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A Multi-Criteria Decision Making for Sustainable Location of Urban Parks

Aida Yarira Reyes Escalante[1], Diego Adiel Sandoval[2], Edith Vera Bustillos[1], Carlos Alberto Ochoa Ortiz Zezzati[1]

[1] Universidad Autónoma de Ciudad Juárez, Mexico

[2] Instituto Tecnológico de Ciudad Juárez, Mexico

aida.reyes@uacj.mx, diegoadiel@yahoo.com

Abstract. The purpose and design of urban parks plays a crucial role for sustainable development of cities. Projects for public spaces and the availability of urban parks allow historic preservation, recreation, and a great variety of social, environmental, and economic benefits. Therefore, is important to comply with diverse sustainability indicators toward parks policy based on contemporary needs. Hence, park planners must consider the analysis of accessibility, transportation, contiguity, proximity and connectivity, natural areas, good land, size, influence, and restrictions, among other elements. In this study, we aim to determine a core alternative for planning a suitable location of an urban park by utilizing a multi-criteria decision making methods, MCDM, and through the applications of the Analytic Hierarchy Process, AHP, and Technical for Order of Preference by Similarity to Ideal Solution, TOPSIS. We linked the multi-criterion to the identification of latent locations of green spaces in Juarez Region, Chihuahua, Mexico, by spatial distribution in five sub-regions -northwest, northeast, central, southwest, and southeast (A thru E). The results of this study allowed determining that only one option (D) obtained the top assessment as the optimum alternative to be transformed as urban park, which is located in the northeast area of the landscape assessed. The approach in this study has provided practical ways of managing not only the spatial distribution of urban parks but understanding some holistic criteria for sustainability.

Keywords: Urban parks, AHP methodology, TOPSIS methodology, multi-criteria decision-making, MCDM, sustainable assessment for locations of urban parks.

1 Introduction

The need for sustainable social development options (e.g. communication, green and recreations spaces areas, living areas and environmental protection areas) calls for improved urban development plans. These plans must consider factors like infrastructure, health, protection and security, among others.

Table 1. Original unit of analysis and the applicability to world cities. Source: Morin & Christodoulou [2].

		Applicability to comparison of sustainability among world cities	
		Yes but conditional	No
Original unit of analysis	Global Country		LPI
		CDI	ESI
		DS	HDI
		WF	EVI
		EF	EPI
		GPI	Satellite-based
		ISEW	sustainability
		GS	WI
		EDP(Green GDP)	
	Region or Local City Other		Applications of composite indices to local contexts
		CDI	
		WF	LPI
		Emergy/exergy	

Sustainable cities are considered those where indicators of economic, social and environmental development are constantly monitored and improved. The aim is to maintain balances in all areas, to make urban spaces more environmentally friendly while being optimal for social development and having activities that drive economic development. Cities are of utmost importance for measuring sustainability. The United Nations Human Settlements Program (UN-Habitat) [1] defines an urban agglomeration as the built-up or densely populated area including the suburbs and continuously settled commuter areas, which may be smaller or larger than a metropolitan area.

The conformation of the city is defined both by the inner space that has been carried by the oldest areas as well as by the areas that have been developed around it, areas that have been added not necessarily in planned form, many of them arose from social needs or demographic growth. The components that make up the cities are varied, such as: communication routes, green spaces, equipment, infrastructure, housing areas, shopping areas, surrounded by the most important, all the components are related to each other, either directly or indirectly.

Mori & Christodoulou [2] defines the indexes and indicators to assess the sustainability in the cities. The results shed light about nine indexes, as follow: City Development Index (CDI), Ecological Footprint (EF), Dashboard of Sustainability (DS), Welfare Index (WF), Genuine Progress Indicator (GPI), Index of Sustainable

Economic Welfare (ISEW), Energy/exergy, Environmentally adjusted Domestic Product (EDP), Genuine Saving (GS), see in Table 1.

Based in the results by Morin, et al [2] is remarkably considered the conclusion related to the need of building a unique indicator to measure the sustainability of the city (CSI) where the environmental aspects take up an important role such as biophysical or ecological thresholds, green space, parks, protected areas, and others.

2 Cities and Green Space

Urban planning is perhaps the main ingredient to achieve sustainability in cities. It provides for social, environmental and economic balances. Since the Nineteenth century, there were already concerns about the issues of an adequate urban planning. Oftentimes, cities fail to provide happiness and recreation, as well as other forms of public space use, such as games, opportunities for playing music, entertainment and education, and others, Howe [3].

Additionally, demographic growth has brought increases of air pollution, vehicular traffic, noise, heat, insolation, loss of vegetation, insecurity, and other city life –related problems. The loss of greenspace follows the growth of the population, which, at its time, drives the city into a series of unwanted conditions, some of them already mentioned.

As we have seen, greenspace offers a variety of services in the urban environment. When adequately used and maintained, forests and urban greenspace are laboratories and classrooms of environmental education. They also offer the opportunity of meeting diverse material needs. On the other hand, these spaces give the possibility of satisfying other non-material needs, such as recreation and collective encountering and interaction with other people [4].

Nielsen and Hansen [5] affirm that the style of urban life, with shortage or lacking of greenspace, relates with many mental diseases (e.g. stress, depression and anxiety). Niemelä et al., [6] indicate that greenspace might mitigate the negative consequences of accelerating urbanization. Urban greenspace provides a diverse set of ecosystem services ranging from those derived physical well-being to those related to psychological comfort. Many countries have actively developed a variety of programmers for sustainable urban planning with respect to greenspace.

Urban parks are a special kind of public space. They constitute fundamental elements for managing and defining the equilibrium between built and unbuilt areas in a city. Many spaces, whether structured or unstructured, expansion zones, empty lots, environmental control stripes, may reconvert into an urban park.

Literature regarding evaluation to determine the location of urban parks shows that: in 2018, there were three studies; six in 2017; one during 2016, 2015, 2014 and 2011 respectively. Although we found many of papers addressing the problem of locating an urban park using a variety of techniques: modeling [7, 8, 9, 10, 11]; urban distributions [12, 13]; health [14]; public policies [15, 16]; hot spots [17]; distribution areas [18, 19]; among others. We found that none of the research approached the multi-criteria analysis

Table 2. Elements of a Sustainable Park. Source: Cranz and Boland [21].

Element	Variables
Social Goal	Human health; ecological health
Activities	Strolling, hiking, biking, passive & active recreation, bird watching, education, stewardship
Size	Varied, emphasis on corridors
Relation to City	Art-nature continuum; part of larger urban system; model for other
Order	Evolutionary aesthetic
Elements	Native plants, permeable surfaces, ecological restoration green infrastructure, resource self-sufficiency
Promoters	Environmentalists, local communities, volunteers groups, landscape architects
Beneficiaries	Residents, wildlife, cities, planet

methods for the decision making of the location of green areas and in specific public parks.

3 Location Urban Park Methods

According to Cranz [20], the urban park concept has evolved throughout four steps: (a) Pleasure Ground (1850–1900), (b) the Reform Park (1900–1930), (c) the Recreation Facility (1930–1965), and (d) the Open Space System (1965–?).

However, Cranz and Boland [21] suggest a fifth category: Sustainable Park (1990-present). The typology includes both the shifting social purposes that parks served and the corresponding variations in designed form. Each park type evolved to address what were considered to be pressing urban social problems at that time, (see table 2).

The location of the park is the most important decision issue. Jim [22] states that spatial permeation and connectivity of greenspace is desired along new roads (amenity strips on roadsides and medians), amenity parcels in roundabouts, and incidental plots. Also, indicate that within lots, greenspace should be located in the grounds of residential, office, government, institutional and community land uses.

The landscape ecology concepts related to the size, shape and connectivity could be applied with imagination to greenspace planning [23, 24]. Davey, [25] recommended a set of cardinal principles to locate an urban park. He used the nature-reserve design, based on island biogeography theory, namely large size, contiguity, proximity and connectivity, can enhance the quality of green sites.

4 Multi-Criteria Analysis to Define Urban Parks Location

Multiple-criteria decision-making (MCDM) also referent as multiple-criteria decision analysis (MCDA) is a sub-discipline of operations research that explicitly evaluates multiple conflicting criteria in decision making. The MCDA is the process of ranking discrete candidate alternatives and finding the best compromise solution based on the decision maker's subjective assessments of multiple evaluative criteria [26].

Ting-Yu Chen [27] indicated the MCDA problems becoming increasingly complicated, exact assessments of the choices based on evaluative criteria may be difficult to measure or quantify along the MCDA cycle. Conflicting criteria are typical in evaluating options: cost, customers, tools, equipment, personals, spaces, in all decisions problems criterial can be use the MCDA.

There are different classifications of MCDA problems and methods. A major distinction between MCDA problems is based on whether the solutions are explicitly or implicitly defined. Two options need to follows: Multiple-criteria evaluation problems or Multiple-criteria design problems (multiple objective mathematical programming problems).

Malakooti [28] indicated the MCDM approaches should have the following nine characteristics: Principle-oriented (axiom-based); Convincing; Coherent; Defendable (justifiable); Enlightening (illuminating; informative; supportive); Versatile (allows for the use of different preferential behaviors); Transparent; Systematic; Verifiable (testable and repeatable).

Different approaches to select MCDA methods to solve specific problems have been used to look at the outcomes [29, 30, 31], see Table 3.

5 Problem Setting and Research Objective

A brief review of the land use patterns of Juarez revealed there are many zones available to potential used to urban park [32].

The rapid and unstructured growth of Ciudad Juarez city has prevented an adequate urban planning. According to official data, there are around 4000 parks in the city.

However, currently only two public parks pertaining to the category of urban (that is, a major large-scale urban park) are available: Chamizal Park and Central Park Hermanos Escobar. The first locates in the northern part of the city and the second in the geographical center of the city.

Studies related to the subject matter are limited; we were no able to find evidence of the use of methodologies for the location of an urban park in Ciudad Juárez.

We can state that a methodological system for planning the location of an urban park in of Ciudad Juarez is not available. This, based on the above, the main objective is to determine the location of an urban park in Ciudad Juarez through multi-criteria analysis.

Table 3. MCDA method.

Inputs	Effort input	MCDA method	Output
Utility function	Very HIGH	MAUT	Complete ranking with score
Pairwise comparisons on a ratios scale and interdependencies	I I I	ANP	Complete ranking with score
Pairwise comparisons on an interval scale	I I	MACBETH	Complete ranking with score
Pairwise comparisons on a ratio scale indifference, preference and veto thresholds	I I I	AHP	Complete ranking with score
	I I I	ELECTRE	Partial and complete ranking (pairwise outranking degrees)
	I I I	PROMETHEE	Partial and complete ranking (pairwise preference degree and score
Ideal option and constraints	I I	Goal programming	Feasible solution with deviation score
Ideal and anti-ideal option	I I	TOPSIS	Complete ranking with closeness score
No subjective inputs required	I Very LOW	DEA	Partial ranking with effectiveness score

6 Method

The study relies on an exploratory analysis carried out in 2019 in Juarez, Mexico. We considered five different sectors: North, East, West, South and Central. In addition, this study involves a quantitative design, adopting a multi-criteria decision methodology to determine a basis for planning the location of an urban park.

Through Analytic Hierarchy Process, AHP, and Technical for Order of Preference by Similarity to Ideal Solution, TOPSIS, we evaluated the location's selection.

We utilized the following criteria evaluation: Nature-reserve design: the space is declaring of protection area; Contiguity: the ground is continuous without breaking; Proximity and connectivity: close to the urban area, connections area; Good land: land in good condition to plant vegetation; Parcels: land used to sow; Size: Great or big space; Influence area; Restrictions section: Airplane, military area, unsafe zone, criminal and insecurity, restricted area; Accesses: streets, avenues, high way; Transport accesses: cars, bicycles, motorcycles, public bus, etc.

Furthermore, we included Beta-values, or compliance (or suitability or fitness) value judgments, with the following arbitrary Lickert scale: (1) Worst (no compliance); (2) Very (low compliance; (3) Undesirable compliance; (4) Slightly undesirable compliance; (5) Neutral compliance, and (6) Slightly desirable compliance. We describe the methodology utilized in the multi-criteria analysis: AHP and TOPSIS.

6.1 Analytic Hierarchy Process AHP

The analytic hierarchy process was development by Thomas L. Saaty in the 1977. It is a mathematical structured method [33] and subdivides a complex decision-making problem or planning issue into its components or levels, and arranges these levels into an ascending hierarchic order [34]. In addition, it indicates that the AHP can provide a framework and methodology for the determination of a number of key decisions. The AHP allows its users flexibility in constructing a hierarchy to fit their needs. Also the AHP provides an effective structure for group decision making by imposing a discipline on the group's thought processes [35].

The process AHP is established in different stages, the formulation of the decision problem in a hierarchical structure is the first and main stage. In this stage, the decision maker involved must break down the problem into its relevant components [35]. To make a decision in an organized way to generate priorities we need to decompose the decision into the following steps:

a. Define the problem and determine the kind of knowledge sought.
b. Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).
c. Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it. The value a_{12} is an approximation of the relative importance of A1 with respect to A2, i.e., $a12 \approx (w1 \,/\, w2)$. This can be generalized and the following:

$$aij \approx \left(wi - wj\right) i,j \;=\; 1,2,\ldots,n\,,$$

$$aii \;=\; 1, i \;=\; 1,2,\ldots,n,$$

$$Si\ aij = \alpha, \alpha \neq 0, entonces\ aji \;= \frac{1}{\alpha}, i \;=\; 1,2,\ldots,n\,.$$

If Ai is more important than Aj, then:

$$aij \cong \left(wi - wj\right) > 1. \tag{1}$$

The matrix A must be positive and reciprocal with ones in the main diagonal, and therefore the decision maker only needs to provide the values of the judgments in the upper triangular of the matrix. To fill these values, we use already established scales 1 to 9. The judgments of the criteria are perfectly consistent as long as it is fulfilled that: $aijajk = aik, i, j, k = 1, 2, \ldots, n, lo\ que\ es\ equivalente\ a: (wi/wj)(wj/wk) = (wi/wk)$.

The eigenvector method produces a natural measure of consistency. Saaty defines the consistency index (CI) as a distance between the λmax and the value of that λmax when the judgments were perfect, ie λmax = n. The CI is defined as follows:

$$CI = \frac{\lambda \max - n}{(n-1)}. \quad (2)$$

d. Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority.

6.2 TOPSIS Method

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a MCDA tool. It was primarily established by Hwang and Yoon in 1981 for ranking based on resemblance to perfect solution, with advancements done by Yoon in 1987, and Hwang, Lai and Liu in 1993. TOPSIS is a prevalent method suitable for taking a multiple criteria decision for rank ordering by comparison. It is a technique for rank ordering based on closeness to perfect outcomes. The ultimate option is the one that is nearest to the perfect positive outcome and extreme from the negative perfect outcome [36].

This study uses the TOPSIS method. A positive ideal solution maximizes the benefit criteria or attributes and minimizes the cost criteria or attributes, whereas a negative ideal solution maximizes the cost criteria or attributes and minimizes the benefit criteria or attributes. The TOPSIS method is expressed in a succession of six steps as follows:

Step 1: Calculate the normalized decision matrix. The normalized value r_{ij} is calculated as follows:

$$r_{ij} = x_{ij} \sqrt{\sum_{i-1}^{m} x_{ij}^2} \quad i = 1, 2, \ldots, m \text{ and } j = 1, 2, \ldots, n. \quad (3)$$

Step 2: Calculate the weighted normalized decision matrix. The weighted normalized value vij is calculated as follows:

$$Vij = rij \, X \, Wj \qquad i = 1, 2, \ldots, m \text{ and } j = 1, 2, \ldots, n. \quad (4)$$

where w_j is the weight of the j^{th} criterion or attribute and $\sum_{j=1}^{n} w_j = 1$.

Step 3: Determine the ideal (A^*) and negative ideal (A^-) solutions:

$$A^* = \{(\max_i v_{ij} \mid j \in C_b), (\min_i v_{ij} \mid j \in C_c)\} = \{v_j^* \mid j = 1, 2, \ldots, m\}, \quad (5)$$

$$A^{-} = \{(\min_i v_{ij} \mid j \in C_b), (\max_i v_{ij} \mid j \in C_c)\} = \{v_j^{-} \mid j = 1,2,\dots,m\}. \quad (6)$$

Step 4: Calculate the separation measures using the m-dimensional Euclidean distance. The separation measures of each alternative from the positive ideal solution and the negative ideal solution, respectively, are as follows:

$$S_i^{*} = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^{*})^2}, \; j = 1,2,\dots,m \quad (7)$$

$$S_i^{-} = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^{-})^2}, \; j = 1,2,\dots,m \quad (8)$$

Step 5: Calculate the relative closeness to the ideal solution.

The relative closeness of the alternative A_i with respect to A^{*} is defined as follows:

$$RC_i^{*} = \frac{S_i^{-}}{S_i^{*} + S_i^{-}}, \; i = 1,2,\dots,m. \quad (9)$$

Step 6: Rank the preference order.

The studies carried out using the two methods of MCDA using AHP and TOPSIS in the analysis of green spaces is increase. The review of the literature allows to visualize how the methods of MCDA are used comparatively to determine the best decisions through AHP and TOPSIS, finding that there is no research where they are used for the decision of Green spaces and urban parks location [37-43].

6.3 Criterial Evaluation Areas

The criterial to perform the evaluation consist in 10 criteria decision:

a. Nature-reserve design: the space is declaring of protection area.
b. Contiguity: the ground is continuous without breaking.
c. Proximity and connectivity: close to the urban area, connections area.
d. Good land: land in good condition to plant vegetation.
e. Parcels: land used to sow.
f. Size: Great or big space.
g. Influence area: 400 mtrs, 1500 mtrs.
h. Restrictions section: Airplane, military area, unsafe zone, criminal and insecurity, restricted area.
i. accesses: streets, avenues, high way.
j. Transport accesses: cars, bicycles, motorcycles, public bus, etc.

The Beta-values, or compliance (or suitability or fitness) value judgments, are made on the following arbitrary licker scale:

1) Worst (no compliance).
2) Very (low compliance).

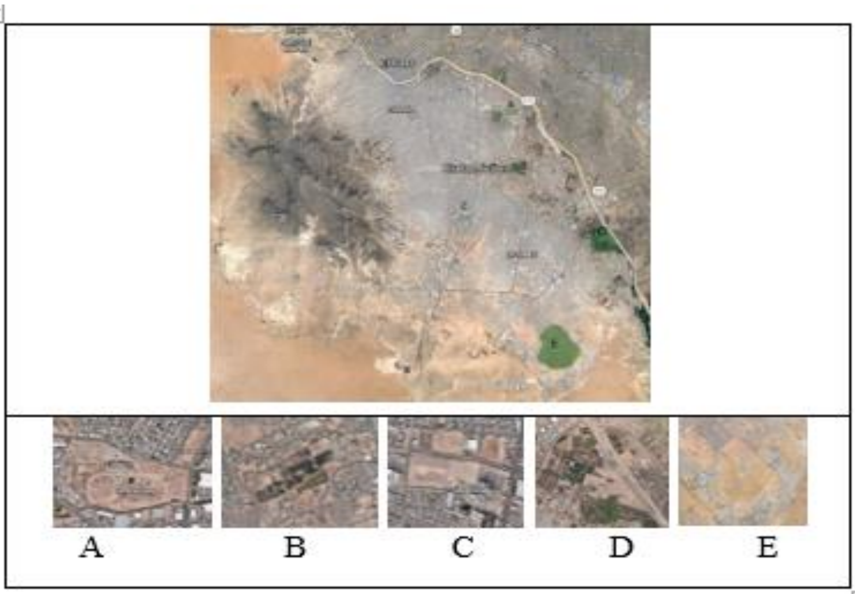

Fig. 1. Decision study sites.

3) Undesirable compliance.
4) Slightly undesirable compliance.
5) Neutral compliance.
6) Slightly desirable compliance.
7) Desirable compliance.
8) Very desirable compliance.
9) Best possible compliance.

7 Results

The results are presented in three moments: (a) map analysis, (b) AHP analysis, and (c) TOPSIS analysis.

(a) The analyses maps determine the site for the location of the park, this analysis was carried out taking as criteria: the location of the space, the free area and access to the site, which is fields uninhabited areas, planting areas, assigned natural areas, airport proximity, restricted or military areas were avoided. We found 5 viable sites for the development of an urban park, see Figure 1. The first evaluation is generated using the beta-values to establish the first relationship, see table 5.

Table 5. Evaluation site using Beta-values.

	A	**B**	**C**	**D**	**E**
Nature-reserve design	1	5	1	9	1
Contiguity	9	9	9	9	7
Proximity and connectivity	9	9	9	7	9
Good land to sow	1	9	1	9	1
Parcels	1	9	1	9	1
Size	5	5	1	9	9
Influence area	9	9	9	5	7
Restrictions section	5	1	1	1	9
Access	9	9	9	9	9
Transport	9	9	9	9	9

Table 6. AHP matrix criteria's example.

Nature-reserve design											
	A	**B**	**C**	**D**	**E**	**Matrix normalized**					**Vector**
A	1	0.2	1	0.11	1	0.05	0.02	0.048	0.05	0.07	0.049
B	5	1	9	0.2	1	0.29	0.1	0.429	0.08	0.076	0.196
C	1	1	1	0.11	1	0.05	0.1	0.048	0.05	0.076	0.065
D	9	7	9	1	9	0.52	0.69	0.429	0.41	0.692	0.549
E	1	1	1	1	1	0.05	0.1	0.048	0.41	0.076	0.138
Total	17	10.2	21	2.42	13						

Table 7. Concentrate Matrix vectors.

	Nature-reserve design	Contiguity	Proximity and connectivity	Good land to sow	Parcels	Size	Influence area	Restrictions	Accesses	Transport
A	0.049	0.20	0.207	0.047	0.047	0.048	0.258	0.287	0.2	0.2
B	0.196	0.20	0.207	0.428	0.428	0.040	0.258	0.059	0.2	0.2
C	0.065	0.20	0.207	0.046	0.047	0.031	0.258	0.059	0.2	0.2
D	0.549	0.20	0.169	0.425	0.428	0.439	0.022	0.059	0.2	0.2
E	0.138	0.16	0.207	0.04	0.047	0.439	0.201	0.534	0.2	0.2

(b) AHP method: According with the stage, the step 1 and 2 was defined in the problem selection. The Step 3. Construct a set of pairwise comparison matrices is presented in the Table 6 the concentrated matrix vector in Table 7. Priority results are presented in Table 8. The best option using AHP is D.

Step 1: Calculate the normalized decision matrix.

	Nature-reserve design	Contiguity	Proximity and connectivity	Good land to sow	Parcels	Size	Influence area	Restrictions section	Accesses	Transport
A	1	9	9	1	1	5	9	5	9	9
B	5	9	9	9	9	5	9	1	9	9
C	1	9	9	1	1	1	9	1	9	9
D	9	9	7	9	9	9	5	1	9	9
E	1	7	9	1	1	9	7	9	9	9

Step 2: Calculate the weighted normalized decision matrix.

	Nature-reserve design	Contiguity	Proximity and	Good land to sow	Parcels	Size	Influence area	Restrictions section	Accesses	Transport
A	0.009174	0.0241	0.024	0.006061	0.00606	0.02	0.028	0.05	0.0222	0.022
B	0.045872	0.0241	0.024	0.054545	0.05455	0.02	0.028	0.01	0.0222	0.022
C	0.009174	0.0241	0.024	0.006061	0.00606	0	0.028	0.01	0.0222	0.022
D	0.082569	0.0241	0.019	0.054545	0.05455	0.04	0.016	0.01	0.0222	0.022
E	0.009174	0.0188	0.024	0.006061	0.00606	0.04	0.022	0.08	0.0222	0.022

Step 3: Determine the ideal and negative ideal solutions.

V+	0.012385	0.0024	0.004	0.008182	0.00273	0	0.003	0.01	0.0011	0.001
V-	0.001376	0.0019	0.003	0.000909	0.0003	0	0.002	0	0.0011	0.001

Step 4: Calculate the separation measures using the m-dimensional Euclidean distance.

Step 5: Calculate the relative closeness to the ideal solution. The relative closeness of the alternative.

Step 6: Rank the preference order.

	Si+	**Si-**	**Pi**	**Rank**
A	0.01403442	0.0044182	0.239433	4
B	0.009364541	0.0080513	0.462296	2
C	0.015746285	0.0015895	0.09169	5
D	0.007490435	0.0085536	0.533132	1
E	0.01344087	0.0083078	0.38199	3

c. TOPSIS method: Using the information in Table 6, the beta-values is using the data to start the evaluation using the TOPSIS method. The best option using TOPSIS is D.

Table 8. Final results.

	Nature-reserve design	Contiguity	Proximity and connectivity	Good land to sow	Parcels	Size	Influence area	Restrictions section	Accesses	Transport	TOTAL
A	0.04	0.208	0.207	0.05	0.047	0.05	0.25	0.28	0.2	0.2	0.157
B	0.19	0.208	0.207	0.43	0.428	0.04	0.25	0.05	0.2	0.2	0.215
C	0.06	0.208	0.207	0.05	0.047	0.03	0.25	0.05	0.2	0.2	0.095
D	0.54	0.208	0.169	0.43	0.428	0.43	0.02	0.05	0.2	0.2	0.275
E	0.13	0.165	0.207	0.05	0.047	0.43	0.20	0.53	0.2	0.2	0.25
Weighted	0.144	0.117	0.097	0.13	0.139	0.04	0.02	0.28	0.0125	0.012	

8 Conclusions

Urbans parks are key elements to pursue sustainability in urban conglomerates. The adequate location of an urban park is paramount for such an endeavor. Parks are public spaces that provides a variety of eco-services. It is important to incorporate sustainable criteria to evaluate their location. Being a determinant factor for urban planning, the location of parks is, therefore, a priority. To determine the best-featured area to locate a park is a task of gliders and researchers interested in these strategies.

This work offers a quantitative multi-criteria framework to determine the best urban alternatives in terms of size, geographical location, access roads, land extension, areas of influence, land types, fundamental elements for decision-making when locating an urban park.

Out of the five identified areas (A-E), evaluated as a potential zone to locate an urban park in the municipality of Juarez, alternative D was optimal according to AHP y TOPSIS methods.

We can conclude that the use of the AHP and TOPSIS methods allow evaluating the location of an urban park using the identified criteria. We conducted from the perspective of the indicated methods and without taking into account other factors like land property, land use, and the eventual existence of public policies that allow knowing if the optimal location has chances of being an urban park.

Both AHP and TOPSIS found option D to be optimal; this zone is located in the Northern area of the city. This area is undergoing an active urban growth, with new constructions and infrastructure projects now in progress. The area was considered in the past decade's part of the reserve natural area, but in the actually is the most important construction urban area.

The approach that we consolidated in this study, offers a comprehensive and effective decision support method to address a core alternative for planning a suitable location of an urban park. It is recommendable the adoption of this multi-criteria techniques for further decisions regarding the parks policy based on contemporary needs.

9 Recommendation

For future studies it is recommended that land use factors, land ownership, and other relevant restrictions be considered. In addition, from the methodologies, it is relevant to consider alternative scenarios, such as: sensitivity analysis, to strengthen the evaluation criteria.

References

1. UN-Habitat: United Nations Human Settlements Programme: The state of the world's cities report 2006/2007 (2006)
2. Mori, K., Christodoulou, A.: Review of sustainability indices and indicators: towards a new city sustainability index (CSI). Environmental Impact Assessment Review, 32(1), pp. 94–106 (2012)
3. Howe, F.C.: European cities at work (2012)
4. Rivas-Torres, D.: Planeación, espacios verdes y sustentabilidad en el distrito federal. División de Ciencias y Artes para el Diseño Especialización, Maestría y Doctorado en Diseño, Universidad Autónoma de México (2005)
5. Nielsen, T.S., Hansen, K.B.: Do green areas affect health? Results from a Danishsurvey on the use of green areas and health indicators. Health Place, 13(4), pp. 839–850 (2007)
6. Niemelä, J., Saarela, S.R., Söderman, T., Kopperoinen, L., Yli-Pelkonen, V., Väre, S., Kotze, D.J.: Using the ecosystem services approach for better planning and conservation of urban green space: A Finland case study. Biodivers Conserv., 19(11), pp. 3225–3243 (2010)
7. Muge-Unal, C.U.: Evaluating and optimizing urban green spaces for com-pact urban areas: Cukurova district in Adana, Turkey. In: ISPRS International Journal Geo-Information, 7(2), pp. 70 (2018)
8. Conghong Huang, Jun Yang, Peng Jiang: Assessing impacts of urban form on landscape struc-ture of urban green spaces in china using Landsat images based on google earth engine. Remote Sensing, 10(10), pp. 1569 (2018)
9. Niedermann, B., Oehrlein, J., Lautenbach, S., Haunert, J.H.: A network flow model for the analysis of green spaces in urban areas. GIScience, 13, pp. 1–13 (2018)
10. Vallejo, M., Corne, D.W., Vargas, P.A.: Online/offline evolutionary algorithms for dynamic urban green space allocation problems. Journal of Experimental and Theoretical Artificial Intelligence, 29(4), pp. 843–867 (2017)
11. Wicaksono, A., Sarapirome, S.: Urban park area feasibility analysis using fuzzy aggregation of multi-spatial criteria and multi-expert weights. In: International Conference on Digital Information Management (ICDIM´17), pp. 246–251 (2011)
12. Van de Voorde, T.: Spatially explicit urban green indicators for characterizing vegetation cover and public green space proximity: A case study on Brussels. Belgium. In: International Journal of Digital Earth, 10(8), pp. 798–813 (2017)

13. Vallejo, M., Rieser, V., Corne, D.W.: Agent-based modelling for green space allocation in urban areas-factors influencing agent behaviour. In: International Conference on Agents and Artificial Intelligence (ICAART), 1, pp. 257–262 (2015)
14. Conghong Huang, Jun Yang, Hui Lu, Huabing Huang, Le Yu: Green spaces as an indicator of urban health: Evaluating its changes in 28 mega-cities. Remote Sensing, 9(12), pp. 1266 (2017)
15. Zhoulu Yu, Yaohui Wang, Jinsong Deng, Zhangquan Shen, Ke Wang, Jinxia Zhu, Muye Gan: Dynamics of hierarchical urban green space patches and implications for management policy. Sensors, 17(6), pp. 1304 (2017)
16. Banzhaf, E., De la Barrera, F.: Evaluating public green spaces for the quality of life in cities by integrating RS mapping tools and social science techniques. In: Joint Urban Remote Sensing Event (JURSE), pp. 1–4 (2017)
17. Kothencz, G., Kiss, M., Petutschnig, A.: Hot spots for improvements: Where to implement new green spaces?. Smart-World, pp. 1–4 (2017)
18. Tongliga Bao, Xueming Li, Jing Zhang, Yingjia Zhang, Shenzhen Tian: Assessing the distribution of urban green spaces and its anisotropic cooling distance on urban heat island pat-tern in Baotou. In: ISPRS International Journal of Geo-Information, 5(2), pp. 12 (2016)
19. Neuenschwander, N., Hayek, U.W., Grêt-Regamey, A.: Integrating an urban green space typology into procedural 3D visualization for collaborative planning. Computers, Environment and Urban Systems, 48, pp. 99–110 (2014)
20. Galen, C.: The politics of park design: A history of urban parks in America. MIT Press (1982)
21. Galen, C., Boland, M.: Defining the sustainable park: A fifth model for urban parks. Landscape Journal, 23, pp. 102–120 (2004)
22. Jim, C.Y.: Green-space preservation and allocation for sustainable greening of compact cities. Cities, 21, pp. 311–320 (2004)
23. Cook-Edward, A.: Landscape structure indices for assessing urban ecological networks. Landscape and Urban Planning, 58(2), pp. 269–280 (2002)
24. Botequilha-Leita, Ä., Ahern, J.: Applying landscape ecological concepts and metrics in sustainable landscape planning. Landsc Urban Plann, 5, pp. 65–93 (2002)
25. Davey, A.G.: National system planning for protected areas. World Conservation Union, Gland (1998)
26. Wan, S.P., Qin, Y.L., Dong, J.Y.: A hesitant fuzzy mathematical programming method for hybrid multi-criteria group decision making with hesitant fuzzy truth degrees. Knowl-Based Systems, 138, pp. 232–248 (2017)
27. Chen, T.Y.: Remoteness index-based Pythagorean fuzzy VIKOR methods with a generalized distance measure for multiple criteria decision analysis. Information Fusion, 41, pp. 129–150 (2018)
28. Malakooti, B.: Double helix value functions, ordinal/cardinal approach, additive utility functions, multiple criteria, decision paradigm, process, and types (Z Theory I). In: International Journal of Information Technology and Decision Making, 14(6), pp. 1353 (2015)
29. Ishizaka, A., Nemery, P.: Multi-criteria decision analysis: Methods and software. Wiley (2013)
30. Ishizaka, A., Nemery, P.: PROMETHEE. In: Multi-Criteria Decision Analysis: Methods and Software, pp. 135–179 (2013)
31. Guitouni, A., Martel, J.M.M., Bélanger, C.: Managing a decision-making situation in the context of the Canadian airspace protection. Centre de Recherche en Modélisation, Information et Decision (CERMID) (1999)

32. IMIP: Atlas de riesgos naturales y atlas de riesgos antropogénicos. Instituto Municipal de Investigación y Planeación (2016)
33. Saaty, T.L.: The analytic hierarchy process. RWS Publications, 4922 (1990)
34. Saaty, T.L.: Decision making with the analytic hierarchy process. International Journal Services Sciences, 1(1) (2008)
35. Saaty, T.L.: Analytic heirarchy process. Wiley (2014)
36. Xing, W.W.: Distance measure between intuitionistic fuzzy sets. Pattern Recognition Letters, pp. 2063–2069 (2005)
37. Guangdong Tian, Honghao Zhang, MengChu Zhou, Zhiwu Li: AHP, gray correlation, and TOPSIS combined approach to green performance evaluation of de-sign alternatives. IEEE Trans. Systems, Man, and Cybernetics: Systems, 48(7), pp. 1093–1105 (2018)
38. Mohammed, A., Harris, I., Soroka, A., Naim, M.M., Ramjaun, T.: Evaluating green and resilient supplier perfor-mance: AHP-fuzzy topsis decision-making approach. In: Proceedings of the International Conference on Operations Research and Enterprise Systems (ICORES´18), pp. 209–216 (2018)
39. Zyoud, S.H., Fuchs-Hanusch, D.: A bibliometric-based survey on AHP and TOPSIS techniques. Expert Systems with Applications, 78, pp. 158–181 (2017)
40. Campos-Guzman, V., García-Cascales, M.S., Sánchez-Lozano, J.M., Pelta, D.A.: Selection of a fuzzy AHP-TOPSIS electrification system for an isolated rural area in southern México. In: IEEE International Conference on Fuzzy Systems (FUZZ-IEEE), pp. 1–6 (2017)
41. Guoying Yang, Qingling Wang, Jianqing Liu: TOPSIS and AHP model in the application research in the evaluation of coal. In: ICIC, 1, pp. 145–152 (2016)
42. Pazand, K., Hezarkhani, A.: Porphyry Cu potential area selection using the combine AHP - TOPSIS methods: A case study in Siahrud area (NW, Iran). Earth Science Informatics, 8(1), pp. 207–220 (2015)
43. Dammak, F., Baccour, L., Alimi, A.M.: A comparative analysis for multi-attribute decision-making methods: TOPSIS, AHP, VIKOR using intui-tionistic fuzzy sets. . In: IEEE International Conference on Fuzzy Systems (FUZZ-IEEE), pp. 1–5 (2015)