CASE STUDY

An approach towards effective ecological planning: Quantitative analysis of urban green space characteristics

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ABSTRACT: In the best practices, planning of urban green spaces is managed in such a way that it follows the key principles such as meeting per capita standards and providing accessible and balanced distribution of these spaces all across the city. In the context of emerging economy, these principles are unfortunately not followed strictly all times. In this study, it is attempted to investigate Tabriz city of Iran is in terms of ecological planning to quantitatively analyse its green space characteristics. The used methodology includes determining the relevant urban green space development indicators (e.g. accessibility, per capita supply, balanced distribution, and continuous development of urban green spaces) from the literature and using the secondary data collected from variety of sources to analyse the study area. The study seeks to provide a comprehensive view on status of green spaces in Tabriz in the light of ecological principles and indicators and GIS-based spatial analysis. Results indicate that: a) Green space per capita provision in Tabriz is much lower than the national and international standards (some districts offer only 0-1 sq.m. per capita green space); b) Districts of Tabriz do not have a balanced distribution of green spaces and access to green spaces on foot (only 18% of the population can access green spaces within a 5 minute walk); c) Except for the provided street side green spaces, all other passive or active types of green spaces in Tabriz are not continuously linked (no continuity to form a green corridor or linear greenways). This study also comes up with some recommendations for Tabriz and other cities with similar characteristics.

KEYWORDS: *Ecological planning; Green space accessibility; Sustainable city; Sustainable urban development; Urban green spaces.*

INTRODUCTION

Since the beginning of the industrial revolution in 1850s, urban expansion has experienced a rapid growth worldwide (Cohen, 2006). During this period, urban areas have developed fast in size and density (Sarimin and Yigitcanlar, 2012; Turrini and Knop, 2015). Urbanisation, industrialisation and globalisation can be viewed as major triggers for land use and land cover change, and these changes also increase by large populations migrating into cities globally (Zhao *et al.,* 2006; Li *et al.,* 2015). Development of green spaces is a critical activity in our cities, particularly considering the increasing of population and construction activities in urban areas. These spaces are needed for physical and mental wellbeing and quality of life of residents (Gudes *et al.,* 2010). In other words, because of the human needs for green spaces to create a social, physical and spiritual balance, maintaining the ecological balance of our cities is vital. Cities that are allocating adequate and highly accessible green spaces to their citizens, not only improve the quality of life but also contribute to the efforts of achieving sustainable urban

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development. In order to establish a liveable and sustainable city, urban and environmental planners in emerging economies need to pay special attention to green spaces planning. However, the current process and practice of improper dealing with urban green spaces, particularly in emerging economies, indicate that if this trend continues, destruction and undersupply of green spaces and agricultural lands will significantly threaten sustainable urban development and ecological balance of our cities. Urban and population growths in Iran, like many other developed or emerging economies, resulted in environmental pollution which requires policies to be controlled. Green space expansion is one of the most important factors in reducing environmental externalities. In this country, expansion of urbanisation—both as sprawling suburban development and infill densification—has been accompanied by declining levels of gardens and agricultural lands, which has led to a significant reduction of urban green spaces. Tabriz city has not been an exception and has suffered from such problem even more than many other Iranian metropolises. The city has been losing its green spaces swiftly for various reasons: a) Converting open spaces during the urban development process to, for example, residential, commercial and industrial or mixed uses. Citizens of Tabriz, once lived among massive gardens and green spaces, now face the perils of rapid urbanisation; and b) Pressure of construction industry on policymakers that have become the victim of wrong decisions. Subsequently, quality and quantity of green spaces have been reducing dramatically almost daily to contribute to personal profits of investors, land/property owners, and developers. Additionally, disproportionate distribution of these spaces at neighbourhood and city levels has resulted in an unjust planning of this important land use type—like in many other cities with emerging economies. The empirical investigation reported in this paper focuses on Tabriz city. Selection of this area as a case study can be justified as follows: a) The city and its districts are under immediate threat of environmental externalities and diminishing quality of life; b) Planning and development decisions in Tabriz have been made without backing of fundamental scientific studies on physical, climatic, social, and demographic conditions of the city; and c) Ineffective urban and ecological planning practice in Tabriz has similarities with those practices followed in many cities with

emerging economies. Against this backdrop, this study aims to address the question that "Is the current status of urban green spaces in Tabriz in accordance with ecological principles?" In order to address this question, the urban green spaces in Tabriz have been evaluated quantitatively. The current study has been carried out in Tabriz, Iran in 2017.

LITERATURE REVIEW

Land utilisation, urban sprawl and land use changes have a massive negative impact on ecosystem, where urban green structures have a conservative impact on the ecosystem and affect the increasing physical activities, psychological conditions, and health of citizens (Wolch *et al.,* 2004). Recently, attentions have been drawn to the urban green landscape in urban issues, indicating that urban green prosperity should be a major component of urban development policies and plans (Waldheim, 2006). The issue is also discussed from the angle of travel self-containment, making cities more efficient in providing services in close proximity to where people live (Yigitcanlar *et al.,* 2007). Green spaces are part of urban open spaces, filled with different kinds of plants and vegetation—and also activities for different age groups—that contribute to health, feeling of safety, comfort, wellbeing, and aesthetic value of urban areas and communities (Groenewegen *et al.,* 2006). In the urban planning process, hence, ecological principles need to be considered along with traditional planning approaches based on socioeconomic and spatial elements. In this regard, policymakers, planners and urban designers should pay particular attention to the improvement of ecological network structures and functions of our cities, where urban green spaces are one of the fundamental factors of this structure (Aminzadeh and Khansefid, 2009; Yigitcanlar, 2009). Rapid development of our cities has a substantial effect on the green space structures (Najihah *et al.,* 2017). Urban strategic and local development plans, which are prepared to guide the development and conversation, have rarely been highly effective in provision of these spaces adequately (Todes, 2012; Sharifi *et al.,* 2014). Appropriate access to urban green spaces for all citizens and distribution of balanced urban green spaces increase urban ecological efficiency, and consequently bring better environmental, economic, social, and psychological conditions for citizens and provide decent living conditions in cities. Therefore,

relying on the fact that the essential indicators of sustainable urban development are expansion and maintenance of green spaces in cities, planning for urban green space development by considering its ecological structure is deemed necessary to improve the sustainability of urban ecosystems and quality of urban life (Dizdaroglu and Yigitcanlar, 2014). Ecology is the science of examining the interaction of organisms with their outer world, which in a broader sense encompasses all environmental conditions (Piri and Rezayirad, 2006). Therefore, the science of ecology analyzes the life of natural phenomena in relation with technology, human civilisation and human environment. Ecology is a guide for urban planners that helps them to navigate the direction of a city's movement in line with environmental programs.

The ecological development of urban green spaces refers to a comprehensive integrated set of measures that cause harmony in all regions and urban areas that promise sustainable urban development. In order to reduce the environmental problems in cities, the presence of nature in the city is considered necessary. However, small and scattered neighbourhood parks and backyard lawns of houses by themselves cannot be enough to compensate the lack of continuous presence of nature corridors in our cities (Werquin *et al.,* 2005). The presence of nature in natural lands, open spaces, and green lands should have the breadth, composition, spatial distribution, and physical connection necessary to interact with the rest of the city (Tjallingi, 2003).

Moreover, the critical factors involved in the ecological approach towards development and preservation of urban green spaces include paying attention to: a) Balanced distribution of green spaces throughout the city; b) Planting species compatible with the climate and nature of the city; c) Protecting existing green spaces; d) Restoring sustainable water resources; e) Air, water and soil conditions; and f) Diversity and density of green spaces and biodiversity (Dizdaroglu *et al.,* 2012). Scholars underline that size, quality and vegetation type and proportion of green space help urban areas to adapt to the impact of climate change and ecological condition of cities (Gill *et al.,* 2007; Luber and McGeehin, 2008; Van den Berg *et al.,* 2010; Oliveiral *et al.,* 2011). For instance, the existence of urban green spaces reduces bad weather conditions, and helps with formation of microclimate (Tjallingii, 2003). The literature highlights the factors that determine the environmental performance of urban green spaces as: a) Size; b) Per capita allocation; c) Diversity of functions; and d) Optimal distribution, design and management (Werquin *et al.,* 2005). Urban green spaces, hence, can be considered as a major tool for comprehensive protection of environmental sustainability and increasing the quality of life in our cities (Mersal, 2017).

MATERIALS AND METHOD

Tabriz city, with an area of about 190 sq.km, is the largest city in the northwest of Iran (Fig. 1). Tabriz is
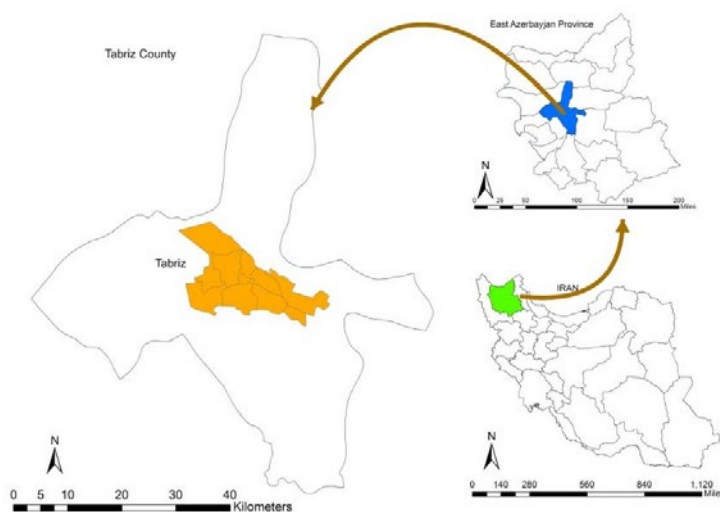

Fig. 1: Location of the study area

divided into 10 districts according to the municipality regulations and the comprehensive plan. According to the census in 2016, about 1,770,000 people were living in Tabriz. Urban green spaces in Tabriz are classified into two groups: a) Artificial green spaces—a combination of equipped urban parks, urban squares, trees planted in residential areas, and green spaces on streets; b) Natural green spaces—all the green spaces that are naturally existing and preserved.

The methodological approach in this study is of descriptive-analytic type, aiming at undertaking an applied research on a case study. In this study, in the first step, the theoretical foundations have been investigated to extract the ecological development indicators of urban green spaces in the light of the reviewed literature. These indicators have been extracted from four sections: a) Social; b) Environmental; c), Natural; d) Physical. These indicators are listed as follows:

- Social indicators: Public health, physical activities, mortality rate, recreation facilities, frequent contacts among neighbours, sense of community and participation in green space conservation (Cranz, 1989; Pretty *et al.,* 1994; Prezza *et al.,* 2001; Takano *et al.,* 2002; Chiesura, 2004; Maas *et al.,* 2006; Mitchell and Popham, 2007; Sugiyama *et al.,* 2008);
- Environmental indicators: Biodiversity, sustainable water resources and planting species according to the local climatic conditions;
- Natural indicators: Natural water resources, type of soil, natural vegetation cover, air quality, precipitation and water quality;
- Physical indicators: Accessibility, per capita supply, balanced distribution and continuous development of urban green spaces (Dizdaroglu *et al.,* 2012).

Following the determination of the key indicators, in the next step, only the physical indicators are investigated in order to study the status of urban green spaces of Tabriz city, in terms of compliance with ecological principles. In order to analyse the current situation of urban green spaces in Tabriz, the following actions are undertaken: a) Accessibility indicator is analysed using network analysis in a geographic information system (GIS) environment, and; b) Areas with accessibility to parks and urban green spaces based on existing standards, as well as the areas beyond accessibility to these spaces are determined. Networks are conjunct systems of linear phenomena

and a framework for resources movements. Through the network analysis, it is possible to find the best route that is generally the closest route between two points in order to reduce travel (Farajzadeh and Hakimi, 2009). Urban green spaces are considered as the centres of service available on the network. Access paths as links and intersections of links are also determined as network nodes (Salehi *et al.,* 2012). The normal pedestrian speed of 0.75 to 1.2 m/s is generally accepted. Thus, the pedestrian speed is considered to be 4 km/h in this study. By designing an access network in a city, the scope of each urban green space service is defined by the maximum distance from the urban green space—e.g., neighbourhood park. The network analysis method is used to analyse the current status of the distribution of green spaces, to investigate their access radius and to determine the areas outside the service coverage of urban parks and green spaces. In this way, all the access networks and passages are originally provided in the Autodesk Map environment. After creating a topology in the ArcGIS environment, some information such as length of the paths, identifiers and the spatial relationship between the grid lines was gained. In order to assess pedestrian access to the nearest park or green space, a maximum distance passed within 15 min. is considered. This means that the service area of each park is to the point where access from that point to the intended park takes 15 min. the maximum (Salehi *et al.,* 2013). Based on existing standards, the radius of operation of parks in the neighbourhood is 600 to 800 meters and sometimes up to 1,000 meters (Teimouri *et al.,* 2010). In this study, the available range for citizens within 5, 10 and 15 min. was determined by using network analysis in the GIS environment. To carry out this analysis, the data obtained from Tabriz Municipality regarding the networks of the city, its districts and locations of green spaces are used. A GIS map of Tabriz is used to study the distribution and continuity of parks and green spaces. In order to investigate the per capita of green space allocation in the city, the existing urban green spaces were evaluated, and the results were compared to standards of per capita green space allocation to extract shortages of parks and other green spaces. In this study, according to the master plan of Tabriz, standard per capita is considered as 9 sq.m. per capita. The master plan determined this figure according to the Supreme Council of Architecture and Urban Development in 2010.

RESULTS AND DISCUSSION

Development, destruction and land use alteration of green spaces

In recent years, the process of dealing with urban green spaces in Tabriz has become a destructive approach and land use change from gardens and green spaces to other uses, such as residential, commercial, and other uses. Most of the mentioned destruction and land use alteration has been made by the directives of urban administrator in the form of urban development plans, in particular by 'Article 5 Commission'. Article 5 Commission is a committee responsible for reviewing and approving or rejecting urban development plans and their alterations in the cities of Iran. This commission consists of top officials of city management. The total land use changes from urban green space to other land uses in the 10 municipal districts of Tabriz from 1996 to 2016 are shown in Fig. 2. As can be seen in Fig. 2, for example in District 5, over 4.5 million sq.m. green space has been converted into other land uses. District 5 has the largest land use change and this has been due to the increasing amount of constructions in recent years in this area (northeast of Tabriz). All these changes have decreased the total area of urban green space in the city, and they have affected the ecology of the city negatively.

Investigation of Article 5 Commission's decisions and actions in the city indicates that the green spaces have been heavily neglected. Only between 2001 and 2011, a large area (165 hectares) of urban green space has changed to residential, commercial, medical, and other uses. Notably, some green spaces such as Aoun Ownebne Ali in the north, and Mountain Park and the continuation of El Goli in the south of the city have

been developed on the fringes of Tabriz. Thus, in the new urban development plan, conservation of green spaces has received less attention. Consequently, the city's green spaces are diminishing day by day (Rahimi, 2012). The regulations of Article 5 Commission established the residential settlements in the eastern part of the city and destroyed the major agricultural lands and gardens (Rahimi, 2012). Only in this area, 2.8 hectares and 84.6 hectares of green spaces have been transformed into road networks and residential use, respectively. The main reason for the lack of parks and green spaces in Tabriz is the ease of plan amendments offered by urban administrator to compensate its financial shortcomings. For example, during the last two decades, many urban green spaces have been converted into more profitable urban utilities such as residential and commercial complexes rather than public utilities such as parks and green spaces for residents. Additionally, inappropriate land and housing policies, disharmonious urban development, conversion of the areas allocated to public utilities and expansion of the residential area of the city towards the eastern corridor exacerbated the problem. Furthermore, expansion of informal/squatter settlements in the north and south of the city, especially on green spaces with a relatively high population density, without providing the minimum public facilities is another factor affecting the shortage of green spaces.

Accessibility of green spaces

Study on the urban green spaces of Tabriz indicates the lack of adequate green spaces and amenities particularly in old/historic and populous areas of
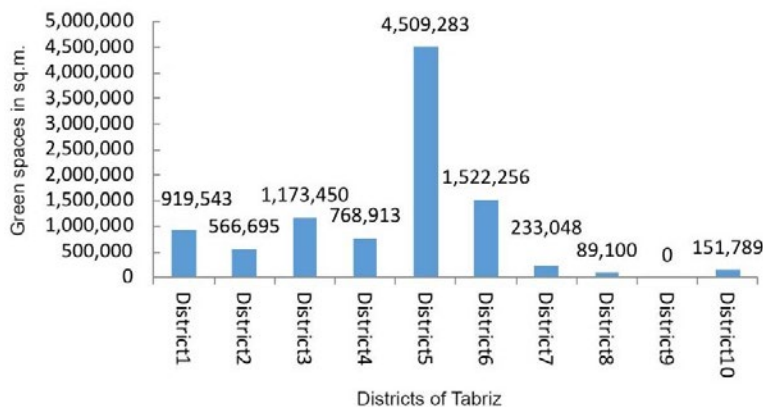

Fig. 2: Level of green space change to other land uses in the municipal districts from 1996 to 2016

the city. Therefore, in these areas, due to the limited or absence of green space supply, access to green spaces is highly difficult. This also creates potential environmental and health consequences such as air pollution, and respiratory and obesity problems. Network analysis is widely accepted as an effective tool for determining the travel time/distance to green spaces based on the type of passageways, service areas, and catchment areas. Using the network analysis method, potential/ideal locations for development of green spaces in the city could be determined. Hence, in this study, the network analysis method is

employed and travel times to green spaces in Tabriz are estimated using 5, 10 and 15 min travel time categories. Commonly accepted ideal and maximum times that a person can walk to a neighbourhood park are 5 and 15 min. respectively. Network analysis calculated the areas inside and outside the urban green space catchments in Tabriz. The results indicate that there is only a very small portion of the city that urban green spaces can be accessed within a 5 min. walk and in the most parts of the city this would be well over a 15 min. walk. Only 18% of the population can access the green spaces within a 5 min. walk, whereas for
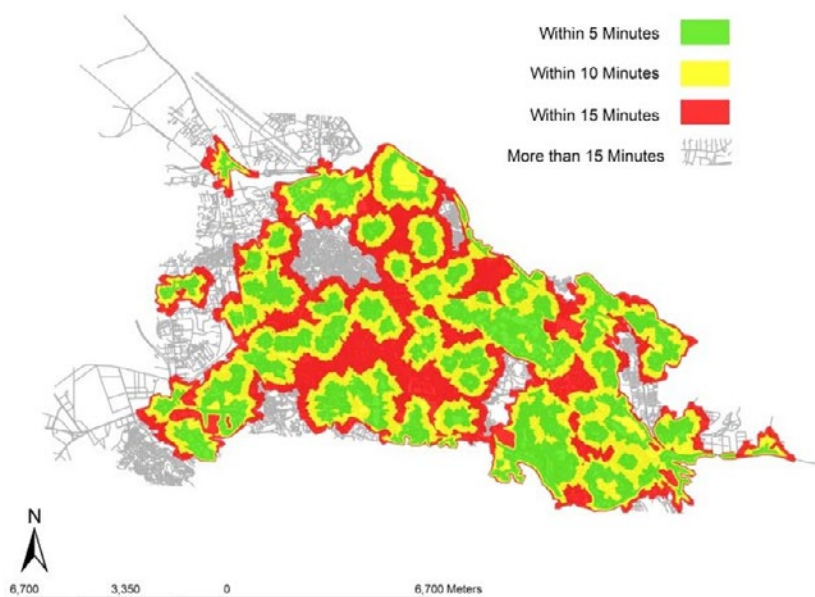

Fig. 3: Access to urban parks on foot in minutes

Table 1: Areas outside the service coverage of urban green spaces based on over 15 minute walk

Districts	Areas outside the service coverage(sq.m.)	Areas (%)
1	280,263	1.86
2	2,389,255	11.43
3	1,0042,647	36.64
4	6,854,988	27.51
5	21,358,368	65.14
6	9,968,438	18.57
7	17,002,504	61.48
8	0	0.00
9	6,307,172	74.65
10	0	0.00
Total	224,837,894	47.89

23% and 59% of the population it would be 10 min. and over 15 min. walks, respectively (Fig. 3).

By examining the accessible green spaces for citizens in Tabriz, it was found that Districts 5, 7, 3 and 4 of Tabriz Municipality have the highest out-of-service green space coverage for citizens, respectively (Table 1).

Most of the urban areas in the city are congested and have a larger population and building densities. The lowest level of access to urban green spaces can be observed in District 8 where is small in size due to its historical, commercial and old texture. Additionally, the existing green spaces in this area are very small. Districts 3 and 4, adjacent to District 8, are also denser in population and buildings (Fig. 4). Therefore, planning to increase green spaces proportional to the existing density, particularly in these areas, is essential in order to generate green space accessibility to local residents.
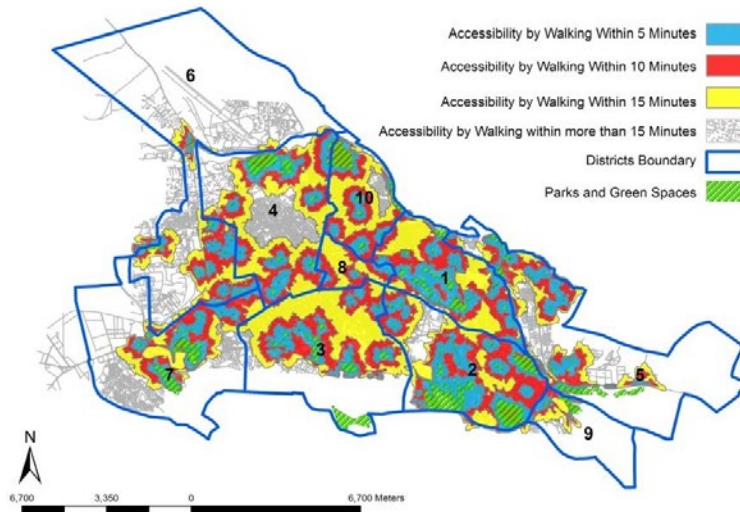

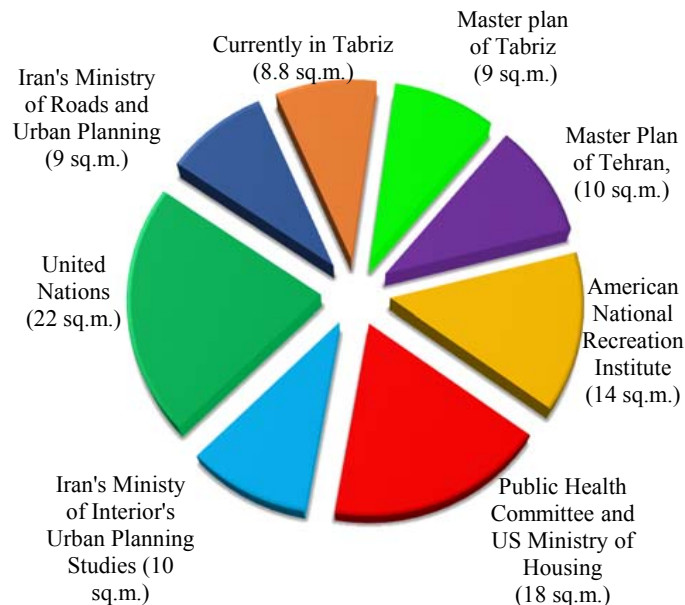Fig. 4: Area coverage of urban green spaces

Fig. 5: Comparison of per capita green space supply in Tabriz with the national and international standards

Per capita of green spaces

According to the studies by the Ministry of Roads and Urban Planning of Iran, acceptable urban green space supply in Iranian cities should be in the range of 7-12 sq.m. per capita; this is less than the range of 20-25 sq.m. per capita suggested by the United Nations Environment Index (Akbarpour-Sarascanrood *et al.,* 2009). Besides, according to Ebrahimzadeh and Ebadi (2008), urban green space supply per capita in Iran is proposed to be in the range of 8-9 sq.m. (Fig. 5).

Comparison of the current per capita green space supply in Tabriz with the criterion of per capita allocation standards reveals that the current per capita allocation is close to the per capita figure suggested in Tabriz Master Plan (Fig. 6). However, most of the city's neighbourhoods face the lack of green spaces due to the development of these spaces on the fringes of the city that makes them inaccessible for most of the citizens. This situation leads to lack of sufficient ecological benefits of green spaces at the inner-city neighbourhoods. These benefits include air purifying, mitigating air pollution, decreasing ambient temperature, and oxygen production as well as social benefits such as social interactions of citizens in open public spaces.
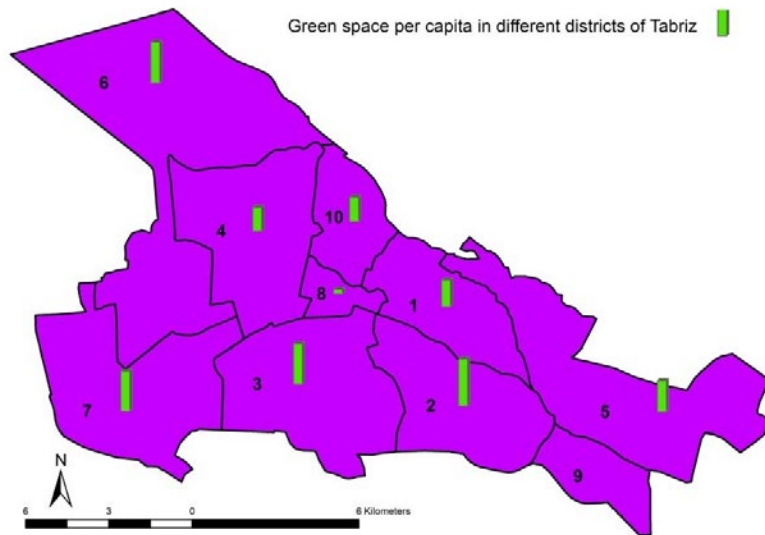

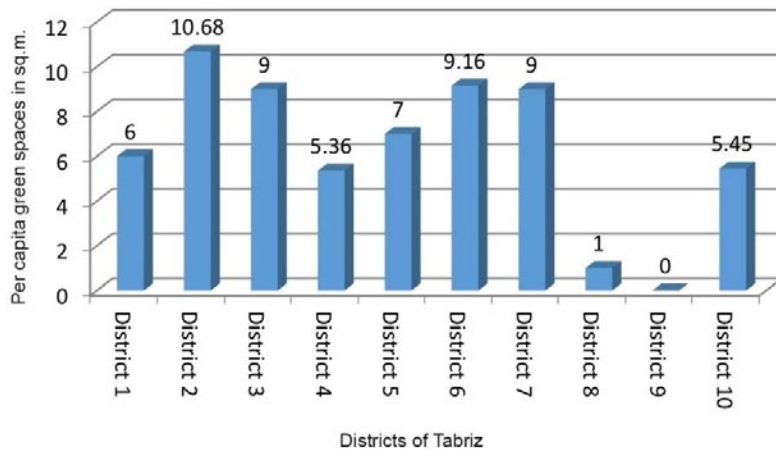Fig. 6: Per capita urban green space supply in the municipal districts

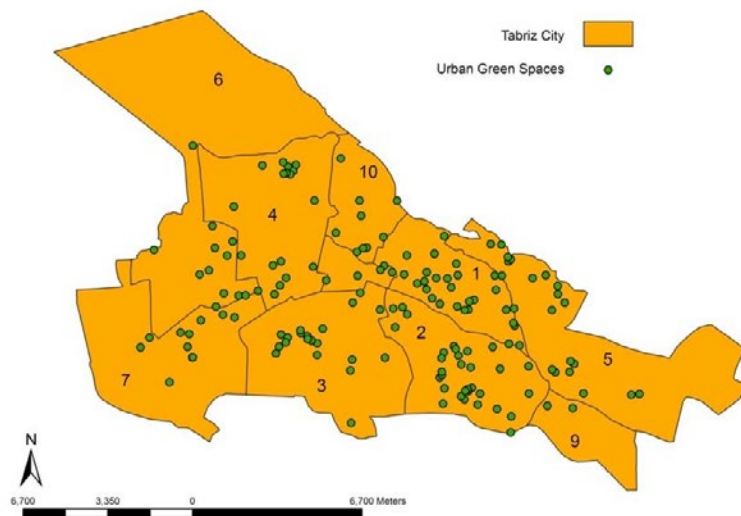Fig. 7: Per capita urban green space supply in the municipal districts

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Fig. 8: Distribution of parks and urban green spaces

Per capita green space supply in District 2, due to the presence of El Goli Park and the plantations in this area, is higher than that in other districts (Fig. 7). Districts 6, 7 and 3, respectively, have the highest per capita green space supply. District 9, due to being a newly built area with incomplete buildings and accommodations, has no green space. District 1, due to having high population and building density and large slum areas, has the second lowest green space per capita supply after District 9.

Distribution and continuity of green spaces

As suggested by Tian *et al.* (2017), connectivity is a vital element in landscape structure because of its importance in species–landscape interactions. As for Brierley *et al.* (2006), connectivity involves linkages of habitats, species, communities and ecological processes at multiple spatial and temporal scales, and it influences biophysical processes and biogeochemical functions. Hence, linear greenways or striped green spaces can enhance urban structural connectivity of green spaces. However, in most of the districts distribution of green spaces are inadequate and do not provide continuity to form a green corridor or linear greenways. Subsequently, most of the residents in neighbourhoods have no access to urban green spaces. Particularly the densely populated areas of the city, including District 8 (old and historical texture), Districts 3 and 4 (dense and old texture), Districts 1 and 10 (marginal and old texture), respectively, have

the highest poverty rates in terms of urban green spaces (Fig. 8). Inadequate planning—that could not maintain an optimal distribution of green spaces at the old and new parts and inner and outer parts of the city—is one of the main reasons for the limited urban green space supply in Tabriz. Therefore, the lack of compliance with ecological principles, and limited or absence of urban green spaces supply throughout the city are among the main challenges associated with green spaces planning in Tabriz.

According to the findings, the following can be recommended for Tabriz and other cities with emerging economies and similar characteristics to move towards an effective ecological planning:
- Integrated management of various organisations related to the planning of green spaces and environmental issues in the city;
- Establishing strong regulations to prevent any changes of green spaces to other land uses;
- Developing the green space area in all parts of the city to increase the ecological balance and realising the green landscape in the city;
- Allocating the appropriate parts of green spaces to pedestrian and cycling access for all citizens;
- Developing urban green spaces in proportion to population density;
- Acquiring and equipping brown fields to include green spaces in the areas lacking these spaces;
- Planning for continuous development of green spaces to enhance green landscape and ecological

balance in the city;

- Increasing green space per capita in dense textures for ease of access and ecological benefits**;**
- Increasing people's participation in planting and maintaining trees and plants;
- Using native plant species considering the regional and climatic conditions;
- Creating vertical green spaces and green roofs in urban areas to enhance the ecological function of green spaces, and;
- Prioritising tree planting instead of grass coverage.

CONCLUSION

This study focused on addressing the question of 'whether the current status of urban green spaces in Tabriz is in accordance with the ecological principles. The findings suggest that response to this question is negative. Considering the increasing population as well as horizontal and sprawl growth of the city, which have been accompanied by destruction of green spaces over the past decades, the greatest destruction of urban green spaces has been attributed to the changes approved by Article 5 Commission and urban administrators, so that almost 10 million sq.m. (Precisely 9,934,077 sq.m.) of green area have changed to other land uses especially housing and commercial ones during the last two decades. Urban green spaces in Tabriz, despite their close proximity to the per capita allocation standards, do not have an equitable distribution to be accessed by all citizen. Only 18% of the population can access green spaces within a 5 min. walk. Moreover, the results indicated that 59% of residents do not have access to green spaces in less than a 15-munite walk. Particularly, the densely populated areas of the city have distinctive poverty in green spaces allocation. Namely District 8 with only 1 meter and District 10 with 5.45 meters green space per capita are the most densely populated urban areas. Most of the urban green spaces are located on the urban fringes, and in low-density higher income residential areas. Full adherence to ecological principles of urban planning to provide all citizens with access to green spaces at the local level is critical. In addition to provision of more green spaces for the residents and visitors, distribution of green spaces in different parts of the city needs to be more balanced. Furthermore, considering various functions of green spaces (such as recreation, exercise, aesthetic, and so on),

continuous and interconnected development as well as achieving picturesque urban landscapes, the urban administrations and planners should reconsider Tabriz to develop its green spaces based on ecological planning principles. In other words, to achieve a sustainable urban development in Tabriz, adoption of ecological planning practices is critically important. The ecological planning principles in line with sustainable urban development goals will not only help the citizens to benefit from better planned green spaces, but also will secure a liveable city for the future generations. This study has limitations mainly due to data availability, which limits the ability to undertake additional in-depth analyses such as developing density, distance, connectivity and other relevant indices. Future studies by authors can be focused on addressing these issues.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interests regarding the publication of this manuscript.

ABBREVIATIONS

GIS	Geographic information system
km/h	Kilometres per hour
min.	Minute
m/s	Meter per second
sq.km.	Square kilometre
sq.m.	Square metre

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