

## Evaluate of Green space (Parks) in Duhok city by use Image satellite, Google earth, GIS, (NDVI), and Field survey Techniques

Salah Shaheen Mohammed and Yousif Hussien Hammo

College of Agricultural Engineering Sciences – University of Duhok - Kurdistan Region –  
Republic of Iraq

Corresponding author Email: [salahk0tuer@gmail.com](mailto:salahk0tuer@gmail.com)

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### Abstracts

Dohuk city represents the center of the Dohuk governorate which is considered the third governorate in the Kurdistan region of Iraq. Duhok is accounted as one of the safest tourist cities in Iraq. It located in the Northwestern part of the Iraqi Kurdistan between the latitude 36° -38°N, longitude 42°-43°E and on elevation 565 meter above sea level with area about 76.06 km<sup>2</sup>. The approximate population of the city for the year 2021 is about 405636 persons according to the Duhok Department of Statistics. The tools and programs used in this study were Image satellite, Google Earth, GIS, GIS and remote sensory (NDVI), Field survey. This study aimed to evaluate the green space (Parks) to provide the best management and improve the quality of life by providing a sustainable green space within Duhok city. The results are summarized as following. Nine parks in Duhok city (Alin, Barzani, Buhar, Azadi, Bekhal, Kani Xishmana, Tahsen Taha, Nawroz and Dilshad M. Said). The total area of these parks was 217318 m<sup>2</sup>, 71.66% of this area was green area. So that the green area percentage for each person in this city was 0.536 m<sup>2</sup> per person when compared with some city per capita share we found that this figure was less than the least one Damascus city (0.7) m<sup>2</sup> per person and far away from Vienna city that reach (124.6) m<sup>2</sup> per person. The evaluation degree of this parks was ranged between 55.2 for Nawroz to 86.6 for Azadi Park (from 100 mark). The irrigation system for all parks were sprinkle. The largest area was Barzani Park with 55879 m<sup>2</sup> whereas the smallest area was Alin (7494) m<sup>2</sup>. The total number of plants are (7280) plants, 2254 of them include many kinds of tree, the highest number was *cupressus sempervirens* (428) tree then *Robinia pseudoacaia* (338) whereas the less one was *Acer negundo* just have (6) trees.

**Keywords:** green space, parks, GIS, Image satellite.

## Introduction:

Many Parks were established in Duhok City, it need continue evaluation for renew and sustainability. Many green and non-green elements were established in this Parks that are among the important recreational areas that residents want to spend time in normal days or during official holidays, these facilities have environmental and climatic effects it is aesthetically pleasing, improves climatic conditions, reduces heat intensity, and restores balance Environmental pollution and reducing air pollution in the city through its precautionary measures to dry out from temperatures Increased humidity and then will have a role in lowering temperatures, especially in the summer (2).

Green space (makes our lives and places better) is term defined very broadly by the European Commission as simply refers to outdoor settings that contain a significant amount of vegetation playing a role in the urban micro-climate and in biodiversity (12 and 18). Parks differ according to their age, levels of maintenance, facilities, and size or partly due to the philosophy that motivated their creation and partly due to land development processes and municipal fiscal constraints (8). Urban green spaces play an important role and have a positive effect on the quality of life in cities (14 and 10). The greener growth is an important component for sustainable development as it protects environment and allow economic growth (7). Parks and any green spaces in the cities it fundamental for the people's needs and their rest and good indicator for progress and development of country and ensure continued tourists attracting, investors, and improving the quality of life for its residents (12). Preserving and maintaining open spaces in

urban environments is considered a crucial aspect of fulfilling environmental quality goals and attaining a livable city (9). About 11% of the total land on earth would need to be fill with trees to reach the goal of removing two-thirds of all carbon emissions in our atmosphere. The removal would prevent the rise of temperature to reach 1.5°C (19). Lawns have shown their capacity to decrease the temperature peaks of hot summer days by approximately 1 °C (17). Also the Landscape plants that including tree, shrubs and turf remove smoke, dust, and other pollutants from the air so they improve air quality, one tree can remove 26 pounds of carbon dioxide from the atmosphere annually, equaling 11,000 miles of car emissions, study showed that 1 acre of trees has the ability to remove 13 tons of particles and gases annually (3). Trees absorb the carbon dioxide that contributes to global warming, as well as other gases that contribute to urban pollution by absorbing the carbon emitted by vehicles, lowering carbon emissions from fossil fuel-burning plants, and reducing the energy used for climate control in buildings. An urban ecosystem analysis of greater San Antonio (Texas) conducted by the organization American Forests has calculated that the area's tree cover is saving the city \$70 million a year in ecological services, including storm water management, air quality, and energy conservation (3 and 21).

Estimated Value of Trees in U.S. Urban Parks \$300 billion, Air temperature reduction likely in the billions of dollars per year, Air pollution removal \$500 million per year, Grass provides the same function, one tree or a 2,500- square foot lawn each release enough oxygen each day to supply a family of four Reduced

ultraviolet radiations likely substantial. Properly selected and placed plantings absorb sound waves, and can significantly reduce unwanted 'noise pollution' additionally, some plants make pleasant sounds of their own. (5).

A recent study at the Sloan Kettering Institute in New York found that women recover from breast cancer surgery quicker if they spend time in a garden, according to a report by the American Horticultural Therapy Association. (11). Kuo, *et al* (15) found the more trees and grass in the common spaces of inner-city neighborhoods, the more that those spaces are used by residents. And, this means more opportunities for informal social interaction. In other words, relationships between neighbors are made stronger simply through the presence of vegetation. Among the participants who now live in a green neighborhood, those feeling depressed decreased by 41.5% and self-reported poor mental health decreased by 62.8% (6). The Aims of this study to evaluate the green space (Parks) to provide the best management and improve the quality of life providing a sustainable green space within Duhok city.

### Material and Methods

The study location is Duhok City, the center of the third Governorate in the Kurdistan region and one of the safe and tourist cities in Iraq, located in the Northwestern part of the Iraqi Kurdistan between the latitude 36°-38°N, longitude 42°-43°E and on elevation 565 meter above sea level with area about 76.06 km<sup>2</sup>, the approximate population of the city for the year 2021 is about 405636 persons, according to the Department of Statistics as shown in Figure (1).

The tools and programs used in this study

- 1- Image satellite (MAXAR technologies, ArcGIS, and ArcMap online, then analysis was done in the GIS program by tools to extract the green space for each Park.
- 2- Use a mobile phone to locate GPS locations for each park or other thing such as Google Earth (is a computer program that renders a 3D representation of Earth based primarily on satellite imagery), Maps.ME (MAPS. ME, detailed offline maps of the world. Data version: 220614-version14.2.7) It functions almost similarly with Google Maps, only that Maps.me can work without internet access). And ArcMap (10.7.1) - Esri Support (version,10.7.1) (is a geographical information system (GIS) that allows handling and analyzing geographic information by visualizing geographical statistics through layer building maps like climate data or trade flows).
- 3- GIS and Normalized Difference Vegetation Index (NDVI), after knowledge of data on the city boundaries of Dohuk Municipal City from maps and knowledge of the total area, polygon the total green space was obtained using remote sensing Difference Vegetation Index (NDVI) quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs).
- 4- Satellite data were that is from sentinel2 (10 m resolution) at date 11-10-2021 (D/M/YEAR) and by using (GIS) technology, analysis by toolbar and then getting the results of the total green areas and non-green areas of the study area.
- 5- Field surveys for nine parks (Alin, Barzani, Buhar, Azadi, Bekhal, Kani

Xishmana, Tahsen Taha, Nawroz, and Dilshad M. Said) were performed to obtain the number and scientific names of trees, shrubs, climbers and any type of ornamental plants and lawns. The total area of all green space, lawn type, irrigation systems, and location of gardens. Evaluation of green space (Parks) by using some world standard, which consists of the number of questions, using the questionnaire for 10 visitors as a (table1). Then analyze it and obtain an evaluation degree.

6- Per capita share from the parks as green areas only, By knowing the total green area (m<sup>2</sup>) from NDVI and the number of people in the city for the year 2021, depending on the statistics department in a city so to calculate it uses the following equation:  $T=G/P$  when T: green area per capita (m<sup>2</sup>/capita), G: green space in the city (m<sup>2</sup>), P: population number in the city (405634 person). So, we find that one per capita green space is calculated, which is estimated at (m<sup>2</sup> per person).

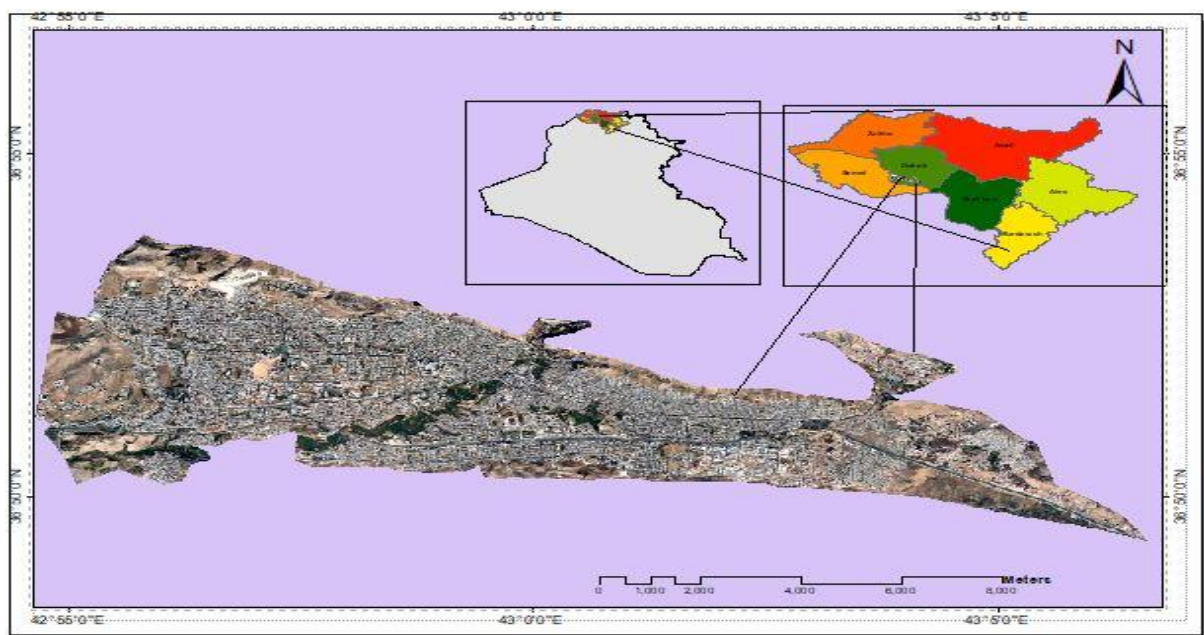
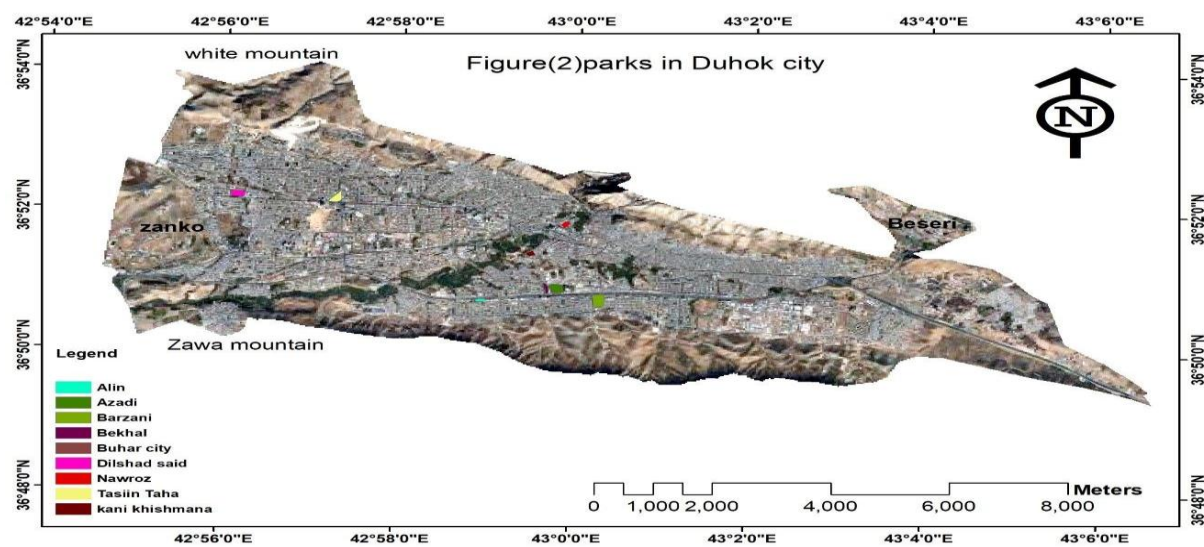


Figure (1). The location of study area (Dohuk city ).



**Figure (2). The Parks locations in the Dohuk city.****Table (1). Standards for Evaluating Landscape Design - Judging Gardens Marilyn, (1999)**

| Questions                                                                                                                                 | standard value |
|-------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| <b>First question</b>                                                                                                                     |                |
| 1- First impression (5%)                                                                                                                  | 5              |
| <b>Second question</b>                                                                                                                    |                |
| 2- Suitability of design to purpose (5%)                                                                                                  | 5              |
| <b>Third question</b>                                                                                                                     |                |
| 3- Design (45%)                                                                                                                           |                |
| A. Functional aspect                                                                                                                      |                |
| 1- Suitability                                                                                                                            | 5              |
| 2- Creation and utilization of space (Including circulation patterns, activities, rest area, etc.)                                        | 15             |
| B. Aesthetic aspect                                                                                                                       |                |
| 1- Design principles employed successfully ((balance, contrast, dominance, proportion, scale, rhythm).                                    | 10             |
| 2- Design elements applied successfully ((line, form, color, texture, pattern, size, space and light).                                    | 10             |
| 3- Originality and distinction ((Including unusual qualities, features, accents, and enhancements. Successful solution of site problems.) | 5              |
| <b>Fourth question</b>                                                                                                                    |                |
| 4- Implementation (30%)                                                                                                                   |                |
| A- Materials and Structures                                                                                                               |                |
| 1- Suitability to purpose, site, and design                                                                                               | 15             |
| 2- Perfection of details                                                                                                                  | 5              |
| B- Plant materials                                                                                                                        | 10             |
| <b>Fifth question</b>                                                                                                                     |                |
| 5- Maintenance (10%)                                                                                                                      |                |
| A- Incorporation of maintenance awareness into design and selection of materials                                                          | 5              |
| B- Current, sustained maintenance                                                                                                         | 5              |
| Six question                                                                                                                              |                |
| <b>Sixth question. Final Impression</b>                                                                                                   | 5              |
| Total                                                                                                                                     | 100            |



## Results and Discussion

### 1- Barzani Park

Data in the table (2) and figure (4) explained that the total area of this park is 55879 m<sup>2</sup>, 38061 m<sup>2</sup> was a green area, total ornamental plants reach (1331) plants, green space evaluation of this park is 75.2 degrees (sensory evaluation). Sprinkler irrigation was used in this location and a mixture of cool-season grasses was planted in it. Fourteen kinds of trees were planted, the largest number is for *Pinus spp* which

reached 193 trees then *Bauhinia variegata* (148) tree, whereas the less number was *magnolia grandiflora* (2) tree only. Eight species of shrubs were found in it the largest number was *Photinia fraseri* (196) shrubs the second was *Jasminum officinal* (87) shrubs while the less number was *Granatum nana* and *Syzygium aqueum* (16) shrubs. A few perennial plants (small shrubs) were planted in this location such as rose spp. (85) plant, and others *Cyperus papyrus* (15).

Table (2). Barzani Park contents (area, evaluation, irrigation system and type of all ornamental plant).

|                                |          |
|--------------------------------|----------|
| Total Area (m <sup>2</sup> )   | 55879    |
| Green Area (m <sup>2</sup> )   | 38061    |
| Evaluation of the garden       | 75.2     |
| Irrigation System              | Sprinkle |
| Types of ornamental plant      |          |
| <b>Trees</b>                   |          |
| <i>Pinus spp</i>               | 193      |
| <i>Bauhinia variegata</i>      | 148      |
| <i>Fraxinus excelsior</i>      | 77       |
| <i>Platanus orientalis</i>     | 46       |
| <i>Arizona Cypress</i>         | 39       |
| <i>Washingtonia filifera</i>   | 34       |
| <i>Cupressus sempervirens</i>  | 31       |
| <i>Olea europaea</i>           | 22       |
| <i>Robinia pseudoacacia</i>    | 18       |
| <i>Morus alba var. pendula</i> | 14       |
| <i>Pissardi plum</i>           | 14       |
| <i>Acer negundo</i>            | 6        |
| <i>Melia azedarach</i>         | 3        |
| <i>Magnolia grandiflora</i>    | 2        |
| <b>Shrubs</b>                  |          |
| <i>Photinia fraseri</i>        | 196      |
| <i>Jasminum officinal</i>      | 87       |
| <i>Ligustrum japonicum</i>     | 79       |
| <i>Lagerstroemia indica</i>    | 40       |
| <i>Thuja orientalis</i>        | 38       |
| <i>Pyracantha coccinea</i>     | 33       |
| <i>Granatum nana</i>           | 16       |
| <i>Syzygium aqueum</i>         | 16       |
| <i>Perennials plant</i>        |          |
| <i>Rosa spp</i>                | 85       |
| <b>Others</b>                  |          |
| <i>Cyperus papyrus</i>         | 15       |
| <b>Lawns</b>                   | Mixed    |
| <b>Total Plants</b>            | 1331     |

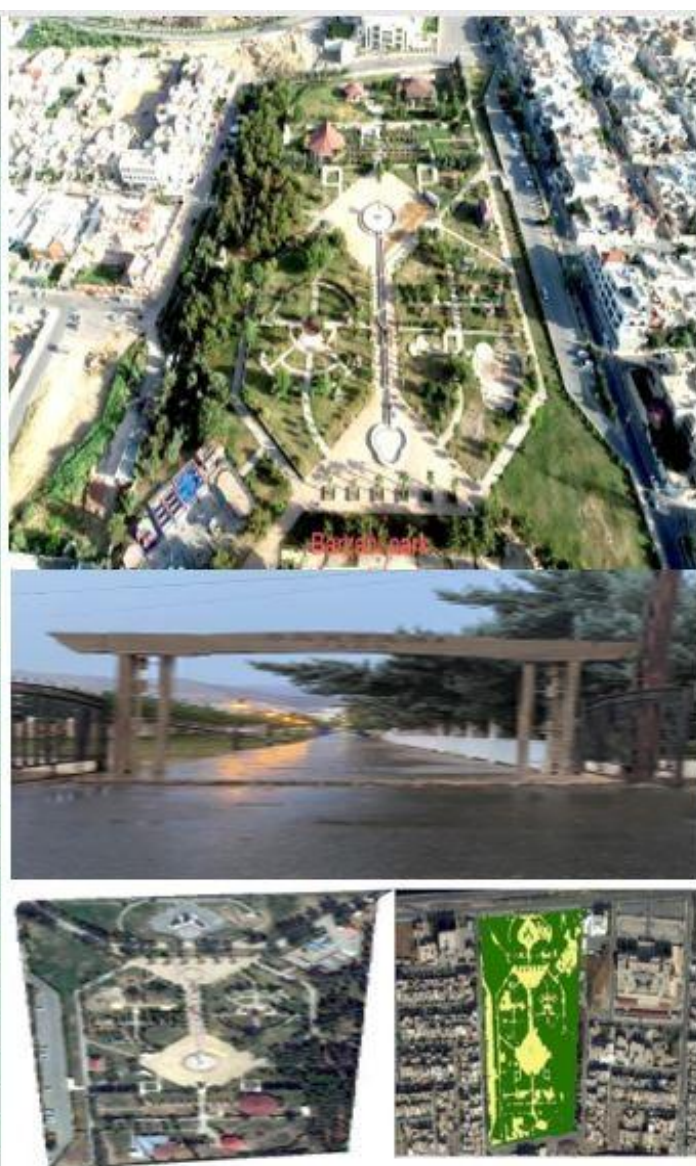


Figure (4) contents (Drone images, photographs and analytics images from GIS program to extract green area.).

## 2- Azadi Park

Data in table (3) and figure (5) explained that the total area of this park 45726 m<sup>2</sup>, 34064. m<sup>2</sup> of this area are green area and the total ornamental plants reach 1745 plants, the evaluation of this park reaches (86.6) degree (sensory evaluation from 100 mark). Sprinkler irrigation was used in this location and cool season grasses mixture are planted. 10 kinds of trees were planted the largest number reached 144 tree was

*Robinia pseudoacacia* then *Arizona Cypress* that reached 129 tree, whereas the less number was *Magnolia grandiflora* (7) tree. Ten species of shrubs were found in it the largest one was *Photinia fraseri* (175) shrub the second was *Pyracantha coccinea* (150) shrub while the less number was *Granatum nana* that reached (8) shrub. Little perennial plant was planted in this location such as *rose spp.* (393). The Climbers include *Parthenocissus tricuspidata* (38) and *Jasminum gradiflorum* (7) shrub

| Table (3). Azadi Park contents (area, evaluation, irrigation system and type of all ornamental plant). |          |
|--------------------------------------------------------------------------------------------------------|----------|
| Total Area (m <sup>2</sup> )                                                                           | 45726    |
| Green Area (m <sup>2</sup> )                                                                           | 34064    |
| Evaluation of the garden                                                                               | 86.6     |
| Irrigation System                                                                                      | Sprinkle |
| Types of ornamental plant                                                                              |          |
| <b>Trees</b>                                                                                           |          |
| <i>Robinia pseudoacacia</i>                                                                            | 144      |
| <i>Arizona Cypress</i>                                                                                 | 129      |
| <i>Fraxinus excelsior</i>                                                                              | 117      |
| <i>Platanus orientalis</i>                                                                             | 90       |
| <i>Catalpa speciosa</i>                                                                                | 18       |
| <i>Cupressus sempervirens</i>                                                                          | 17       |
| <i>Washingtonia filifera</i>                                                                           | 14       |
| <i>Pissardi plum</i>                                                                                   | 14       |
| <i>Melia azedrach</i>                                                                                  | 13       |
| <i>Magnolia grandiflora</i>                                                                            | 7        |
| <b>Shrubs</b>                                                                                          |          |
| <i>Photinia fraseri</i>                                                                                | 175      |
| <i>Pyracantha coccinea</i>                                                                             | 150      |
| <i>Ligustrum japonicum</i>                                                                             | 102      |
| <i>Ligustrum vulgare</i>                                                                               | 101      |
| <i>Thuja orientalis</i>                                                                                | 83       |
| <i>Buxus sempervirens</i>                                                                              | 68       |
| <i>Lagerstroemia indica</i>                                                                            | 28       |
| <i>Hibiscus rosa sinensis</i>                                                                          | 18       |
| <i>Syzygium aqueum</i>                                                                                 | 11       |
| <i>Granatum nana</i>                                                                                   | 8        |
| <b>Perennials plant</b>                                                                                |          |
| <i>Rosa spp</i>                                                                                        | 393      |
| <b>Climbers</b>                                                                                        |          |
| <i>Parthenocissus tricuspidata</i>                                                                     | 38       |
| <i>Jasminum gradiflorum</i>                                                                            | 7        |
| <b>Lawns</b>                                                                                           |          |
| <b>Total Plants</b>                                                                                    | 1745     |

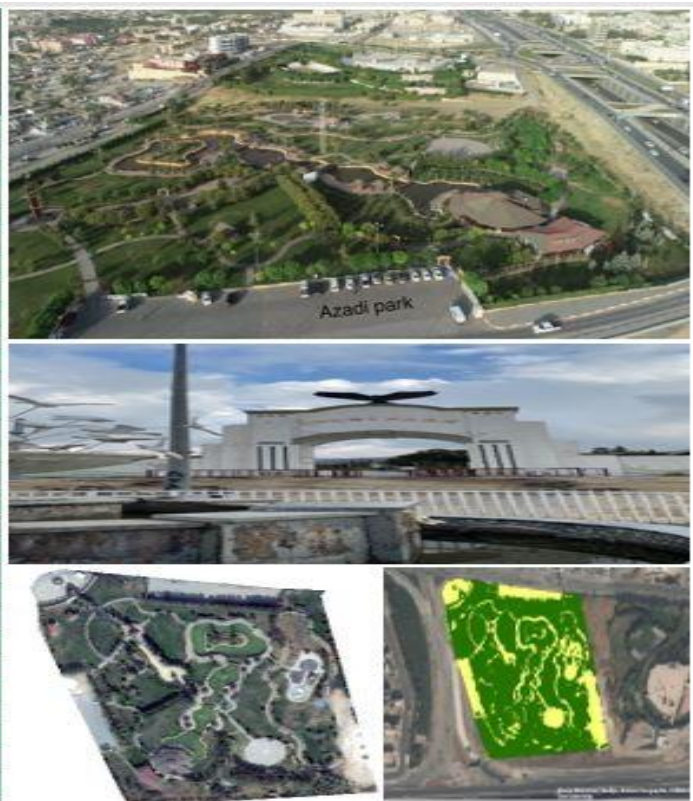


Figure (5) contents (Drone images, photographs and analytics images from GIS program to extract green area.)



### 3- Bekhal Park

Data in table (4) and figure (6) clarified that the total area of this park was 11000 m<sup>2</sup>, 9502 m<sup>2</sup> of this area are green area and the total ornamental plants reach (606) plants, the evaluation of this park reached (67.4) degree. Sprinkler irrigation was used in this location and cool season grasses mixture were planted. Five kind of

trees were planted in this park the largest number was *Cupressus sempervirens* (332) tree then *Platanus orientalis* that reach 36 tree, whereas the less number was *Robinia pseudoacacia* (8) tree. Six species of shrubs were found in it the largest one was *Dodonaea viscosa* (76) shrub the second was *Buxus sempervirens* (56) shrub while the less number was *Photinia fraseri* that reach (5) shrub.

| Table (4). Bekhal Park contents (area, evaluation, Irrigation system and type of all ornamental plants). |          |
|----------------------------------------------------------------------------------------------------------|----------|
| Total Area (m <sup>2</sup> )                                                                             | 11000    |
| Green Area (m <sup>2</sup> )                                                                             | 9502     |
| Evaluation of the Garden                                                                                 | 67.4     |
| Irrigation System                                                                                        | sprinkle |
| Types of ornamental plant                                                                                |          |
| <b>Trees</b>                                                                                             |          |
| <i>Cupressus sempervirens</i>                                                                            | 332      |
| <i>Platanus orientalis</i>                                                                               | 36       |
| <i>Washingtonia filifera</i>                                                                             | 17       |
| <i>Salix safsaf</i>                                                                                      | 11       |
| <i>Robinia pseudoacacia</i>                                                                              | 8        |
| <b>Shrubs</b>                                                                                            |          |
| <i>Dodonaea viscosa</i>                                                                                  | 76       |
| <i>Buxus sempervirens</i>                                                                                | 56       |
| <i>Callistemon floribunda</i>                                                                            | 22       |
| <i>Ligustrum japonicum</i>                                                                               | 22       |
| <i>Lagerstroemia indica</i>                                                                              | 21       |
| <i>Photinia fraseri</i>                                                                                  | 5        |
| <b>Lawns</b>                                                                                             | Mixed    |
| <b>Total Plants</b>                                                                                      | 606      |



Figure (6) contents (Drone images, photographs and analytics images from GIS program to extract green area.)



#### 4- Kani xishmana

Data in table (5) and figure (7) clarified that the total area of this park 8865 m<sup>2</sup>, the green area reach 7934 m<sup>2</sup> of this area, the total ornamental plants reach 1153 plants, the evaluation of this park reach 62 degree. Sprinkler irrigation was used in this location and the Cool season grasses mixture are planted in it. Tow kind of trees were planted the largest number was

*Platanus orientalis* (60) tree, whereas the less number was *Platanus orientalis* that reached 36 tree. Two species of shrubs were found in it the largest number was *Buxus sempervirena* (445) while the less number was *Jasminum officinal* that reached (5) shrub. Perennial plant was planted in this location such as *rose spp.* that reached 560 plant.

| Table (5). Kani xishmana Park contents (area, evaluation, irrigation system and type of all ornamental plants). |          |
|-----------------------------------------------------------------------------------------------------------------|----------|
| Total Area (m <sup>2</sup> )                                                                                    | 8865     |
| Green Area (m <sup>2</sup> )                                                                                    | 7934     |
| Evaluation Of The Garden                                                                                        | 62       |
| Irrigation System                                                                                               | Sprinkle |
| Types of ornamental plant                                                                                       |          |
| <b>Trees</b>                                                                                                    |          |
| <i>Platanus orientalis</i>                                                                                      | 60       |
| <i>Cupressus sempervirens</i>                                                                                   | 36       |
| <b>Shrubs</b>                                                                                                   |          |
| <i>Buxus sempervirena</i>                                                                                       | 445      |
| <i>Jasminum officinal</i>                                                                                       | 52       |
| <b>perennials plant</b>                                                                                         |          |
| <i>Rosa spp</i>                                                                                                 | 560      |
| <b>Lawns</b>                                                                                                    | Mixed    |
| <b>Total Plants</b>                                                                                             | 1153     |

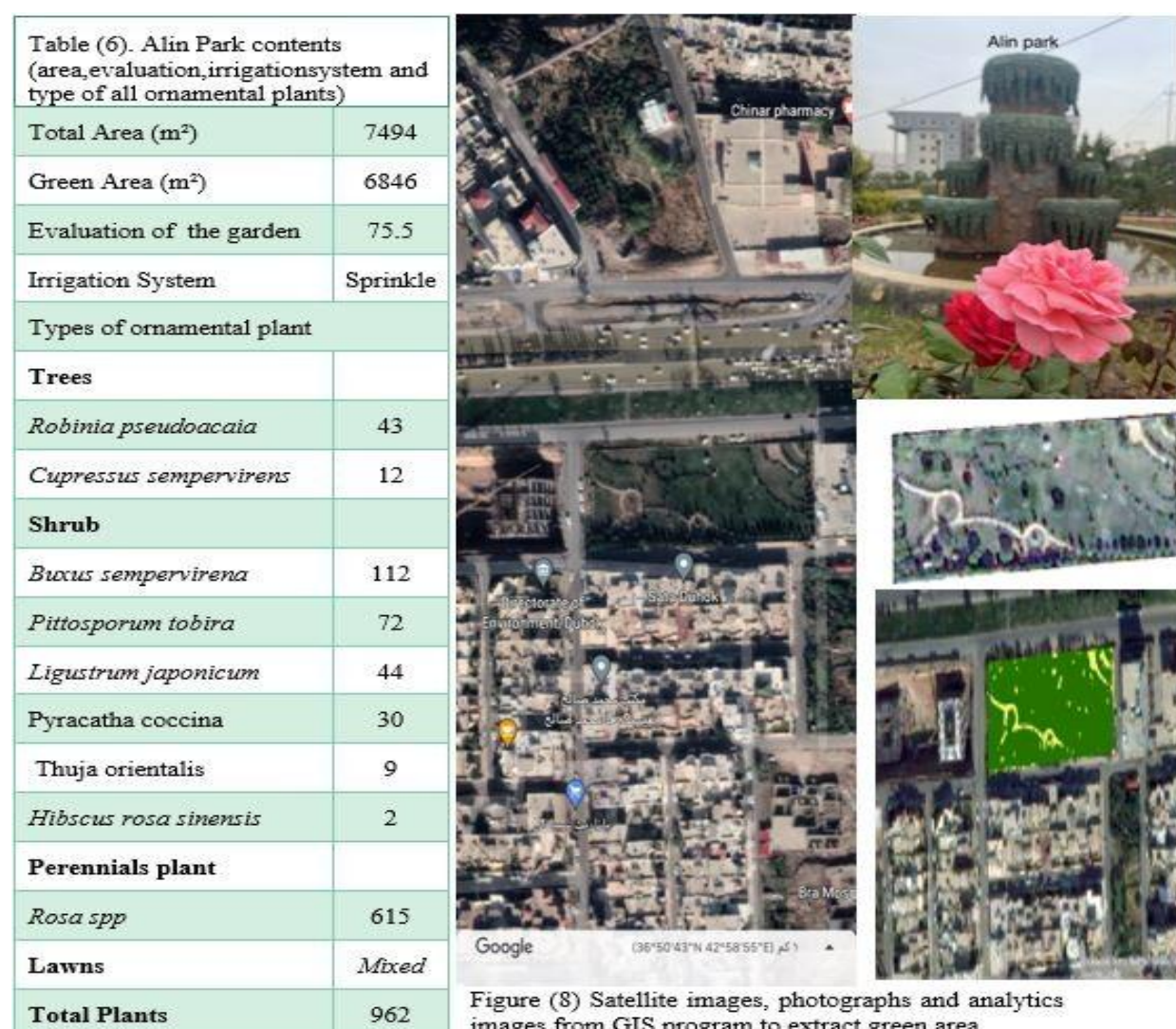


Figure (7) contents (Drone images, photographs and analytics images from GIS program to extract green area.).

## 5- Alin Park

Data in table (6) and figure number (8) clarified that the total area of this park (7494) m<sup>2</sup>, 6846 m<sup>2</sup> of this area are green area and the total ornamental plants reached (962) plants, the evaluation of this park was about 75.5 degrees (sensory evaluation). Sprinkler irrigation was used in this location and cool season grasses mixture were grown in it. Two kinds of

trees were planted the largest number was *Robinia pseudoacacia* that reach 43 tree then *Cupressus sempervirens* (12) tree. Six species of shrubs were found in it the largest number was *Buxus sempervirens* (112) shrub, the second was *Pittosporum tobira* (72) shrub while the less number *Hibiscus rosa sinensis* that reached only 2 shrub. Little perennial plant were planted in this location such as *rose spp.* (615) plant.





## 6- Buhar city Park

Data in table (7) and figure number (9) showed that the total area of this park (11868) m<sup>2</sup>, the green area reach 8083 m<sup>2</sup> and the total ornamental plants reached (830) plants, the evaluation of this park is reached (66.4) degree (sensory evaluation). Sprinkler irrigation was used in this location and cool season grasses mixture were grown in it. One kind of trees was

planted *Robinia pseudoacacia* that reached (38) tree. Sex species of shrubs were grown in it the largest number was *Buxus sempervirena* (64) shrubs whereas the second was *Ligustrum japonicum* (46) shrub, the less number *Lagerstroemia indica* that reached (6) shrubs only. A few perennial plant was planted in this location such as *Rosa spp.* (616).

| Table (7). Buhar Park contents (area, evaluation, irrigation system and type of all ornamental plants). |          |
|---------------------------------------------------------------------------------------------------------|----------|
| Total Area (m <sup>2</sup> )                                                                            | 11868    |
| Green Area (m <sup>2</sup> )                                                                            | 8083     |
| Evaluation of the garden                                                                                | 66.4     |
| Irrigation System                                                                                       | Sprinkle |
| Types of ornamental plant                                                                               |          |
| <b>Trees</b>                                                                                            |          |
| <i>Robinia pseudoacacia</i>                                                                             | 38       |
| <b>Shrubs</b>                                                                                           |          |
| <i>Buxus sempervirena</i>                                                                               | 64       |
| <i>Ligustrum japonicum</i>                                                                              | 46       |
| <i>Pittosporum tobira</i>                                                                               | 29       |
| <i>Pyracantha coccinea</i>                                                                              | 17       |
| <i>Callistemon floribunda</i>                                                                           | 14       |
| <i>Lagerstroemia indica</i>                                                                             | 6        |
| <b>perennials plant</b>                                                                                 |          |
| <i>Rosa spp</i>                                                                                         | 616      |
| <b>Lawns</b>                                                                                            |          |
| <b>Total Plants</b>                                                                                     | 830      |



Figure (9) Satellite images, photographs and analytics images from GIS program to extract green area.

## 7- Nawroz Park

Total area of this park reached 12418 m<sup>2</sup> as shown in table (8) and figure number (10), 2161 m<sup>2</sup> of are green area and the total ornamental plants that planted in it reached 378 plants, the evaluation of this park reaches 55.2 degree (sensory evaluation). Sprinkler irrigation was used in this location and cool season grasses mixture were planted in it. Three kind of trees were planted the largest number was *Platanus*

*orientalis* that reached 51 tree then *Melia azedrach* (50) tree, whereas the less number was *Salix safsaf* (8) tree. Five species of shrubs were found in it the largest number was *photinia fraseri* (150) shrub the second was *Duranta erecta* (66) shrubs while the less number was *pyracatha coccina* that reach (2) shrub only. Many perennial plant (small shrubs) were planted in this location such as *Berberis Vulgaris* (20) and *rose spp* (18) plant.

| Table (8) Nawroz Park contents (area, evaluation, irrigation system and type of all ornamental plants). |          |
|---------------------------------------------------------------------------------------------------------|----------|
| Total Area (m <sup>2</sup> )                                                                            | 12418    |
| Green Area (m <sup>2</sup> )                                                                            | 2161     |
| Evaluation of the Garden                                                                                | 55.2     |
| Irrigation System                                                                                       | Sprinkle |
| Type of ornamental plant                                                                                |          |
| <b>Trees</b>                                                                                            |          |
| <i>Platanus orientalis</i>                                                                              | 51       |
| <i>Melia azedrach</i>                                                                                   | 50       |
| <i>Salix safsaf</i>                                                                                     | 8        |
| <b>Shrubs</b>                                                                                           |          |
| <i>Photinia fraseri</i>                                                                                 | 150      |
| <i>Duranta erecta</i>                                                                                   | 66       |
| <i>Jasminum officinal</i>                                                                               | 8        |
| <i>Buxus sempervirena</i>                                                                               | 3        |
| <i>pyracatha coccina</i>                                                                                | 2        |
| <b>perennials plant</b>                                                                                 |          |
| <i>Berberis Vulgaris</i>                                                                                | 20       |
| <i>Rosa spp</i>                                                                                         | 18       |
| <b>Lawns</b>                                                                                            | Mixed    |
| <b>Total Plants</b>                                                                                     | 376      |

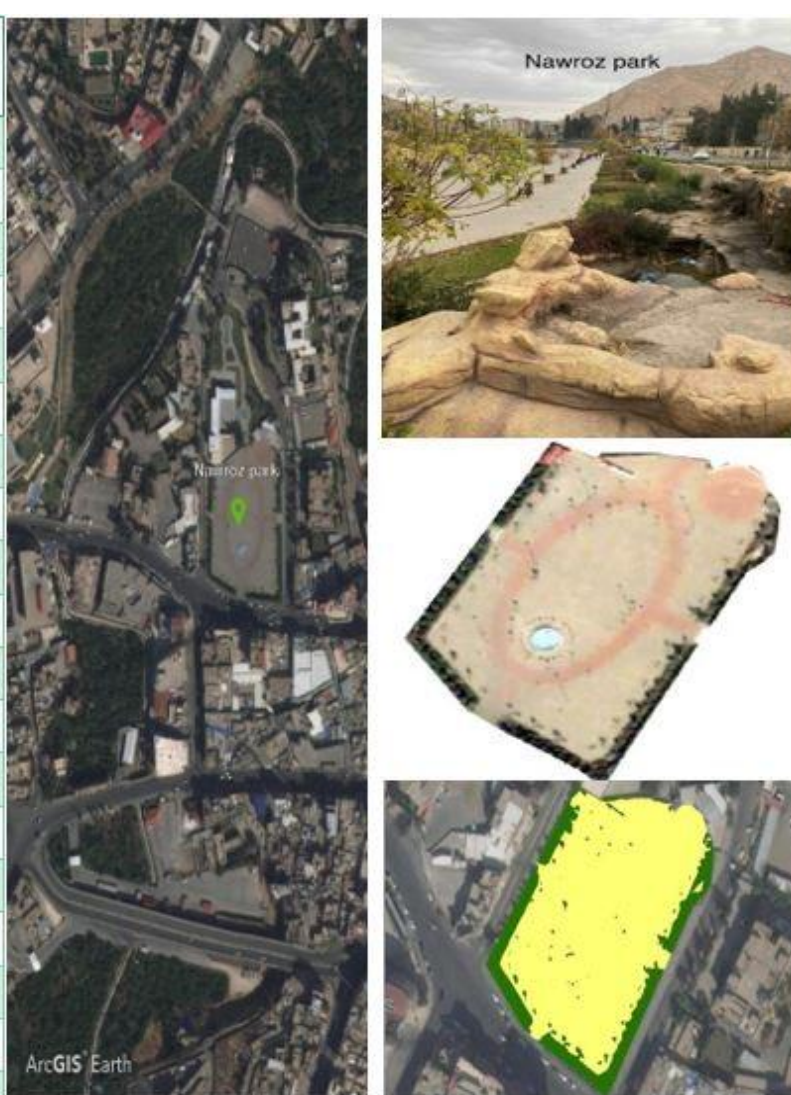


Figure (10) Satellite images, photographs and analytics images from GIS program to extract green area.



### 8-Tahsin Taha Park

The total area of this park was 31620 m<sup>2</sup> as shown in table (9) and figure number (11), 19791 m<sup>2</sup> of this area were green area and the total ornamental plants reached 7869 plants, the degree of its evaluation reached (73) mark. Sprinkler irrigation was used in this location and cool season grasses mixture were planted in it. Three types of trees were planted in this park the largest number reached (24) tree was

*Washingtonia filifera* then *Morus alba* var.*pendula* that reached (14) tree, whereas the less number was *Pinus spp* (11) tree. Seven species of shrubs were found in it the largest number was *Dodonaea viscosa* (3500) shrub then *pittosporum tobira* (193) shrub whereas the less number was *Duranta erecta* that reached (6) shrub. Many perennial plant (small shrubs) were planted in this location such as *Rosa spp* (3208) plant and *Berberis Vulgaris* (550) plant.

| Table (9). Tahsin Taha Park contents (area, evaluation, irrigation system and type of all ornamental plants). |          |
|---------------------------------------------------------------------------------------------------------------|----------|
| Total Area (m <sup>2</sup> )                                                                                  | 31620    |
| Green Area (m <sup>2</sup> )                                                                                  | 19791    |
| Evaluation of the garden                                                                                      | 73       |
| Irrigation System                                                                                             | Sprinkle |
| Types of ornamental plant                                                                                     |          |
| <b>Trees</b>                                                                                                  |          |
| <i>Washingtonia filifera</i>                                                                                  | 24       |
| <i>Morus alba</i> var. <i>pendula</i>                                                                         | 14       |
| <i>Pinus spp</i>                                                                                              | 11       |
| <b>Shrubs</b>                                                                                                 |          |
| <i>Dodonaea viscosa</i>                                                                                       | 3500     |
| <i>pittosporum tobira</i>                                                                                     | 193      |
| <i>Photinia fraseri</i>                                                                                       | 164      |
| <i>Ligustrum japonicum</i>                                                                                    | 110      |
| <i>Parthenocissus tricuspidata</i>                                                                            | 75       |
| <i>Jacaranda ovalifolia</i>                                                                                   | 14       |
| <i>Duranta erecta</i>                                                                                         | 6        |
| <b>Perennials plant</b>                                                                                       |          |
| <i>Rosa spp</i>                                                                                               | 3208     |
| <i>Berberis Vulgaris</i>                                                                                      | 550      |
| <b>Lawns</b>                                                                                                  | Mixed    |
| <b>Total Plants</b>                                                                                           | 7869     |



Figure (11) Satellite images, photographs and analytics images from GIS program to extract green area.

### 9- Dilshad .M said Park

Data in table (10) and figure number (12) clarified that the total area of this park (32448) m<sup>2</sup>, 29289 m<sup>2</sup> of this area was green area and the total ornamental plants reached 2425 plants, the evaluation of green space of this park was (76) mark. Sprinkler irrigation was used in this location and cool season grasses mixture were planted in it. Five kind of trees were planted the largest number that reached (164) tree was *Melia azedrach* then *Thuja orientalis* (98) tree, whereas the less number was *Parthenocissus triuspidata* (20) tree. Nine species of shrubs were found in it the largest number was *Buxus sempervirena* (193) shrub, the second was *Ligustrum japonicum* (167) shrub, while the less number *Parthenocissus triuspidata* that reached (6) plant. Many perennial plant were planted in this location such as *rose spp* (1191) plant and *Berberis Vulgaris* (226) plant.

|                                                                                                                    |          |                                                                                      |
|--------------------------------------------------------------------------------------------------------------------|----------|--------------------------------------------------------------------------------------|
| Table (10). Dilshad .M said Park contents (area, evaluation, irrigation system and type of all ornamental plants). |          |    |
| Total Area (m²)                                                                                                    | 32448    |                                                                                      |
| Green Area (m²)                                                                                                    | 29289    |                                                                                      |
| Evaluation of the garden                                                                                           | 76       |                                                                                      |
| Irrigation System                                                                                                  | sprinkle |                                                                                      |
| Types of ornamental plant                                                                                          |          |   |
| <b>Trees</b>                                                                                                       |          |                                                                                      |
| <i>Melia azedrach</i>                                                                                              | 164      |                                                                                      |
| <i>Thuja orientalis</i>                                                                                            | 98       |                                                                                      |
| <i>Robinia pseudoacacia</i>                                                                                        | 87       |                                                                                      |
| <i>Arizona Cypress</i>                                                                                             | 21       |  |
| <i>Washingtonia filifera</i>                                                                                       | 21       |                                                                                      |
| <b>Shrubs</b>                                                                                                      |          |                                                                                      |
| <i>Buxus sempervirena</i>                                                                                          | 193      |                                                                                      |
| <i>Ligustrum japonicum</i>                                                                                         | 167      |                                                                                      |
| <i>Jasminum gradiflorum</i>                                                                                        | 116      |  |
| <i>Thuja orientalis</i>                                                                                            | 98       |                                                                                      |
| <i>Dodonaea viscosa</i>                                                                                            | 60       |                                                                                      |
| <i>Callistemon floribunda</i>                                                                                      | 35       |                                                                                      |
| <i>pittosporum tobira</i>                                                                                          | 25       |                                                                                      |
| <i>Lagerstroemia indica</i>                                                                                        | 15       |  |
| <i>Parthenocissus triuspidata</i>                                                                                  | 6        |                                                                                      |
| <b>perennials plant</b>                                                                                            |          |                                                                                      |
| <i>Rosa spp</i>                                                                                                    | 1191     |                                                                                      |
| <i>Berberis Vulgaris</i>                                                                                           | 226      |                                                                                      |
| <b>Lawns</b>                                                                                                       | Bermuda  |  |
| <b>Total Plants</b>                                                                                                | 2425     |                                                                                      |

Figure (12) Satellite images, photographs and analytics images from GIS program to extract green area.

Figure (12) Satellite images, photographs and analytics images from GIS program to extract green area.



**10- All Parks in Duhok city**

Nine parks in Duhok city (Alin, Barzani, Buhar, Azadi, Bekhal, Kani Xishmana, Tahsen Taha, Nawroz and Dilshad M. Said). The total area of these parks were 217318 m<sup>2</sup>, 71.66% of this area was green area whereas the 28.44% were roads building and non-green garden elements with evaluation degree between 55.2 for Nawroz to 86.6 for Azadi park (from 100 mark), the system irrigation is sprinkle for

all parks. The largest area was Barzani Park with 55879 m<sup>2</sup> whereas the smallest area was Alin (7494) m<sup>2</sup>. The total number of plants are (7280) plants, 2254 of them include many kind of tree, the highest number was *cupressus sempervirens* (428) tree then *Robinia pseudoacaia* (338) whereas

**Table (11). All Park contents (area, evaluation, irrigation system and type of all ornamental plants)**

| PARKS                         | Barzani  | Azadi    | Bekhal   | Kani Xishmana | Alin     | Buhar City | Nawroz   | Tahsen Taha | Dilshad .M Said | Total Area |
|-------------------------------|----------|----------|----------|---------------|----------|------------|----------|-------------|-----------------|------------|
| Total AREA(M <sup>2</sup> )   | 55879    | 45726    | 11000    | 8865          | 7494     | 11868      | 12418    | 31620       | 32448           | 217318     |
| Green Area(M <sup>2</sup> )   | 38061    | 34065    | 9502     | 7934          | 6846     | 8083       | 2162     | 19791       | 29289           | 155733     |
| Evaluation Of The Garden      | 75.2     | 86.6     | 67.4     | 62            | 75.5     | 66.4       | 55.2     | 73          | 76              |            |
| Irrigation System             | sprinkle | sprinkle | sprinkle | sprinkle      | sprinkle | sprinkle   | sprinkle | sprinkle    | sprinkle        |            |
| Types of ornamental plant     |          |          |          |               |          |            |          |             |                 |            |
| <b>Trees</b>                  |          |          |          |               |          |            |          |             |                 |            |
| <i>cupressus sempervirens</i> | 31       | 17       | 332      | 36            | 12       |            |          |             |                 | 428        |
| <i>Robinia pseudoacaia</i>    | 18       | 144      | 8        |               | 43       | 38         |          |             | 87              | 338        |
| <i>Platanus orientalis</i>    | 46       | 90       | 36       | 60            |          |            | 51       |             |                 | 283        |
| <i>Melia azedrach</i>         | 3        | 13       |          |               |          |            | 50       |             | 164             | 230        |
| <i>Pinus spp</i>              | 193      |          |          |               |          |            |          | 11          |                 | 204        |
| <i>Fraxinus exceisior</i>     | 77       | 117      |          |               |          |            |          |             |                 | 194        |
| <i>Arizona Cypress</i>        | 39       | 129      |          |               |          |            |          |             | 21              | 189        |
| <i>Bauhinina varigata</i>     | 148      |          |          |               |          |            |          |             |                 | 148        |
| <i>Washingtonia filifera</i>  | 34       | 14       | 17       |               |          |            |          | 24          | 21              | 110        |
| <i>Morus alba var.pendula</i> | 14       |          |          |               |          |            |          | 14          |                 | 28         |
| <i>pissardi plum</i>          | 14       | 14       |          |               |          |            |          |             |                 | 28         |

|                            |     |     |    |     |     |     |      |      |      |
|----------------------------|-----|-----|----|-----|-----|-----|------|------|------|
| <i>olea europaea</i>       | 22  |     |    |     |     |     |      |      | 22   |
| <i>Salix safsaf</i>        |     |     | 11 |     |     | 8   |      |      | 19   |
| <i>Catalpa speciosa</i>    |     | 18  |    |     |     |     |      |      | 18   |
| <i>magnolia</i>            | 2   | 7   |    |     |     |     |      |      | 9    |
| <i>grandiflora</i>         |     |     |    |     |     |     |      |      | 6    |
| <i>Acer negundo</i>        | 6   |     |    |     |     |     |      |      | 225  |
| <b>Total trees</b>         |     |     |    |     |     |     |      |      | 4    |
| <b>Shrubs</b>              |     |     |    |     |     |     |      |      |      |
| <i>Dodonaea viscosa</i>    |     |     | 76 |     |     |     | 3500 | 60   | 363  |
| <i>Buxus</i>               |     | 68  | 56 | 445 | 112 | 64  | 3    | 193  | 941  |
| <i>sempervirena</i>        |     |     |    |     |     |     |      |      | 690  |
| <i>photinia fraseri</i>    | 196 | 175 | 5  |     |     |     | 150  | 164  | 570  |
| <i>Ligustrum</i>           | 79  | 102 | 22 |     | 44  | 46  |      | 110  | 319  |
| <i>japonicum</i>           |     |     |    |     |     |     |      |      | 232  |
| <i>pittosporum</i>         |     |     |    |     | 72  | 29  |      | 193  | 228  |
| <i>tobira</i>              |     |     |    |     |     |     |      | 25   | 180  |
| <i>pyracantha coccinea</i> | 33  | 150 |    |     | 30  | 17  | 2    |      | 123  |
| <i>Thuja orientalis</i>    | 38  | 83  |    |     | 9   |     |      | 98   | 110  |
| <i>Ligustrum vulgare</i>   | 79  | 101 |    |     |     |     |      |      | 94   |
| <i>Jasminum</i>            |     | 7   |    |     |     |     |      |      | 72   |
| <i>gradiflorum</i>         |     |     |    |     |     |     |      | 116  | 27   |
| <i>Lagerstroemia</i>       | 40  | 28  | 21 |     |     | 6   |      | 15   | 24   |
| <i>indica</i>              |     |     |    |     |     |     |      |      | 20   |
| <i>callistemon</i>         |     |     | 22 |     | 23  | 14  |      | 35   | 14   |
| <i>floribunda</i>          |     |     |    |     |     |     |      |      | 728  |
| <i>Duranta erecta</i>      |     |     |    |     |     |     | 66   | 6    | 0    |
| <i>syzygium aqueum</i>     | 16  | 11  |    |     |     |     |      |      | 147  |
| <i>Granatum nana</i>       | 16  | 8   |    |     |     |     |      |      | 119  |
| <i>Hibiscus rosa</i>       |     | 18  |    |     | 2   |     |      |      | 266  |
| <i>sinensis</i>            |     |     |    |     |     |     |      |      | 668  |
| <i>Jacaranda</i>           |     |     |    |     |     |     |      | 14   | 6    |
| <i>ovalifolia</i>          |     |     |    |     |     |     |      |      | 796  |
| <b>Total shrubs</b>        |     |     |    |     |     |     |      |      | 748  |
| <b>Climbers</b>            |     |     |    |     |     |     |      |      |      |
| <i>jasminum officinal</i>  | 87  |     |    | 52  |     |     | 8    |      | 2    |
| <i>Parthenocissus</i>      |     | 38  |    |     |     |     |      | 75   | 6    |
| <i>tricuspidata</i>        |     |     |    |     |     |     |      |      | 119  |
| <b>Total climbers</b>      |     |     |    |     |     |     |      |      | 266  |
| <b>Perennials plant</b>    |     |     |    |     |     |     |      |      |      |
| <i>Rosa spp</i>            | 85  | 393 |    | 560 | 615 | 616 | 18   | 3208 | 1191 |
| <i>Berberis Vulgaris</i>   |     |     |    |     |     |     | 20   | 550  | 226  |
| <b>Total perennials</b>    |     |     |    |     |     |     |      |      | 748  |
| <b>plant</b>               |     |     |    |     |     |     |      |      | 2    |
| <b>Others</b>              |     |     |    |     |     |     |      |      | 15   |
| <i>cyperus papyrus</i>     | 15  |     |    |     |     |     |      |      |      |

|                                |      |      |     |      |     |     |     |      |      |           |
|--------------------------------|------|------|-----|------|-----|-----|-----|------|------|-----------|
| <b>Lawns</b>                   | 1331 | 1745 | 606 | 1153 | 962 | 830 | 376 | 7869 | 2425 | 172<br>97 |
| Bermuda grass                  |      |      |     |      |     | 1   |     |      | 1    |           |
| Mixed(cool<br>season grasses ) | 2    | 2    | 2   | 2    | 2   |     | 2   | 2    |      |           |

the less one was *Acer negundo* just have (6) trees. The total number of shrubs are (7280) which distributed in many types and area the kinds and highest number of shrubs are *Dodonaea viscosa* which reached (3636) decreasing to *Buxus sempervirena* (941) until reach the less one which are *Jacaranda ovalifolia* just have (14) shrubs. The total numbers of climbers are (266) plant, divided in to two types. *Parthenocissus triuspadata* just have founded in both Tahsen Tahaand, Azadi and Dilshad .M Said about (75, 38, 6) and *Jasminum gradiflorum* have little founded in Barzani, Kani Xishmana and Nawroz as (87, 52, 8). The Total number of perennials plant are (7482). The highest number was *Rosa spp* which reached (6686) and *Berberis Vulgaris* (796) plant.

11- Per capita share from the green areas (parks only) and compared with some country or city in the world by use the International Standard criteria (1). By knowing the total green area in the nine parks in Duhok city (217318) m<sup>2</sup> which clarified in table (11) and the number of population approximately (405634) persons (Duhok Statistics Department, 2021), and by dividing the total green area of the nine Parks on the number of persons we found that 0.536 m<sup>2</sup> per person is the percentage for each person in this city and when compared this percentage with some city per capita share (table 12) we found that this figure was less than the least city which that Damascus (0.7) m<sup>2</sup> per person and far away from Vienna city that reach (124.6) m<sup>2</sup> per person.

**Table (12). Per capita share of green spaces in the cities of developed and non- developing countries (13).**

| Developed countries |                                                            | Non-developing countries. |                                                            |
|---------------------|------------------------------------------------------------|---------------------------|------------------------------------------------------------|
| City                | Per capita share of green space, m <sup>2</sup> per person | City                      | Per capita share of green space, m <sup>2</sup> per person |
| Rome                | 23.5                                                       | Cairo                     | 1.5                                                        |
| Brussels            | 29.2                                                       | Damascus                  | 0.7                                                        |
| Copenhagen          | 35                                                         | Dubai                     | 13.1                                                       |
| Glasgow             | 55.6                                                       | Manama                    | 2.5                                                        |
| Vienna              | 124.6                                                      | Baghdad                   | 1                                                          |



## Conclusion

The numbers and the total area of Parks in Dohuk city is very little, so the Per capita share was only 0.536 m<sup>2</sup> per person compared with some cities (table 12), we note that the range of the service and the green areas do not cover all the neighborhoods of the city. Most public parks do not perform their purpose and function for there are no essential elements in the garden, so it is considered as a green space only. Irregular distribution of plants (the right plant in the right place) led to the creation of a kind of crowding, especially in public parks. Lack of importance and maintenance of children's playgrounds in parks, and their complete absence in public parks. So, we recommend the responsible in this city to giving the green spaces the same importance that is given to buildings during planning and increase the number and the areas of parks and distribute them in many deferent locations in the city. Cultivation of plants that tolerate the conditions of the region according to the results of Iraqi research, which classifies the types of plants that tolerate the northern regions, in addition to the new tolerant types.

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