Remote Sensing and Topographic Information in a GIS environment for Urban Growth and Change: Case Study Amman the Capital of Jordan

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***Abstract*—**Urbanization results in the expansion of administrative boundaries, mainly at the periphery, ultimately leading to changes in landcover. Agricultural land, naturally vegetated land, and other land types are converted into residential areas with a high density of constructs, such as transportation systems and housing.

In urban regions of rapid growth and change, urban planners need regular information on up to date ground change. Amman (the capital of Jordan) is growing at unprecedented rates, creating extensive urban landscapes. Planners interact with these changes without having a global view of their impact.

The use of aerial photographs and satellite images data combined with topographic information and field survey could provide effective information to develop urban change and growth inventory which could be explored towards producing a very important signature for the built-up area changes.

***Keywords*—**Urban growth, aerial photographs, remote sensing, urban inventory, Amman.

I. Introduction

The world has experienced a dramatic growth of its urban population for over the last 50 years. In addition, the rate of the urban population growth is more than that of the rural population (Mahmoud M. Albattah, 1999). Urban population was estimated at 3 billion in 2003, and is expected to rise to 5 billion by 2030. By then; almost two thirds of the world population will be living in towns and cities. More importantly, the speed and scale of this growth have usually been concentrated in developing countries which are characterized by larger metropolitan areas and great number of mega cities.

Cities are expanding in all directions resulting in large-scale urban sprawl and changes in urban land use. With the development and infrastructure initiatives mostly around the urban centers, the impacts of urbanization and sprawl would be on the environment and the natural resources. According to misuse of urban land along with urban sprawl improperly concentrating activities in one region and leaving much waste land, results in environment deterioration problem (e.g. increase of air and water pollution). Transport is a significant source of air pollution and, for some pollutants, the main contributor. 90 per cent of total emissions of Carbon monoxide (CO) in Arab countries are due to vehicular transportation. Arab countries emit 16 million tons/year* of CO (World Bank, 1994). CO can also indirectly contribute to the increase of "greenhouse gases" which are the cause of global climate warming. The Arab world's motor vehicles emit 1.1 million tons/year* of Nitrogen oxides (NOx) (40% of total-60% originates from the energy and industry sectors). A combination of Nitrogen oxides and Sulfur oxides (SOx) contributes to a large extent (about one third) to acid deposition on soil, vegetation and water, thus causing damage to crops, forest, fish, etc. Most importantly, NOx are a cause (or "precursor") of the photochemical smog often observed in large conurbations, particularly during the summer (http://www.un.org/esa/sustdev/csd/csd14/escwaRIM_bp1.pdf)

The spatial pattern of such changes is more clearly noticeable on the urban fringes or city peripheral rural areas, than in the city center. Inadvertently this results in an increase in the built up area and associated changes in the spatial urban land use patterns.

This urban expansion causes loss of productive agricultural lands, other forms of greenery, loss in surface water bodies, reduction in ground water aquifers and increasing levels of air and water pollution. Further, it is widely agreed that fragmentation of land use is also harmful to biological conservation. There has been lot of debates on how to confine urban sprawl and conserve agricultural land resources. There is a demand to constantly monitor such urban changes and understand the processes for taking effective and corrective measures towards a planned and healthy development of urban areas.

Over 50% of the world population lives in urbanized areas. Recent developments of population growth, urban regional migration, and increasing ecological problems require advanced methods for city planners, economists, ecologists and resource managers to support sustainable development of these fast-changing regions. In order to make intelligent decisions and take timely and effective action, planners need extensive, comprehensive knowledge about the causes, chronology, and effects of these processes.

In recent years, cities all over the world have experienced rapid growth because of the rapid increase in world population and the irreversible flow of people from rural to urban areas. Specifically, in the larger towns and cities of the developing world the rate of population increase has been constant and nowadays, many of them are facing unplanned and uncontrolled settlements at the densely populated sites or fringes. To prevent from such occasions urban planners need detailed updated data for thorough planning and management. However, most city planners have a lack of such data and often they possess old data which is not relevant for current decision making. Even if they do not hold detailed updated data of the city area regularly updated data with an acceptable accuracy (urban planners and decision-makers need to have the detailed integrated spatial data sets compiled within a geographical information system (GIS). However, most city planners, especially from developing countries, have a lack of the integrated spatial information relevant for current decision-making) can at least give them an impression about the changes in the city area. While the global population has grown dramatically during the last century, we also have witnessed a 'population implosion': the unprecedented concentration of humans into urban areas around the globe. Since 1800 the number of urban dwellers has jumped by a factor of 100 to 2.5 billion individuals, or nearly one-half of the world's population (Fig. 1). Once confined to the industrialized regions of Europe and North America, the trend is now global, with cities in developing nations growing by up to 7% per year. For this reason the global change that most of Earth's inhabitants will experience during the next decades may well be dominated by the changing demographic, economic, and environmental conditions of the world's cities, rather than by comparatively subtle shifts in climate (Amarsaikhan D, Ganzorig M, Moon TH , 2005), (Mahmoud M. Albattah, 2009)

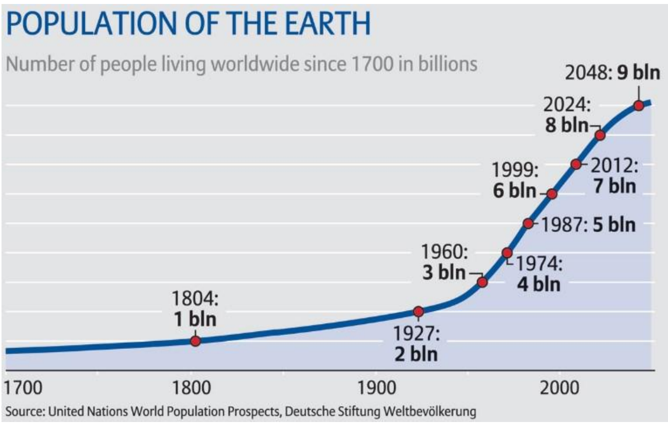

Fig. 1 Global trends in urbanization since 1700, showing the total global urban population

From a broader perspective urbanization is just one of many ways in which humans are altering the landcover of the globe. Most of these landscape transformations occur within a regional context, but the specific, year-to-year changes occur at local scales, often distributed in a seemingly random pattern. Although these human induced land transformations may seem of relatively minor impact considered against the vast reaches of the planet, these changes are estimated to have significantly altered more than 80% of the Earth's land area over the last several centuries.

Of critical importance is linking these observed changes in landcover to the driving socio-economic or environmental origins. In particular, the geography of urban growth offers a graphic depiction of the interplay between economics, political systems, and the environment. While the growth of cities may appear inexorable and monolithic, it reflects a multitude of conscious choices made by individuals and institutions reconciling these competing factors for their own 'best interests'. The sum of these choices appears as the suburbs, shopping complexes, and industrial centers that now populate the globe. It is also true that urban development usually does not follow any simple plan. Early urban growth models based on the steady outward expansion from an intact urban core have yielded to a reality that is far more varied and complex. The spatial organization of cities varies widely, and in part reflects the culture and economic standing of the host region. Viewed through time, urban areas rarely remain static and changes in urban infrastructure, the reallocation of capital, and land conversion can all alter the fabric of the urban plan.

Taken in sum the modern urban plan looks less like clockwork, and more the result of a complex, dynamic system, responding to competing forces.

Assessment and monitoring of urbanization and other localized land transformation is exceptionally difficult at regional and global scales (Mahmoud M. Albattah, 1997), (Mahmoud M. Albattah, Hottier Ph.,199). For some regions of the world, where sophisticated government agencies maintain accurate records for taxation and development purposes, it is often possible to extract at least region-level statistics. However, even in these cases there is rarely specific geographical information to support such figures. In many regions of the world there are no regionally accurate figures on land transformations. This information simply is not gathered, or even when gathered, made publicly available.

One technology which offers considerable promise for monitoring landcover change is satellite remote sensing and aerial photographs. This observation technology provides globally consistent, repetitive measurements of earth surface conditions relevant to climatology, hydrology, oceanography and land cover monitoring. One mission in particular, the Landsat series begun in 1972, was designed and continues to operate with the objective of tracking changes in landcover conditions. The high spatial resolution and regular revisit times of the Landsat mission are well suited to studies of regional, national, and global urbanization. While census data provide a statistical view of demographics and economics, the actual spatial patterns of urban infrastructure only emerge from remotely sensed imagery. Furthermore, the frequent revisit times of satellite sensors constantly update our view of the urban landscape, creating a detailed time-series of urban growth. Rather than simply showing the gross change over a long period, these satellite time-series can record the variability of urban development in space and time, thus permitting a rigorous comparison with economic and demographic data (Mahmoud M. Albattah, Hottier Ph.,1990).

Jordan, as many of the developing countries has a problem with the urban expansion and the growth of population in the main cities especially in the capital Amman. For example, over the last decades Amman, the capital city of Jordan has significantly expanded due to different development activities and migration of people after the Gulf wars in 1990 and in 2004. Various changes have been and are occurring in the city but there are no regularly updated urban data to indicate those changes.

II. Study Area And Population Of Amman

A. Population of Amman

Amman has growth rapidly through a combination of natural population increase, rural-urban migration, influx of migrant labours and Palestinian settlement. Following Israeli occupation of the West Bank of Jordan, many Palestinians settled east the river of Jordan and were further bolstered by 300000 leaving Kuwait after the Gulf War. Combining with very high rates of natural population with in-migration the population of Jordan as a whole has risen dramatically between 1954 and 1994. About half of the population lives within the urban area of Amman and its satellites towns Zarqa and Suwaeleh. The rapid growth of a low density city has not only changes the balance of urban-rural population but has consumed land which is capable of sustaining rain-fed agriculture which is a rare commodity in Jordan.

Water demand has increased with population and has required ground water to be exploited and pumped to Amman.

In general, it should be interesting to study the urban growth in the capital city comparing the growths occurred before 1990 with the changes occurred after this date.

B. Study Area

Amman is located on the undulating plateau that makes up the north-west of Jordan (see Figs. 2 and 3 for a general location map). The original site of the city occupied seven hills or ‘jabals’ around the Wadi ‘Ras el Ain which flows north-east from the plateau toward the River Zarqa basin (see photograph Fig. 4). The original central part of the city was at an altitude of between 725 and 800m. Expansion of the city in the past 25 years has resulted in the occupation of some 19 hills in total with an altitudinal extension to 875m and above. The topography of the city consists of a series of steep hills and deep and sometimes narrow valleys. Most of the districts of Amman take their names from the jabals on which they are situated. While initially development was principally on the upper slopes and crests and the lower slopes of this hill–valley system, the upsurge in urban development over the last 60 years has seen extensive development on the frequently steeper mid-slope locations.

Fig. 2 Map of Jordan from Google

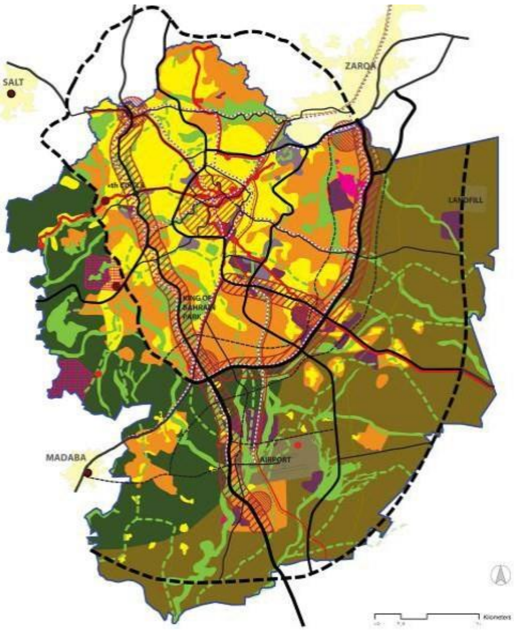

Fig. 3 Amman: general location map from Municipality of Greater Amman (2010)

Fig. 4 Amman: Wadi Ras el Ain from Municipality of Greater Amman (2010)

III. Urban Growth Systems

Urban development is one kind of emergent phenomenon of urban system, which is very complex and hard to measure.

A. Urban Growth

Urban growth indicates a transformation of the vacant land or natural environment to construction of urban fabrics including residential, industrial and infrastructure development. It mostly happens in the fringe urban areas. This process can be regarded as the spatial representation of the economic structural shift of labor away from agricultural to industrial-based activities. Crucial to this shift are the output gains associated with resource transfers from the low-productivity agricultural sector to the high productivity industrial sector.

From systematic view, we can divide urban growth into spontaneous and self-organization process. Spontaneous growth results in a homogeneous and sparse spatial pattern, which contains more random components, whereas self-organizational growth result in spatial agglomeration pattern, which is combined with more socio-economic activities. Clearly, urban growth is one complex spatial changing phenomenon in urban system.

B. Urban Growth Complexity

Modeling urban growth aims to support urban development planning and sustainable growth management. Scientific planning and management must be based on the proper understanding of the dynamic process of urban growth, i.e. from past to present to future. Such understanding enables planners to experimentally simulate "what-if" decision making based on various scenarios. However, the dynamic process involves various socio-economic, physical and ecological components at varied spatial and temporal scales, which result in such a complex and dynamic system. Consequently, it requires a systematic perspective to understand this complexity.

Cities can be understood as complex systems considering their intrinsic characteristics of emergence, selforganizing, self- similarity and non-linear behavior of land use dynamics. As a result of the operation of complex urban system, there exist some spatial processes, like urban expansion, urban pattern change, land use conversion, urban population growth, social development, economic development, etc (Arnold C. L., Gibbons J. C., 1996), (Barros, J. and Sobreira, F., 2002).

Among all these items, some are presented as spatial and temporal changes.

C. Projection of Complexity in Urban Growth

Urban growth consists of the various scales of new projects. Large-scale projects are characterized by heavy investment, long-term construction and the number of actors involved; examples include airports, industrial parks and universities. By contrast, small scale projects are characterized by rapid construction, light investment and few actors; examples can be a private house and a small shop. Urban growth results in various land uses with different levels of social, economic and environmental values. This is a higher dimension of heterogeneity, indicated in the attributes of spatial objects. New development units are the spatial entities carrying heterogeneous social, economic and environmental activities (Clarke, K. C., and Gaydos, J., 1998), (Cheng, J. and Masser, I. (2003)), (W. D. Doyle, 1987).

D. Spatial Complexity

A frequently cited shortcoming of GIS and most spatial analysis tools is their difficulty in dealing with dynamic processes over landscapes. This is not because of a lack of people thinking about dynamic processes in space, nor is it from a lack of talent or technology. It has more to do with the fact that space is inherently complex, and dynamic processes often become complex when they are regarded in a spatial context. As a result, the first step to spatial modeling is to recognize the spatial complexity in the study. Spatial complexity may include spatial interdependence, multi-scale issues and structural or functional complexity (Benfield, F. K., Raimi, M., and Chen D., 1999), (Batty, M., 1981), (Helton D., Gall, M., 1998).

Spatial dependence is defined as a functional relationship between what happens at one point in space and what happens at a neighboring point. In urban growth, spatial dependence is indicated by the impacts of neighboring sites on land conversion of any site which is the result of a causal relationship among neighboring entities, e.g. interaction. The impacts can be twofold: positive (stimulation) or negative (constraint) from three systems. Examples of positive impacts may include transport infrastructure or developed urban area; in particular fringe growth is highly dependent on transport infrastructure. Examples of negative impacts may be steep terrain (slope) and non-developable land such as deep lakes. The complexity lies in the following facts:

- The impacts are determined by an unknown number of factors and their spatial relationships are nonlinear.
- The intensity of spatial dependence or neighborhood size is spatially and locally variable.
- Land conversion includes probability (occurred or not), density (scale), intensity (floor number), function (land use) and structure (shape or morphology); each may have distinguished spatial dependence (Mahmoud M. Albattah, 2004), (Cohen, J., 1995), (Yeh A G, Li X, 2001), (ESRI, 2006).

Urban growth involves a number of hierarchical structures. In the spatial dimension, U includes different levels of shopping centers and road networks; system N includes different levels of ecological units; system P contains different levels of urban planning (general plan, district plan and zoning plan). As a result, urban growth G may be related to more complex spatial hierarchies as interacting with three systems. Urban growth involves both; structure is more linked with pattern and function rather than with process.

The representation or semantics understanding of a spatial system is diverse. The spatial representation of structure and function may influence the spatial understanding of urban growth pattern and process. Its complexity lies in the following:

- The self-organized process of urban growth has complex spatial representation and understanding.
- The interaction between pattern and process is dynamic and non-linear.

E. Temporal Complexity

Urban growth means only increasing the number of new units transformed from nonurban resources. Urban growth is largely controlled or impacted by its economic development scale and environmental protection strategy. Or rather it is controlled by the systematic coordination between the three systems. For example, when system N is not influential and strong, more agricultural land might be lost. Economic development is not predictive, in particular in the long term, due to numerous uncertain factors. The nonlinear interactions between the three systems lead to a non-linear curve of urban growth (Mahmoud M. Albattah, 2008), (Wu, F., and Webester, C. J., 2000).

F. Decision-Making Complexity

Decision-making complexity is indicated in the unit and process of decision-making, and actors or decision-makers. The decision-making unit and process of large-scale projects are relatively more complicated than those of small-scale ones. They involve more actors or decision-makers. However, a small building only needs the decision-making of one private developer. Large-scale projects are limited in quantity and their decision-making is more certain and well planned if compared with others. The latter are large in quantity and their decision-making is more uncertain, dynamic and less organized. However, the collective behaviors of small-scale projects can be emergent, which are controlled or guided by various management and urban development policies. From the perspective of self-organizing theory, all of these small-scale and large-scale projects are spatially and temporally self-organized into an ordering system. The decision-making behaviors of different functions of projects are also disparate, e.g. commercial and residential.

IV. Methodology

In this study we will use data from Remote Sensing (RS) images, Photogrammetry (aerial photographs) combined with topographic data with ArcGis software in urban planning, in order to be able to accurately simulate and model the urban sprawl phenomena in developing countries in general and more precisely in the Jordanian context and thus assess the effect of such urban expansion (Mahmoud M. Albattah, 2004), (Mahmoud

M. Albattah, and H. Kharabsheh, 2000), (Mahmoud M. Albattah, 1988), (Bryant,C.R., Russwarm, L.H. and McLellan, A.G., 1982).

Land use/cover patterns for 1989, 1996 and 2007 were mapped by the use of Multi-date Landsat Thematic Mapper (TM) data, SPOT XS and panchromatic images, aerial photographs, Topographic maps scaled 1:50000, Geologic maps scaled 1:100000, Soil maps scaled 1:50000 and field information about the study area have been collected from several resources such as Royal Jordanian Geographic Center (RJGC), Ministry of public works, Natural resource authority (Mahmoud M. Albattah, 2003), (Mahmoud M. Albattah, 2003).

Landsat thematic mapper and SPOT XS images have been corrected (Image to Map), as follows:

- Four sheets of topographic maps scaled to 1:50000 are used to cover the entire study area, these sheets are called Amman, Sahab, Swaileh, Al-zarqa and they are used as a reference for the image correction.
- Polynomial interpolation using 42 ground control points to get the relationship image-map
- Corrected image are then derived by a resampling process

Features has been enhanced by radiometric correction of Spot XS and Landsat images

SPOT XS and panchromatic images are combined by geometric correction and resampled to derive 10-m resolution SPOT XS images (Mahmoud M. Albattah, 1988), (Hottier Ph., Mahmoud M. Albattah, 1990), (Mahmoud M. Albattah, 1997).

The geometric center of Greater Amman is defined as the intersection point between Princess Basma Street and Wadi Abdoon Street (35°54' E and 31°56N)

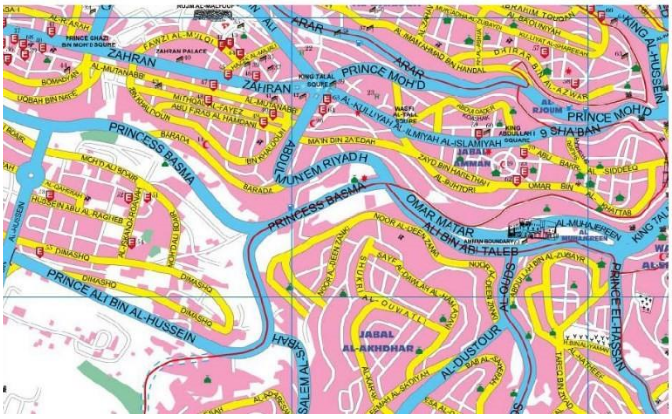

Fig. 5 Amman: Geometric center of Greater Amman location map from RJGC (2007)

Nine land use and land cover types are identified and used in this study, including:

(1) Water area, (2) Built-up area, (3) Cultivated areas, (4) Woods, brushwood, scrub areas, (5) Distorted surface, (6) Quarry or mines, (7) Grassy areas, (8) plowed areas, and (9) Cemeteries. With the aid of Erdas Imagine computer software, each image was enhanced using histogram equalization (in order to gain a higher contrast in the 'peaks' of the original histogram) to increase the volume of visible information. This procedure is important for helping identify ground control points in rectification (Mahmoud M. Albattah, 2000), (Mahmoud M. Albattah, 1999).

As previously stated, all images are rectified to a common UTM (Universal Transverse Mercator) coordinate system based on the 50 000 topographic maps of Greater Amman. Each image was then radiometrically corrected using relative radiometric correction method. A supervised classification with the maximum likelihood algorithm was conducted to classify the Landsat images using bands 2 (green), 3 (red) and 4 (near-infrared). The accuracy of the classification was verified by field checking or comparing with existing land uses and cover maps that have been field-checked. In performing land use/cover change detection, a cross-tabulation detection method was employed. A change matrix was produced with the help of Erdas Imagine software.

Quantitative areal data of the overall land use/cover changes as well as gains and losses in each category between 1989 and 2007 were then compiled (Mahmoud M. Albattah, 1988), (Daniels,T. L., 1997), (Cheng, J. and Masser, I., 2003).

In order to analyze the nature, rate, and location of urban land change, an image of urban and built-up land was extracted from each original land cover image extracted images were then overlaid and recoded to obtain an urban land change (expansion) image. The urban expansion image was further overlaid with several geographic reference images to help analyze the patterns of urban expansion, including an image of the city boundary, major roads, and major urban centers. These layers were constructed in a vector GIS environment and converted into a raster format (grid size=30m) (Bertuglia, C. S., Leonardi, G. and Wilson, A. G., 1990), (Bockstael, N. E., 1996).

The city boundary image can be utilized to find urban land change information within the city. Because proximity to a certain object, such as major roads, has an important implication in urban land development, urban expansion processes often show an intimate relationship with distance from these geographic objects. Using the buffer function in GIS, a buffer image was generated, showing the proximity to the major roads of the study area. Local conditions have been taken into account in selecting the buffer widths. The buffer image was overlaid with the urban expansion image to calculate the amount of urban expansion in each zone. The density of urban expansion was then calculated by dividing the amount of urban expansion by the total amount of land in each buffer zone. These values of density can be used to construct a distance decay function of urban expansion [28], (Brockerhoff, M.P., 2000), (G. R. Faulhaber, 1995), (Mahmoud M. Albattah, and H. Kharabsheh, 2000).

Satellite High Resolution Image Classification

Satellite High Resolution Image Classification

1-Principle of Classification:

The basic principle of the classification is to assign a label to each instance, which is for remote sensing images either a pixel or a region. Each label corresponds to a class having its own properties. The algorithm that assigns these labels is called classifier. The classifier, which can be supervised or not, uses extracted features from the data to choose the labels.

Each region must be characterized by some values to perform a classification that is why we need to extract features from these regions. The following part will present the features that we extracted. Let r be a region of the segmented image and $\Pr = p_{1,r},\ldots p_{k,r}$ *be the set of pixels of size K belonging to the region r.* $I_{p,b}$ *is the intensity of the pixel p in the band b.*

The intensity is defined as the mean of the intensity of the pixels belonging to the same region. With multi-spectral data the mean can be computed on each band. The mean intensity for a region r in the band b is given by

$$I_{mean,r,b} = \frac{\sum_{i=1}^{K} I_{pi,r,b}}{K}$$

Two features can also be interesting when using multi-spectral data: the red-infrared and red-green ratios. The first one is useful to detect the wooded areas, since vegetation has a low intensity in the red band but is very sensitive in the near infrared band. The second one can be helpful in the recognition of some farming areas.

The red-infrared ratio is computed with the following equation:

$$Ratio_{R,PIR,r} = \frac{I_{mean,r,R}}{I_{mean,r,PIR}}$$

and the red-green ratio is given by

$$Ratio_{R,G,r} = \frac{I_{mean,r,R}}{I_{mean,r,G}}$$

The standard deviation of intensity is given by

$$I_{std,r,b} = \sqrt{\frac{\sum_{i=1}^{K}(I_{pi,r,b} - I_{mean,r,b})^2}{K}}$$

2-Classifiers:

There is a wide range of classifiers. It is beyond the scope of this work to describe all of them in details. That is why we will first present an overview of some of the most known classifiers. Next, the advantages or disadvantages of each classifier will be discussed. Finally the classifiers that we used in our study will be presented.

Note that we make the difference between unsupervised classifiers, which only need samples to perform automatic classification, and supervised classifiers, which have to be trained with a set of samples whose labels are known, called the training set.

3-Unsupervised classifiers include

- *K-means algorithm*. This starts with arbitrary clusters in the feature space, each of them defined by its centre. The first step consists in assigning the nearest cluster to each sample. In the second step the centers are recomputed with the new clusters. These two steps are repeated until convergence.

- The second algorithm is the *Finite Gaussian Mixture Model*. The model can also be applied to the classification step. In this case each component of the created mixture corresponds to a label

4-Supervised classifiers include:

- *Finite Gaussian Mixture Model*. This is the supervised version of the FGMM. In the first step, the distribution of the training instances for each class is approximated with a mixture of Gaussian probability density functions. Then for each testing sample the best distribution in terms of maximum likelihood is selected and the corresponding label is assigned to the sample.

- The second classier is the *Mahalanobis Distance*. For each class the mean and the covariance matrix are computed according to the training instances. Then for each testing sample we compute the *Mahalanobis Distance* to each class. The nearest class is then assigned to each testing sample.

- The third classifier is the *K-nearest Neighbors*. For each testing sample we search the *K* nearest training instances and the most represented label among these instances is selected.

- *Neural network*. This is a classifier which tries to find nonlinear separating surfaces in the feature space.

- *Support Vector Machine*. The basic principle of a support vector machine in a two-class case is to locate a linear hyper plane that maximizes the distance from the members of each class to the optimal hyper plane. As it is sometimes not possible to separate classes with a linear hyper plane without misclassification, the support vector machine tries to find the optimal nonlinear transformation to apply to the data in order to find a linear separating plane without misclassification. Finally, each testing instance is transformed and the class is chosen depending on which side of the hyper plane this instance lies. This can be easily extended to multi-class cases.

5-Unsupervised FGMM

The FGMM assumes that the data are generated by Gaussian distributions, each of it characterized by its center μ, its covariance matrix Σ and its prior probability α.

This algorithm is implemented as follows:

1. Initialization of parameters Θ_g
2. For each component k of the mixture, compute

$$p(k|x_r,\theta^g) = \frac{p_k(x_r|\theta_k^g)\alpha_k^g}{\sum_{k=1}^{M} p_k(x_r|\theta_k^g)\alpha_k^g}$$

$$\alpha_k^{new} = \frac{\sum_{r=1}^{R} p(k|x_r,\theta^g)}{R}$$

$$\mu_k^{new} = \frac{\sum_{r=1}^{R} x_r\, p(k|x_r,\theta^g)}{\sum_{r=1}^{R} p(k|x_r,\theta^g)}$$

$$\Sigma_k^{new} = \frac{\sum_{r=1}^{R} p(k|x_r,\theta^g)(x_r-\mu_k^{new})(x_r-\mu_k^{new})^T}{\sum_{r=1}^{R} p(k|x_r,\theta^g)}$$

3. Repeat step 2 until convergence of Θ^g.
4. For each sample x_r compute the corresponding label lr given by

$$l_r = \arg\max_k (p_k(x_r|\theta_k))$$

For the classification step, the number of components is simply equal to the number of classes that the user needs to extract from the satellite image. As for the GHMRF algorithm used for the segmentation step, the initialization is very critical because the FGMM is only able to converge to a local minimum. We also suggest to use the k-means algorithm to approximate the components of the mixture. The stopping criterion is fixed around 0.1 percent (Albattah M.M.S., 2014)

V. Results And Discussion

The magnitude of the urban sprawl depicts the state of land use and urbanization process at a particular point of time.

Using a combination of different data types and formats in monitoring urban development makes the study difficult. The main problem encountered during the study is using the data in different coordinate systems (scale, screwing, etc.) and structure (raster, vector). The changes on residential areas obtained via aerial photographs, satellite images, and field data between 1989 – 1996 and 1996-2007 as periods, using effective techniques of Remote Sensing and GIS (ArcGIS software)

TABLE I

PER CENT PROPORTION OF LAND USE TO TOTAL LAND, YEAR 1989

No of Land Use Categories	*Land Use Categories*	*Area in pixels*	*Per cent Proportion of Land Use to Total Land*
1	Wood , Scrub	1197808	7
2	Distorted area	1381163	8
3	Quarry or Mine	1614610	10
4	Plowed areas	2206507	13
5	Grassy areas	7247914	43
6	Cultivated areas	2223111	13
7	Built-up areas	752134	5
8	Water Surfaces	8953	0
9	Unclassified	247585	1
Total		*16879785*	*100*

Table I depicts that the year 1989 has 5 per cent of built-up areas, 13 per cent of cultivated areas, 13 per cent of plowed areas and 43 per cent of grassy areas

TABLE II

PER CENT PROPORTION OF LAND USE TO TOTAL LAND, YEAR 1996

No of Land Use Categories	*Land Use Categories*	*Area in pixels*	*Per cent Proportion of Land Use to Total Land*
1	Wood , Scrub	1173146	7
2	Distorted area	1301246	8
3	Quarry or Mine	1713245	10
4	Plowed areas	1996401	12
5	Grassy areas	6993215	42
6	Cultivated areas	1924768	12
7	Built-up areas	1375381	8
8	Water Surfaces	8623	0
9	Unclassified	194561	1
Total		*16680586*	*100*

Table II depicts that the year 1996 has 8 per cent of built-up areas, 12 per cent of cultivated areas, 12 per cent of plowed areas and 42 per cent of grassy areas. This depicts how the process of land acquisition has taken place by engulfing these areas under the built-up.

TABLE III

PER CENT PROPORTION OF LAND USE TO TOTAL LAND, YEAR 2006

No of Land Use Categories	*Land Use Categories*	*Per cent Proportion of Land Use to Total Land*
1	Wood , Scrub	7
2	Distorted area	7
3	Quarry or Mine	10
4	Plowed areas	11
5	Grassy areas	41
6	Cultivated areas	10
7	Built-up areas	13
8	Water Surfaces	0
9	Unclassified	1
Total		*100*

Table III depicts that the year 2006 has 13 per cent of built-up areas, 10 per cent of cultivated areas, 11 per cent of plowed areas and 41 per cent of grassy areas. This depicts how the process of land acquisition continues to engulfing mainly the cultivated and plowed areas under the barren domain and built-up areas. During this period the built-up area extended along the main high-ways connecting the capital the major cities of the Kingdom.

The growth and trend of urban sprawl can be analyzed by the determination of the change in the per cent of various land use categories during the periods 1989-1996 and 1996-2006. We can notice an increase of 8 per cent (from the total area) in the built-up land and to compensate a strong decline in the cultivated and plowed areas (Mahmoud M. Albattah, 1997), (Mahmoud M. Albattah, 1997), ([22] Wu, F., and Webester, C. J., 2000).

VI. Conclusion

Jordan, as many of the developing countries has a problem with the urban expansion and the growth of population in the main cities especially in the capital Amman. For example, over the last decades Amman, the capital city of Jordan has significantly expanded due to different development activities and migration of people after the Gulf wars in 1990 and in 2004. Various changes have been and are being occurred in the city but there are no regularly updated urban data to indicate those changes.

In this study we presented and applied a methodology for the use of the latest computing and information technology trends (Geographic Information Systems (GIS), combined with Remote sensing (RS), Photogrammetry in urban planning, in order to be able to accurately simulate and model the urban sprawl phenomena in developing countries in general and more precisely in the Jordanian context and thus assess the effect of such urban expansion.

The urban expansion in Amman (the study region) is governed by the transport network. The main arteries along which the sprawl is taking place include, the downtown, Swaileh, Naour, and along the national highways connecting the major cities of the Kingdom.

Results and analysis depict how the process of land acquisition has taken place by engulfing the cultivated and the plowed areas under the built-up and barren domain.

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