INTERNATIONAL JOURNAL OF GEOMATICS AND GEOSCIENCES
Volume 4, No 2, 2013

Research article ISSN 0976 – 4380

Suitability analysis for tourist infrastructures utilizing multi-criteria GIS: A case study in Al-Hada city, Saudi Arabia

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ABSTRACT

Nowadays, GIS is widely recognized as a valuable decision support system that enables the determination of suitable spatial locations for a specific objective based on a group of criteria. This paper aims to utilize such a comprehensive approach for delineating suitable sites to set up future tourist infrastructures in Al-Hada city, southwest Saudi Arabia. Several recent databases have been gathered, integrated, processed, and analyzed for that city. Six criteria have been designed and applied for finding safe, homogenously-distrusted, and economical optimal locations for potential tourist facilities in the study area. A suitability map has been developed based on a weighted integration of the chosen six criteria. The accomplished results show that there exist 124 candidate sites with a suitability index ranges from 5 to 10 on a 10-point scale. It is recommended that these findings being considered in the development plan of Al-Hada city, and the developed GIS mutlicriteria suitability analysis being applied for all Saudi tourist cities.

Keywords: GIS, multi criteria analysis, site suitability, tourism land use, Saudi Arabia.

1. Introduction

Geographic Information Systems (GIS) technology has been utilized in the last two decades in a wide range of geographic, engineering, planning, and environmental applications. Examples of such utilizations include: flood hazard monitoring (Dawod et al. 2012), urban planning (e.g. Arnous 2013), underground water quality (e.g. Alqadi et al. 2013), transportation networks analysis (e.g. Aljoufie et al. 2013), water resources management (e.g. Dawoud 2013), land degradation monitoring (e.g. Mohamed and Saleh 2012), tourism management (Abomeh et al. 2013), and agriculture sustainability (Abdel Kawy 2011).

One of the major characteristics of GIS is its capability to integrate heterogeneous datasets in a unique framework, that leads to the performance of multi-criteria analysis. Thus, suitability models can be developed for the determination of appropriate spatial locations for specific objectives. The site suitability has been a novel regular GIS practice in various disciplines nowadays. Kumar and Shaikh (2013) has applied mutlicriteria GIS analysis for the determination of suitable sites for urban development. On another scale, Bagdanaviciute and Valiuliunas have performed a study to identify potential pollution sources based on sixteen different environmental factors for the sack of land use planning. Additionally, GIS mutlicriteria has been utilized in identifying optimal landfill sites in several countries (e.g. Khamehchiyan et al. 2011, and Al-Rehaili 2010). Suitable sites for public parks are, also, identified based on GIS suitability analysis (e.g. Chandio et al. 2011). Moreover, a similar investigation has been carried out to delineate the development zones of educational infrastructure facilities based on mutlicriteria analysis (e.g. Bhunia et al. 2012). Krishnaveni (2012) has applied GIS-based suitability analysis for the determination of optimal wastewater

treatment plants. Furthermore, a GIS-based location-allocation method has been applied for the optimal distribution of smoking cessation centers in relation to the spatial distribution of the smoking population (e.g. Ajebon and Asikhia, 2013). The current research study aims to identify optimal geographic locations for establishing new tourist infrastructures in Al-Hada tourist area, southwest Saudi Arabia, based on mutlicriteria GIS approach.

2. Study area

Al-Hada city is a tourist area located in Makkah administrative area southwest Saudi Arabia, on the road from Makkah city to Al-Taif city. It is bounded by latitude 21o 20' and 21o 23'N, and by longitude 40o 15' and 40o 18' E (Figure 1). The main geographic feature of Al-Hada city is its high elevation above mean sea level compared with eastern neighboring cities such as Makkah and Jeddah. That city is located on the cliff of Al-Hejaz mountainous series. So, the average level of Al-Hada area is about 2000, which is 1700 and 2000 meters higher than that of Makkah and Jeddah cities respectively (Figure 2).

Figure 1: The study area

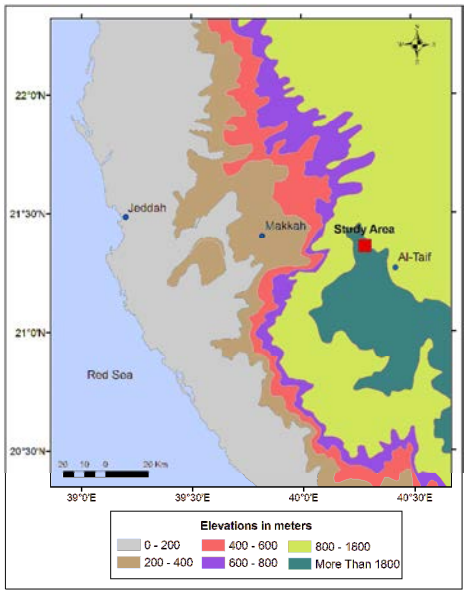

Figure 2: Topography of Southwest Saudi Arabia

Thus, the air temperature in Al-Hada is lower than its neighboring cities by almost ten degrees, particularly in the summer season (Organgi et al 2013). Consequently, Al-Hada is traditionally considered as a summer resort for residents, not just for Saudi but for tourists come from many gulf countries. The topography of Al-Hada range from 1900 to 2165 meters above mean sea level, with an average equals 2000 meters (Figure 3).

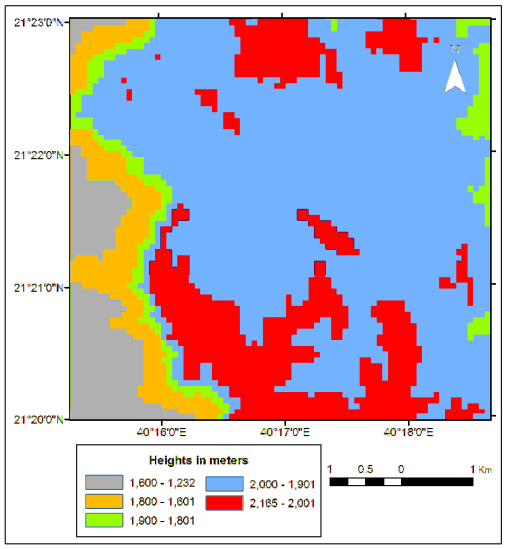

Figure 3: Topography of Al-Hada City

3. Methodology

The data processing has been performed in several stages in order to acquired up-to-data spatial datasets regarding the study area. In the first step, a recent high-resolution satellite image has been obtained, and then digitized through the Arc GIS 10 software. Secondly, a field campaign has been organized to collect field data about land use types for the recognized 1357 parcels. Integrating such attribute data into the study area shapefile enables the categorizing of available land uses in Al-Hada city. A total of 31 land use sub-types has been obtained for the urban boundaries of Al-Hada city that extend over more than 8 million square meters. The chief land use kinds are depicted in Figure 4. Farms constitute 28% of the study area, while empty parcels comprise 27%. The existing tourist infrastructures occupy 747823 square meters, which represents only 9% of the overall land uses.

Regarding the existing tourist infrastructures, it has been found that 4 types of tourist facilities are available: (1) resorts that constitute 69% of the entire area of tourist land uses; (2) hotels, which occupy 27% of the tourist total areas; (3) furnished apartments representing only 4%; and (4) rest houses occupy less than 0.5% of the area of tourist facilities in the study area (Figure 5). It can be obviously realized that the spatial distribution of these infrastructures is not homogenous over the study area. The standard distance, at one-standard-deviation level, has been presented in Figure 6. It can noticed that this circle lies in the west region of Al-Hada city, with a radius equals 1281 meters. Thus, there is a vital need to establish new tourist infrastructures that are homogeneously distributed over the city. Since it is quit important that new infrastructures being safe regarding flood hazards, the ARC GIS hydrological analysis tools have been utilized to delineate the hydrological stream network in the study area (Figure 7).

The multi-criteria site suitability analysis is performed to identify appropriate spatial locations based on a group of criteria or constraints. In the recent study six criteria have been designed to construct a tourist infrastructure' suitability model. These conditions aim to (1) identify safe locations against flood hazards, (2) fulfill spatial homogenous distribution over the city, (3) reduce construction' costs by allocating sites close to an existing road, being in a flat or small-slope areas, and currently being empty parcels, and (4) select appropriate locations with areas fit tourist infrastructures. Accordingly, these criteria composite of:

1. Criteria 1: at least 100-meter away from hydrological streams.
2. Criteria 2: less than 10 degrees terrain slopes.
3. Criteria 3: The land use type must be an empty parcel.
4. Criteria 4: Away from an existing tourist infrastructure by at least 200 meters.
5. Criteria 5: Away from an existing road by no more than 100 meters.
6. Criteria 6: The area of the proposed site is larger than 1000 square meters.

Lastly, a weighted multi-criteria analysis is performed to spatially integrate the first five conditions in a weighted manner. The designed weights have been selected to be: a weight of 0.25 for the first three conditions, and a weight of 0.125 for the next two constraints. The last criteria has been performed separately after the site suitability model is obtained, in order to define appropriate sites.

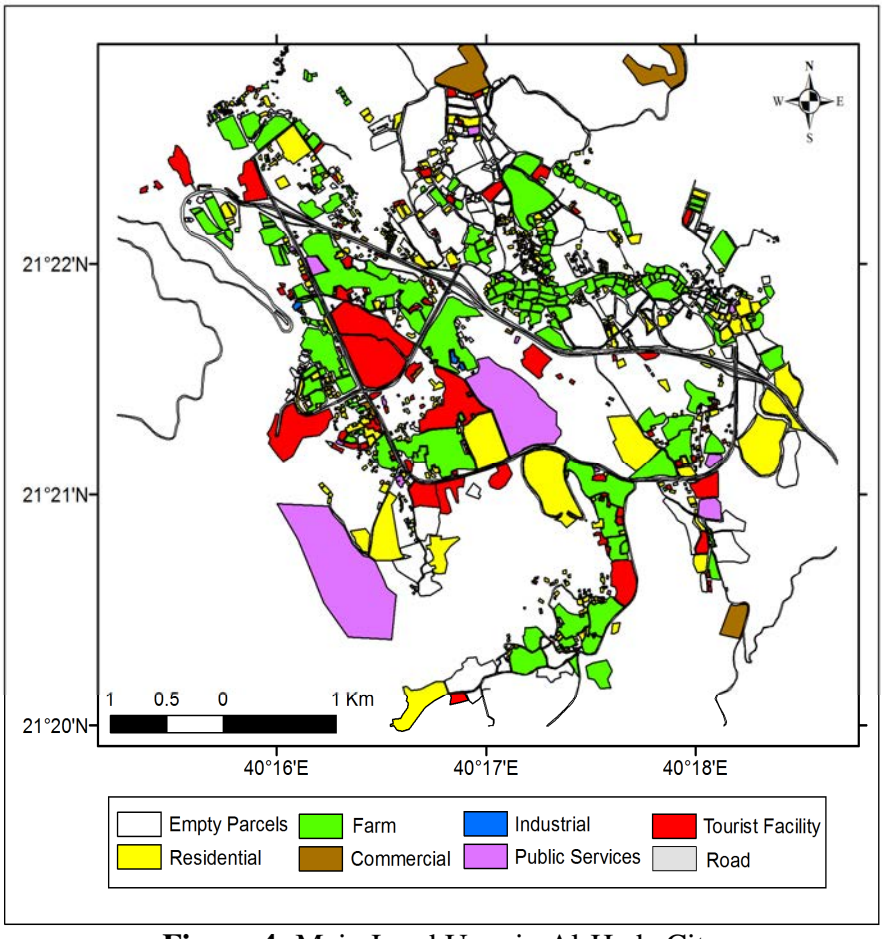

Figure 4: Main Land Uses in Al-Hada City

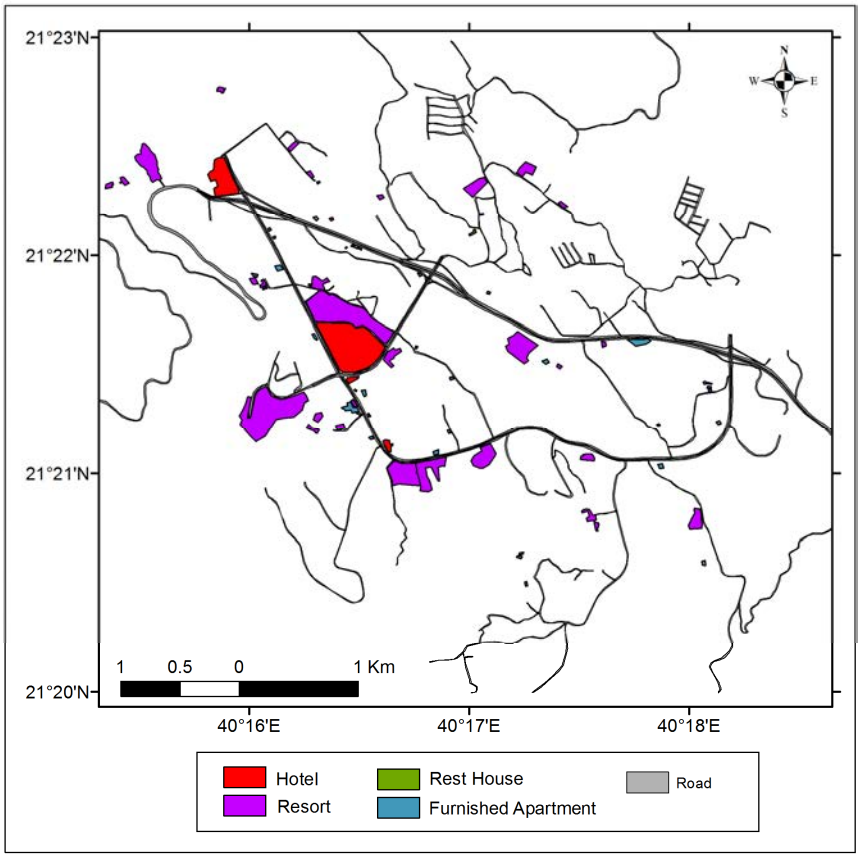

Figure 5: Tourist Land Uses in Al-Hada City

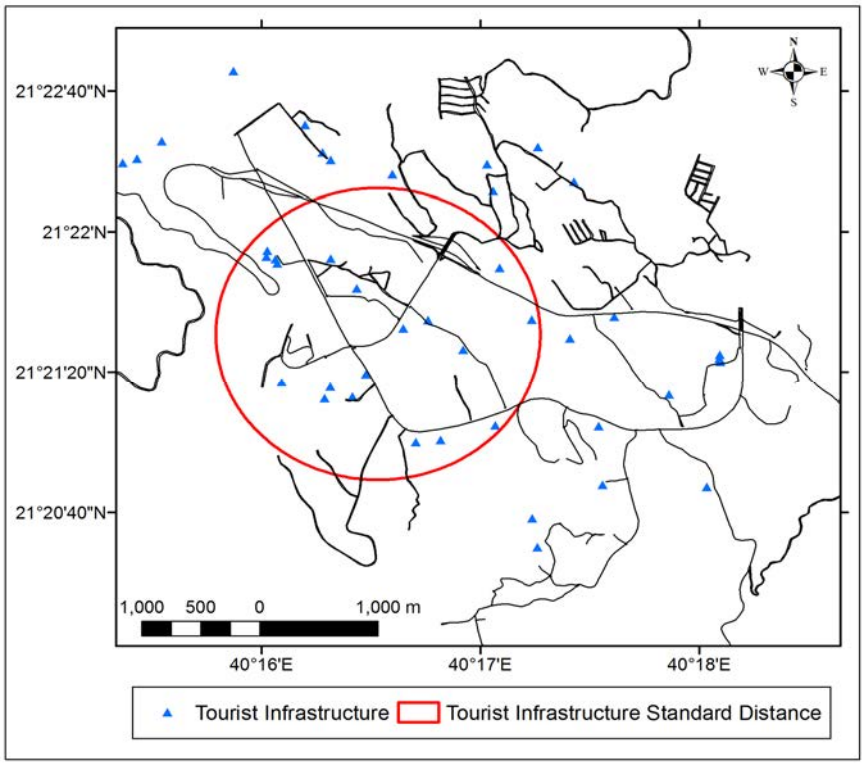

Figure 6: Spatial Distribution of Tourist Infrastructures

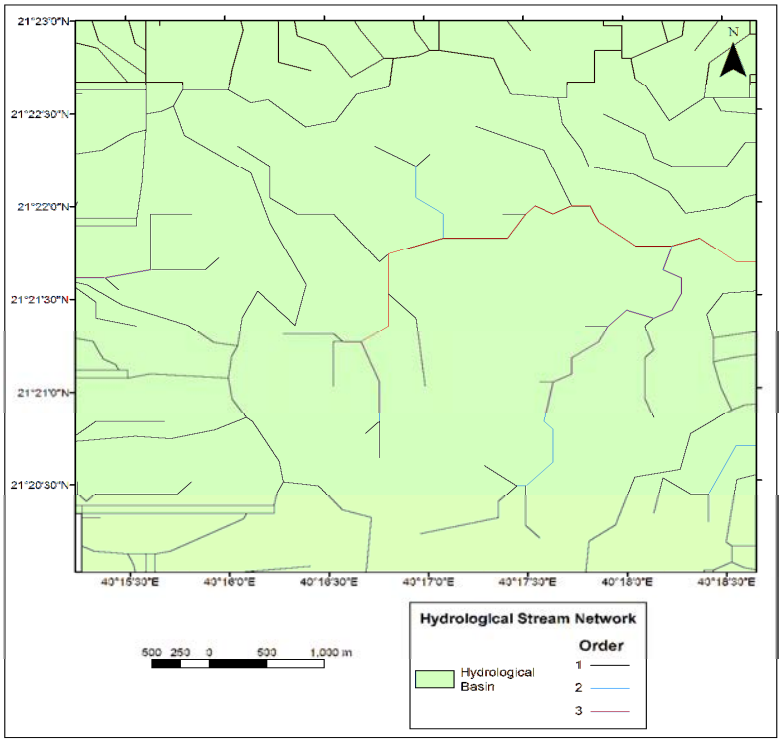

Figure 7: Hydrological Stream Network

4. Results and analysis

Firstly, the ArcGIS spatial analysis tools have been applied for each criterion individually. Thus, 5 distinct suitability models have been obtained, one for each specified constraint. The spatial results of each attained model have been divided into three categories: low, medium, and high suitability. The only exception are the terrain slope and the empty land use suitability models, which are divided only into two categories: suitable or not suitable. Such results are depicted in figures 8 to 12.

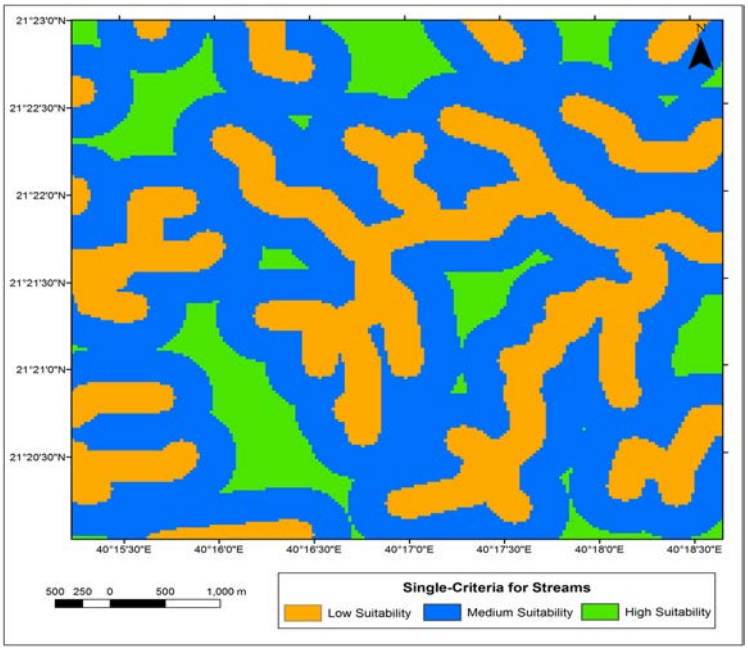

Figure 8: Hydrological Streams Suitability Model

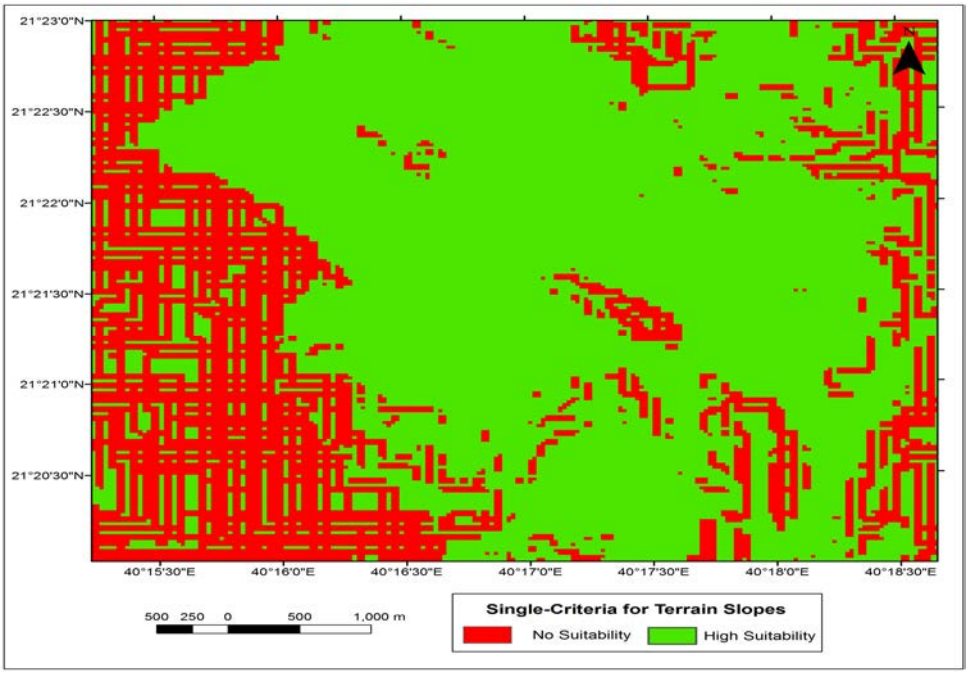

Figure 9: Terrain Slopes Suitability Model

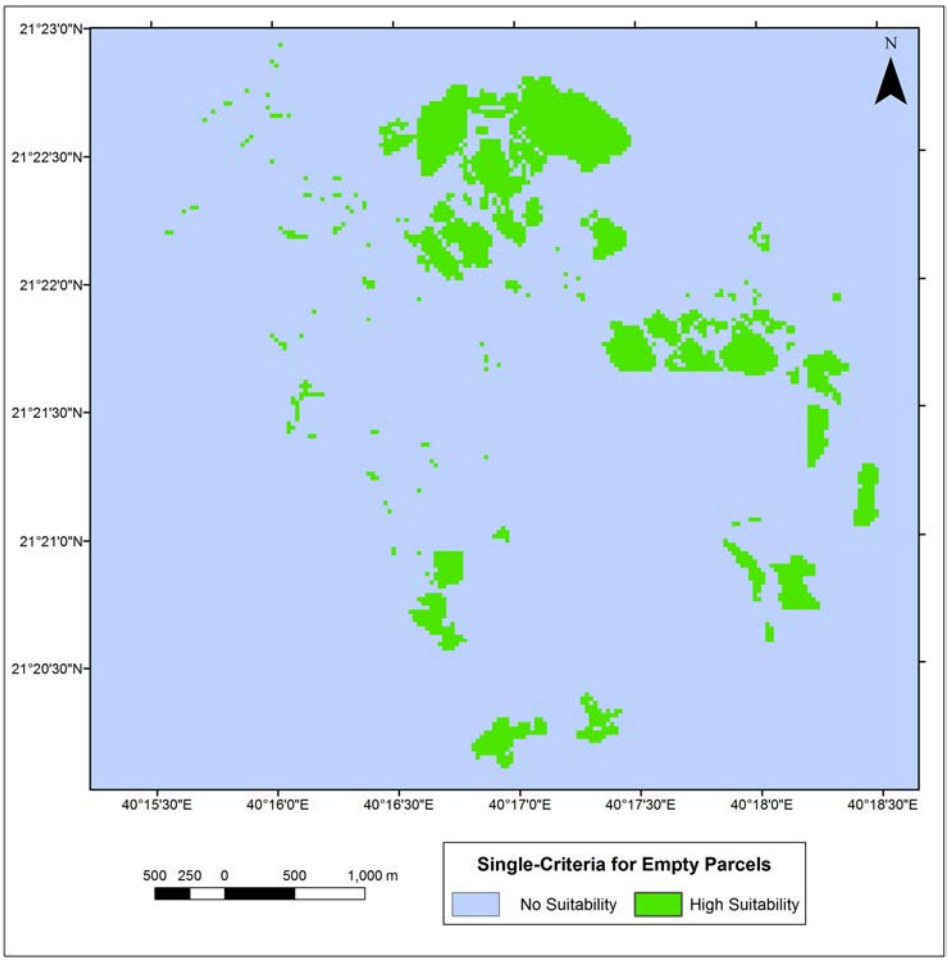

Figure 10: Land Uses Suitability Model

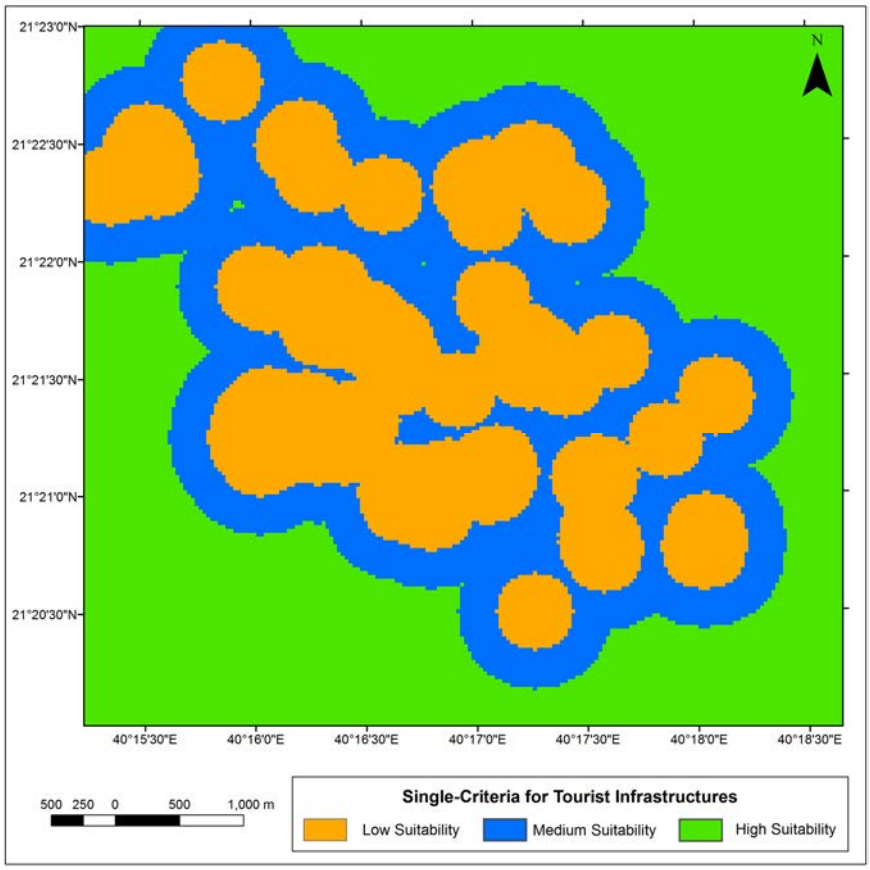

Figure 11: Tourist Infrastructures Suitability Model

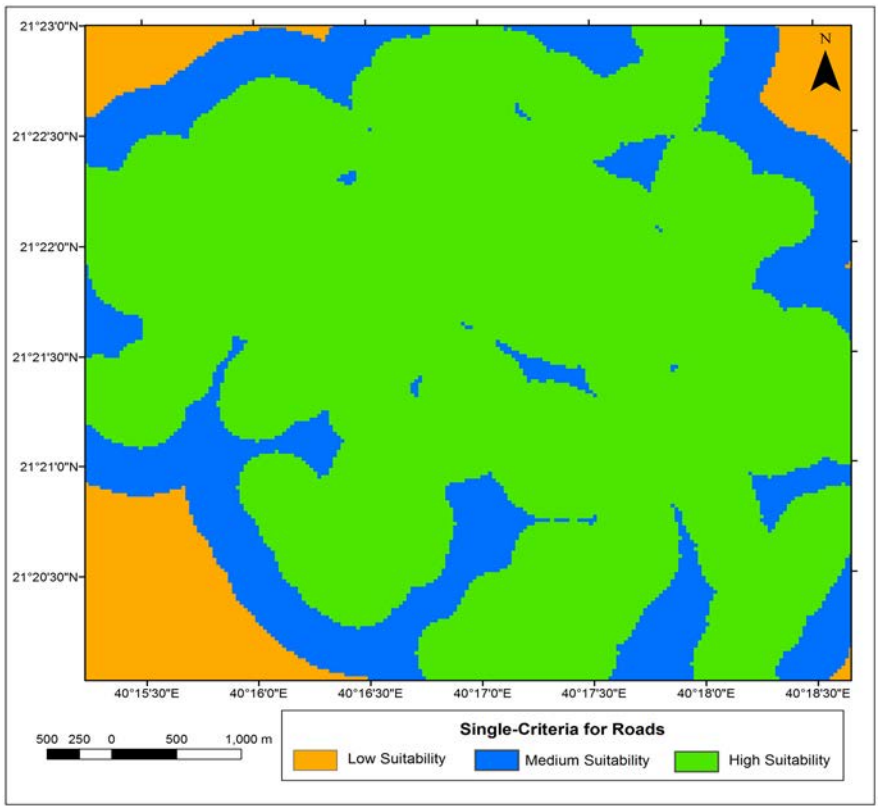

Figure 12: Road Distance Suitability Model

It can be noticed that the five single-condition result in different spatial locations that satisfy each single constraint. The multi-criteria GIS analysis integrates such conditions in a distinctive way to produce a unique appropriate spatial solution. Thus, in the second processing stage the five raster images corresponding to the five criteria, have been spatially integrated in a weighted manner. The weights have chosen as 0.25 for terrain slopes, hydrological streams, and land uses, and 0.125 for both roads and tourist infrastructures. That results in a new weighted suitability model that identifies suitable geographic sites for establishing new tourist infrastructures in the study area. For simplicity, the suitability model has been ranked on a scale from 1 to 10, as seen in Figure 13. Clearly, it can be seen that the most-suitable locations exist in the center of the study area, and the suitability index is deceased as we move to the borders. The sixth criterion has been applied in the last processing step. The suitability index has been interpolated for empty parcels, so that each parcels gets a unique suitability index. Then, parcels with areas less than 1000 square-meters have been excluded. The suitability index for the remaining 124 empty parcels range from 5 to 10, on a scale of 10. The final output is depicted in Figure 14. It has been found that there exist 6 locations with a medium suitability index, that ranges from 5 to 6, and 45 sites have a good suitability index ranges from 7 to 8, and 73 sites with excellent suitability index equals 9 or 10. These results conclude that there exist several geographic locations within the study area that are appropriate for establishing new tourist infrastructures.

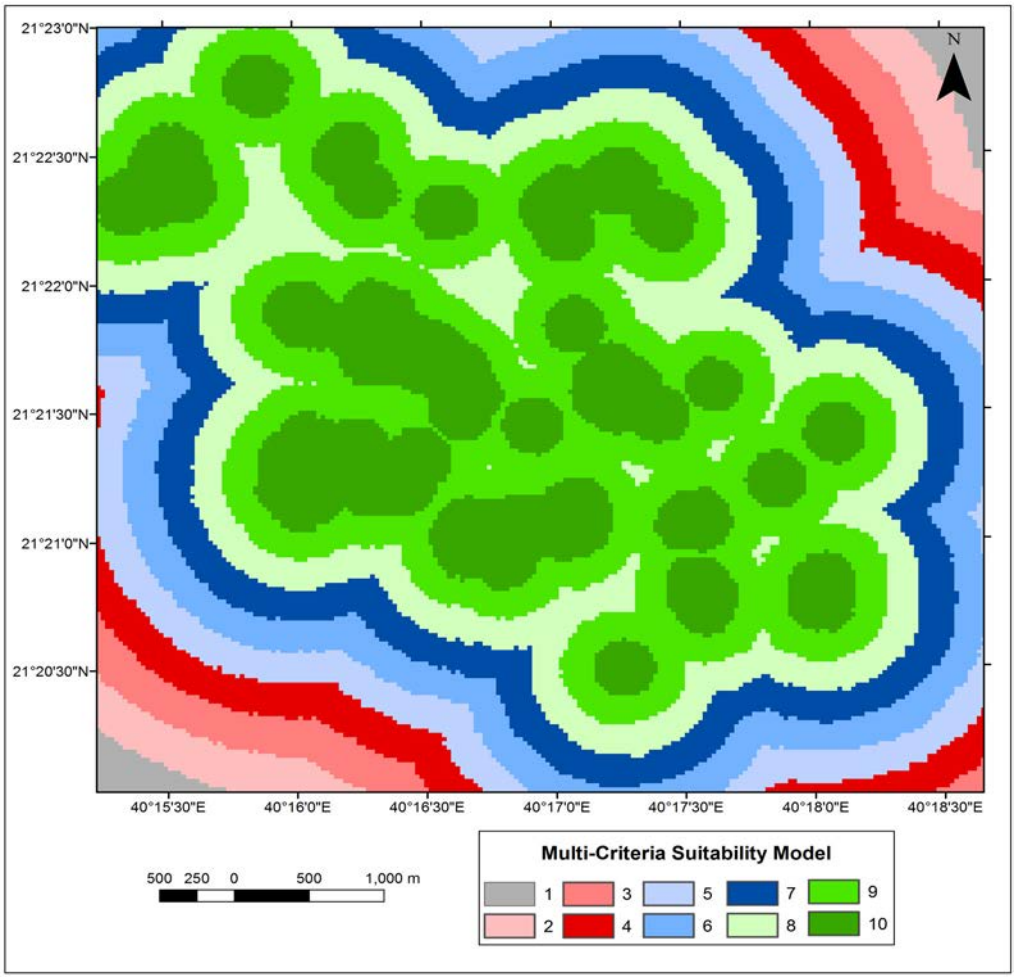

Figure 13: Five-Criteria Suitability Model

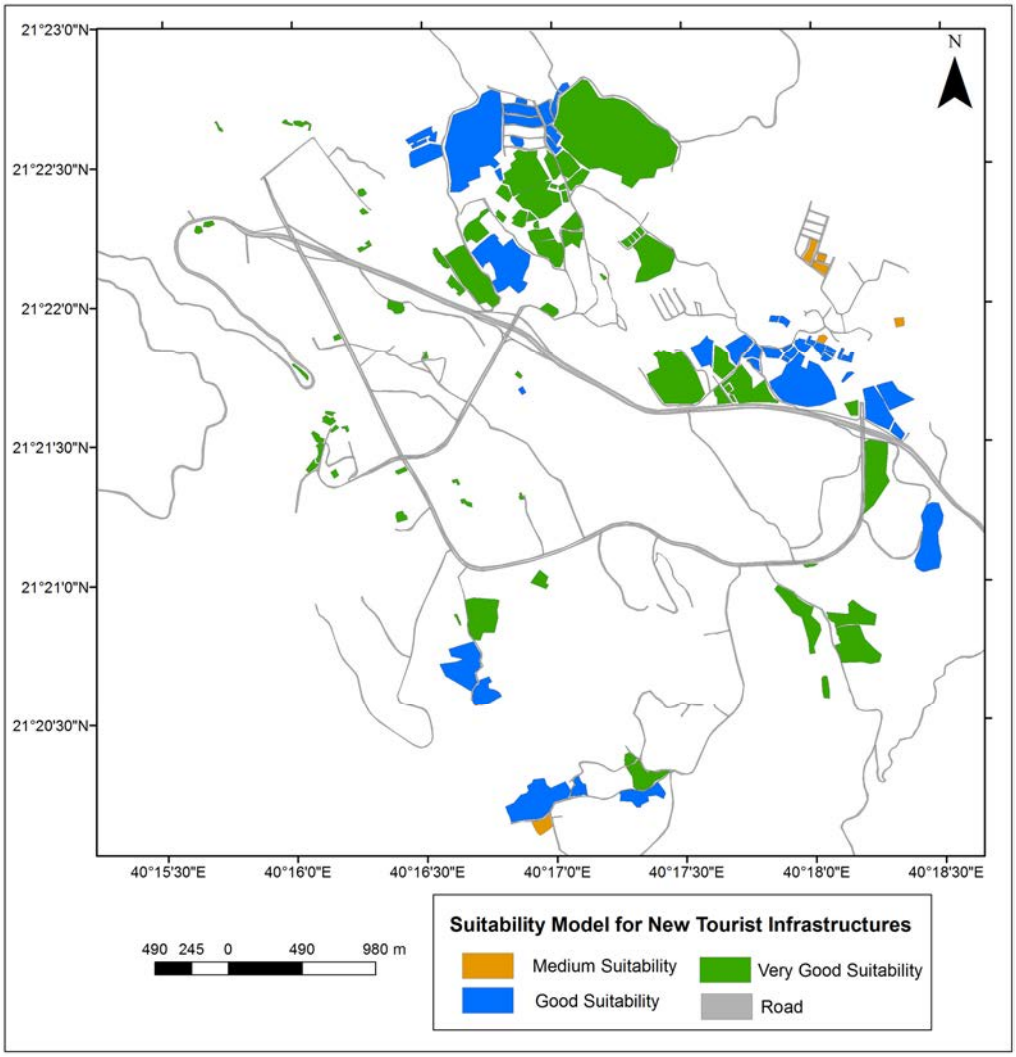

Figure 14: Suitable Locations for New Tourist Infrastructures

5. Conclusions

With advances in information technologies, computer-based decision support models have been developed for a wide range of development applications. In this research, the GIS mutlicriteria analysis, as a decision support system, has been performed to identify appropriate sites for establishing future tourist infrastructures in Al-Hada city, southwest Saudi Arabia. Results show that there exist 124 empty parcels that represent proper candidate sites, with a suitability index varies from 5 to 10, on a scale of 10. Hence, it is recommended that the accomplished results being considered by the local decision makers in Al-Hada city in any future city planning. In addition, it is recommended that city and regional planning activities, within Saudi Arabia, should regularly apply the GIS multi-criteria analysis for efficient resources management.

Acknowledgment

The author acknowledges the financial support provided by the Scientific Researches Institute of Umm Al-Qura university, Makkah, Saudi Arabia.

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