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Comparative analysis of key factors influencing urban green space in Mashhad, Iran (1988–2018)

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Abstract

This paper analyzed the role of national economic factors, in addition to some key city-level variables, in the variation of the urban green space (UGS) in Mashhad City (Iran) during three decades (1998–2018). The correlation result revealed the effects of the increasing trend of land price, population rate, and construction of built-up areas in the decreasing trend of UGS in the study area (R from −0.95 to -0.99 at p-value > 95%). Also, the country-level economic factors, i.e., GDP per capita, oil price, export total value, and FDI, represented the overall increasing trend from 1988 to 2018, correlating with the decrease of green space areas (R from −0.76 to -0.92 at p-value > 75%). Some statistical analyses, such as the run-test, the skewness and kurtosis tests, the Kolmogorov-Smirnov test, and the ANOVA test were done to confirm the normality of the data distribution and reliability of the results. Ultimately, clustering the research variables based on the significance and confidence levels of the estimated correlation results revealed that the change in the oil price and national export values in the petroleum-dependent economy of Iran can be assumed as the lead key economic factors to fluctuate all city-level variables, particularly the UGS variations.

Keywords Country-level, Economic factors, Remote sensing, Urban development, Urban green space, GIS, Statistical analysis

Introduction

Urban green space (UGS) is a broad and complex concept (Taylor and Hochuli 2017), which is usually defined as open spaces primarily covered by natural and semi-natural vegetation within urban areas (Stessens et al. 2017; Lu et al. 2023). UGS is also referred to as a blue-green zone, because of urban water, such as streams, channels, and inland waterways (Haase et al. 2014; Garrett et al. 2019; De Haas et al. 2021). As a multidisciplinary concept, UGS can comprise multiple components, e.g., social, economic, and ecological elements (Taylor and Hochuli 2017).

UGS can also enhance the quality of the urban environment (Wilkerson et al. 2018), contributing to local gentrification through rising real estate prices. Hence, the relationships between UGS and multidiscipline variables are a very interesting category for researchers. In this regard, worldwide works reported the relationship between the variation of UGS and socioeconomic status in recent years (Fobil et al. 2010; Kabisch and Haase 2013; Holt et al. 2015; Hoffimann et al. 2017).

Recently, Sun et al. (2020) revealed that the economic development of the upper-income countries can increase the urban green areas significantly. However, most of the mentioned studies in the literature have not focused on

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the role of national economic factors in the change of land use and land cover changes. On the other side, there has been no observed research in Iran, as a lower-middle-income country (World Bank 2023), to investigate the effects of the national economy on the urban green space variations. Meanwhile, the role of UGS in the urban life of lower-middle-income regions and countries is more important than upper-income areas due to their more willing to use them (Wendel et al. 2012; Vaughan et al. 2018).

Particularly, the decreasing trend of urban green spaces (UGS) has been a significant concern in urban areas of Iranian cities within the last decades, which have faced a rapid urbanization rate (Shabahang et al. 2019; Soltanifard et al. 2020). One of these cities is Mashhad city, which is the second-largest city and the most significant population center in the northeast of Iran. The lack of sufficient investigation of endogenous and exogenous economic factors, influencing the UGS qualities and quantities is a main research gap in Mashhad City, due to the main role of tourism and pilgrimage in the economic environment of the city. Meanwhile, the increasing importance of UGS in enhancing citizen's and pilgrim's wealth provided more attention by urban decision makers and researchers paying to UGS's potential and planning in recent years. Hence, the present study is a novel and important research, that aims to comparative analysis for the role of national economic factors, in addition to some key city-level variables, in the variation of urban green spaces in Mashhad city during three decades (1998–2018).

Literature review

According to the literature review, some researchers explored the social aspect of UGS (e.g., Lachowycz and Jones 2013; Kabisch et al. 2015; Li et al. 2015a; Jennings and Bamkole 2019). Some other scholars investigated the economic aspects and contributions of UGS (Arvanitidis et al. 2009; Zhang et al. 2014; Wheeler et al. 2015; Aram et al. 2019). Besides, the ecological aspect of UGSs regarding the ecosystem services, environmental integrity, urban climate, and population carrying capacity (Wolch et al. 2014; Liu and Shen 2014; Southon et al. 2017; Mansouri Daneshvar et al. 2017; Soltanifard et al. 2022). The contribution of a UGS to sustainable socioeconomic development has been highlighted by various international organizations (e.g., UN-Habitat 2009; EEA 2010; Madanian and Costa 2017). Urban planners, designers, and researchers need to focus on UGS strategies that explicitly promote socioeconomic sustainability (Wolch et al. 2014). Hence, a large number of studies have been carried out based on the correlation between socioeconomic factors and the UGS features in the last years (e.g., Grove et al. 2006; Troy et al. 2007; Di Giulio et al. 2009; Luck et al. 2009; Gong et al. 2013; Zinia and McShane 2018; Soltanifard et al. 2020).

In the scale of our study area (Mashhad City), the research background of the UGS is observed in different fields. For instance, ecological attitudes revealed that the more role of green spaces and areas the more quality of ecosystem services and ecological carrying capacity in the study area (Mansouri Daneshvar et al. 2017; Soltanifard and Jafari 2019; Ramyar 2019). From an urban climate viewpoint, Mansourmoghaddam et al. (2023) and Shabahang et al. (2019) revealed that an increase in green areas can reduce thermal effects and expansion of heat islands in Mashhad city. Also, from the healthcare viewpoint, Rahnama and Shaddel (2019) and Kamrani et al. (2020) demonstrated a significant relationship between human health and high per capita green spaces in different areas of Mashhad. However, socioeconomic research in the field of UGS is rare in the study area and needs to be more investigated.

Data and methods

Study area

Mashhad city is one of the main metropolises of Iran with more than three million inhabitants (SCI 2022). The location of the study area situates between northern latitudes from 36°37′ to 36°58′ and eastern longitudes from 59°26′ to 59°44′ (Kardani-Yazd et al. 2019). Over the past 100 years, Mashhad was drastically transformed by modernization policies, in which the area increased 47 times and the population multiplied 56 times, approximately (Soltanifard et al. 2022). In the last decades, it has continuously experienced rapid population growth and corresponding physical transformation due to its excellent pilgrimage, tourism, agricultural, and commercial contexts (Soltanifard et al. 2022). Among these situations, the legal development plan of the city attempted to point out a greenbelt around the city to protect all UGSs interior the belt boundary, however, the leapfrog sprawl has dilapidated these spaces with illegal and informal settlements within the last decades (Kardani-Yazd et al. 2019). According to the statistical analysis in GIS the surface area of total UGSs (with a total area of 30 km^2) was considered greater than 2 ha in the study area (Mansouri Daneshvar et al. 2017).

Data collection and analysis

Remote sensing of land data

A large number of previous studies indicated the relevance of the estimation of green spaces and pixels based on satellite imagery (Li et al. 2015b; Rahnama and Shaddel 2019), particularly Landsat imagery data (e.g., Naserikia et al. 2019; Kardani-Yazd et al. 2019; Mansourmoghaddam et al. 2023). In the present study, the satellite imageries of Landsat sensors, including TM, ETM+, and

OLI at equal time intervals were considered to detect the change rates of green spaces (including green and blue patterns), open spaces (including brown and bare fields without land uses), and built-up areas (including real estates and roads) during periods of 1988, 1998, 2008, and 2018, exactly in the driest month of the August, to remove the error of sky cloudiness. Satellite data were obtained from the Landsat archive of remote sensing data, hosted by the United States Geological Survey (USGS 2022) via a web-based Earth-Explorer program with the corrected format of geometric and radiometric errors. After the spatial analysis, the GIS software was used to present the output maps of variation of green spaces in the study area from 1988 to 2018.

Time series preparation

The present study attempted to investigate the role of some national economic factors, in addition to some city-level factors, in the variation of urban green spaces in the study area (see Table 1). For this purpose, some city-level variables were obtained from land remote sensed data (Landsat imageries) and the Statistical Center of Iran (SCI 2022). The remote sensed surface area for key spatial patterns in the study area was assumed as [1] urban green space in units of square kilometers, [2] urban open space in units of square kilometers, and [3] urban built-up area in units of square kilometers. Also, two city-level key variables of [4] land price in units of thousand USD per square meter and [5] population rate in units of million inhabitants were collected based on the official reports of SCI (2022).

Besides, some econometric time series were acquired at the country level from the World Development Indicators of the World Bank (2022) and the International Monetary Fund database (IMF 2022), similar to a recent work by Mansouri Daneshvar et al. (2024). In this regard, some time series of major national economic factors were collected into annual-scale databank from 1988 to 2018, including [1] gross domestic product (GDP) per capita in units of current USD, [2] oil price in units of USD per Barrel of Brent crude, [3] export total value in unit of billion USD, and [4] the financial development index (FDI) of the national economy (unitless). The mentioned variables in the previous econometric studies have been chosen by several scholars, such as Kilian and Murphy (2013), Shabbir et al. (2020), Akbar et al. (2020), and Dinh (2020). For instance, FDI is a multidimensional measure, that depends on economic growth and stability (Kunt and Levine 2009; Norris and Srivisal 2013; Mansouri Daneshvar et al. 2024).

Table 1 All research variables including city-level and country-level factors, units, and sources

Scale	Variable	Unit	Source
City-level	Green space	Square kilometers	SCI (2022)
	Built area	Square kilometers	SCI (2022)
	Open space	Square kilometers	SCI (2022)
	Land price	Thousand USD per square meter	SCI (2022)
	Population	Million inhabitants	SCI (2022)
Country-level	GDP per capita	Current USD	World Bank (2022)
	Oil price	USD per Barrel of Brent crude	World Bank (2022)
	Export total value	Billion USD	World Bank (2022)
	FDI	Rate (unitless)	IMF (2022)

Data analysis

Ultimately, the correlation methods have been applied to investigate constant relationships between independent measures and urban spatial patterns same as the previous studies (e.g., Schindler et al. 2009; Tian et al. 2011; Fan and Myint 2014; Peng et al. 2015; Soltanifard and Jafari 2019; Soltanifard et al. 2020; Han and Keeffe 2020). Hence, the present study attempted to investigate the relationships between the variation of UGS (as a dependent variable) in Mashhad city and some independent variables at the city-level (e.g., land price, population rate, open space, and built area) and in country-level (e.g., economic factors of GDP per capita, oil price, export total value, and FDI) using the formal Pearson correlation test. For this method, the range of variables was prepared based on validating access and study periods in the Excel tables. Afterward, the correlation tests were calculated to determine the relationship coefficients between the dependent and independent variables in SPSS software, exposing the positive or negative values of R-values as the direct or inverse correlations (Hasani and Sarvari 2024). In this regard, the R-value indicates strong and significant correlations by values above 0.6. (Campbell and Swinscow 2009). It should be noted that we carried out some extra statistical analysis in the SPSS software for the detection of the randomizing and normality of data distribution such as run-test, the skewness and kurtosis tests, and Kolmogorov-Smirnov test, before the correlation tests. Meanwhile, the ANOVA test was done to confirm the correlation reliability after the correlation tests.

Results and discussion

Remote sensing outputs

In the present study, the satellite imageries of Landsat 4, 5, 7, and 8 were analyzed to detect the spatial variation of green spaces, open spaces, and built areas within four temporal intervals of 1988, 1998, 2008, and 2018. According to Kardani-Yazd et al. (2019) and Naserikia et al. 2019; the maximum likelihood classifier was applied for the land use/cover classification according to pixel-group samples using ENVI software. The overall accuracy

Table 2 Information of satellite imageries, sensors, overall accuracy, and Kappa coefficient

Year	Satellite	Sensor	Overall accuracy	Kappa coefficient
1988	Landsat 4	TM	84%	0.87
1998	Landsat 5	TM	86%	0.78
2008	Landsat 7	ETM+	94%	0.89
2018	Landsat 8	OLI-TIRS	95%	0.86

and the Kappa coefficient were also obtained for all years, averaging over 0.90% and 85%, representing the normal ranges for urban land cover classification. Overall accuracy depends on the corrected classification of sample pixels and the Kappa coefficient depends on the random-based expected classification. All the obtained information on the overall accuracy and Kappa coefficient of the land use/ cover classification and specifications of the aforementioned satellite imageries are shown in Table 2. The classified output maps for green spaces, open spaces, and built areas were produced in true natural color (RGB) in GIS and then polished in Photoshop (Figs. 1 and 2).

These outputs corresponded based on the legal city limitation in quo status (2023). The legal city limitation is defined by the municipality of Mashhad city in 2023 as equal to 305.75 km^2, which comprised all land cover changes during the three last decades (from 1988 to 2018). The estimations of the statistical analysis of spatial maps are also represented in Table 3. The estimation of the remote sensing analysis revealed that the UGS surface area in Mashhad City decreased from 88.15 km^2 (1988) to 44.05 km^2 (2018) with a mean alteration rate of -0.50. In the same status, the open space surface area in Mashhad City decreased from 102.25 km^2 (1988) to 23.75

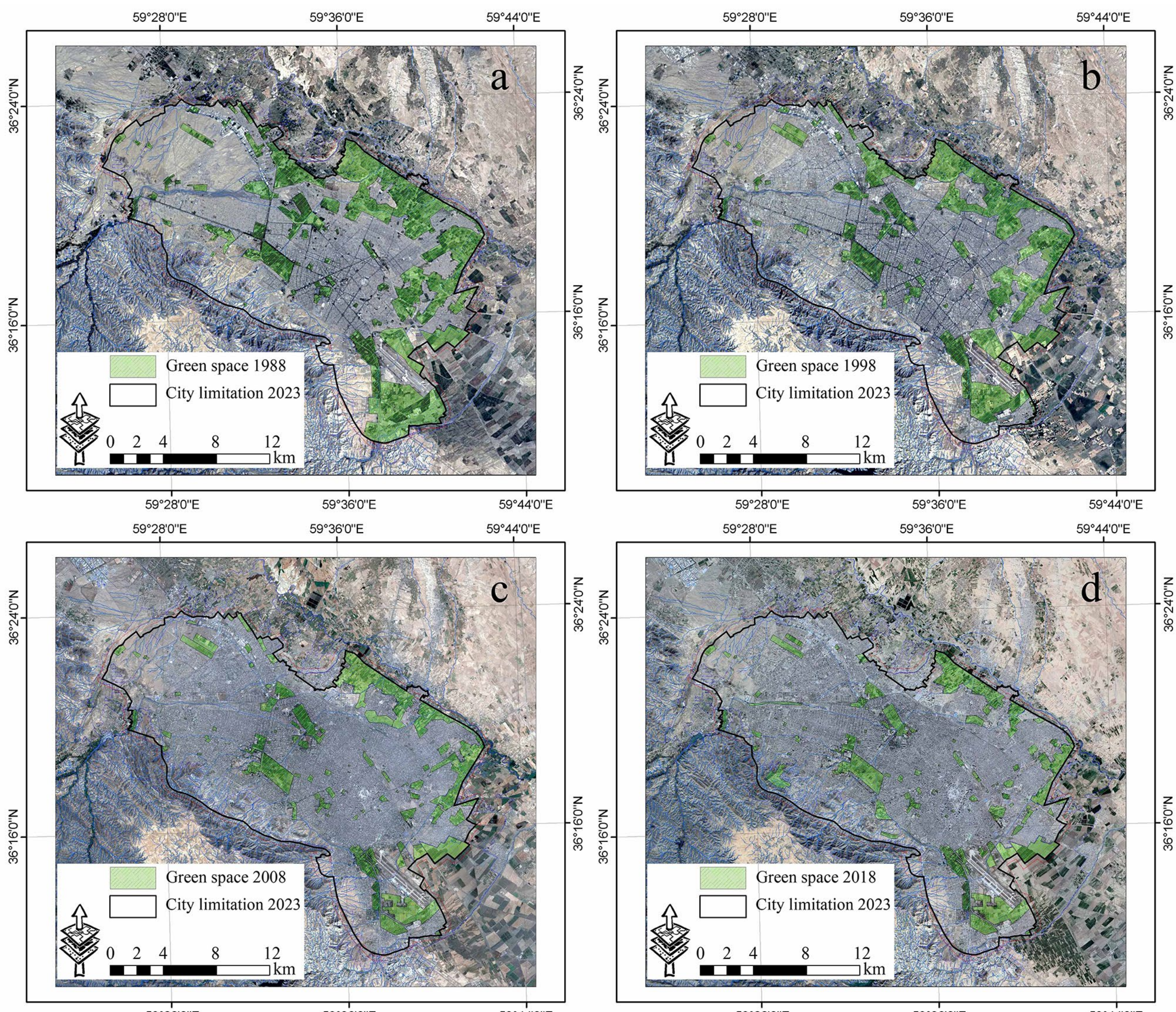

Fig. 1 Classified extraction of urban green spaces based on the Landsat imageries in periods of (**a**) 1988, (**b**) 1998, (**c**) 2008, and (**d**) 2018

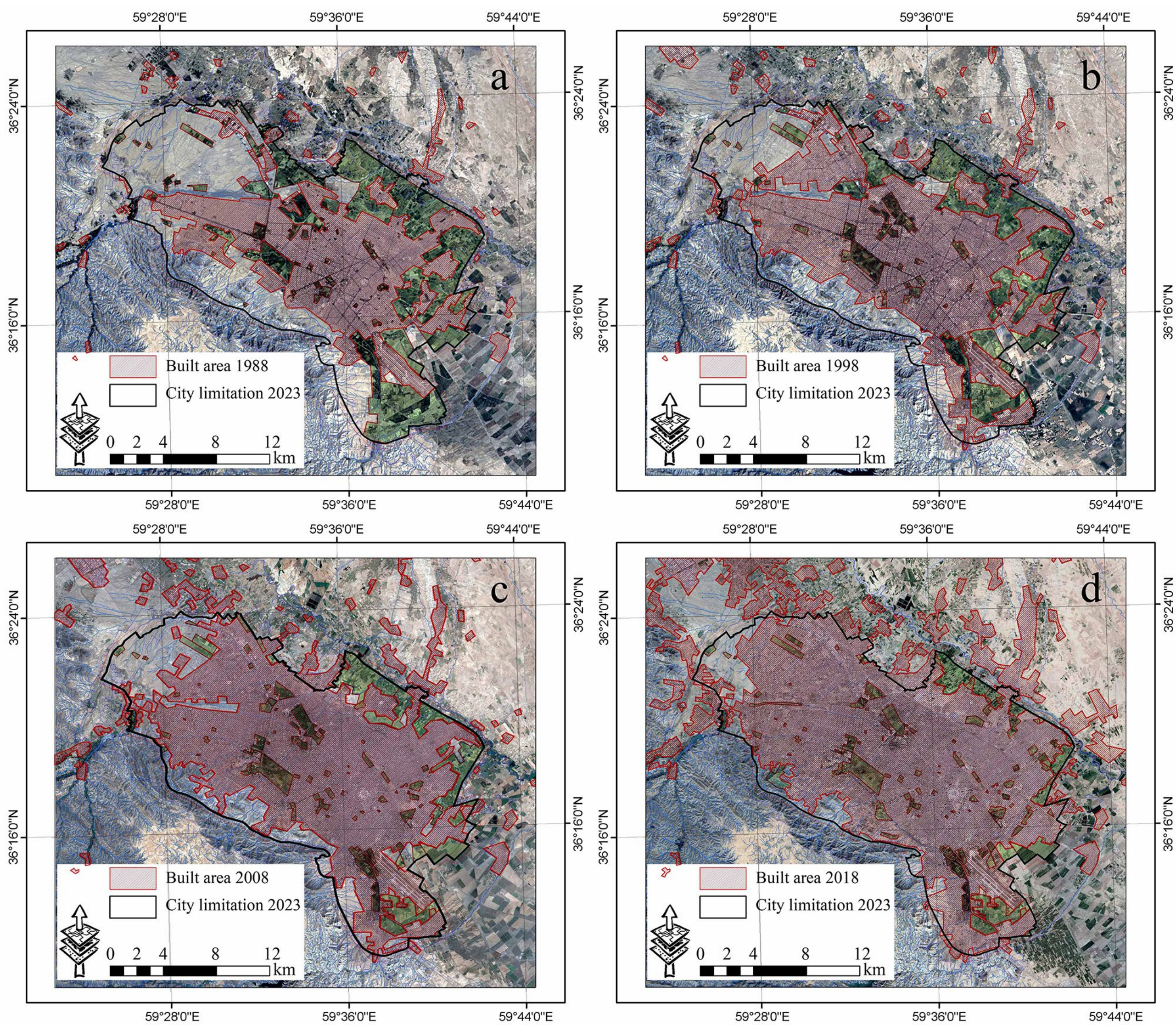

Fig. 2 Classified extraction of urban built areas based on the Landsat imageries in periods of (**a**) 1988, (**b**) 1998, (**c**) 2008, and (**d**) 2018

Table 3 Surface areas of green space, open space, and built area pixels based on the satellite imageries inside the legal limitation of the Mashhad city in 2023 besides city-level variables of land price and population rate

Year	Green space (km^2)	Open space (km^2)	Built area (km^2)	Land price (USD)	Population (million)
1988	88.15	102.25	115.35	250	1.46
1998	71.15	74.15	160.45	290	1.88
2008	50.05	44.75	210.95	830	2.41
2018	44.05	23.75	237.95	880	3.10
Mean	63.35	61.23	181.18	563	2.21

km^2 (2018) with a mean alteration rate of -0.77. Based on the classified satellite imageries, the built areas in Mashhad city increased from 115.35 km^2 (1988) to 237.95 km^2 (2018) with a mean alteration rate of +1.06. On this basis, the dominant trend of land cover change in the study area revealed an increasing trend for built-up areas and a decreasing trend for green space and open space areas during 1988–2018.

Investigation of two other city-level variables of land price and population rate in synchronized time intervals showed increasing values for land price [population rate] from 250 USD per square meter [1.46 million inhabitants] to 880 USD per square meter [3.10 million inhabitants] with mean alteration rates of 2.52 [1.12]. These facts revealed the faster growth of land price, population rate, and construction of built-up areas against the urban green space and open space areas, exposing the possible effects of socio-economic changes in the land cover changes in the study area.

Table 4 Research economic factors at the country-level

Year	GDP per capita (USD)	Oil price (USD)	Export total value (billion USD)	FDI (0–1)
1988	2,237	24	19.3	0.25
1998	1,738	13	13.2	0.24
2008	5,624	97	113.7	0.28
2018	3,874	72	103.4	0.37
Mean	3,368	52	62.4	0.29

Table 5 Statistics of skewness and kurtosis tests to recognize the initial normality of data distribution for each variable

Scale	Variable	Skewness test *	Kurtosis test **
City-level	Green space	0.50	-2.47
	Built area	-0.35	-2.02
	Open space	0.23	-1.66
	Land price	0.01	-5.82
	Population	0.46	-0.83
Country-level	GDP per capita	0.71	-1.43
	Oil price	0.27	-3.80
	Export total value	0.02	-5.75
	FDI	1.55	2.23

*: Std. Error of Skewness is 1.01, **: Std. Error of Kurtosis is 2.62

Table 6 Statistics of Kolmogorov-Smirnov test to recognize the perfect normality of data distribution for each variable

Scale	Variable	Kolmogorov-Smirnov test	Asymp. Sig. (2-tailed)
City-level	Green space	0.490	0.970
	Built area	0.416	0.995
	Open space	0.369	0.999
	Land price	0.579	0.891
	Population	0.361	0.999
Country-level	GDP per capita	0.480	0.975
	Oil price	0.511	0.956
	Export total value	0.579	0.890
	FDI	0.567	0.904

Table 7 Correlation coefficients between dependent variable (urban green space) and city-level independent variables (i.e., built area, open space, and population rate) within 1988–2018 ($N=4$)

Variable	Pearson correlation test	Built area	Open space	Land price	Population
Green space	(R)	-0.99	0.99	-0.95	-0.96
	Sig. (2-tailed)	0.00	0.00	0.05	0.04

National economic factors

In recent decades, the national economy of Iran has experienced unprecedented financial challenges, resulting in fluctuations in some economic factors, such as national GDP and export values. The abnormal changes in the national economy of Iran leveraged seriously urban patterns because people have tended to invest in the real estate sector (Mansouri Daneshvar et al. 2024). It seems that more consideration to invest and construct in the urban built areas influenced the qualities and quantities of the UGS in the Iranian cities.

In this study, we investigated four time series of economic factors during 1988–2018 (Table 4). On this basis, the statistics revealed that GDP per capita, oil price, export total value, and FDI increased from 2237 USD, 24 USD, 19.3 billion USD, and 0.25 to 3874 USD, 72 USD, 103.4 billion USD, and 0.37, respectively between 1988 and 2018. However, the overall increasing trend for the aforementioned country-level factors is not seen as linear, and distinct fluctuations were observed during the time series.

Correlation analysis

Before the correlation test, we should carry out the Run test for detection of the randomizing and normality of data distribution for each variable. In the first step, the run-test to recognize the randomizing data distribution for each variable revealed the number of runs/cases, Z median value, and Asymp. Sig. (2-tailed) equal 2/4, -0.612, and 0.541, respectively. Based on the Asymp. Sig. (2-tailed) in the run-test, which is over 0.5, the data distribution in each variable (both city-level and country-level variables) is assumed as random with no homogeneity.

In the second step, we estimated the statistics of skewness and kurtosis tests to recognize the initial normality of data distribution for each variable (Table 5). Based on all skewness values (from −0.35 to +1.55), which lay between −2 and +2, the data distribution for each variable revealed the initial normality without skewness. Furthermore, the statistics of the Kolmogorov-Smirnov test were calculated to recognize the perfect normality of data distribution for each variable (Table 6). Based on the high values of Asymp. Sig. (2-tailed) in the Kolmogorov-Smirnov, which is over 0.5, the data distribution in each variable (both city-level and country-level variables) is assumed as normal, letting us do further analysis of correlation tests.

In the third step, correlation tests between the dependent variable of urban green space (UGS) and city-level/country-level independent variables were estimated within four time-intervals of 1988–2018 ($N=4$). The correlation coefficients between the dependent variable (UGS) and city-level independent variables (i.e., built area, open space, and population rate) are shown in Table 7. On this basis, the UGS has significant negative correlations (R from −0.95 to -0.99) with three city-level variables of built area, land price, and population rate at a confidence level of >95% (Sig.<0.05). It means that increasing values of the mean land price, amount of built-up areas, and population rates influenced the decrease of green space areas in the study area from 1988 to 2018.

However, the significant positive correlation between the UGS and open space areas (R=0.99) revealed that the reduction of UGS areas occurred simultaneously with the reduction of open space areas. Previously, Soltanifard et al. (2020), Shabahang et al. (2019), and Rafiee et al. 2009) demonstrated that rapid expansion of built-up areas and population rates in Mashhad City decreased the rate of green spaces in urban areas.

Also, the correlation coefficients between the UGS and country-level independent variables (i.e., land price, GDP per capita, oil price, export total value, and FDI value) are shown in Table 8. On this basis, the UGS has significant negative correlations (R from −0.76 to -0.92) with four country-level variables of GDP per capita, oil price, export total value, and FDI value at a confidence level of >75% (Sig.<0.25). It means that increasing values of all national economic factors influenced the decrease of green space areas in the study area during 1988–2018. Ultimately, the ANOVA test in Table 9 confirmed the correlation reliability (both correlation coefficients at the city level and country level) based on their significance (Sig.<0.05) and confidence levels (P>95%).

Table 8 Correlation coefficients between dependent variable (urban green space) and country-level independent variables (i.e., land price, GDP per capita, oil price, export total value, and FDI value) within 1988–2018 (N=4)

Variable	Pearson correlation test	GDP per capita	Oil price	Export total value	FDI
Green space	(R)	-0.76	-0.92	-0.90	-0.78
	Sig. (2-tailed)	0.24	0.08	0.10	0.22

Table 9 ANOVA test results between green space and other variables

Scale	Variable	Std. Error of the Estimate	ANOVA test		
			Mean Square	F	Sig.
City-level	Built area	5.495	8812.013	291.816	0.003
	Open space	5.335	3465.513	114.763	0.009
	Land price	126.467	312286.960	19.525	0.048
	Population	0.256	1.373	20.992	0.044
Country-level	GDP per capita	1412.155	5293267.156	2.654	0.245
	Oil price	27.562	3209.674	4.225	0.076
	Export total value	28.305	6988.575	8.723	0.098
	FDI	0.045	0.006	3.081	0.221

Discussion

It should be noted that the UGSs can be categorized into three groups small UGSs (community scale, 2–20 ha), medium-sized UGSs (district scale, 20–100 ha), and large UGSs (city scale, more than 100 ha) (Fan et al. 2017; Lu et al. 2023). On this basis, the distribution of all green spaces in the study area can be categorized dominantly into private medium-sized gardens (25% of total UGSs) public community spaces, and city-scale parks (75% of total UGSs). A review of the medium-sized green spaces of Mashhad exposed their appropriate potential for urban agricultural functions (Cinà and Khatami 2017). However, the rapid urbanization rate in the study area has gradually eliminated these medium-sized UGSs. Rafiee et al. (2009) have also researched changes to this type of UGSs in Mashhad and their results showed that during 1988–2007 the proportion of green spaces dropped significantly (Shabahang et al. 2019).

In this regard, our results revealed that the faster growth of land price, population rate, and construction of built-up areas against the urban green space and open space areas can reflect the possible effects of socioeconomic changes in the land cover changes in the study area. The land cover change was carried out dominantly against the UGS in the eastern part of the city, which has the highest density in population and built-up construction. These findings correspond to the previous works, revealing the urbanization effects in the occupation of more green spaces by urban constructions, leading to the reduction of the UGS (Maimaitiming et al. 2013). According to the literature, the decrease in UGS in Iran can follow the population and construction rates (Soltanifard et al. 2020). Some worldwide studies have approved the correlations between the total built-up area and the urban green space (Fuller and Gaston 2009; Kabisch and Haase 2013). Also, coupled with the dense population associated with urbanization, the variations in the spatial pattern of UGS is a challenge for the major cities in the world (Gan et al. 2014; Wang et al. 2019; Lu et al. 2023).

Compared with the decreasing trend of UGS in the study area, the selected national economic factors, i.e., GDP per capita, oil price, export total value, and FDI, represented the overall increasing trend in the scale of country-level from 1988 to 2018. Hence, it can be assumed that there is a hidden relation between the UGS variation and country-level factors of the economy. In this regard, the correlation coefficients between UGS variation and the mentioned factors revealed that increasing values of all national economic factors influenced the decrease of green space areas. Previous works revealed that differences in socioeconomic status have been directly and indirectly linked to the UGS at multiple levels and variations in national economic factors can lead to significant variability in UGS facts and figures (McDonald 2009; Escobedo et al. 2011; Wilkerson et al. 2018; Lategan et al. 2022).

Clustering the research variables based on the significance and confidence levels of the estimated correlation results revealed three groups, including cluster A at p-value > 95%, cluster B at p-value > 90%, and cluster C at p-value > 75% (Fig. 3). All city-level variables can be categorized in cluster A. However, among the country-level economic factors, we can distinct two separate clusters namely cluster B with high p-value (oil and export) and cluster C with less p-value (GDP and FDI). Overall, it seems that the change in the oil price and export values in cluster B can be assumed as the lead key economic factor to fluctuate other city-level and country-level variables, in which the major share of national revenue in the petroleum-dependent economy of Iran depends on the oil export (Mansouri Daneshvar et al. 2024). Finally, we can describe that the enhancement of national revenue from total export values (including oil export), first, could accelerate the GDP per capita and national index of financial development. Second, it can fluctuate the land price and increase the tendency of built-up construction and the density of population in the cities. This realistic process decreased gradually the green and open space surface areas in the study area within three decades.

Conclusions

The main aim of the present study was to comparative analysis of the role of national economic factors, in addition to some key city-level variables, in the variation of the UGS in Mashhad city during three past decades (1998–2018). For this purpose, some well-known variables were extracted from land remote sensed data (Landsat imageries), the Statistical Center of Iran (SCI), the World Bank, and the International Monetary Fund (IMF) databases. The remote sensing procedure was applied to land classification and showed an increasing trend for built-up areas, co-registered with a decreasing trend for green space and open space areas as the dominant trend of land cover change in the study area during 1988–2018. The statistical analysis represented that the increasing values of the mean land price, amount of built-up areas, and population rates influenced the decrease of UGS through the city-level scale. Besides, the selected national economic factors, i.e., GDP per capita, oil price, export total value, and FDI, represented the overall increasing trend in the scale of country-level against the UGS variation in the study area. Finally, we can describe that the enhancement of national revenue from total export values (including oil export) can be assumed as a key factor, influencing urban green space in Mashhad, Iran (1988–2018).

The study provided some implications for understanding the urban green space and urban development patterns in Iranian cities. The theoretical implication relates to the urban greenery studies and the role of country-level factors in the change of urban land cover. Also, the study can be categorized along with the United Nations Sustainable Development Goals (SDGs), in which the UGS is vital to the achievement of by 2030, namely SDG11 (Sustainable Cities and Communities) (UN 2015; Pinto et al. 2021). Practically, the study considered the remote sensing procedure to produce reliable research data and variables (such as green space and built-up areas). Our results suggested a realistic process, defining the gradual decrease of the green and open space surface areas influenced by national revenue from total export values (including oil export) in the study area within the three last decades.

The research provided an outline for the policy-makers at the city and national levels, regarding the improvement of the quality and quantity of urban environment. Such factors can shape the quantity and quality of green spaces and their ability to supply services by influencing management and planning decisions (Wilkerson et al.

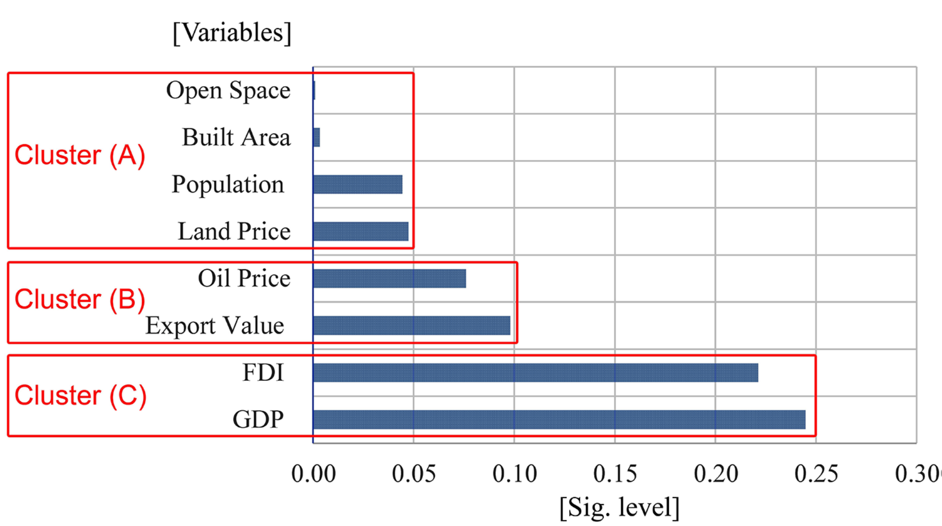

Fig. 3 Clustering the research variables based on the significant and confidence levels of the estimated correlation results; cluster A at $P > 95\%$, cluster B at $P > 90\%$, and cluster C at $P > 75\%$

2018). In this regard, the main limitation of the research depended on the acceptable datasets, time series, and research cases for required variables. It seems that to address this issue we need to prepare a bigger set of raw and re-analyzed variables and factors with more time intervals in different city and country-level scales. Hence, future research could investigate the certain effects of the key country-level factors in the variation of UGS in the extended and continued time series at several research cases and urban regions.

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Author contributions
All authors were equally involved in data analyzing, defining the strategies, and editing the paper. Also, all authors read and approved the final manuscript.

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Data availability
The data that support the findings of this study are available from the corresponding author upon request.

Declarations

Ethics approval and consent to participate
This article does not contain any studies with participants performed by any of the authors.

Consent for publication
Not applicable.

Informed consent
Informed consent was obtained from individual participant included in the study.

Competing interests
The authors declare no competing interests.

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