THE IMPACT OF SOCIAL AND SECURITY FACTORS ON RESIDENTIAL SITE SUITABILITY BY USING GIS-BASED MCDM APPROACH: A CASE STUDY THE CITY OF KIRKUK, IRAQ

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ABSTRACT

Unplanned population growth, alongside unplanned development, lack of good housing and inadequate infrastructure resulted in a lot of slums and informal settlements in Iraqi cities. In 1980s there were major housing shortage in Iraq as a result of war and political instability which led to economic meltdown. Kirkuk city was one of the most affected cities by multiethnic crises as a result of employment, housing and local government members' concentration in Kirkuk which led to political and economic migration. Suitable site selection for housing is complicated not just because it has to do with technical procedures and topography but due to environmental, social and political issues which can lead to conflict. Hence, this study seeks to discover the suitable site selection for housing using Geographical Information System (GIS), high resolution remote sensing data and multi criteria analysis (MCA)

Keywords: GIS, Residential Planning, Social and Security.

1. INTRODUCTION

The rapid growth of urbanization around the world has lowered the living standards of most urban dwellers (Weber and Puissant, 2003). The world's urban population is predicted to grow to about 2.5 billion people in 2050, especially in Asia and Africa with close to 90% of this increase concentrated in this continents (United Nations, 2014). This continuous population increase and urbanization due to migration from rural to urban areas, creates many social, economic and environmental problems, and will gradually leads to spatial settlements and conversion of natural land for urban use (Overman and Venables, 2005; United Nations, 2014; Abdullahi et al., 2015).

Iraq is a developing country with an increased population size from approximately 13.7 million in year 1980 to approximately 31 million in year 2010. It is believed that the population will keep on increasing, reaching about 71.3million in year 2050 (Landry, 2012) .The rate of population growth in Iraq increased between 1980-1985 from 2.64 percent to 3.12 per cent in 1995-2000. In 2005-2010 it decreased to 2.46 percent. It is further expected to increase to 2.89 in 2010 - 2015 and then eventually decrease to 1.45 per cent in 2045- 2050 (United Nations, 2014).

Iraq has faced major shortage in housing supply since 1980, with not much new development occurred. Housing development and new infrastructure was negatively affected after The First Gulf War of 1991 which was followed by

international sanctions. This led to deteriorate houses in many cities in Iraq because of inability of citizens to rehabilitate own houses (Dobbins, 2003; Nagy, 2006). A survey carried out by Ministry of Municipality & Public Works and Ministry of Construction & Housing IRAQ (State of Iraqi Cities Report, 2007) in order to get a detailed picture and analysis of the reasons for the shortage of housing and how to solve this problem. The estimated demand for housing is approximately 6,8 million units in the year 2030, which means approximate 340.000 units is demanded every year (Al-Shaher, 2013).

The last time Kirkuk had an official plan was in 1975 by Doxiadis and was updated in 1986 by the municipality ministry of Iraq. The city has been altered by the present circumstance and growth. Therefore, there is need for an official master plan that will guide the future growth and development of the city. Figure 1 shows the Master Plan for Kirkuk in 1986 by Doxiadis (taken from the report by DUP Consultants). This master plan indicates key features such as industrial areas at the south (Al Sayida) and to the east (largely undeveloped), green space along the river and a large proposed green area to the east. The master plan has not been implemented, but has become a location for recent informal settlement. Most of the areas proposed for residential development in the Doxiadis Plan have seen some development, although it is clear that there remain significant areas that have not been taken up (Frischmann, 2009).

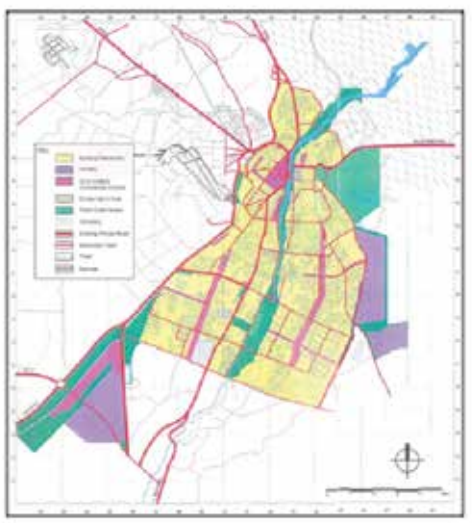

Fig.1: Master Plan by Doxiadis, from report by (DUP Consultants, March 2006)

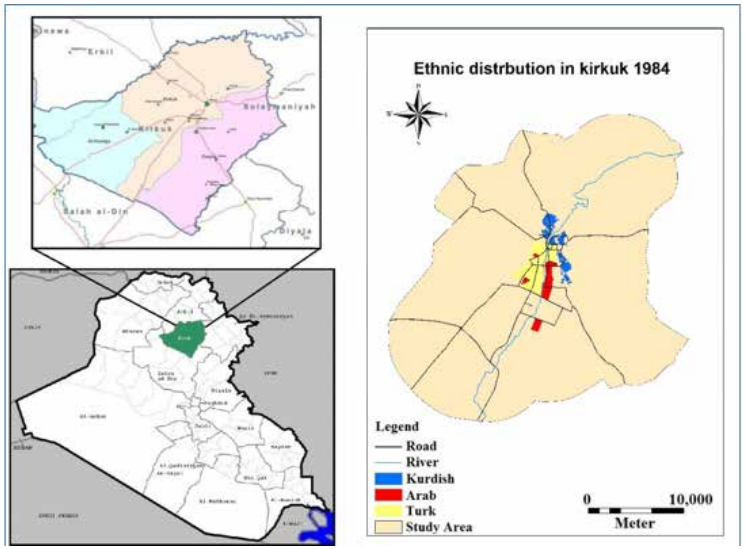

Fig.2: Study area: Kirkuk city (A. A. and M. Knights, 2010)

2. MATERIALS AND METHOD

A large number of data and information are required for a reliable and comprehensive housing site suitability analysis. GIS is capable in managing large dataset such as data input, storage, and retrieval, manipulation and analysis. This capability of performing an integrating spatial and attribute data is useful to obtain information in particular applications and analysis as well as producing maps. In addition, GIS is also capable of integrating multisource dataset such as data of land use, population, transportation, vegetation, infrastructure, climate and etc. GIS may assist town planner deals with the power relationship and complex urban problems such as socio political aspects (Malczewski, 2004).

In this study, data preparation is divided into two steps; i) Primary data to measure the pattern of spatial urban growth, and temporal datasets of Landsat Enhance Thematic Mapper (ETM) and Thematic Mapper (TM) images. This data was obtained from The United States Geological Survey (USGS) website. The source of digital elevation model (DEM) was the project Shuttle Radar Topography Mission (SRTM) which is operated by the USGS (Omar et al., 2014). Other dataset such as thematic map of master plan (1:20.000) and high resolution Arial image were collected from municipality and physical

planning office; ii) The secondary dataset comprise of Demographic Data and Analytical Hierarchy Process (AHP) questionnaires. Planners and decision-makers interview, group discussions, and literature review were done to identify and investigate the driving factors for residential site suitability.

The methodological process of the site selection for residential development is shown in Figure 3. Based on literature and interviews with local experts influenced factors selected which are; distance from the river, distance from built up area, population density, slope, distance from road, income (land value), proximity from security area, distance from environmental sensitive area (ESA) and ethnic community characteristics. In addition, the factors were categorized into four groups of physical, socio-political, environmental, and socio economic factors. The physical factors consist of slope, built up area and river, while the environmental factors consist of environmental sensitive area. The socio-economic factor includes land values and population density and socio-political factor represent the security area and the ethnicity area.

Reponses from the participants were keyed into an attribute table in software of EXPERT CHOICE during the interview as row and column. The data obtained include vector layers, thematic base map, the aerial imagery with resolution 0.1 m and topographic map illustrating the natural region and surrounding of Kirkuk city. The topographic sheet of 1:500,000 was used in this paper to possess attributes such as administrative territories, road network and land-use and slopes. The ethnic group distribution area conducted from Kirkuk census and statistics office, literatures and discussion with experts. All these were obtained to support the creation of a new map for the study area. Furthermore, the cartographic department of physical planning also provided two data sets of base map which contained thematic data layers, roads, parks and rivers; a bigger map covering the secondary area was also gotten from the cartographic department of physical planning.

The lack of availability of land value data was the main challenge faced to develop socio-economic factors; hence this information was created by interpolation based on property evaluation as well as population density (Samat, 2007). Constrain factors were considered as oil and gas plants and companies which surrounds the study area especially on the north-west of the city. In addition environment sensitive areas (ESA) and military campus which were considered as constraint areas for urban development. Finally socio-political factors showed the relationship between securities around Kirkuk district. This problem of insecurity has made some inhabitants of Kirkuk city flee to other areas in search for safety. Also as a solution to this problem, authorities plan to create formal security zones starting from Kirkuk North and extending towards the boundary to the East (M. Knights & Ali, 2010). The problem of insecurity within this area has been experienced ever since US occupied Iraq in 2003.

Kirkuk diverse ethnic composition enjoyed peaceful co-existence before it was affected by political instability and political interest which designed programs aimed at disrupting the unity of these ethnical groups so as to gain control of the oil-rich city. This has made Kirkuk as dangerous as other major cities in Iraq. According to commentators the true image of Kirkuk was last captured in the 1957 census before the political conflict of interest which changed the ethnic composition of Kirkuk (Anderson, Liam and Stansfield, 2009).

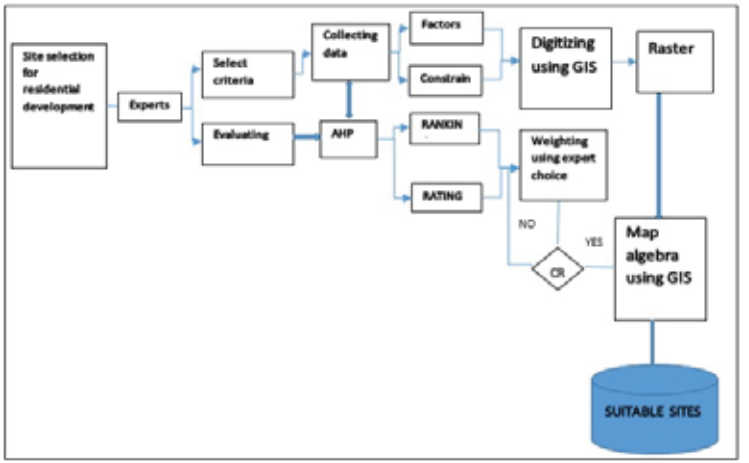

Fig.3: GIS modelling process for suitable site selection

These nine factors were also divided into spatial (such as road accessibility, distance to built-up area, slope, river, environmental sensitive area) and non-spatial sub-factors (such as population density, ethnic area, land value and security area). In order to extract the most effective factors for residential development weighting process was performed based on interview with 22 local experts and heads of government offices who are directly involved in urban planning in Kirkuk, decision makers, twenty two experts include (local planners and several social researchers and politicians). A set of weights was derived using geometric mean to calculate the average of all values. To determine the geometric mean (GM) of the twenty two decision makers for normalization, the weight of each factor is divided by the total weight of other factors.

$$GeoM = \prod_{i=1}^{n}(1 + ri)^{1/n} - 1 \quad \ldots\ldots\ldots \text{Eq (1)}$$

Where GeoM is Geometric mean, n is the number of experts and ri is the factor value.

Table 1 Weighting score for factors

No.	Factors	GEO Mean	Normal Mean
1	Distance from Built up Area	0.065878278	0.07276139
2	Topographic (slope)	0.027829953	0.03073769
3	Distance from River	0.026794743	0.029594319
4	Population Density	0.066261118	0.07318423
5	Income (land value)	0.097365057	0.107537979
6	Distance from Road	0.100875205	0.111414875
7	Proximity from Security Area	0.246769163	0.088229016
8	Distance from ESA	0.079882691	0.088229016
9	Proximity from same Ethnic community area	0.193745382	0.213988338
	Sum	0.90540159	1

High resolution (0.1 m) Arial image was collected from the municipality of Kirkuk city to Geo-reference the spatial layers of different thematic maps of the study area. Layers are created by digitizing process using GIS software (ARCMAP 10). All features which were digitized from the Arial image were compared with other features from the master plan such as population density, ethnic distribution, built-up areas, road network, river, ESA (environmental sensitive area), land value as well as security layer. Topography factor (slope) was obtained from available DEM data of year 2013.

To calculate the geographical features of the selected factors (such as road, ESA, distance from built-up, river, security area and ethnic), Euclidean distance tool was applied on each corresponding layer (Figure 3). In addition, inverse distance weighted (IDW) using ARCMAP 10 software was used to calculate social factors such as land value and population density statistically. Next, experts' knowledge weighting process was performed and average values were determined as shown in Table 1. These values were evaluated based on the most common MCA techniques, known as Analysis hierarchy process (AHP) (Saaty, 1994; Al-Shalabi et al., 2006; Abdullahi et al., 2014). Weighting were obtained from interviews conducted among twenty two different local experts based on the AHP questionnaires matrix. The factors were evaluated based on their effectiveness on residential growth site suitability. In order to perform sensitivity analysis of weighting process, nine different pairwise comparisons for major factors were put together for each preference factors. To reflect the preference of certain factors, matrix for both spatial and social factors were used. However, it is important to evaluate the reliability and consistency of experts' judgments through consistency ratio (CR) assessment (Vaidya and Kumar, 2006; Gorsevski et al., 2012; Rikalovic et al., 2014). Each matrix used for comparison by experts was adjusted till acceptable consistency was achieved.

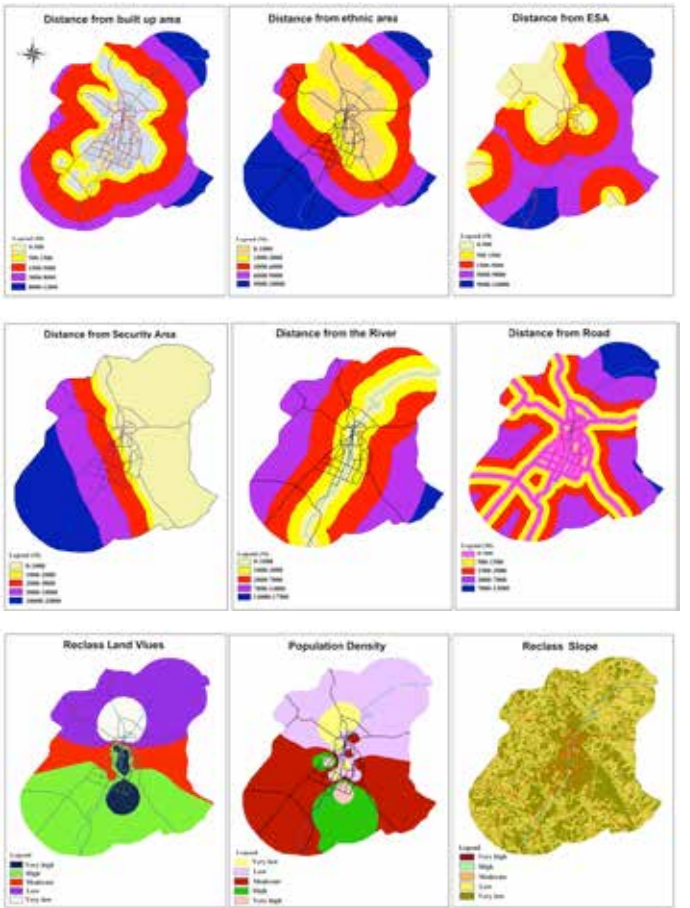

Fig.4: Input factors

The relative weights of the nine factors were then used as input for ArcGIS spatial analysis in order to create residential suitability map.

In GIS environment, Map Algebra tool was used to aggregate the produced layers (driving factors) mathematically. Map algebra creates intrinsic suitability map based on the weighing of the criterion from AHP and expert choice software using Equation (2).

$$LS = \sum_{n=1}^{i}((R_{n1} * w_{i1})+(R_{n2} * w_{i2})+(R_{n3} * w_{i3})+(R_{n4} * w_{i4})+(R_{n5} * w_{i5})+\ldots n\mathcal{G})) \quad \text{Eq (2)}$$

Where LS is the land suitability, $R_{\_nl}$ is the raster of the factor and w_iis the score weight.

Hence, all the effective factors were aggregated based on this process to create residential site suitability map.

3. RESULTS AND DISCUSSION

Figure 5 illustrates the produced residential site suitability map with four different suitability classes. From 773.76 km2 of the study area, 7.6% are categorized as very suitable, 20.9% suitable, 30.63% moderately suitable and 40.84% less suitable for growth of residential development. By comparing this result with master plan of Kirkuk city (developed by the Ministry of Municipality, Iraq), it was revealed that the city trend of urban development tilt towards the North and East which are non-permissible zones. This is not in-line with zoning of the master plan that supports the development towards the South and West which is suggested by the report of a master plan developed by Doxiadis associated International Consultant in development and ekistics in 1975. In fact, the Northern and Eastern parts of the city are hilly area with limited infrastructural facilities and site preparation cost will be high. In addition, the most suitable and very suitable area for residential growth is supported by presence of adequate security. Hence, it can be concluded that, effective security, availability of infrastructure and social amenities play a vital role in suitable site selection. In contrast, areas that are not suitable for residential usually lack adequate infrastructure, ineffective security and poor transport network. As explained in literature, the master plan was developed by Doxiadis, 1975, renewed by Ministry of Municipality, Iraq in 1985 and the most recent renewal was performed by Pull Frischmann in 2009 under the supervision of Kirkuk governorate admission for the expansion of the West and South to capture spatial factors. However, the proposal for the master plan developed by Pull Frischmann Consultancy for USA Iraq Transition Assistance Office as shown in Figure 4 could not obtain a traction number of Kirkuk Province Council (KPC) because of political and ethnic conflicts (Katzman, 2010). From the results, it is glaring that most zones and suitable sites are not located at the desirable and permissible zones for residential development compared to what was suggested by the latest master plan.

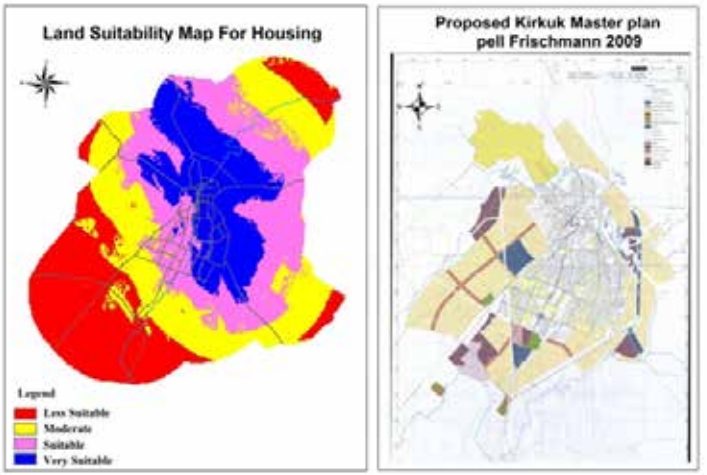

Fig 5 : Final residential growth suitability map and master plan by Pell Frischmann

4. CONCLUSION

The GIS was used as a tool based on multi-criteria decision making represented by the AHP technique to examine how land suitability is affected by spatial land social factors. The final map illustrates the growth of residential development suitability. For policy recommendations, the integrated GIS and AHP are most suitable to provide appropriate solutions. Knowledge and information on the best site for residential and urban development are retrieved because of their relevance to the study. The final map encompasses previous master plan 1975 to 2000 and a proposed master plan which span from the period 2009 to 2030. As revealed by the result, factors such as politics, ethnicity and security plays very important role in selecting the direction and location of resident. These factors also contribute to reshaping the city. The result shows that direction towards the North and East are the best despite noticeable limitations that might emanate from slope, presence of oil companies and cost of repairing the lands. Moreover, distinct site selections for residential and urban development are driven by local politics, security, culture, history and ethnicity. Therefore, the result of this study will provide support to decision makers in developing residential projects in the future.

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