past 50 years. All these factors have caused a recession in developed and vanishing of uses in the old districts of the city and the lack of balanced and regular urban growth in the newly constructed districts of the city.

Today, the decay of urban buildings is considered as one of the most important and fundamental obstacles in the process of urban development. The city of Bandar Abbas, given its old history, has been witnessing many changes due to the political, social, health, and natural events. These factors have had significant impact upon the behavioral pattern of the inhabitants of regions and citizens, an instance of which being the changes made to the uses and buildings of the city. Unfortunately, due to the lack of investigation into the old and less developed areas of the city of Bandar Abbas, now more than half of the city of Bandar Abbas has old and decayed buildings scattered. In some areas of the city where the density of decayed buildings is more, we are witnessing stunted development and lowered quality of residence.

In what follows in the present research, the identification of the lands suitable for development and redevelopment and planning of lands determined are addressed based on smart growth model. Urban areas are constantly evolving and growing just like vital structure of living organisms and malicious factors definitely have a negative impact on the continuation of this process.

Several factors are involved in the formation and evolution of cities and each factor has several parameters in turn. In the first instance, the identification of the factors contributing to urban growth is very important, although in urban studies the identification and collection of the

effective parameters are very difficult. On the other hand, the use of the appropriate quantitative and qualitative models based on efficient tools is highly important in urban studies. Thus, urban studies are introduced as multi-dimensional topics and each dimension complements other dimensions of urban issues.

Accuracy and precision of spatial and attribute data play a significant role in providing an analysis and getting optimal results. Due to their size and scale, the city-forming components need information with high accuracy and the lowest error. Also, the models used in research must have high abilities in the analysis.

In urban studies, spatial and attribute data collection and creation of a comprehensive database is very difficult and costly, and in many cases, due to such factors, the accuracy of urban studies is reduced drastically. Additionally, statistical and mathematical models which have this ability with a minimum of data entry and analysis to provide results close to reality are very few. For most models of analysis, if lacking appropriate input data, their simulation results and estimations will be less close to the reality. Thus, the aforementioned factors cause difficulties for the managers and urban planners in providing correct and rational decisions.

In this study, using comprehensive spatial and attribute data as well as appropriate qualitative and quantitative models, efforts were made to study the process of land use changes, urban growth, and identify suitable lands, hence planning it based on reality, correctly and with high accuracy.

1.3 Goal and Objectives

Given the importance of effective criteria and various challenges in urban growth studies and landscape and landuse changes, generally, the aim of this research is to improve understanding of the spatial and temporal dynamics of urban spatial growth through integration of quantitative and qualitative models with remote sensing data and GIS technique. In this research how to use quantitative and qualitative models, remote sensing and GIS data in determining the process of growth in Bandar Abbas boundary in 60 years are examined. Identification of urban lands suitable for development and redevelopment and determination of pattern of development of the regions identified based on smart growth model and smart code are addressed. The specific objectives are as follows:

i) To examine the detection of changes in land use/cover and in the patterns of urban sprawl in the city of Bandar Abbas from 1956 to 2012 by using remote sensing and geographic information systems.

ii) To analysis the urban growth (instead of urban development that includes urbanization) with the use of remote sensing data in the past and present along with the statistical models used in different spatial and temporal dimensions.

iii) To identify suitable lands for an urban development and redevelopment based on its applications in the real world and specific criteria and sub-criteria.

iv) To determine the new development pattern based on the Smart Growth Model and Smart Code for suitable lands for development and urban decay area for redevelopment.

In this research effort was made to achieve the specified objectives using the remote sensing data (aerial photos and satellite images), GIS techniques and quantitative and qualitative models based on criteria (historical and cultural, environmental and ecological, physical, economic, social, structural, and access) and specific sub-criteria. Also, according to spatial data of urban growth pattern in over past 60 years and changes in land use, the statistical models were developed for estimation of the process of urban development in Bandar Abbas. It should be noted that in the present research, the study of the process of growth and development of the city depends on the observed patterns.

1.4 Scope of Research

The scope of this research in the first step depends on the simulation and estimation of the process of urban growth and land-use changes so far (1956-2013), used by the aerial photos and satellite images with high spatial resolution. In the second step, the process of identifying lands suitable for development and redevelopment is based on historical and cultural, environmental and ecological, physical, economic, social, structural, and access criteria and the sub-criteria. Each criterion is based on the opinions of experts and attribute and spatial data associated with them. In the final step, the urban growth patterns on the areas identified as suitable for development and redevelopment are used by model of smart growth and smart code.

The scope of mathematical and statistical models used in this research is limited to their performance in simulating the existing reality depend on the spatial and attribute database and opinions of the experts. Also the range of precision of pixels used in the qualitative and quantitative models is 1 meter, established which the geographical effects are extracted from the spatial and attribute database. The region under study is limited to Bandar Abbas as the area under the direct impact and the lands in the urban limits of the policy as being under the indirect impact.

1.5 Thesis Organization

This thesis is organized in seven chapters. The first chapter is devoted to a brief introduction of the concepts and previous researches, problem statements, objectives of the study, and scope of the research.

Second chapter, first defines the basic and applied concepts of urban growth and development. Then, given the objectives of the study, the literature, techniques and models developed such as: changes in land use, urban growth, development and redevelopment of urban land use, smart growth, remote sensing and geographic information systems are discussed.

The third chapter introduces the methods and models used in this research. In the first step, the characteristics of the study area (Bandar Abbas) are explained based on the criteria and sub-criteria of the research. Then, in the second step, the methods of collecting spatial and attribute data, creating a database, and describing the research methodology are addressed. In the final step, in particular, the methods and models used in the study, including land use/cover change (LULC), urban growth, Pathway Analysis, Analytical Hierarchy Process (AHP), Fuzzy AHP, Frequency Ratio (FR), Bivariate Statistics (Weighting index (Wi) and Weighting factor (Wf)), Fuzzy TOPSIS, and Smart Growth are explained.
The fourth chapter analyzes the results obtained from the first objective of the study, which involves assessing changes in land use and urban growth is in the timeframe of 1956-2012.

In the fifth chapter, based on the first part of the third and forth objectives of the research, first by using field observations, experts' opinions and Pathway Analysis model, the results of optimization criteria and sub-criteria in the study were analyzed. In the same chapter, then the results obtained from research models for identification of lands suitable for urban development and their planning were described.

In the six chapters, based on the second part of the third and forth objectives of the research, then the results obtained from research models for identification of lands suitable for urban redevelopment and their planning were analyzed.

Finally, the seventh chapter concludes the results obtained from the analysis of the models used in this thesis based on the research objectives. Also, in the same chapter, the research contributions are described and in the end, some recommendations are provided for the improvement of future research.

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