Examining Types and Performance of Urban Green Space: Case Studies of Toronto, Milan, and Isfahan

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Abstract

Cities have significant impacts on sustainability and sustainable development. In the context of global development, especially in developing large metropolitan areas, the urban population is growing resulting in social and environmental challenges that threaten the sustainability of cities. One of the challenges of this modern urbanization addresses urban green spaces (UGS) regarding their quantity and performance. UGS are essential parts of urban areas lack of which can compromise urban ecology and human well-being. Enhancing UGS is an approach to overcome some of these challenges. Little research has been done on the UGS typologies and different variables affecting their performance, and also the literature on comparing this feature in hugely different contexts is missing. This paper intents to compare UGS categories in the three selected cases, which are the cities of Toronto (Canada), Milan (Italy), and Isfahan (Iran), and analyze their performance variables.

Keywords: Modern urbanization, sustainable cities, UGS typology, UGS performance variable, context.

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1. Introduction

As declared by the New Urban Agenda and the 2030 Sustainable Development Goals, cities play an important role in sustainability and sustainable development (Calheiros & Stefanakis, 2021), and are important influencers of sustainability by having an impact on environment, economy, and society (United Nations General Assembly, 2017). Therefore, achieving safe, resilient, inclusive, and in general sustainable cities, is a global goal (Calheiros & Stefanakis, 2021). To have a sustainable future, cities should be planned in a sustainable way and should be livable. One of the most important criteria for future sustainable cities is to achieve balance between how it is performing currently and how it will be performing in the future considering modern urbanization and its rapid growth (Kucherova & Narvaez, 2018). Growth of urban settlements should be managed in a way that minimizes environmental degradation and at the same time maximizes the benefits for urban dwellers to be aligned with sustainable development (Calheiros & Stefanakis, 2021).

In the context of global development, urban settlements such as suburbs, towns, and cities, accommodated 55% of the world's population by 2018 (United Nations, 2019). According to the United Nations, this tendency of living an urban life is growing and the percentage of the world's population living in cities will reach 67% by 2050 (Besir & Cuce, 2018). Accordingly, cities and urbanized spaces are getting bigger by expanding the boundary between the urban built-environment and nature, and denser by attracting higher population (Wang et al., 2020), especially in developing large metropolitan areas and in big cities where there is a higher trend of growing population (Golasz-Szolomicka & Szolomicki, 2019).

Contemporary urban development brings about social-environmental challenges that jeopardizes sustainability of cities as well as welfare of the citizens (Pérez-Urrestarazu et al., 2015). One of these challenges is the quality and quantity of urban green spaces (UGS) which are essential components in urban areas and the lack of them can affect urban ecology as well as human health and well-being (Tzoulas et al. 2007). Although there is not a single definition for urban green spaces, it is defined as "any vegetated land adjoining an urban area" (Taylor & Hochuli, 2017, p. 29). There is an important relationship between green space and human well-being (Tzoulas et al., 2007; De Luca et al., 2021; Luo et al., 2021; etc.), which highlights the importance of social-environmental perspective (Wang et al., 2020). It is acknowledged that green spaces positively affect physical and mental health by facilitating physical activities, providing a ground for social cohesion and social inclusion, and promoting mental relaxation (Kwon et al., 2021). Urban communities have become concerned about the nature and its integration into the built-environment and are becoming aware of the importance of creating and preserving the nature in urban areas (Baycan-Levent & Nijkamp, 2004).

In cities, 'nature' can be perceived as available green spaces (Kabisch et al., 2016). Introducing Nature-Based solutions (NBSs) and developing urban greening concepts in modern urbanization are approaches to overcome the contemporary challenges of urban sprawl, biodiversity loss, climate change, and economic and social problems (e.g., economic downturn, social inequity and health, etc.), and to mitigate the impact of

urbanization on environment and society in a way that contributes to sustainable development (Calheiros & Stefanakis, 2021; Pérez-Urrestarazu et al., 2015). Urban green spaces have a significant role in enhancing the quality of life of the citizens and viability of cities, and can improve urban quality if designed, managed, and maintained properly. Urban green space planning policies need to be specific to the context in order to meet the local needs which is an important factor to be successful. Hence, an up-to-date database of each context is needed (Baycan-Levent & Nijkamp, 2004) in order to be able to provide further recommendations and interventions for designers, planners, and decision-makers to enhance quality of life in cities.

1.1. Research gap

Considerable research has been done on the necessity of vegetation and green spaces in urban areas (Price et al., 2015), the effects of urban sprawl and development on urban green spaces (Koprowska et al., 2020), and the impact of urban green spaces on human health (De Luca et al., 2021; Tzoulas et al., 2007; Zhang & Tan, 2019; etc.). Nonetheless, less research has been done on the urban green space typologies (Bell et al., 2007; Rall et al, 2015) and different variables and criteria that affect the performance of urban green spaces (Campagnaro et al., 2019; Rigolon et al., 2018; Žlender & Ward Thompson, 2017). Most urban development plans adopt a population-based standard approach which valorizes items by the number of inhabitants to satisfy the city dwellers' need of green space (Baycan-Levent & Nijkamp, 2004) without considering other variables such as function, accessibility, users' needs and preferences, etc. affecting the quality and performance of such spaces. In addition, while a lot have been done on urban green spaces in a single context especially in European and North America setting (Mabon & Shih, 2021) and comparative analysis of urban green spaces in European cities (Baycan-Levent & Nijkamp, 2004; Baycan-Levent & Nijkamp, 2009; Žlender & Ward Thompson, 2017; etc.), comparative studies in different contexts (continents) – given the different environmental characteristics, urban patterns, and policy approaches – is missing. This paper intends to address this research gap to highlight the importance of contextualization in policy design for urban planning.

1.2. Purpose statement

The aim of this research is to compare urban green space categories in the three selected cities and analyzes variables affecting the performance of urban green space. Three case studies have been selected to be studied. These three case studies are: Toronto (Canada), Milan (Italy), and Isfahan (Iran). The research intents to contribute to the future research and scholarship by providing comprehensive frameworks for urban green space categories and performance variables. It is also oriented to helping designers, urban planners, and policy makers with recommendation for the cities of the future, and to help enhancing city's quality of life for dwellers and reaching a sustainable city.

1.3. Objectives

The following objectives guide this study:

Objective One. to review the existing literature on urban green spaces as an element in sustainable cities.

Objective Two. to describe the categories of urban green space in three cases

Objective Three. to analyze the consideration given to urban green spaces performance in three cases.

1.4. Document structure

This section sets out the organization of this document and briefly communicates what is covered in each chapter. Chapter 2 that is the literature review provides an overview of available literature on urban green space and sustainable cities, urban green space typologies, and urban green space performance variables. The next chapter, chapter 3, refers to materials and methods where research method is explained, case study selection is described, data collection and analysis are explained, and finally, limitations and delimitations of this research are outlined. Chapter 4 presents the result of case study analysis and consists of results for the cases of Toronto, Milan, and Isfahan, regarding their context, urban green space categories, and urban green space performance variables. This chapter is followed by chapter 5 in which cross-case results are presented and discussed. The next is chapter 6 that refers to conclusion and recommendations where the rational for the research is revisited, and the statement purpose, methods, results, and the main findings of the research are briefly reviewed. Besides, some recommendations for future scholarship and practice are provided in this chapter. Finally, a list of reference is included in chapter 7 and appendices is included in the final chapter, that is chapter 8.

2. Literature review

There is a large body of literature focusing on the relation between global population and modern urbanization, and their socio-environmental challenges. There is also a great deal of literature about green spaces in urban environment, the key role they play on the environment and the human health, and their influence on mitigating these socio-environmental challenges and thus, on sustainability of cities. In addition, some research has been done on urban green space typologies and their categories' definition, different variables, criteria, and indicators that affect the performance of urban green spaces. In this section the literature on urban green space and sustainable cities, and urban green space typologies and performance is studied.

2.1. Urban green space and sustainable cities

Cities, as one of the urban settlement types that house a high percentage of the world's population, affect the society, environment, and economy, and thus, play a key role in sustainable development (Calheiros & Stefanakis, 2021; United Nations, 2017). In the process of urbanization and urban transition, it is important to keep the balance between the built environment and open space in order to lessen the environmental pressure (Calheiros & Stefanakis, 2021; Pérez-Urrestarazu et al., 2015) such as land conversion, densification of built-up areas, and increase in traffic resulting in air pollution (Kabisch & van den Bosch, 2017) and overcome socio-environmental challenges driven by being disconnected with nature (Calheiros & Stefanakis, 2021; Pérez-Urrestarazu et al., 2015). Some of these challenges are human health problems due to being exposed to air pollution (Kabisch & van den Bosch, 2017), distracting the feeling of happiness, and affecting mental health. Besides, some studies have shown that being disconnected from nature "may well be the world's greatest environmental threat" (Ives et al., 2018, p. 1392) as being connected to nature is associated with the willingness of conserving the nature (Ives et al., 2018, p. 1392). Urban societies have become aware of the importance of being connected to nature and preserving the nature in urban areas (Baycan-Levent & Nijkamp, 2004). These socio-environmental challenges threaten the well-being of urban inhabitants and thus overshadow sustainability of a city (Calheiros & Stefanakis, 2021; Pérez-Urrestarazu et al., 2015). One way to moving towards sustainable cities to address these challenges is to apply nature-based solutions (NBSs) into the process of urban transformation (Calheiros & Stefanakis, 2021).

Nature, in cities, is perceived as green spaces which are available to citizens (Kabisch et al., 2016). According to studies, there is a strong relationship between using urban green space and physical and mental health of citizens as urban green space has the potential to promote mental health by facilitating social inclusion, social cohesion, providing mental relaxation, etc., and to promote physical health by providing a ground for physical activities (Tzoulas et al., 2007; De Luca et al., 2021; Luo et al., 2021; Kwon, et al., 2021). Accordingly, urban green space not only affects urban viability, but also plays a key role in citizen's quality of life (Baycan-Levent & Nijkamp, 2004). This fact is confirmed by Rigolon et al. (2018) that state, "Urban green space is a fundamental element of sustainable, healthy, and livable cities" (Rigolon et al., 2018). Therefore, urban greening and providing adequate quality urban green spaces which are fundamental components of urban areas are ways to move towards a future sustainable city (Tzoulas et al. 2007). However, it should be kept in mind that without

proper design, planning policies, and management, these spaces cannot deliver their best, meet the needs of the context and their local users, and cannot be successful (Baycan-Levent & Nijkamp, 2004).

While urban green space has been defined under different terms, in this paper, the term "Urban Green Space" (UGS) or "green space" refers to open spaces in urban environment and cities that are accessible, and vegetation is the main characteristics of them (Taylor & Hochuli, 2017). On the contrary to some definitions and inclusion of certain types of urban green space such as tree canopy, this paper focuses mainly on types of green spaces which can be used by community members and serve for recreation or socialization and have aesthetic values (Rigolon et al., 2018).

2.2. Green space typologies and performance

2.2.1. Green space typologies

According to a definition by Nind and Lewthwaite (2020), A typology is "a classification of practice that distils complex data through the identification of key parts or categories" (p.468). A typology relies on reducing concepts and data to identify their different dimensions, and order diverse cases into several homogenous types (Nind & Lewthwaite, 2020).

There are various typologies of urban green space, each broken into several categories and sub-categories, and yet, there is neither a single framework for these categorizations nor a final listing due to social, environmental, and technological transformation (Rall et al., 2015). However, some of these typologies and categorizations have been reviewed from a larger body of literature to provide a context for creating a new categorization that is aligned with the purpose of this research and fits the scope of this paper. A comprehensive list of categories which is a summary of two different typologies presented by two authors, Bell et al., 2007, and Rall et al., 2015 includes allotment, community gardens, and urban farms; agriculture lands; building greens; private, commercial, industrial, institutional green spaces; green riverbanks; parks, gardens, and recreation; natural, semi-natural, and feral areas; green corridors; blue spaces; and public spaces (Bell et al., 2007; Rall et al., 2015). Table 1 presents the summary of the two typologies by these two authors and illustrates a broad range of green spaces, classified into a detailed list of urban green space categories and sub-categories. While there are also other inventories based on green space usage (Hofmann & Gerstenberg, 2014, as cited in Rall et al., 2015), scale (Byrne & Sipe, 2010, as cited in Rall et al., 2015), and their combination with other open spaces (Bell et al., 2006, as cited in Rall et al., 2015), they are not discussed here in order to keep the scope of the research.

Table 1. Main categories of urban green space and their sub-categories

Author	Main category	Sub-category
Rall et al., 2015	**Allotments and community gardens**	Allotments
		Community garden
	Agriculture lands	Arable land
		Grassland
		Tree meadow/ orchard

		Biofuel production/ agroforestry
		Horticulture
	Building greens	Balcony green
		Ground base green wall
		Façade-bound green wall
		Extensive green roof
		Intensive green roof
		Atrium
	Private, commercial, industrial, institutional green spaces	Bioswale
		Tree alley and street tree, hedge
		Street green and green verge
		House garden
		Railroad bank
		Green playground, school ground
	Green riverbanks	Green riverbanks
	Parks and recreation	Large urban park
		Historical park/ garden
		Pocket park
		Botanical garden/ arboreta
		Zoological garden
		Neighborhood green space
		Institutional green space
		Cemetery and churchyard
		Green sport facility
		Camping area
	Natural, semi-natural, and feral areas	Forest (remnant woodland, managed forests, mixed forms)
		Shrubland
		Abandoned, ruderal, and derelict area
		Rocks
		Sand dunes
		Sand pit, quarry, open cast
		Mine
		Wetland, bog, fen, marsh
	Blue spaces	Lake, pond
		River, stream
		Dry riverbed, rambla
		Canal
		Estuary
		Delta
		Sea cost
Bell et al., 2007	**Parks and gardens**	Urban parks and gardens
		Private gardens
		Country parks
	Natural and semi-natural spaces	Water and wetlands
		Woodland

		Remnant, vacant land, and green belt and wedges
		Post-industrial land
	Green corridors	Tree belts and woodland
		Linear green spaces
		Canal and riverbanks
		Disused railways
	Outdoor sports facilities	School playing fields
		Other playing fields and pitches
		Other sports
	Amenity green spaces	Housing green space
		Informal recreation areas
		Other amenity green space
	Provision for children and young people	Children's play
		Facilities for special activities such as skateboarding
		Facilities for young people
	Allotments, community gardens, and urban farms	Allotments
		Community gardens
		City farms
		Urban agriculture
	Cemeteries, disused churchyards, and other burial grounds	Cemeteries
		Disused churchyards
		Other burial grounds
	Public space	Streets
		Residential roads
		Civic squares
		Seafronts and promenades
		Market places
		Shopping precincts
		Setting for public and heritage buildings
		Other hard surface space

While Bell et al., 2007 and Rall et al., 2015 differentiated urban green spaces into main categories and then divided them into sub-categories, there are other authors that classified urban green spaces as well. However, they classified green spaces through a more specific lens focusing on selected sub-categories rather than through a broader lens with a focus on main categories. This listing consists of cemeteries and churchyards; community gardens; farmlands; forests; gardens including rain gardens, urban gardens, and vertical gardens; green corridors; green roofs; natural and semi-natural areas; parks including community parks, neighborhood parks, pocket parks, and urban parks; play spaces; protected areas; roadside vegetation and street trees; riverbank; roof gardens; amenity green spaces including sport fields and outdoor sport facilities; woodlands; and finally, yards including front yard and backyard (Žlender & Ward Thompson, 2017; Wu & Kim, 2021; Maat & De Vries, 2006; Luo et al., 2021; Ugolini et al., 2020; Zhang & Tan, 2019; De Luca et al., 2021). Table 2 gives a list of urban green spaces according to these various authors.

Table 2. Green space categorization according to different authors' listing

Sub-category	**Author**
Cemeteries and churchyards	• Žlender & Ward Thompson, 2017
Community gardens	• Wu & Kim, 2021 • Žlender & Ward Thompson, 2017
Farmlands	• Wu & Kim, 2021
Forests	• Wu & Kim, 2021
Gardens; *Rain gardens/ Urban gardens/ **Vertical gardens	• Maat & De Vries, 2006 • **Luo et al., 2021 • *Ugolini et al., 2020
Green corridors	• Žlender & Ward Thompson, 2017
Green roofs	• Luo et al., 2021
Natural and semi-natural areas	• Maat & De Vries, 2006 • Zhang & Tan, 2019
Parks; *Community parks/ Neighborhood parks/ Pocket park/ Urban park	• Maat & De Vries, 2006 • Ugolini et al., 2020 • Wu & Kim, 2021 • Žlender & Ward Thompson, 2017 • Zhang & Tan, 2019 • * De Luca et al., 2021
Play spaces	• Žlender & Ward Thompson, 2017
Protected areas	• Žlender & Ward Thompson, 2017
Roadside vegetation/ Street trees	• Ugolini et al., 2020 • Wu & Kim, 2021 • Zhang & Tan, 2019
Riverbank	• Ugolini et al., 2020
Roof gardens	• Luo et al., 2021

	• Zhang & Tan, 2019
Amenity green spaces; Sport fields/outdoor sport facilities	• Žlender & Ward Thompson, 2017
Woodlands	• Zhang & Tan, 2019
Yards; Front and backyard	• Zhang & Tan, 2019

Since a single integrated classification of typology and categorization does not exist, there is a new categorization proposed for the purpose of this research, that is established on the basis of the existing categorizations by Bell et al., 2007 and Rall et al., 2015 which include all relevant categories and sub-categories. This newly established categorization provides a platform for assessing the enhancement of green space quality based on different variables defined by other authors and used in this research. Since the focus of the paper is on types of green spaces that has social, recreational and aesthetic values, the new typology synthesizes the previously discussed typologies and lists the two authors' mutual categories and sub-categories of urban green spaces. Therefore, categories such as agriculture lands, blue spaces, and public spaces, and sub-categories such as atriums, bioswales, street green and green verge, railroad banks, historical parks, pocket parks, botanical and zoological gardens, neighborhood green spaces, institutional green spaces, country parks, disused railways, and informal recreation areas, which are not mutual between these two authors are not discussed in this paper. Some of the sub-categories indicated by Rall et al. (2015) and Bell et al. (2007) such as green playground and school playing fields are also merged to avoid the duplication. Moreover, natural and semi-natural areas are not discussed in this research due to their vast broad field and the time constraint. Green balconies are also exclusive in this new proposed typology as they are owned and managed by their sole resident(s) and they have no obligation for following urban policies and strategies. This new proposed urban green space typology according to the scope of this research is illustrated in Table 3.

Table 3. Proposed urban green space typology according to the project's scope (Adapted from Rall et al., 2015 & Bell et al., 2007)

Main category	**Sub-category**	**Description (see Appendix A for full description)**
A. Building green	1. Green wall	-Known as: vertical greening systems, green vertical systems, vertical greenery systems -A greening system for vertical surfaces that can be ground-based or façade-bound -Division: living walls and green façades

	2. Green roof	-Known as: a living roof, eco-roof, vegetated roof -An engineered system to be installed on a waterproofed constructed structure -Division: into intensive, extensive, and semi-intensive green roofs
B. Park, garden, and recreational space	1. Urban Park	-Large green areas in an urban setting -May include trees, shrubs or grasses, playgrounds, etc. -Purpose: recreational for urban population
	2. Private garden	-Known as: home garden, house garden, or domestic garden -Private open space near a place of residence maintained by the owner/owners
	3. Green playground /School playing field/Camping area	-Purpose: green areas for playing, outdoor activities, camping activities
C. Urban agriculture	1. Allotment garden	-Separate parcels of land allocated to individuals or households for personal use -Purpose: recreation and non-commercial food production
	2. Community garden	-Cultivated by a group of individuals collectively -Purpose: recreation and food production
D. Green corridor	1. Green canal and riverbank	-Vegetation and green spaces along a river, canal, or stream
	2. Tree alley and street tree	-Usually has a pedestrian or bicycle path
E. Cemetery and churchyard	1. Cemetery and churchyard	-Green lands covered with lawns, trees, and ornamental plants

2.2.2. Variables affecting the performance of urban green space

There are several variables that impact the performance and quality of urban green space. Some authors have identified some of these variables which include accessibility, quantity (Campagnaro et al.,2019; Rigolon et al., 2018; Žlender & Ward Thompson, 2017), and quality (Rigolon et al., 2018; Žlender & Ward Thompson, 2017), while others look at urban green space quality and performance through a different lens, a policy evaluation perspective, and focus on policy and management related variables including quantity and availability of green spaces, importance of green spaces, changes in green spaces, financing green spaces, planning green spaces, and performance of green spaces (Baycan-Levent & Nijkamp, 2009). In general, the performance and relatively the use of green spaces depend on combination of these different variables (Žlender & Ward Thompson, 2017), nonetheless, the majority of studies consider quantity, quality, and accessibility as the most influential variables associated with the performance of urban green space. Table 4 presents a cohesive list of variables by different authors.

Table 4. Cohesive list of variables by different authors

Variable	**Author**
Quantity (availability)	-Campagnaro et al.,2019
Accessibility	-Rigolon et al., 2018 -Žlender & Ward Thompson, 2017
Quality	-Rigolon et al., 2018 -Žlender & Ward Thompson, 2017
Preservation of urban green spaces' current situation or their development	-Campagnaro et al.,2019
Quantity and availability	-Baycan-Levent & Nijkamp, 2009
Importance of green spaces	
Changes in green spaces	
Financing green spaces	
Planning green spaces	
Level of performance	

There are several indicators for each of the variables. Identifying these indicators and monitoring them help to understand whether there are any planning and management goals and whether they are applied in their implications. Accordingly, they provide a guideline to assess planning and management practices. However, it should be kept in mind that there is not a single framework for these indicators since they are context-specific based on local needs and values (Campagnaro et al., 2019).

While Baycan-Levent and Nijkamp (2009) introduces a list of variables and indicators affecting the quality and performance of urban green spaces from a policy perspective

(Table 5), Campagnaro et al. (2019) introduces a more common inventory (Table 6). Campagnaro et al. (2019) who has conducted a study on indicators for urban green space planning and management, makes a list of three variables consisting of availability, accessibility, and the preservation of urban green spaces' current situation or their development, and creates a detailed set of 11 indicators for these variables. In his research, the importance of tree diversity and having access to urban green spaces, especially regarding equity, is highlighted. These proposed indicators are appropriate for assessing green spaces in city or municipal scale (Campagnaro et al.,2019). Furthermore, some other authors center size (Baycan-Levent & Nijkamp, 2009; Campagnaro et al.,2019; Rigolon et al., 2018; Žlender & Ward Thompson, 2017) and number as indicators for quantity (Rigolon et al., 2018); proximity or distance (Baycan-Levent & Nijkamp, 2009; Campagnaro et al.,2019; Rigolon et al., 2018; Žlender & Ward Thompson, 2017), connectivity (Baycan-Levent & Nijkamp, 2009; Žlender & Ward Thompson, 2017), and ease of access (Žlender & Ward Thompson, 2017) as indicators for accessibility; and safety (Rigolon et al., 2018; Žlender & Ward Thompson, 2017), amenities (Rigolon et al., 2018) and attractiveness (Žlender & Ward Thompson, 2017), and maintenance standards as indicators for quality (Rigolon et al., 2018).

Table 5. Variables of urban green space planning and management (Baycan-Levent & Nijkamp, 2009).

Variables	**Indicators**
Quantity and availability of green spaces	Proportion (total area %)
	Proportion per 1,000 inhabitants (m^2)
Importance of green spaces	Importance to the city compared to other land use functions from planning authorities' viewpoints (very important/ important/ medium/ less important/ not important)
Changes in green spaces	Recent changes in total area in the last 10 years (increase/ decrease/ no change)
Financing of green spaces	Budges changes in the last 2 years (increase/ decrease/ no change)
Planning of green spaces	Existence of special planning instruments (urban green spaces as special planning issue and integrated in urban planning) (yes/no)
	Number of responsible departments (only 1 department/ more than 1 department)
	Experience with citizen participation (yes/no)
Level of performance	Success level based on supply and maintenance strategies (degree a policy target is reached) (very successful/ moderately successful/ marginally successful/ low successful/ no success at all)

Table 6. Indicators for urban green space planning and management (Campagnaro et al.,2019)

Variables	**Indicators**
Availability	Public green area per capita [m^2/inh.]
	Percentage of public green areas [%]
Accessibility	Residents within 300 m distance [%]
Preservation of urban green spaces' current situation or their development	Trees per 100 residents
	Trees on streets [trees/km]
	Tree density in green spaces [trees/ha]
	Number of species per 100 trees *
	Number of species over 5% *
	Equitability * (distribution of trees)
	Tree DBH distribution *
	Canopy cover [%]

For the purpose of this study and based on the more prevalent framework of urban green space performance variables, which is alike between several different authors, and in order to provide feasible criteria and measurable indicators regarding the limitations of the three case studies, availability of data, and possibility of making comparisons between the cases while staying within the scope of this research, a new framework is proposed. This framework synthesizes the most relevant variables which are quantity; accessibility; (Baycan-Levent & Nijkamp, 2009; Campagnaro et al.,2019; Rigolon et al., 2018; Žlender & Ward Thompson, 2017); and quality (Baycan-Levent & Nijkamp, 2009; Rigolon et al., 2018; Žlender & Ward Thompson, 2017), and respectively their criteria including size (as a criterion for quantity); proximity and ease of access (as criteria for accessibility); safety, attractiveness, and ecosystem health (as criteria for quality) (Baycan-Levent & Nijkamp, 2009; Campagnaro et al.,2019; Rigolon et al., 2018; Žlender & Ward Thompson, 2017). Planning of green spaces (Baycan-Levent & Nijkamp, 2009) as one of the variable and existence of special planning instruments (Baycan-Levent & Nijkamp, 2009) as its indicator are excluded in the new framework as covering the other variables releases planning purposes and instruments.

Quantity:

Quantity and availability of urban green space in a city refers to the size of these spaces in the city that are within reach (Rigolon et al., 2018). The size of urban green spaces can be measured by their area in the total area of the city (also can be measured by their proportion in the total area) and their area per inhabitants (Baycan-Levent & Nijkamp, 2009). This area can be measured using GIS, land-use and land-cover maps (Kwon et al., 2021).

Accessibility:

Accessibility is an important variable to consider due to the ever-changing and continuous urbanization and to the investigation showing some sorts of green spaces such as green corridors and wedges can promote sustainable modes of transportation

like walking or cycling, by linking urban elements (Žlender & Ward Thompson, 2017). Accessibility to urban green space relates to proximity on one side, which is assumed to be associated with human health (Kwon et al., 2021) and to ease of access on the other side. Distance that people travel to get to a space is an indicator for measuring proximity. This is an important criterion to consider for the performance of urban green spaces as there are some studies assuming that accessibility to green space is related to the provision of green spaces that is within walking distance of residential areas (Campagnaro et al.,2019; Rigolon et al., 2018). For measuring ease of access, there are two indicators one of which is the transportation mode that refers to different possibilities for reaching a space i.e., by walking, using private vehicles, or using public transportation. Another indicator for measuring ease of access is connected network. A study by Žlender and Ward Thompson (2017) assumes that city dwellers less frequently use certain green spaces as there is not easy and quick access to them. A network of urban green spaces linking residentials with business and leisure can encourage people to walk to or ride a bicycle which helps to improve accessibility (Baycan-Levent & Nijkamp, 2009).

Quality:

Quality of urban green space in a city is associated with different criteria such as safety (Rigolon et al., 2018), attractiveness (Zlender et al., 2016), and ecosystem health (Campagnaro et al., 2019). Apart from the ecosystem services provided by green spaces and many physical and mental health benefits they bring for humans, these spaces have the potential to carry negative impacts and disadvantages to the users. One of these disadvantages is the perceived fear and not having the feeling of safety while using the space which discourage the users to come and enjoy the green space. Hence, safety is one of the main criteria affecting the quality variable and thus, performance of urban green spaces. This indicator can be measured through various criteria one of which is the visibility that is related to provided lighting, visible frontage, etc. (Murathaveeran, 2010). In addition, indicators that correspond to attractiveness are different amenities an urban space provides to city dwellers (Rigolon et al., 2018) such as recreation opportunities (Rigolon et al., 2018; Sugiyama et al., 2010), urban furniture (Maruthaveeran, 2010, Rigolon et al., 2018), and bicycle and/or motorcycle parking space (Maruthaveeran, 2010); public facilities provided in that space such as shops and stalls, public toilet and telephone, lodging, and prayer room (Maruthaveeran, 2010); and maintenance (Maruthaveeran, 2010; Sugiyama et al., 2010). Although maintenance is so generic by itself, maintenance of walking and cycling path and maintenance of natural features such as watercourses and tree shades are considered as indicators to assess attractiveness (Sugiyama et al., 2010).

In addition to safety and attractiveness, ecosystem health is another important criterion for urban green space quality which is multi-dimensional and considers ecology, economy, and human health simultaneously. Even though there is not a definite standard for assessing urban ecosystem health due to the everchanging human needs and expectations from urban ecosystem (Su et al., 2010), several studies have covered data about ecosystem health criteria and indicators. A study by Su et al. (2010) lists ecological sustainability, public health, community management, and social equity as criteria that shape a healthy ecosystem (Su et al., 2010), while another study by Zeng et al. (2016) talks about “function and service” and “structure and resilience” as two

urban ecosystem health criteria, and points green area per capita and built-up area green coverage rate as indicators for function and service, and cropland, grassland, and forest cover percentage as indicators for structure and resilience (Zeng et al., 2016). Tree density in green spaces, canopy cover, and number of species are considered as indicators urban ecology by contributing to ecosystem services provision (Campagnaro et al., 2019).

Green infrastructure, on the other side, can play a role on urban ecosystem health (Tzoulas et al., 2007) by its capacity to affect human health – through providing various ecosystem services – and urban ecology. A green infrastructure with its elements contributes to biological diversity conservation by providing vegetation cover and thus, habitats for various species. Knowing that ecosystems which are rich in species, better maintain their organizations compared to the ones which are less diverse, a green infrastructure helps biological diversity and so the integrity and resiliency of a habitat system resulting in a positive influence on ecosystem health. Accordingly, a green infrastructure play an important role on both ecosystem health and public health by offering ecosystem services and ecological functions (Tzoulas et al., 2007).

Air quality, soil structure, energy and material cycling, water quality, habitat and species diversity, and ecosystem resilience are indicators for assessing ecosystem health (Tzoulas et al., 2007). On the other hand, habitat and species diversity as one of the indicators for ecosystem health sheds light on the importance of native species versus invasive species. Invasive plant species, for instance, can cause threat to native species and can negatively affect ecosystem service by changing availability of resources and accordingly affect ecosystem health (Pysek & Richardson, 2010). Synthesizing different studies about ecosystem health indicators, vegetation cover regarding cropland and grassland (Zeng et al., 2016), and tree density and canopy cover (Campagnaro et al., 2019); environmental quality regarding air and water quality (Tzoulas et al., 2007; WHO, 2000); habitat and species diversity (Tzoulas et al., 2007); invasive and native species (Pysek & Richardson, 2010); and ecological corridor/network (Tzoulas et al., 2007) are selected for the purpose of this research as indicators affecting urban ecosystem health to highlight the link between green infrastructure and focus on the factors representing urban greening concepts. Moreover, among the many indicators, the ones which are easy to measure and probable to be observed in official plans and municipality documents are selected.

Table 7 which synthesizes the most relevant variables and criteria affecting the performance of urban green space, and indicators for measuring their performance, is the proposed framework for the purpose of this study.

Table 7. Proposed framework of variables and indicators affecting the performance of urban green space

Variables	**Criteria**	**Indicators**
Quantity	Size	Green space area
		Green space per capita (m^2/inh)
Accessibility	Proximity	Distance (refers to distance people travel to get to the green space)

	Ease of access	Transportation mode (refers to different possibilities for reaching the green space)
		Connected network
Quality	Safety	Visibility (e.g., improved lighting, visible frontage)
	Attractiveness	Amenities • Recreation opportunities • Urban furniture • Bike/motorcycle parking space
		Public facilities • Shops and stalls • Public toilet and telephone • Lodging • Prayer room
		Maintenance • Walking and cycling path • Natural feature (i.e., watercourses, shade)
	Ecosystem health	Vegetation cover • Cropland and grassland • Tree density and canopy cover
		Environmental quality • Air quality • Water quality
		Habitat and species diversity
		Invasive and native species
		Ecological corridor/network

3. Materials and methods

For this research, a multiple-case study is conducted to study and analyze urban green spaces in different cases, compare the cases, and explain the similarities and differences among the cases based on the results in a discussion format. Selecting cases, gathering data, and doing analysis are the steps to take for conducting a multiple-case study (Goodrick et al., 2020). Three cities of Toronto (Canada), Milan (Italy), and Isfahan (Iran) are selected as the case studies due to the gap in literature of comparing urban green spaces in different social and environmental contexts. Content analysis is selected as the research method for this paper. It is guided by the frameworks for exploring urban green space typologies and performance variables, as synthesized from the literature in the previous section. Primary and secondary documents are selected for each case to be reviewed and coded. Case analysis results present a brief description of each case's context followed by the results from coding. At last, cross-case analysis and pattern matching is conducted to show the similarities and differences between the cases' results which is complemented by an explanation for observed similarities and differences.

3.1. Research method

The methodology approach of this research is multiple-case study focusing on green space typologies and performance variables. This methodology is selected firstly as it provides causal explanation and inferences with "how" and "why" questions behind the observed patterns as in statement of purpose and research objectives. Secondly, the focus of the research is on a contemporary phenomenon, as in this research is the role of green space in sustainable cities and on citizens' quality of life, on which the researcher has little control and cannot manipulate the relevant behaviors (Yin, 2009). As Yin states (2009), the case study method is an empirical in-depth investigation of a contemporary phenomenon and in a real-life context. "How" and "why" questions being more explanatory, this methodology focuses on creating explanatory claims for the *evidence-informed* cases and makes an assumption of realism which in a social context is adaptive and context-based. Context not only refers to a geographic setting, but also refers to sociocultural dimensions, social values, and social relationships (Goodrick et al., 2020; Yin, 2009). There are many variables of interest in case study methodology, hence, various sources of evidence can be used such as documents, direct observation, and interviews with involved stakeholders (Yin, 2009). However, to stay within the scope of this research as well as reflect the focus on planning and policies, documents are selected as the main source of evidence.

While conducting multiple-case study research, it is necessary to explain the instrument for conducting this research as well as the procedures, which is called a case study protocol. In a multiple-case study, the number of case study questions is few as provided information about various cases cannot be in great depth (Yin, 2009). The objectives are set out in Section 1.3. guide this investigation and the following sections set out the protocol.

3.2. Case study selection

Selecting the cases for study requires sufficient access to various types of data whether it is documents, field observations, or interviews (Yin, 2009). Toronto (Canada), Milan (Italy), and Isfahan (Iran) are the case studies of this research which are selected primarily due to pragmatic reason of having access to local data. Case selection began with noticing the research gap on urban green space comparison between different countries in different continents each with specific demography, geographical and environmental characteristics, socio-cultural and economic characteristics, and urban patterns. In this comparison similarities and differences are both important to be considered as this is including both that reveals the real difference in policy approaches and shows policy and planning priorities.

Regarding the similarities between the three cases, all three cities are large metropolitan areas that are classified as areas with population above 1,500,000 (OECD, 2012; Karimi et al., 2021; Mohammad, 2014). As the research mainly focuses on the challenges of modern urbanization in large metropolitan areas, due to the fact that they are attracting higher population to their centers affecting the quantity and quality of urban green spaces, this similarity is an important criterion to consider while choosing the cases. Furthermore, urban population in these cities ranges between 2,203,552 and 6,291,669 (PopulationStat, 2022) that is another important similar criterion to consider for selecting the cases as this research declares that the broad global challenge for sustainability in cities is overpopulation (Besir & Cuce, 2018; United Nations, 2019).

Regarding the differences, each city is located in different countries of different continents – North America, Europe, and Asia – that makes them interesting to compare as every different country, let along continent, has unique climate characteristics that affect green spaces as well as particular geopolitical situation. This is a vital different criterion to consider for selecting cases to study and compare. Besides, two of these countries, Italy and Canada, are considered as Global North countries while on the contrary Iran is listed in Global South countries (OWSD, n.d.). According to Rigolon et al. (2018), Global South countries are the countries with lower levels of wealth and economic development in compared to North American and European countries which constitute the Global North. Considering this difference is important as economy play an important role for addressing urban challenges. Table 8 presents geographic and demographic information of the three cities.

Table 8. Demographic and geographic information of Toronto, Milan, and Isfahan ("Climate Toronto", 2021; "Milan Climate", 2021; "Isfahan climate", 2021; "Toronto at a glance", n.d.; Comero, 2015; Golestan-nezhad, A., 2015; "Toronto, Canada population", 2022; "Esfahan, Iran population", 2022)

	Toronto	**Milan**	**Isfahan**
Continent	North America	Europe	Asia
Average annual precipitation (mm)	845	1,160	97
City area (km^2)	630	181.67	550
Population in city area	2,600,000	1,371,498	1,547,165
City density (inh/km^2)	4,127	7,550	2,813

3.3.Data collection and analysis

An effective way of collecting data for case study research is by providing sources of evidence such as documents and observations each related to the question of interest (Yin, 2009). In order to collect data and respond to the main question of the paper, content analysis is selected as the research method.

Content analysis, which provides a framework for analyzing text (Anandarajan et al., 2018), evaluates the pattern and the frequency of an idea in specific content (Forman & Damschroder, 2007). Content analysis "…is a particularly effective technique to gauge the extent to which conceptual principles are expressed within policy documents and municipal official plan" (Plummer et al., 2010, p. 537). To explore typologies of urban green space, a preliminary analysis of relevant texts is done and in order to keep the data to a manageable size, a new framework synthesized from the existing literature is proposed to be studied (Table 3). The same process is followed for investigating the variables affecting the performance of urban green space (Table 7).

3.4.Case study data collection and analysis

Content analysis in each case is employed independently to find out about different categories of urban green space, to study urban green space performance variables and criteria, to assess their performance through analyzing the indicators, and finally, to compare similarities and differences between the cases. Based on the literature review, all the possible codes are extracted (Appendix B, Table B1 and Table B2). For this purpose, specific municipality documents of each case are studied and coded. A primary document which is selected for each case to be studied shows existing and future urban planning policies and strategies in each city. In addition to the primary document, a secondary document for each case is selected to study about consideration of performance criteria and indicators in the most frequent urban green space category which is selected based on the results from analyzing the frequency of urban green space categories on the primary document, which in this research is the parks category. In order to assure that the materials are reliable, the ones which are published by municipalities is used. Due to various locations of case studies and not being able to collect paper-based material directly from municipalities, only online material on municipalities' webpages is studied and analyzed.

The primary municipality document for analyzing the city of Toronto's urban green space categories and performance criteria and indicators, is the "Toronto Official Plan" (City of Toronto, 2022). In addition to this document, the "Parkland Strategy" (City of Toronto – Parks, Forestry, and Recreation, 2019) document is studied to find out about performance criteria and indicators specifically in parks. This document, which is a 20-year plan for improving existing parks and planning for new parks and expansion ("Parkland strategy", n.d.), is reviewed as a secondary document. For the case of Milan, the primary document is Milan's "Piano di Governo Territorio (PGT) – Milano 2030: Documento di piano" (Comune di Milano, 2019) which is the general report of the latest approved planning document by the municipality of Milan, and the secondary document is Milan's "Paesaggi Futuri – Documento d'indirizzo strategico", translated to Milan's *Future Landscapes – Strategic guidance document* (Comune di Milano, 2016), that is retrieved from the municipality of Milan and covers a considerable

amount of information for Milan's parks. In addition, in order to study urban green space categories and performance criteria and indicators in Isfahan, "Isfahan Master Plan" (Isfahan Municipality, 2012) is reviewed as the primary document. This municipality document is based on a comprehensive plan consisting of principles for land uses, traffic network, etc. The secondary document for analyzing park category's policy and planning, is "ضوابط طراحی فضاهای سبز شهری" which is translated into *Criteria for Designing Urban Green Spaces* (Strategic Planning and Supervision Organization, 2011). Due to the intention of focusing on parks planning and strategy for analyzing the secondary document for each case, the secondary documents of Milan and Isfahan are skimmed thoroughly, as they are not solely about parks on the contrary to Toronto Parkland Strategy, and sections related to parks are studied in detail and coded.

Analyzing each of the three cases of Toronto, Milan, and Isfahan's municipality documents, the presence of urban green space categories in accordance with the newly proposed categorization (Table 3) is first screened. Due to the language differences and the possibility of using different terms and phrases, the definition of each category from Table 3 is studied prior to studying the municipality document. Appendix C, Table C1, C2, and C3 show related terms and phrases used in each city's municipality documents for each of the categories which are used in the process of coding. Data is assessed for coding and all possible codes are extracted (Elo & Kyngäs, 2008). For managing the data, assigning codes to data, and interpreting the data, QDA Minor Lite software is used (Forman & Damschroder, 2007). However, in the case of Isfahan, coding is done manually and in Microsoft Word due to language restriction of the software. Coded statements for urban green space categories are commented as "number and proportion of occurrences in official plan/PGT/master plan" in the documents for the categories that are mentioned in an implicit sense with no reference to the future design and/or planning and are commented as "number and proportion of occurrences in future planning" for the categories that shows a reference to the future design and/or planning. Differentiating these statements help to figure out which categories are considered more in the future of urban green spaces. The result from this software is analyzed independently for each case study.

The same process is followed for analyzing the criteria and indicators affecting the performance of urban green space – following Table 7 as a reference table – in each case. Each case's primary document is reviewed and coded first for the criteria as a more general view for indicators. Corresponding statements are assigned to codes regarding performance criteria which are divided into explicit, implicit, and neutral. Explicit statements are differentiated from implicit and neutral statements considering the specific words or statements such as "must", "will", and "require", (Plummer et al., 2011) "should", "need", and statements that imply essentiality and principles, while implicit statements contain specific words such as "intend", "consider", "vision", "aim", "objective", "may", "expect". The rest of the statements are considered as neutral. Due to language difference, these words are searched for in the case of Toronto and their synonyms in Italian language for the case of Milan and in Persian for the case of Isfahan are looked for. For the case of Milan, words such as "rechiedere" (meaning require), "dovere" (must), "sviluppare" (meaning develop), "necessario" (meaning necessary) refer to explicit statements and "considerare" (meaning consider), "prevedere" (meaning expect), "proporre" (meaning propose), "intervenire" (meaning intervene), "intendere" (meaning intend), and statements that imply visions and

possible actions refer to implicit statements. The rest are considered neutral. Besides, in Isfahan's documents, words such as "بایستی" (meaning must), "الزامی است" (meaning it is necessary), and similar notions are considered as explicit, and "توصیه میگردد" (meaning recommend), "بهتر است" (it is better to), and similar statements are considered as implicit.

In addition to coding for criteria, a coding process is done at the indicator level to show results of the coding at the most detailed level. The reason for coding at indicators level is that indicators signal the presence of a criteria, and those criteria connote the extent to which a variable is present. Moreover, in the process of coding at criteria level it is observed some of the criteria are expressed in a broad sense without referring to a specific indicator. Therefore, such statements count as codes for criteria but not for indicators.

In order to be able to calculate the magnitude of each criterion and indicator, explicit statements receive a score of 2, implicit statements receive a score of 1, and neutral statements receive a score of 0. The following formulas are used for calculating the magnitude, "where M_k is the magnitude score for indicator k, N_{kE} is the number of explicit occurrences for indicator k, N_{kI} is the number of implicit occurrences for indicator k, N_{k0} is the number of empty occurrences for indicator k, and N_k is the total number of occurrences for indicator k (Plummer et al., 2011, p.5).

$$M_k = \frac{2N_{kE} + N_{kI}}{2N_k} \times 100\%$$

$$N_k = N_{kE} + N_{kI} + N_{k0}$$

Followingly, cross-case analysis is undertaken to identify similarities and differences between the cases. Cross-case analysis considers the consistency of results regarding urban green space typology and variables affecting the performance of urban green space. Replication across cases enables results to be stated more assertively, with cross-case consistency (Yin, 1994). Pattern-matching is used in order to compare the results, as suggested in multiple-case study (Yin, 2009). A pattern is conceived as "an arrangement of occurrences, incidents, behavioral actions, or the outcomes of interventions that are apparent in the raw data" (Almutairi et al., 2014, p. 240). Given the nature of this research, it is complemented with explanation building, a special type of pattern matching in which an explanation is built about how and/or why (Yin, 2009; Miles and Huberman, 1994). Ultimately, an explanation is built to make understandable the observed similarities and differences.

3.5.Limitations and delimitations

There are some limitations for this research to notice. The main limitation, that at the same time is the intent of this research, is the three cases being located in three different countries and continents making it impractical to go and visit in person and collect related material. Hence, no field observation is done for analyzing and comparing urban green space categories and performance variables and only online official documents

are reviewed for case analysis. Even though the latest version of the official documents is studied and analyzed, the year of their publishes are different among the cases. The results from analyzing the cases based on these documents might not be the same as reality of today; however, some discussion has been presented based on personal observation, knowledge, and experience about the contexts. Besides, the types of secondary documents selected to be studied is another limitation. While the secondary document for the case of Toronto focuses specifically on parks in this city, there are not found municipality documents that are solely dedicated to parks planning and policies for the cities of Milan and Isfahan; however, the selected secondary documents for this research contain a great deal of information about parks. This leaves a possibility of finding other secondary documents that may be more focused on this green space category. In addition, even though all relevant documents could be found easily for the case of Toronto, it was a bit harder for the case of Milan and much harder to for the case of Isfahan, first due to limitations of updated material posted by municipality's webpages, and second and most importantly, due to the ongoing political upheaval in Iran and restriction for accessing government-related websites through an IP outside of the country. Also, it was not possible to ask for help from a family/friend in Iran for such searching due to internal internet shutdown at the time and a continuous internet constraint as of now. Another limitation of this research is the language differences especially for the case of Milan. Although there is a knowledge of Italian language, it is neither a mother-tongue language as Persian nor the proficiency is the same with English language. It is tried to understand the policy documents as much as possible, but there might be some misunderstanding of specific terms and notions. Besides, some non-English material is used as references for this research, including some in Latin and non-Latin scripts, which are translated into English, however, their original language is cited in the reference list and wherever mentioned for the first time in text, their translations are followed by the original scripts.

4. Results

In this section, the results of the content analysis of the three case studies – Toronto, Milan, and Isfahan – are presented separately. There are three sections for each of the cases' analyses that correspond with this study. The first section is the context. In this section, a general description of each case study is presented consisting of geographic information, urban area and population, development pattern, and a brief explanation of the economy. This information is covered to reflect the similarities and differences between the cases based on which the case studies are primarily selected for this research. Furthermore, as the cases are located on different continents, a geographical map of three different scales is included to better demonstrate their location.

The second section presents categories of urban green space in each case study. A primary document for each case is studied and searched for the occurrences of urban green space categories. The results are illustrated first in a bar chart showing the frequency of each category within the associated document and then are presented in a table format to show the number of occurrences of each category with more details. The occurrences either show urban green space categories implicitly mentioned in this document – with a corresponding statement of "proportion of occurrences in the policy document" – or are considered in future planning policies and/or regulations – with a corresponding statement of "proportion of occurrences in future planning of the policy document". The results reflect the importance of each category for the future planning of each case.

The third section reveals the results of analyzing urban green space performance variables and indicators in each case study. Similar to the second section, the third section represents the results of analyzing the primary document for each case in search of the urban green space performance indicators demonstrated in a bar chart showing the frequency of urban green space performance indicators in each case. Followingly, a table is provided that lists the number of occurrences for each urban green space performance indicator in the associated policy document and differentiates and counts the corresponding statements by explicit, implicit, and neutral. This table helps attain the following bar chart that reveals the magnitude scores of urban green space performance criteria in each case's policy document. Thereafter, the same data is provided for performance indicators in the category of parks for which the analyzed document is the secondary document that is different in each case and is explained in the methods.

4.1.Case study of Toronto

4.1.1. Context

Toronto in Canada (North America) is located in the province of Ontario northwest of Lake Ontario which can be seen on Map 1. Toronto has warm summers with daytime and nighttime temperatures between 25.6℃ to 14.6℃, and long and cold winters with day and night temperatures between 2.2℃ to -7.7℃. It has precipitation throughout the year with a yearly average of 845 mm and yearly average humidity of 71% ("Climate Toronto", 2021). Figure 1 illustrates the geographical location of the city of Toronto.

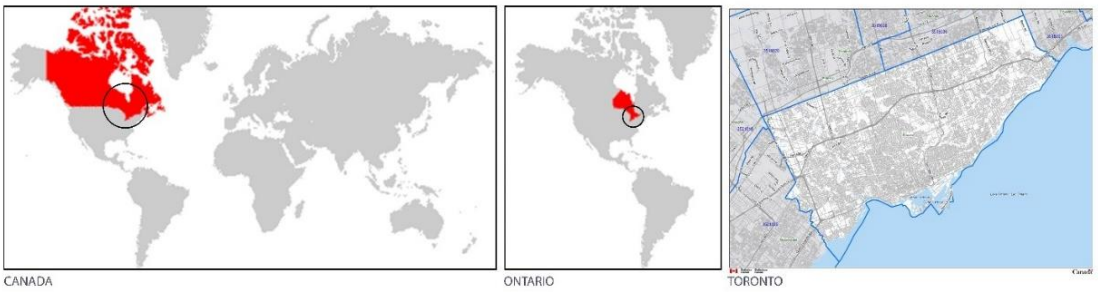

Figure 1. Toronto's geographical location (Reference map adapted from "Canada map", n.d.; "Ontario map", n.d., Statistics Canada, 2021); Left) The country of Canada is highlighted in red on the world map and the circle shows the location of the province of Ontario. Middle) The province of Ontario is highlighted in red on the map of North America and the circle shows the location of the city of Toronto. Right) The city of Toronto territory

The region of Toronto with an area of 5,903 km^2 ("Toronto at a glance", n.d.) is considered a large urban population center with a population of 6,334,755 in 2022 in its urban area while the city of Toronto has a population of 2,600,000 ("Toronto, Canada population", 2022) over the land area of 630 km^2 ("Toronto at a glance", n.d.) resulting in a density of 4,127 inh/km^2. Toronto is considered the most populous city in Canada, and it is a focal point of GTA's (Greater Toronto Area) development (Toronto City Planning, 2021). 51.5% of the population in the city of Toronto consists of immigrants making this city a multicultural city ("Toronto at a glance", n.d.) Besides, Toronto is among the top 10 most livable cities in the world ("World rankings", n.d.).

Toronto has experienced residential and non-residential development through the years. According to the Development Pipeline 2021, intensification has happened across the city of Toronto, yet gradually. However, the purpose is to direct the growth to designated areas away from residential neighborhoods and green spaces (Toronto City Planning, 2021). There are some other challenges that the city of Toronto encounters such as climate change and pollution that poses threats to marine life, terrestrial ecosystems, and citizens' health, lack of access to green spaces, biodiversity loss, and habitat fragmentations. The importance of urban green spaces is highlighted in the city of Toronto knowing that green infrastructure is a mean for mitigating these socio-environmental challenges (Woodhouse, 2019).

4.1.2. Categories of urban green space

Toronto's green space system is comprised of various categories. Studying Toronto Official Plan document and searching for urban green space categories that exist in this city according to this document, whether they are considered in future planning of the city or mentioned implicitly in the documents and confronting them with the reference table – which is Table 3 – it is observed that all the categories are considered in the official plan document except green walls, and green canals and riverbanks. While green walls are not mentioned in any of the chapters of this document, green canals and riverbanks exist under different categorizations such as "green waterfront" or "hydro corridor" which is mentioned a few times in some chapters. However, they are not

coded as green canals and riverbanks but instead, as parks whenever accompanied by the term “parks”.

Figure 2 shows the frequency of each of the urban green space categories in Toronto Official Plan, and it discloses that parks categorization has the highest frequency being mentioned in all chapters of the studied official plan. The Parks category, which itself divides into several smaller categories, is mentioned 131 times in Toronto Official Plan, more than 10 times more often than other categories, and is the most frequent urban green space category in the city of Toronto. Green roofs, community gardens, and green playgrounds/ school playing fields/ camping areas are mentioned fairly often in Toronto Official Plan. Cemetery and private gardens are rarely mentioned in the official plan followed by tree alley and allotment garden. As mentioned before, no instances of green walls and green canals and riverbanks were found. However, in the process of coding, another category that cannot be seen in Table 3 is found which is the ravine system.

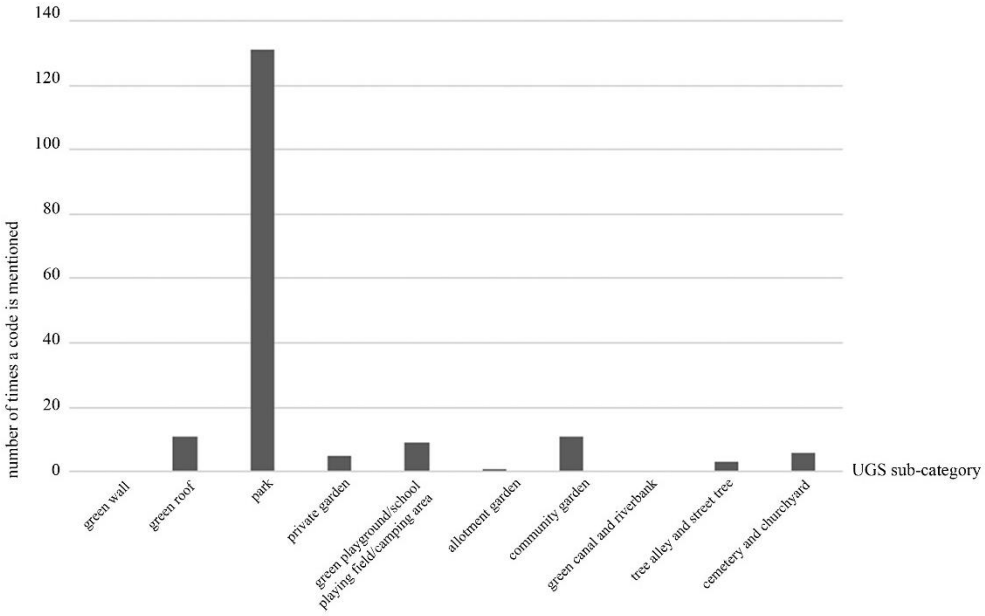

Figure 2. Frequency of urban green space categories in Toronto Official Plan

When the categories are mentioned implicitly in official plan documents with no reference to the future design and planning, they are commented as “number and proportion of occurrences in official plan” – for example, “As Downtown’s population increases, more residents are using its parks and open spaces as their shared backyards and gathering areas” (City of Toronto, 2022, Chapter 2, p. 14) – and the rest are commented as “number and proportion of occurrences in future planning” – for example, “The Centre ’s intensity will be balanced with a generously landscaped, enhanced public realm and new parks and open spaces” (City of Toronto, 2022, Chapter 2, p. 18). While allotment gardens and cemeteries are not considered in future planning of the city, the parks category is the most important green space being considered in future planning. Table 9 presents the number of times an urban green space category is mentioned in the analyzed document – consisting of five chapters of the official plan.

Table 9. Number of occurrences of each urban green space category in Toronto Official Plan

Urban green space category	Total number of occurrences in Toronto Official Plan	Number and proportion (%) of occurrences in Toronto Official Plan	Number and proportion (%) of occurrences in future planning in Toronto Official Plan
Green wall	0	0 (0%)	0 (0%)
Green roof	11	8 (73%)	3 (27%)
Park	131	92 (70%)	39 (30%)
Private garden	5	4 (80%)	1 (20%)
Green playground	9	8 (89%)	1 (11%)
Allotment garden	1	1 (100%)	0 (0%)
Community garden	11	8 (73%)	3 (27%)
Green canal and riverbank	0	0 (0%)	0 (0%)
Tree alley and street tree	3	2 (67%)	1 (33%)
Cemetery and churchyard	6	6 (100%)	0 (0%)

4.1.3. Performance variables in urban green space

4.1.3.1. *Toronto Official Plan*

In order to discover which urban green space performance criteria and indicators are considered by Toronto's municipality documents, first the official plan is reviewed and coded into the six criteria. The result shows that ecosystem health and ease of access are the most common indicators in the document, representing approximately 26% and 25% respectively of the total occurrences, following attractiveness, size, safety, and finally proximity which represents below 2% of the occurrences.

Moreover, it is important to determine the magnitude of each of the performance criteria the city of Toronto considers in its official plan. Thus, codes are differentiated by corresponding statements of "implicit" – such as "The Authority's "Living City" vision focuses on three objectives: healthy watercourses and shorelines, regional biodiversity, and sustainable communities" (City of Toronto, 2022, Chapter 3, p. 48) –, "explicit" – "We must not only protect the existing urban forest, by also enhance it, especially by planting native trees and trees that increase canopy coverage and diversity, or other non-invasive species where urban conditions may limit the survival of native species" (City of Toronto, 2022, Chapter 3, p. 43)–, and "neutral" – such as "More than three million trees dominate our ravines, line our boulevards and beautify our parks" (City of Toronto, 2022, Chapter 3, p. 43), which helps calculate their magnitude. The majority of the explicit statements refer to ease of access while the minority refers to proximity being expressed only two times in explicit phrases. However, in general, it is observed that all of the indicators are occurred more explicitly in the text except for the ecosystem health which is mostly expressed in a neutral statement. When analyzing Toronto

Official Plan, another indicator that affect the performance of a green space is observed which is not included in Table 7, and that is sense of belonging.

Figure 3 presents the number of occurrences for each urban green space performance criteria in Toronto Official Plan, illustrates the magnitude of each criterion and shows the percentage of explicit occurrences of each criterion in Toronto Official Plan. In general, the quality variable consisting of safety, attractiveness, and ecosystem health criteria, has the highest frequency in Toronto Official Plan while the accessibility variable consisting of proximity and ease of access criteria, has the second highest frequency, and lastly, the quantity variable consisting of size criterion has the third and the least frequency in this document.

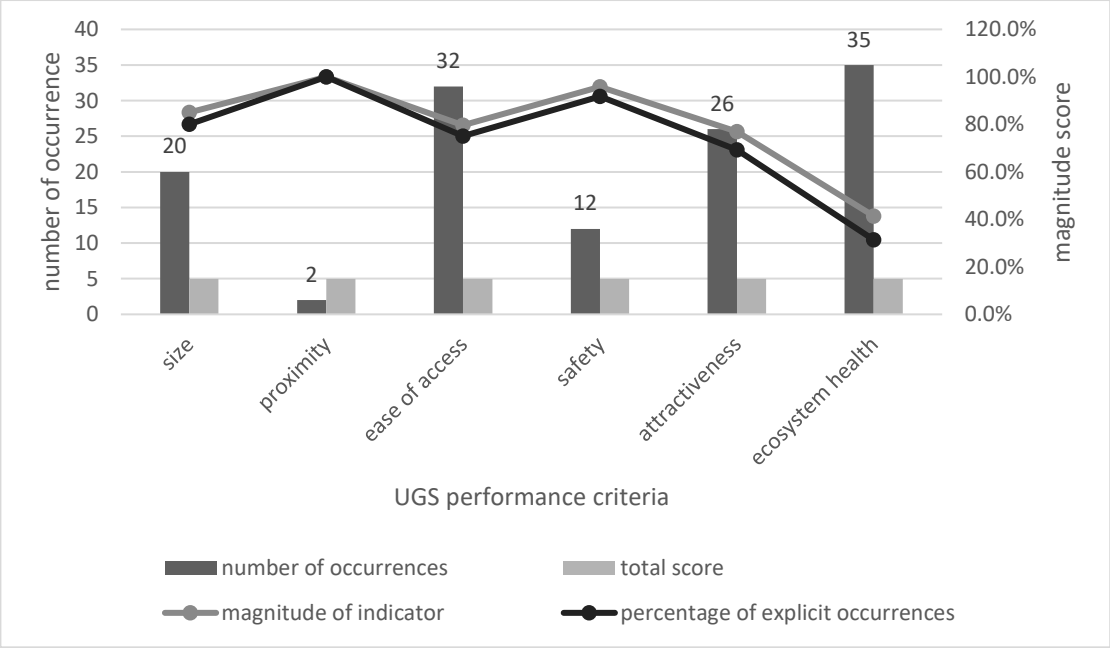

Figure 3. Results for urban green space performance criteria in Toronto Official Plan

Referring to Table 7, there are several indicators for each of the criteria which are searched and coded throughout the document. In Toronto Official Plan, there are 96 indicator occurrences out of 127 occurrences showing that 31 of the criteria occurrences have no instances in any of the indicators. For example, “provide and improve the frontage, visibility, access and prominence of natural and human-made features including parks, cemeteries, school yards and campus lands” (City of Toronto, 2022, Chapter 3, p. 4) talks about improving access and coded for the “ease of access” criterion but not as an indicator since it is not clearly about “transportation mode” or “connected network”.

Connected network and habitat and species diversity are the most frequent indicators in this document being expressed 16 times followed by the green space area, amenities and environmental quality, visibility, transportation mode and maintenance, invasive and native species, ecological corridor/network, and finally distance and green space per capita which are the least frequent indicators happening only two and one times.

Yet, no instances of public facilities are found in the document. All of the indicators receive magnitude scores higher than 50% which shows them being explicitly occurring in the documents except for one indicator which is habitat and species diversity. Table 10 shows the result for urban green space performance indicators in Toronto Official Plan.

Table 10. Results for urban green space performance indicator in Toronto Official Plan

Urban green space performance indicators	Number of occurrences in Toronto Official Plan	Magnitude of indicators
Green space area	13	88.5%
Green space per capita	1	100%
Distance	2	100%
Transportation mode	5	100%
Connected network	16	65.6%
Visibility	6	83.3%
Amenities	9	77.8%
Public facilities	0	0%
Maintenance	5	70%
Vegetation cover	3	66.7%
Environmental quality	9	55.5%
Habitat and species diversity	16	43.7%
Invasive and native species	4	100%
Ecological corridor/network	3	100%
Total occurrences	**92**	

4.1.3.2. *Toronto Parkland Strategy*

In addition to analyzing performance criteria and indicators in urban green spaces in general, performance criteria and indicators in parks are also studied. The second document being reviewed to find out about performance criteria and indicators in parks in the case of Toronto is the Parkland Strategy. Among these criteria, safety has the greatest magnitude (100%) while it has the lowest occurrences, and ecosystem heath has the lowest magnitude (20.5%). It is found that more criteria are neutral in this document except for safety that is occurred only in explicit statements, and ease of access which is almost equally mentioned in explicit, implicit, and natural phrases. While size is the most common criterion, these are the ease of access and attractiveness that are expressed the most in explicit statements with a magnitude score of 51.3% and 45.1% respectively. When analyzing Toronto Parkland Strategy, few other indicators are observed that are excluded from Table 7, which are sense of belonging, sense of place, social equity and inclusiveness, and multi-functionalism (e.g., multi-functional parks). Figure 4 reflects the number of occurrences for the performance criteria of urban green spaces as well as their magnitude and percentage of explicit occurrences in Toronto Parkland Strategy. The result shows that the quality variable occurred the most in Toronto Parkland Strategy followed by accessibility and lastly, quantity.

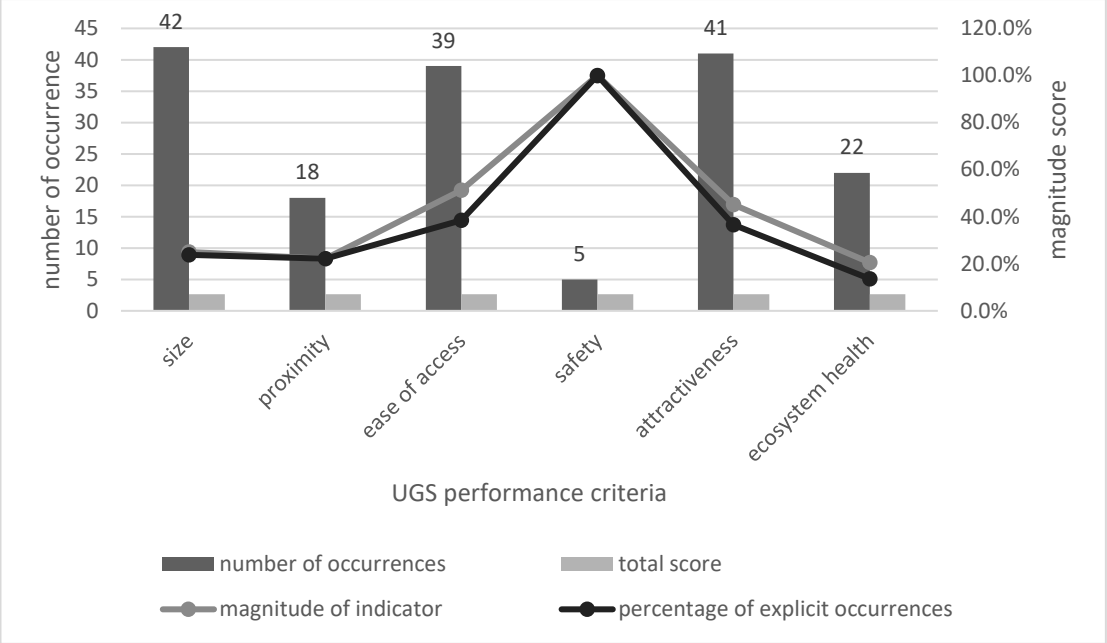

Figure 4. Results for urban green space performance criteria in Toronto Parkland Strategy

Moreover, urban green space indicators are also coded in Parkland Strategy document. The result shows that there are 77 indicator occurrences out of 167 showing that 99 of the criteria occurrences have no instances in any of the indicators. Connected network has the greatest occurrence of 14 times while visibility, public facilities, and invasive and native species have no instances. Table 11 reveals the result for performance indicators in Toronto Parkland Strategy.

Table 11. Results for urban green space performance indicator in Toronto Parkland Strategy

Urban green space performance indicators	**Number of occurrences in Toronto Parkland Strategy**	**Magnitude of indicators**
Green space area	12	25%
Green space per capita	7	0%
Distance	11	18.2%
Transportation mode	10	40%
Connected network	14	53.6%
Visibility	0	0%
Amenities	12	25%
Public facilities	0	0%
Maintenance	1	100%
Vegetation cover	1	0%
Environmental quality	2	50%
Habitat and species diversity	4	25%
Invasive and native species	0	0%
Ecological corridor/network	3	33.3%
Total occurrences	**77**	

4.2. Case study of Milan

4.2.1. Context

The city of Milan in the metropolitan area of Milan is located in the Lombardy region, in north-west part of Italy which is the most industrialized regions in Italy (Padoa-Schioppa et al., 2009). Figure 5 depicts the location of the city of Milan on the globe. The average temperatures in summer times range between 16.2℃ and 28.8℃ and the average temperatures in winter times range between -1.2℃ and 8.8℃. This city has a high humidity with an annual average of around 71% and has a high precipitation rate with an annual average of 1,160 mm ("Milan Climate", 2021).

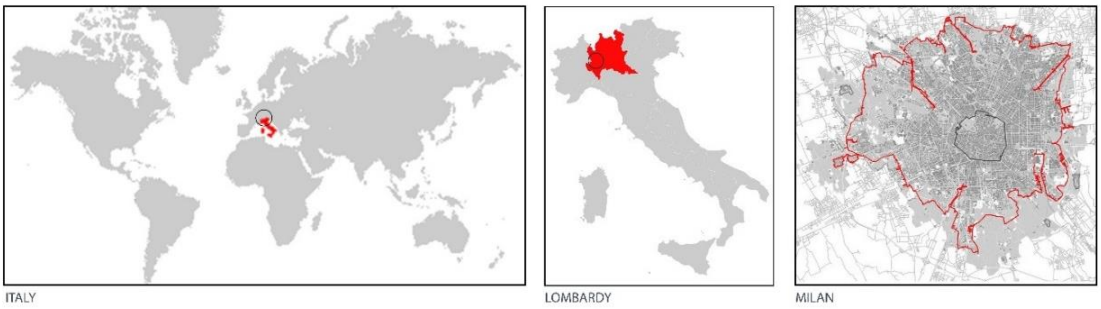

Figure 5. Milan's geographical location (Reference map adapted from "Italy map", n.d.; "Map of Lombardy", n.d.; "Scheme boundary", n.d.) The country of Italy is highlighted in red on the world map and the circle shows the location of the region of Lombardy. Middle) The Region of Lombardy is highlighted in red on the map of Italy and the circle shows the location of the city of Milan. Right) The city of Milan territory

The metropolitan area of Milan which is the second most populous city in Italy (Europe) has an urban area of 1,575 km^2 (Comero, 2015) with a population of 3,150,876, resulting in an urban density of 2,000 inh/km^2, while the city of Milan itself has a population of 1,371,498 ("Milan, Italy population", 2022) over 181.67 $km^{2.}$, thus a city density of 7,550 inh/km^2. Milan is considered one of the most densely populated areas in Europe and is second most densely populated cities in Italy. One of the challenges that Milan faces is the scarcity of available green spaces such as parks and gardens to citizens (Tavano Blessi et al., 2015). It is a challenge for the future of this city due to the fact that using green spaces directly affect physical and mental health of citizens (Tzoulas et al., 2007; De Luca et al., 2021; Luo et al., 2021; Kwon, et al., 2021). This city also faces challenges regarding the air quality due to several facts such as high population density, industrial activity, and traffic, which confirms the importance of the role of green spaces (Comune di Milano, 2018). Milan has committed to set targets for addressing climate change in a global scale as part of the "General Development Plan 2006-2011". One of the city's actions in this regard is increasing public urban green areas through improvements of accessibility and safety of the existing green areas and enlarging them (Comune di Milano, 2009).

4.2.2. Categories of urban green space

Analyzing the planning document of the city of Milan and discovering which ones of the urban green space categories are mentioned in the document regardless of being

considered implicitly in the document or being considered in future planning of the city, it is seen that the majority of the categories are not expressed throughout the text and only a few of them exist. Yet, it is observed that there are some instances of other categories that are not coded since they refer to specific projects or are being mentioned on maps. An example is a cemetery and churchyard which occurred six times on the maps i.e., "Cimitero Lambrate" (Comune di Milano, 2019, p. 117). The urban green space categories mentioned in Milan's PGT are green roofs, parks, private gardens, and allotment gardens. Yet, these categories are only expressed once or twice except for the parks category which is expressed 29 times along the document that makes it the most frequent urban green space category on Milan's PGT. Figure 6 illustrates the frequency of urban green space categories in Milan's PGT and clearly confirms the park category as the most frequent one.

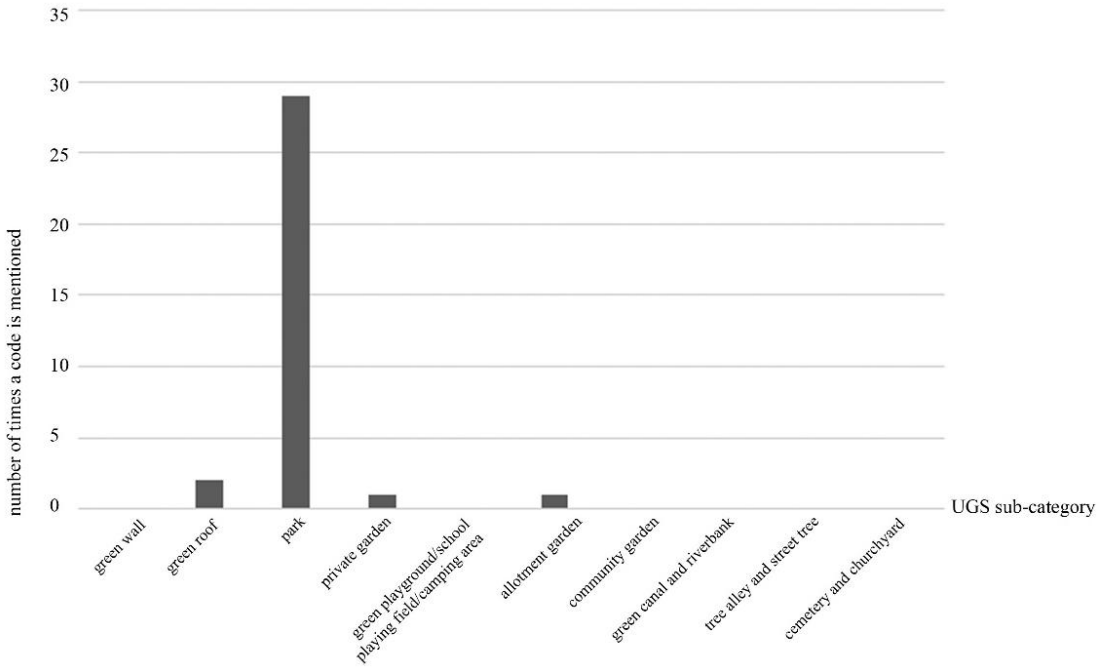

Figure 6. Frequency of urban green space categories in Milan's PGT

The same as the case of Toronto, coded categories are divided into "proportion of occurrences in PGT" and "proportion of occurrences in future planning". An example of a statement that refers to being considered implicitly in the PGT is "I parchi locali possono apportare conoscenze dettagliate del territorio" (Comune di Milano, 2019, p. 103) translated as "local parks can provide detailed knowledge of the area", and an example of a statement that refers to being considered in future planning is "Il complesso delle aree protette esistenti pone le basi per la realizzazione di un grande Parco metropolitan" (Comune di Milano, 2019, p. 103) translated as "The complex of existing protected areas lays the foundations for the construction of a large metropolitan park". The only category being considered in the city's future planning is the parks. Table 12 illustrates the number of times an urban green space category is mentioned in the analyzed document of the city of Milan.

Table 12. Number of occurrences of each urban green space category in Milan's PGT

Urban green space category	Total number of occurrences in Milan's PGT	Number and proportion (%) of occurrences in Milan's PGT	Number and proportion (%) of occurrences in future planning of Milan's PGT
Green wall	0	0 (0%)	0 (0%)
Green roof	2	2 (100%)	0 (0%)
Park	29	14 (48%)	15 (52%)
Private garden	1	1 (100%)	0 (0%)
Green playground	0	0 (0%)	0 (0%)
Allotment garden	1	1 (100%)	0 (0%)
Community garden	0	0 (0%)	0 (0%)
Green canal and riverbank	0 (0%)	0 (0%)	0 (0%)
Tree alley and street tree	0 (0%)	0 (0%)	0 (0%)
Cemetery and churchyard	0 (0%)	0 (0%)	0 (0%)

4.2.3. Performance variables in urban green space

4.2.3.1. Milan's *PGT*

Milan's PGT is studied and coded as the primary document to find out whether urban green space performance criteria – with a reference to Table 7–- occurred in the document. According to Figure 8 that shows the frequency of each of the criteria in Milan's PGT, ecosystem health is the most common indicator that is occurred along the text two times more than the second most common indicator which is the size (nineteen times and nine times respectively). After the size indicator, ease of access (occurred four times) and proximity (occurred only once) are the least common indicators. However, no instances of indicators of safety and attractiveness are seen in the text.

In order to determine the magnitude of performance criteria expressed within Milan's PGT, corresponding statements of explicit, implicit, and neutral are assigned to codes. An example of an explicit statement is "Questa scelta consentirà di consentirà di individuare le Infrastrutture Verdi e Blu e di rafforzare le connessioni ecologiche tra le grandi dotazioniverdi di scala metropolitana, poco accessibili e in condizioni di trascuratezza, e la trama minuta e frammentata del verde urbano esistente nelle parti più centrali della città." (Comune di Milano, 2019, p. 73) which is translated into "This choice will make it possible to identify the green and blue infrastructures and to strengthen the ecological connections between the large green areas on a metropolitan scale, which are inaccessible and in conditions of neglect, and the small and fragmented plot of urban green existing in the most central parts of the city". "nuovi parchi >10.000 m² previsti in città" (Comune di Milano, 2018, p. 47) translated into "new parks >10,000 m² planned in the city" is an example of an implicit statement, and "Dal punto di vista ambientale una maggiore presenza di alberature, in particolare lungo i marciapiedi e all'interno di spazi pubblici, contribuiranno a ridurre gli inquinanti

atmosferici migliorando la qualità dell'aria e a ridurre gli effetti delle isole di calore*"* (Comune di Milano, 2018, p. 17) translated as "from an environmental point of view, a greater presence of trees, especially along sidewalks and in public spaces, will help reduce air pollutants by improving air quality and reducing the effects of heat islands" is assigned a neutral statement.

Figure 7 illustrates this result showing number of occurrences, percentage of explicit occurrences, and the magnitude of each of the criteria in Milan's PGT. It is observed that the main portion of the statements are neutral statements among which ecosystem health is occurred the most and proximity the least. Whereas the size indicator is the indicator that is expressed in an explicit way. Even though the proximity indicator is occurred in the text, since it is only occurred in a neutral phrase, its magnitude is still 0%. In general, the quality variable has the highest frequency while accessibility has the lowest frequency in Milan's PGT.

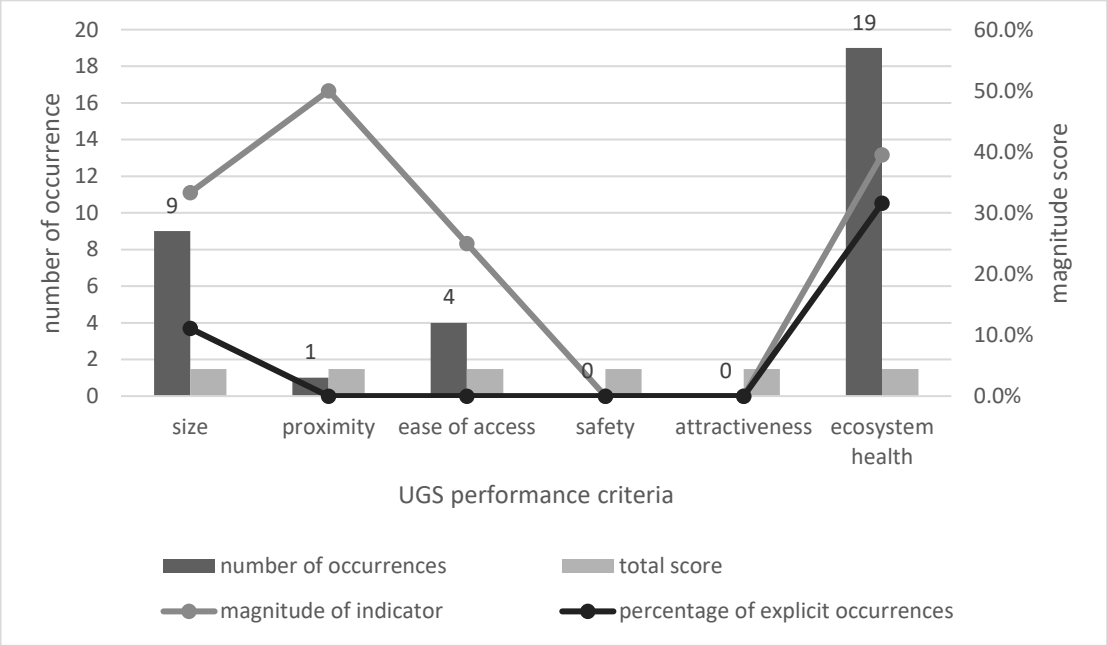

Figure 7. Results for urban green space performance criteria in Milan's PGT

The total number of criteria occurrences in the case of Milan's PGT is 33 and the total number of the indicator occurrences is 30. It shows that only three coded criteria are expressed in a broad sense without any reference to associated indicators. These broadly expressed criteria, as it can be seen from Figure 3, are categorized under ecosystem health. As there are no instances of safety and attractiveness criteria, there are no instances of related indicators which are visibility, amenities, public facilities, and maintenance. Percentage of green space, as an indicator for urban green space size, is the most frequent indicator mentioned nine times. Respectively, there are ecological corridor/network, environmental quality, and habitat and species diversity – all correlate to ecosystem health criteria – transportation mode and connected network, and finally, distance. All indicators receive a magnitude of 50% and below acknowledging the indicators are mostly occurred neutral or implicit. Table 13 shows the number of indicator occurrences and their magnitude scores in Milan's PGT.

Table 13. Results for urban green space performance indicator in Milan's PGT

Urban green space performance indicators	Number of occurrences in Milan's PGT	Magnitude of indicators
Green space area	9	33.3%
Green space per capita	0	0%
Distance	1	50%
Transportation mode	2	25%
Connected network	2	25%
Visibility	0	0%
Amenities	0	0%
Public facilities	0	0%
Maintenance	0	0%
Vegetation cover	0	0%
Environmental quality	5	40%
Habitat and species diversity	4	50%
Invasive and native species	0	0%
Ecological corridor/network	7	21.4%
Total occurrences	**30**	

4.2.3.2. Milan's *Future Landscapes*

The second document that is reviewed for searching for urban green space performance criteria and indicators in parks is Milan's Future Landscapes (Comune di Milano, 2016). The result that is reflected on Table 14 shows that proximity to urban green spaces and attractiveness are not considered in this document. Ease of access and its associated indicator of connected network are the most frequent criteria and indicator in parks according to Milan's Future Landscapes; nevertheless, connected network has the lowest magnitude score of 30%. Highest magnitude, however, belongs to transportation mode which occurred only two time in the document. The main portion of the statements, however, are expressed in an implicit way. Figure 8 shows the results for performance criteria in Milan's Future Landscapes, and the following table (Table 14) reveals the indicators' frequency and their magnitude scores. The result shows that accessibility criteria occurred the most in Milan's Future Landscapes, followed by quality, and quantity.

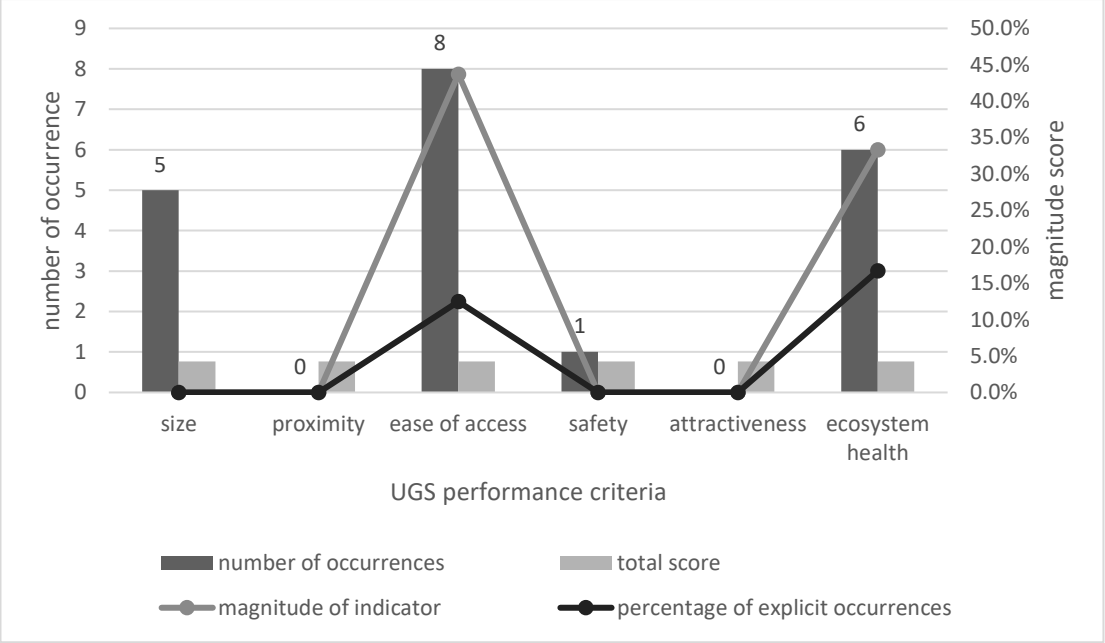

Figure 8. Results for urban green space performance criteria in Milan's Future Landscapes

Table 14. Results for urban green space performance indicator in Milan's Future Landscapes

Urban green space performance indicators	Number of occurrences in Milan's Future Landscapes	Magnitude of indicators
Green space area	4	50%
Green space per capita	0	0%
Distance	0	0%
Transportation mode	2	75%
Connected network	5	30%
Visibility	0	0%
Amenities	0	0%
Public facilities	0	0%
Maintenance	0	0%
Vegetation cover	1	50%
Environmental quality	0	0%
Habitat and species diversity	1	0%
Invasive and native species	0	0%
Ecological corridor/network	1	50%
Total occurrences	**14**	

4.3.Case study of Isfahan

4.3.1. Context

The city of Isfahan is located in the central plateau of Iran, in the northwest of Isfahan province which is limited to the desert from its northern and eastern parts and is limited to Zagros highlands from its southern and western parts. Figure 9 demonstrates the geographical location of the city of Isfahan. This city has a moderate and dry climate

(Golestan-nezhad, A., 2015) with an average temperature between 18.9℃ and 36.9℃ during summer and -3.4℃ and 12.6℃ during winter. Average annual precipitation in this city is 97 mm and the annual average humidity is 30% ("Isfahan climate", 2021).

Figure 9. Isfahan's geographical location (Reference map adapted from "Iran map", n.d.; "map of Iran", n.d.; "Isfahan city", 2019) The country of Iran is highlighted in red on the world map and the circle shows the location of the province of Isfahan. Middle) The province of Isfahan is highlighted in red on the map of Iran and the circle shows the location of the city of Isfahan. Right) The city of Isfahan territory

The city of Isfahan covers an area of around 550 km^2. It is a large metropolitan city (Golestan-nezhad, A., 2015) with an urban population of 2,234,754 and a city population of 1,547,165 resulting in a city density of 2,813 inh/km^2 and is considered as the third biggest city in Iran, Asia (*Esfahan,* 2022). The existing infrastructure of the city of Isfahan is based on two perpendicular axes, one is the natural axis of the Zayandeh-Roud River and the other is the central axis of the city which was once surrounded by palaces and gardens. Zayandeh-Roud River, which is the largest river of the central plateau of Iran passing through this city has affected its climate conditions. Another important water feature of this city is the system of Madies – "مادی" in original language – (Golestan-nezhad, A., 2015) which is a water distribution network for transporting the water from Zayande-Roud River into the sub-parts of the city.

One of the most important environmental challenges that the city of Isfahan encounters is air pollution. The geographical and climate conditions of this city cause the accumulation of polluted air and reduce the air quality by being surrounded by mountains and stillness of the air due to lack of wind throughout a year. Hence, green spaces play an important role for the environment of this city since they have the capacity to improve air quality. On the other hand, the province of Isfahan which is dominated by dry and semi-arid climate in more than 80 percent of its land area and has experienced the drying up of the Zayandeh-Roud River for several times, faces the threat of drought, so as the city of Isfahan. Drought causes severe damages to green spaces as it has direct impact of green spaces' water sources (Golestan-nezhad, A., 2015).

4.3.2. Categories of urban green space

The formation of green spaces and gardens in the city of Isfahan dates back 400 years ago which made Isfahan known as a "Garden City" (Golestan-nezhad, A., 2015). In order to determine whether urban green space categories and categories referenced to Table 3 exist or not exist in the city of Isfahan's municipal documents, master plan of

Isfahan is studied. It is seen that neither the urban agriculture category consisting of allotment gardens and community gardens, nor the category of green walls are observed within this document. The category of the cemetery is only coded once even though they appeared a few times but with their proper noun which is only known to the citizens of Isfahan (“تخت فولاد”, “باغ رضوان”).

Figure 10 shows that in the city of Isfahan private gardens category, mostly known as yards (“حیاط”, “حیاط مرکزی”, “حیاط خلوت”), has the highest frequency being mentioned 32 times while green roof and cemetery and churchyards have the lowest frequency being mentioned only once in the analyzed document. The second highest frequent category is parks which is close to private gardens. Moreover, green playground and tree alley and street tree categories are mentioned few times along the text, and the green canal and riverbank category is rarely mentioned although there are some instances of them in the document but coded as parks since they are written as “parks along Zayandeh-Roud River” – “پارک های حاشیه زاینده رود” in original language. As it is stated, green wall, allotment garden, and community garden categories do not have instances in the document. In the process of coding, however, it is observed that not only parks are divided into several categories, but also private gardens – or yards in this case study – have also different types based on their location on the property, function, etc. In the case of Isfahan, yards are divided into; “open space-yard” and “backyard”. Open space-yard refers to a surface of a property with no buildings only allocated for green space and tree plantation, gardening, water features, and other landscape uses without roofs that itself has various patterns such as “Central courtyard” and backyard refers to a space outside of the building without a roof or with a transparent one that is used for lighting and ventilation; and (Isfahan Master Plan, p. 4). Another category that is observed in the document but does not listed in Table 3 is called “patio” which is defined as a space among other spaces in a buildings, without a roof or with a transparent roof, used designed and used for lighting, ventilation, flowering and decoration (Isfahan Master Plan, p. 4).

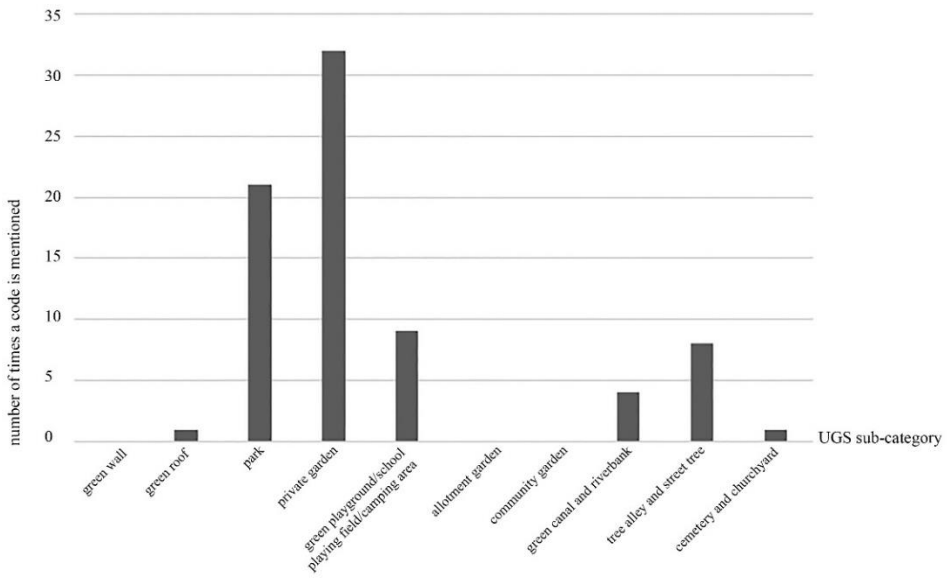

Figure 10. Frequency of urban green space categories in Isfahan Master Plan

Whereas all the categories are mentioned mostly in the official document with no reference to future planning, green roofs are considered in the future planning and not considered implicitly in the master plan, "Implementing the green roofs according to related regulations and by observing safety tips is allowed and recommended" (Isfahan Master Plan, p.156). Although private gardens – yards – has the highest frequency of being mentioned, they are least considered in future planning along with green playground, and green canal and riverbank. The Table 15 shows how many times urban green space categories are coded within Isfahan Master Plan.

Table 15. Number of occurrences of each urban green space category in Isfahan Master Plan

Urban green space category	**Total number of occurrences in Isfahan Master Plan**	**Number and proportion (%) of occurrences in Isfahan Master Plan**	**Number and proportion (%) of occurrences in future planning of Isfahan Master Plan**
Green wall	0	0 (0%)	0 (0%)
Green roof	1	0 (0%)	1 (100%)
Park	21	13 (61.9%)	8 (38.1%)
Private garden	32	24 (75%)	8 (25%)
Green playground	9	6 (75%)	2 (25%)
Allotment garden	0	0 (0%)	0 (0%)
Community garden	0	0 (0%)	0 (0%)
Green canal and riverbank	4	3 (75%)	1 (25%)
Tree alley and street tree	8	4 (50%)	4 (50%)
Cemetery and churchyard	1	1 (100%)	0 (0%)

4.3.3. Performance variables in urban green space

4.3.3.1. *Isfahan Master Plan*

The same as the other case studies, the performance criteria and indicators of urban green spaces is studied in the city of Isfahan municipality documents. It is seen that proximity is the most frequent indicator in Isfahan Master Plan, which is expressed 21 times, followed by size and attractiveness, being expressed 12 times and 10 times respectively. Ease of access criteria is fairly mentioned in the document. Further, safety and ecosystem health are the least frequent indicators that occurred by being mentioned respectively only three times and two times. While reviewing this document, a different performance indicator is observed which mostly refers to regulations for buildings and building greens that is called "moshrefiat" that carries the notion of predominancy over one's privacy. Although this indicator is not coded in the text, it relates to the attractiveness criteria as being relevant to the sense and feelings of comfort and privacy for the society. Figure 11 presents the frequency for each urban green space performance criteria in Isfahan Master Plan.

In addition, the same as the case of Toronto and Milan, corresponding statements of explicit, implicit, and neutral are assigned to each criterion and indicator. Being familiar with the context also helped for differentiating explicit statements – "حداقل 50% فضای آزاد باید به فضای سبز اختصاص یابد" (Isfahan Master Plan, 2012, p. 149) being translated as "At least 50% of the open space should be dedicated to green space."– from implicit statements – "بوستان کودک نزدیک مرکز واحد همسایگی و نزدیک به مسیرهای اصلی پیاده قرار گیرد" (Isfahan Master Plan, 2012, p. 20) translated as "The children's park to be located near the neighborhood center and close to the main pedestrian routes" – from neutral statements – "بوستان کودک: همجواری با کانون های آموزش مثل کودکستان ها" (Isfahan Master Plan, 2012, p. 20) as translated into "the children's park: adjacent to education centers such as kindergartens". The greatest percentage of explicit statements and the highest magnitude score refers to the safety criteria even though it has the lowest frequency after ecosystem health. On the contrast, proximity that has the highest frequency, receives the lowest magnitude score and percentage of explicit occurrence. Figure 12 presents the number of occurrences, the magnitude score, and the percentage of explicit occurrences of each criterion in Isfahan Master Plan. In general, in Isfahan Master Plan the accessibility criteria occurred the most and the quantity criteria occurred the least.

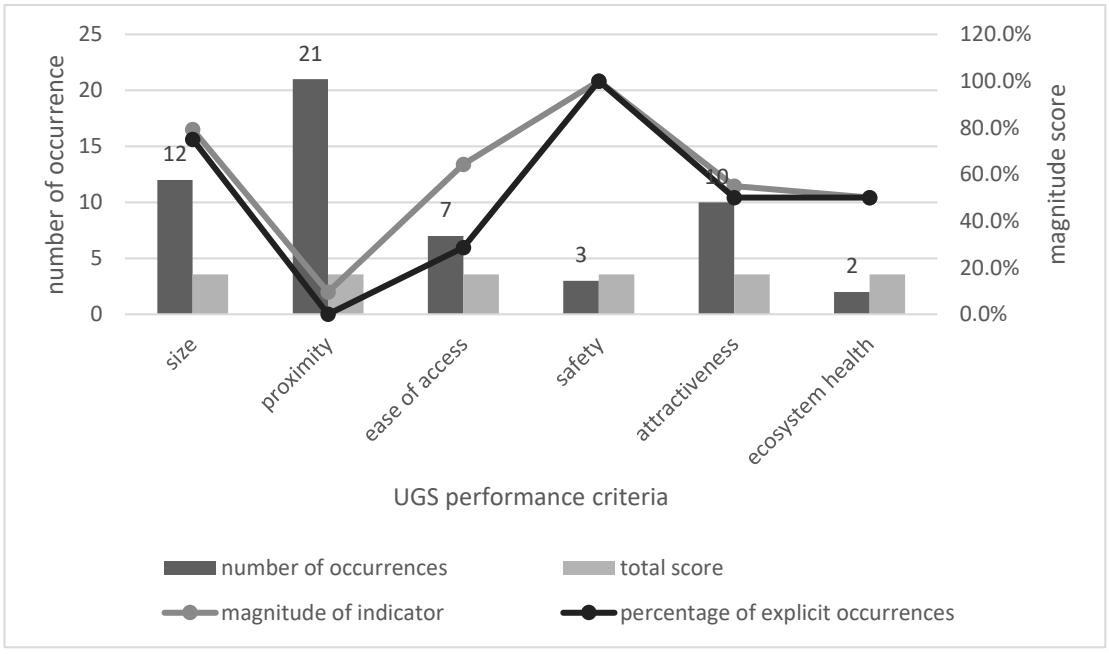

Figure 11. Results for urban green space performance criteria in Isfahan Master Plan

On the other hand, Table 16 that presents the results for performance indicators in Isfahan Master Plan shows that there are 47 occurrences of indicators out of 55 occurrences of criteria, meaning that 8 of the criteria occurrences have broad implications. The main portion of these broadly implicated criteria are associated with safety and attractiveness. Distance has the highest number of occurrences (20 times) which is two times more than the second highest number of occurrences which is green space area, with the lowest magnitude of 10% amongst all, except for ones with a magnitude of 0%. Transportation mode and amenities are fairly mentioned in the document and the rest of the indicators have no, one or two instances in Isfahan Master Plan.

Table 16. Results for urban green space performance indicator in Isfahan Master Plan

Urban green space performance indicators	Number of occurrences in Isfahan Master Plan	Magnitude of indicators
Green space area	10	75%
Green space per capita	2	100%
Distance	20	10%
Transportation mode	6	66.7%
Connected network	0	0%
Visibility	0	0%
Amenities	4	25%
Public facilities	2	50%
Maintenance	1	100%
Vegetation cover	1	0%
Environmental quality	0	0%
Habitat and species diversity	0	0%
Invasive and native species	1	100%
Ecological corridor/network	0	0%
Total occurrences	**47**	

4.3.3.2. Isfahan's *Criteria for Designing Urban Green Spaces*

In addition to the Isfahan Master Plan, "The criteria for designing urban green spaces" (Strategic Planning and Supervision Organization, 2011) is studied as a second document for studying about green space performance criteria and indicators in parks. Hereafter, it is referred as "*Isfahan's park-related document*". Figure 12 illustrates the result for performance criteria in Isfahan's park-related document and Table 17 presents the result for performance indicators in Isfahan's park-related document. Visibility which is the only indicator for safety according to Table 3 has not occurred in this document; however, the safety criteria has occurred six times, revealing that all the statements are broad implications. In addition to visibility, ecological corridor/network is another indicator with no instances in this document. It is observed that attractiveness has the highest frequency and the greatest magnitude amongst which indicators amenities occurred the most (15 times) and receive the magnitude score of 80 percent. In Isfahan's park-related document, the quality variable occurred the most, followed by accessibility and quantity.

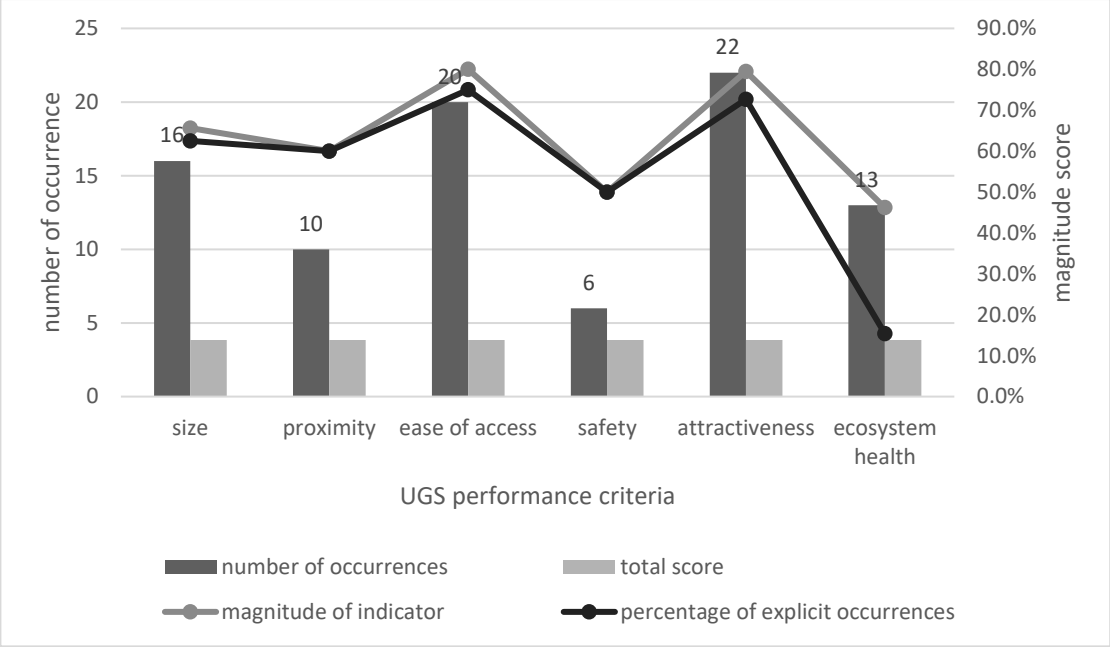

Figure 12. Results for urban green space performance criteria in Isfahan's park-related document

Table 17. Results for urban green space performance indicator in Isfahan's park-related document

Urban green space performance indicators	**Number of occurrences in Isfahan's park-related document**	**Magnitude of indicators**
Green space area	10	50%
Green space per capita	6	100%
Distance	8	50%
Transportation mode	12	75%
Connected network	3	100%
Visibility	0	0%
Amenities	15	80%
Public facilities	3	83.3%
Maintenance	2	100%
Vegetation cover	6	41.7%
Environmental quality	4	12.5%
Habitat and species diversity	1	0%
Invasive and native species	2	0%
Ecological corridor/network	0	0%
Total occurrences	**72**	

5. Cross-case results and discussion

After analyzing and revealing the results for each case separately, cross-case analysis is done for comparing first, context of the three cities of Toronto, Milan, and Isfahan, second, categories of urban green space between each of the cases, and third, their performance criteria and indicators both in primary and secondary documents to find out the similarities and differences between them. Cross-case analysis also makes a platform for interpreting the reason behind differences and commonalities. The cross-case analysis follows the same template of the case result and consists of comparing contexts, categories of urban green spaces, and performance criteria and indicators of urban green spaces. Results from cross-case analysis and pattern matching are explained to show how they relate to literature and how the cases are similar and different. Further, the reason behind these similarities and differences are interpreted in a discussion format.

5.1. Cross-case results: Context

To start with the comparison of the context, each of the three cities is located not only in a different country but also in a different continent. Keeping this in mind, they all have specific climate condition. Isfahan has drastically the lowest average annual precipitation while Milan has the highest. Based on the case results, Isfahan faces the threat of draught and low precipitation has made a challenge for urban green spaces especially for their conservation and maintenance. It is observed that several grasslands have been dried and many old trees have been perished in recent years due to the hot climate condition, low precipitation, and draught in this city. This fact has threatened the ecosystem health criteria in this city by affecting vegetation cover, environmental quality, habitat and species diversity, and invasive and native species, thus, it challenges the sustainability of this city.

All these cities are large populated metropolitan areas with Toronto being the most populous one. Yet, this city has a large area which keeps the city less dense. Among these three cities, Milan significantly has the smallest city area that has made this city the densest one amongst others resulting in some challenges for providing enough and quality urban green spaces. As urban green space area and green space per capita are two indicators for measuring the size of green spaces, and as the size is an important criterion for the performance of green spaces, this fact pressurizes the current and future green spaces, affecting the sustainability in this city. However, the municipality of Milan have improvised strategies and timeline for achieving a sustainable city by 2030 (Comune di Milano, 2019). It is also observed that the city of Milan has been implementing some categories of green spaces that are not specifically mentioned in the PGT, which is the category of green walls. Also, "*Bosco Verticale*" building (meaning vertical forest) in Milan is awarded as the best tall building in the world in 2015 by the *Council for Tall Buildings and Urban Habitat* which is a revolutionary idea of bringing the trees to the sky by growing them on balconies and is a model of sustainable housing (Kucherova & Narvaez, 2018). Figure 13 compares the cases' contexts in terms of average annual precipitation, city population, city area, and city density.

Locating in different countries, each of these cities has specific geopolitical situations on one side, and specific economic situations on the other side. Iran is considered a Global South country by having lower levels of wealth and economic development, while Italy and Canada are considered Global North countries by having greater levels of wealth and economic development (OWSD, n.d.; Rigolon et al., 2018). It is believed that a better economy and economic development helps a city to improve in several areas such as green spaces by offering opportunities with lesser money-wise limitations to design, plan, and implement ideas, policies, and strategies.

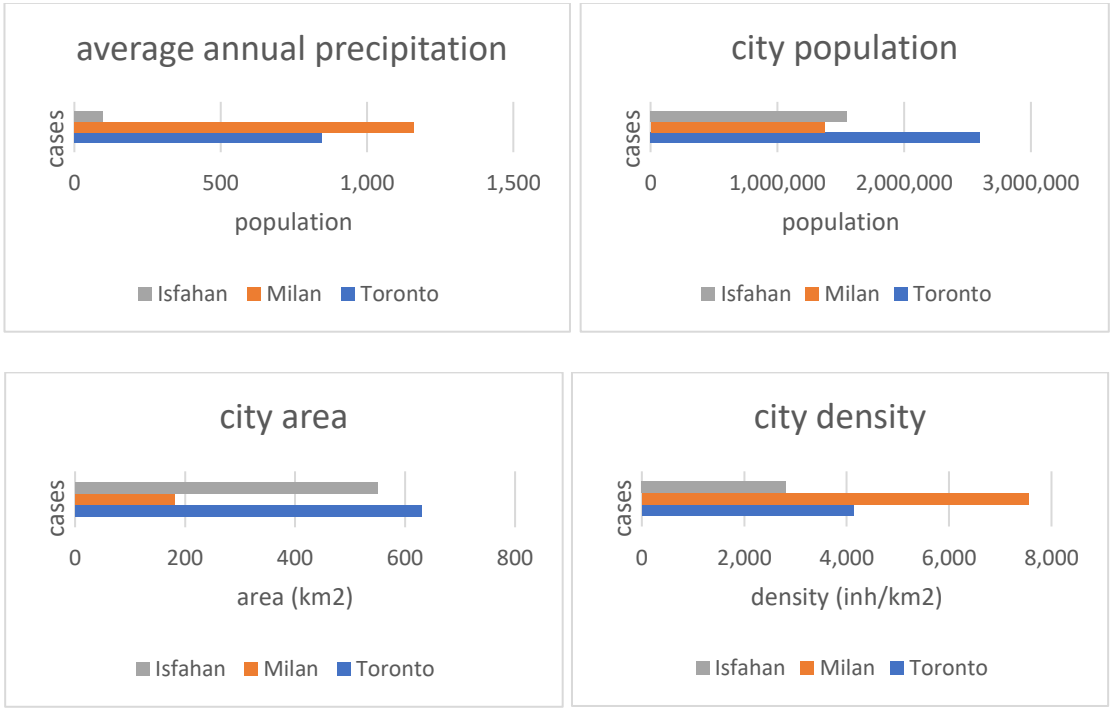

Figure 13. Cross-case comparison of the contexts

5.2. Cross-case results: Categories of urban green space

After cross-case analyzing the contexts, urban green space categories are compared between the cases to better demonstrate the similarities and differences. The pattern demonstrates that parks are the most common and frequent type in Toronto's and Milan's municipality documents, with a drastic difference in the case of Toronto, whereas in Isfahan's municipality document the most common category mentioned is private gardens, placing the parks at the second most common. On the contrary, in none of the cases' municipality documents, green walls occurred, community gardens are only expressed in Toronto's, and allotment gardens are the least frequent category in Toronto's and Milan's documents with no instances in the case of Isfahan. Green canal and riverbank, on the other hand, is the only category that has few instances in Isfahan's municipality document and non in Toronto's and Milan's. Figure 14 presents the comparison of the number of occurrences of urban green spaces among the three case studies.

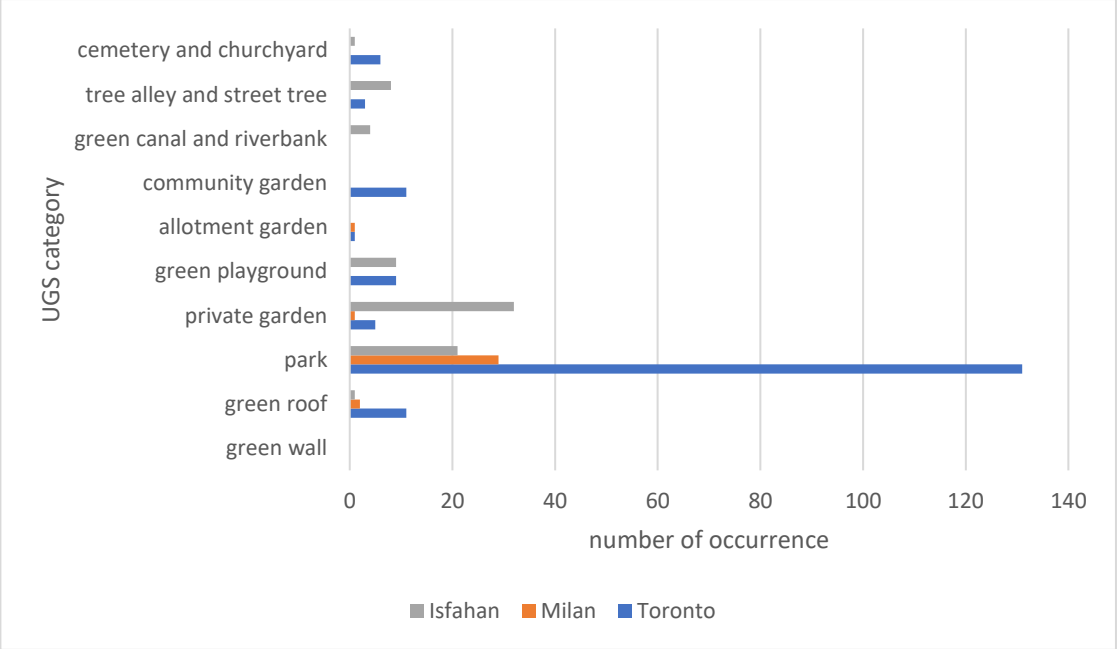

Figure 14. Cross-case comparison of the number of occurrences of urban green space categories

While the frequency of parks is the highest amongst all in Toronto's and Milan's municipality documents, it is the second highest in Isfahan's after the private gardens. This confirms the important role contexts play and it shows the cultural and religious aspects reflected in Isfahan's document. Green walls category does not have instances in any of the three cases even though they are observed in these cities, especially in Milan. Milan's PGT tend to be more general with differentiation between categories and that might be a reason why many of the categories are not observed in this document. Even if allotment gardens and community gardens have low frequency in Toronto's and Milan's municipality documents, neither have they occurred in Isfahan Master Plan, nor any examples are observed in this city. One of the reasons may be the unfamiliarity of the city planners and other related associations with these new concepts. Despite the observation of green canals and riverbanks in all the three cities, it has low frequency due to different wording and expression in the documents.

The findings from cases and cross-case analysis confirms Rall et al. (2015)'s statement that there is not a single framework for urban green space typologies. Although Bell et al. (2007) and Rall et al. (2015) present a comprehensive list of urban green space categories and sub-categories, based on which the newly proposed synthesized categorization (Table 3) is presented, some green space categories are found out in each case's municipality documents such as ravine systems in Toronto and patios in Isfahan which are excluded from Table 3 and also from these two authors' categorizations. While Rall et al. (2015) infers that it is social, environmental, and technological transformation that prevent achieving a single green space typology framework, this research adds another aspect that is the context. Geographical locations and climate characteristics, geopolitical and economic situation, religious and cultural aspects, values and needs, etc. are the criteria that define the context. Urban green space typology can be different among different contexts as they are improvised to meet the

local needs and desires, and meeting the local needs, and respecting local values and cultures is one of the keys to success.

5.3. Cross-case result: Performance criteria and indicators

Next, a cross-case analysis is conducted for comparing urban green space performance criteria and indicators between the three cases' primary documents. Among the criteria which are effective in the performance of urban green spaces according to Table 7, the pattern reveals that except for the proximity, all of the urban green space performance criteria have occurred in Toronto the most. Ecosystem health is an indicator with the greatest occurrences in municipality documents of both Toronto and Milan, while it has the lowest occurrences in the case of Isfahan. Conversely, proximity as an indicator occurs the least in Toronto's and Milan's documents – considering safety and attractiveness are not mentioned in the case of Milan – whereas it is an indicator of the greatest occurrences in Isfahan. Figure 15 shows the comparison of the number of occurrences of urban green space criteria in the primary documents among the three case studies.

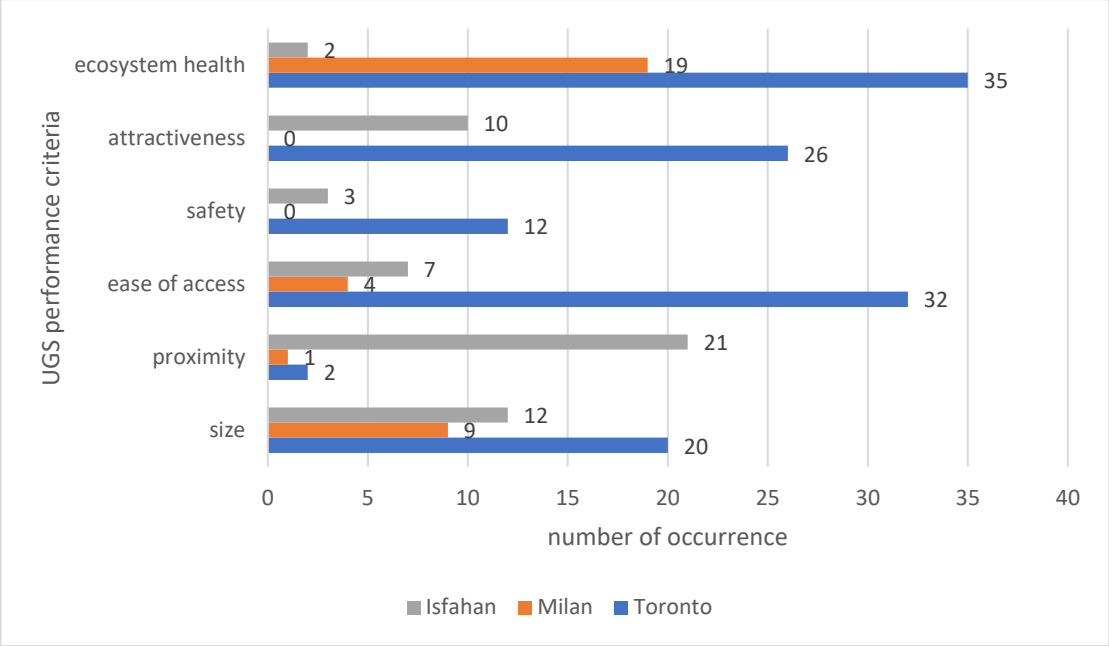

Figure 15. Cross-case comparison of number of occurrences of urban green space performance criteria in the primary documents

Figure 16 displays the magnitude score of each of the performance criteria in the three cities of Toronto, Milan, and Isfahan. Proximity has the greatest magnitude in Toronto Official Plan while having the lowest number of occurrences among the other indicators in this case contrary to the case of Isfahan in which proximity occurs the most and it has the lowest magnitude score among the rest of the indicators. Although safety has no instances in Milan's municipality document and thus no magnitude score, it is an indicator of the highest magnitude in Isfahan and the second-highest magnitude in Toronto.

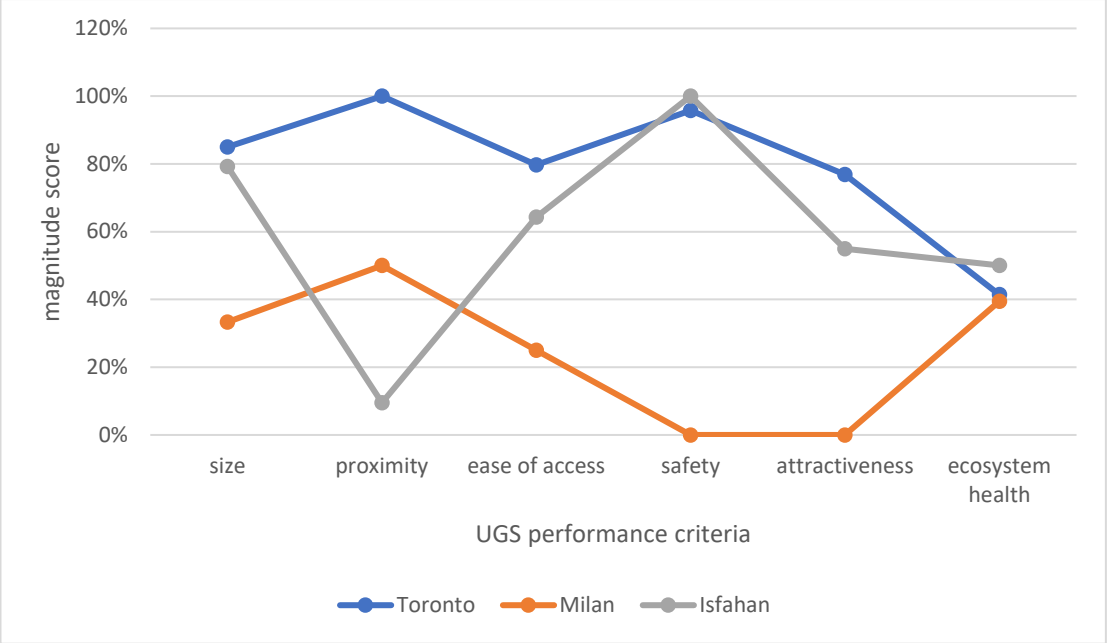

Figure 16. Cross-case comparison of magnitude scores for urban green space performance criteria in primary documents

Toronto Official Plan tend to be the most comprehensive not only for the categorization of urban green spaces but also for performance criteria. It has the highest overall frequency of performance criteria and indicators with the highest overall magnitude scores for these criteria and indicators on the contrary to Milan which has the lowest frequency and magnitude suggesting that Milan's PGT is more implicit and tend to be more general. Another reason is that Milan's PGT mostly refers to specific projects and sites, which are not coded in this research, rather than general policies and regulations. Furthermore, Isfahan has the medium overall frequency of performance criteria and indicators in compared to Toronto and Milan, but the related magnitude scores fluctuate drastically between criteria.

After conducting the cross-case analysis for performance criteria, cross-case analysis for performance indicators is also conducted to give a more detailed view. Among the indicators, distance that refers to proximity criteria has the highest occurrence being occurred in the case of Isfahan while it has occurred only once and twice in Milan and Toronto respectively. In addition to this indicator, green space area and transportation mode are the only indicators that have occurred in all the three cases' municipality documents, whereas the other indicators do not have instances in Isfahan's or Milan's cases. However, it is seen that Toronto Official Plan covers all of the indicators except for public facilities – which only occurred in Isfahan. The second highest occurrence are both the indicators of connected network and habitat and species diversity that has occurred in the case of Toronto. Figure 17 demonstrates the comparison of the number of occurrences of urban green space indicators among the three case studies in their primary documents.

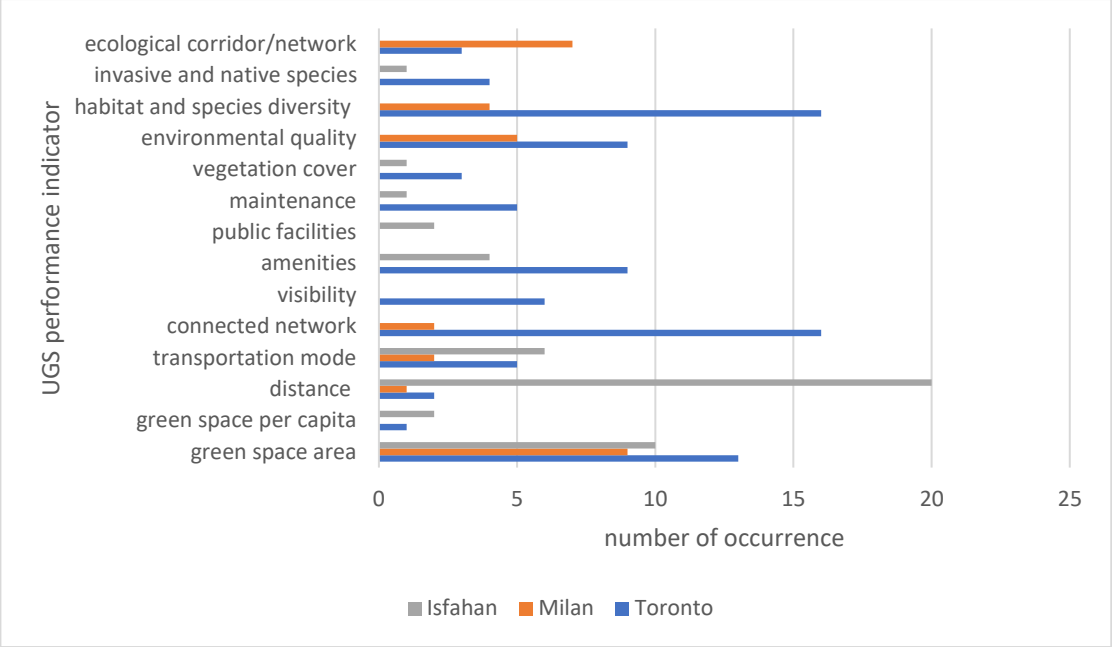

Figure 17. Cross-case comparison of number of occurrences of urban green space performance indicators in primary documents

Moreover, occurrences and magnitude scores of urban green space criteria and indicators that are analyzed in each cases' secondary documents which is in regard to the park category are compared between the cases. Figure 18 illustrates the cross-case comparison of number of occurrences of urban green space performance criteria in park-related documents, Figure 19 compares the criteria magnitude scores, and Figure 20 shows the comparison of performance indicators along the same documents. All of the criteria have occurred the most in Parkland Strategy document of Toronto, in compared to the other two cases, except for the safety that has occurred the most in the case of Isfahan, while all have occurred the least in Milan's green vision. Analyzing and comparing the indicators for each of the criteria, it is seen that the majority of indicator occurrences relates to the size, proximity, and ease of access criteria, while safety has no instances of visibility as its indicator and the indicators related to attractiveness and ecosystem health have very few instances. It shows that even though these two criteria have occurred along the document, but they are expressed in a broad sense without referring to any of the indicators.

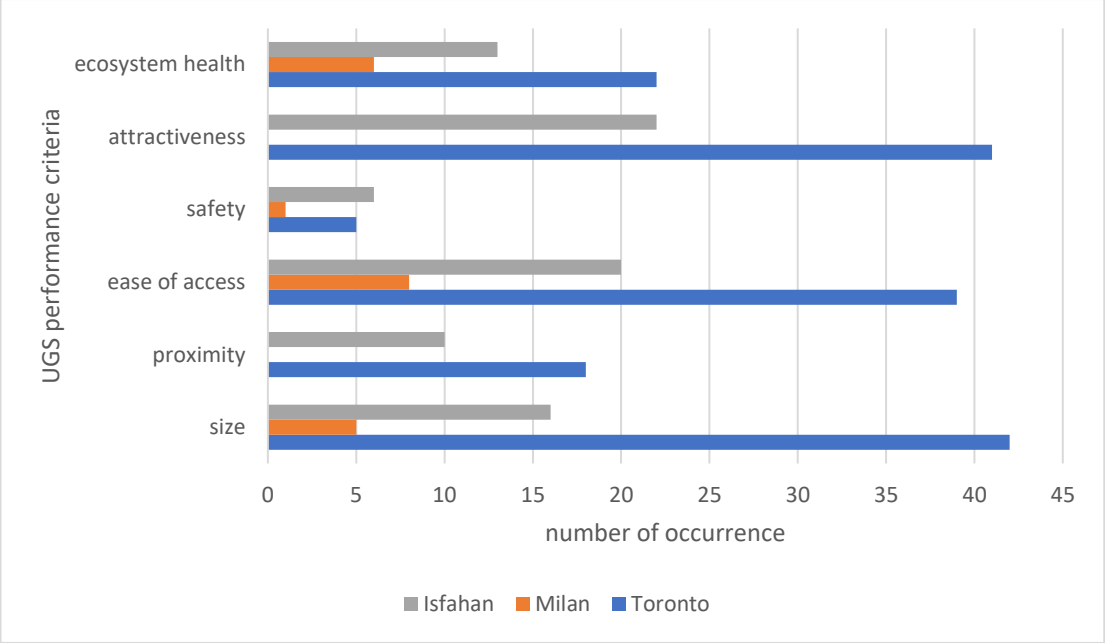

Figure 18. Cross-case comparison of number of occurrences of urban green space performance criteria in park-related document

On the other hand, the comparison of magnitude scores for urban green space performance criteria in park-related document shows that the in Toronto Parkland Strategy safety has the highest magnitude of 100%, while this criterion's magnitude in Isfahan related document is 50% and in Milan's is zero. When the performance criteria's magnitude score highly fluctuates in Toronto Parkland Strategy (between 20.5% to 100%), it is moderate in the case of Isfahan ranging between 48.1% to 80%, and in Milan's case it varies between zero percent and 43.7 percent.

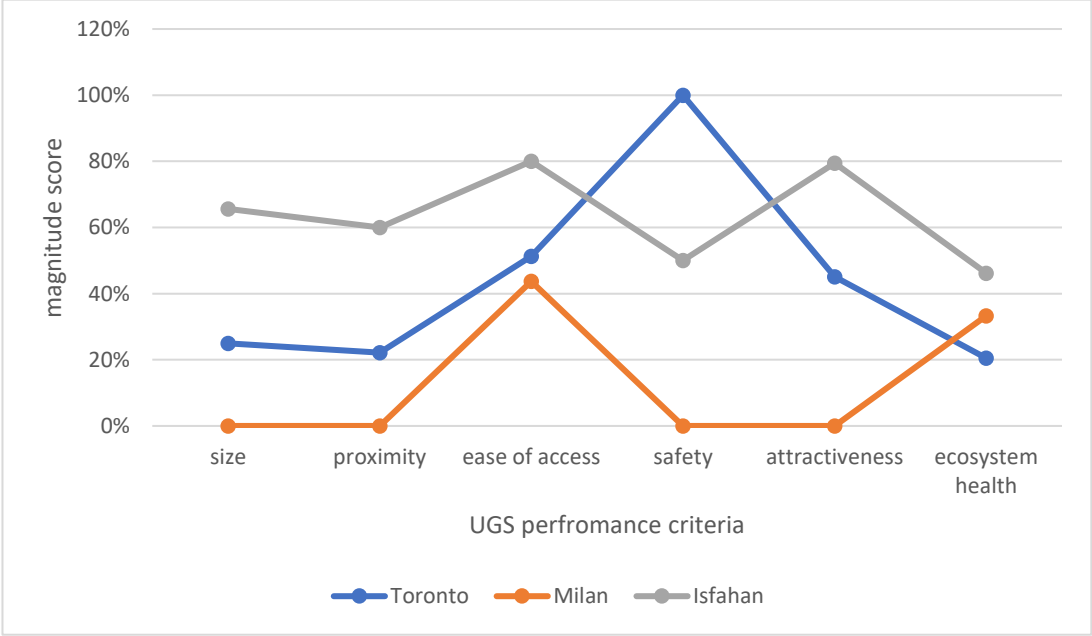

Figure 19. Cross-case comparison of magnitude scores for urban green space performance criteria in park-related document

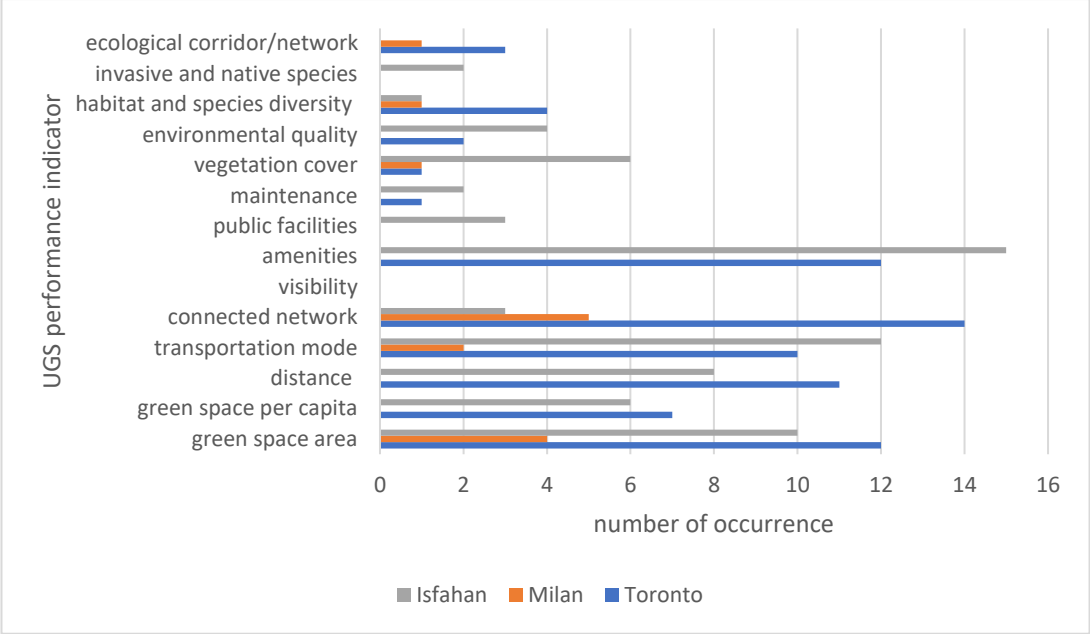

Figure 20. Cross-case comparison of number of occurrences of urban green space performance indicator in park-related document

In park-related documents for each case, no specific pattern is seen. The performance criteria's magnitude score experiences a drastic fluctuation in Toronto Parkland Strategy, when it is moderate in the case of Isfahan.

From an environmental perspective and analyzing ecosystem health in these cases' primary and secondary documents, it is seen that Toronto highly consider ecosystem health, especially habitat and species diversity as one of the indicators, nonetheless the associated statements are more general and information-based rather than being explicit. The case of Milan considers ecosystem health fairly with the greatest focus on ecological corridor/network. The case of Isfahan, instead, rarely talks about ecosystem health or any of its indicators.

The findings of this research about urban green space performance criteria and indicators confirms Campagnaro et al. (2019) that there is not a single framework for urban green space performance variables, criteria, and indicators and considering them in policy documents reflect the context. Although a comprehensive framework on the basis of the conducted literature review is synthesized and proposed (Table 7), there are some criteria and indicators which are not listed in this table such as sense of belonging, social equity, and inclusive spaces. Considering these criteria and indicators is a mirror that reflects important values for a specific context showing the extent to which these values are considered in planning and policymaking. The findings also approve Žlender and Ward Thompson (2017), on the fact that the performance of green spaces does not rely on a sole variable, but a combination of variables and criteria, by observing occurrences of various criteria and indicators in each case's municipality documents and addressing many of them in their future planning.

In addition, cross-case analysis findings highlight the importance of the three variables of quantity, accessibility, and quality in general and verify the statement of a group of

authors (Baycan-Levent & Nijkamp, 2009; Campagnaro et al.,2019; Rigolon et al., 2018; Žlender & Ward Thompson, 2017) for considering these three variables as the most influential ones associated with the performance of urban green spaces. It is due to observing high frequency of these criteria on cases' municipality documents. On the other hand, the findings do not align with Baycan-Levent and Nijkamp (2009) about considering "planning of green spaces" as a variable for affecting urban green space performance as it is believed that covering the other variables reveals planning purposes due to observing that some of these variables, criteria, and indicators are expressed in a way that reveal future planning purposes. The findings also challenge the narrowness of literature about the safety criteria. As indicators for safety mostly refer to visibility according to Murathaveeran (2010), the findings show that municipality documents do not consider this criterion by its associated indicators.

6. Conclusion and recommendations

In this section the rationale for considering this research and the aim of this project is briefly reviewed. In order to study urban green space categories and performance variables and to analyze these features in each case, literature has been reviewed and existing information has been synthesized to provide new assessment frameworks aligned with the purpose of this research. The main outcomes of analyzing urban green space categories and performance variables in each case and among cases are highlighted in this conclusion. Subsequently, six recommendations based on the analysis are proposed for future urban designers, urban planners, and policy makers.

6.1.Conclusion

Impetus for this research came from the challenges of modern urbanization due to overpopulation and its relation to sustainability and sustainable future cities. Designers, planners, and policy makers are responsible for context-specific, quality urban green space to enhance citizen's quality of life. Achieving a sustainable city is a global goal due to the fact of global overpopulation especially in urban areas like cities that welcome a high percentage of population (Calheiros & Stefanakis, 2021) leading to urban expansion and urban densification, particularly in developing large metropolitan cities (Golasz-Szolomicka & Szolomicki, 2019; Wang et al., 2020). The balance between the urban built-environment and nature has been disturbed as a result of the contemporary urban development resulting in environmental challenges by negatively affecting urban ecology and in social challenges by influencing human well-being (Calheiros & Stefanakis, 2021; Pérez-Urrestarazu et al., 2015) considering being connected to nature has positive impacts on human health (Tzoulas et al., 2007; De Luca et al., 2021; Luo et al., 2021). Thus, sustainability of cities is overshadowed (Calheiros & Stefanakis, 2021; Pérez-Urrestarazu et al., 2015).

In response, this research aims to compare urban green spaces in three selected cases, Toronto in Canada, Milan in Italy, and Isfahan in Iran, through studying their municipality documents and analyzing the urban green space categories and analyzing variables that affect their performance considered by these municipality documents.

The first objective of this research is to study literature about urban green spaces as one of the main aspects of a sustainable city. A literature review that is found in chapter 2 is conducted which focuses on the role of urban green spaces in relation to the sustainability in cities, urban green space typologies, and variables that affect the performance of urban green spaces. It is found out that green space has the potential to promote mental health by facilitating social inclusion, social cohesion, etc., and to promote physical health by providing a ground for physical activities (Tzoulas et al., 2007; De Luca et al., 2021; Luo et al., 2021; Kwon, et al., 2021). Applying nature-based solutions (NBSs) into the process of urban transformation and enhancing urban green spaces are approaches to lessen the environmental pressure, mitigate the impacts of rapid urbanization on society, and integrate nature into urban built-environment (Calheiros & Stefanakis, 2021; Pérez-Urrestarazu et al., 2015). Therefore, providing adequate quality urban green spaces which are fundamental components of urban areas are ways to move towards a future sustainable city.

It is seen that there is a lack of research on urban green space typologies in literature. Even though there are various typologies of urban green space, each broken into categories and sub-categories, yet there is not a single framework for this typology (Rall et al., 2015). Thus, for the purpose of this research, a new classification is proposed based on the existing typologies to be used as a reference for analyzing and comparing the cases' urban green space categories and sub-categories. This synthesized scholarship addressing urban green space typology is found in Table 3 consisting of green roofs and green walls (as sub-categories of building green), parks, private gardens, and green playground/school playing field/camping area (as sub-categories of park, garden, and recreational space), allotment gardens and community gardens (as sub-categories of urban agriculture), green canals and riverbank, and tree alley and street trees (as sub-categories of green corridor), and cemeteries and churchyards (as sub-categories of cemetery and churchyard).

Furthermore, different variables that impact the performance of urban green space are found through reviewing the literature, each divided into several criteria. Besides, there are several indicators for each of the criteria. Identifying these indicators and monitoring them help to understand how each of the green spaces perform. Nonetheless, in general, urban green space performance depends on combination of these variables (Žlender & Ward Thompson, 2017). Based on the more prevalent framework of urban green space performance variables and criteria, and to provide measurable indicators, and as no single framework exists for variables and criteria, a new framework aligned with the purpose of this study is proposed. This synthesized scholarship addressing urban green space performance variables, criteria, and indicators is found in Table 7, lists the most relevant variables which are quantity, accessibility, and quality. It consists of size (as a criterion for quantity), proximity and ease of access (as criteria for accessibility), and safety, attractiveness, and ecosystem health (as criteria for quality). In addition, this framework list indicators for the criteria which are green space area and green space per capita for measuring the size, distance for measuring proximity, transportation mode and connected network for measuring the ease of access, visibility for measuring safety, amenities, public facilities, and maintenance for measuring attractiveness, and finally, vegetation cover, environmental quality, habitat and species diversity, invasive and native species, and ecological corridor/network for measuring ecosystem health.

The second objective of this paper is to find out about urban green space categories in the three selected case studies. All these cities are considered populated large metropolitan areas, however there are significant differences in climate aspects such as precipitation rate, city density, geopolitical situations, and economic situation that are influential for urban green spaces and their performance. Urban green space categories are studied in each of the cases separately. Primary documents are selected to be reviewed and looked for occurrences of specific urban green space categories in each case study. The findings of the cases' analysis demonstrate that there are categories in some of the cases which are excluded from Table 3, such as ravine system in the case of Toronto and patio in the case of Isfahan. It is concluded that no single framework exist for urban green space typologies including various categories and sub-categories and a typology is specific to context.

Among the cases, Milan has the least occurrences of green space categories as its primary document addresses the green spaces in a broader view rather than classifying them into more detail categories and sub-categories. In the primary documents it is also observed whether specific categories are considered in future planning of each city, or they are implicitly mentioned in the document. Despite Milan's approved policy plans for 2030 and highly consideration of green spaces in this document in general, the analysis shows few instances of various green space categories, and it is believed that the reason is assigning green space categories to specific projects rather than clarifying them explicitly in policies, such as cemetery and churchyard category. Moreover, the pattern found in Figure 14 shows that parks have the greatest occurrence in primary documents of Toronto and Milan, while in the case of Isfahan the greatest occurrence is for private gardens and the second greatest occurrence refers to the park category. It is suggested that the high frequency of private gardens or yards in the city of Isfahan relates to the cultural and religious aspects that once again confirms the important role context play on urban green spaces

The third objective is to figure out the consideration of green space performance in the three cities by analyzing the occurrences of performance criteria and indicators in each case and by calculating their magnitude. This analysis helps to anticipate whether there are any planning and management goals and whether they are applied currently in their implications. Accordingly, they provide a platform to give recommendations for each city to enhance their urban green space performance. Urban green space performance criteria and indicators are searched for in the primary document of each case separately to realize how many times they have occurred in the document. Each occurrence of performance criteria and indicators is also assigned a corresponding statement that helps calculating their magnitude.

The findings from analysis of each case declares that there are some criteria and indicators in each case which are not included in Table 7, which is a reference table for urban green space performance criteria and indicators to be used in this research. Some of these indicators are sense of belonging which occurred in the case of Toronto and "moshrefiat" which occurred in the case of Isfahan. As Table 7 synthesizes the most relevant urban green space performance variables, criteria, and indicators based on the studied articles from a group of authors, and yet some of the observed indicators in cases' municipality documents are excluded from this table, it is concluded that there is not a single framework for urban green space performance criteria and indicators, and they are mainly context specific. It is also observed which criteria and indicators have the highest magnitude and which have the lowest. The pattern, which is found in Figure 15 and 16, demonstrates that Toronto Official Plan not only considers green space performance criteria and indicators the most among the cases, but also it considers these criteria in an explicit way that makes their magnitudes the highest compared to the other cases.

On the other hand, secondary documents which are park-related documents retrieved from the municipality references are studied to look for performance criteria and indicators in parks. Parks category is selected to be studied more in detail due to their importance and their great consideration in the primary documents of the case. As the same as analyzing the primary documents, these secondary documents are also studied and searched for occurrences of green space performance criteria and indicators, and

their magnitude is calculated. Once again, it is monitored that some indicators expressed in these secondary documents are not contained in Table 7 such as the sense of place, space inclusiveness and multi-functionalism that are expressed and considered in Toronto Parkland Strategy. The pattern from Figure 18 reveals that the majority of performance criteria and indicators occurred the most in Toronto Parkland Strategy and occurred the least in Milan's Future Landscapes. Nevertheless, as presented by Figure 19, Isfahan's park-related document considers these criteria more explicitly, hence has the highest magnitude scores of urban green space criteria.

6.2.Recommendations

This research aims to help urban designers and planners, and policy makers for future cities with a vision of enhancing citizen's quality of life and reaching a future sustainable city. It also contributes to future research and scholarship on this important subject. Thus, some recommendations have been proposed based on the results of the case studies.

Recommendation 1: The first recommendation targets municipalities and is about official documents containing a section in which the context is explained clearly. Each city will include a brief chapter in its official/master plan that reflects the social and environmental characteristics, society's values, and limitations and barriers of its context. It is suggested that urban designers, urban planners, and policymakers, consider social and cultural values of the society, society's historical background, leisure activities, and society's needs in addition to environmental characteristics. Having this information in mind, future designers, planners, and policymakers will know the setting in which they present their design and planning policies. An urban green space that considers these aspects, is more welcomed by the society and used more often since the needs are met, resulting in enhancement of society's physical and mental health (Baycan-Levent & Nijkamp, 2004).

Recommendation 2: The second recommendation is that researchers provide a comprehensive list of urban green space categories, with their definition, design criteria and characteristics, and barriers, with as much as detail as possible to be used by urban designers, urban planners, and urban policy makers. As this is a transdisciplinary field, researchers from various disciplines such as geography, sustainability, social science, etc. will be invited to participate in providing this list. Even though a single framework does not exist due to rapid social, environmental, and technological transformation (Rall et al., 2015), this list will be used as a reference list and guideline for all the countries and cities, yet municipalities should provide an online accessible platform for all researchers to let them frequently update this list and adjust them for each single city according to their social and environmental characteristic and the society's need. This comprehensive list helps the planners to discover urban green space categories which do not exist in the city or not mentioned in the city's official/master plan. When the designers and planners learn more about the categories they are not aware of, they will assess the possibility of applying them in the current context. For instance, allotment gardens and community gardens neither exist nor are they mentioned in the city of Isfahan in the policy document while they can be considered in this case.

Recommendation 3: The third recommendation is that each city provides a separate document specific to design and planning of each of the green space categories. As this document is dedicated to a specific green space category, the provided information, standards, policies, strategies, etc. by researchers and policymakers are clearer, more detailed, and comprehensive. Thus, the probable confusion and misunderstanding of information by designers and planners for various categories would be decreased. This document will consider context first, and then based on the context provide guidelines for designing and planning the green spaces, such as Parkland Strategy document in the case of Toronto that is dedicated only to parklands. Although park-related documents with information about park designing and planning policies are found in the case of Isfahan and Milan, the same document as Parkland Strategy with all the details specific to parks and the city itself are not found.

Recommendation 4: In this research, two frameworks are proposed, one for urban green space categories, and one for urban green space performance variables, criteria, and indicators. These newly proposed frameworks are comprehensive and are synthesized from the existing literature, comparing different authors' classifications, finding mutual ones, and then are adjusted to the purpose of this research. The urban green space categories framework (Table 3) consists of all relevant categories and sub-categories that are associated with urban green spaces that has social, recreational, and aesthetic values. This framework can be used in future research for studying and analyzing urban green spaces and assessing their performance in policy documents. The urban green space performance variables framework (Table 7) includes the most relevant and common variables and synthesizes not only existing frameworks for variables, but also searched for possible criteria and indicators associated with these variables in literature and presents these criteria and indicators. Future research can use this framework as it provides feasible criteria and measurable indicators for assessing urban green space performance in policy documents.

Recommendation 5: The fifth recommendation targets urban designers, planners, and policy makers to provide an inclusive green space that meet the needs of different communities regardless of their background, age, ethnicity, ability, etc. Urban green space has the potential to promote mental health by facilitating social inclusion and social cohesion (Tzoulas et al., 2007; De Luca et al., 2021; Luo et al., 2021; Kwon, et al., 2021). On the other hand, an inclusive space can invite different communities and encourage them to use the space. Thus, the more inclusive green space, the more welcoming and popular space to be used by its communities resulting in a better performance of the space. Therefore, it is recommended that social inclusion and cohesion be considered by urban designers, planners, and policy makers as an important criterion for green spaces. For instance, accessibility of disabled people to a green space is a very important aspect that policymakers consider in policy documents. It is suggested that these kinds of criteria be expressed in an explicit way in policy documents in order to reduce the avoidance.

Recommendation 6: The sixth recommendation mainly targets urban planners to consider planning for creating a green corridor that connect urban green spaces of various kinds together. This green corridor not only enhances the connectivity and increases possibilities of reaching any of the green spaces (which are the two indicators for the ease of access criteria according to Table 7) but also improve the ecological

corridor which is an indicator for ecosystem health. A green corridor invites more people to use green spaces more often, whether they are large such as urban parks or small such as a parkette by providing various options and opportunities and through meeting the need of different local communities.

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8. Appendices

Appendix A: Description of urban green space categories and sub-categories

A. Building green:

1. **Green wall:** A green wall – also known as "vertical greening systems", "green vertical systems", and "vertical greenery systems" – in general, refers to a greening system for vertical surfaces such as facades and walls. In this system selected plants and vegetation are planted on or within a building façade or wall (Manso & Castro-Gomez, 2014). Different authors give different classifications of a green wall. As indicated by Rall et al. (2015), green walls can be ground-based or façade-bound, while Kohler (2008) subdivides the green wall system into living walls and green façades.
2. **Green roof:** A green roof – also known as a living roof, eco-roof, and vegetated roof – is a sub-category of building greens and is a type of NBS at a building scale. A green roof is an engineered system to be installed on a waterproofed constructed structure that provides ecosystem services. This system consists of several layers (roofing membrane, protection, drainage, and filter layer) on an insulated structure, followed by a substrate for vegetation to be planted on and an irrigation system (Calheiros & Stefanakis, 2021). Green roofs can be divided into three main categories: intensive green roofs, extensive green roofs (Calheiros & Stefanakis, 2021; Rall et al., 2015), and semi-intensive green roofs, each having its specifications and standards (Calheiros & Stefanakis, 2021).

B. Park, garden, and recreational space:

1. **Urban Park:** usually large green areas in an urban setting, within a city, that may include trees, shrubs or grasses, playgrounds, etc., and serve the urban population for recreational purposes (Rall et al., 2015).
2. **Private garden:** sometimes known as a home garden, house garden (Rall et al., 2015) or domestic garden, is a private open space located near a place of residence that is maintained by the owner/owners (Cepic & Tomicevic-Dubljevic, 2017).
3. **Green playground / School playing field/ Camping area:** green areas for playing, outdoor activities, and camping activities (Rall et al., 2015).

C. Urban agriculture: As defined by FAO (2007), Urban Agriculture or UA is "the growing of plants and the raising of animals for food and other uses within and around cities and towns, and related activities such as the production and delivery of inputs, processing, and marketing of products" (FAO, 2007, P.1). The most significant component of urban agriculture, as stated by Drescher et al., 2006, is urban gardening which can be divided into allotment gardens, community gardens, and home gardens (Drescher et al., 2006).

1. **Allotment garden:** as Drescher et al., 2006 indicate, allotment gardens as one type of urban gardens are "separate parcels of land allocated to individuals or households for personal use" (Drescher et al., 2006, p. 318), on which each household works and cultivates individually and independently while following common rules from the allotment association (Cepic & Tomicevic-Dubljevic, 2017; Drescher et al., 2006). Recreation and

non-commercial food production are the purposes associated with allotment gardens (Rall et al., 2015).

2. **Community garden:** community gardens are another type of urban garden that, on contrary to allotment gardens, are cultivated by a group of individuals collectively. Even though a community garden provides an opportunity for its individuals to have individual plots and produce fruits and vegetables for personal consumption, it is by purpose a collectively shared space. This feeling of taking part collectively and the community spirit is what differentiates community gardens from allotment gardens (Cepic & Tomicevic-Dubljevic, 2017; Drescher et al., 2006). In addition to food production, recreation is another function of such spaces (Rall et al., 2015)

D. Green corridor: Green Corridor is a typically linear approach that links vegetation and plants to form continuous urban green areas. Green corridors not only provide and support wildlife but also provide recreational benefits to their users (Almasri et al., 2019).

1. **Green canal and riverbank:** vegetation and green spaces along a river, canal, or stream that usually has a pedestrian or bicycle path (Rall et al., 2015).
2. **Tree alley and street tree:** tree alley and street trees refer to trees, single or in a row, which are planted along a street or a path (Rall et al., 2015).

E. Cemetery and churchyard: green spaces of cemeteries and churchyards refer to green lands covered with lawns, trees, and ornamental plants (Rall et al, 2015).

Appendix B: Codebook

Table B 1. Codebook used for analyzing urban green space categories and sub-categories in three case studies (Adapted from Rall et al., 2015 & Bell et al., 2007; City of Toronto, 2022; Comune di Milano, 2019; Isfahan Municipality, 2012)

Codes for categories	**Codes for sub-categories**	**Sub-codes for sub-categories**
Building green	Green wall	Green wall; “giadino verticale”; دیوار سبز
	Green roof	Green roof; rooftop garden’ “tette verde”;بام سبز
Park, garden, and recreational space	Park	Park; urban park; park and garden; parkland; park and open space; “parco”; “giardino”; “parco metropolitano”; “parco urbano”; بوستان ;پارک شهری City-wide parkland; district park; city park; “parco regionale”; پارک ناحیه ای ; پارک همسایگی ;ای پارک منطقه

		Local parkland; parkette; local park; "parco locale"; پارک محله ای
	Private garden	Private garden; family gardens; housing green space; private green space; private courtyard; backyard; yard; "cortile private"; "cortile"; حیاط
	Green playground/school playing field/camping area	Green sports facility; sports facilities, campsites, and tourist accommodations and facilities; schoolyard; campus land; school playground; playing field; sport field; فضای ورزشی ;کمپینگ ;فضای بازی کودکان روباز
Urban agriculture	Allotment garden	Allotment garden; "orto urbano"
	Community garden	Community garden; "giardino condiviso"
Green corridor	Green canal and riverbank	Canal and riverbanks; riverbank green space; green riverbank; فضای فضای سبز حاشیه رودخانه ;انهار ;سبز حاشیه
	Tree alley and street tree	Linear green spaces; street green; tree-lined street; "verde stradale"; حریم سبز معبر ;رفیوژ خیابان
Cemetery and churchyard	Cemetery and churchyard	Cemetery; disused churchyard; "cimitero"; گورستان ;آرامستان

Table B 2. Codebook used for analyzing urban green space performance variables in three case studies (Adapted from Baycan-Levent & Nijkamp, 2009 & Campagnaro et al.,2019)

Codes for variables	**Codes for sub-variables**	**Sub-codes and terms about codes for sub-variables**
Quantity	Size	Proportion; Green space per capita; Green space percentage; Green space area; Per cent; Expansion; Creating new; "Consumo di suolo"; "Metri quadri"; %; m^2
Accessibility	Proximity	Distance; Travel; Distribution; Adjacency
	Ease of access	-Connectivity; Network; Linkage; "Connessioni" -Transportation; Reaching to green space -Disabled accessibility; Width
Quality	Safety	-Safe; Visibility; Lighting; Safe access;

	Attractiveness	-Attractive; Enjoyment; Sense of belonging; Bringing people together; Comfortable -Amenity; Facilities; Recreational opportunities; Play equipment; Sports equipment; Equipment; Urban furniture; Street furniture; Furniture; Bicycle parking; Motorcycle parking -Public services; Vendor; Shop; Stall; Public toilet; Public telephone; Lodging; Prayer room -Maintenance; Protection; Enhancement; Restore; Improvement; Walking path; Pathway; Walkway; Bikeway; Pedestrian lane; Bicycle lane; Water feature; Waterbody; Shade
	Ecosystem health	-Vegetation cover; Vegetation density; Tree canopy; Canopy cover; Tree density; Cropland; Grassland -Environmental quality; Air quality; “Qualità dell'aria”; Air pollution; Water quality; Water pollution -Habitat and species diversity; Biodiversity; Species; Flora and fauna; “Biodiversità” -Invasive species; Native species -Ecological corridor; Ecological network; “reti ecologiche”; “connessioni ecologiche”

Appendix C

Table C 1. Urban green space categories and their related terms and phrases used in Toronto’s municipality documents

Urban green space categories	**Related terms and phrases for urban green space categories in Toronto’s municipality documents**
Green wall	NA
Green roof	Green roof; rooftop garden; green and cool roof

Park	Parkland; park; park and open space; local park; city park; local parkland; city-wide parkland; parkette; district park; linear park and trail; “science park”; planned park; natural park; ravine park
Private garden	Backyard and garden; rare and side yard; private green space
Green playground/school playing field/camping area	School yard and campus land; school playground and playing field; play space for children; golf course; sports field
Allotment garden	Allotment garden
Community garden	Community garden; community park
Green canal and riverbank	NA
Tree alley and street tree	Tree-lined street
Cemetery and churchyard	Cemetery

Table C 1. Urban green space categories and their related terms and phrases used in Milan’s municipality documents

Urban green space categories	**Related terms and phrases for urban green space categories in Milan’s municipality documents**
Green wall	NA
Green roof	“tette verde”
Park	“parco” ; “giardino” ; “parco metropolitano” ; “parco urbano” ; “parco regionale” ; “parcho locale”
Private garden	“cortile private”; “cortile”
Green playground / school playing field / camping area	NA
Allotment garden	“orto urbano”
Community garden	“giardino condiviso”
Green canal and riverbank	NA
Tree alley and street tree	“verde stradale”
Cemetery and churchyard	“cimitero”

Table C 2. Urban green space categories and their related terms and phrases used in Isfahan’s municipality documents

Urban green space categories	**Related terms and phrases for urban green space categories in Isfahan’s municipality documents**
Green wall	NA
Green roof	بام سبز

Park	پارک ناحیه ;پارک محله ای ;پارک همسایگی ;پارک شهری پارک ;پارک منطقه ای ; پارک بازی کودکان ;بوستان ;ای پارک کوهستانی;طبیعی
Private garden	حیاط مرکزی;حیاط خلوت;حیاط
Green playground / school playing field / camping area	فضای ;کمپینگ ;فضای بازی کودکان ;زمین ورزشی کودکان ورزشی روباز
Allotment garden	NA
Community garden	NA
Green canal and riverbank	فضای سبز حاشیه مادی ها ;فضای سبز محور زاینده رود
Tree alley and street tree	فضای سبز حاشیه محور ;حریم سبز معبر ;رفیوژ خیابان ; ردیف درخت ;ترافیکی
Cemetery and churchyard	گورستان