



## RESEARCH ARTICLE

## Green Network Panoramic Vision: Erbil City as a Case Study

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## ABSTRACT

Most cities worldwide suffer from the unequal distribution of urban areas and country areas around them and the growth of dangerous environmental issues. One of the primary causes of the imbalance is the continued expansion of building blocks and urban development against the open spaces and green areas either in or out of cities. Furthermore, the natural landscape, in general, has a significant impact on protecting the climate from rising temperatures and pollutants. Hence, the aim of this research is to identify a panoramic vision of a green network and get to use sustainable land in a strong and socially solid society. As a result, the research problem reads: there is dispersion and disintegration in urban open space planning and its development. To solve the research problem, a hypothesis is proposed stating that “the absence of a panoramic vision of green networks and disconnection with the surrounding region is one of the most important causes of dispersion in those spaces”. Erbil city is one of the Iraqi cities in the northern part, was chosen as a case study to examine the green network components or elements. The results showed that Erbil has many aspects of the green network. This study offers some suggestions to fulfill the missing parts of it.

**Keywords:** Green network, greenways, urban open space, green network components, green network indicators

## INTRODUCTION

Numerous academic writings discuss various aspects of urbanization that have altered the values of human standards for the vast majority of the world's population. From this point, people's typical usages and needs have shifted, resulting in new usage and a lack of adequate balance and equitably. Moreover, the urbanization fever has spread to the master plans, resulting in considerable problems in cities, such as fragmented and scattered expansion due to the loss of open space, which resulted in an obsession with available space occupation, mainly green space. At this point, researchers start to think about how to develop innovative solutions that focus on the recurring difficulties caused by the overuse of open spaces rather than on the remaining areas in the master plans. As a matter of fact, this is the primary key element or that might be used as basis for planning in framing urban and natural environments. Hence, open spaces are the primary objective of the search. The research problems state that there are dispersion and disintegration in the planning of urban open spaces and their development. The research objective is to identify and clarify the concept of green networks and their characteristics and effective indicators. The methodology adopted is based on presenting an analytical theoretical background of the subject starting gradually from a small scale of the subject (urban open spaces), which represents the core of the problem reaching to the most extensive scale in the landscape (green network). The research hypothesis is stated during the continuous

study: “Absence of panoramic vision of green networks and disconnection with the surrounding region is one of the most important causes of dispersion in those spaces”. This research tries to identify the essential characteristics of a green network strategy to give an appropriate theoretical framework to solve this problem by analyzing Erbil city master plan as a case study to investigate, find suitable graphical solutions, and develop Erbil landscaping and urban planning development.

## GREEN NETWORK

The term “green network” was described when formally identified as “green infrastructure” for the first time. It refers to a connected network of open spaces, waterways, wetlands, forests and wildlife habitats, and other natural areas and trees found in streets, parks, and green areas in both urban and rural areas. This improved the public standard of living in USA and other countries and communities serving as a natural

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life support system, highlighting the network connectivity and multifunctionality.<sup>[1]</sup> There are a lot of definitions of green networks, none of them provides a comprehensive description that includes them all. Recently, a comprehensive definition was provided that looks at the most critical concepts dominated by continuity and multi-functionality and seeks to provide access to the best places from an environmental, economic, and social perspective across various scales. These scales define the “Green Network” as a network of multiple open spaces with interconnected functions, whether natural or man-made, that contributes to the protection of natural habitats and biodiversity in urban and rural areas. It is capable of responding to climate change and other biosphere changes promote sustainable and healthy lifestyles and enhance prosperity.<sup>[2,3]</sup>

## The Historical Background of the Green Network

Many efforts and researches have appeared to develop more theories that encourage individuals and increase their benefits and potential on urban open spaces. Thus, different modern planning trends arrange various types of urban open space as chronologically demonstrated below. The first steps of development in urban open spaces which return back to 150 years ago are based on two main critical concepts:<sup>[4]</sup>

Connecting and developing parks and other urban open spaces for the benefit of public.

Preserving the link between natural regions to get benefit from the biodiversity in the area and hinder the disintegration phenomena in wildlife habitats.

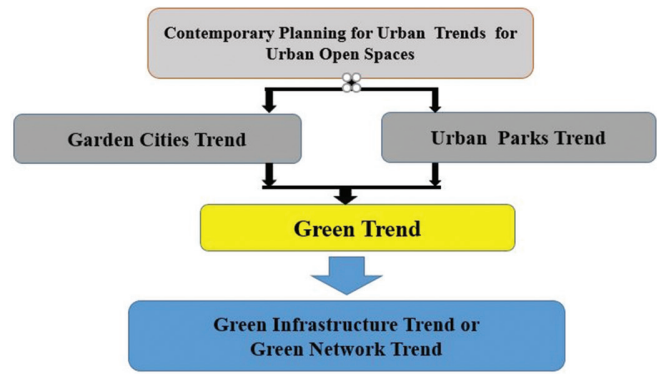
Figure 1 demonstrates a review highlighting the most significant historical tendency in the USA and the UK that led to the creation the green network concept. These tendencies have been classified into three stages as illustrated.

### The First Stage

This stage consists of two trends organized chronologically: urban parks trend and garden cities trend.

#### Urban parks trend

This trend began in the early 20<sup>th</sup> century when landscape architect (Frederick Law Olmsted, 1970) recognized the importance of nature and open spaces in urban cities (urban parks) in the USA through his innovative designs in New York City and Boston. He and his partner (Vaux) won the 1857 competition for proposing a master plan for New York's Central Park. The project's objective was to reintroduce the nature spirit and its values to the city, making it the city's natural lung capable of breathing and providing sources of solace and an escape from the crowded city. Furthermore, it provides recreational areas for the locals.<sup>[5]</sup> This park contains a primary idea for a system of paths called the “parkway system.” These paths serve no purpose other than to serve as recreational pathways and the paths in this park are regarded as the first step that led to the development of other relational trends such as the modern greenways trend.<sup>[6]</sup> Following that, Olmsted searched the park's merits and possible benefits to the urban environment. He was convinced that connecting a lot of



**Figure 1:** Divisions of contemporary planning trends of urban open spaces according to their development. Reference: The researcher

parks would result in several benefits that would outweigh any individual user, thus he wrote his famous phrase:

*“No single park, no matter how large and well designed, would provide the citizens with the beneficial influences of nature.”*

That is mean, no park, regardless of its size or design, can give the benefits of nature to the population”.Then he added later;

*“A connected system of parks and parkways is manifestly far more complete and useful than a series of isolated parks. Parks must be, instead, linked to one another and to the surrounding residential neighbourhoods.”*

This statement was translated and adapted in the “Prospect Park” design in Boston, Massachusetts, USA, which became the first park system in the USA. This park system was composed of a set of small parks located throughout the crowded city and connected by a pathway system.

Thus, it differs significantly in design from the previous example, “central park” which although it is similar in aim, involving nature features and a range of environmental activities.<sup>[7]</sup>

#### Garden cities trends

This trend began in Europe, especially in London, during the same period as Olmsted worked on his idea in the mid-eighteenth century, at a time when (Ebenezer Howard,1970) was developing a new proposal to solve the city's issue by “doubling the city” or what is referred to as the “garden city,” which combines urban and rural characteristics. Howard illustrated this concept with a chart for his famous “three magnets diagram,” which addressed the issue of the ideal city model that attracts people and provides them with the necessary quality of life and entertainment. It illustrated this concept with three magnets, as shown in [Figure 2]. Each piece represents a model to live in.

The first item is “town” which reflects the city's way of life and its positive and negative characteristics. The second piece is “country” which depicts both the positive and negative aspects of rural living. The third piece is “town-country” which refers to a new way of life coming from rural and urban life fusion.

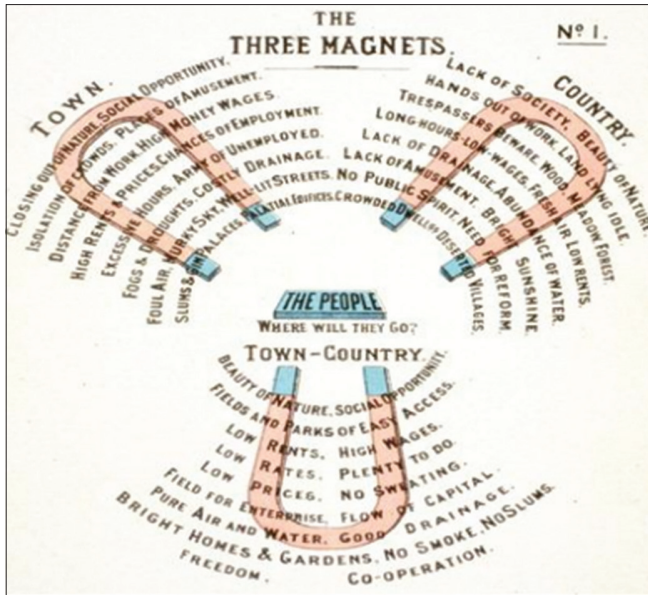


Figure 2: The concept of the three magnets. Reference: Howard<sup>[8]</sup>

The new system is more suitable for the population and gives a better life for them by these words "It carries all the advantages of city life in terms of energy and activity while also providing the beauty of nature and rural purity life." A barrier in the shape of an annulus called "Grand Avenue" was suggested in the concept of the "Garden city," which surrounds the internal residential area of the city and forms what is now known as the "greenbelt." This three-mile green cover or nearly 4.8 kilometers isolates them from commercial and industrial areas, as well as surrounds the entire city with farms.<sup>[8]</sup> This concept aims at limiting the city's population and industrial growth. To avoid urban sprawl throughout Modern Britain, a wide network of green urban open spaces and controlling urban expansion should be mitigated. According to Olmsted and Howard, there are numerous flaws in the implementation in the concept of Garden City. However, it has evolved into the fundamental principle that has led the way for the future idea of sustainable cities.<sup>[9]</sup> Both Olmsted and Howard's work has had a significant impact on the evolution of cities in the modern era. Since that time, the value and necessity of urban open spaces, particularly green ones (garden systems, green belts) in cities, have been emphasized. Their perspective on urban open spaces, on the other hand, was constrained to the esthetic and entertainment aspects, as well as the social benefits.

## The Second Stage

Following a discussion of the first stage and its most significant trends, here begins the second stage, in which the two preceding trends of "urban parks" and "garden cities" are combined into a single hybrid trend, the "greenways trend" which serves as the primary entry point for the concept of the green network. This will be explained in detail in the coming section.

### Greenways trend

The rise of problems over the past two decades and the increase of the issues including the most severe climate changes, air

pollution, and disappearance of natural land has increased interest and awareness about biological and environmental issues. These modifications led to the creation of the dimensions which symbolize the new thinking of the greenways trends which was concerned with and influenced by the environment. This trend dominated the twentieth century by implementing urban planning regulations that included urban open space and environmental considerations.<sup>[10]</sup> Greenways emerged as a concept and received attention in urban open space and urban planning in the eighth decade of the 20<sup>th</sup> century, as a result of a 1987 report by the Presidential Commission on American open-air activities for the USA, in which the concept of greenways articulated a view of the future through the following statement:

*"Living network of greenways to provide people with access to urban open spaces close to where they live and to link the rural and urban spaces together in the American landscape... threading through cities and Countryside like a giant circulation system."*

This indicates that the living greenways network connects rural and urban areas in the USA urban landscape, permeating cities, and countryside with a system resembling a massive movement, "a gigantic circulation system". The phrase "Greenways" has become more prevalent throughout the years, but it has gained much popularity recently. It has gained many acceptance among designers and urban planners, especially in the USA. There are over 660 examples of greenways in the USA. Elly, the committee (as part of its work on highways and rail system design) began establishing greenways in little sections and areas of the urban landscape as the sequential planning stages progressed. The planners then connected these components in a network or system and at the metropolitan level. Thus, the difference between them and highways and rail systems at the regional level is that the greenways system proposed by this trend is a network comprised of natural and artificial components which include natural corridors that already exist in nature as well as linear elements in the urban landscape.<sup>[11]</sup> They are used by more than 80% of the residents who live in cities.<sup>[12]</sup>

## The Third Stage

This stage is considered as the starting point for a more complex level of the trend known as the "green infrastructure trend" representing the most recent stage in the historical development of open layouts and natural urban open spaces. This will be described in detail.

### Green infrastructure trend

The concept of green networks first appeared with a different term, transient the green infrastructure, in 1994 in a report outlining a strategy for preserving natural spaces and resources. The report was proposed by "The Florida Greenways Commission." The aim was to increase the quality of social and functional biological systems to the same level as the benefits of grey systems. The commission's vision represented a fundamental shift in land protection, emphasizing the natural systems and shared aims. To the extent that this network constitutes the country's green infrastructure. It is no less essential than conventional infrastructure for natural

resource protection and management. Green network is described as primary foundation which found any society or country and makes it grow. After that, specifically in August 1999, the United States Department of Agriculture's (USDA) conservation and forests fund formally introduced this term to be adopted and worked on by government agencies and environmental organizations to plan and organize open spaces.<sup>[13]</sup>

## Green Network Components

The term "Green Network" is applied to various conservation aspects relating to local, regional, and national natural resources and landscape features, along with the containment of urban open spaces. It encompasses large areas of public land including desert land, as well as open land, river banks, streams, environmental corridors, floodplains, steep slopes, coastal areas, and wetlands all of which exist to support the people and wildlife needs.<sup>[14]</sup> A large number of research investigations classified the green network into distinct components. As with the first classification of urban open spaces, this separation will be based on the component form (stable or dynamic). All green networking components are, to a large extent, part of the larger ground or public landscapes which is referred to as the "matrix," and these components are classified into three categories.<sup>[15-17]</sup>

Patches contain a diverse range of habitats. They can be compared to these places as fragments of mosaic dispersed over the landscape. It is a space or parcel of land that contains sensitive ecosystems and serves as a habitat for wildlife. Moreover, these pieces of lands vary in area and size, have homogeneous qualities, are on huge or small forms, can be in different types such as reserves lands. They are large protected lands outside the urban region such as forests, parks, and wilderness areas. Managed native landscapes encompass huge areas with significant publicly owned and beyond the urban area, that is, such as undeveloped national forest for natural resource extraction and recreational activities. Furthermore, agricultural preservation districts, "St. Whiey" are farms owned by the private sector and managed for production purposes, cultural, and historic. Productivity sites include city parks, the last trailheads are designated places for environmental and productivity purposes and cultural and historical significance that serve as nodes and provide services to individuals who use these routes.

Connectors (corridors) are the most critical component of a green network since they act as connectors connecting network components to assist in creating work infrastructure. Connectors are dynamic elements that are different from the surrounding areas which may consist of natural scenes or separate land habitat that connects one land habitat to another. They are classified into three categories based on the expectations of scientists and planners and have been organized as follows; first, landscape linkages which contain significant protected natural areas that connect existing parks, natural habitats, provide sufficient habitat for plants and animals, and act as connectors between rural and urban ecosystem; second, conservation corridors, (greenbelts) which consist of protected natural and synthetic landscapes

that serve as the basis for development and preservation of local ecosystems, as well as providing guidelines for urban and suburban developments. Furthermore the greenway is designed as walking paths that promote access to and protection of natural areas and other green spaces. The third component is "site," which are small patches of natural landscapes or wild habitat that act as bridges or methods of communication for wild species to migrate between the giant patches by volume. A few studies have referred to it as a form of connection.

## Green Networks Scales

Green networks can be defined as elements at different scales capable of establishing open relationships with various environments. This concept has expanded to include multiple levels in recent years, ranging from the smallest part of the city and urban space (open and built) to a more significant part of the landscape of vast networks of natural areas. They are distinguished from other strategies by their diversity of levels and their ability to be applied at any scale or level, with each scale having its aligned approach. The following are the two levels of application.<sup>[18]</sup>

### *Site scale*

This level focuses on two distinct parts (the building and the street), focusing on the fusion and integration of these two components in a manner consistent with the surrounding urban open spaces, that is, integrating those areas with their nearby structures to make them more functional, focusing on integrating pedestrian-friendly nature paths. In addition, it includes several applications, the most significant of which are as follows: (green roofs, green streets techniques, and the design of the sidewalks and streets).

### *Urban scale*

This level scale encompasses the urban area which includes resident neighborhood sods, suburbs, and sectors. It enables multiple communication and continuity features between spaces by connecting them to provide a balance and consistency between green and grey features in all network elements, including (open urban spaces and green streets).

### *Regional scale*

It includes areas surrounding cities, whether agricultural or large expanses of forest, desert, wetland, and wild habitats.

The primary and fundamental objective of the green network is to maintain the integrity of the landscape. If designed and implemented correctly, it will help cities and communities adapt to nature, manage the climate changes on one hand, and maintain extreme weather events on the other. The existence of this network will promote diversity and improve the quality of public life by enhancing natural scene integration as cohesive natural scenes to the environmental and cultural resources that will be protected and maintained to give people a strong sense of place through harmony with their surroundings. Moreover, it will allow individuals to engage in decisions that influence their total urban and natural environments.<sup>[19]</sup>

## Green Network Characteristics and Indicators

Many areas which were mentioned in the previous definitions recline in the various scales of the green network, which the research previously addressed demonstrating a set of features that distinguish this network from other open space planning techniques.

There was a group of researchers who studied this topic from various perspectives and visions that reflects diverse aspects of the subject. Table 1 manifests the essential collection of their researches:

Even though the qualities described are fragmented and independent. They work together to create a unique and new approach to open space planning and design as a broad field that meets various aspects and needs. Thus, the researchers proposals and opinions with their essential elements presented in the green network scales were collected and formed as a set of common characteristics of green networks, as previously shown in [Figure 3].

These characteristics include the following:<sup>[24]</sup>

**Identity:** This refers to determining the most significant aspects of the properties location and those that distinguish it from other sites, such as green area, climate, topography,

water sources, built environment, road network, and social nature. It also includes (natural greening such as parks, and the artificial greening).

**Connectivity:** This helps determine the most critical natural or artificial elements to secure the linkage and connectivity of green networks such as (types of greenways and greenbelts).

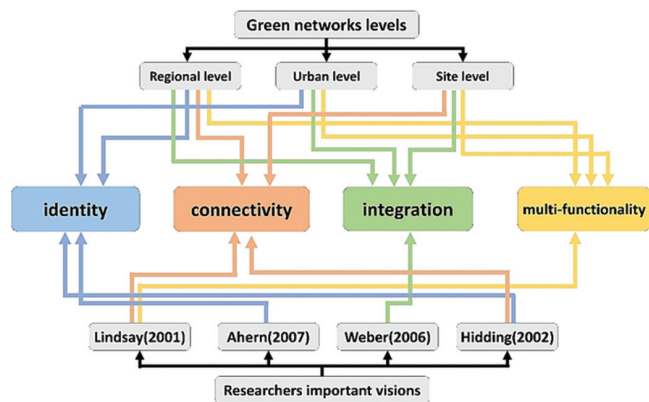
**Integration:** This characteristic refers to the coordination of the green network components with existing grey infrastructure such as (integrated streets and economic projects).

**Multi-functionality:** This term refers to the ability of all green network components of any size to perform a variety of multi-functional community (social, economic, and environmental) activities when merged into a single integrated network.

The characteristics above summarize what has been accomplished in this paper although they have been identified simply and clearly by researchers, they represent the green network panoramic vision which can essentially be adopted as indicators for the mechanism pursued by the green network to achieve the sustainability in the conservation and use of the urban and natural resource. These characteristics assist in assuring the network strategy's success and effectiveness and providing a schematic of a strategic approach or framework for preserving the available land, the biodiversity, and the wild habitat with the increase of social contact.

**Table 1:** The different researcher's visions

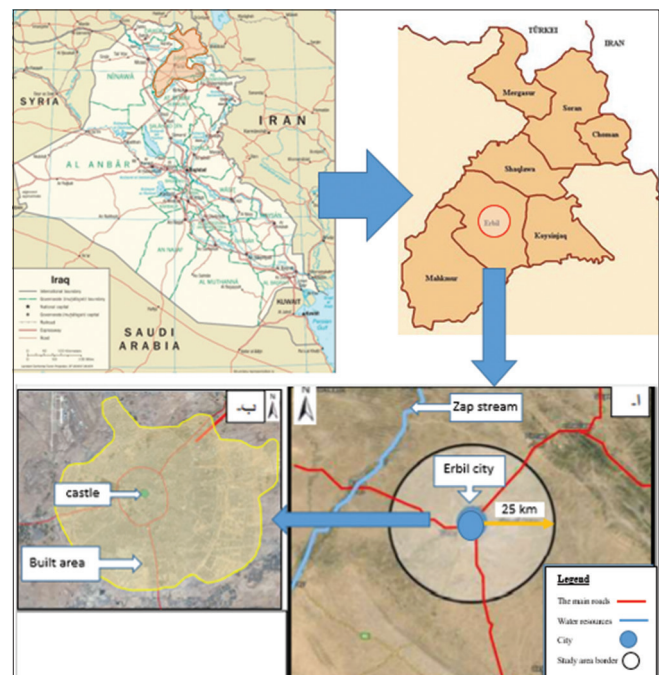
Researchers	Their point of view and vision
Lindsey (2001) <sup>[20]</sup>	Green network multi-functionality, connection, and what they offer in terms of natural and environmental assistance in restoring the balance of nature.
Hidding (2002) <sup>[21]</sup>	The focus was on the integration and connectivity of green networks at various landscape scales particularly at the urban and regional higher scales. In addition to the national rankings which were recommended.
Weber (2006) <sup>[22]</sup>	Emphasize the adoption and application of Green Networks as a critical part of the integration.
Ahern (2007) <sup>[23]</sup>	He studied the significance of physical components of Green Network and discovered the identity of the place under investigation.



**Figure 3:** The raw of the green network attributes. Reference: The Researcher according to Lindsey *et al.*,<sup>[20]</sup> Hidding and Teunissen,<sup>[21]</sup> Weber *et al.*,<sup>[22]</sup> Ahern<sup>[23]</sup>

## THE METHODOLOGY OF THE RESERCH

Erbil city has chosen as a case study. The existing situation of the study area [Figure 4], will be examined and prepared as well as the master plan for Erbil city (2010-2030) by Dar



**Figure 4:** Administrative map of Iraq showing Erbil Governorate to the far north and borders of the study area

Al- Hadassah-Al company. This will be achieved by applying the green network indicators.

Data and information were collected through:

Environmental data and statistics of the present situation are being collected in collaboration with Erbil Department of Urban Planning, Erbil Directorate of Parks Engineering, and Kurdistan Region Ministry of Municipalities and Tourism.

Field survey and photographic documentation:

The author created the maps using the AutoCAD program also maps and information from the Department of "GIS"

at the Department of Urban Planning for Erbil/Kurdistan Region.

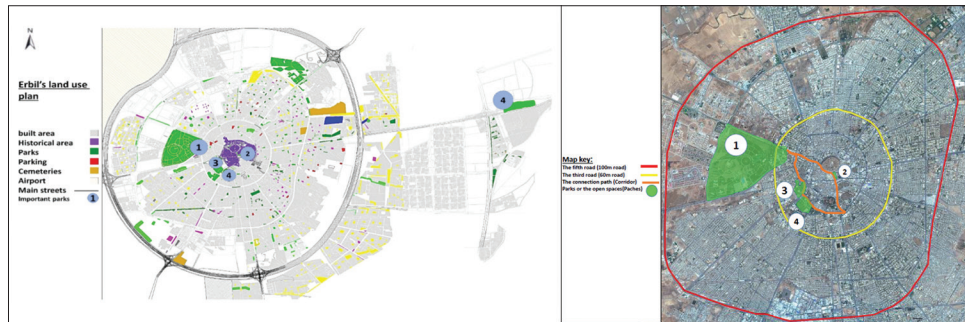
### ERBIL CITY MASTER PLAN 2010: CASE STUDY

#### Erbil City, the Study of Border Area

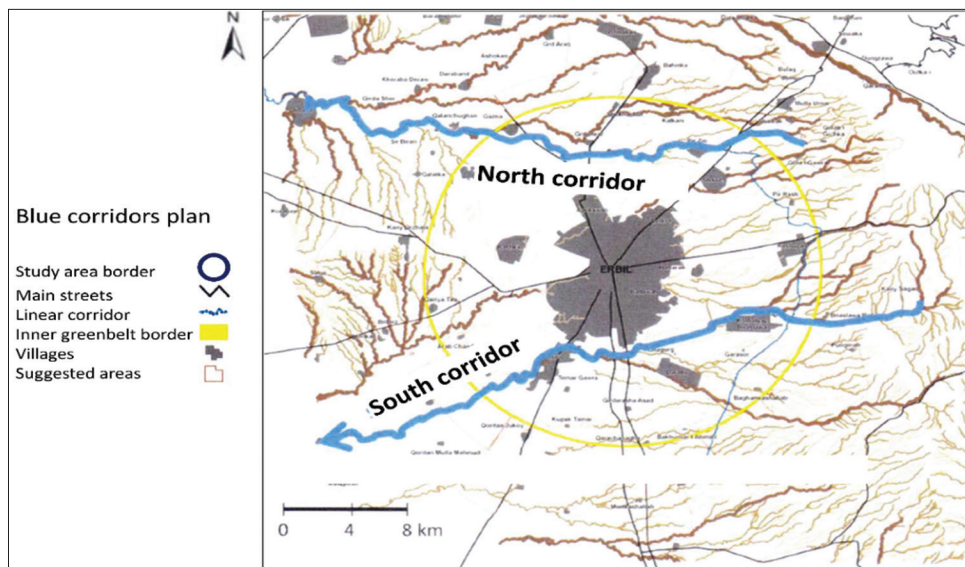
Erbil governorate is located in the North of Iraq (north of Nineveh governorate). Kirkuk governorate is located in the southwest of Nineveh Governorate. It is bounded by Iran and a part of the Sulimanya Governorate in the East. Erbil is the fourth-largest city by area in Iraq after Baghdad, Mosul,

**Table 2:** Main parks of Erbil city through the study

Parks	Area (Hectares)	Date of construction	Main characteristics
Sami Abdurrahman	87.5	2000	It is located near the third ring road; it is the city's largest and most important part.
Castle	0.62	2007	Located near the citadel, this space is considered as one of the essential spaces visited by tourists.
Manara	8	2005	This space is near the third ring road, which has historic value due to Erbil's minaret.
Shani Dar	10	2008	This space is located opposite Manara Park and consists of three connected parts



**Figure 5:** Erbil land-use plan with the suggested inner green network (site and neighborhoods scale). Reference: The researcher uses the AutoCAD2019 program, depending on GIS system maps for the Department of Urban Planning – Erbil



**Figure 6:** Erbil blue greenways (urban scale). Reference: The researcher depends on GIS system maps for the Department of Urban Planning – Erbil

and Basra, as illustrated in [Figure 4], and its capital is Erbil city.

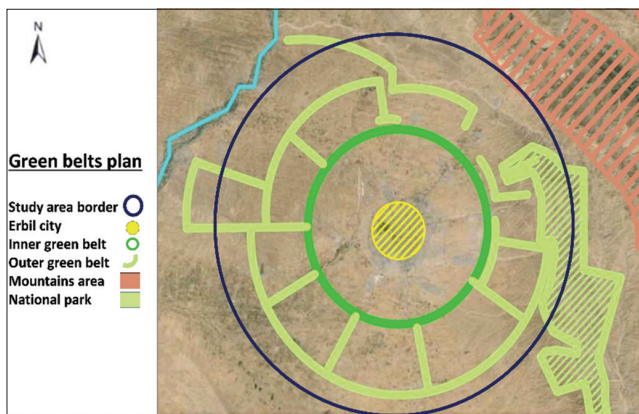
The most important reasons for selecting Erbil as a case study are as follows:

1. Erbil is shifting from a medium-sized city to a metropolitan city, with a predicted population of (7.1) million by 2030. This implies that the city is under construction which facilitates leading it toward developing sustainable plans.
2. Within (2003–2007), urban expansion outside of the preliminary master plan and the random distribution of housing projects resulted in dispersion in the planning of open spaces in and around the city, which is one of the main problems that occur in and around the city.
3. The existence of some of the green network components in the Erbil master plan (2010–2030).

### Results and discussion (Analysis of the Green Network Characteristics and Indicators)

#### Identity

Natural greening is a manifestation of many components. After analyzing the case study and the master



**Figure 7:** Erbil green belts (external and internal). Reference: The author depends on GIS system maps for the Department of Urban Planning – Erbil (Regional scale)

plan for Erbil city (2010–2030) the following have been found:

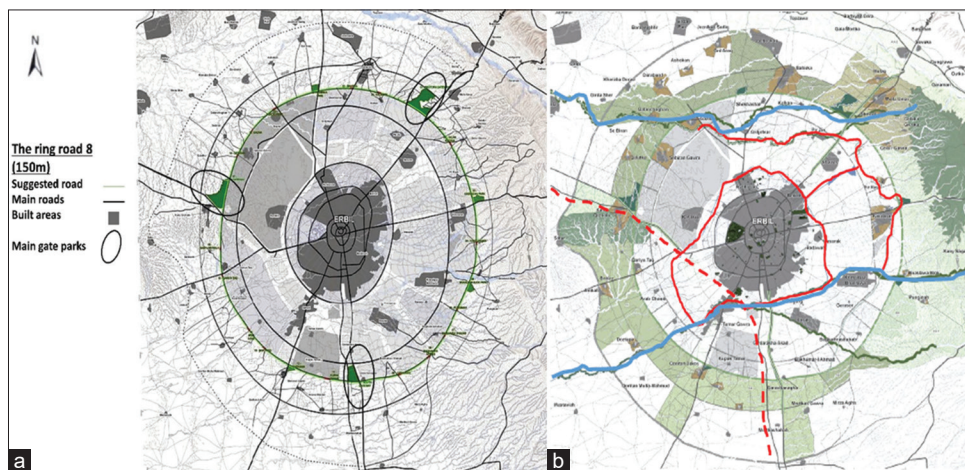
According to the survey, (20) parks and more than (450) residential parks were identified. From these parks only five of them as mentioned and shown in Table 2 and Figure 5, consider the biggest and the important parks in Erbil city such as (Sami Abdulrahman park, castal park, Manara park, and Shani Dar park), which are considered the most identifiable parks in the city and had a cultural background, and it can be connected by a greenway ring that consists of pedestrian and bikepath to be an inner parks green network for the city.

#### Connectivity

From the analysis of the master plan of Erbil city (2010-2030) for the connectivity indicator, the following elements were found:

**Greenways:** The master plan specified two blue linear corridors to connect the two sides of the inner green belt, aiming to ensure the network’s continuity and connectivity. The first is located north of Erbil, while the other is south of the city as shown in [Figure 6]. The appropriate designs and treatments for these corridors have been developed. The lanes proposed in the plan are intended to act as dynamic, open spaces with recreational value and their intended use as pedestrian and bicycle paths. The Northern corridor width is (100 m.), while the Southern corridor reaches its full width with vegetative edges (60 m.).

**Greenbelts:** The second component of connectivity is the green belts. The master plan put two green belts (internal and external). The inner greenbelt was identified: as an agricultural belt due to the belt’s agricultural lands and, for recreational purposes, also will introduce the Kurdish cultural practices. The outer belt consists of national parks. The aim is to pull the external nature within the city, which is regarded as complementary to the inner belt. It is divided into nine radial green bands with an oversized attached strip representing the natural park (proposal) [Figure 7].



**Figure 8:** (a) Erbil’s road network. (b) The proposal of the railway (Regional scale) and the connection between the North and South green ways (urban scale). Reference: The researcher depends on GIS system maps for the Department of Urban Planning – Erbil

## Integration

### Green streets

These are the integration indicator of primary components (stormwater management and green roofs). As for the study area, road network of Erbil city is considered as one of the world unique networks, defined by the presence of concentric ring roads. This is consistent with the central core (the castle). Radial penetrations form the road network system by a tide development. The primary and proposed road network comprises nine concentric ring roads surrounding the central business district, with radial intersections stretching from them. The city main exterior highways are Kirkuk Road to the south (towards Baghdad) and Mosul road to the North. Erbil city master plan of (2021–2030) has already finished seven routes. Road number (7), which is the (150m.), planned to be an integrated service street as shown in Figure 8a. In addition, three main gate parks located on each gate. These parks will



**Figure 9:** The suggested design of the integrated Road ring (7) network. Reference: The researcher depends on the Department of Urban Planning – Erbil

work as attractive places for the tourists and bring many economic benefits to the city [Figure 9].

### Rail ways

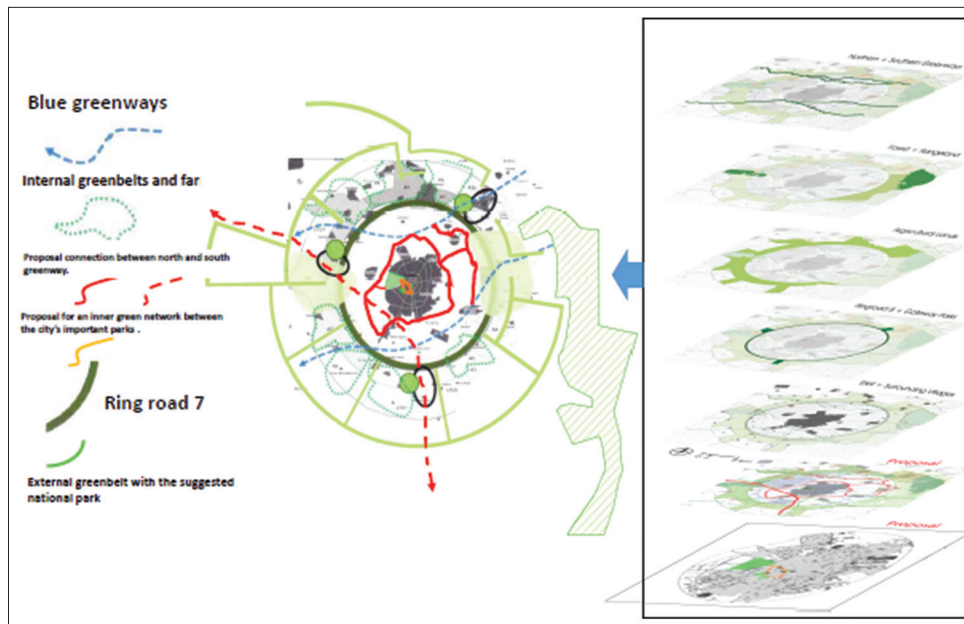
From analyzing Erbil city master plan of (2021–2030), it been found a proposal to establish a railway linking the city of Kirkuk with the city of Mosul, and passing through the city of Erbil. This line can be included as a multi-use regional integrated green corridor within the green network as shown in Figure 8b, to encourage investments and tourism, between the three cities and preparing it to be another natural wild habitat in the green network, which will benefit the three cities.

### Gray infrastructure

It introduced within the gray infrastructure plan in Erbil city master plan of (2021–2030) several manufactured canals, including: A canal to collect rainwater that runs from North to West to pour into a stream paths toward Al Zab Al kabeer, passing through part of the North Blue Greenway, and a canal surrounding the city center, which was called (Erbil River inner river), which is linked to an artificial lake. Through this research, it suggested to use these canals to connect between the North and South greenways as shown in Figure 8 and used as an integrated corridors.

## MULTI-FUNCTIONALITY

As for the last indicator, the green network components should work together as one complete system. Hence, by collecting and organizing all the previous layers of plans of the elements to create a conceptualization for the green network framework, as shown in [Figure 10], which can reflect the multi-functionality of the network.



**Figure 10:** Different layers of Green Network plan and the final Erbil city green network plan. Reference: The researcher depending on the previous plans in the paper, with the added proposals layers



**Table 3:** Natural and man-made elements of the green network of Erbil city

Green network characteristics and indicators in Erbil city master plan (2010-2030)	Natural and man-made elements
Identity	Five main parks shown in Table 2 and Figure 6, such as (Sami Abdulrahman park, castal park, Manara park and Shani Dar park), <i>it can be connected by a greenway ring consist of pedestrian and bikepath to be an inner parks green network for the city</i> (proposal).
Connectivity	<p><i>Greenways:</i> two blue linear corridors to connect the two sides of the inner green belt, aiming to ensure the network's continuity and connectivity. The first is located North of Erbil, while the other is South of the city [Figure 6].</p> <p><i>Greenbelts:</i> two green belts (internal and external), also will introduce the Kurdish cultural practices. The outer belt consists of national parks. The aim is to pull the external nature within the city, which is regarded as complementary to the inner belt. It is divided into nine radial green bands with an oversized attached strip representing <i>the natural park</i> (proposal). See [Figure 7].</p>
Integration	<p><i>Green streets:</i> Road number (7), which is the (150m.), planned to be an integrated service street as shown in Figure 8a. In addition, three main gate parks located on each gate. These parks will work as attractive places for the tourists and bring many economic benefits to the city.</p> <p><i>Railways:</i> Railway linking the city of Kirkuk with the city of Mosul, and passing through the city of Erbil. This line can be included as a multi-use regional integrated green corridor within the green network as shown in Figure 8b (proposal).</p> <p><i>Gray Infrastructure:</i> several manufactured canals. Through this research, it suggested to use these canals to connect between the North and South greenways as shown in Figure 8 and used as an integrated corridors (proposal).</p>
Multi-functionality	The green network components should work together as one complete system.

## CONCLUSION

By discussing the urban open spaces, the green network characteristics and indicators, and by analyzing the master plan of Erbil city (2010–2030), the following have been found:

1. Green network trend results from different previous urban open space trends. It has a wide range of uses throughout the world.
2. Green network approach necessitates a comprehensive framework for urban sustainability in the city and region at which it is located. Starting from the bottom toward upward, that is, from the local scale to organize human

relationship with the environment and the urban scale, to the regional scale, the main goal is to generate an integrated scene between humans and mother nature.

3. Green network aims were defined from the sustainability perspective (environmental, social, and economic). Its components and scales were identified to produce a basic knowledge of the structure of the concept.
4. Green network general identifying characteristics are as follows: (identity, connectivity, integration, and multifunctionality) which interact to produce the network overall functional and physical structure. Those characteristics of green network represent the planning stages.
5. From the existing situation of the study area and examining the master plan for Erbil city (2010–2030), some gaps were found in the plan. The researcher tries to fulfill these gaps by several suggestions to strength the green network plan: In the site and neighborhoods scale (connecting between the important parks by an inner green network), in the urban scale (connect between the North and South greenways by the gray infrastructure stormwater canales), and last in the regional scale (a proposal for a multi-use regional integrated green corridor).
6. The final green network elements have been defined (as shown in Table 3), and they are as follows: (Parks and the inner green network (proposal by the researcher), different types of corridors, green belts, natural areas, integrated streets, Railway (proposal by the resercher), Gray infrastructure stormwater canals (proposal by the researcher), and economic projects. The study area developed the necessary features for the establishment of a green network. It was found that most of the characteristics require the establishment of an integrated
7. Green network applied to this plan through the analysis of the master plan of Erbil city (2010–2030). Erbil is recognized as the founder of establishing a green network plan within the framework of the master plan. It serves as a model for the rest of Iraqi cities to follow in this field.

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