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Land Suitability Analysis for Public Parks using the GIS Application

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Abstract: The provision of public facilities including public parks is a major urban planning issue in various cities of the developing world. Thus, the city of District Larkana, Sindh, Pakistan is selected as a case area. In this research, an Analytic Hierarchy Process (AHP) framework as a multi-criteria decision approach of integrating with Geographic Information System (GIS) was carried-out to indicate different parameters for selection of a suitable site of public parks. While the selection of optimal site for public parks, land suitability model was applied. The Exert Choice (decision support system) software was used for calculating the weights from alternative scenarios asked by different experts. Computed weights were introduced into GIS through spatial analysis tools, produced land suitability maps, and proposed different sites around the city for public parks. In the end, the findings were made and suggested suitable locations for public parks to provide amusement facilities in Larkana city. This study may assist and benefit to city planners, real estate developers, and government officials in examining the public facilities including parks & their accessibility related issues at urban level and act as to ensure proper land use planning and management of the urban areas.

Keywords: Urbanization; Public Parks; Green Spaces; MCDA; AHP; GIS; Expert Choice; Land Suitability.

1. INTRODUCTION

Public Parks in the cities are significant aspects of urbanized ecosystems. They provide a variety of environmental and social services for enhancing life values in the urban areas (Pham Duc Uy., 2008). Public Parks can be expressed and classified by their specific demands and requirements (Bonsignore, 2003).. Urban Public Parks play an essential role to preserve biodiversity within urban vicinities (McHale, 2007). In this regard, urban parks hold crucial role for improving the dwellers' life values in neighborhoods. Urban Parks are not only taken into environment perspective, but also encompasses with socioeconomic aspects. Thus, they provide places to exercise and community forums for getting socially interaction formally and informally. Worldwide, the provision of public facilities including urban parks has been adversely impacted by the rapid urbanization since the end of the twentieth century. Nowadays, the provision of Public Parks for highly urbanized areas in developing countries is a vast challenge for the local authorities. The land availability and raises of its value are becoming the major challenge for the provision of public parks within urban areas. Therefore, innovative strategies, i.e. reusing of unconventional sites or transforming abandoned areas in public parks need to be developed for the provision of urban parks (Thompson, 2002). Moreover; green spaces included public parks absorb Carbon Dioxide (CO2) and turn out Oxygen (O2) (Hyun-Kil., 2002). Green spaces decrease air and noise pollution (Yang, 2005), and reduce other natural or fabricated bio-impacts of urban environment (Shin, 2005). Green spaces also maintain atmosphere, social and recreational values (Tarrant, 2002) and provide a livable environment in terms of health, social, safety and well being (Groenewegen, *at. el*, 2006). Such factors, i.e. shape, size, history, distribution and diversity of green spaces in a city plays a crucial role in defining quality of urban life (Gilbert, 2013). Hence, suitable site selection for development of public parks is needed to ensure their roles and functions. For this concern, Geographical Information System (GIS) based land suitability analysis (LSA) technique is used to analyze suitable site for urban green spaces including; playgrounds, parks, and green routes, which is efficient and effective application within urban land use planning (Gillenwater, *at. el*, 2006). GIS Suitability analysis is a geographic method used to assess the aptness to a given area for a specific use. The simple objective of site suitability analysis via GIS means considering all land use characteristics for the targeted site within the context of bylaws (Malczewski, 2004). For the display of results often researcher uses a map, including areas having low to high suitability. A model based on GIS site suitability analysis typically answers about best locations and proposed to them for public parks, particularly in urban areas (Murphy, 2005).

The purpose of this research is to identify existing urban open spaces specifically for public parks and conduct suitability analysis on a particular land parcel by using GIS in the city area of the Larkana district of

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Sindh. This study may assist and benefit to city planners, real estate developers, and government officials in examining the public facilities including parks & their accessibility related issues at urban level and act as to ensure proper land use planning and management of the urban areas.

2. MATERIALS AND METHODS

2.1 Materials

The study area was selected; as City Municipal area of District Larkana, Sindh, Pakistan. Larkana is the most prominent settlement in western upper part of Sindh Province. It is centrally located on 27º33' North latitudes and 68º12' East longitudes.

Fig-1. Location map of Larkana

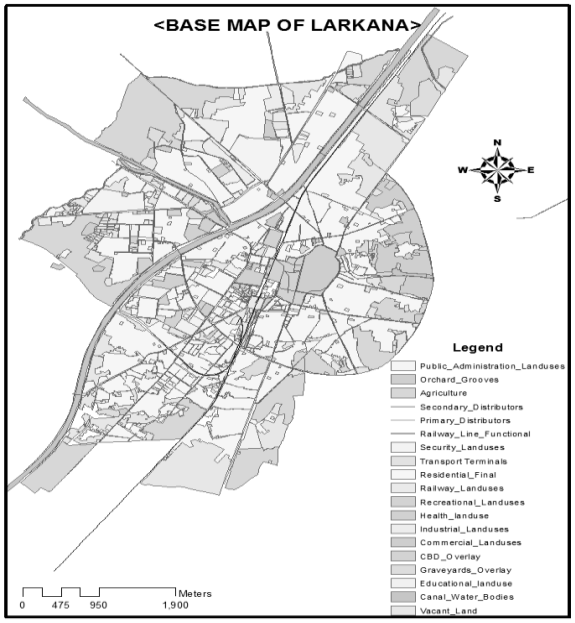


Fig-2. Base map of the Larkana City

2.2 Methods

The researcher used different techniques for gathering information either primary or secondary sources to provide a suitable solution for land suitability of urban green spaces including public parks. The methodology of research is discussed as follows:

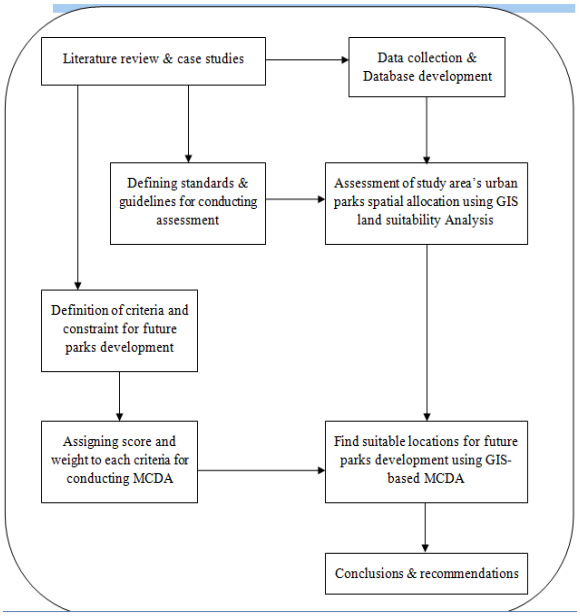


Fig-3. Research Methodology

In this research study, the GIS based land suitability analysis (Joerin, *at. el*, 2001) technique applied as the multi-criteria decision analysis (MCDA). LSA allows integrated GIS-based land suitability modeling for suitability of site (Mendoza, 1997). LSA works logically to settle a problem into its smaller elements which helps decision makers in all the way (Saaty, 1985). Meanwhile, Analytical Hierarchy Process (AHP) technique was also used to set the criteria for having the information about various land suitability alternatives from different experts. AHP guides decision-makers for taking decisions to overcome the problems on priorities basis systematically (Miller, 1998). However, in this study, the several criteria/factors of a problem into a hierarchy related to a tree form arrangement through AHP method managed by authors, i.e. land availability, accessibility and socio-economic condition of the site and took the decisions from those factors came to expert's opinions.

2.3 Data collection

The spatial and non-spatial data were gathered physically from various government departments and authorities by authors, i.e. Town Planning Department, Sindh Building Control Authority, Larkana Development Authority and City District Government Larkana.

2.4 GIS database development

In this research, GIS database was developed by putting criteria and sub-criteria opinions taken from different technical experts by asking close-ended questions through an AHP sample questionnaire. The Larkana City base map was scanned and fixed it through Geo-referencing to get it on the actual position of earth. Later, Map was digitized in ArcGIS 10.3 and developed various data layers.

2.5 Development of the pair-wise comparison matrix

The pair-wise comparisons Matrixes were generated by the authors through conditions that judgments are evaluated finding suitable alternatives to estimate associated absolute numbers from 1 to 9. The fundamental scales of the AHP (Saaty, 2007), three alternative scenarios were produced by using AHP in the suitable site selection of public parks. AHP is the rational planning process in locating public facilities within premises of towns (Banai-Kashani, 1989).

2.6 The pair-wise comparison matrix computation

Exhibits the criteria and sub-criteria, considered in the land suitability analysis, authors were provided three alternatives (scenarios) by using the ArcGIS 10.3 spatial analysis tool i.e. land availability, land value and park accessibility. Later, factors and parameter weights were calculated for land suitability by using Expert Choice 11.5 software, keeping in view the consistency ratio (CR). If CR is satisfactory, it does not exceed the desired range, i.e. >0.10. If the CR value is in an undesirable range, the obtained judgment matrix is needed to be reviewed till these values have improved and have come to satisfactory. These values were calculated by Expert Choice automatically. Then, to compute composite weights (Zhang, *at. el*, 2007), the weighted linear technique (Mohit, 2006) was applied to yield a suitability map by the following mathematical formula:

$$E = \sum_{i=1}^{n} wi * vi$$

Where; Wi = weight of factors/parameters or relative importance i, Vi = relative weight of parameters i, and n = total number of parameters related to the study.

2.7 GIS based Land suitability analysis

Suitability analysis is a process of systematically identifying or rating potential locations with respect to a particular use (Javadian, *at. el*, 2011). In this study, land suitability analysis (LSA) for building a green space, including public parks map was carried out based on existing detailed land use plans. For land suitability analysis, spatial analysis applications through GIS were used, i.e. identified and collected spatial data, weighted with the analytic hierarchy process (AHP), integrated data, analyzed data through GIS, and evaluated outputs (Pham 2008) as described in **(Fig.4).** Hence, researchers found suitable land for provision of public parks by using this process through GIS (Zhang, *at. el*, 2007).

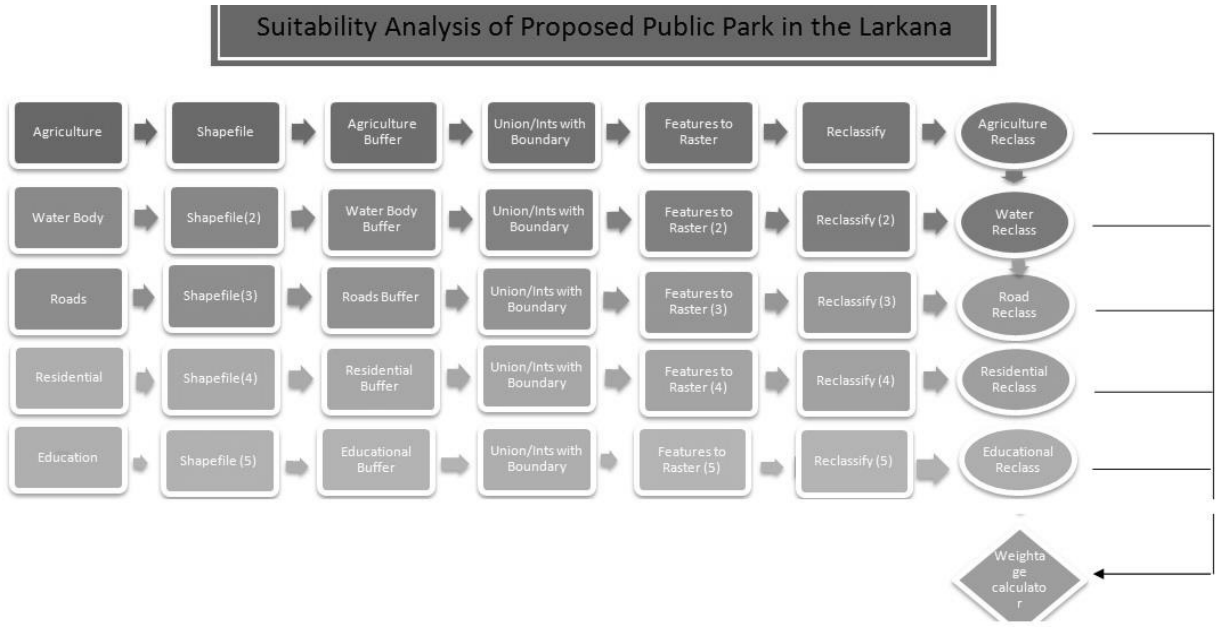


Fig.4. Process of land suitability analysis for proposed public parks

3. RESULTS AND DISCUSSION

The study was conducted to select a suitable site for public parks by applying land suitability analysis approach in the Larkana city. The land suitability opinions were taken from various relevant field experts through a sample of questionnaire and measured composite weights of different alternatives of each factor and sub-criteria. The factor and sub-criteria weights were evaluated using Analytical Hierarchy Process (AHP). The AHP method was made in Geographic Information System (GIS) and produced land suitability model through Multi-Criteria Decision Analysis (MCDA) in GIS.

As for Spatial Data concerns, existing Larkana city map and secondary database collected from Local development authorities. Scanned map was digitized in GIS using different land uses shape files as indicated in **(Fig-5)**.

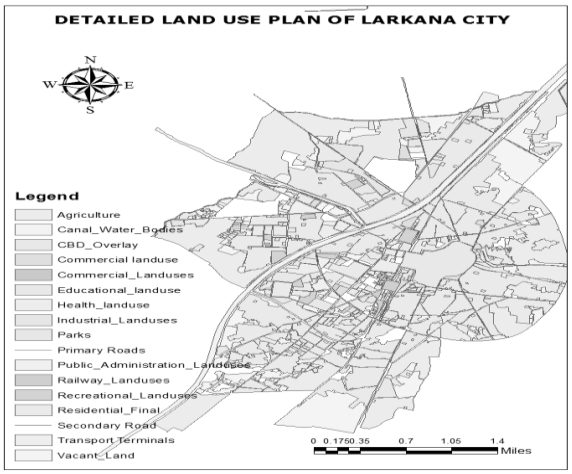


Fig.5. Digitized scanned map in GIS using shapefiles

Buffers were assigned to each land use as per given criteria by Environmental Protection Agency, Pakistan. The various land use buffer standards are mentioned in **(Table-1)**.

Table-1. Land uses buffer

S. No.	Land Uses	Buffer
01	Recreational	200m
02	Agricultural	200m
03	Commercial	200m
04	Educational	100m
05	Health	100m
06	Secondary Road	50m
07	Transport Terminal	350m
08	Canal/Water Bodies	300m
09	Residential	30m

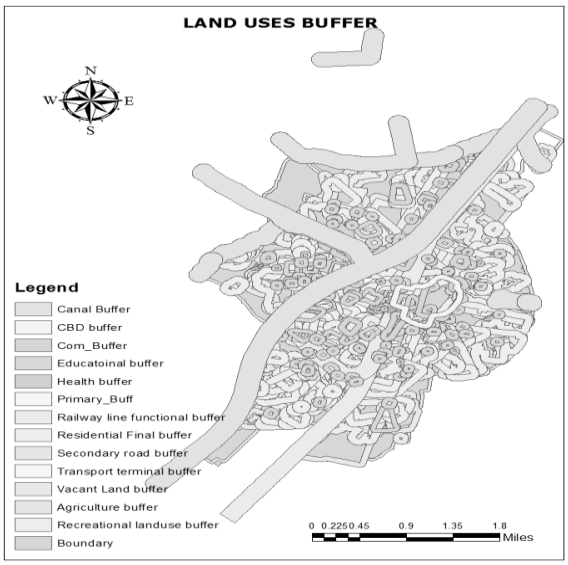
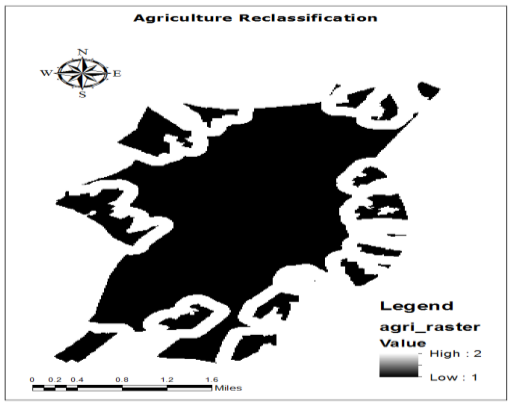
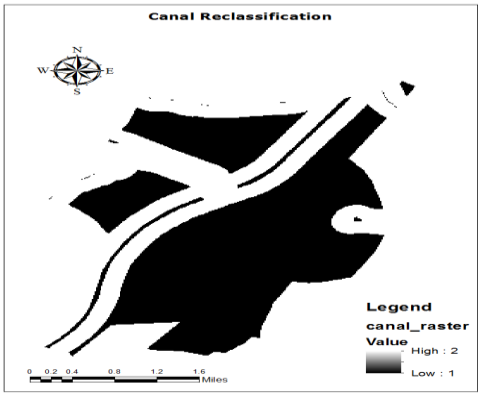


Fig.6. Land uses Buffer

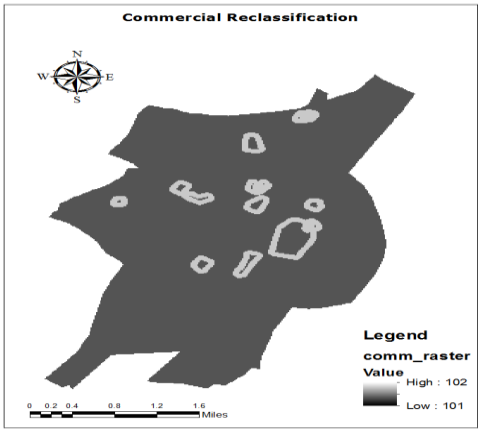
Later on, each land use buffer was processed using GIS reclassify application and converted into Raster form as to specify the high and low potentiality of land around each land use activity as pointed-out in **(a-i figures)**.



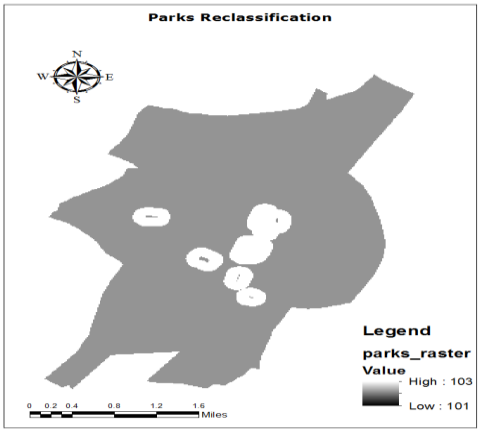
(a) Agricultural uses



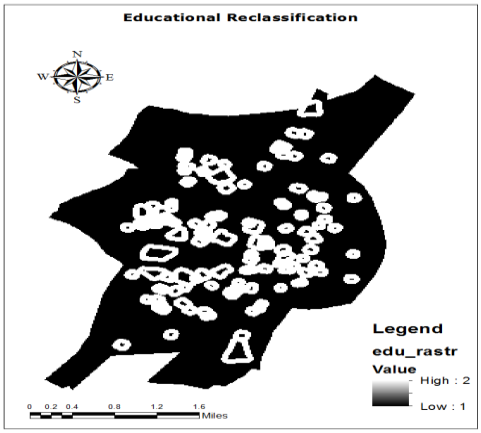
(b) Water Bodies uses



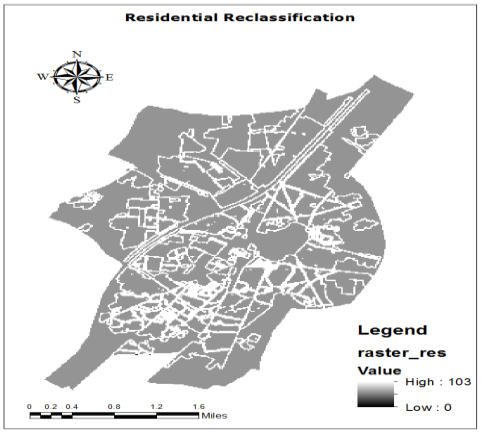
(c) Commercial uses



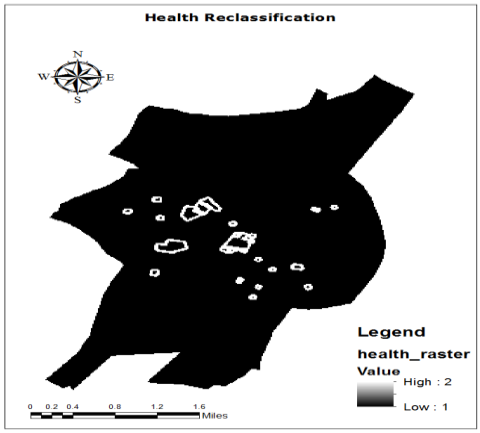
(f) Recreational uses



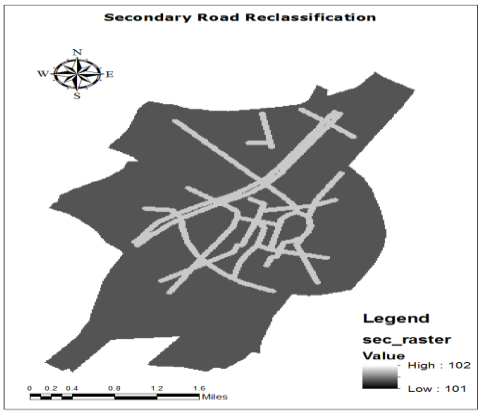
(d) Educational uses



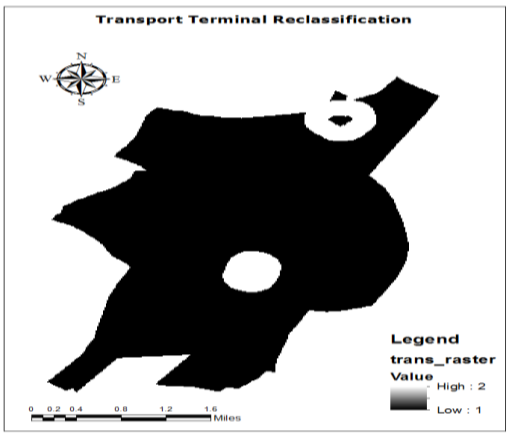
(g) Residential uses



(e) Health uses



(h) Secondary Road uses



(i) Transport Terminal uses

At the end, while performing the land suitability analysis calculated each land use weights were inserted in GIS. The weighted-sum tool was applied through GIS and evaluated the most suitable land for public parks based on inserted weights scenarios as given in **(Table-2)**.

Table-2. Land uses weighted criteria

S. No.	Land Uses	Criteria (Wt)
01	Recreational	0.05
02	Agricultural	0.6
03	Commercial	0.04
04	Educational	0.04
05	Health	0.04
06	Secondary Road	0.04
07	Transport Terminal	0.04
08	Canal/Water Bodies	0.1
09	Residential	0.05

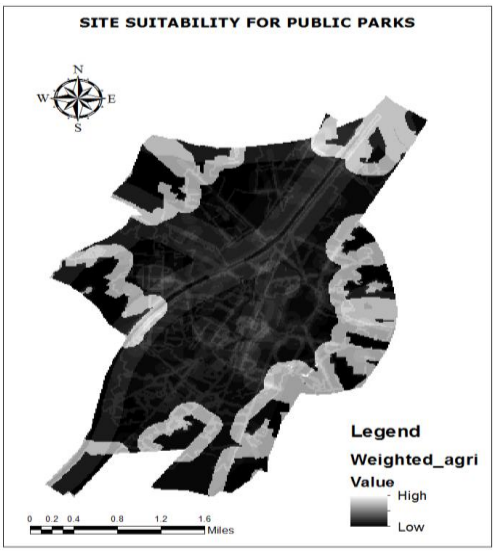


Fig-6. GIS based site suitability for public parks

In this study, the GIS based degree of a land suitability scenario for public parks was measured by researchers. The criterion weighted of different land uses was calculated in GIS by applying spatial analysis tools. In which, 0.6 means most preferable weight was provided to Agriculture uses, secondly 0.1 weight was suggested for Canal/Water bodies and remaining were below weighted than both land uses as outcome by Experts' decision making software (Expert Choice). Hence, the composite weighted result illustrates the degree from high to low potentiality of land. It is also presented in while to black color. The high potentiality of land can be proposed for public parks in the Larkana city. Almost 1658Acres/6.73sq.km potential land is available for proposing public parks around and across the city, which is also nearer to preferable criterion based land use as given in **(Table-2)** and rest of the land is less potential for public parks as shown in **(Fig.6)**.

In conclusion, this research work may useful for professionals who utilize the AHP as a multi-criteria evaluation approach through GIS and may give expertise for taking land use planning decisions by applying GIS based land suitability analysis models for future development, including public parks in the study area.

4. CONCLUSION

This study dealt with choosing the optimal site for development of public facilities specifically parks in the city of Larkana. An integrated Multi-Criteria Decision Approach (MCDA) through Analytical Hierarchy Process (AHP) was undertaken to decide suitable site for public parks. Various factors and parameters were examined, based on different criteria and sub-criteria by AHP assessment and information about land suitability alternatives was taken from different experts. Moreover; assessed factors weights from alternative scenarios were calculated in the decision support system software (Expert Choice). Later on, ArcGIS 10.3 spatial analyst tools were adopted and produced Land Suitability Model to allocate the suitable land for development of public parks in Larkana city. The Land Suitability Model was also derived and generated different data layers in ArcGIS 10.3. Each data layer was categorized into appropriate weights and decisions were made by applying Multi-Criteria AHP technique with GIS for provision of public parks in Larkana, Sindh, Pakistan. Results found that mainly existing city periphery means near about an agricultural belt or outside of city center, development area is suitable for public parks whenever city government may get interesting to develop them for urban dwellers. This study can be helpful for city planners, real estate developers, and government officials in examining the public facilities including parks & their accessibility related issues at urban level

and may act as to take decisions for proper land use planning and development of public facilities including public parks within urban areas.

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