ISSN 2303-4521
Periodicals of Engineering and Natural Sciences *Original Research*
Vol. 11, No. 3, May 2023, pp.203-216

Optimization of the urban green area in Erbil territory for sustainable development

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ABSTRACT

This research paper studies the status and condition of the green areas in the city of Erbil, for this purpose all green areas in the city (763 plots) and all population number according to 12 sectors are collected according to their locations and are analyzed spatially by GIS program (Moran I). Researchers have proved that distribution of green areas is random. Moreover, this distribution is not based on the urban planning basics and its criteria: green area per person (GAPP) and green area to the city ratio (GAR) also not based on the basics of urban planning for two criteria , GAPP is optimized from 9.3 to 14 and GAR optimized from 0.06 to 0.09 while the equilateral tringle adopted as optimum distribution for green area units GAU, for 12 sectors adopted combined standards together and the solution was the population density ratio must be 0.01 or less, to obtain criteria and this must preserved and adhered to the planning and laws and regulations strictly. This method can be applied to the study of the spatial distribution in order to compare it with the distribution of schools, health centers and other services or infrastructures.

Keywords: GA, GAPP, GAR, , SA, Spatial analysis, Statistical analysis

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1. Introduction

Although the United Nations through its organizations which concerned with thus field tried to unify and set the international United Nations, throughout its organizations, tries to unify and set international standards regarding the percentage of green areas relevant to settlement areas and land usage [1] It is also important to specify walking areas for residents and classify the kinds of green areas. al standards regarding the percentage of the green area in the green area up to settlement area land use [2]walking distance, success to green area for residents and classification of types of green areas.

It is very important to focus on the factors that have effects on both the quantity and quality aspects of the green area growth. These include the climate, the abundance of water, rivers, in addition to the soil quality [3]. These factors vary from one country to another in the world. Therefore, specialists in this field. And urban planners do not agree on the necessary standards appropriate to each country[4].

Green areas are well known as being artificial spaces that are allocated inside cities and which play a role in enhancing the weather and climate of cities but these require a budget and a financial allocation for maintaining green area infrastructures [5]. Last studies, especially in the developed countries, have emphasized the importance of finding solutions to pollution problems and pay more interest in reserving green spaces and environment.,

It is worthy to mention that green spaces work as a human lung, as they represent the city's lung in providing oxygen and reducing carbon dioxide. They work as filters to reduce dust and dirt, in addition to the aesthetic

aspects [6] . These areas can be used as playgrounds for children, places for elderly and disabled people to spend leisure time [7] areas for exercising and walking, in addition to their role in minimizing temperature heat especially during summer time [8].

Many ancient civilizations were aware of the necessity of green areas and their positive role as this was documented and found in the historical references and their remaining historical monuments such as Babylonian hanging gardens and the gardens of the Pharaonic and Persian civilizations [9].

2.Material and method

Erbil is a historical city which was established six thousand years ago. Its old citadel which lies in the middle of the city and the Mudhafaryia minaret was established one thousand and two hundred years ago [10] . There are also more than a hundred ancient hills in the city that lie at the longitude 43.9930° E and the latitude 36.1901° N [11] . Erbil now is the fourth largest city in Iraq after the capital Baghdad, Mosul, and Basra. It is the sixth in terms of population as it has a population of more than one million people. Another important point is that Erbil is the capital of the Kurdistan Region of Iraq.

Erbil's position is between four cities Mosul, Kirkuk, Sulaymaniyah, and Duhok. Due to the rapid and huge developments that have taken place in the past two decades, there has been a huge settlement expansion as the number of residential reached more than eighty and investment housing projects also reached more than eighty projects while many of them include residential towers [12].

Unfortunately, this massive development, in many cases, threats the environment in general and green areas in particular. The rapid increase in the number of vehicles in the city has led to air suffocation and environment pollution [13].

This research paper investigates the reality of the green areas and the pattern of their distribution in the city and evaluates their status in terms of two criteria, the ratio of green areas to the city and the standard of the ratio of each individual to the green space, this research will try to determine the shortages of both standards and the how it is going to be the need to these green areas up to the next five years by citizens in Erbil.

Figure 1. Map of Iraq and Location of Erbil city (Source GIS Basemap)

A null hypothesis supposes that green areas in Erbil city are random and are not based on sustainable planning and standards [14]. They also need development in their future planning. It is also hypothesized that green areas are distributed regularly and depending on sustainable criteria [15].

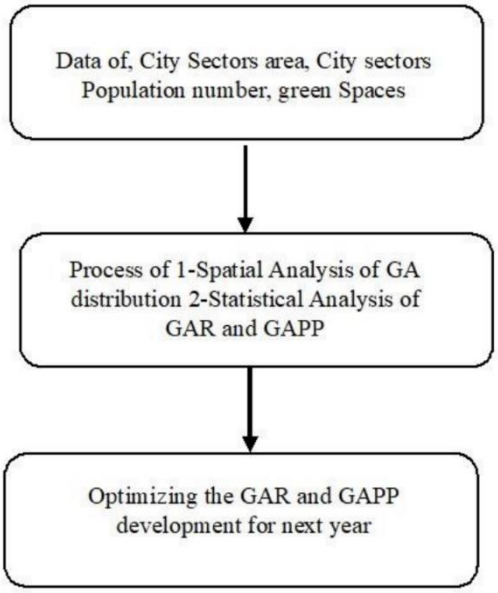

Diagram 1. Methodology Flowchart

Spatial distribution analysis. The researchers have checked the following in order to be able to make appropriate analysis Checking the obtained green areas from different directories: Parks Engineering Directory, Erbil Municipality Presidency, Real estate registrations, Geo-refresing 6 AutoCAD maps from parks engineering of 6 partial municipality and then converting the file to ArcGIS to polygons shape, and finally adding the missed green areas from other maps to complete all green areas.

Checking polygon numbers to avoid duplicating by convert polygon to point in GIS version10.8 comparing attribute tables of both polygon layer with point layer [16] and finalized by 763 green areas (polygons)

Checking all green area with base map in GIS program Figure 2.

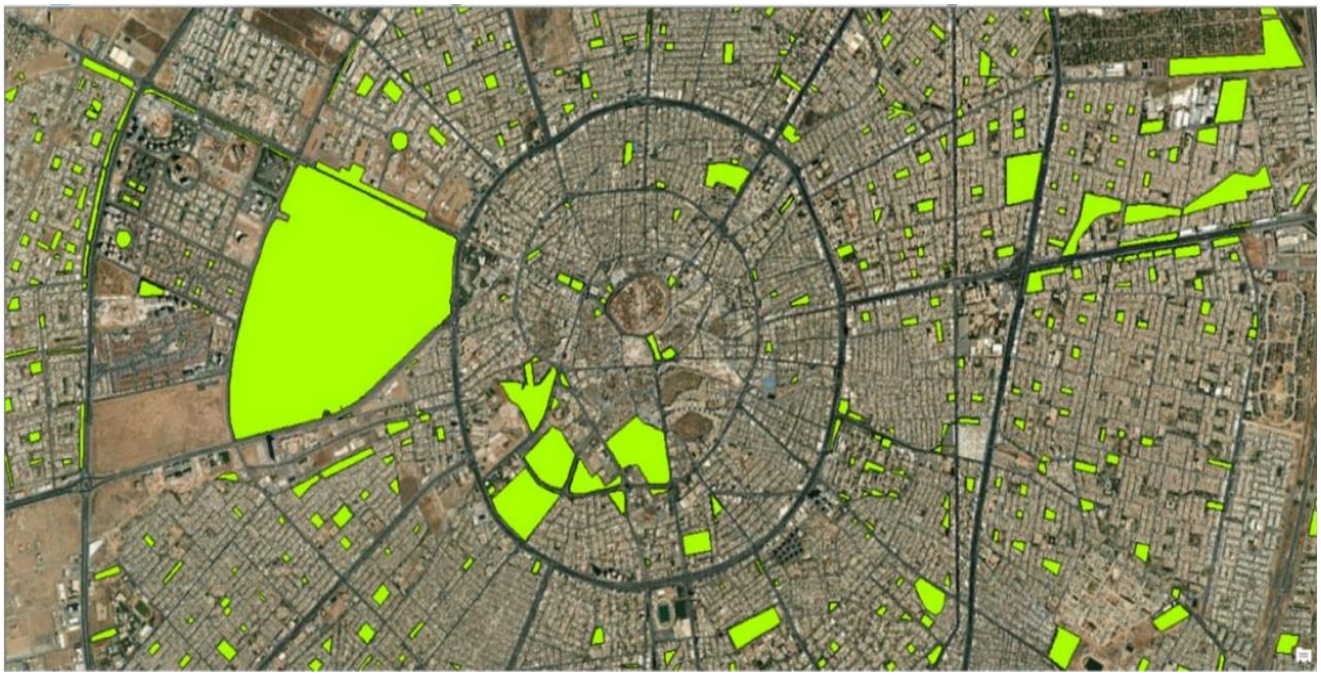

Figure 2. Layer of center Green Area and base map of Erbil city in GIS application

There is a layer for green area polygon and layer for Erbil City out line, depending on 12 sectors there is public park for residentials GAPP and street strips GAR figure 3

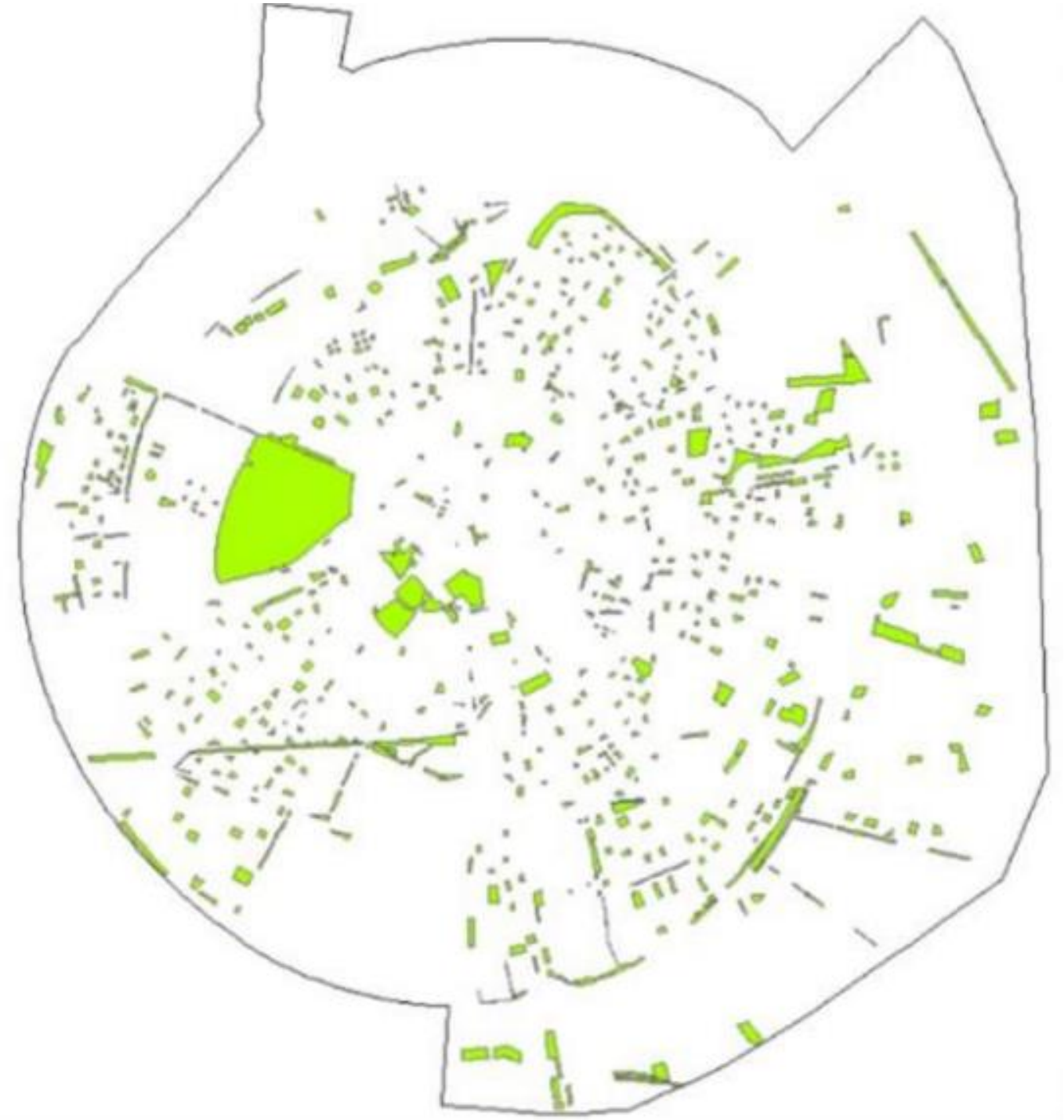

Figure 3. The Layer of all green spaces and their area from attribute table

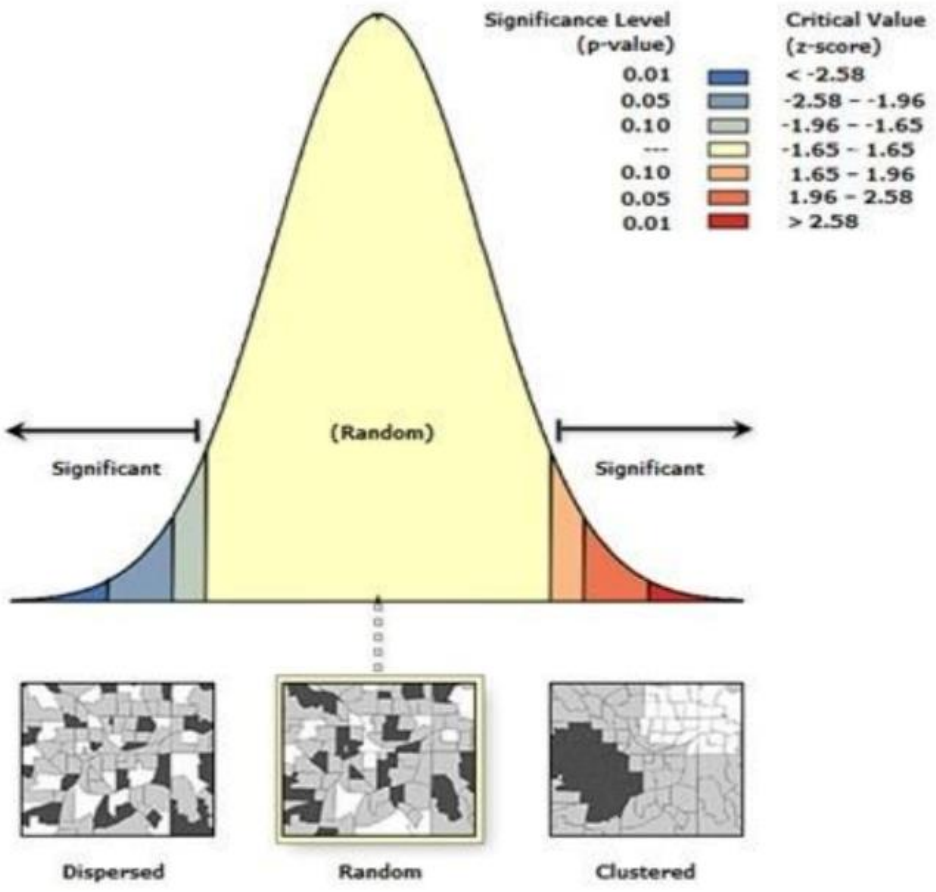

Figure 4. Spatial statistical moran I report for green area distributions

The Moran I analysis with p value 0.937243 and index 0.010801 indicates the random pattern of distribution, Additionally, statistics of GIS attribute for green areas indicates the huge amount of variation between their sizes and there are areas which are completely without green spaces.

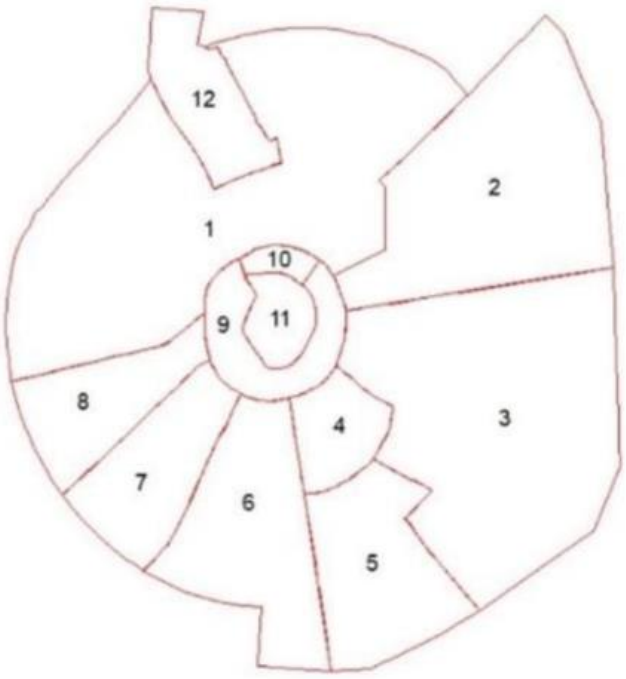

Figure 5. The 12 sectors of Erbil city according to population size

Arranging and downloading the sectors area and their population with Existing GAR and population density in table 1.

Table 1. The area of 12 sectors and existing area and population (Source Researchers)

Sector. No.	Sectors Neighborhoods name	SA m²	No. of GA Units	GA m²	P	Population Density
1	Shorsh,Salahaddin,Aulama,Questan	35393286.03	203	3282296.44	124237	0.004
2	Raparin,Hay Shurta,Brayati, Basta Piaza,	20278212.83	91	1029519.23	101531	0.005
3	Setaqani Saru, Badawa, Balashawa, Gulan	28500206.42	143	1242175.60	166888	0.006
4	Iskan,Ronaki, Mentkawa,Zraah	3720040.86	44	216557.35	51998	0.014
5	Mhabad,92,94, 99	9758226.16	68	497764.15	69061	0.007
6	Azadi,Adala,Rasti	11984949.84	40	442639.11	34006	0.003
7	Kuran,Majidawa,Kurdistan, Hay Umal	7441518.41	73	468407.22	118211	0.016
8	Nishtimam,Nawroz	6591022.91	38	237959.43	42787	0.006
9	Setaqani khwaru ,Saidawa,Taejeel	4611976.85	30	452083.55	65124	0.014
10	Tairawa,	847184.04	4	57860.50	33945	0.040
11	Inside 30 m , Tairawa ,Khanaqah,Taajeel	2314503.82	13	162352.80	40859	0.018
12	Ainkawa , Kurani Ainkawa	5431089.16	16	140336.51	35068	0.006
	Total	136872217.31	763	8229951.89	883715	0.006

The size hierarchy of GA units.

Table 2. GAU area according to range area (Source researchers)

Range area m²	No. OF GA	Ratio
1-1000	67	0.088
1000-1999	140	0.183
2000-2999	115	0.151
3000-3999	103	0.135
4000-4999	72	0.094
5000-5999	49	0.064
6000-6999	31	0.041
7000-7999	17	0.022
8000-8999	21	0.028
9000-9999	25	0.033
10000-10999	15	0.020
11000-11999	7	0.009
12000-12999	15	0.020
13000-13999	6	0.008
14000-14999	7	0.009
15000-15999	1	0.001
16000-16999	4	0.005
17000-17999	4	0.005
18000-18999	3	0.004
19000-19999	3	0.004
20000-24999	10	0.013
25000-29999	6	0.008
30000-39999	8	0.010
40000-50000	15	0.020
50000-1000000	10	0.013
100000-200000	7	0.009
200000-500000	1	0.001
1000000-5000000	1	0.001
Total	763	1.000

Fixing the exact boundary of 12 sectors for preparing the green area for each sector separately figure 4. From attribute table can find the area of 763 green area polygons and the statistics of average minimum maximum and total area and standard deviation figure 6.

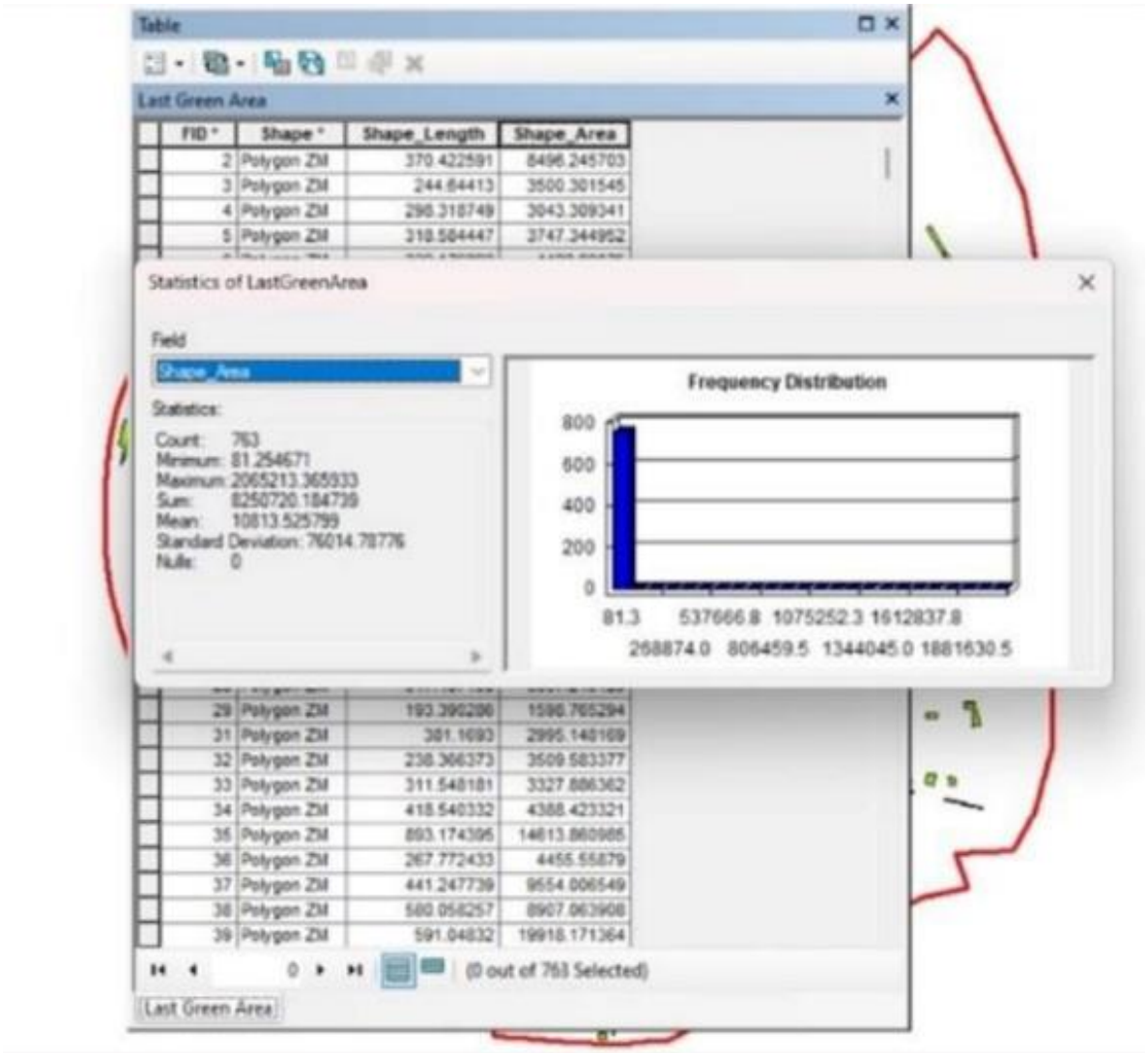

Figure 6. The statistics of 763 green area GIS application

The distance between GA units:

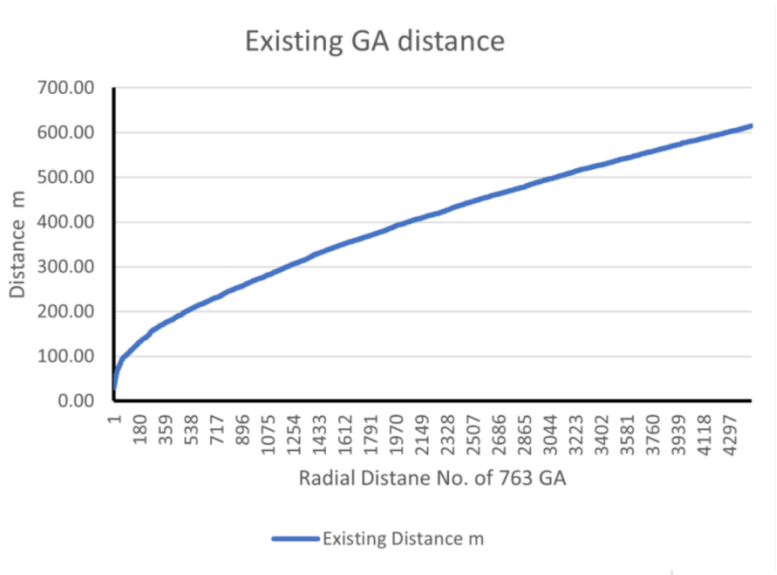

Figure 7. The different distance between green units

The researchers have applied GIS program to find the distance between green areas prove that a huge variation from minimum 40 m in sector 11 to maximum 615.04m sector 4. This shows that there is an absence in the distribution planning of green areas on the bases of regular and standard distances.

Concerning the ratio of GAPP, it is proven that it varies from 4 to 26.41 and GAR from 0.03 to 0.1 as shown in table 2

Table 3. Existing GAPP and GAR of 12 sectors (Source Researchers)

Sector No.	Present		Required		The Minimum between two ratios
	GAPP	GAR	GAPP 10	GAR 0.1	
1	26.41	0.09	Justified	0.01	GAR
2	10.14	0.05	Justified	0.05	GAR
3	7.44	0.04	2.56	0.06	GAR
4	4.16	0.06	5.84	0.04	GAPP
5	7.21	0.05	2.79	0.05	GAR
6	13.02	0.04	Justified	0.06	GAR
7	3.96	0.06	6.04	0.04	GAPP
8	5.56	0.04	4.44	0.06	GAR
9	6.94	0.1	3.06	Justified	GAPP
10	1.7	0.07	8.3	0.03	GAPP
11	3.97	0.07	6.03	0.03	GAPP
12	4	0.03	6	0.07	GAR

1.1. The Statistical and Mathematical Analysis

The researchers have collected data and maps from directories which are all arranged in table (1) to summarize and prepare them to be analyzed.

There is a great variation between different areas for both criteria for the area per person the minimum 1.7 m², and the green area ratio 0.07 in sector 10 which is the old district Tariawa. The center of Erbil city is of high land values in the past therefore, there was not much care for planning green areas. On the other hand, In sector 1, which is the golden zone, it includes many parks especially the regional parks like Abdul -Rahman which its area is about (2065213.37) m²

There isn't any similarity between GAR and GAPP Which means that there is not isn't any planning and designing of sustainable green areas.

For assessing the city green Areas, there should be a calculation of the ratio of the citythe ratio of city area depending on population size:

Here the ratio indicates that there are enough spaces for increasing green area because the ratio is more than 100, which means that there can be an increase in the increasing the GAR to 0.10 and also the GAPP to 10 m² because the green area ratio to the city radio is less than 0.10. Finally, the researchers have come up to conclude that the city criteria fall within the international standards [17]but there is a strong deviation from one sector to another.

1.2. The Optimization of GA for next year

The combined criteria is to achieve both ratio of green area per person and green area ratio to the city ratio together, because one criteria is not enough to achieve the sustainable development of green area. Therefore, if the area per person ratio is achieved, this means that there is a green area to population, but the problem is that the city has big areas and less population. This leads to not having healthy weather, environment, natural creatures, organisms, plants and natural resources in general. On the other hand, if the green area to the city area ratio is only satisfied, this does not mean that there is enough space for each individual, and this is always present in densely populated areas especially those areas of high-rise buildings and apartments [9].

For the optimization the population density is the solution from table 1 sectors of population density less than 0.01 can increase the Gar to 0.1 for next year using equation (1) to find the

(Optimized GA)/ (SA) =0.1 ……. (1

Then applying equation (2) to find the GAPP

(Optimized GA)/ (P in next year) = 10 ……. (2

For sector 7 the GAPP needs optimizing first, therefore applying equation (2) to find (Optimized GA) depends on population in next year and then applying equation 1 to find (Optimized SA) . Then for sectors of population density more than 0.01 (sectors 4,10,11) cannot be optimized because they are bounded and can't extended sector 9 GAR already justified and GAPP don't reach the standard in next year and arranging the results in table 4.

Table 4. The optimization of GAR and GAPP for 8 sectors

Sector. No.	SA m²	GA m²	P Year 2023	GAR	GAPP
1	35393286.03	3539328.60	127964	0.10	27.66
2	20278212.83	2027821.28	104577	0.10	19.39
3	28500206.42	2850020.64	171895	0.10	16.48
4	3720040.86	216557.35	53558	0.06	4.16
5	9758226.16	975822.62	71133	0.10	13.71
6	11984949.84	1198494.98	35026	0.10	34.22
7	12175700	1217570	121757	0.10	10
8	6591022.91	659102.29	44071	0.10	14.96
9	4611976.85	452083.55	67078	0.10	6.74
10	847184.04	57860.50	34963	0.07	1.65
11	2314503.82	162352.80	42085	0.07	3.86
12	5431089.16	543108.92	36120	0.10	15.04
Total	132823995.4	13900123.52	910226		

Spatially can select the sectors that under the criteria [18].

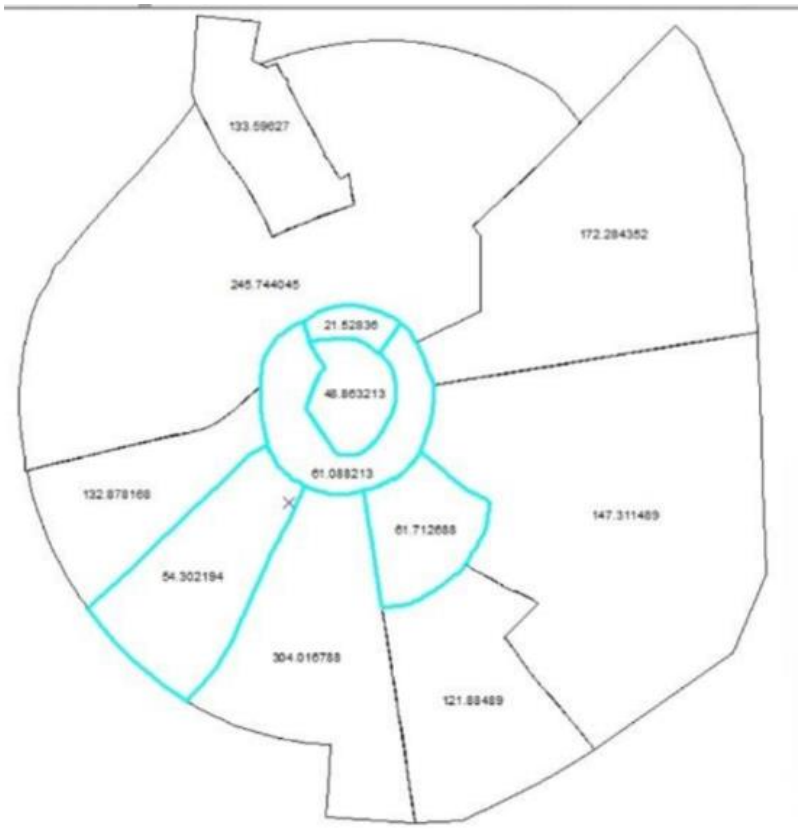

Figure 8.Five sectors with under GAPP and GAR criteria

Figure 8: Determine the sectors that cannot be extended for the purpose of accommodate population density 0.01 using select by attribute

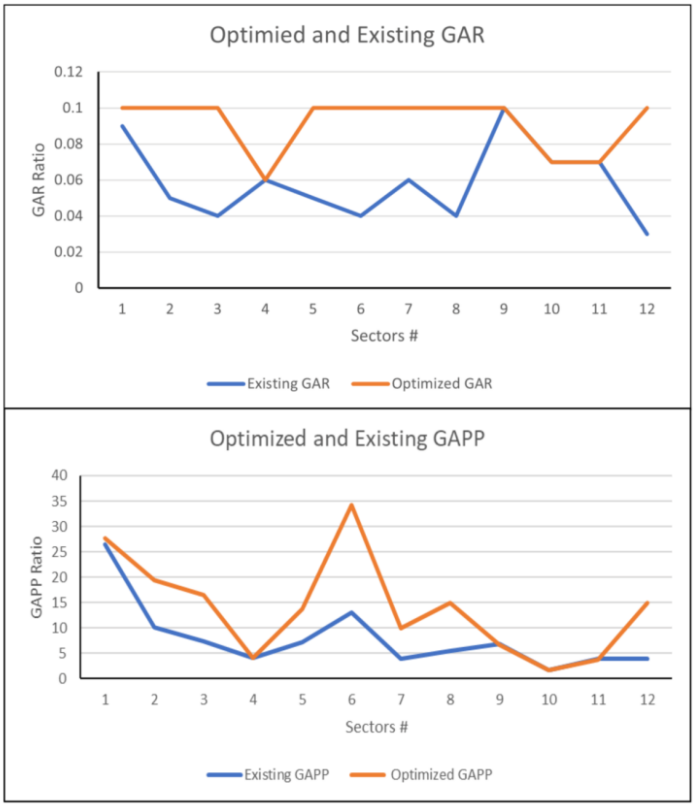

Figure 9. The Optimized and Existing GAPP and GAR

Equilateral Triangle is the base of green unit network because of the equidistance for all directions in both simultaneous and future extensions

$SA = n \sqrt{3}/4\ d^2$ ……(3

$n = SA/ \sqrt{3}/4\ d^2$……..……(4

Green Unit Area = GA/n ……..……(5

N is number of green area unit, $\sqrt{3}/4d^2$ is equation of equilateral triangle area d is the side distance of equilateral triangle representing the distance between GAU figure 10

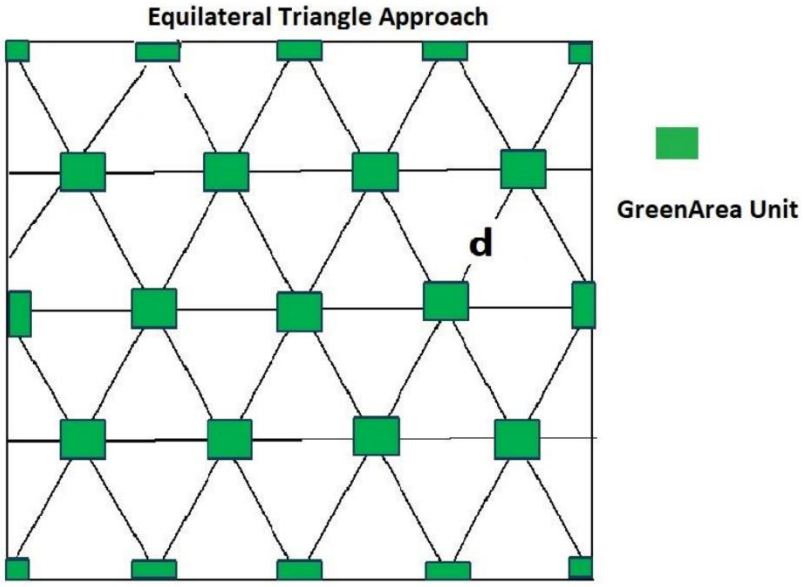

Figure 10. The equilateral triangle Approach to regular distributions of green area units.

Applying the equation 4 and 5 assuming d as 500 m [19]. Can forecast the no. of green area units and green area size for table 5

Table 5: The Required number of Green Area unit and green unit area of 12 sectors (Source Researchers)

Sector No.	SA m²	Required GA m²	No. of GAU units Required for 500 m distance	GAU m²
1	35393286.03	257032.16	327	786
2	20278212.83	998302.05	187	5329
3	28500206.42	1607845.04	263	6107
4	3720040.86	0	34	0
5	975822.62	478058.46	9	53034
6	11984949.84	755855.87	111	6810
7	12175700	749162.78	113	6630
8	6591022.91	421142.86	61	6904
9	4611976.85	0	43	0

Sector No.	SA m²	Required GA m²	No. of GAU units Required for 500 m distance	GAU m²
10	847184.04	0	8	0
11	2314503.82	0	21	0
12	5431089.16	402772.41	50	8028
Total	132823995.4	5670171.63	1229	

3.Results and discussion

Based on what have been explained earlier, it has been proven that the null hypotheses are true. The ratio green area per person is and green area ratio in actual the GAPP is 9.3 m² over all city, the green area ratio 0.06. Moran, I index is 0.010801 z- score 0.078736 p-value 0.937243 indicate the random distribution of green areas. For the next year can optimizing GAR to 0.1 in 9 sectors from 12 sector and GAPP to more than 10 for 7 sectors, for all the city GAR optimized from 0.06 to 0.09 and GAPP from 9.3 to 14. Equilateral triangle is a best distribution to cover equivalent spaces inside the city to distribute GA [20].

4. Conclusion

Urban planners must take into consideration green areas by depending on both criteria GAPP and GAR. The land value has a role in minimizing green areas due to the change of GA to commercial areas, there are not standard distances between green spaces, because some green areas are neglected and they are vacant only because there is not enough budget for maintaining green areas. There must be more interest in maximizing areas of green spaces by planting more trees especially evergreen trees which greatly affect the weather and improve the environment.

Abbreviation:

GA; green area
GAR: green area to city area ratio
GAPP; green area per person
GAU: green area unit, public and private garden
UA: urban area
SA: sector area

Declaration of Competing Interest

The authors declare that they have no recognized non-financial or financial competing interests in any materials conversed in the current work.

Funding

No funding was gained from any financial organization for conducting the current work.

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