USING QGIS-BASED ANALYSIS TO ESTIMATE THE AVAILABILITY AND ACCESSIBILITY OF URBAN GREEN SPACES IN TIRANA

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Approval sheet of the Thesis

This is to certify that we have read this thesis entitled **"Using QGIS-based analysis to estimate the availability and accessibility of the urban green spaces in Tirana"** and that in our opinion it is fully adequate, in scope and quality, as a thesis forthe degree of Master of Science.

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

USING QGIS-BASED ANALYSIS TO ESTIMATE THE PLACEMENT AND ACCESSIBILITY OF URBAN GREEN SPACES IN TIRANA

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Tirana in the last 30 years has experienced a constant urban densification. This has been translated into a complex urban fabric with a densely built area that had resulted in the shrinking of urban green spaces. The latter has also been encouraged by the lack of focus on urban planning initiatives. A new future sustainable plan foresees the creation of a green ring on the outskirts of the city but there are little to no plans for making greenery a factor in the inner fabric of the ring where the life of the city resides.

The aim of this study is to conduct a quantitative research to find the next appropriate areas in need of green spaces in the city of Tirana. This will be done by first documenting all the existing green areas in Tirana based on thematic categories. With the use of QGIS software will be done the evaluation of all the indicators of the urban greenery, their location, and availability. Finally, based on service area network analysis, evaluate their accessibility by studying their geographical coverage in regards to the city area and producing maps of the isolated areas. In the last stage a weighted overlay suitability will be tested to find areas with the potential for green spaces and parks in Tirana that are within standards and easily accessible to residents near them.

Keywords: *Urban Green Spaces, QGIS, urban scale, city scale, thematic mapping, NDVI, accessibility, walkability, suitability analysis, Tirana, green network*

ABSTRAKT

PËRDORIMI I ANALIZAVE TË BAZUARA NË QGIS PËR TË VLËRESUAR VENDODHJEN DHE AKSESUESHMERINË E HAPËSIRAVE TE GJELBËRUARA URBANE NE TIRANË

Sadushi, Sabrina

Master Shkencor, Departamenti i Arkitektures

Udhëheqësi: Dr. Anna Yunitsyna

Tirana në 30 vitet e fundit ka përjetuar një densifikim urban konstant. Kjo është përkthyer në një strukturë urbane komplekse me një zonë të ndërtuar ngjeshur, që ka rezultuar në zvogëlimin e hapësirave të gjelbërta urbane. Kjo e fundit gjithashtu është nxitur dhe nga mungesa e fokusit në iniciativat e planifikimit urban. Një plan i ri, i ardhshëm parashikon krijimin e një unaze të gjelbërt në pjesën periferike të qytetit, por ka pak ose aspak plane për të bërë gjelbërimin një faktor në strukturën e brendshme të unazes ku eshte e perqendruar jeta e qytetit.

Qëllimi i këtij studimi është të kryejë një kërkim sasior për të gjetur zonat e ardhshme të përshtatshme për hapësirat e gjelberta në qytetin e Tiranës. Kjo do të bëhet duke dokumentuar fillimisht të gjitha zonat ekzistuese të gjelberuara në Tiranë në bazë të kategorive tematike. Me përdorimin e softuerit QGIS do të kryhet vlerësimi i të gjithë treguesve të gjelberimit urban, vendndodhja e tyre dhe disponueshmëria. Së fundi, duke u bazuar në analizën e zonave te shërbimit, do të vlerësohet lehtiesia ne aksesimin e tyre duke studiuar mbulimin gjeografik në lidhje me zonën e qytetit dhe duke prodhuar hartat e zonave të izoluara. Në fazën e fundit, do të testohet përshtatshmëria bazuar në analiza kriteresh te ponderuara, për të gjetur zona me potencial për hapësira të gjelbëruara dhe parqe në Tiranë që janë në përputhje me standardet dhe lehtësisht të arritshme për banorët pranë tyre.

Fjalët kyçe: *Hapësirat e Gjelbërta Urbane, QGIS, shkalla urbane, shkalla e qytetit, harta tematike, NDVI, aksesueshmëria, ecja, analiza e përshtatshmërisë, Tiranë, rrjeti i gjelbër*

ACKNOWLEDGEMENTS

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CHAPTER 1

INTRODUCTION

1.1 Problem Statement

Tirana has had a continuous development throughout its history, the nature of which has changed based on the driving forces of it, let those be political, social, economic or natural. At the moment there is a boom in building and infrastructure and new plans regarding its urban structure. Based on Green City Action Plan of Tirana [1] there is a future proposal for 2030 for a compact city surrounded by an outer green ring that will stop the urban sprawl and densify the city inside as shown in *(Figure 1).* A similar approach of a circular ring around a central urban area is depicted in cities like: Lucca, Italy; Capalaba, Australia; Munster, Germany; and Cracow's Old Town, Poland [2]**,** that is one of the biosphere reserve typologies regarding sustainable urban green space integration in a compact city.

By a simple examination of the Map of Tirana in *(Figure 2),* it is easily identifiable that the location of the future Metro Bosco is in a sub urban–rural area that is already green and not urbanely developed while the inner area of it is densely built and in need of new urban green spaces. Regarding the inner densely part, is mentioned that The Territorial Urban Plan of Tirana indicates that: "The ratio of open green space per 100,000 inhabitants is only 4.6ha. This is an alarming low value, and inhabitants have complained about the lack of green area within their neighbourhood, indicating this is a local issue for many areas of the city." To resolve this, there are proposed "pocket parks in residential blocks" but they are defined as a medium priority on the list while the Metro Bosco green ring a high priority.

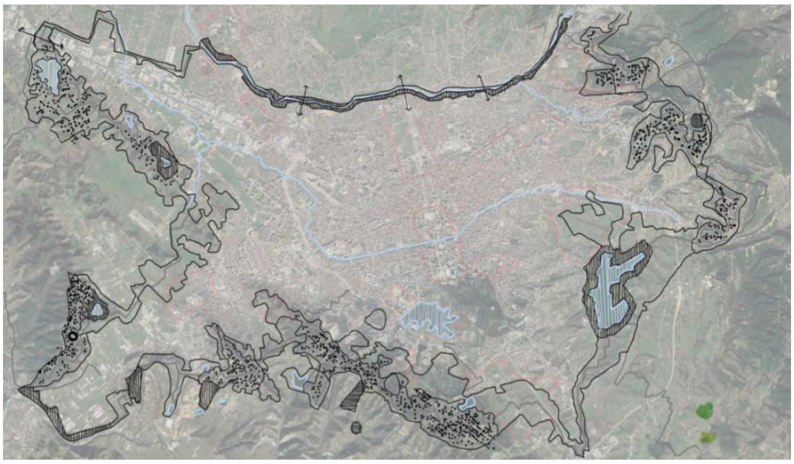


Figure 1. Location the Metro Bosco [1]

Figure 2. 2030 Metro Bosco plan [1]

Considering other reports, over 27% of the area of Tirana is covered by greenery but the distribution is heterogeneous among administrative [3]. Because the data from these reports is from 2016, it would of interest to learn and analyze if the amount of green spaces has changed since then, considering the rise of building density.

Documents from the municipality of Tirana indicate a per capita open green area of $0.46m^2$, based on the available data, which indicates a notably low amount of urban green space in the city. This finding is concerning in light of the World Health Organization's recommendation of a minimum of 9 square meters of green space per person, with an ideal goal of 50 square meters per person [4]. Given the potential implications for public health and well-being, it is crucial to investigate these values further. Additionally, the data reveals an uneven distribution of urban green spaces across the various municipal zones, as well as accessibility issues. Investigating the relationship between the area per capita of urban green spaces and their proximity to residential areas would contribute significantly to urban planning and policy formulation. These findings demonstrate the need for targeted interventions to increase the quantity and accessibility of urban green spaces in Tirana, in accordance with international standards and for the benefit of the city's residents.

In the case of the Metro Bosco green ring, it might increase the number of formal parks and their area but they would be harder to access from the higher percentage of the population compared to a neighborhood park. This research is also important in a global scale as there is a constant need for data regarding cities that undertake sustainable urban plans like that of polycentric compact cities and they differ in their urban fabric like in the case of Tirana where a tentative for this type of urban development is in an urban fabric with a potential low number of green spaces. Understanding the relationship between urban population and the quality and amount of green space is vital in terms of sustainability, health and resilience of urban areas.

1.2 Thesis Objective

This study aims to evaluate Tirana's urban green spaces and recommend strategies for enhancing the city's green infrastructure. The purpose of the study is to address the existing disparities in green space distribution and accessibility within the city, especially in relation to the proposed Metro Bosco project.

There will be evaluated the extent and distribution of urban green areas in Tirana: This study will quantify the coverage of vegetated areas and analyse their distribution across different municipal zones through a comprehensive assessment. This analysis will identify areas with high and low urban green space concentrations.

The study will assess the accessibility of recreational areas in Tirana, including playgrounds, pocket parks, and the urban forest. By considering distance and travel time, the analysis will identify areas that lack adequate access to these green spaces, highlighting the need for accessibility improvements.

Propose new suitable urban green spaces: The study will identify potential locations for new urban green spaces in Tirana based on the findings of the accessibility analysis. This will involve a weighted overlay analysis that takes vacant land and other pertinent factors into consideration. The objective is to propose areas suitable for future development of green infrastructure, with the aim of increasing the coverage and accessibility of urban green spaces.

By accomplishing these goals, the study aims to provide valuable insights into the current state of urban green areas in Tirana, highlight areas for improvement in terms of distribution and accessibility, and suggest strategies for enhancing the city's green infrastructure. This study’s findings can be valuable in future similar research.

1.3 Scope of Work

Overview of the Project:

The objective of the project is to evaluate the accessibility and availability of urban green spaces in Tirana. To identify green spaces within the inner ring of the city, the assessment will involve gathering the necessary data and running various analyses. Since there isn't a database specifically for the municipality of Tirana, analysis methods like NDVI and OSM TOOL will be used, with manual extraction supporting the OSM method.

Collecting and evaluating data

Gather all the necessary data needed to evaluate Tirana's urban green spaces. Calculate quantitative metrics like the urban green coverage and green areas per capita by using NDVI analysis to extract green areas as well as zonal statistics for both area coverage and green area for zonal population. Calculate the distribution of green spaces using administrative unit data.

Grouping of Green Spaces:

Use the OSM data and manual categorization based on a predefined table to apply a classification methodology. To categorize various kinds of green spaces, take into account various elements such as typology, function, vegetation density, and accessibility. Create thematic maps that depict the various types of green spaces.

Analysis of Accessibility

Pay attention to the thematic maps that show accessible, public urban green spaces for recreation. To evaluate the accessibility of these spaces, use the QNEAT3 plugin and service area analysis based on time and speed. Locate areas with poor accessibility, and produce results showing areas that are underserved as well as completely unserved.

Weighted overlay analysis

Within the scope of this study, a weighted overlay analysis was conducted to identify locations in Tirana for new urban green spaces. This analysis involved assigning weights to a variety of criteria, based on their relative significance in determining an area's suitability for the development of urban green infrastructure. The suggested sites were then put through service area analysis of accessibility to see how the distribution of served areas change after the additions.

1.4 Thesis Organization

This study comprises seven chapters that systematically investigate urban green spaces (UGS) in Tirana. The first chapter sets the foundation with an introduction, outlining the problem statement, thesis objectives, and scope of work. Moving into Chapter 2, a thorough literature review is conducted, classifying UGS based on ownership, type of green infrastructure, and size and function. This chapter also emphasizes the importance of UGS in cities and people’s life. Chapter 3 introduces the methodology, providing an overview of the research approach, study area description, and the software and tools utilized. Data sources, such as NDVI and OSM in QGIS, are detailed in relation to the study's methodology. In Chapter 4, the focus shifts to documentation and quantification, where the NDVI method and the OSM + Manual method are applied to categorize, classify, and analyze UGS. A comparative analysis between the two methods is also performed. The fifth chapter delves into the service area analysis of UGS, employing network analysis based on time and distance to create maps for various UGS types. Unserved areas within the city are identified as well. Chapter 6 presents the proposal for new urban space areas through multi-criteria weighted-overlay analysis, vectorizing, and accessibility analysis. Lastly, Chapter 7 wraps up the paper with discussions, comparing findings, addressing limitations, providing recommendations, and drawing conclusions based on the research outcomes.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A range of natural and semi-natural locations, including parks, gardens, woods, trails, and other green spaces, can be referred to as urban green spaces. Depending on the research or study being done, the definition of urban green space may vary or be extended, but generally speaking, it refers to urban areas that are primarily covered in the vegetation of any kind [5].

Another important aspect is that they should serve a number of benefits to the residents and the environment that they are in. They should provide opportunities for community engagement, relaxation, and activity participation that benefit physical and mental health and well-being. Urban green spaces should provide ecological benefits to the urban environment like the reduction of the heat island effect, reduction of air pollution, or noise buffering.

Urban green space can refer to a wide range of areas within urban environments, as long as they fulfill the mandatory variables of being covered with vegetation and providing a positive impact on the environment as well as the people who use them.

2.2 Classification of UGS

There are numerous categorizations that can be done to urban green spaces as they change in regard to the criteria that is beneficial to the study being conducted. Based on the literature review conducted, as seen in (*Figure 3*), the main bases on which the literature is based on are: their classification, importance and how they are evaluated.

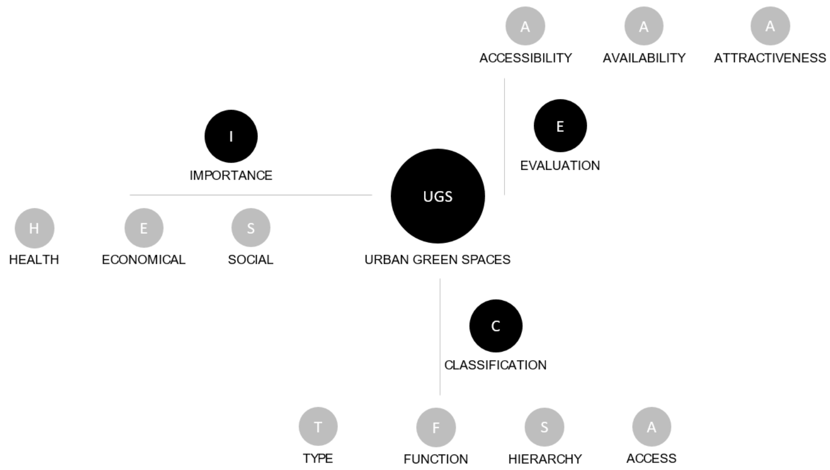


Figure 3. Illustration of Literature Review

2.2.1 Classification by ownership

Both public and private urban green spaces are possible in cities. Local parks and open spaces are examples of public green spaces that are often owned and operated by the government and accessible to the general public. Contrarily, private green spaces, such as private gardens or green terraces, are owned and maintained by specific people or groups [6].

Urban areas can benefit from a variety of social, ecological, and economic benefits from both public and private green spaces. Public green spaces have the potential to be crucial for fostering community involvement, offering opportunities for exercise and enjoyment, and boosting the aesthetic appeal of the urban setting. On the other hand, private green spaces can offer advantages including lowering the heat island effect, enhancing air quality, and raising house prices. [7]

Private green spaces can nonetheless contribute to the overall green infrastructure of an urban region and serve crucial ecological functions even though they might not be open to the general public. Private green areas might occasionally be opened to the public for specific occasions or activities. It is crucial to remember, nevertheless, that many urban planners and officials prioritize public green areas since they are frequently seen as essential parts of urban infrastructure. [8]

The concept of urban green spaces in urban planning and design extends beyond public and private areas to include semi-public and semi-private spaces. The general public has access to semi-public spaces, such as an urban square with a park, but greater control is exercised over when and how access is permitted. These areas may be surrounded by fences and closed during certain hours to increase safety and prevent abuse. In contrast, semi-private spaces, such as front gardens or communal garden areas shared by particular residents, are typically more private and restrict access to visitors or designated individuals [9]. Understanding the differences between semi-public and semi-private urban green spaces is essential as it enables the creation of environments that accommodate varying levels of accessibility and exclusivity while promoting community engagement and responsible use of green areas.

2.2.2 Classification by type of green infrastructure

There are different distributions of landscape features in the city fabric. The ideal patterns of distribution have been a subject of study and research for more than a century [10]. They depend on the type of basic patterns of metropolitan settlements they lie on; sprawl, galaxy, compact, star, and ring. [2] One of the approaches that has been repeated the most in the history of city expansions is that of urban sprawl.

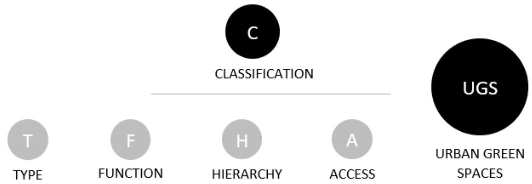
Uncontrolled expansion due to the urbanization of cities and towns is known as urban sprawl, and it is usually characterized by low-density, automobile-oriented development and a lack of clear centers or boundaries. It frequently results in longer commutes, social isolation, and environmental damage. Forecasts suggest that expansion rates will dramatically increase the size of cities tripled by 2050, with expansion rates of 2.4% and expanding speeds over 300 ml per year [11]; [12]. Urban green spaces play a remarkable role to reduce bad consequences of the rapid rate of urbanization. That is why to protect natural and agricultural land from urban development, a greenbelt of designated green spaces that frequently surround a city or other metropolitan center has been established in a number of cities. Moreover, greenbelts can offer urban people recreational activities and act as crucial animal habitats. Currently, cities like Vienna, Barcelona, Budapest, and Berlin use European Greenbelt techniques.
Greenbelts were first thought to serve the purposes of limiting further urban expansion, preventing the merging of cities, and separating the usual characteristics of town and countryside [8].

Due to the impending problem of brownfield development, nature preservation and urban regeneration were forced. There has never been an agreement on how the greenbelt and urban development are related. While one more liberal stance characterized the Greenbelt as an overflow feature to separate communities in a city region, a more rigorously restrictive position defined it as a "stopper" of urban growth [13].

The last sustainable acts have shifted from the notion of greenbelts and are looking into ways on including urban green areas in a compact city, as it is in high demand considering current city developments. A high-density mixed-use pattern that provides room for the countryside, agriculture, nature, and recreation is known as a compact city. It involves a clearly defined distinction between the city and the countryside in terms of how land use affects city people's quality of life [14]. With increased activity in urban dense areas, decreased personal automobile trips, provision of a variety of services through mixed land use, and revitalization of older urban neighborhoods (i.e., preventing infill construction), this sort of strategy is thought to prevent urban sprawl [15], [16]. These characteristics are thought to help create functional urban design, which would then allow more sustainable living arrangements in such places [17].

But in the same way that urban sprawl endangers rural regions, densification efforts in towns and cities run the risk of endangering urban green spaces [18] . There is proof that dense development and other densification processes are putting pressure on urban green space [19], [20], [21]. Planning and managing green spaces can be quite difficult, especially in areas of densification when fewer green spaces are expected to provide essential functions. Thus, it is necessary to analyze previous research that have examined the planning of urban green spaces in developing cities.

Overall green areas that are integrated throughout the urban fabric rather than being restricted to a few sizable parks or greenbelts, according to the classification known as distributed green urban fabric are the most appropriate involvement of green spaces in city life. Also, the most challenging in the current compact city fabric that is being advertised and developed in the last few years.



RESEARCHER	YEAR	Hierarchy	Type	Function	Access
[24] Iraegiu, E., Augusto, G., Cabral, P.	2020	Residential dis: 150m, 0.1 ha; Neighborhood dis:400m, 1 ha; Quarter dis: 800m, 5 ha, district dis: 1600m, 30ha; City dis: 3200m, >60ha			
[23] Tannous, H., Furla, R., Major, M.	2020	Local 0.4-1 ha (400 m catchment), Neighborhood 1-5 ha (800m cat.), District 5-20 ha (2km cat.), Regional 20ha+		Recreation, Sport, Nature	
[20] Wood, L., Hooper, P., et al.	2017	Mini-neighborhood, Neighborhood, Community, Regional, Metropolitan/National, Promenade			
[21] Lahoti, Sh., Kef, M., Lahoti, A., Saito, O.	2019		Recreational; Parks& Gardens, Playground, Lakes, Forest, River., Open; River., Public Institution: Government inst., Infrastructure & Utility corridor; Road Networks, Vacant Land		
[34] Chen, W., et l.	2018			Public Park; Municipal, Theme, CommunityRoadside., Subsidiary; Residentil, Green Buffer	
[6] Texire, M., Schiel, K., Caruso, G.	2018				Private, Public, Semi-public.
[9] Northern Architecture	2023				Private, Public, State Owned

Figure 4. Classifications of UGS based on literature.

2.2.3 Classification by size and function

As seen in (*Figure 4*), urban green spaces can be categorized in various ways depending on the study being conducted. Sometimes there needs to be a hierarchical organization based on the function and size of the green spaces because the size of a certain green space serves a certain demographic and it needs to be closer and intentionally designed for them. All hierarchical levels of UGS are important as they cater to different user groups at every level of the hierarchy and should be assessed by employing the different walking distances at each hierarchy [24].

For example, ***Table 1***, American system defines accessibility in terms of service radius, Greater London plan in terms of maximum walking distance, Korean system in terms of catchment distance and in Flanders Belgium in terms of max distance from home [24]. This classification is based on the smallest green areas to the largest. In the case of America, it classifies them based on the area while Belgium based on minimum surface.

It is in a studies interest to do its hierarchical classification based on case studies of similar cities as well as based on the strategic urban development plan of their own city.

Table 1. UGS classification in different regions [24]

Hierarchical Level and Urban Green Space standards in different regions			
Classification of Parks in America (Jia 2001)			
Class	Area	Serving Population	Service Radius
Children's park	200-400 m2	500-2500	Neighborhood (300-400 m)
Small Pleasance	200-400 m3	500-2500	Neighborhood (300-400 m)
Neighboring Park	2-8ha	2000-10000	400-800m
Disrtrict Park	8-40-ha	10000-50000	800-5000m
Large Urban Park	>40ha	>50000	Riding distance within an hour(by car)
Regional Park	>100ha	Serving a larger region	Riding distance within an hour(by car)
Specific Facility	Including avenues,Seashore,square, historic relic,flood plain,small park lawn,forestry land etc		
Classification of Parks in London Plan			
Parks Smaller than 20Ha in Size	-	-	400m
Korean Urban Green Space System (Oh and Jeong 2007)			
Parks			Catchment Distance
Children' Park	Over 1500		Less than 250m
Neighborhood Park	Over 10,000		Less than 250m
Walkable area parks	Over 30,000		Less than 1000m
Local Parks	Over 1,000,000		No limit
City Level Parks	Over 1,000,000		No limit
Urban Natyral Parks	Over 100,000		No limit
Cemetery Parks	Over 100,000		No limit
Sports Complex Parks	Over 10,000		No limit
Minimum Standarts for urban green spaces for Flanders, Belgium (Van Herzele and Wiedemann, 2003)			
Functional level	Min,surtance(ha)		Max,Dist,From home(m)
Residential green	-		150
Neighborhood green	1		400
Quarter green	10		800
District green	30		1600
City green	60		3200
Urban Forest	>200		5000

The classification varies also on the region being studied, it could be a country, a city or part of a city. In the case of the study of Qatar [25], part of the classification is also metropolitan/national parks, the biggest one being almost 1 000 000 m2, ***Table 2***. Other studies focus on the smallest units of green areas like tot lots, as the smallest green areas in hierarchy are the ones more frequently used as they are supposed to be located closer to residential and activity zones but also the most neglected in planning as their optimal distribution sometimes leads to the displacement of the various population for that it is meant for [26] .

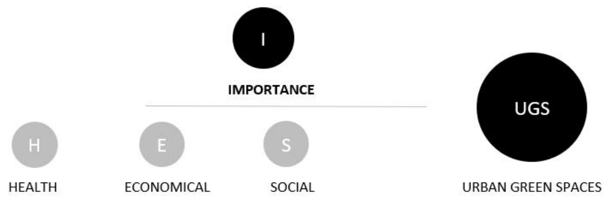
Table 2. Initial categorization of public parks, promenades, and green spaces [25]

Type	Number	Area	Service Radius
Mini-neighborhood	10	<4	1/4 miles radius
Neighborhood	4	4–10	1 miles radius
Community	2	20–50	2–5 miles radius
Regional	3	50–150	6+ miles
Metropolitan/national	2	>150	service the entire metropolitan region and/or serve as an urban setting on a national basis
Promenade	2	N/A	N/A
TOTAL	23		

2.3 The importance of UGS in cities

It is common knowledge that the environment we live in is very impactful in people's health and well-being. It seems that you can notice the changes due to environmental changes even subconsciously. Connections between green space and health have long been known, and this connection served as one of the impetuses for the 19th-century urban parks movement in both Europe and North America [27]. Many of the mechanisms behind these connections, meanwhile, lacked solid scientific support or were poorly understood. Modern scientific standards of evidence are required to support policy and practice, and new research tools offer opportunity to examine the mechanisms underlying correlations between green space and health with growing sophistication. So, this well-known fact is not just based on human experience as there have been numerous qualitative and quantitative studies that support the idea that green spaces are beneficial in a person's health. However, for the importance of green spaces in urban areas there is less evidence-based literature for a number of reasons; being costly or in nobody's interest who sees urban land as an economic opportunity. [28]

Conflicting findings have been extracted from different researches regarding urban green areas and their influence on an individual's health. There is a lot of qualitative proof of the importance of green spaces in an individual's life meanwhile there is less quantitative studies but they are definitely growing considering that 60% of the world will be living in urban areas by 2030 [29].



RESEARCHER	YEAR	ILLUSTRATION	IMPORTANCE	BENEFITS
[28] A.C.K. Lee, R. Maheswaran [3] Z. Teqja., E. Lekaj., Z. Libohova., N, Brdhi.	2010 2020		**Health**	• An environment that encourages activities beneficial to health • Obesity • Heart Health • Stress & Anxiety • Respiratory
[30] Inostroza. L., Baur. R., Csaplovics. E.	2013		**Economic**	• Raises property values • Stimulate local economy • Tourism • Jobs
[32] Hartig T, Mitchell R, De Vries S, Frumkin H. [34] Rigolon, A.	2014 2016		**Social**	• Socialize • Connect • Community • Activities • Athletics • Environmental Education

Figure 5. Importance of UGS based on literature review

2.3.1 The impact of UGS on the social, economic aspect and health of a community

Urban green spaces (UGS) are valuable resources that serve communities in many ways. This is supported by different studies as seen in (*Figure 5*). Public parks, gardens, green roofs, and greenways are examples of UGS. Communities can benefit from these areas in a number of ways, including by enhancing their social, economic, and health conditions.

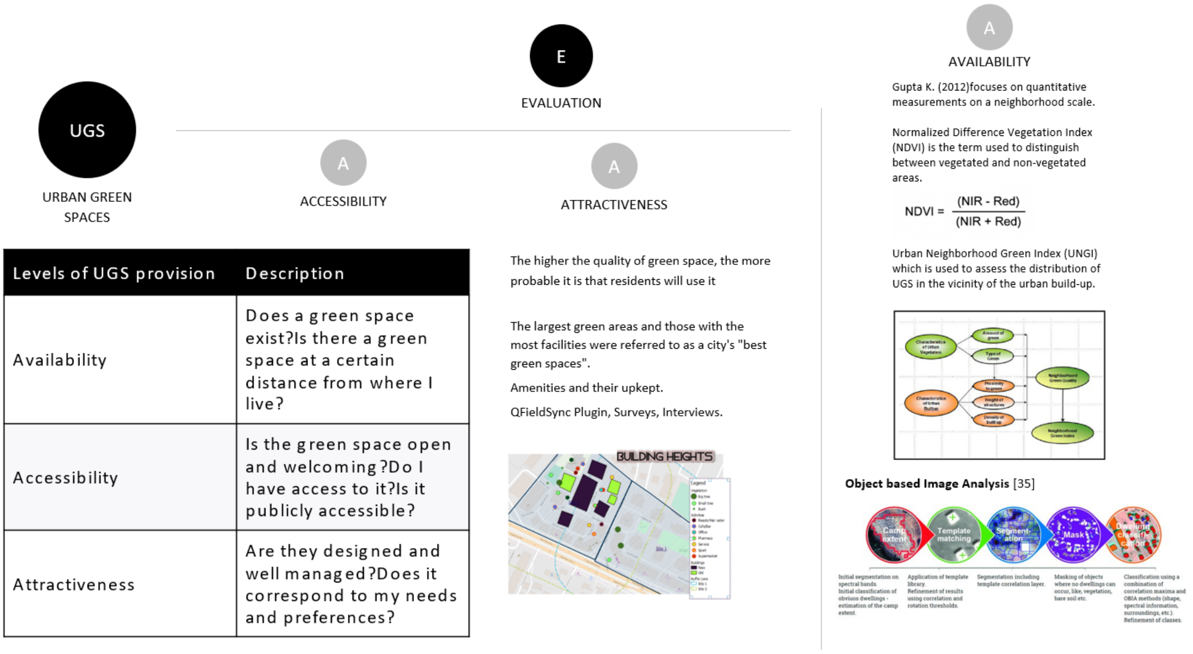
UGS can be very important in helping a community develop its social capital. They give people a place to socialize and connect with one another, which is crucial for fostering a sense of community, [28] Picnics, athletics, and cultural events are a few examples of activities that people might engage in to promote social cohesion. UGS can be used as a tool for environmental education and to assist individuals gain a better understanding of the environment.

A community's economy may benefit from UGS. For instance, they may raise local property values, stimulating the local economy [30]. Companies close to UGS can also profit since they draw clients who utilize the venues. UGS may also draw tourists, which might help the local economy. Last but not least, the development and upkeep of UGS may result in the creation of jobs, which may stimulate the local economy.

In regards to health, green spaces aren't the direct influential factor but rather the environment that encourages activities that are beneficial to health. The presence itself of green space is unlikely to explain the public health benefits suggested and the relationship is likely to be complex and influenced by multiple factors including attributes of the environment and the individual [31]. They offer a setting for exercise, which can help fight obesity and other health problems. Those who live close to UGS have higher levels of physical activity and better health outcomes, according to research. UGS also offer chances for stress management, which can enhance mental wellness. Besides beneficial, exposure to green places might lessen anxiety and despair. UGS can also enhance air quality by eliminating airborne contaminants, which can enhance respiratory health. [32]

2.4 Evaluation of Urban Green Spaces (UGS)

It was repeatedly noticed that many studies have the 3 main points of evaluation for urban green spaces where: Proximity, quantity, and quality [28], [33], [34], (*Figure 6*). Proximity describes "how close is the nearest park;" quantity describes "how many parks, or acres [hectares] of parks, are within reach;" and quality describes "what is the quality and the maintenance level of parks within reach" [28]. Although proximity, quantity, and quality all describe features of green space located near one's residence, they have some fundamental differences [28]. Proximity considers the distance to the closest green space, but it does not account for green space number, size, amenities, maintenance, and safety. Quantity focuses on the size and number of green spaces within reach, but not on their amenities, maintenance, and safety. Additionally, quality considers the amenities, maintenance, and safety of green spaces within reach, but not their number and quantity. [35]



Levels of UGS provision	Description
Availability	Does a green space exist?Is there a green space at a certain distance from where I live?
Accessibility	Is the green space open and welcoming?Do I have access to it?Is it publicly accessible?
Attractiveness	Are they designed and well managed?Does it correspond to my needs and preferences?

Figure 6. Evaluation of UGS based on literature

2.4.1 Quality

In the paper that conducted a review on the Urban Green Spaces of the Global South, the 3 parameters were categorized by types of measurements that belonged to the parameter. The various quality metrics are not exclusive of one another. Several quality kinds were measured in certain research.

Urban green areas' quality is determined by a number of factors, including their upkeep, the existence of facilities like benches and playgrounds, and the variety of plant species present. When assessing urban green spaces, quality is a crucial factor to take into account because the higher the quality of green space, the more probable it is that residents will use it and take advantage of it. In the study about the Global South [34], the largest green areas and those with the most facilities were referred to as a city's "best green spaces". The terms "maintenance and safety" refer to actual and perceived levels of crime prevention and maintenance. Reports of levels of appreciation for green places, including their aesthetic value, were referred to as "Satisfaction and Aesthetics." Green spaces can have a variety of facilities like playgrounds, sports fields, and picnic places. These amenities were referred to as "amenities." The term "green space compactness" was used to describe how interconnected or dispersed parks and open spaces are. The same thing would apply to the other parameters as well.

It has been demonstrated that applying quantitative criteria without considering quality criteria results in poorly maintained green space. In cities, where green space supplies per resident may be high overall and create social scale scarcity, pure quantitative standards without regard for access and quality are useless that is why studies on the qualitative aspect of UGS are important.

2.4.2 Quantity

The overall amount of urban green space that a city has to provide is referred to as quantity. When assessing urban green spaces, it is crucial to take quantity into account since the greener space there is, the more probable it is that citizens will have access to it. Quantity of UGS is of prime concern for planners and city administrators [36].

A study by Gupta K. [36] focuses on quantitative measurements on a neighborhood scale. Normalized Difference Vegetation Index (NDVI) is the term used to distinguish between vegetated and non-vegetated areas, methodology of which *(Figure 7)* is presented below. Other quantity indexes mentioned are Urban Neighborhood Green Index (UNGI) which is used to assess the distribution of UGS in the vicinity of the urban build-up.

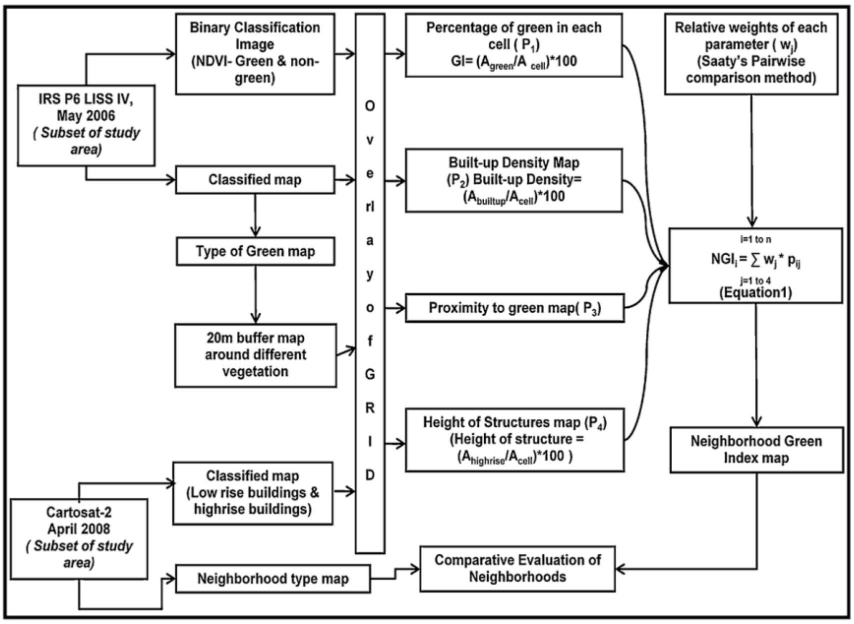


Figure 7. Methodology chart. [36]

Urban green spaces can be quantified but their distribution is equally important. Only a quantitative analysis of UGS is not enough to have a definite idea for the changes to be constructed.

2.4.3 Proximity

The distance between urban green spaces and residents is referred to as the proximity. Urban green spaces must be evaluated with proximity in mind because residents are more likely to use them if they are close to them [37]. According to studies, people are more inclined to use green spaces if they are close to their houses and can walk there as illustrated in *(Figure 8)*.

By placing public green spaces in unsuitable places, the populations they are intended to serve may have less access to them, which could result in underused or neglected areas or, in the worst case, abused areas that may be used for illegal and criminal activity [38].

Accessibility is one of the major factors influencing the frequent use of UGS and improving the well-being among its. Accessibility analysis is crucial for urban planning and evaluating urban green spaces as it helps to understand how easily residents can access these green spaces and their potential benefits [39]. By measuring accessibility, city planners can identify areas that lack adequate access to green spaces, prioritize locations for new green spaces, and optimize the distribution of existing ones to ensure equitable access for all residents. Over the years, various computational methods have been developed to conduct accessibility analysis. An approach that can be used is buffer analysis, which entails constructing buffers around open areas to count the number of people who live nearby and benefit from these spaces. Only that this practice doesn't use the road network so it is reliable. A different approach is network analysis which takes the street network's connectivity into account to determine how simple it is to get to green spaces. Researchers and planners have widely used Geographic Information Systems (GIS), a potent tool for conducting these analyses, to comprehend the spatial distribution of urban green spaces and the accessibility of those spaces to urban populations. Network accessibility analysis involves assessing the ease of movement between locations using the transportation network. Various methods are used for this purpose, including shortest path analysis to find the most direct route between origin and destination, service area analysis to determine reachable areas within specified travel times or distances [40], and accessibility indices to quantify relative ease of reaching multiple destinations from a specific location. Multimodal network analysis [41] considers different transportation modes, and network density analysis measures network connectivity. Gravity models predict movement flow based on distance and attractiveness. To perform these computational analyses, essential components are an origin point and a road network, typically processed using Geographic Information Systems (GIS) software.

Figure 8. Relationship between accessibility and UGS hierarchy.

2.5 Similar Studies

In order to conclude any research, it is important to look at other studies that have similar intentions for their research so that it is based on legitimate grounds. A number of studies have been published in regard to urban green spaces. They usually associate their physical aspect in the city with a social condition that affects its residents and see how they influence each other.

For this study, the main keys of research were: the quantification and classification of urban green spaces, finding appropriate accessibility analysis methods, and lastly, urban green spaces proposals using computational methods.

Data on urban green spaces' quantity in a city is essential for developing cities that are healthier, more resilient, and environmentally sensitive. This information is useful in urban planning and design because it helps decision-makers create cities that are sustainable and aesthetically pleasing. Based on the pre-conducted studies the cities that had a developed municipal dataset of LULC maps and more specific ones about the urban green areas where cities located in western Europe [42] and in richer, more developed parts of the city [43], [44].

There are several computational ways to generate the quantity of urban green spaces. These methods rely on Geographic Information Systems (GIS) and remote sensing technologies to analyze spatial data and extract information about green areas in urban environments.

In a study conducted in Tirana [3], the aim was to assess the extent of urban green spaces in the city using orthophoto data from 2015. The researchers evaluated the total area covered with greenery across 11 administrative units of the city and examined its distribution within these units. The method used was Object-Based Image Analysis of the orthophoto of the city. Additionally, the study estimated the green area surrounding noise and air pollution monitoring points in specific parts of the city. These measurements were then compared with data on noise and pollution levels, as well as data on the number and causes of death in the city. The findings revealed that approximately 27% of Tirana's territory is covered by green spaces; however, the distribution of green areas was uneven across the city. The study highlighted the need for further research to understand the impact of greenery on noise levels in Tirana.

The study conducted in Germany [45], aimed to identify and classify Urban Green Spaces (UGSs) in Augsburg, Germany, using a combined approach of Sentinel-2 imagery and Random Forest (RF) classification. The researchers used freely available high-resolution multi-spectral remote sensing data and derived vegetation indices (NDVI, NDWI, and SAVI) to capture information about greenery. They collected 1500 training data points for model development and implemented three different RF models to explore the efficacy of using single spectral bands, vegetation indices, and a combination of both. The results showed that all three models achieved high accuracy, with the final model combining spectral bands and vegetation indices reaching an accuracy of around 97%. The RF classification successfully identified approximately 56 km2 of UGSs, including forests, parks, green corridors, and urban gardening areas. The study demonstrated the potential of the Sentinel-2 and RF approach for accurately mapping UGSs, providing valuable information for urban planning and resource management activities. However, the resolution of the data was noted to be a limitation in identifying very small and complex green spaces, suggesting the need for even higher-resolution imagery for certain cases.

Another research [46] is focused on optimizing the acquisition of Urban Green Spaces (UGS) inventories in rapidly expanding metropolitan regions. Using very high-resolution (VHR) satellite imagery, two deep-learning model strategies for semantic segmentation of UGS polygons are tested. In order to identify geometric patterns in the images, the models employ several convolutional neural network encoders using the U-Net architecture. The best model has an overall accuracy of 0.97 and a Dice coefficient of 0.57, IoU of 0.75, recall of 0.80, and kappa coefficient of 0.94. This suggests dependable performance in identifying UGSs' variable geometry. A comprehensive database of UGS polygons, divided into types and municipalities, was compiled by the researchers, providing for standardized and up-to-date information at the metropolitan level. The methodology produced precise digital tools for evaluating urban management and conservation activities by successfully extracting and updating geometrical UGS databases.

After finding the location and quantity of urban green spaces, it is important to analyze them based on different qualities of classification because not all the green spaces that exist serve the residents with the same benefits. That is why it is important to classify them. The classification depends on the sort of issue that you want to highlight in the study.

A study in India [23], explores a mapping methodology using GIS to create a thematic map of public urban green spaces (UGS) in Nagpur City, India, in the face of limited fine-grain data availability in rapidly developing urban centers of developing nations. The objective was to provide relevant spatial data for planners and policymakers, with detailed UGS typologies, and to assess the overall availability and distribution of recreational green spaces in the city. Fieldwork and GIS analysis resulted in a holistic dataset and a highly accurate thematic map (0.93 kappa coefficient). The classification of UGS based on typologies allows for a comprehensive understanding of their distribution and functionality, enabling effective UGS governance toward broader urban sustainability. This classification methodology can be vital for future research, providing a foundation for studying specific types of green spaces, their benefits, ecological functions, and socio-economic impacts, thus contributing to urban planning and sustainable development initiatives in developing urban centers.

A research study by Chen W. et al [47] focused on developing an original methodology to map urban green spaces (UGS) based on their social functions, in addition to their physical features. Unlike traditional UGS mapping that relies solely on remote sensing data, this approach integrated remote sensing with social sensing to capture both the vegetation and socioeconomic characteristics. The methodology involved extracting vegetation patches using the Hyperplanes for Plant Extraction Methodology (HPEM) in a selected area of Beijing, with OpenStreetMap (OSM) road networks as the analytical units. Near-convex-hull analysis (NCHA) and text-concave-hull analysis (TCHA) were employed to combine the data sources effectively. The results demonstrated high overall accuracies of 92.48% and 88.76% for mapping Level I and Level II social function types of UGS, respectively. This research contributes to a deeper understanding of UGS and offers valuable data for urban planning purposes.

Another study [48] addresses the lack of comprehensive open datasets on urban green spaces by proposing a methodology to fuse Sentinel-2 satellite imagery and OpenStreetMap (OSM) data. These data sources have their limitations; Sentinel-2 cannot distinguish public from private green spaces, and OSM data lacks consistent and complete mapping of green spaces. To overcome these challenges, the researchers used the Dempster-Shafer theory to fuse the Sentinel-2 derived Normalized Difference Vegetation Index with OSM data to enhance the detection of small vegetated areas. They also employed a Bayesian hierarchical model to distinguish between public and private green spaces using OSM data. The methodology was tested in Dresden, Germany, and achieved an impressive overall accuracy of 95% for mapping public urban green spaces. The study demonstrates the potential of integrating different data sources to create more accurate and detailed maps of urban green spaces, contributing to better urban planning and enhancing the quality of life in cities.

Various studies had been conducted on accessibility analysis. The most elaborated ones were case studied on European cities that used network analysis methods for the assessment. They usually incorporated a social factor in the process to see how the accessibility to urban green spaces affected it, like Covid-19, race, mental health. In order to produce a reliable work it waw necessary to have legitimate data sources that sometimes was not possible for developing cities.

In a study conducted in Tirana [40], Albania, the researchers employed QNEAT Service Area Analysis to evaluate pedestrian accessibility to public services. Its focus is not on urban green spaces but on examining accessibility to essential amenities in the city. By utilizing the QNEAT tool, the study considered the road network and origin points representing public services to calculate accessibility. The results offer valuable insights into the spatial distribution of public services in Tirana, which can significantly contribute to urban planning and decision-making processes.

A study focuses on quantifying access to public green spaces in Switzerland [41]and its impact on society, particularly in terms of public health and sustainable urban development. The researchers applied a methodology using AccessMod and ArcGIS travel time functions to model physical accessibility at national and sub-national scales using walkability and motorized transport as variables. The results indicate that a significant portion of the Swiss population, approximately 75%, and 36%, can access the nearest urban green space within 5 minutes and 15 minutes, respectively, using motorized transport. For forest patches, 72% and 52% of the population are within 5 minutes and 15 minutes of motorized access, respectively. However, access varies significantly at cantonal and municipal levels, depending on road density, green space density, and population distribution. The study highlights the importance of quantifying green space accessibility and provides a replicable approach for future studies and comparisons with other European countries.

Another study [49] presents a methodology for modeling the physical accessibility of urban green spaces in four European cities using a combination of satellite and crowdsourced Earth Observations (EO) data. The goal is to contribute to monitoring the United Nations Sustainable Development Goal (SDG) indicator 11.7.1, which aims to globally monitor the amount of land dedicated to public spaces in cities. The researchers utilized GIS and remote sensing techniques to identify vegetated areas and urban extents. They also developed a public/private mask using crowdsourced data from OpenStreetMap to distinguish between accessible green spaces. The proposed methodology demonstrates technical feasibility and provides a reliable, low-cost, and continuous source of information for sustainable urban development. The results show that a significant portion of the population in each city can access the nearest urban green space within specific travel times, but there are disparities at different geographical levels. The study considered two scenarios, "Fast" and "Slow," to model accessibility based on different walking speeds in urban and rural areas. This approach can facilitate EU reporting for better comparisons between EU countries in terms of green space accessibility.

A study on Delhi [24], proposes to apply network analysis in geospatial environment to various hierarchies of UGS with walking distances rather than applying uniform distance to all hierarchies. The was because the people who frequent the space are different based on the hierarchy of spaces. In the case of neighborhood parks for example, the people who usually accompany it are children you have a certain speed of walking and need to walk short safe distances near their homes. The findings indicate that using this method, a more precise assessment of the UGS deficiency at different hierarchies might be made. In this study, the network analysis was successfully used to evaluate the accessibility by hierarchy. It may also be used to identify any gaps at each hierarchy that are not served by public green spaces and that require attention for UGS's future development. The study underlines the necessity to use network analysis to examine how easily accessible UGS is in places like Delhi and other emerging countries, which are home to more than half of the world's urban population.

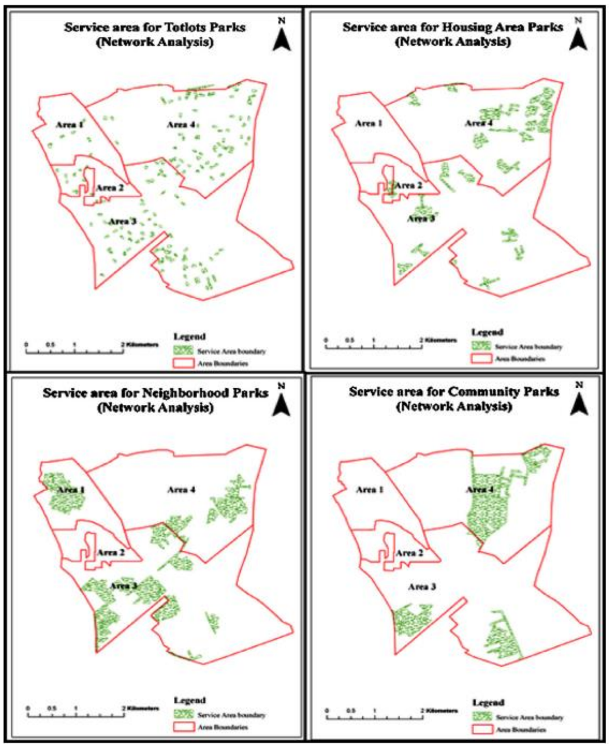


Figure 9. Result differences [24]

It is important to decide on the type of analysis that you will carry out your study as the results may vary depending on it and how specific it is to the problem to be solved as seen in *(Figure 9)*. This may depend on a number of variables, including the purpose of the study or application, the quantity and variety of geospatial datasets available, and the methodological assumptions and decisions (such as the choice of distance, the use of centroids or census tracts) that were made. In the case of QGIS it could be a network analysis or buffer analysis, it can depend on the point taken as the base, if the mode of transport will be walking, by bicycle, or public transport, speed, road limitations and other variables. Other methods like the incorporation of space syntax in QGIS studies shows how integrated/shallow or segregated/deep is a space within the urban spatial network [25] . Global integration represents where you are in relation to everywhere else in that network. Higher levels of integration often result in more movement and, as a result, a greater ability to access various types of land use.

When it comes to urban planning, digital computational methods have become crucial for suggesting urban green spaces. These techniques use geospatial data, remote sensing, and sophisticated algorithms to analyze a number of variables, including topography, accessibility, population density, and land use, in order to find locations for green spaces. Geographic information systems (GIS) make it possible to combine various datasets, giving planners the ability to visualize, evaluate, and pinpoint the urban landscape's current state and the areas that most urgently require green space.

In order to support efficient planning processes for green areas in a sustainable way, a study [50] set out to locate potential locations for urban green spaces in Sululta town, Ethiopia. The researchers used a GIS-based multi-criteria analysis (MCA) approach, taking into account key criteria affecting the suitability of green spaces such as existing land use, proximity to settlement, road and water bodies, population density, land ownership, topography, and scenic attractiveness. The findings showed that for the development of urban green space, 13.6% of the study area is highly suitable, 34% is suitable, 28% is moderately suitable, and 18.9% is poorly suitable. 5.5% of the total area was also determined to be unsuitable for urban green spaces. This study emphasizes the usefulness of GIS-based MCA as a site selection tool for urban green space planning, not only in Sululta town but also for national urban planning initiatives.

CHAPTER 3

METHODOLOGY

3.1 Overview

This study employs a three-step methodology to conduct a comprehensive analysis of Tirana's urban green spaces. These stages include the extraction and documentation of green areas, the analysis of the accessibility of public urban spaces, and the identification of potential new green areas as illustrated below *(Figure 10)*.

Figure 10. Steps of the methodology conducted in the study.

NDVI (Normalised Difference Vegetation Index) and the OSM (OpenStreetMap) + Manual approach are used to extract and document green areas in the initial stage. The NDVI analysis enables the identification of vegetated areas within the city limits and provides an overview of the green coverage as a whole. In addition, the OSM + Manual method is used to document and classify specific urban green based on a predefined table of classes and attributes.

Assessing the accessibility of the identified public urban spaces is the focus of the second phase. Using the QNEAT3 plugin for QGIS, an accessibility analysis is conducted based on time and distance considerations. To calculate service areas using isochrones, various variables specific to each type of green space are assigned. This analysis contributes to a comprehensive understanding of the accessibility of green spaces by shedding light on their availability and proximity to various municipal zones.

Comparing existing green spaces with service areas identifies unserved areas during the third phase. This helps to locate areas where accessible green spaces are lacking. Using a suitability raster map, a weighted overlay analysis is then conducted to identify potential locations for new urban green spaces. The suitability map incorporates multiple factors, such as the availability of vacant land, categorized spaces, and manual extractions, to identify areas suitable for green space expansion.

To ensure the dependability of the proposed green spaces, comparisons are performed to validate the suitability map's precision. In addition, the proposed urban green spaces are subjected to an accessibility analysis using isochrones to evaluate the changes in the served area from the urban green areas compared to the map of the existing ones. Using this methodology, this study aims to provide a comprehensive understanding of the existing urban green spaces, evaluate their accessibility, and propose potential locations for new green areas to improve Tirana's urban environment. A detailed workflow diagram in *(Figure 11)* shows the steps taken to conduct the assessment, analysis and proposal.

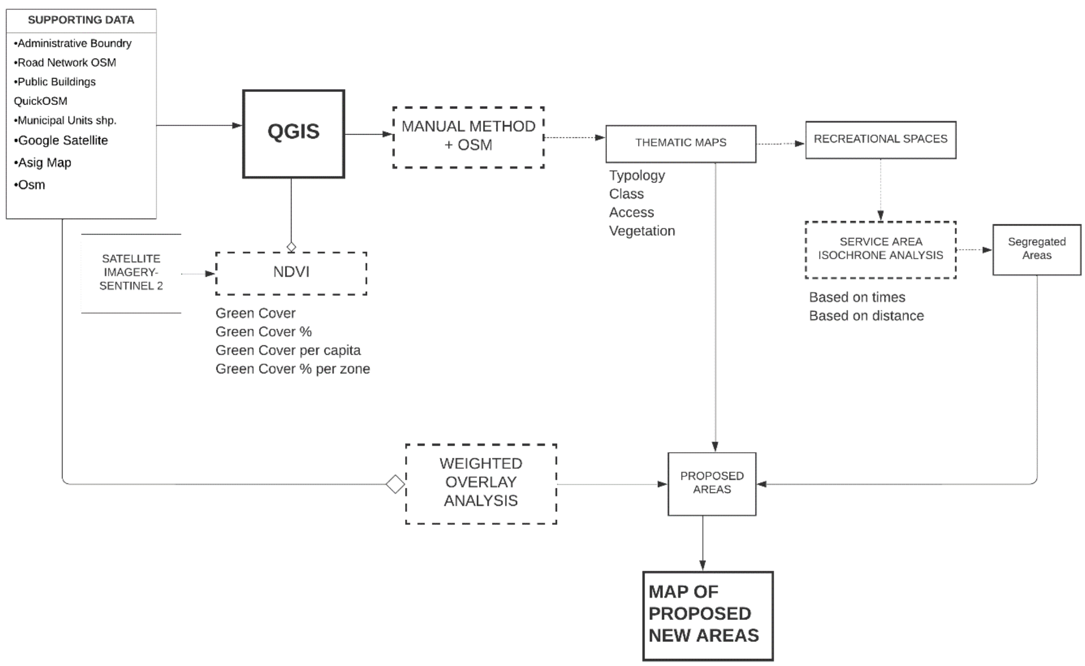


Figure 11. Workflow diagram of the study conducted.

3.2 Study area

The study area of this research paper is the city of Tirana *(Figure 12)*, which is also the capital and the largest city of Albania. Throughout the last two decades has had impressive growth and development in various aspects, making it a significant hub of economic, social, and cultural activity. With a metro area population of 520,000 in 2023, a 1.56% increase from 2022, Tirana stands as the most populated city in the country, demonstrating the major demographic shift towards urban areas.

Geographically, Tirana is located in the central part of the country, surrounded by the Dajti Mountain Range to the east and the coastal plain to the west. With mild winters and hot summers, the city has a Mediterranean climate, attracting visitors throughout the year. In recent years it has experienced a touristic boom with over 1.5 million visitors exploring its attractions, historical sites, and growing cultural scene.

On the downside, the city has experienced extensive urban sprawl and building densification due to the rapid urban growth, which has posed challenges in both urban planning and the provision of urban green spaces.

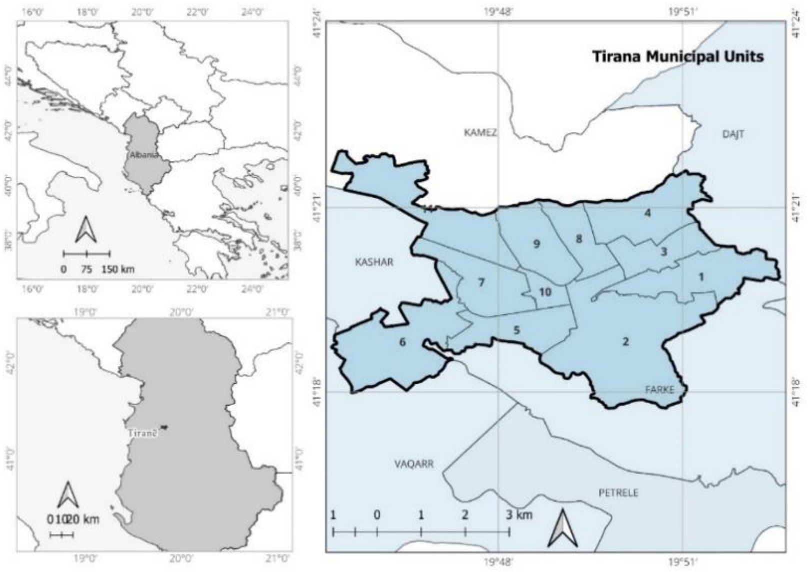


Figure 12. Location of the study area and municipal units.

3.3 Software and tools

This paper was conducted using the QGIS 3.28.0 version during the work process. The software is being consistently introduced with thematic plugins which bring new analytical workflows that deal with specific geospatial themes.

QNEAT3 IS A Python-based plugin that is used to perform advanced network analysis algorithms. The main two inputs for the workflow are the point layer of the service location and the polyline feature of the road network shapefile. The the plugin workflow works is that it first produces a heatmap based on graph analysis and later produces polygons to define isochrones as polygon shapefile.

3.4 Data used

Multiple data sources were utilised to assess the urban green spaces in Tirana. Using the OSM + Manual method, a 2018 georeferenced orthophoto of Tirana was integrated and refined, resulting in a higher image resolution. Additionally, Google Satellite imagery was used to create a basemap in QGIS and compare it to the OSM + Manual method. OpenStreetMap (OSM) data were incorporated as a basemap into the OSM + Manual method. For NDVI calculations, bands 4 (near red) and 8 (near infrared) of Sentinel-2 satellite imagery acquired on April 23, 2023 were used. A land use and land cover (LULC) map obtained from the Copernicus Land Monitoring Service provided a geospatial representation of various land cover classes. QuickOSM, a GIS extension, was used to extract information from the OpenStreetMap database, including the road network, various types of green land, schools, and institutions. The ratio and indexes of urban green spaces in relation to Tirana's population were analysed using population data for each municipal unit in Tirana. These diverse data sources and tools, ***Table 3.*** Data used in the analysis., enabled a comprehensive evaluation of Tirana's urban green spaces.

Table 3. Data used in the analysis.

Name	**Description**	**Use**	**Layer Type**	**Source**
Orthophoto	Georeferenced orthophoto of Tirana 2018	Integration and refinement of the OSM + Manual method due to higher imagery resolution	Raster	ASIG
Google Satellite	Satellite image tiles provided by Google to create a basemap in QGIS	Integration and refinement of the OSM + Manual method for comparison	Raster	QGIS
OSM	Serves as a basemp in QGIS created by a collaborative mapping project	Integration in the OSM + Manual method	Raster	QGIS
Satellite Imagery	Sentinel-2 Band 4 (near red) and Band 8 (near infrared) Imagery date: 23 April 2023	Used to conduct NDVI calculations	Raster	Europe Space Agency (ESA)
LULC Map	Land use and land cover map that shows a geospatial representation of the different land cover classes.	To evaluate and compare the used methods	Raster	Copernicus Land Monitoring Service
QuickOSM	GIS extension used to access data from the OpenStreetMap database	Used to extract the road network, all the types of green land, schools, and institutions	Vector	QGIS
Population data	Shows the population number for each municipal unit in Tirana	Used to find the ratio and indexes of urban green spaces in relation to the population	Delimitated text	Excel

On the other hand, *Table 3*, shows the data regarding the municipal units names, their population and area of each. They are obtained from the municipality website, that are necessary to conduct the assessments of this study.

Table 4. Population and area date for each municipal unit

Area Name	**Municipal Unit**	**Population**	**Area (m2)**
Tirane		547.932	40.034.832
Ali Demi	1	43.808	3.568.959
Bulevardi Bajram Curri, Bulevardi Zhan Dark, Qyteti Studenti, Sauku	2	70.778	9.307.263
Brryli, Xhamlliku	3	38.57	2.049.532
Kinotudio, Babrru, Allias	4	55.514	3.601.476
Blloku, Selita, Tirane e Re	5	73.875	2.672.654
Kombinati, Yzberisht	6	60.599	5.661.487
21 Dhjetori, ish Fusha e Aviacionit	7	65.119	3.012.792
Selvia, Medreseja e Tiranes	8	32.871	1.893.659
Lagja e Trenit, Brraka, Don Bosko(part)	9	53.463	2.787.278
Central Tirana	10	23.335	770.284
Lapraka,Instituti, Don Bosko (part)	11	30	4.740.654

3.5 NDVI

One index that is used to measure the amount of green spaces in urban areas is Normalized Difference Vegetation Index or NDVI. It provides objective measurements of healthy vegetation levels using satellite imagery.

NDVI measures the ratio of the reflective difference in the red and the near-infrared portions of the spectrum, to the sum of red and near-infrared reflectance.

Green health vegetation reflects light in the near-infrared portions of the spectrum and absorbs red light. NDVI ranges from values of 1.0 to -1.0 where larger positive values indicate green vegetation. In the case of this paper values >0.25 were considered as vegetated areas.

$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{Red})}{(\mathrm{NIR} + \mathrm{Red})}$$ (Equation 1)

Green cover different from any other vegetation index refers to the extent of vegetation, including forests, trees, shrubs, grasslands, and other forms of greenery, in a particular area. It is a measure of the amount and density of vegetation present in a given region. Green cover plays a crucial role in maintaining ecological balance, supporting biodiversity, mitigating climate change, and providing numerous ecosystem services. Through the use of NDVI raster, it is intended that the data extracted to give information about the percentage of green cover in the city.

3.6 OSM in QGIS

OSM is a collaborative mapping project aimed at creating an open digital map of the world. Anyone can contribute to the project by mapping various kinds of geo-spatial objects. The geometric data structures used to represent objects are nodes (points), ways and relations (both lines and polygons). Properties of objects are described using tags consisting of a key and a value, e.g., highway=footpath or amenity=bench. Each feature in OSM may contain one or multiple tags with different keys. To keep the data consistent, the meaning and usage of tags are discussed by the OSM community and documented within the OSM Wiki .The values used for the extraction of green areas are located in different keys that were defined in Ludwig's research [48]:

Table 5. Key values for UGS classification.

Key	Value
amenity	graveyard
landuse	allotments, cemetery, farmland, forest, grass, greenfield, meadow, orchard, recreation_ground, village_green, vineyard
leisure	garden, golf_course, nature_reserve, park, pitch
natural	Wood, scrub, heath, grassland, wetland

CHAPTER 4

DOCUMENTATION AND QUANTIFICATION

4.1 NDVI Method

The steps taken to generate the urban green cover of Tirana based on NDVI (Normalized Difference Vegetation Index) were to first download a satellite imagery from the website of Europe Space Agency. In this study where used Sentinel-2 imagery as it has a high resolution of 10 m. The date selected was that of April 23rd 2023 as a day with a good weather and clear sky necessary for accurate results. The bands needed in Sentinel-2 imagery for NDVI calculation are Band 4 and Band 8. Applying the formula on the raster calculator in QGIS a comprehensive NDVI raster layer was produced and then classified in ranges; -1-0: 0, 0-0.1:1, 0.1-0.25:2, 0.25-0.4: 3, 0.4-1:4, that were each represented in a color ram from not vegetated at all to vegetated, this way visualizing better the spatial distribution of the vegetation *(Figure 13)*.

In order to use this data in the statistical analysis regarding the vegetation in the city and in each municipal unit, using the raster calculator values higher than 0.25 were selected only. This raster was then clipped to the city boundary and turned into a vector layer with values 0 for not vegetated and 1 for vegetated *(Figure 14)*. With the below Python Console script only the values 1 were saved while the 0 were deleted.

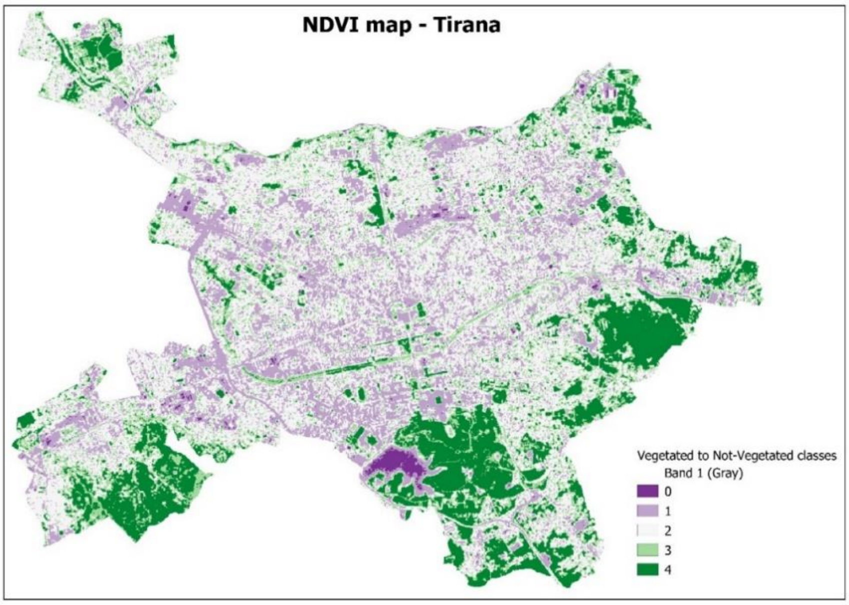


Figure 13. NDVI classified.

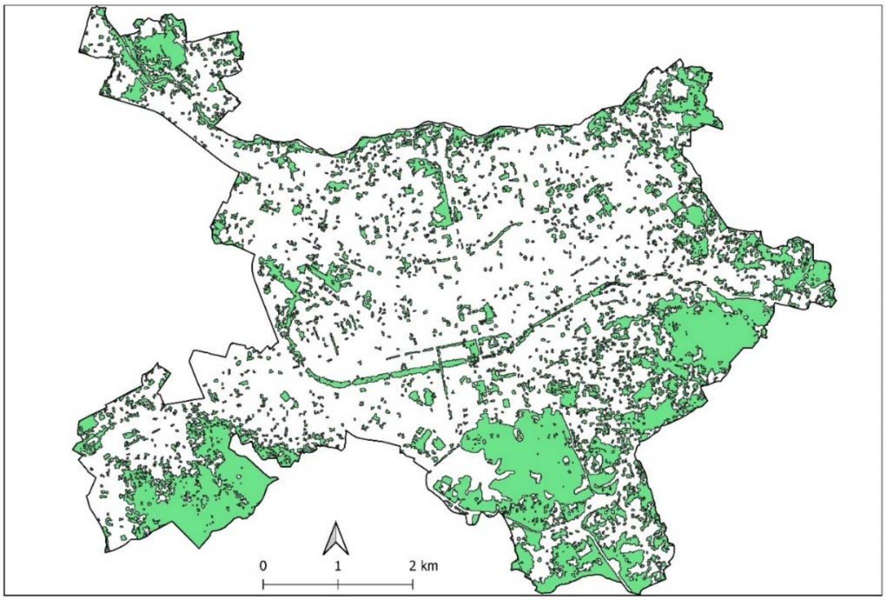


Figure 14. Green spaces extracted from NDVI.

layers = QgsProject.instance().mapLayersByName('raster to vector')

#print(layers)

layer = layers[0]

caps = layer.dataProvider().capabilities()

```
feats = layer.getFeatures()

dfeats = []

if caps & QgsVectorDataProvider.DeleteFeatures:

    for feat in feats:

        if feat['DN'] == 0:

            dfeats.append(feat.id())

    res = layer.dataProvider().deleteFeatures(dfeats)
```

Later using the select features by attributes table command was used to select only the polygons with areas bigger than 500 m^2, based on similar study that had done the same only with a bigger area due to the contextual factors [51]. After cleaning up the green cover polygon layer, zonal statistics were run for each municipal unit to whom were assigned the green areas geographically corresponded to them. This way data is extracted specifically, from the area of green cover in the urban boundary of the city as well as in each municipal unit. From these were extracted the percentages covered in vegetation compared to the city and to each zone. Other statistical calculations were produced regarding the amount of vegetation per capita of the city and to each municipal zone. There results can be seen in Table, where they area compared with the results from the Manual + OSM method.

4.2 OSM + Manual method

4.2.1 Categorization and classification

Due to there not being any available data in Tirana that show the availability of all the urban green spaces of the city, it was seen as necessary to produce a map with all the urban green spaces that are open to the public as well as make thematic categorizations of them. These thematic maps would be helpful in other stages of accessibility assessment. The suggested scheme in ***(**Figure 15**)***, provides a framework for categorizing and organizing these areas based on various criteria or features, defining the classification points for urban green spaces.

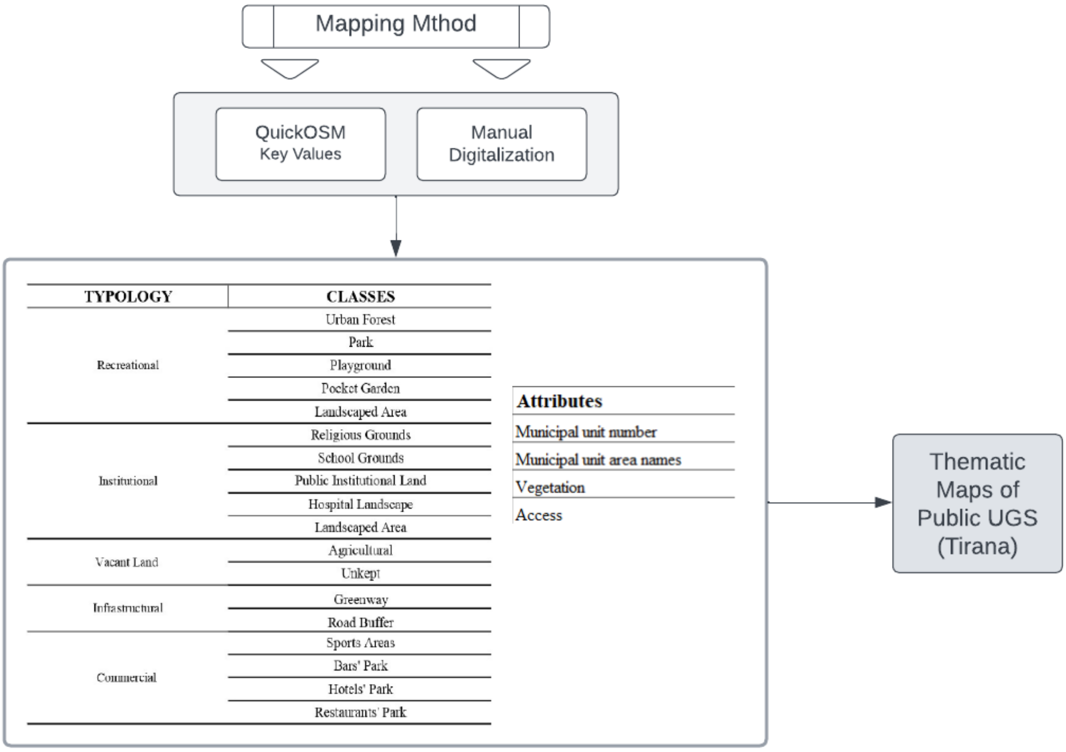


Figure 15. Scheme displaying the categorization basis.

First the green spaces where just manually selected and identified by a unique ID that corresponded in number with the municipal area that the UGS was located for ease of classification later ***(Figure 16.*** Green spaces extracted from Manual method + OSM *Figure* ***16.*** Green spaces extracted from Manual method + OSM. Later the polygons from the keys mentioned in *Table 5.* Key values for UGS classification.were downloaded from QuickOSM and then proceeded with a comparative analysis where polygons were added to the manual public UGS database. Lastly the extracted polygons where all classified based on the classes and typologies of *Table 6.*

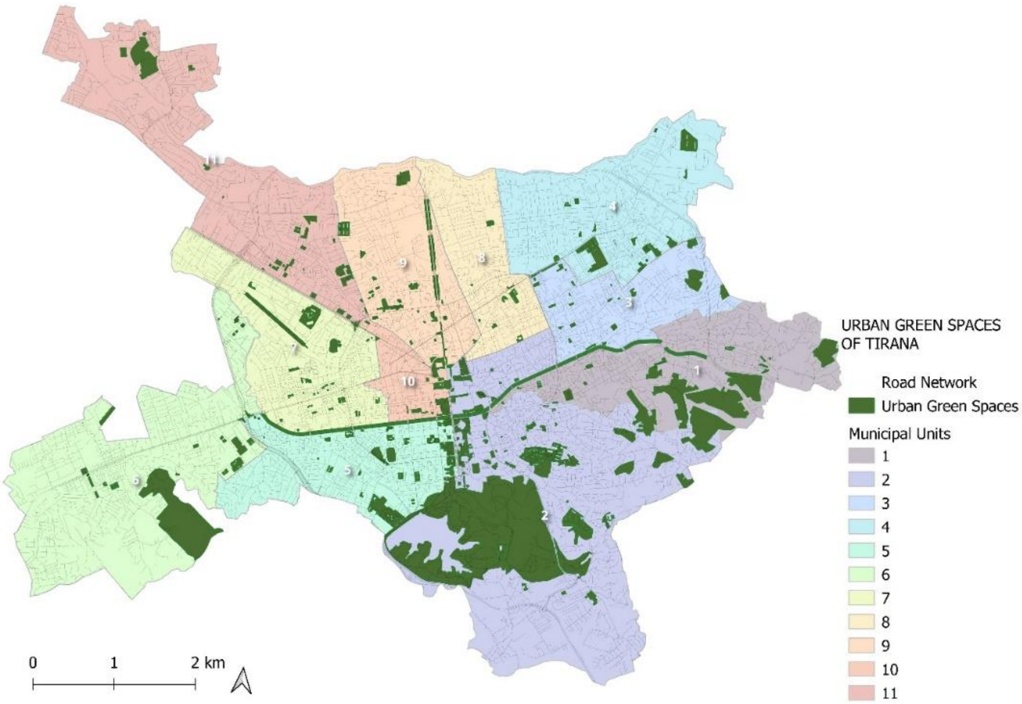


Figure 16. Green spaces extracted from Manual method + OSM

Table 6. The UGS typologies and classes used in the thematic maps

TYPOLOGY	CLASSES	DESCRIPTION
Recreational	Urban Forest	Aimed recretional spaces that are planned and taken care of.
	Park	
	Playground	
	Pocket Garden	
	Landscaped Area	
Institutional	Religious Grounds	Maintained UGS but with limited or targeted access to a group of individuals
	School Grounds	
	Public Institutional Land	
	Hospital Landscape	
	Landscaped Area	
Vacant Land	Agricultural	Currently unmaintained UGS plots of land, subjected to change potential for UGS
	Unkept	
Infrastructural	Greenway	Part of the built infrastructure offer some recreational value but primary function is not to offer dedicated spaces for active engagement
	Road Buffer	
Commercial	Sports Areas	UGS developed for commercial or business-oriented purpose. Accessible but limited to payment
	Bar's Park	
	Hotel's Park	
	Restaurant's Park	

Additionally, to the categorization based on typologies and classes on the polygons representing UGS, additional attributes were added based on observations from field work as well as from supportive imagery from Google Satellite and Asig Orthophoto of Tirana. The attributes assigned are explained in ***Table 7.*** The UGS attributes..

Table 7. The UGS attributes.

Attributes	
Municipal unit number	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Municipal unit area names	1. Ali Demi
	2. Qyteti Studenti, Sauku
	3. Brryli, Xhamlliku
	4. Kinostudio, Babrru, Allias
	5. Blloku, Selita, Tirana e Re
	6. Kombinati, Yzberisht
	7. 21 Dhjetori, Ish-Fusha e Aviacionit
	8. Selvia, Medreseja e Tiranës
	9. Lagja e Trenit, Brraka, Don Bosko (part)
	10. Central Tirana
	11. Lapraka, Instituti, Don Bosko (part)
Vegetation	Course (medium-high)
	Spare (low-medium)- manicured
	Scrub (low)- peripheral
Access	Open-Public
	Limited- Semi-Public
	Targeted- Semi-Private

4.2.2 Site visit photo classification

A lot of site visits were conducted for this research in order to find the main qualities in which the classification of the UGS was going to be conducted as seen in the images of *(Figure 17).*

RECREATIONAL

Ismail Qemali – Park | Park Kinostudio | Playground- SHALLVARET



INSTITUTIONAL

Kryeministria | Police Directorate | Religious grounds landscape



Public institutional landscape | Landscaped area Public institutional | Religious Land

Vacant land | Infrastructural | Commercial



Unused potential space | Greenway | Pocket garden 1 May

Figure 17. Illustrative images of all the typologies of UGS in Tirana

4.3 Comparative analysis between NDVI and OSM + Manual Method results

The comparative analysis reveals substantial differences between Tirana's green cover and urban green space areas. 11 680 319.71 m2 (11 km2) is the total area of green cover extracted from the NDVI analysis, indicating the extent of all types of green spaces in the city. The area of urban green spaces determined by manual extraction and OSM data is 4,371,817 m2 (km2), which represents the portion of publicly accessible green areas.

Examining the proportion of green cover to municipal unit area reveals that 29% of Tirana's total area is covered by vegetation. Nevertheless, the ratio of urban green spaces to municipal unit area is lower, at 11%. This disparity is to be expected due to the fact that urban green space calculations emphasize only publicly accessible areas. Another thing to be noted is that even though the green cover area is 29% the distribution of greenery is uneven and heterogeneous. As seen in the Table A2 in the appendix the green cover area varies in each of the zones from very high percentages to lower insignificant ones in others.

The green space per capita ratio is determined by dividing these values by the population of the city and each municipal zone. The ratio of green cover to population in a city is 21,32 m2 per person, indicating the average amount of green space available to each person. Compared to the ratio of urban green spaces to population, which is 7.98 m2 per person, we observe a decrease in the availability of green areas that are open to the public.

Examining the values of each municipal zone through *(Figure 18)*, reveals the distribution and accessibility of green spaces in Tirana. Zone 2 has the highest proportion of green cover to municipal unit area, at 45%, as well as the highest proportion of urban green spaces, at 23%. This indicates that Zone 2 contains a greater proportion of green spaces relative to its total area due to the Lake of Tirana and the urban forest surrounding it being located here.

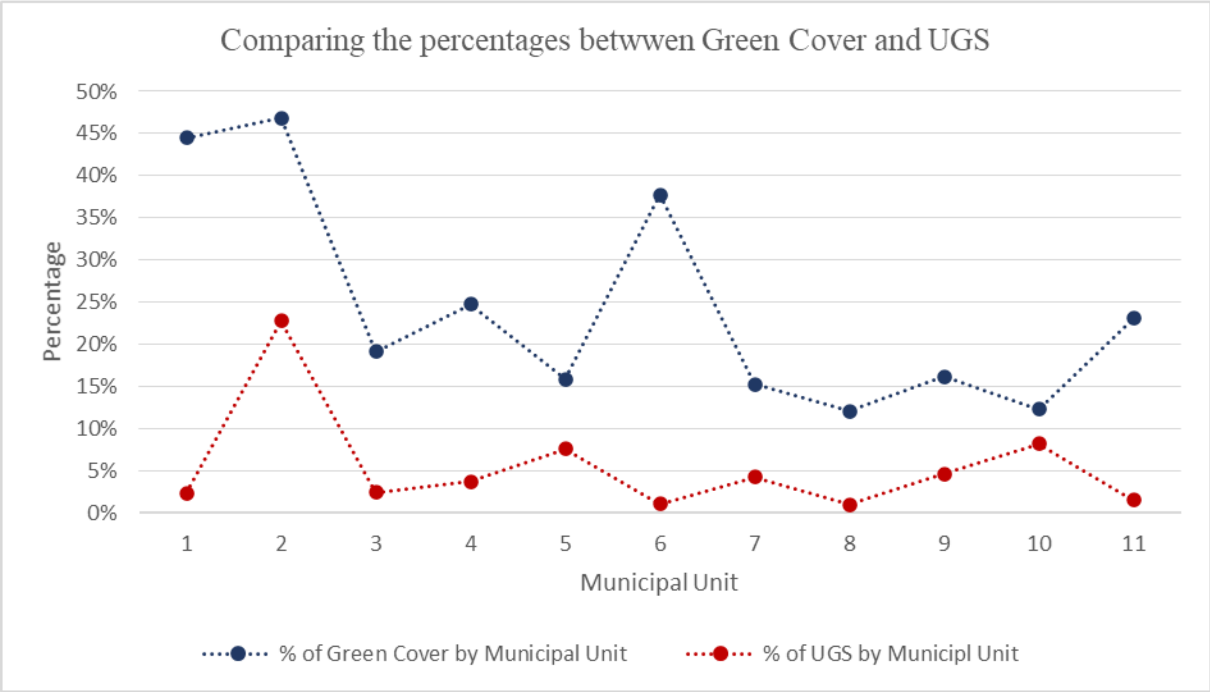


Figure 18. Comparing the percentages between Green cover and UGS

Zone 8 has the lowest proportion of green cover to municipal unit area (11%), as well as the lowest proportion of urban green spaces to municipal unit area (1%). It was quiet difficult to extract public green spaces from zone 8, where most of the ones extracted where the school courtyards. This indicates that there are fewer public green spaces in this zone relative to its total area.

Analyzing the ratio of green space per capita for each zone in *(Figure 19)*, we find that Zone 2 has the highest ratio at 58.76 m2 per person, indicating that its population has access to relatively more green spaces. In contrast, Zone 6 has the lowest ratio at 35.23 m2 per person, indicating that its residents have less access to publicly accessible green spaces. Interestingly enough Zone 6 has one of the biggest green covers compared to the other zones but most of it is agricultural land in the sub urban edges.

Overall, the comparative analysis reveals variations in Tirana's green space distribution and accessibility. While the green cover analysis indicates the extent of greenery in the city as a whole, the urban green space analysis focuses on areas that are open to the public. The disparities between the two measures and the variations in the green space per capita ratio between zones demonstrate the necessity of assessing the distribution and availability of urban green spaces to ensure equitable access and promote a sustainable urban environment.

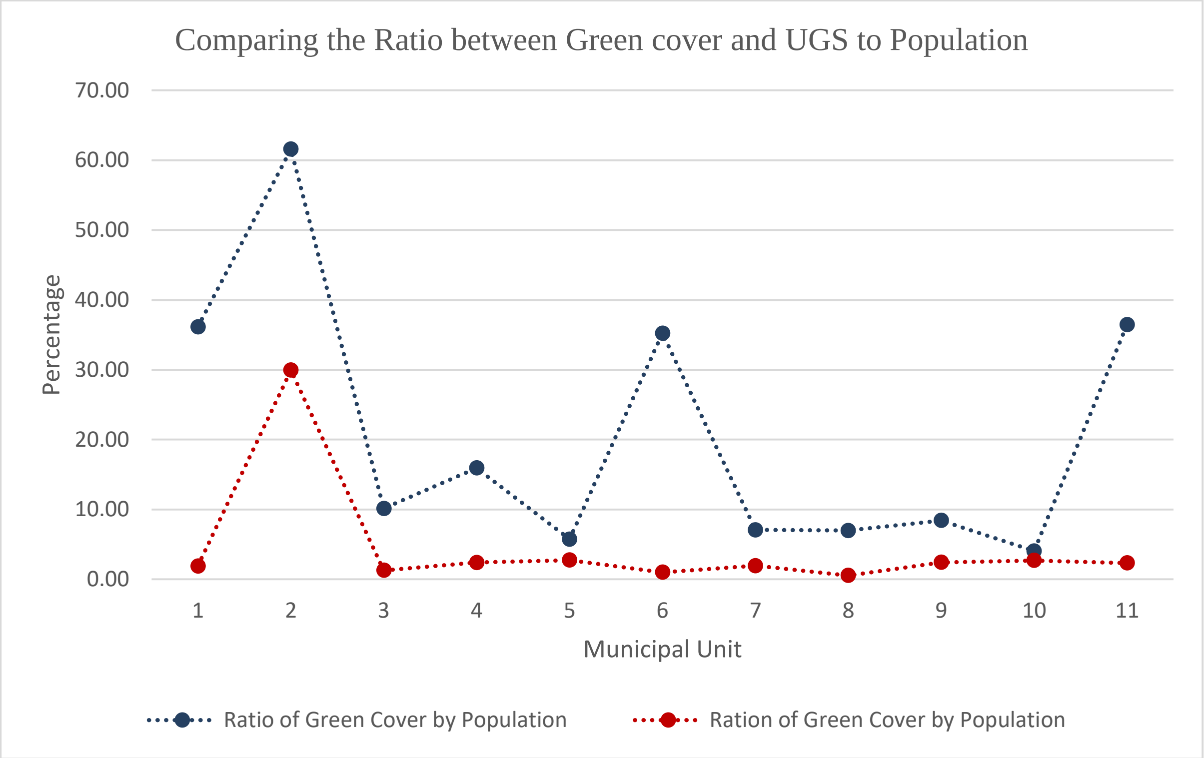


Figure 19. Comparing the Ratio between Green cover and UGS to population

4.4 Thematic Documentation

4.4.1 UGS Classification based on typology

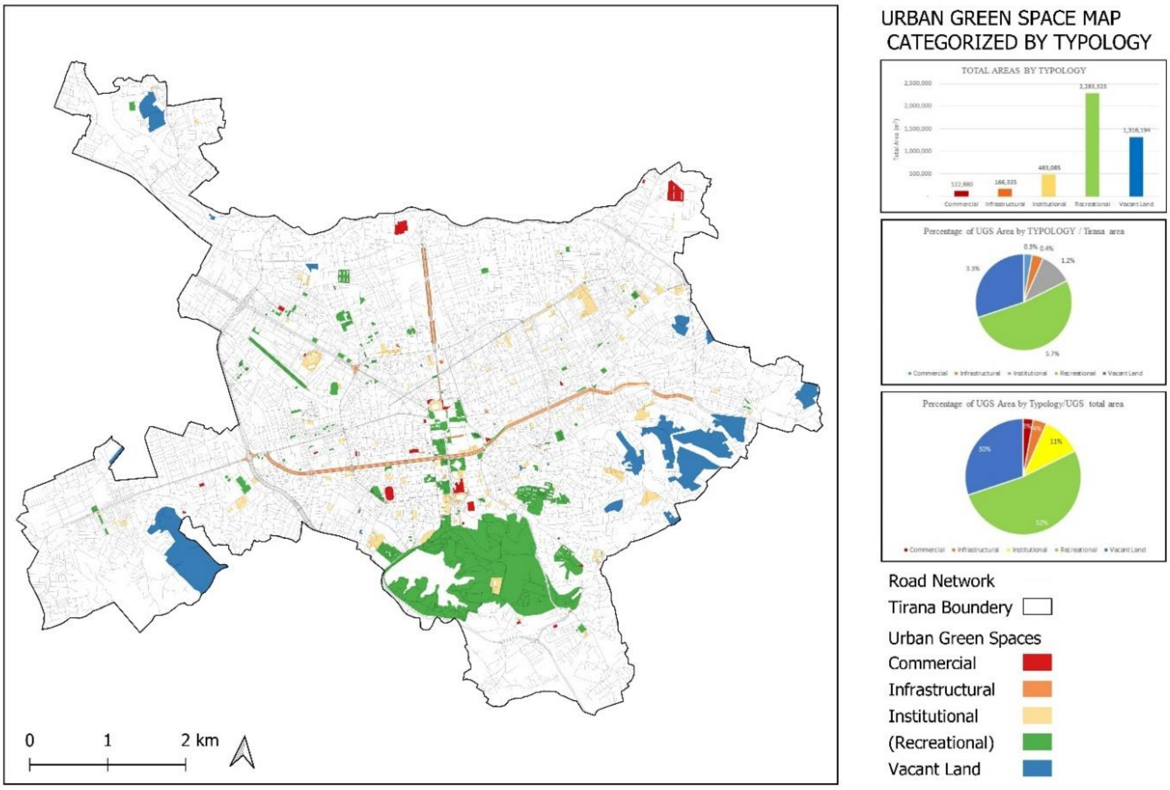


Figure 20. UGS classification based on typology

The presented information in *(Figure 20)*, presenting an analysis of Tirana's public urban green space typologies reveals important information about their distribution and characteristics. These results can be linked to the core function of these areas, which is to provide the general public with accessible and entertaining environments. Recreational areas stand out among the listed categories as being the most significant because they make up a sizeable fraction of the entire urban green space. This can be attributed to the fact that from the listed typologies, recreational areas have the highest probability to be public. Particularly, recreational grounds cover an area of around 2,283,323 square meters, or about 5.7% of Tirana's total size, and make up a sizable chunk of the city's network of green spaces.

In contrast, the urban green space contains a relatively small amount of land set aside for commercial purposes. Based on the categorization only 122,880 square meters of Tirana's total area are devoted to commercial space, which accounts for 3% of the city's network of green areas and only 0.3% of the entire area. The primary goal of commercial places, which often foster commercial private activity over public accessibility, can be used to explain this gap.

Another significant category is institutional areas, which have a total land area of about 483,085 square meters. This accounts for 11% of the network of urban green spaces and roughly 1.2% of Tirana's total land area. Institutional places, such as government structures, educational institutions, healthcare facilities, and other public amenities, frequently perform specialized public tasks. These locations aid in enhancing the general public's access to and use of urban green spaces.

Attention should also be paid to the integration of infrastructure-based urban green areas. According to the analysis, infrastructure areas take up about 166,335 square meters of land, or 0.4% of Tirana's overall area and 4% of the city's network of green spaces. It is important to emphasize that only those infrastructure spaces that provide somewhat active functions for people are included in this study's classification of infrastructure spaces. Greenways and pedestrian-friendly road buffers are examples of this. However, areas that are primarily intended for traffic separation, like those near highways where pedestrian circulation is constrained, are not taken into account within this classification. Because of the emphasis on integrating urban green spaces that promote public use and mobility, the share of infrastructure areas within the network of urban green spaces continues to be relatively modest.

Furthermore, it is important to recognize the substantial representation of vacant land in the typologies of urban green spaces. A sizeable land area of about 1,316,194 square meters is taken up by vacant land, which includes both neglected and abandoned parts inside the city as well as green agricultural zones on the periphery undergoing suburban transition that increase the numbers of this category significantly. This group makes up 30% of the network of urban green spaces and approximately 3.3% of the total area of Tirana.

In conclusion, based on the presented data, an analysis of the types of public urban green spaces in Tirana indicates various distributions that are influenced by their intended public nature. Recreational places and institutional areas stand out as important categories, taking up a sizable share of the network of urban green spaces. Commercial urban green spaces that offer public service are far less noticeable, stressing commercial activity over accessible for the general public. Infrastructure spaces are just those that allow for some limited active services for people, whereas vacant land includes abandoned urban areas and rural green spaces undergoing suburban development.

4.4.2 UGS Classification based on classes

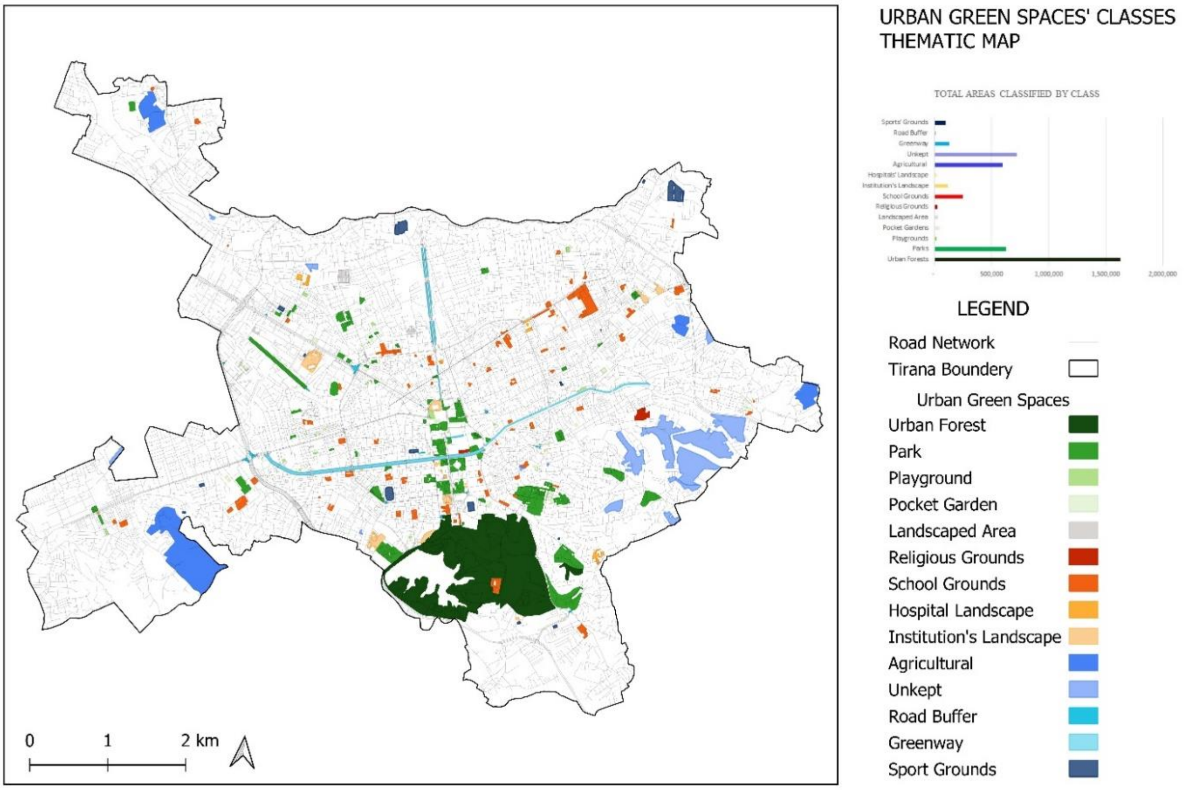


Figure 21. UGS classification based on classes.

Interesting trends in the distribution and make-up of Tirana's urban green areas are revealed through class-based study of the city's green spaces as seen in *(Figure 21)*. Urban forest stood out among the recognized classifications as the dominating category, taking up a sizable amount of land space—roughly 1,630,968 square meters. This makes up a sizeable section of the network of urban green spaces and amounts to about 4.07% of Tirana's total land area. It is important to note that the urban forest contributes significantly to the part of the city located in the Lake of Tirana area as a zone with a significant difference of green area compared to the others.

As compared to Tirana's overall area and the network of urban green spaces, the distribution of different types of green space shows a more varied range of percentages. Another noteworthy category is parks, which have a total land area of about 628,545 square meters. This accounts up roughly 1.57% of Tirana's total area and makes up 14.4% of the city's network of green spaces. Similar to this, different percentages of the network of urban green spaces are taken up by playgrounds, pocket gardens, manicured areas, institutional landscapes, hospital landscapes, agricultural regions, unkempt spaces, greenways, traffic buffers, and sports fields.

It's crucial to remember that while some classes, like urban forests and parks, contribute significantly to the network of urban green spaces overall, other classes have proportionally lesser percentages. For instance, less than 1% of Tirana's total area is occupied by playgrounds, pocket gardens, landscaped areas, religious grounds, hospital grounds, and road buffers, which together make up less than 3% of the city's network of green spaces. These groups represent more modest but yet important parts of the city's public urban green spaces.

Additionally, the existence of agricultural lands inside the network of urban green spaces is noteworthy as they occupy a total land area of about 596,223 square meters. This group makes up roughly 13.6% of the network of urban green spaces and accounts for about 1.49% of Tirana's total land area. The inclusion of agricultural spaces emphasizes how natural and productive landscapes are blended with green and agricultural aspects inside the city's urban fabric.

In conclusion, the analysis of Tirana's green spaces, categorized by class, emphasizes the dominance of urban forests within the network of urban green spaces, which are mostly centered around the Lake of Tirana area. The remaining classifications of green space show a wide range of percentages, which reflects the city's uneven distribution of public urban green spaces. While some types—like parks and agricultural areas—contribute greatly to the network of urban green spaces, others are less prominent but nevertheless significant.

4.4.3 UGS Classification based on vegetation

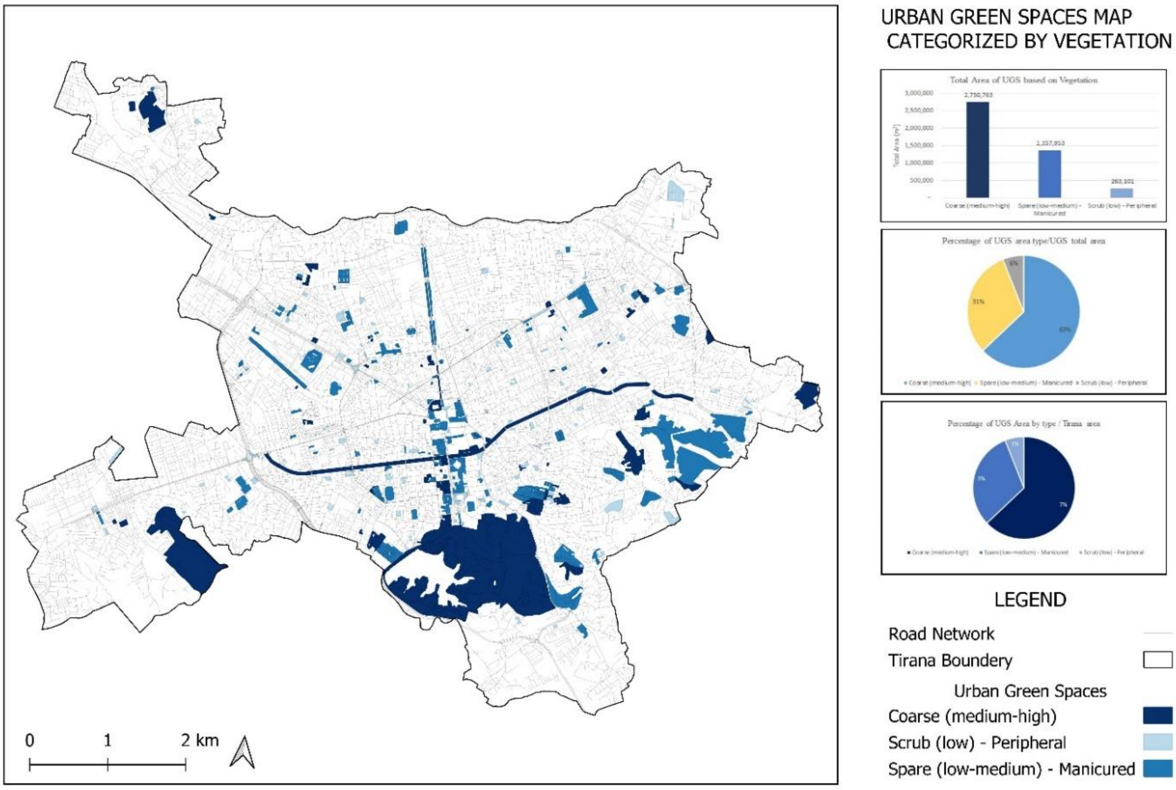


Figure 22. UGS classification based on vegetation.

The distribution and characteristics of greenery within the city are revealed by the examination of Tirana's vegetation states *(Figure 22).* With a sizeable area of around 2,750,763 square meters, coarse (medium-high) vegetation stands out as the main category among the varieties of vegetation that have been discovered. This makes up a sizeable section of the network of urban green spaces and equates to about 7% of Tirana's total land area. The urban forest in the east side of the city, which corresponds to municipal unit number 2, as well as the agricultural lands in municipal units six and eleven, are notable examples of where coarse greenery is concentrated.

In comparison, sparse (low-medium) manicured vegetation covers 1,357,953 square meters of land, or around 3% of the total area of Tirana. This kind of vegetation is mainly found along the city's axis, especially along Bulevardi Nene Tereza and in the central part of the city. With a higher standard of maintenance and aesthetically pleasing landscaping, these manicured green spaces present a well-maintained appearance.

A further 263,101 square meters, or around 1% of Tirana's total area, are covered with scrub (low) vegetation, which is mainly found in the city's periphery. These places have lower levels of greenery and are sometimes characterized by naturally occurring vegetation that requires little upkeep and has a more untamed or wild appearance.

Different reasons may be to blame for the changes in vegetation type percentages. The presence of landscaped areas with less vegetation may account for the lower values of greenery in some regions, especially those close to residential areas. These locations frequently focus on paved paths, benches, or other features rather than substantial greenery because they are intended to act as utilitarian or recreational areas for locals.

Another key factor is the decreased amount of vegetation in schools, especially following rehabilitation operations. Even though these renovations might have enhanced the structures and infrastructure, they might also have reduced the amount of vegetation compared to how it was before. Space restrictions or architectural decisions that place more emphasis on other elements of the school environment may be to blame for this decline.

In conclusion, Tirana has a broad distribution of greenery throughout the city, according to the examination of plant types in the area. The middle axis is characterized by sparsely maintained greenery, whereas scrub vegetation is more common in the periphery. Coarse vegetation predominates in some areas, such as the urban forest and agricultural zones. Due to space constraints, design decisions, and trade-offs between practical and aesthetic considerations, greenery values are lower in some areas, such as residential areas and schools.

4.4.4 UGS Classification based on access

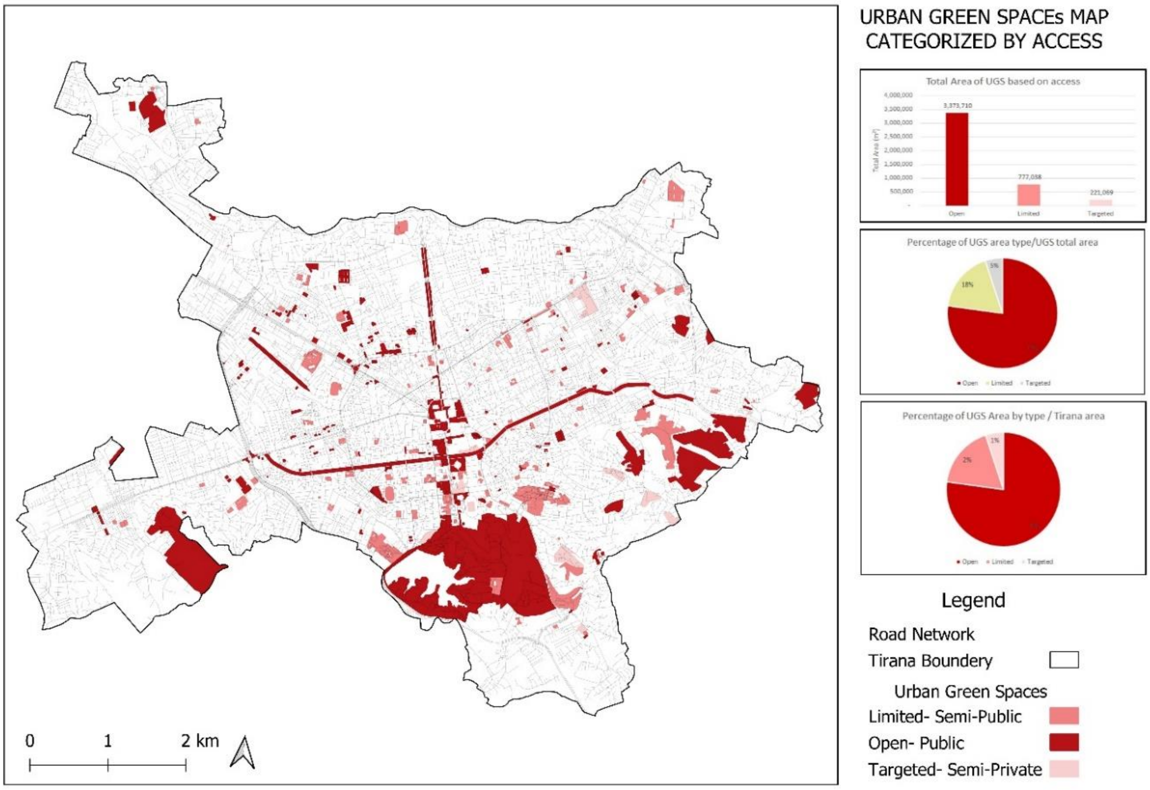


Figure 23. UGS classification based on access.

The analysis of access types in Tirana *(Figure 23)*, sheds light on the distribution and characteristics of public spaces within the city. It is important to remember that this study only examines public locations; it does not include private areas like backyards or homes with no apparent public or service use. There are, however, some types of spaces that are included, such as commercial locations that charge a price for entry, such as sports facilities, hotels, bars, and restaurants, as well as green spaces and theme parks.

The abovementioned classes are included in the limited, Semi- Public category. "Limited" access is one of the categories found in the examination; it covers an area of roughly 777,038 square meters, or about 2% of Tirana's total area. Part of these areas were also considered playgrounds of certain schools that had an appropriate amount of vegetation. They cater to a particular population like students in schools and have limited access. often cater to particular populations, such as students in schools or other institutions with rigorous access requirements. They are characterized by restricted access which accounts for the lower total percentage.

The category of "targeted" access was also noted; it has an area of about 221,069 square meters, or about 1% of Tirana's total area. These areas are particularly specific and have strict access rules. Some examples representing this are the embassies, the Tirana Sewage Water Deposits, institutions like The Guard of Tirana, or gated neighborhoods are a few examples of places with strict admission requirements. The vegetation size and importance of these locations in the urban environment justifies their inclusion in the study even when they are designed for a specific audience or have targeted access.

The majority of the access categories are "open" areas, which cover a total area of about 3,373,710 square meters and account for about 8% of Tirana's total area. There are no significant limits placed on these areas, and they are open to everyone. They include open-access parks, playgrounds, pocket gardens, forests and any recreational space with open access.

In conclusion, Tirana has a diversified distribution of public areas with various accessibility levels, according to the analysis of access types. The absence of private spaces concentrates the study on public spaces, such as fee-based commercial spaces, places with restricted access, like schools, and spaces with targeted access that have certain admission requirements.

CHAPTER 5

SERVICE AREA ANALYSIS

5.1 Network Analysis based on time and distance

The whole point of Network Analysis is to provide context around the element that interests us and play with the scales of analysis to avoid being locked in only one dimension of our object.

The accessibility analysis of this paper was conducted in the form of service areas or isochrones. To do that was used the QGIS plug-in QNET3 as it offers analysis like: shortest path, OD Matrix and, isochrones areas. In the case of service area analysis done in this research, the necessary parameters that need to be put were, as also seen in ***Table 8***:
The road network layer was extracted from the QuickOSM TOOL. Later after the categorization into thematic maps it was decided that for the study of accessibility to be used only the recreational classes of: playgrounds, pocket gardens, parks and urban forest based on the literature read where this where always considered the openly public spaces as seen in *(Figure 24).*

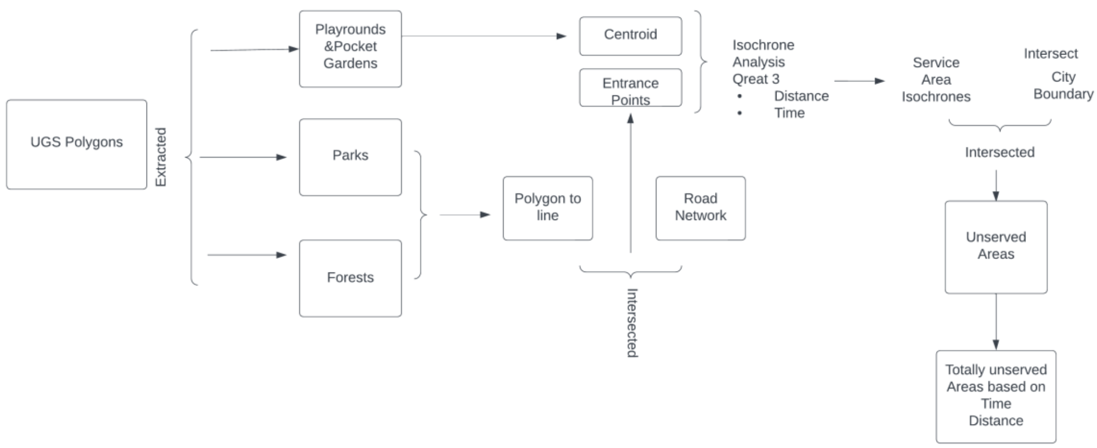


Figure 24. Service area analysis workflow

As mentioned, to conduct the analysis there was the need for a layer with the points of facility as the origin (in this case are the urban green spaces) and the road network. The points were derived by first turning the polygons of the urban green areas in line shapefiles so that they would be intersected with the road network shapefile. Doing these the park entrances were produced. This method was one for the parks layer and the urban forest layer. For the playgrounds and pocket gardens layer, the centroids of the polygons were taken as their areas is so small that it wouldn’t cause any difference.

Table 8. Mandatory parameters for QNEAT 3

Mandatory Parameters	Type	Info
Network Layer	Vector Layer	Geometry type must be LineString
Start Point Layer	Vector Layer	Geometry must be Point
Size of Iso-Area	user input	dep. on strategy: max. distance / max. time(sec)
Contour interval (distance or time value)	user input	dep. on strategy: max. distance / max. time(sec), determines number of contours in output.
Cell Size	user input	set higher for faster but more inacurate results
Optimization Criterion	Shortest | Fastest	-
Interpolation Layer	Output Raster Layer	optional
Polygon Layer	Output Vector Layer	-

Two key scenarios can be taken into account in service area isochrone analysis QNEAT3 in QGIS: analyzing based on time traveled and analyzing based on distance traveled. Both scenarios offer important information on the reachability and coverage of urban green spaces as starting points.

The benefit of doing analysis based on the distance walked is that you can comprehend the temporal component of accessibility. You can distinguish between regions that can be reached in a certain amount of time by producing isochrones based on time. This scenario takes into account variables including traffic conditions, modes of transportation, and preferred journey times. In this study no traffic conditions or movement limitations were considered but the mode of transportation was set to pedestrian and the journey times were set based on the hierarchical level of UGS.

Analyzing accessibility based on distance traveled, on the other hand, concentrates on the spatial aspect of accessibility. You can identify regions that are within a specific distance from the urban green zones by producing isochrones based on distance. This hypothetical situation considers physical proximity and might be more beneficial to get a better picture of the actual possible traveled distance.

Urban green area accessibility is better understood when both time traveled and distance traveled scenarios are taken into account in the service area isochrone analysis. In order to ensure fair access for a wider range of people, it helps us select regions that are both temporally and spatially well-connected to the natural spaces.

As seen on ***Table 9***, the analysis carried out in this study used a thorough methodology based on time and distance traveled to assess the accessibility of urban green spaces. The purpose of this study was to take into account the various traits and user types connected to various kinds of green spaces. For the analysis, three different scenarios were created: one for parks and playgrounds, one for pocket gardens and playgrounds, and one for urban forests.

Table 9. Scenarios for the analysis.

Based on time	**Based on distance**
Playgrounds and Pocket Gardens:	Playgrounds and Pocket Gardens:
15 min catchment area	300 m catchment area
5 min intervals	100 m intervals
Speed: 4km/h	Speed: 4km/h
Parks:	Parks:
20 min catchment area	600 m catchment area
5 min intervals	200 m intervals
Speed: 5km/h	Speed: 5km/h
Urban forest:	Urban forest:
30 min catchment area	1000 m catchment area
5 min intervals	200 m intervals
Speed: 5km/h	Speed: 5km/h

According to the distinct walking preferences and abilities of various user groups, various walking speeds were taken into consideration. As this is the typical speed seen among children and seniors who frequently use parks and playgrounds, a walking speed of 4 km/h was taken into account for these areas. The choice of this speed takes into account the close proximity of these green spaces to residential neighborhoods as well as the limited mobility of children and the elderly, who might not be able to travel long distances by themselves.

In order to account for the fact that the impact and reach of urban green spaces vary depending on their hierarchical level, the analysis also included various catchment areas for each scenario. Because of their localized nature and intended use by neighbors, playgrounds and pocket gardens had smaller catchment areas. Because they were larger and offered more amenities, parks had larger catchment areas, which helped to account for their greater accessibility. In recognition of its unique place in the network of urban green spaces, the urban forest, which is distinguished by its vast size and ecological significance, was linked to an even larger catchment area.

5.2 Network Analysis based on time Maps

5.2.1 Playground and Pocket Gardens

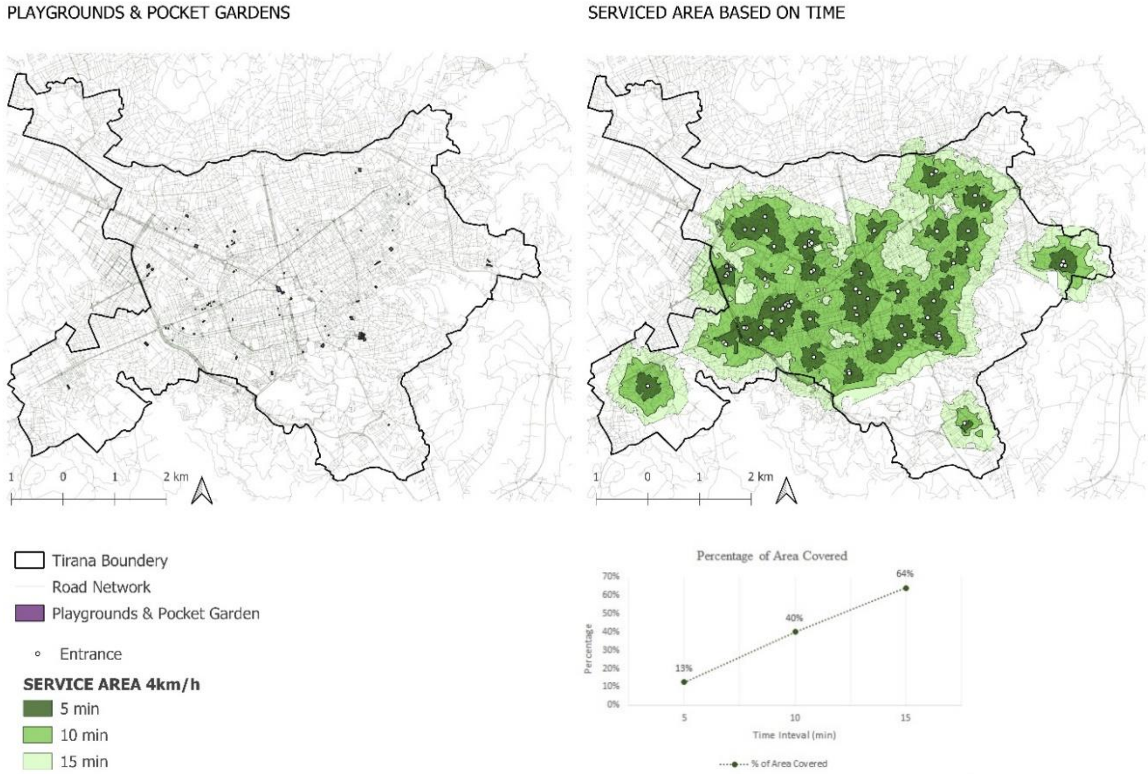


Figure 25. Playground and Pocket Gardens

To determine the size of the area occupied by these green spaces, the analysis took into account various time intervals, ranging from 5 to 15 minutes *(Figure 25)*.

The serviced area at the 5-minute interval makes up 13% of Tirana's total area. This shows that, in terms of playgrounds and pocket gardens, a modest amount of city area is served by this UGS to residents within a quick 5-minute walk, considering the fact that this type of UGS area supposed to be very close to residents.

The coverage significantly increased to approximately 16,031,966 square meters as the time interval increased to 10 minutes. This made up 40% of Tirana's total area, showing a significant improvement in the serviceability of these green spaces within a little bit longer walking distance.

The analysis also showed that the serviced area increased and now covered about 25,634,092 square meters at the 15-minute time interval. This made up an astounding 64% of Tirana's total area. These results emphasize the value of playgrounds and small gardens in giving Tirana residents access to green spaces. It would be more appropriate if the higher value of coverage corresponded to a smaller catchment area considering the small size of pocket gardens and playgrounds wouldn't make it suitable to travel a long time for a lot of people. The areas showing a mostly connected serviceability correspond s to the west areas of 21 Dhjetori, Tirane e Re and Blloku, central Tirana and the areas on the upper North-East of Brruli and Kinostudio. The ones that are not served by any playgrounds and pocket gardens are on the edges of the city boundary.

5.2.2 Parks

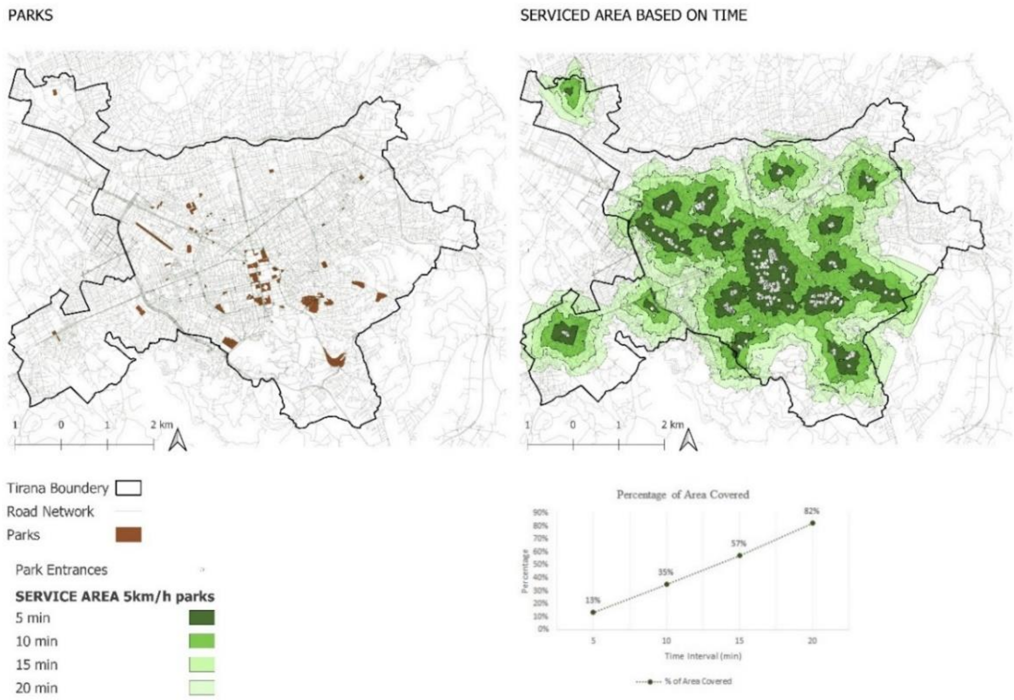


Figure 26. Service area for parks based on time.

The next type of urban green spaces that were used for the analysis are parks, *(Figure 26)*. The isochrones show that the area of the city that can be reached within 5 km/h walking speed grows as the time interval does.

It is clear from the specific results that the city's center and the Lapraka neighborhood have the best-connected coverage of parks' service area. The findings show that within a 15-minute walk, about 57% of the city is covered, and within a 20-minute walk, this coverage rises to 82%. These statistics show how important parks are in providing Tirana residents with accessible green spaces. The isochrone analysis based on time traveled concludes that parks in Tirana occupy a sizable portion of the city and provide residents with easily accessible green spaces at least in the biggest part of the city's area.

5.2.3 Urban Forest

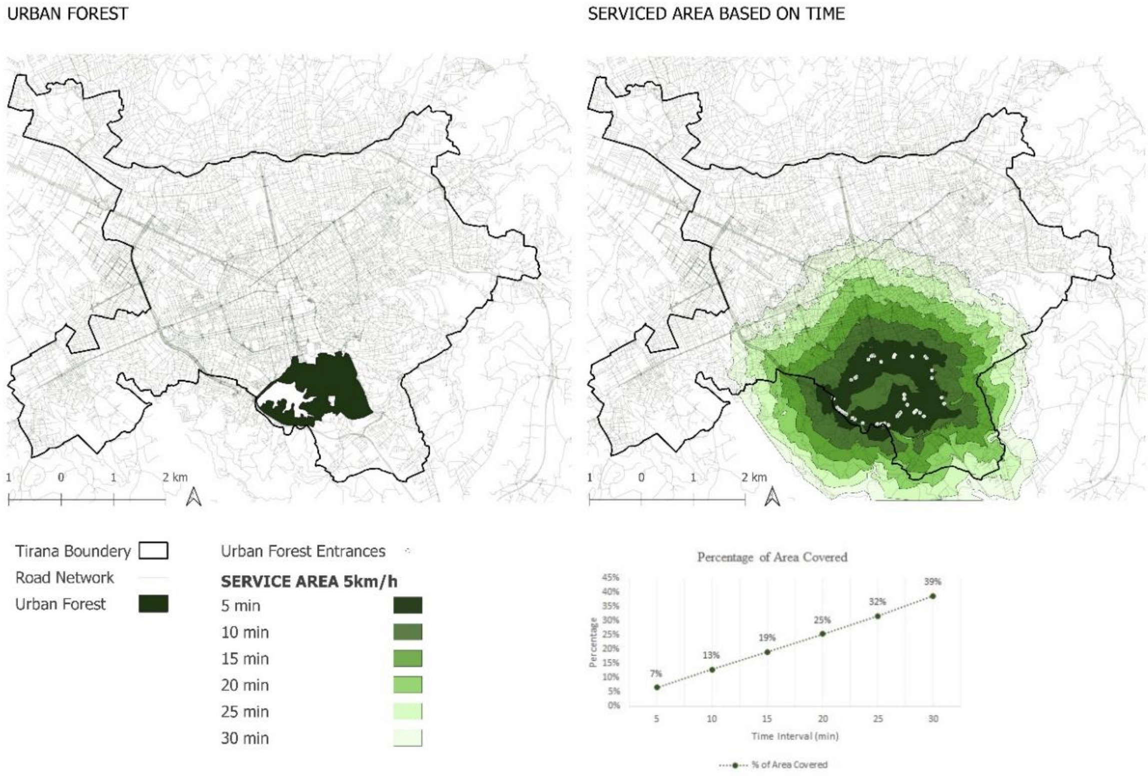


Figure 27. Service area for urban forest based on time.

The last time based, service area analysis was done of the urban forest located on the Artificial Lake of Tirana, *(Figure 27).* The results show that a larger portion of the city is covered within the catchment area of the urban forest isochrones as the time interval increases.

According to the analysis, the urban forest makes up about 7% of the Tirana area within a 5-minute walk. Within a 30-minute walk, this coverage increases gradually, reaching 39%. These findings show how the urban forest significantly contributes to giving city residents a sizeable and accessible green space.

The urban forest isochrones larger catchment area than other green areas is assigned due to its size and significance to the environment. The urban forest draws residents who are willing to travel further distances because it provides a distinctive natural setting and recreational opportunities. The urban forest's value and significance within the city's green infrastructure are highlighted by the fact that people are willing to spend more time traveling to access it.

However, it is important to take into account where comparable urban green spaces are located in other areas of the city. Although the urban forest is easily accessible, it comfortably encloses the eastern portion of Tirana, including the city's center, the Blloku neighborhood in the west, and the Qyteti Studenti neighborhood in the east. Beyond these distances, it is more likely that visitors will need to use personal vehicles, like cars, to access the urban forest. A wider range of city residents would benefit from similar environmental advantages and recreational opportunities if additional urban green spaces were established in other parts of the city.

The isochrones analysis results highlight Tirana's extensive urban forest coverage, in conclusion. The urban forest is a significant green space that draws people from all over the city. Although its wide catchment area reflects its size and significance, the creation of comparable green spaces in other locations would improve accessibility and encourage fair access to nature for all Tirana residents.

5.3 Network Analysis based on distance Maps

5.3.1 Playground and Pocket Gardens

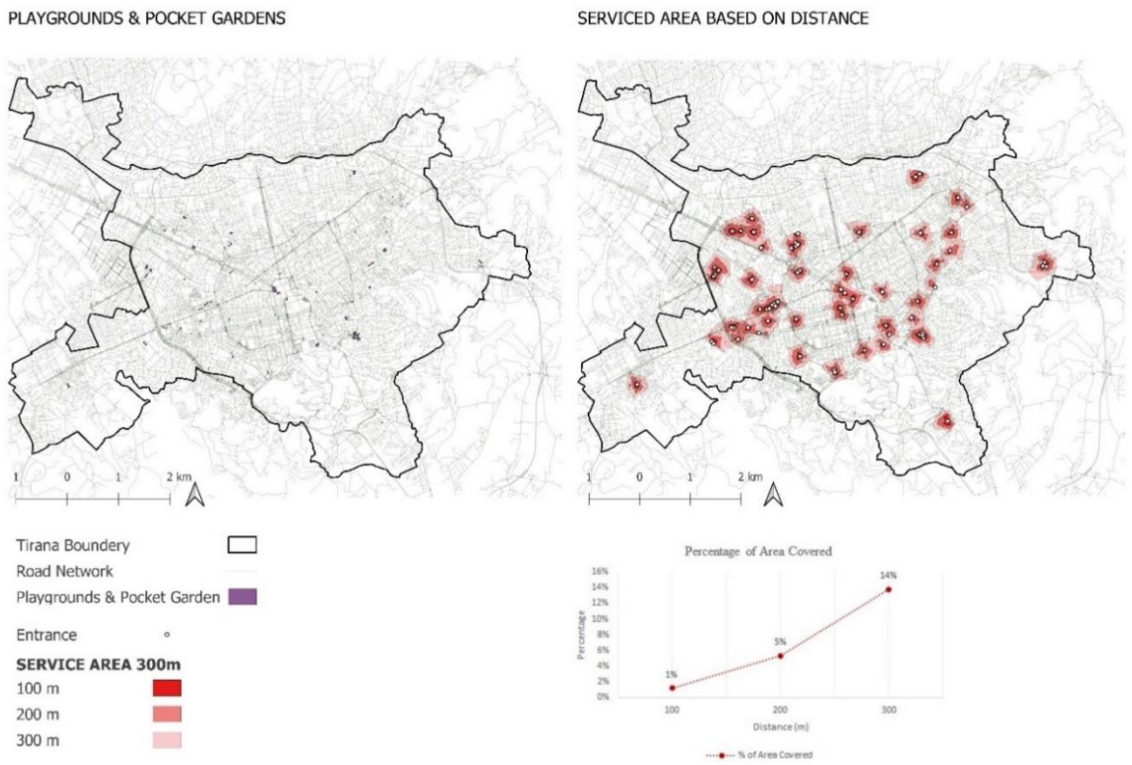


Figure 28. Service area of Playground and Pocket Gardens

Interesting details about the distribution of playgrounds' and pocket gardens' service area in Tirana are revealed by the analysis based on the distance traveled, *(Figure 28)*. According to the findings, compared to the analysis based on time intervals, the catchment area of these isochrones is significantly smaller in all the catchment intervals.

The isochrones of playgrounds and pocket gardens within a 100-meter radius, according to the findings, occupy about 1% of the Tirana area. The coverage increases to 5% at a distance interval of 200 meters and to 14% at a distance of 300 meters.

Playgrounds and pocket gardens' obvious reduction in catchment area when compared to the time-based analysis emphasizes their spatial distribution and availability. The large gap distances between the isochrones suggest that there aren't enough playgrounds and small gardens spread out throughout the city. The catchment area would probably be smaller if more of these spaces were available because of the shorter assigned distance, but the overall area coverage would be higher.

The lack of pocket gardens and playgrounds in Tirana highlights the requirement for a more extensive and evenly dispersed network of these recreational spaces. More convenient access for residents would be offered by increasing the number of playgrounds and pocket gardens in different neighborhoods. As a result, a larger overall area would be covered, giving kids, families, and others plenty of opportunities for outdoor play and recreation.

5.3.2 Parks

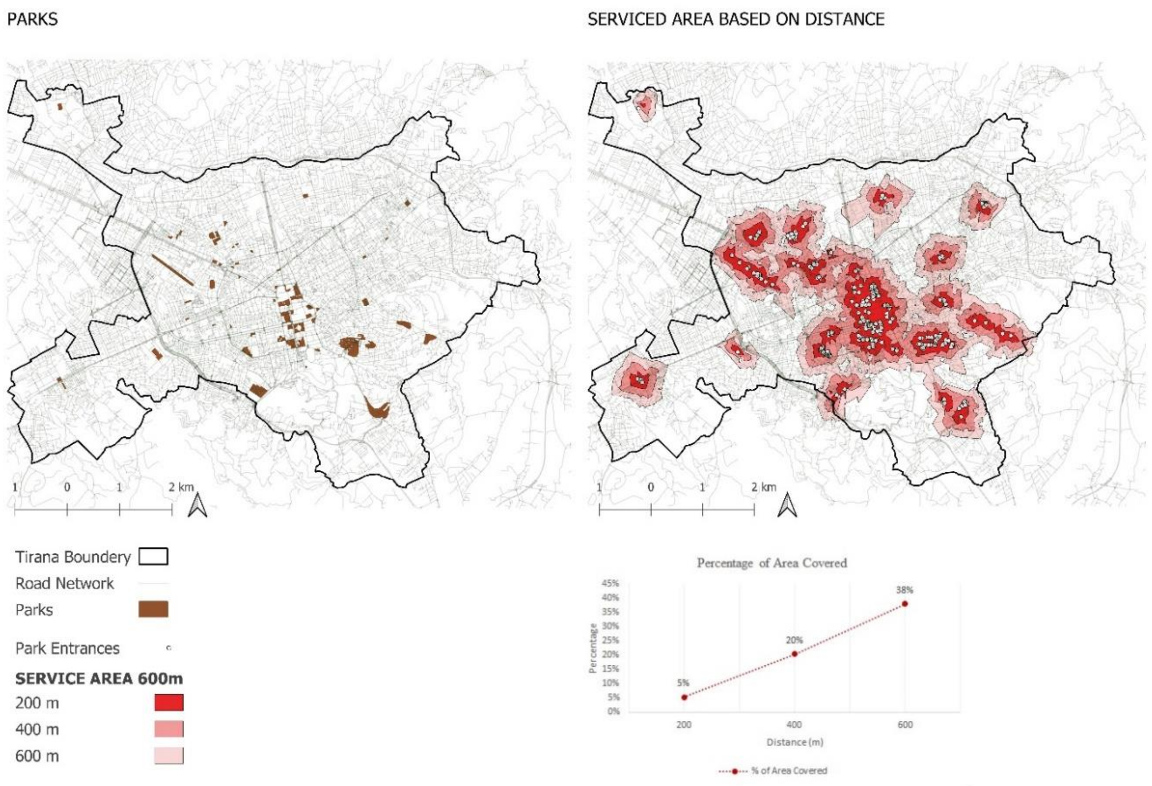


Figure 29. Service area for parks based on distance.

The isochrone analysis findings for parks in Tirana are shown in based on travel distance, *(Figure 29)*. Findings show that the isochrone of parks within a 200-meter radius occupies about 5% of the Tirana region. The coverage increases to 20% at a distance interval of 400 meters and to 38% at a distance of 600 meters.

The coverage of parks based on the distance traveled reveals a noticeably smaller served area when compared to the time-based analysis. When the distance intervals are taken into account, the percentages show that the area covered by the parks' isochrones is significantly less.

The isochrones of parks are most connected in the center of the city and along the Rruga e Durresit axis, as can be seen by looking at the map. This emphasizes how important these locations are as hubs for park accessibility, where locals can take advantage of outdoor recreation and green spaces.

The need for a wider distribution of parks throughout Tirana is highlighted by the reduction in the served area of parks when analyzing based on distance traveled. The accessibility and coverage of green spaces for citizens throughout the city can be improved by strategically placing parks at various distances and ensuring their even distribution. The analysis based on distance traveled concludes by showing the uneven coverage of parks in Tirana.

5.3.3 Urban Forest

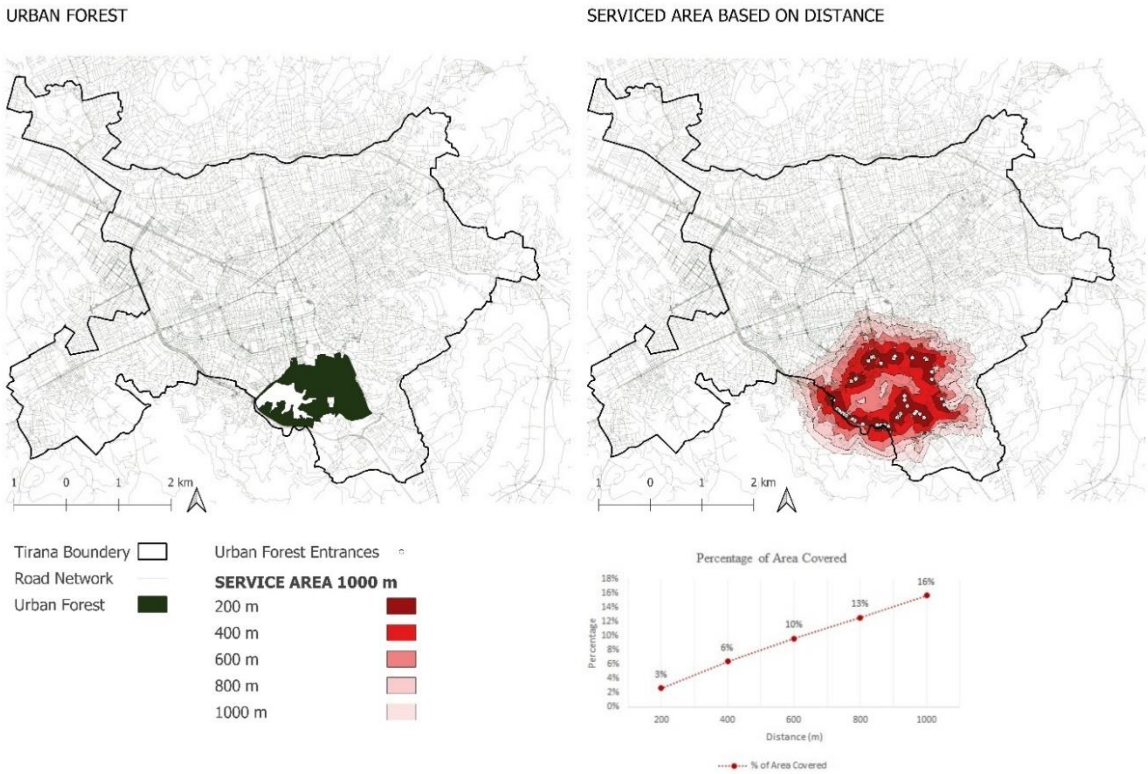


Figure 30. Service area of urban forest based on distance.

The analysis in *(Figure 30)* provides details on the analysis of the service area of the urban forest based on the distance traveled. The percentage of the Tirana area covered by the urban forest is shown along with the area covered by the isochrones at various intervals of distance.

The isochrone of the urban forest, according to the findings, encloses approximately 3% of the Tirana region within a 200-meter radius. The coverage increases from 4% to 6% and then to 10% within a 600-meter radius as the distance interval rises to 400 meters. At larger intervals of distance, the coverage keeps growing, reaching 13% at 800 meters and 16% at 1000 meters.

The service area of the urban forest exhibits a reduction in coverage when compared to the time-based analysis, just like the other types of urban green spaces analyzed based on distance. This implies that when taking into account the distance traveled, the urban forest's spatial reach is more constrained.

The analysis shows that the municipal unit number two, where the urban forest is located, is primarily served by it. The region of Sauk, which is outside the city's urban boundary, is moderately included in the isochrones. Although the urban forest is a great urban green space for people living in municipal zone number two, people from other parts of the city have a harder time using it because of the great distance.

In conclusion, the analysis of distance traveled highlight the accessibility restrictions for people living farther from the urban forest. While it provides the residents of municipal zone number two with a valuable green space, efforts should be made to create comparable green spaces in other parts of the city to ensure that every resident has access to nature and recreational opportunities.

5.4 Unserved Areas of the city

After completing the analysis based on both time and distance, it became important to identify areas in Tirana that were completely unserved by any of the urban green spaces (UGS) considered in the study, namely playgrounds and pocket gardens, parks, and the urban forest. This process allowed for the extraction of features that fell outside of the overlapping areas. The resulting unserved area maps for each UGS type were further analyzed using the intersection tool in QGIS, combined with the urban area boundary, to extract the portions that overlapped. These areas represented the parts of the city that were completely unserved. The extracted areas were then converted into percentages for statistical analysis

After completing the analysis based on both time and distance, it was necessary to identify areas in Tirana that were completely unserved by any of the urban green spaces (UGS) considered in the analysis, including playgrounds and pocket gardens, parks, and the urban forest. To accomplish this, the scenarios from both types of analysis were overlaid using the vector overlay difference tool along with the city's urban area boundary. This procedure enabled the extraction of features outside of the overlapping regions. The overlapping portions of the resulting unserved area maps for each UGS type were extracted using the intersection tool in QGIS in conjunction with the urban area boundary. These areas represented the parts of the city that were completely unserved. For statistical analysis, the extracted areas were then converted into percentages.

The numerical results show that based on the time-based analysis, approximately 17% of the urban area of Tirana is unserved by any of the UGS considered in the analysis. However, the distance-based analysis reveals a more concerning outcome, showing that 52% of the urban area of Tirana lacks access to any of the UGS considered in this analysis. This finding suggests that the distance-based analysis expresses a more problematic condition in terms of service coverage.

The graphical information presented in *(Figure 31)*, derived from the maps serves as a valuable reference for next analysis and decision-making processes that will be made in the next section, particularly regarding the identification of suitable areas for proposing new urban green spaces proposals.

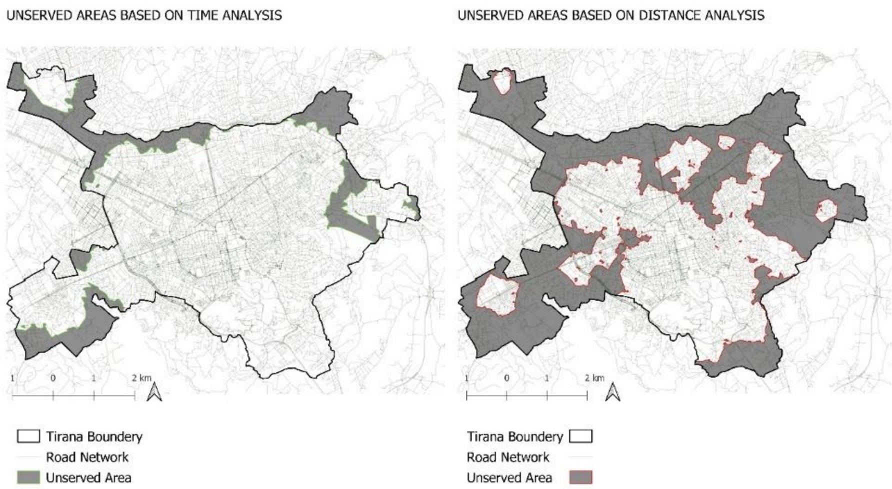


Figure 31. Unserved areas based on time and distance.

CHAPTER 6

PROPOSAL OF NEW URBAN SPACE AREAS

6.1 Multi-criteria weighted-overlay analysis

The multi-criteria weighted-overlay analysis is a geospatial method used to label areas based on multiple attributes that define the desired characteristics of the selected areas. This method *(Figure 32)*, involves overlaying vector layers with geoprocessing tools such as buffer, dissolve, difference, and intersection. It is especially helpful when working with a limited number of layers and seeking a binary answer of suitability or unsuitability. This analysis, unlike a simple overlay, can be performed in a raster space and provides a ranking of suitability rather than a single optimal location. In addition, it allows the combination of multiple input layers and the assignment of different weights to each criterion.

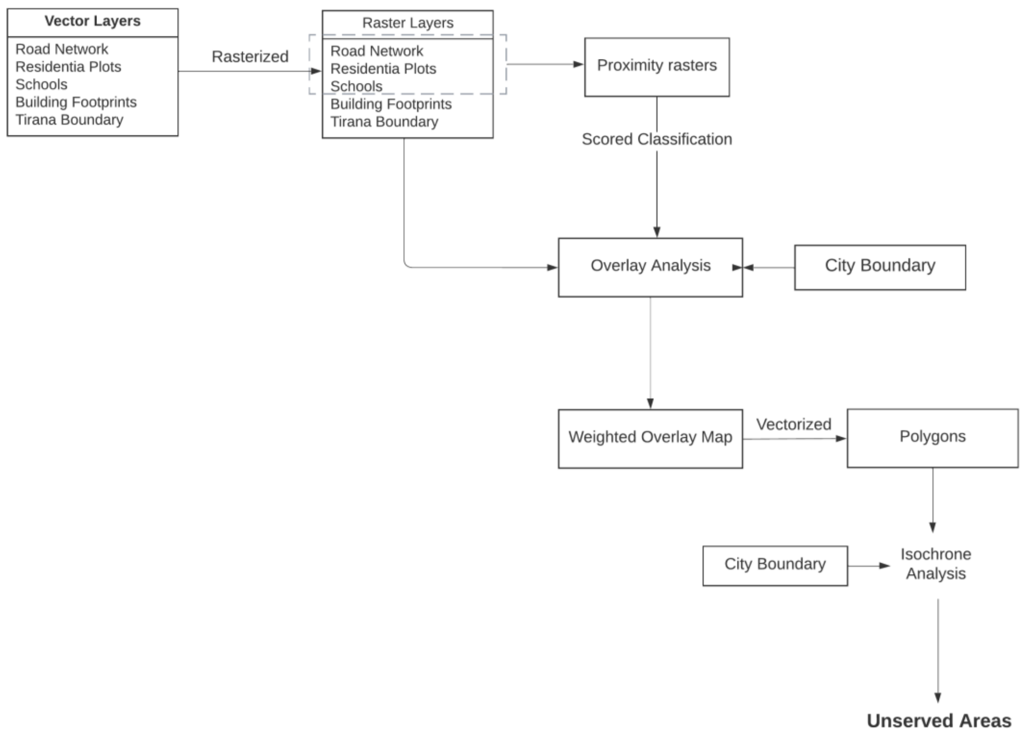


Figure 32. Suitability analysis workflow

In the context of this study, a multi-criteria weighted-overlay analysis was used to propose locations for urban green spaces based on a number of predefined criteria that are mentioned in ***Table 10***.

Table 10. Criteria for the weighted overlay analysis

Criterion	Data Needed	Source
Close to the roads, not segregated	Road Network of Tirana	OSM
Close to the schools	Schools' polygon layert	QuickOSM
In or close to residential areas	Residential area polygons	QuickOSM
Not in built areas	Building Footprint	HCMGIS plugin
In vacant land	Keys: Landuse_meadow, landuse_greenfield, Landuse_construction,landuse_brownfield, natural	QuickOSM
In Tirana	City Boundary	QuickOSM

Using the rasterize (vector to raster) algorithm, each data layer was converted to a raster format prior to analysis in QGIS. The city's boundary was used as a reference to ensure that all rasters had the same size. The goal was to generate output rasters in which the desired layer attributes were assigned a value of 1 and all other areas were assigned a value of 0. Then, these rasters were georeferenced and standardized to a 15-meter resolution, which was represented by black-and-white pixels.

Using the proximity algorithm, proximity rasters were then generated for the road, school, and residential layers. Proximity rasters display the distance between each pixel and the nearest feature in the input raster. This data was used to identify suitable locations within a predetermined distance of the desired features. The assignment of proximity values of 1000 meters or 1 kilometer produced continuous rasters with values ranging from 0 to 1000. To facilitate the subsequent overlay analysis, these proximity rasters were reclassified so that pixels near the desired proximity values received higher scores.

In this case the following scheme was used for the three layers:

600m -> 100)

(1000-5000m -> 50)

(>5000m -> 10)

This scheme was included as the criteria in the input expression:

```
100*("layer_proximity@1" <= 600) +
50*(" layer_proximity@1"  > 600)*100*("layer_proximity@1"<=1000)
+  10*("layer_proximity@1">1000)
```

Where “layer_proximity” needs to be substituted with the raster layers of the roads, schools and residential areas.The new reclassified layer has only 3 different values, 10, 50 and 100 indicating relative suitability of the pixels with regards to distance from roads.

In the final overlay analysis, factors such as proximity to the road network, absence of segregation, and proximity to schools and residential areas were considered. Using the raster calculator, the suitability evaluation was conducted with the below expression

(“roads reclassified@1” + “schools reclassified@1” + “residential reclassified@1”)*(landuse@1=1)*(building footprint raster@1!=1)*”raster boundary Tirana@1”

In the end the expression needs to be multiplied with the raster of the city boundary to remove pixel values outside the urban area of Tirana. The weight given to the criterion can be different based on the importance of them and the complexity of analysis being done but, in this case, they were given equal weights based on the thought that they are equally important criterion. The resulting raster overlay, *(Figure 33)*, has pixel values in the raster range from 0 to 200 - where 0 is the least suitable and 200 is the most suitable area for development. Figure is the final output that shows areas that are suitable for urban green spaces development.

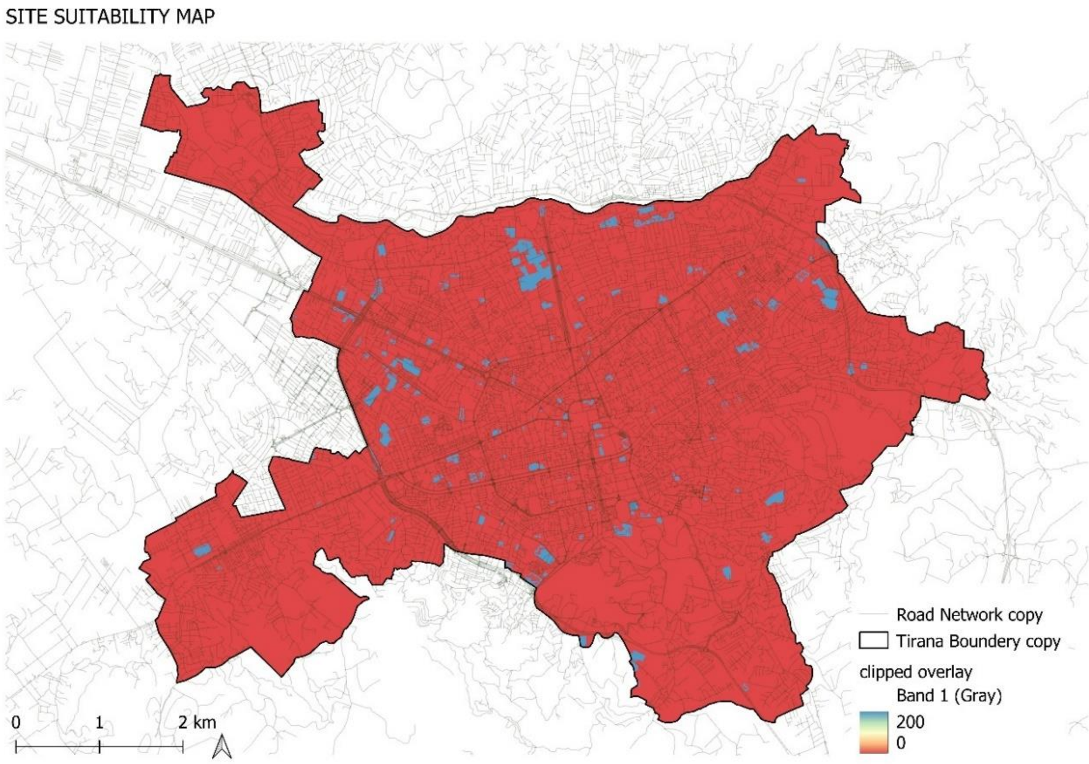


Figure 33. Unserved areas based on time and distance.

6.2. Vectorizing and Comparing

Following the completion of the weighted overlay analysis, the resulting raster layer was vectorized to generate a more accurate representation of urban green spaces. To achieve a more precise depiction, two actions were taken. First, pixels representing unsuitable regions with a value of 0 were eliminated, leaving only pixels representing suitable regions. A fix edge algorithm was then applied to the newly vectorized urban green areas to correct their squared appearance caused by extraction from a pixelated image.

After these operations, it was necessary to evaluate the vectorized outcomes. Three datasets in QGIS were compared: OpenStreetMap, Asig Orthophoto 2018 and Google Satellite imagery. While the map aligned well with OpenStreetMap and Asig data Google Satellite imagery revealed significant discrepancies. This difference was caused because the latest data that can be used in QGIS about Tirana are at least a few years old, whereas

Google Satellite imagery provided more current information. Notably, *(Figure 34)*, several vacant land areas suggested as suitable for urban green spaces in the map were now observed as built-up or under construction, as showed in Figure.

To address this issue, manual adjustments were necessary to correct the map. The process involved removing the areas that had been developed and incorporating new areas based on theoretical knowledge and manual extraction. The final map was thus a combination of urban green spaces derived from the weighted overlay analysis, areas manually extracted or modified, and vacant land categorized within the typology classification outlined in Chapter 3.

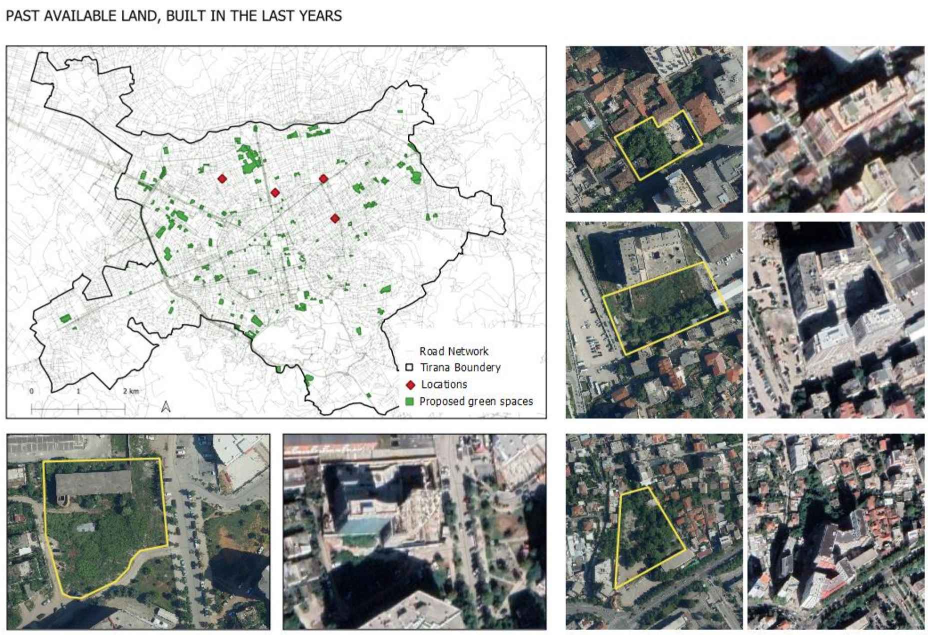


Figure 34. Past available land, built in the last couple of years.

6.3. Theoretical suggestions for site selection

Given the challenges posed by the macro-scale nature of the study, it was determined that a framework was required to facilitate the manual selection of proposed urban green spaces in Tirana. Several orientation points were considered to guide the decision-making process in light of extensive research. Identifying potential suitable areas along key axes, informed by relevant literature and the city's own characteristics, was a crucial aspect. For example, papers on urban green space development and the city's own examples highlighted the potential for green spaces along horizontal axes, particularly along the Lana and Tirana rivers in the city's upper north.

Due to their natural beauty and the restrictions on development that preserve their ecological significance, these areas are incredibly valuable for recreational purposes. The inclusion of recreational amenities along these river axes not only contributes to environmental sustainability but also improves the well-being of the population. Similarly, incorporating greenery along street axes, primarily in the form of trees, provides opportunities for activities such as jogging and biking while enhancing the aesthetic appeal of the urban environment.

In addition, unserved areas with unrealized potential for urban green spaces were considered. Large expanses of undeveloped land characterize the urban peripheries, which offer promising opportunities for recreational activities and serve a significant portion of the population. The absence of dense buildings and a high population density makes it easier to plan and implement large-scale green spaces, which can become iconic recreation landmarks.

Within the urban fabric, residential plots were given special consideration. These areas play a vital role in providing space for parks and playgrounds, especially in close proximity to residential areas, allowing residents easy and unsupervised access. However, the planning of green spaces within residential plots presents unique challenges, as these areas are constantly at risk of being replaced by buildings or complexes, resulting in an insufficient number of low-vegetation green spaces. In addition, the complexity of resident activity patterns necessitates careful study and analysis to effectively meet their diverse needs.

In addition to residential areas, schoolyards and adjacent land were also considered as potential green spaces. In addition to utilizing school playgrounds and courtyards, the availability of nearby parcels of land is promising for the development of green spaces that can be utilized by children and the larger community outside of school hours. This strategy acknowledges the significance of providing children with easy access to green spaces, a demographic that greatly benefits from such environments.

Likewise, outdoor areas of public institutions were identified as potential urban green space locations. Despite the fact that these spaces are frequently underutilized by workers and the general public, maximizing their potential during off-hours can revitalize them and make them more vibrant during the day. By activating these outdoor spaces, public institutions can contribute to the city's overall green infrastructure and promote healthier and more engaging community environments.

The framework aimed to guide the selection of proposed urban green spaces in Tirana through the systematic consideration of these orientation points, taking into account various factors such as ecological value, proximity to residential areas and schools, and the potential for community engagement. The new map with the suggested areas is shown in *(Figure 35)*.

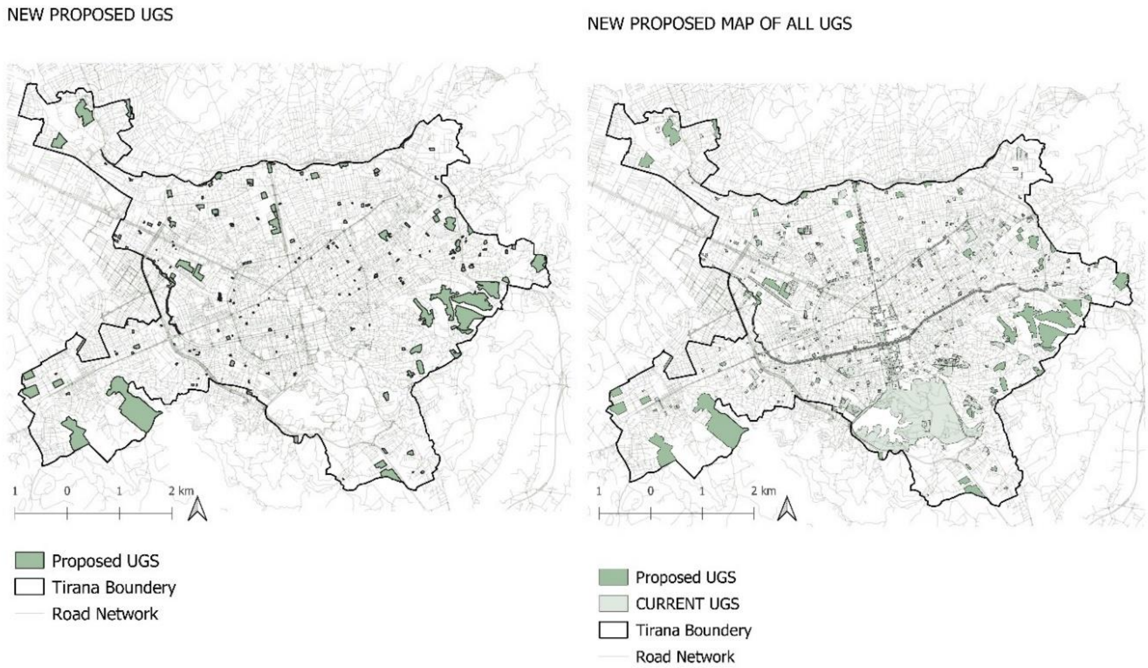


Figure 35. a. New proposed UGS. b. New proposed map of all UGS

6.4. Accessibility analysis of new proposals

To conclude the analysis of the existing and proposed urban green spaces in Tirana, a service area method with isochrones accessibility analysis was conducted. The distance-based analysis was chosen because it revealed the smallest area of coverage compared to other types of analysis performed on the current urban green spaces. For the analysis of the proposed green areas, a consistent methodology was used, taking into account a uniform speed of 5 km/h and 1 km catchment areas with 200-meter intervals. This decision was made due to the scope and limitations of this study, which focuses on the evaluation of Tirana's urban green spaces. Complex analyses involving multiple classifications and consideration of multiple factors would exceed the scope and objectives of this particular study. Instead of delving into intricate urban planning analysis and development plans, the purpose of this study is to provide a comprehensive evaluation of existing and proposed urban green spaces using a consistent and manageable approach.

The resulting map shown in *(Figure 36)* illustrates a network of well-connected and evenly distributed urban green spaces. The area that remains unserved is that of the Lake of Tirana. However, it should be noted that the area surrounding the lake has a diverse and established green landscape that does not require significant intervention.

Following the analysis of the service area, the vector difference tool was utilized to determine the unserved areas. The intersection tool algorithm was then applied to the unserved areas derived from the distance analysis of the existing urban green spaces and the proposed areas, along with the city boundary. Figure 2 depicts the areas that continue to be underserved despite the addition of new urban green spaces to the overall greenery map. Statistical analysis reveals that approximately 2% of Tirana's urban area remains unserved, which is a vast improvement from the initial 52% unserved area.

Overall, the service area analysis, in conjunction with the vector overlay and intersection tools, was able to effectively identify the areas lacking sufficient access to urban green spaces. The findings indicate a substantial increase in coverage and accessibility as a result of the addition of proposed green areas, highlighting the positive impact of the suggested interventions on the overall distribution and availability of urban green spaces in Tirana

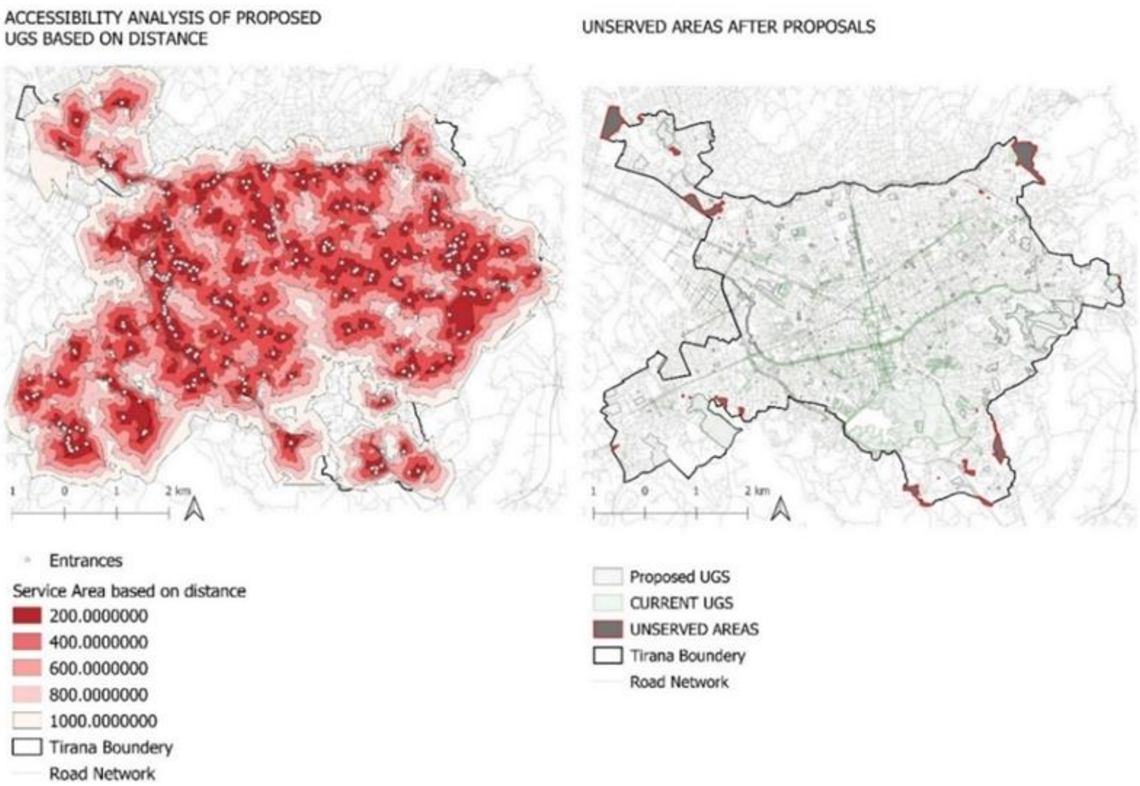


Figure 36. a.Accessibility analysis. b.Unserved areas after proposals

CHAPTER 7

DISCUSSION AND CONCLUSIONS

7.1 Comparisons

In a 2020 study [3], the effect of Tirana's green spaces on health indicators was examined. The study recommended using high-resolution orthophotos and object-based analysis for classification, as it was believed that the resulting raster would allow for a more precise spatial analysis. Particularly interesting were the results of the orthophoto analysis, which revealed that 27% of the city was covered in vegetation. This value was 2% greater than the green cover determined by the NDVI method utilised in this study as seen in ***Table 11***. A reevaluation of the results presented in the table of the previous paper revealed two significant findings. First, the total area of green cover comprised 27.7% of the city's area, which, when rounded to the nearest percentage point, equaled 28%.

Table 11. Comparison between study from literature (bold) and this study (light)

Green Cover (km^2)	**Green Cover (km^2)**	**% of Green Cover to Municipal Unit**	Green Area (km^2)	Total Area (km^2)	% of Green Cover
11.68	40.00	29%	11.56	41.73	28%
1.38	3.55	39%	1.22	3.06	40%
4.16	9.30	45%	3.98	9.58	42%
0.39	2.04	19%	0.4	2.01	20%
0.88	3.58	25%	1.29	4.92	26%
0.42	2.67	16%	0.46	2.87	16%
2.13	5.61	38%	1.67	5.48	30%
0.46	3.06	15%	0.48	3.06	16%
0.21	1.89	11%	0.28	1.95	14%
0.45	2.78	16%	0.55	2.82	20%
0.09	0.77	12%	0.11	0.77	14%
1.09	4.73	23%	1.12	5.21	21%

In addition, the city boundary considered in the previous study was larger than the one derived from the OSM extracted layer in this study. This process of verification confirmed the accuracy and acceptability of the green area value derived from this study. The selection of the NDVI method over orthophoto analysis was motivated by the continuous updating of Sentinel 2 imagery, which ensures the use of recent and appropriate satellite data captured on days with clear weather. Another unexpected result still was that the total green cover of the city had not decreased from 2016 when the other study was conducted.

This study's NDVI map revealed that the majority of the vegetation contributing to the percentage was primarily located in Zone 2, which encompasses the urban forest. Additionally, vegetation was found in Zone 6, which consists of the Kombinat hills, Zone 1 (an agricultural region), and a portion of Zone 11. Recent tree-planting initiatives may have had a positive impact, but the study highlighted the need for park and non-concrete green space improvements. Notably, this study considered only the presence of green spaces and did not assess their proportion to the built environment. Nonetheless, another study on the urban neighbourhood green index [36] includes this crucial variable, thereby enhancing the significance of the investigation of urban green spaces.

Several other studies, including [46] and [47], have utilised high-resolution satellite imagery to extract and categorise urban green spaces. In contrast to these studies, the current paper employs NDVI as a tool within a broader study, without the intention of introducing new deep learning techniques for urban planning initiatives.

This study's data documentation method was partially derived from [23] and [48]. Due to the absence of a universally accepted definition of urban green spaces and variations in their significance based on a city's level of development, various studies employ distinct categorization criteria. Both Nagpur and the current research were conducted in developing areas with limited municipal data availability, so they shared similarities. Although the typologies and classes for categorization were based on the Nagpur study, some modifications were made. For example, water bodies were excluded and new categories, such as commercial typologies, were added. Essentially, the categorization was modified to accommodate the characteristics of urban green spaces in Tirana.

In addition, the study by Ludwig C. [48], provides insightful information regarding the extraction of green areas from QuickOSM. However, it was difficult to locate these areas in the database due to their placement under different keys.

This study demonstrates a comprehensive approach to accessibility analysis by considering multiple scenarios based on the demographics of visitors and the hierarchical significance of the analysed urban green spaces. This method provides a clearer representation of the city's actual service patterns. In contrast, studies such as the one on urban green area accessibility in Switzerland [41] are limited by a lack of research into the characteristics of green spaces. In addition, the study examining the accessibility of green space in four European cities encounters a significant drawback where it takes as park entrances the centroids of the polygons regardless of their size. That can be done for small playgrounds but on a city park with big areas it would show incorrect results as much of the service area isochrone would be occupied by the park itself. A model of study that had a well-developed framework was that of [24] where the urban green areas' accessibility scenarios were based on the hierarchical and functional character of the park. Their approach in this paper considering different travel speeds based on the demographic that would mostly use those areas was inspired by this paper.

In this study, a comparison is made with other studies that employ weighted overlay analysis to identify sites suitable for urban green area proposals. Despite the fact that the present study employed a simplified methodology, it is essential to note that this type of analysis can be conducted at more complex levels. Some of the reviewed papers utilised scripts to overlay criteria within the analysis, providing a more sophisticated approach. In addition, it was observed that many researchers conducted their analyses with ArcGIS, which provides a wider range of advanced analytical capabilities than QGIS. In this study, however, raster classifying algorithms in QGIS were used to perform the weighted overlay analysis, ensuring compatibility with the software utilized throughout the research.

7.2 Limitations and recommendations

OSM data is beneficial as long as the information that you want to gather is about the public When gathering information on public spaces, the use of OpenStreetMap (OSM) data proves useful. When it comes to private areas such as residential blocks, however, OSM depicts them as undefined grey areas. The limitations affect a few phases of the analysis. First, relying solely on OSM layers during the computation of urban green areas produced insufficient results. It was necessary to include manually added green spaces and classify them based on site observations in order to improve the accuracy of the extracted spaces.

The road network presented an additional minor inconvenience. It is essential to have point layers representing the entrances to green spaces and a road network layer projected in Universal Mercator (UM) zones in order to generate isochrones for service area analysis. As the service area analysis relies on the path of the road network, the road network must be well-connected and it is important to study and observe the road network provided for Tirana for any problems because the service area will be based on the path of the road network. Sometimes the point layer of entrances did not touch the road network, which is this case was not a big issue as the QNEAT3 tools can assign the road even if the point does not touch it but if they are far away because the road network is not well updated and does not go until the end of destinations, the analysis may show errors that are presented in the isochrones.

The part of the analysis that showed the most difficulties in production was the weighted overlay of raster production for the most suitable areas. As mentioned earlier due to the year of production of the data, the results compared to the current state of the city show that many identified vacant plots for recreation are now being constructed or already built. It was considered in this part of the analysis to take different criterion specifically:

1. NDVI imagery for the location of vegetated areas
2. A QGIS database based on the PDV that shows private areas and areas opened for recreation. The "Plan i Detajuar Vendor" (PDV) in the Republic of Albania is an instrument that provides detailed specifications and regulations at the level of one or more structural units based on the "Plan i Prgjithshm Vendor" (PPV). Through

building permits, the PDV also establishes conditions for development within a specific area.

3. The other criterion that was used in the study except the OSM DATA.

Upon communicating with municipality representatives, it was discovered that there was no approved PDV of Tirana yet and that there was still not such data about the city. The only things that could be found were private land information about certain neighborhood that usually real estate brokers keep in their database. Due to this problem the analysis on the suitable areas were done with the data that were accessible to anyone.

Future research papers could expand this methodology by classifying the urban green areas proposed in the last chapter. Based on that categorization, different scenarios can be provided about the serviceability of the proposed green areas that might show even more accurate results regarding the unserved areas by this UGS. But the basis of that classification needs to have some strong roots because it is not simple to properly assign vacant land for future uses.

7.3 Conclusions

This paper was written in response to the new plans for the Metro Bosco, which aim to encompass the Tirana metropolitan area. The study revealed that the area surrounding Metro Bosco was already green, whereas the inner city, particularly beyond the main access points, lacked significant urban green spaces. It was observed that few studies had focused on vegetation as a primary characteristic, prompting a comprehensive investigation of the city's urban green spaces.

The research progressed through various phases, beginning with the documentation phase. The NDVI analysis provided an evaluation of the total vegetated area coverage within the city limits, and a QGIS file database was created to attribute and categorise all extracted green spaces. This database contains crucial information for future research because it was not previously accessible.

Using the QNEAT3 plugin, the study also included an accessibility analysis of recreational areas, including playgrounds, pocket parks, and the urban forest. Based on time and distance, two scenarios were considered, with values reflecting the size and functionality of each urban green space. A service area analysis utilising isochrones revealed unserved urban areas for each type of urban green space. Based on the worst-case scenario, 52 % of the city remained unserved, highlighting the need for improvement.

Using a weighted overlay analysis, a map of potential suitable new urban green spaces in Tirana was generated. This analysis included both automated and manual extractions of vacant land extracted from the classified spaces. With the proposed new urban green spaces, only 2% of Tirana's urban territory would remain unserved, demonstrating the positive impact of the proposed interventions.

This study provides important insights into the evaluation and analysis of urban green spaces in Tirana. The findings highlight the significance of addressing the uneven distribution of green spaces within the city and provide a foundation for future urban planning initiatives aimed at improving the quality and accessibility of urban green spaces for Tirana residents.

REFERENCES

[1] Municiplaity of Tirana, "Green City Action Plan of Tirana I Version 1.0," p. 63, 2018.

[2] A. Russo and G. Cirella, "Modern Compact Cities: How Much Greenery Do We Need?," *International Journal of Environmental Research and Public Health,* vol. 15, no. 10, p. 2180, 2018.

[3] Z. Teqja, E. Lekaj, Z. Libohova and N. Bardhi, "Assessment of the green space of Tirana city and its imapct on some public health indicators," p. 2, 2020.

[4] W. H. Organization, "Urban Planning, Environment and Health: From Evidence to Policy Action," 2010.

[5] M. Rakhshandehroo, M. Yusof and S. Afshin, "Terminoogy of Urban Open and Green Spaces," in *11th ASEAN Postgraduate Seminar, APGS 2017* , Malaysia, 2017.

[6] C. Henry and J. Meesters, "Private and public green spaces: Meaningful but different settings," *Journal of Housing and the Built Environment* , vol. 27(1), pp. 49-67, 2011.

[7] K. Tzoulas, K. Korpela, S. Venn, V. Yli-Pelkonen, A. Kazmierczak, J. Nimela and P. James, "Promoting ecosystem and human health in urbn areas using Green Infrastructure: A literature Review," 2007.

[8] M. Kuhan, "Greenbelt and Green Heart: Seperating and integrating landscapes in European city regions," Vols. 64(1-2), pp. 0-27, 2003.

[9] Northern Architecture, "Types Of Urban Space," 29 June 2023. [Online]. Available: https://www.northernarchitecture.us/residential-areas/types-of-urban-space.html.

[10] K. Lynch, "The pattern of metropolis. Daedalus, Journal of the American Academy of Arts and Sciences," pp. 79-98, 1961.

[11] K. Seto, A. Reenberg, C. Boone, M. Fragkias, D. Haase, T. Langanke, P. Marcotullio, D. Munroe, B. Olah and D. Simon, "Urban land teleconnections and sustainability," pp. 7687-7692, 2012.

[12] L. Inostroza, R. Baur and E. Csaplovics, "Urban sprawl and fragmentation in Latin America: a dynamic quantification and characterization of spatial patterns," pp. 87-97, 2013.

[13] M. Elison, "Green Belts: Conflict Mediation in the Urban Fringe," London, 1986.

[14] J. Westerink, D. Hase, A. Bauer, J. Ravetz, F. Jarrige and C. Aalbers, "Dealing with Sustainability Trade-Offs of the Compcat City in Peri-Urban Planning Across European City Regions," vol. 21, pp. 473-497, 2013.

[15] K. Mouratidis, "Is compact city livable? The impact of compact versus sprawled neighbourhoods on neighbourhood satisfaction," Urban Stud., 2017.

[16] J.-J. Lin and A.-T. Yang, "Does the Compact-City Paradigm Foster Sustainability? an Empirical Study in Taiwn," pp. 365-380, 2006.

[17] M. Artmann, M. Kohler , G. Meinel, J. Gan and I.-C. Ioja, "How smart growth and green infrastructure can mutually support each other- A conceptual framework for compact anf green cities," pp. 1-13, 2017.

[18] C. Haaland, C. Bosch and V. Konijnendijk, "Challenges and strategies for urban green-space planning in cities undergoing densification: a review.," *Urban Forestry & Urban Greening,* 2015.

[19] S. Pauleit, "Perspectives on urban green spaces in Europe," *Built Environment 29*, pp. 89-93, 2003.

[20] R. Rafiee, A. Mahiny and N. Khorasani, "Assessment of changes in urban green spaces of Mashad city using satelite data," *International Journal of Applied Earth observation and Geoinformation* , pp. 431-438, 2009.

[21] T. Bykomesh , N. Nakagoshi and A. Dewan , "Urbanization and green space dynamics in Greater Dhaka, Bangladesh," in *Landscape and Ecological Engineering 8*, 2012, pp. 45-58.

[22] L. Wood, P. Hooper and et al, "Public green spaces and positive mental health - investigating the relationship between access, quantity and types of parks and mental wellbeing," *Health Place,* 2017.

[23] S. Lahoti , M. Kefi, A. Lahoti and O. Saito, "Mapping Methodology of Public Urban Green Spaces Using GIS: An Example of Nagpur City, India," *MDPI,* 2019.

[24] K. Gupta, A. Roy, K. Luthra and S. Maithani, "GIS-based analysis for assessinf the accessibility at hierarchical levels of urban green spaces," in *Urban Forestry & Urban Greening*, 2016.

[25] H. Tannous, M. Major and R. Furlan, "). Accessibility of Green Spaces in a Metropolitan Network Using Space Syntax to Objectively Evaluate the Spatial Locations of Parks and Promenades in Doha, State of Qatar.," in *Urban Forestry & Urban Greening*, 2020.

[26] E. Iraegiu, G. Augusto and P. Cabral, "Assessing Equity in the Accessibility to Urban Green Spaces According to Different Functional Levels," *ISPRS International Journal of Geo-Information*, vol. 9, no. 5, p. 308, 2020.

[27] D. Schuyler, The New Urban Landscape: The Redefinition of City Form in Nineteenth-Century America (New Studies in American Intellectual and Cultural History), 2023.

[28] A. Lee and R. Maheswaran, "The health benefits of urban green spaces: A review of the evidence," *Journal of Public Health* , vol. 33, no. 2, pp. 212-222, 2011.

[29] "Urban Green Spaces: a brief for action," World Health Organization, 2016.

[30] L. Inostroza, R. Baur and E. Sclapovics, "Urban sprawl and fragmentation in Latin America: A dynamic quantification and characterization of spatial patterns," *Journal of Environmental Management*, vol. 115, pp. 87-97, 2013.

[31] M. Braubach, A. Egorov, P. Mudu, T. Wolf, C. Ward Thompson and M. Martuzzi, "Effects of Urban Green Spaces on Environmental Health, Equity and Resilience," *Theory and Practice of Urban Sustainability Transitions* , pp. 187-205.

[32] T. Hartig , R. Mitchell, S. De Vires and H. Frumkin, "Nature and health," *Annu Rev Public Health*, pp. 207-228, 2014.

[33] A. Rigolon, "A complex landscape of inequity in access to urban parks: A literature review," *Landsc. Urban Plan*, pp. 160-169, 2016.

[34] A. Rigolon, M. Browning, K. Lee and S. Shin, "access to Urban Green Spaces in Cities of the Global South: A systamic Literature Review," pp. 67-91, 2018.

[35] T. Blaschke, S. Lang and G. Hay, "Object-Based Image Analysis – Spatial concepts for knowledge-driven remote sensing applications," Springer, 2008.

[36] K. Gupta, P. Kumar , S. Pathan and K. Sharma, "Urban Neighbourhood Green Index- A measure of green spaces in urban areas," *Landscape and Urban Planning* , vol. 105, pp. 325-335, 2012.

[37] Center of Disease Control and Preventation , "Parks, Recreation and Green Spaces," CSDC, 2023.

[38] B. Hillier, "Space as Paradigm for understanding strongly relation systems.," in *In Proceedings of the 2nd International Space Syntax*, Brazilia, 1999.

[39] W. Hansen , "How accessibility Shapes Land Use," *J.Am.Plan.Assoc.,* vol. 25, pp. 73-76, 1959.

[40] A. Kucukali , R. Pjeternikaj, E. Zeka and A. Hysa, "Evaluating the pedestrian accessibility to public services using open-source geospatial data and QGIS software," 2022.

[41] C. Chenes, G. Giuliani and N. Ray, "Modelling Physical Accessibility to Public Green Spaces in Switzerland to Support the SDG11," *MDPI,* 2021.

[42] A. Comber , C. Brunsdon and E. Green, "Using a GIS-based network analysis to determine urban greenspace accessibility for different ethnic and religious groups.," *Landscape and Urban Planning* , vol. 86(1), pp. 103-114, 2008.

[43] Y. Chen, W. Yue and D. La Rosa, "Which communities have better accesssibility to green space? An investigation into environmental inequality using big data," *Landscape and Urban Plannng* , 2020.

[44] T. Asell-Burt, X. Feng, S. Mavoa, H. Badland and B. Giles-Corti, "Do low-income neighbourhoods have the least green space? A cross-sectional study of Australia's most popular cities.," *BMC Public Health* , vol. 14(1), 2014.

[45] I. Ismayilova and S. Timpf, "Classifying Urban green Spaces using a combined Sentinel-2 and Random Forest approach," in *AGILE Conference in Geographic information Science* , Augsburg , 2022.

[46] R. E. Huerta, F. D. Yepez, D. F. Lozano-Garcia and et al, "Mapping Urban Green spaces at the Metropolitan level Using Very High Resolution Satellite Imagery and Deep Learning Techniques for Semantic Segmentation," 2021, 2021.

[47] W. Chen , H. Huang, J. Dong, Y. Zhang, Y. Tian and Z. Yang, "Social functional mapping of urban green space using remote sensing and social sensing data," *ISPRS Journal of Photogrammetry and Remote Sensing,* vol. 146, no. 0924-2716, pp. 436-452, 2018.

[48] C. Ludwig, R. Hecht, S. Lautenbach, M. Schorcht and A. Zipf, "Mapping Public Urban Green Spaces Based on OpenStreetMap," *International Journal of Geo-Information,*

2021.

[49] G. Giuliani, E. Petri, Interwies, V. Vysna, Y. Guigoz, N. Ray and I. Dickie, "Modelling Accessibility to Urban Green Areas Using Open Earth Observations Data: A Novel Approach to Support the Urban SDG in Four European Cities," *MDPI,* 2021.

[50] E. Gelan, "GIS-based multi-criteria analysis for sustainable urban green spaces planning in emerging towns of Ethiopia: the case of Sululta town.," *Environ Syst Res* , 2021.

[51] A. Herzele and T. Wiedemann, "A monitoring tool for the provision of accessible and attractive urban green spaces," in *Landscape and Urban Planning*, 2003.