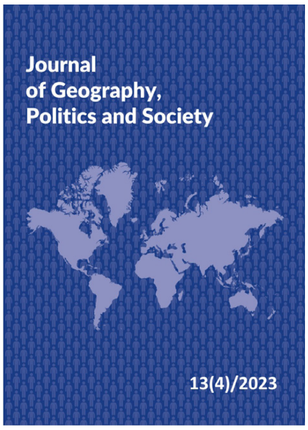

Journal of Geography, Politics and Society
2023, 13(4), 26–39
https://doi.org/10.26881/jpgs.2023.4.03

IDENTIFICATION OF THE SOCIAL ECONOMIC AND ENVIRONMENTAL CONTEXT OF THE CONCEPT OF CITY SUSTAINABILITY, BASED ON THE EXAMPLE OF TERNOPIL, UKRAINE

Stabak Roy (1), Lidia Nazarkiv (2), Tetiana Markulchak (3), Grażyna Chaberek (4)

(1) Department of Geography and Disaster Management, Tripura University, Suryamaninagar 799022, Tripura (West), India, ORCID 0000-0001-6937-9301
e-mail: stabak.roy@gmail.com
(2) Institute of Pedagogics and Psychology, Ternopil Volodymyr Hnatiuk National Pedagogical University, Kryvonosa 2, 46027 Ternopil, Ukraine
e-mail: lnazarkiv@gmail.com
(3) Institute of Pedagogics and Psychology, Ternopil Volodymyr Hnatiuk National Pedagogical University, Kryvonosa 2, 46027 Ternopil, Ukraine
e-mail: markulchaktatiana@gmail.com
(4) Institute of Human Geography and Spatial Management, University of Gdansk, Bażynskiego 8, 80–309 Gdańsk, Poland, ORCID 0000-0002-9572-3337
e-mail: grazyna.chaberek@ug.edu.pl (corresponding author)

Citation
Roy S., Nazarkiv L., Markulchak T., Chaberek G., 2023, Identification of the social economic and environmental context of the concept of city sustainability, based on the example of Ternopil, Ukraine. *Journal of Geography, Politics and Society*, 13(4), 26–39.

Abstract
The main intent of the study is to investigate the conceptual framework of sustainability associated with the social, economic, and environmental context of the city of Ternopil, Ukraine. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses have been used to better understand the conceptual threshold area of sustainability. Geospatial approaches are used to measure the city's sustainability. The results indicate that Ternopil city's socio-economic context moderately supports sustainability, while the environmental context is less supportive. The study found that the city's economic growth and development have caused environmental degradation, leading to the loss of biodiversity and natural resources. However, the study revealed that the city is adopting sustainable practices. The city's strengths, weaknesses, opportunities, and threats (SWOT) have been analysed in light of sustainability. The study recommends that policymakers and stakeholders in Ternopil City should prioritise sustainable development practices, such as implementing public transport and promoting sustainable urban planning. Overall, the study provides insights into the relationship between socioeconomic and environmental factors and sustainability in Ternopil City and highlights the need for sustainable development practices to ensure a sustainable future for the city.

Key words
PRISMA, Content Analysis, Geospatial Analysis, SWOT, Ternopil, Sustainable City.

Received: 10 November 2023 **Accepted**: 27 December 2023 **Published**: 31 January 2024

1. Introduction

Sustainability is the ability to meet the needs of the present generation without compromising the ability of the future ones to meet their own needs (World Commission on Environment and Development, 1987). It encompasses economic, social, and environmental dimensions and is often called the «triple bottom line» (Strano et al., 2013). The goal of sustainability is to create a world that is equitable, resilient, and environmentally sound (Corvalan et al., 2020).

While the concept of city sustainability has gained significant popularity in recent years, it is not without criticism (Moreno et al., 2021). Some of the criticisms of the concept of city sustainability include the lack of a clear definition, overemphasis on environmental sustainability, and difficulty in implementation (Elder et al., 2016). The term is often used in different contexts and can mean different things to different people, making it difficult to measure and monitor progress (Toli, Murtangh, 2020; Purvis et al., 2018). Another criticism of city sustainability is overemphasising environmental sustainability at the expense of social and economic sustainability (Kuhlman, Farrington, 2010). While environmental sustainability is essential, it is only one aspect of sustainability, and it is essential to balance environmental, social, and economic sustainability (Woo, Kang, 2020). City sustainability has also been criticised for its difficulty in implementing sustainable practices (Williams, 2009). Implementing sustainable practices often requires significant investment, political will, and changes in behaviour, which can be challenging to achieve (Dearing, 2000).

City sustainability is a complex system that varies from city to city due to spatial organisation, social structure, economic space, institutional intervention, and legal framework. In the contemporary geopolitical scenario, Ukraine is the most promising emerging market for sustainable urban development due to its growing commitment to environmental protection and its favourable geographic location for renewable energy production. The main objective of the study is to identify the socio-economic and environmental sustainability of Ternopil city.

2. Material and methods

2.1. Methods of identification of city sustainability

By using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria, this study presents a systematic review of the literature on urban sustainability evaluation (Moher, 2009; Mulrow, 1987). In order to better understand how sustainability evaluation is used in urban contexts, content analysis has been conducted in this research to uncover themes and arrange qualitative data from the literature. Web of Science reliably searches across publishers. Due to its size and use of numerous databases, the Web of Science has been used to generate bibliometric data (Roy, Mitra, 2021). To search the database four keywords were used: “sustainable city”, “sustainable urban policy”, “sustainable city management”, and “Termopil”. Figure 1 shows the process of selection of literature records for further analysis.

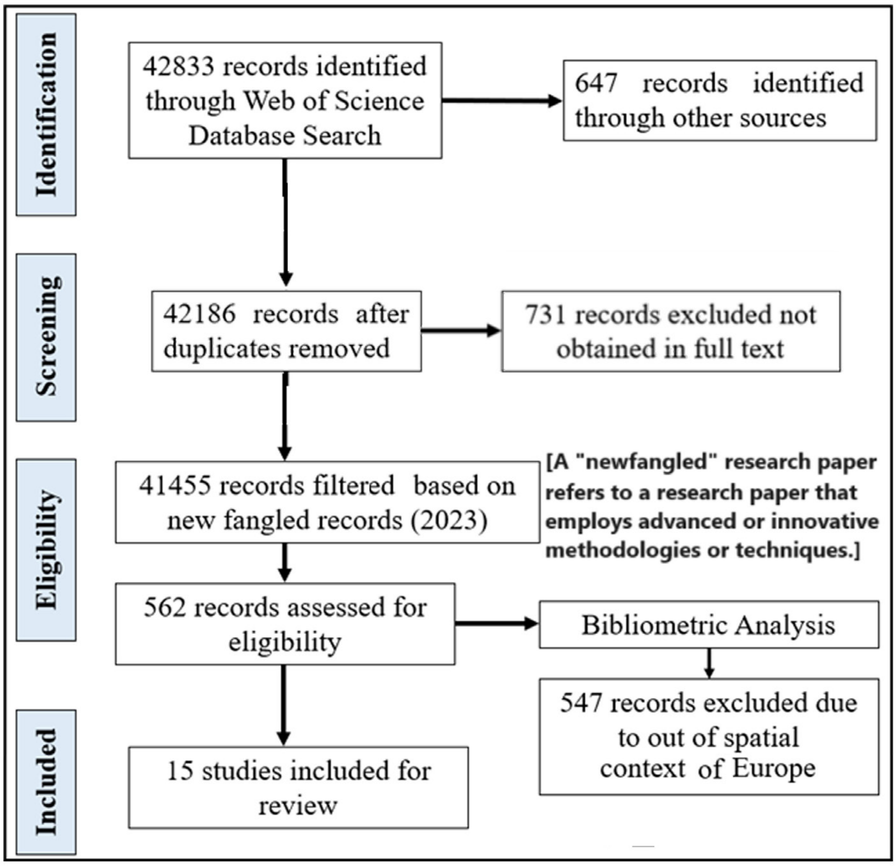

Fig. 1. Flow diagram of literature selection for review through PRISMA.
Source: own study, based on Page et al., 2021

Table 1 shows the dimensions used in the evaluation of city sustainability models across the European context literature.

Measuring city sustainability is crucial for promoting sustainable development and addressing environmental challenges. However, there are only a limited number of studies that consider all three dimensions of sustainability. M. Baran et al. (2023) emphasise how important sustainable systems are for cities and how attitudes toward environmental awareness can influence environmental actions.

S. Caputo et al. (2023) discuss the benefits of community gardens in post-earthquake recovery and during economic downturns. M. Ciommi et al. (2023) show how population dynamics affect policy measures related to urban sustainability and metropolitan resilience. A.C. Ferrari et al. (2023) analyse how digitalization transforms agriculture and rural spaces and reduces urban dependency. A. Gomez-Ortega et al. (2023) highlight the importance of technology and sustainable development for promoting public transportation.

J.K. Huerta and D. Geneletti (2023) demonstrate how Environmental Justice indicators can help identify which communities can benefit from green space implementation. P. Legutko-Kobus et al. (2023) provide an overview of natural protected areas in Poland and Romania and their planning and legal constraints. A. Mayor et al. (2023) conduct a nitrogen flow analysis to determine the feasibility of recovering this element from its material flow cycle. E. Medeiros and B. Valente (2023) evaluate the significance of investments in environmental sustainability under the EU Cohesion Policy. V. Miles et al. (2023) analyse urban heat islands in the largest cities in the European Arctic, identifying cities and seasons with statistically significant trends and suggesting that the variability of a city's temperatures significantly impacts urban

Tab. 1. Literature for the systematic review (n = 15). Dimensions of city sustainability evaluation.

No	Sources	City and Country	Context of Sustainability		
			Social	Economical	Environmental
1.	Baran et al., 2023	Greece, Poland, Portugal, Sweden, and the United Kingdom	✓	☒	✓
2.	Caputo et al. 2023	London, UK	✓	✓	✓
3.	Carlicci et al., 2023	Athens, Greece	✓	✓	✓
4.	Ciommi et al., 2023	Athens, Greece	✓	✓	☒
5.	Ferrari et al., 2023	Uppsala, Sweden and Calabria, Italy	✓	✓	☒
6.	Gomez-Ortega et al., 2023	Madrid, Spain	☒	✓	✓
7.	Huerta & Geneletti, 2023	Canary Islands, Spain	✓	☒	✓
8.	Legutko-Kobus et al., 2023	Romania and Poland	☒	☒	✓
9.	Mayor et al., 2023	Balearic and Canary Islands, Spain	☒	☒	✓
10.	Medeiros & Valente, 2023	Northern Portugal	☒	✓	✓
11.	Miles et al., 2023		☒	☒	✓
12.	Pignatelli et al., 2023		✓	✓	✓
13.	Przezdziecki & Zawadzki, 2023		☒	☒	✓
14,	Sandstrom et al., 2023		✓	☒	✓
15.	Tarasevych et al., 2023		✓	✓	✓

✓ dimension of sustainability taken into consideration; ☒ dimension of sustainability not taken into consideration

Source: own study.

sustainability. M. Pignatelli et al. (2023) propose a multidisciplinary GIS-based framework for evaluating KPIs to support local development planning. K. Przezdziecki and J. Zawadzki (2023) discuss the impact of urban heat on cities and their residents. C. Sandstrom et al. (2023) assess the level of implementation and prospective choices for mainstreaming biodiversity and Nature Contributions to People (NCP) within seven critical policy and economic sectors across Europe and Central Asia. O. Tarasevych et al. (2023) emphasise the importance of resilience and transparency in promoting sustainable development and addressing challenges faced by cities and countries. Overall, these studies provide valuable insights into the importance of sustainability in addressing a range of social, economic, and environmental challenges facing cities and regions in Europe.

2.2. Methodology used

This study attempts to measure the socio-economic sustainability through the following selected parameters: population density, road network, road density, public transport stops, LULC, built environments, settlement typologies, functional urban area, and open public spaces, based on literature.

Data on different socio-economic parameters were collected from various geo databases (Tab. 2). Population density has been calculated using the Fishnet tool of ArcGIS with inverse distance weighted interpolation (Roy, Mitra, 2023). The road network has been extracted from the open street map. To know the present nature of the road connectivity

Tab. 2. Assessment of socio-economic parameters through geospatial techniques.

No	Socio-economic parameter	SDG Indicator	Data Source	Spatial Resolution
1.	Population Density	SDG11.2.1	World Population Data	100 m x 100 m
2.	Road network	SDG11.2.1	Open Street Map	
3.	Public transport stops	SDG11.2.1	SAS Planet	
4.	LULC	SDG11.3.1	Sentinel-2A images	10m
5.	Built environments	SDG11.3.1	Sentinel-2A images	10m
6.	Settlement typologies	SDG11.3.1	Sentinel-2A images	10m
7.	Functional urban area	SDG11.3.1	Google Maps	
8.	Open public spaces	SDG11.3.1	SAS Planet	

Source: own study.

in the study area, diverse connectivity indices like Alpha (α), Beta (β) and Gamma (γ) are calculated by using the following formulas:

$$Alpha\ Index(\alpha) = \frac{e - v + 1}{2v - 5}, \ldots\ldots(1)$$

$$Gamma\ Index(\gamma) = \frac{e}{3(v-2)}, \ldots\ldots(3)$$

where,

e = number of edges or routes

v = number of vertices or nodes

Recent research has utilised a variety of indicators to assess the sustainability of cities (Mitra et al., 2021). These include geo-coded public transport data and land use, and cover maps, building footprints, settlement typologies, and data on functional urban areas and open public space. Environmental sustainability is assessed through measures such as biological diversity, global surface temperature, atmospheric CO_2, and air quality (Mitra et al., 2022). A SWOT matrix categorizes a city's strengths, weaknesses, opportunities, and threats in the context of sustainability, providing policymakers with a valuable tool to develop sustainable strategies for the future.

The authors faced some limitations in the study. The study is based on the available data, which may be limited or outdated.

2.3. The study area

Ternopil is the third smallest (13834 km^2) region of Ukraine after Zakarpattia and Kiyv City. Ternopil city (106 km^2) is one of the major cities of Western Ukraine, located on the bank of the river Seret surrounded by forests and hills (Fig. 2). The geomorphology of Ternopil is characterised by its hilly landscape, with elevations ranging from 230 to 325 meters above sea level.

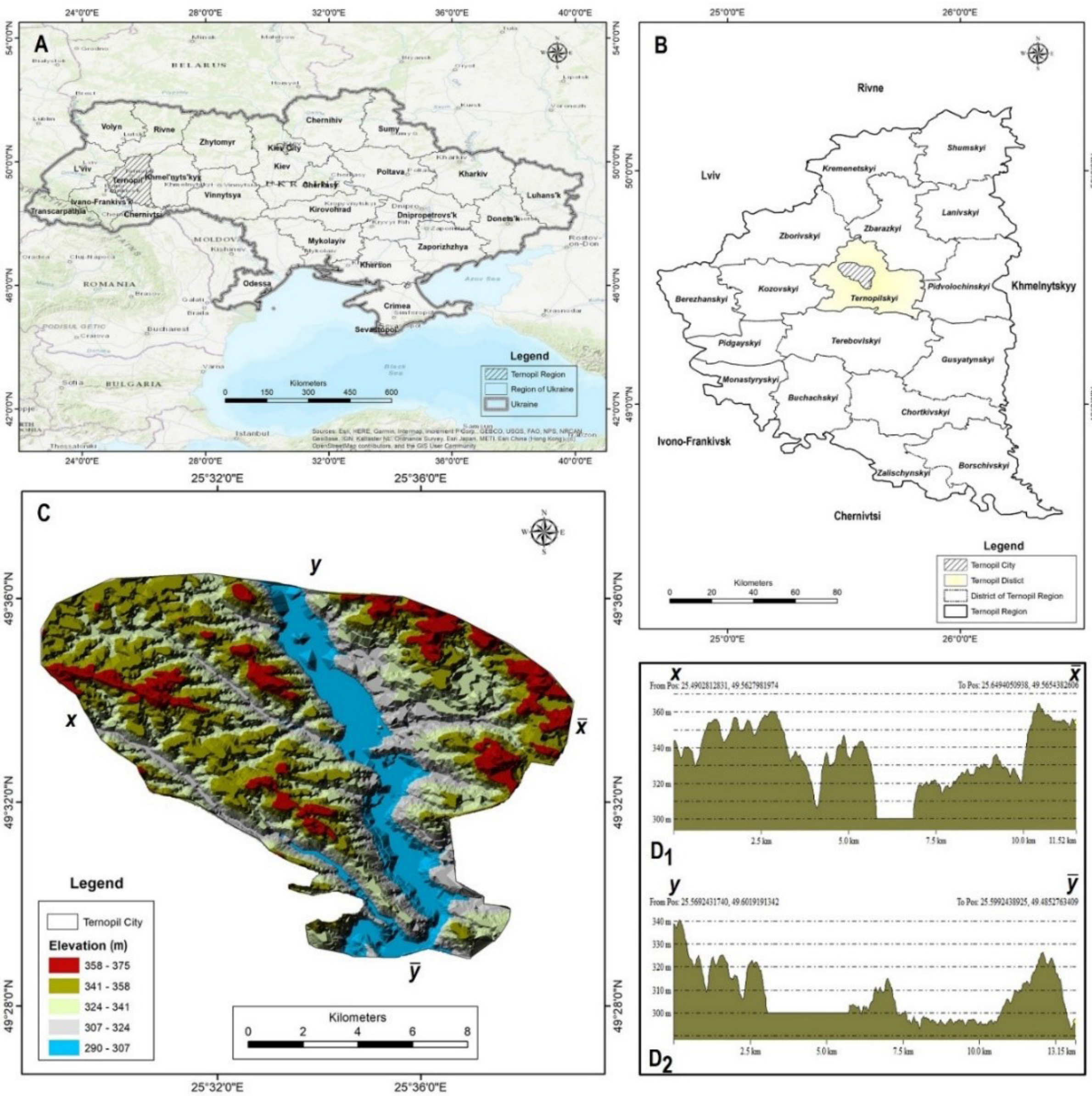

Fig. 2. Location map of the study area.

Source: Own study, 2023; data extracted from DIVA GIS and SRTM DEM.

The city is situated on the eastern edge of the Podolian Upland, which is known for its rich black soils and agricultural productivity. The social structure of Ternopil is diverse, with a population of approximately 220,000 people. Ternopil, a city with a mix of Ukrainian, Polish, and Jewish inhabitants, relies on agriculture and light industry, specifically grain production, textiles, and IT, to drive its economy.

3. Results and discussion

3.1. Social and economic sustainability

Population density is an important indicator to measure sustainable development (Tikodis et al., 2022). There is no standard population density for sustainable cities. However, many sustainability experts recommend a range of 5,000 to 20,000 people per km^2 as an ideal population density for urban areas that are designed to be sustainable (Palevicius et al., 2019; Lehmann, 2016). The population density of Ternopil city varies between 1131 persons/km^2 to 4525 persons/km^2 which is far lesser than 5000 persons/km^2. Therefore, it can be asserted that in terms of population density Ternopil is sustainable (Figure 3).

It has been observed that population density is higher in the central part of the city. Population density significantly decreases with the increasing distance from the central business district of Ternopil. The maximum area (34.57%) of the city has an incredibly low population density. In terms of micro-regional population density, the western and southern parts of the city are more sustainable than the central part (Figure 3).

Keeping population densities within this range can encourage the development of road networks and the use of public transportation (Cooke, Behrens, 2017; Tiwari, Phillip, 2021). The development of industries, trade, and commerce is aided by the roads, which can lead to job opportunities and boost the general economic growth of the city (Kniivila, 2007). There is no one-size-fits-all approach to designing a perfect road network for a sustainable city, as each city has its unique challenges and opportunities (Chaberek, 2021). However, some general principles can guide the development of a sustainable road network, including prioritising public transport and creating a pedestrian and bicycle-friendly environment (Montella, et al., 2022). In Ternopil City there are about 1736.56 km of roads (Figure 4).

The M19 highway is the main highway that passes through Ternopil. It connects the city with Lviv to the west and Vinnytsia to the east. Other major roads in Ternopil include Pochaivska

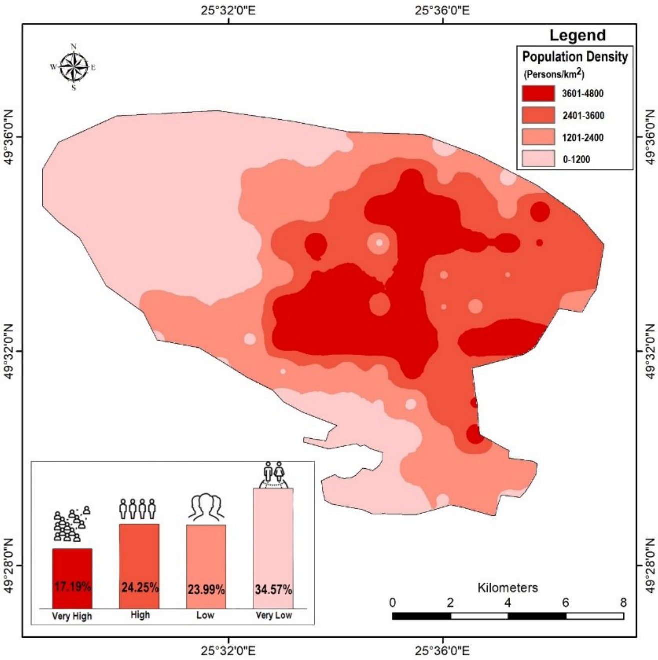

Fig. 3. Population density of Ternopil city 2023.

Source: Own study, 2023; data extracted from the Humanitarian Data Exchange.

Fig. 4. Road network map of Ternopil city 2023.

Source: Own study, 2023; data extracted from the Open Street Map.

Street, Mykulynetska Street, and Khmelnytskoho Street. Within the city, the road network consists of several main streets and numerous smaller streets and alleys. The main streets in Ternopil include Ruska Street, Zamkova Street, Kryvonosa Street, and Tekstylnykiv Street. Ternopil has a well-connected and developed road network that provides easy access to other parts of Ukraine and allows for efficient transportation within the city. Sustainable modes of transportation, such as cycling and walking, are provided via dedicated lanes and pedestrian-friendly infrastructure. Cycleways and footways are 3.54 km (0.20%) and 305.79 km (17.60%) long, respectively. The length of the cycleway is insufficient for an ideally sustainable city (Figure 4).

Road connectivity is crucial for sustainable development, as it can improve access to economic opportunities, education, healthcare, and other essential services. According to research road connectivity can contribute to sustainable development (Kaiser, Barstow, 2022). Three widely used connectivity indices, i.e., Alpha, Beta, and Gamma, have been used to assess the road network connectivity of Ternopil City (Rodrigue, Slack, 2017).

About 40955 nodes and 36182 edges are found in Ternopil. According to Alpha (0.058), Beta (0.88) and Gamma (0.29) indices, road connectivity of Ternopil is moderate to poor. There are about 288 bus stops in Ternopil which provide services to city dwellers (Figure 5).

Public transport stops are essential for sustainable transportation systems, as they promote sustainable modes of transportation, reduce traffic congestion, enhance urban mobility, encourage compact and mixed-use development, and promote social equity (Shishegaran et al., 2020; Lejda et al., 2017).

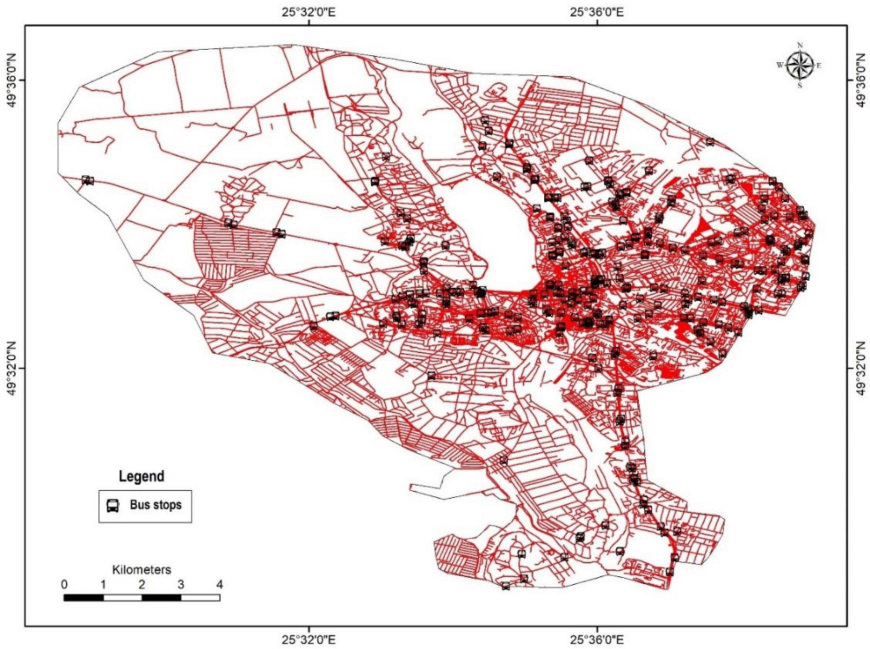

Fig. 5. Public transport stops in Ternopil city 2023.

Source: Own study, 2023; data extracted from the SAS Planet.

Ternopil has bus connections to over 29 cities throughout Ukraine, and international connections to 10 countries. There are 36 national and 77 international bus departures from Ternopil.

"Land use" is the term used to describe how humans use land, including farming, forestry, urbanisation, and mining (Nedd et al., 2021). The term «land cover» describes the physical and biological covering of the land, including urban areas, marshes, grasslands, and woods (Bielecka et al., 2020).

In Figure 6, the red colour represents the built-up area, blue represents water, deep green represents trees, light green represents vegetative cover, yellow represents cropland, and light brown represents the bore ground (Figure 6).

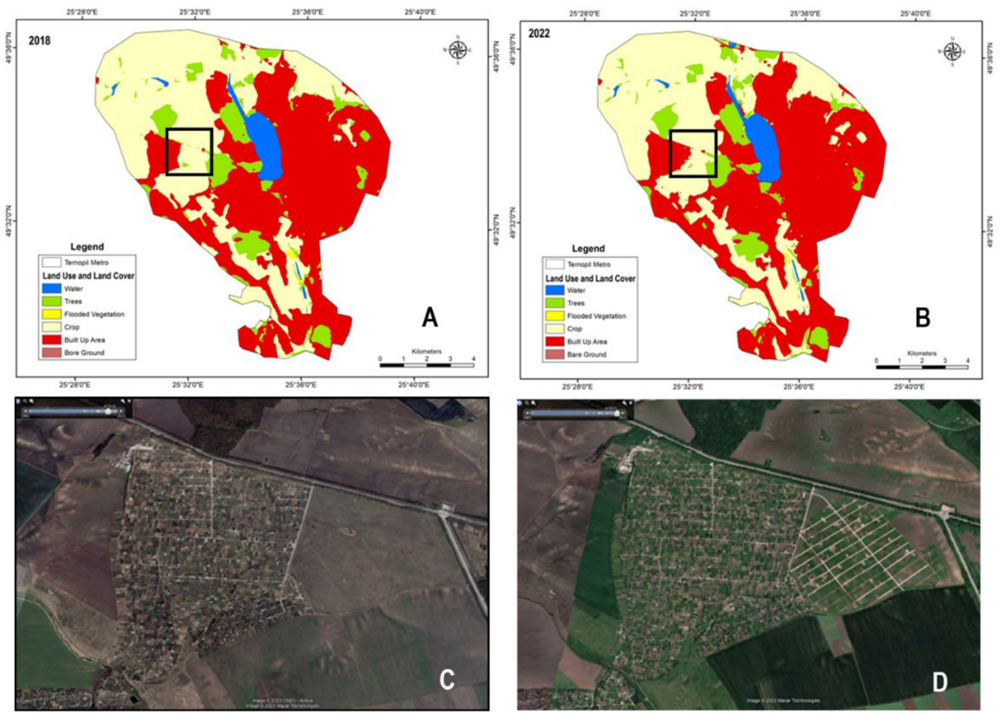

Fig. 6. Land use and land cover of Ternopil city 2023.

Source: Own study, 2023; data extracted from the ESRI Living Atlas.

It has been reported that the city's built-up area increased from 47.57 percent in 2018 to around 49.48 percent in 2022 with a 0.99 percent annual growth rate (Table 3).

The results indicate that Ternopil has experienced sustained urban growth as a result of the conversion of agricultural land to built-up areas (Figure 7).

Tab. 3. Land Use and Land Cover Change Statistic of Ternopil City between 2018 and 2022.

Land Classes	Area percentage (2018)	Area percentage (2022)	Relative change	Compound annual growth rate
Water	3.32	3.3	-0.02	-0.15
Trees	9.25	9.07	-0.18	-0.49
Flooded Vegetation	0.13	0.11	-0.02	-3.58
Crop	39.66	38.01	-1.65	-1.06
Built-Up Area	47.57	49.48	1.92	0.99
Bore Ground	0.08	0.03	-0.05	-21.59

Source: Own study, 2023; data extracted from the ESRI Living Atlas.

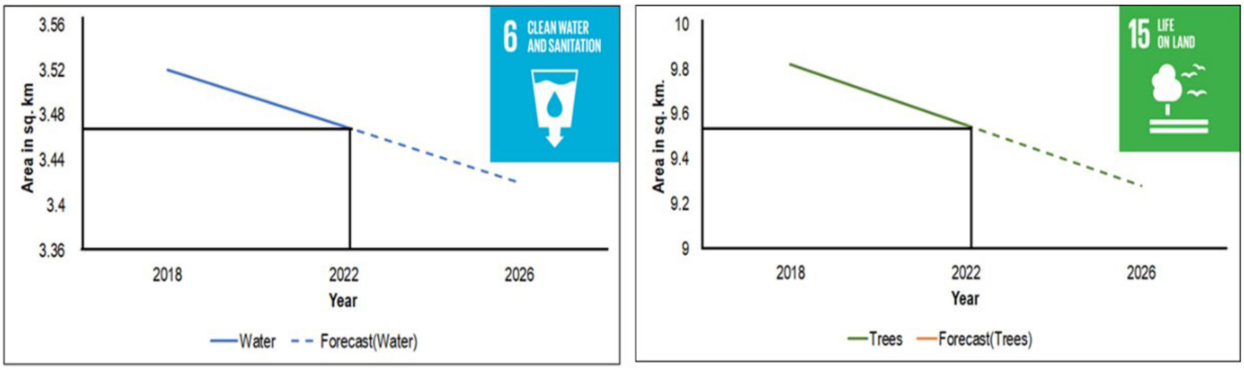

Fig. 7. Deducting trends of blue and green infrastructure in Ternopil.

Source: Own study, 2023.

But water body and vegetation cover of the city gradually decreased, which indicates the threat of sustainable development goal 6 (clean water and sanitation) and 15 (life on land).

Blue and green infrastructure are vital components of a city's ecosystem and provide numerous benefits, including improved air and water quality, reduced urban heat island effects, enhanced biodiversity, and increased recreational opportunities (Shao, Kim, 2022; Brown, Mijic, 2019; Depietri, McPhearson, 2017). The city has several blue and green infrastructures that contribute to its ecological, social, and economic sustainability, i.e., Ternopil pond (49°33'57.87»N and 25°34'37.28»E), the central park (49°32'54.77"N and 25°34'47.80"E), a botanical garden (49°33'22.61"N and 25°34'3.17"E). Green roofs, which are examples of green infrastructure and offer several advantages, including insulation, stormwater management, and improved air quality, are present on a number of buildings in Ternopil City. For instance, the Ternopil National Economic University's Green Building has a green roof of over 700 square meters in size. In the city of Ternopil, there are a number of streets that are lined with trees. These forms of green infrastructure provide several benefits, including shade, air filtering, and aesthetic value. But slowly and gradually, the blue and green infrastructure of Ternopil City has been decreases over a period of time, which might exacerbate air pollution, reduce biodiversity, increase urban heat island effects, and increase flood risk. Overall, a decrease in blue and green infrastructure can have a significant negative impact on the environment, public health, and the quality of life of Ternopil in the near future.

Settlement typologies of Ternopil play a critical role in promoting sustainable development by promoting efficient land use, accessibility, energy efficiency, water conservation, social inclusion, and disaster resilience. By considering the long-term impacts of settlement design and development, planners and policymakers can help to build more sustainable and resilient communities. As per data from 2019, the city has about 30,402 buildings including residential houses, business complexes, warehouses, hospitals, hotels, churches, and academic institutes, like schools, colleges, universities, etc. (Figure 8). Ternopil is a diverse city with a variety of settlement typologies that reflect its rich history and modern economy.

Urban sustainability can be greatly influenced by functional areas of the city, such as the residential, commercial, industrial, and recreational ones. The functional areas might support urban sustainability through efficient land use, access to essential services, energy efficiency, water conservation, social inclusion, and disaster resilience (Flores, Peralta, 2020; Leigh, Lee, 2019).

The main functional areas of Ternopil City have been divided into four classes including residential, commercial, industrial, and educational ones. Some of the notable residential areas include Novy Ternopil, Velyka A, Zamkova, and Zhivova. The city centre, which contains a large number of stores, cafes, and restaurants, as well as the area around the Ternopil Trade and Economic Institute are a few of the key commercial areas in Ternopil.

The Ternopil Carriage Works and the Ternopil Electrical Machine Building Factory are just two of the city's industrial hubs. The Ternopil National Economic University, Ternopil State Medical University, and Ternopil Ivan Pul'uj National Technical University are among the city's 6 institutions, 8 colleges, 59 schools, 38 hotels, 31 hospitals, and 76 churches. The Ternopil Regional Hospital, the Ternopil Children's Hospital, and the Ternopil City Hospital are only a few of the medical facilities in Ternopil.

Ternopil Lake, Ternopil Park, and Fountains Park are only a few of the city's recreational spaces. Ternopil, as a whole, is a varied city with numerous useful districts that contribute to the city's sustainability (Figure 9).

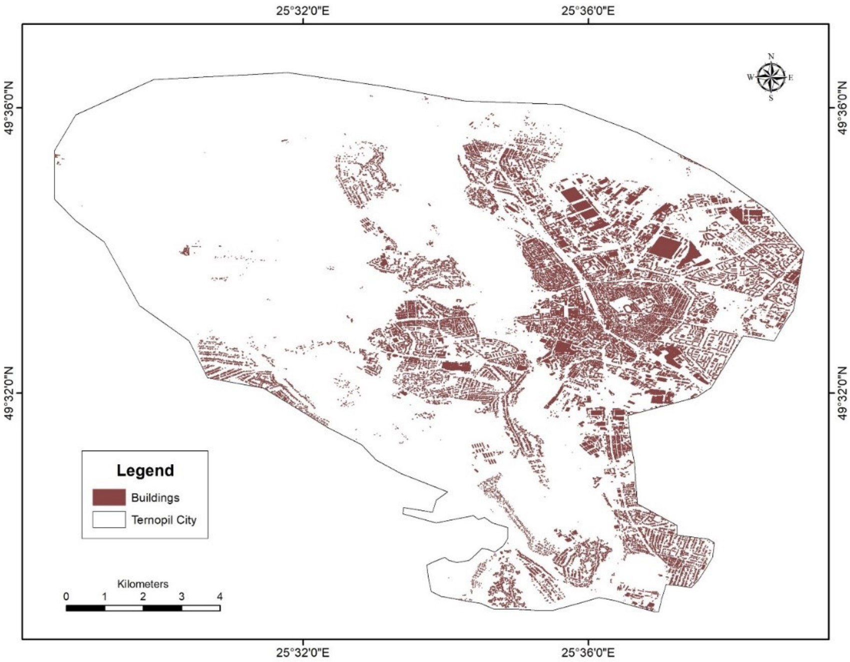

Fig. 8. Settlement typologies of Ternopil City.

Source: Own study, 2023; data extracted from the Open Street Map.

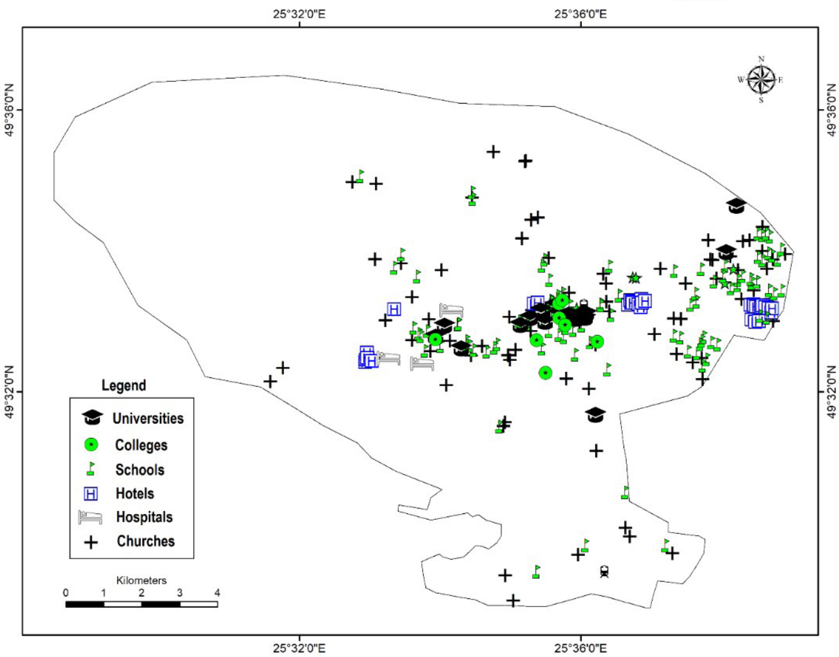

Fig. 9. Settlement typologies of Ternopil City.

Source: Own study, 2023; data extracted from Google Maps.

Ternopil City has several public places, including a park and a lake for picnicking, biking, and strolling. The Fountains Park has water features for cooling down, while Zamkova Mountain offers hiking and a breathtaking view. Shevchenko Park near the university is ideal for families and students. The central square is a hub for events and shops. These green spaces in Ternopil promote sustainability in the city.

3.2. Environmental Sustainability

The area in which Ternopil City is situated is rich in natural resources, including woods, rivers, and fertile soils. Environmental hazards like pollution, deforestation, and climate change pose a threat to the metropolis. Biological diversity (above-ground biomass), carbon footprint (atmospheric CO_2), average global surface temperature, and the air quality index have been calculated to measure environmental sustainability (Hill et al., 2019).

It has been observed that in 2001, Ternopil had 6.00kha of tree cover, extending over 8.2 percent of its land area. In 2021, it lost 2.77 ha of the tree cover (Figure 10). Ternopil had 82.7t/ha of live woody biomass density and 65.3 kt of total aboveground biomass in 2000. To prevent the loss of trees, the city has implemented initiatives such as organising tree planting drives and providing care to existing trees.

Ternopil authorities have appointed tree experts who regularly inspect and maintain the trees to prevent damage and diseases. Strict regulations have been implemented to prevent unauthorised tree cutting, and the city aims to reduce tree loss to 0 ha by 2028 with continued efforts (Figure 11).

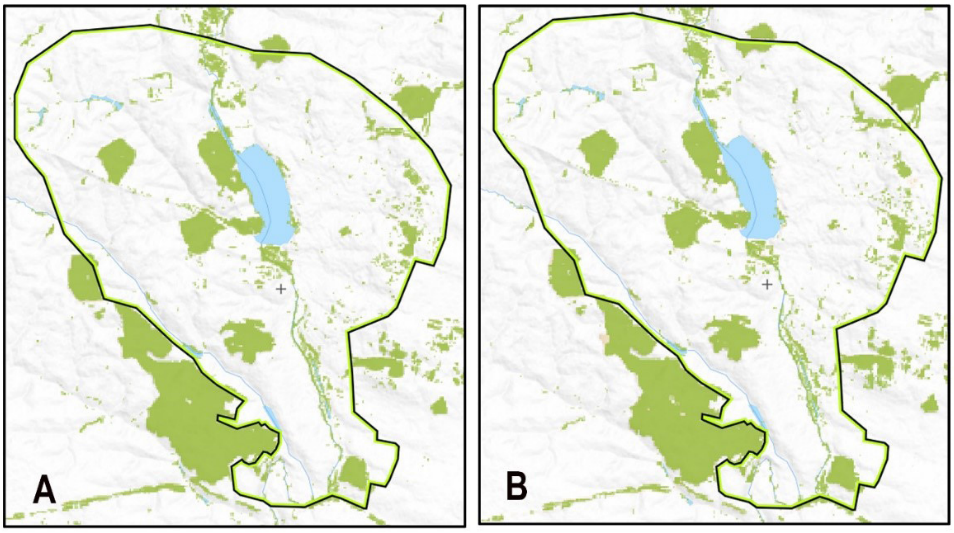

Fig. 10. Forest cover (A. 2001 and B. 2021) of Ternopil city.

Source: Own study, 2023; data extracted from Global Forest Watch.

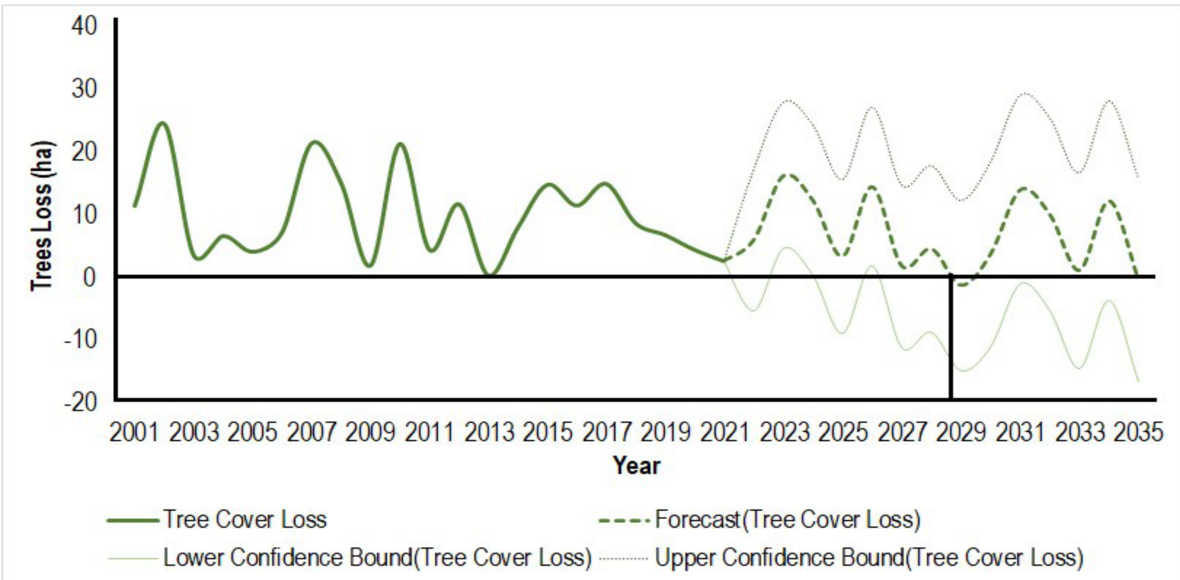

Fig. 11. Predictive model of tree loss in Ternopil city.

Source: Own study, 2023; data extracted from Global Forest Watch.

The city aims to cut its average carbon emission by 3055.86 mg per year by promoting public transit, biking, and walking. It encourages renewable energy sources, energy-efficient buildings, conservation campaigns, sustainable business practices, tree planting, and an efficient waste management system.

The city experienced maximum carbon emissions during 2007 and 2012. Due to the sustainable initiative by the city authorities, the growth of carbon emissions is almost static (r=0.0003), which is a positive sign for the city's sustainability (Figure 12).

Ternopil has a yearly average temperature of 9.78ºC, slightly cooler than the national average. Summers are mild with occasional clouds, while winters bring snow and strong winds. Ukraine's temperatures fluctuate 7–9°C annually, with summer temperatures below 22°C and colder winter months.

Ternopil's air quality is evaluated using the Air Quality Index (AQI), which includes pollutants such as PM2.5. The current AQI of Ternopil is moderate to good, indicating satisfactory air quality for most individuals (Figure 13). However, those with respiratory issues may experience negative health effects. It is recommended to monitor the AQI regularly and take measures, such as limiting outdoor activity during high pollution periods and using air purifiers indoors. Ternopil has poor air quality due to pollutants from cars, factories, and houses, but the city is taking steps to reduce pollution, such as promoting renewable energy and public transit and enforcing environmental laws.

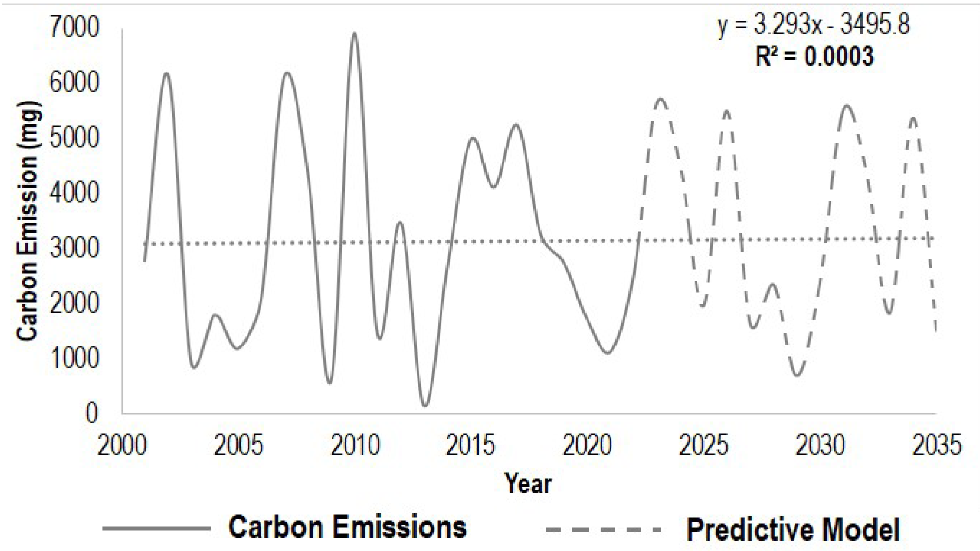

Fig. 12. Trends of carbon emissions in Ternopil city.

Source: Own study, 2023; data extracted from Global Forest Watch.

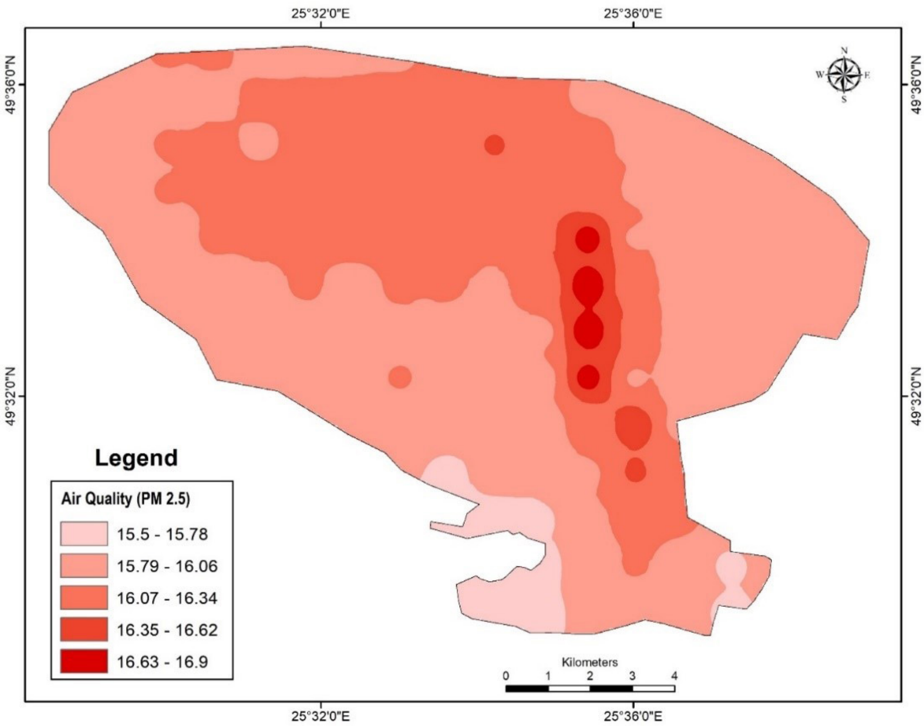

Fig. 13. Air quality of Ternopil city.

Source: Own study, 2023; data extracted from ECMWF.

4. The SWOT analysis and conclusion

The study found the importance of geospatial approaches to measure the sustainability of cities, as well as their complex dynamics, including socio-economic, institutional, and legal frameworks. The case study of Ternopil City in Ukraine reveals its dependence on agriculture and light industry, natural beauty, and varying population densities, with certain areas being more sustainable than others. The settlement typologies of Ternopil City, including its residential, commercial, industrial, and recreational spaces, play a crucial role in achieving urban sustainability. Furthermore, the study shows that blue and green infrastructures, such as parks and lakes, are essential components of a city's ecosystem, reduce urban heat island effects, enhance biodiversity, improve air and water quality, and increase recreational opportunities (Table 4).

To conclude, despite its natural beauty, Ternopil struggles with environmental issues, including air and water pollution, but has taken steps to improve sustainability through recycling and public transport initiatives. The city boasts several open public spaces, such as Ternopil Lake, Zamkova Mountain, and Central Square, contributing to its sustainable development.

However, the city needs to do more to preserve its environment, especially addressing urban heat islands and carbon emissions. Sustainable development is crucial to secure the city's future, with each city having to address its unique challenges and opportunities. Ternopil City has a well-educated workforce, diversified economy, and cultural heritage to form a strong socio-economic sustainability baseline. Nonetheless, urgent actions are required to promote environmental sustainability for the city's future.

Tab. 4. SWOT analysis of Ternopil city.

<table>
<tr><td rowspan="6">Positive Factors</td><td colspan="2">Internal Factors</td><td rowspan="6">Challenging Factors</td></tr>
<tr><td>Strengths</td><td>Weaknesses</td></tr>
<tr><td>1. Transport Infrastructure
2. Bicycle path
3. 50% area with a non-built environment
4. Educational infrastructure</td><td>1. Development of transport network
2. Water management
3. Building policy
4. Urban flooding
5. Aging infrastructure</td></tr>
<tr><td colspan="2">External Factors</td></tr>
<tr><td>Opportunities</td><td>Threats</td></tr>
<tr><td>1. Education
2. Tourism
3. Scope of BUSINESS INVESTMENT</td><td>1. The Russian invasion
2. Natural disasters
3. Unemployment</td></tr>
</table>

Source: Own study.

References

Baran M., Hazenberg R., Iwinska K., Kasianiuk K., Perifanos I., Ferreira J.M., 2023, Between innovative and habitual behavior. Evidence from a study on sustainability in Greece, Poland, Portugal, Sweden, and the United Kingdom, *Frontiers in Energy Research*, 10, 1030418. doi: 10.3389/fenrg.2022.1030418

Bielecka E., Jenerowicz A., Pokonieczny K., Borkowska S., 2020, Land Cover Changes and Flows in the Polish Baltic Coastal Zone: A Qualitative and Quantitative Approach, *Remote Sensing,* 12(13), 2088. doi: 10.3390/rs12132088

Brown K., Mijic A., 2019, *Integrating green and blue spaces into our cities: Making it happen*, Grantham Institute, London.

Caputo S., Schoen V., Blythe C., 2023, Productivity and Efficiency of Community Gardens: Case Studies from the UK, *Land*, 12(1), 238. doi: 10.3390/land12010238

Carlicci M., Polinesi G., Salvati L., 2023, Agglomeration vs amenities? Unraveling the latent engine of growth in metropolitan Greece, *Environment and Planning B: Urban Analytics and City Science*, 50(9), 2491-2509. doi: 10.1177/23998083231159110

Chaberek G., 2021, Designing Streets for Smart Cities, [in:] P. Sharma (Ed.), Geospatial Technology and Smart Cities, ICT, *Geoscience Modeling, GIS and Remote Sensing*, Springer, Chem, 59–74. doi: 10.1007/978-3-030-71945-6_4

Ciommi M., Egidi G., Vardopoulos I., Chelli F.M., Salvati L., 2023, Toward a 'Migrant Trap'? Local Development, Urban Sustainability, Sociodemographic Inequalities, and the Economic Decline in a Mediterranean Metropolis, *Social Sciences*, 12(1), 26. doi: 10.3390/socsci12010026

Cooke S., Behrens R., 2017, Correlation or cause? The limitations of population density as an indicator for public transport viability in the context of rapidly growing developing city, *Transportation Research Procedia*, 25, 3003–3016. doi: 10.1016/j.trpro.2017.05.229

Corvalan C., Prats E.V., Sena A., Campbell-Lendrum D., Karliner J., Risso A., Vinci S. et al., 2020, Towards Climate Resilient and Environmentally Sustainable Health Care Facilities, *International Journal of Environmental Research and Public Health*, 17(23), 8849. doi: 10.3390/ijerph17238849

Dearing A., 2000, *Sustainable Innovation: Drivers and Barriers,* World Business Council for Sustainable Development, Geneva.

Depietri Y., McPhearson T., 2017, Integrating the Grey, Green, and Blue in Cities: Nature-Based Solutions for Climate Change Adaptation and Risk Reduction, [in:] N. Kachisch, H. Korn, J. Stadler, A. Bonn (Eds.), *Nature-Based Solutions to Climate Change Adaptation in Urban Areas*, Springer, Chem, 91–109.

Elder M., Magnus B., Akenji L., 2016, An Optimistic Analysis of the Means of Implementation for Sustainable Development Goals: Thinking about Goals as Means, *Sustainability*, 8(9), 962. doi: 10.3390/su8090962

Ferrari A.C., Corrado A., Fama M., 2023, Digitalisation, politics of sustainability and new agrarian questions: The case of dairy farming in rural spaces of Italy and Sweden, *Sociologia Ruralis*, 63(3), 703–728. doi: 10.1111/soru.12420

Flores A., Peralta L., 2020, *The enhancement of resilience to disasters and climate change in the Caribbean through the modernization of the energy sector*, United Nations, Santiago.

Gomez-Ortega A., Flores-Ureba S., Gelashvili V., Jalon M.L., 2023, Users' perception for innovation and sustainability management: evidence from public transport, *Review of Managerial Science,* 2023. doi: 10.1007/s11846-023-00625-0

Hill S.L., Arnell A., Maney C., Butchart H.M., Hilton-Taylor C., Ciciarelli C., Burgess N.D., 2019, Measuring Forest Biodiversity Status and Changes Globally, *Frontiers in Forests and Global Change*, 2, 70. doi: 10.3389/ffgc.2019.00070

Huerta J.K., Geneletti D., 2023, A distributive environmental justice index to support green space planning in cities, *Landscape and Urban Planning,* 229(3), 104592. doi: 10.1016/j.landurbplan.2022.104592

Kaiser N., Barstow C., 2022, Rural Transportation Infrastructure in Low- and Middle-Income Countries: A Review of Impacts, *Implications, and Interventions, Sustainability*, 14(4), 2149. doi: 10.3390/su14042149

Kniivila M., 2007, Industrial development and economic growth: Implications for poverty reduction and income nequality, [in:] J. DiSano (Ed.), *Industrial Development for the 21st Century: Sustainable Development Perspectives,* United Nations, New York, 295–331.

Kuhlman T., Farrington J., 2010, What is Sustainability? *Sustainability*, 2(11), 3436–3448. doi: 10.3390/su2113436

Legutko-Kobus P., Nowak M., Petrisor A., Barbulescu D., Craciun C., Garjoaba A., 2023, Protection of Environmental and Natural Values of Urban Areas against Investment Pressure: A Case Study of Romania and Poland, *Land*, 12(1), 245. doi: 10.3390/land12010245

Lehmann S., 2016, Sustainable urbanism: towards a framework for quality and optimal density?, *Future Cities and Environment,* 2, 8. doi: 10.1186/s40984-016-0021-3

Leigh N.G., Lee H., 2019, Sustainable and Resilient Urban Water Systems: The Role of Decentralization and Planning, *Sustainability*, 11(3), 918. doi: 10.3390/su11030918

Lejda K., Mądziel M., Siedlecka S., Zielińska, S., 2017, The future of public transport in light of solutions for sustainable transport development, *Scientific Journal of Silesian University of Technology,Series Transport*, 95, 97–108. doi: 10.20858/sjsutst.2017.95.10

Mayor A., Beltran E., Cortina J.L., Valderrama C., 2023, Nitrogen flow analysis in Spain: Perspectives to increase sustainability, *Science of the Total Environment*, 858(3), 160117. doi: 10.1016/j.scitotenv.2022.160117

Medeiros E., Valente B., 2023, Assessing impacts of public policies towards environmental sustainability in an EU region: North of Portugal, *European Planning Studies,* 31(1), 1–20. doi: 10.1080/09654313.2023.2169068

Miles V., Esau I., Miles M.W., 2023, The urban climate of the largest cities of the European Arctic, *Urban Climate,* 48,101423. doi: 10.1016/j.uclim.2023.101423

Mitra S., Hore S., Roy S., Debbarma D., 2021, Micro-level classification of road network connectivity of Agartala Municipal Corporation, *Geographical Review of India,* 83(3–4), 214–234.

Mitra S., Roy S., Hore S., 2022, Assessment and forecasting of the urban dynamics through lulc based mixed model: evidence from Agartala, India, *GeoJournal*, 83(4), 1–24. doi: 10.1007/s10708-022-10730-4

Moher D., Liberati A., Tetzlaff J., Altman D.G., 2009, Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement, *PLOS Medicine*, 6(7), 1–6.

Montella A., Chiaradonna S., Mihiel A.C., Lovegrove G., Nunziante P., Riccardi M.R., 2022, Sustainable Complete Streets Design Criteria and Case Study in Naples, Italy, *Sustainability*, 14(20), 13142. doi: 10.3390/su142013142

Moreno C., Allam Z., Chabaud D., Gall C., Pratlong F., 2021, Introducing the "15-Minute City": Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities, *Smart Cities,* 4(1), 93–111. doi: 10.3390/smartcities4010006

Mulrow C.D., 1987, The Medical Review Article: State of the Science, *Annals of Internal Medicine,* 106(3), 485–489. doi: 10.7326/0003-4819-106-3-485

Nedd R., Light K., Owens M., James N., Johnson E., Anandhi A., 2021, A Synthesis of Land Use/Land Cover Studies: Definitions, Classification Systems, Meta-Studies, Challenges and Knowledge Gaps on a Global Landscape, *Land*, 10(9), 994. doi: 10.3390/land10090994

Page M.J., McKenzie J.E., Bossuyt P.M., Hoffmann T.C., Mulrow C.D., Boutron I., 2021, The PRISMA 2020 statement: an updated guideline for reporting systematic reviews, *BMJ,* 372, n71. doi: 10.1136/bmj.n71

Palevicius V., Burinskiene M., Antucheviciene J., Saparauskas J., 2019, Comparative Study of Urban Area Growth: Determining the Key Criteria of Inner Urban Development, *Symmetry*, 11(3), 406. doi: 10.3390/sym11030406

Pignatelli M., Moghadam S.T., Genta C., Lombardi P., 2023, Spatial decision support system for low-carbon sustainable cities development: An interactive storytelling dashboard for the city of Turin, *Sustainable Cities and Society,* 89, 104310. doi: 10.1016/j.scs.2022.104310

Przezdziecki K., Zawadzki J., 2023, Impact of the Variability of Vegetation, Soil Moisture, and Building Density between City Districts on Land Surface Temperature, Warsaw, Poland, *Sustainability*, 15(2), 1274. doi: 10.3390/su15021274

Purvis B., Mao Y., Robinson D., 2018, Three pillars of sustainability: in search of conceptual origins, *Sustainability Science,* 14, 681-695. doi: 10.1007/s11625-018-0627-5

Rodrigue J.P., Slack B., 2017, *The Geography of Transport Systems*, Routledge, New York.

Roy S., Mitra S., 2021, Rail Freight Transport System in Tripura: An Analysis of Performances and Prospects, [in:] S. Mitra, S. Bandyopadhyay, S. Roy, T.P. Dentinho (Eds.), *Railway Transportation in South Asia*, Springer, Chem, 103–130.

Roy S., Mitra S., 2023, Does Physio-environmental Determinism Influence the Infrastructural Development of Railway Stations?, *Journal of Infrastructure Development,* 14(2), 91–126. doi: 10.1177/09749306221140720

Sandstrom C., Ring I., Olshewki R., Simoncini R., Albert C., Acar S., Pergl J., 2023, Mainstreaming biodiversity and nature's contributions to people in Europe and Central Asia: insights from IPBES to inform the CBD post-2020 agenda, *Ecosystems and People,* 19(1), 1–14. doi: 10.1080/26395916.2022.2138553

Shao H., Kim G., 2022, A Comprehensive Review of Different Types of Green Infrastructure to Mitigate Urban Heat Islands: Progress, Functions, and Benefits, *Land*, 11(10), 1792. doi: 10.3390/land11101792

Shishegaran A., Shishegaran A., Mazzula G., Forciniti C., 2020, A Novel Approach for a Sustainability Evaluation of Developing System Interchange: The Case Study of the Sheikhfazolah-Yadegar Interchange, Tehran, Iran, International *Journal of Environmental Research and Public Health,* 17(2), 435. doi: 10.3390/ijerph17020435

Strano A., Luca A.I., Falcone G., Iofrida N., Stillitano T., Gulisano G., 2013, Economic and environmental sustainability assessment of wine grape production scenarios in Southern Italy, *Agricultural Sciences*, 4(5B), 12–20. doi: 10.4236/as.2013.45B003

Tarasevych O., Akhromkin Y., Volkova A., Zablodska D., Akhromkin A., 2023, Resilient Openness of Eastern European Cities in the Conditions of Sustainable Development, *Problems of Sustainable Development,* 18(1), 111–119. doi: 10.35784/pe.2023.1.11

Tikodis I., Farrow K., Mebiame R.M., Oueslati W., 2022, Beyond average population density: Measuring sprawl with density-allocation indicators, *Land Use Policy*, 112, 105832. doi: 10.1016/j.landusepol.2021.105832

Tiwari G., Phillip C., 2021, Development of public transport systems in small cities: A roadmap for achieving sustainable development goal indicator 11.2, *IATSS Research,* 45(1), 31–38. doi: 10.1016/j.iatssr.2021.02.002

Toli A.M., Murtangh N., 2020, The Concept of Sustainability in Smart City Definitions, *Frontiers in Built Environment*, 6, 77. doi: 10.3389/fbuil.2020.00077

Williams K., 2009, Sustainable cities: research and practice challenges, *International Journal of Urban Sustainable Development*, 1(1–2), 128–132. doi: 10.1080/19463131003654863

Woo E.J., Kang E., 2020, Environmental Issues As an Indispensable Aspect of Sustainable Leadership, *Sustainability*, 12(17), 7014. doi: 10.3390/su12177014

World Commission on Environment and Development, 1987, *Report of the world commission on environment and development: our common futur*e, Oxford University Press, Oxford.