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Spatial Relationships between Urban Areas and Industrial Facilities in Gjilan, Kosovo: A GIS-based analysis

Industrial zones within urban areas today are facing various challenges, due to human activities and the rapid urbanization of cities. In many cities of Kosovo, industrial facilities are located within the urban area. Based on this, it is thought that industrial zones within urban areas should have special treatment in spatial planning. There are several methods for the spatial distribution of industry in the city, based on the location and type of industry. The objective of this paper is to analyze the relationships between industrial facilities and the urban area, as well as determine the cause-effect relationship for use as a basis. The study mainly focuses on several analyses of the state of the city of Gjilan, the distance of industrial facilities from the city center, the access of industrial facilities to streets, and the position of these facilities in relation to residential areas.

The results indicate that most industrial facilities are concentrated 600–900 m from the city center. Furthermore, the analysis revealed that a considerable number of residential, educational and healthcare facilities are located within the protection zones surrounding industrial areas, indicating deviations from spatial planning standards prescribed in Kosovo. These findings highlight the need for improved spatial planning and land-use management to ensure sustainable urban development.

Key words: Gjilan, industrial facilities, industrial location, urban area, GIS analysis, buffer zone, spatial planning.

Introduction

The industrial revolution changed the form and function of cities. The industrial revolution was characterized by improvements in industrial machinery, improvements in the steam engine and its use as a source of energy, and the use of coal (Flanagan, 2010). Urbanization emerged as a defining characteristic of this era. Cities were exposed to industrial activities expressed in the form of employment and production, which had a strong impact on the city and surrounding settlements (Maarefdoust, 2015). These changes led to the formation of industrial areas connected to residential areas, especially for employees and service areas, which have an important role in the growth and development of cities. The centralization of industrial cities attracted the rural population, increasing the population, and resulting in territorial expansion, centralization, and inappropriate density. This is also reflected in the formation of cities without planning and the abuse of urban land by industry. Industry occupies a small part of the general space of the city, while most of the labor force works there (Ramadani, 2013). The location of industry within the urban area is a fundamental component of urban spatial structure. Understanding the location of industry within an urban area is crucial to developing a comprehensive set of urban spatial structures. While cities play a major role in achieving the goals of sustainable development, one of the functional elements of a city is the industrial sector, especially the creation of industrial value that directly contributes to the economic development of society (Juraschek et al., 2018). In this context, urban planning and organization are fundamental components to ensure sustainable development. Reconstruction, modernization, and redevelopment influence the reorganization of industrial areas which allow the effective use of the urban area, ensuring sustainable development (Baranova et al., 2021). The reconstruction of individual buildings effectively enables the redevelopment process, which aims to change existing buildings, including industrial areas, and allows them to achieve financial, social, and environmental goals (Baranova et al., 2021). The process of redevelopment in the last 40–50 years has become the norm all over the world, when industrial enterprises began to move their production to the outskirts of cities, to operate effectively and to improve the environment in urban centers (Baranova et al., 2021).

This study examines the spatial relationships between industrial facilities and urban areas in the city of Gjilan, Kosovo, using GIS-based spatial analysis. Particular attention is given to the location of industrial facilities within the urban structure, their proximity to the city center, and their relationship with residential, educational and healthcare facilities. Using buffer zone and spatial proximity analyses, the study evaluates the compatibility of existing industrial land use with urban development patterns and spatial planning regulations. Despite the growing importance of industrial–urban interactions in contemporary spatial planning, this issue has received limited attention in Kosovo, particularly from a GIS-based perspective.

Review of scientific literature

The industry is a generator of the development of a region or country; therefore, this influenced the change of the physiognomy of space and the way of life of the population at a high speed (Ramadani, 2016). Most of the research on the position of industrial facilities in recent years has been empirical, answering the questions raised by the regional and urban needs of spatial planning (Wood, 1979). The common aspect of many previous papers is the presence of industrial facilities in urban areas with production activity. Such facilities have inadvertently become part of the urban environment, which is a result of the city's growth towards the suburbs (Kreuz et al., 2020). Based on city-factory-product connection, a typology emerged around the definition of industrial facilities in urban areas, while two definitions emerge from this (Ijassi et al., 2022). Industrial facilities in urban areas are located within the urban territory with inputs (materials, employees, etc.) that are from the same urban area, and its output (products) that is distributed in the same urban area (Ijassi et al., 2022. Semi-urban industrial facilities are located within an urban area, with their input or output logistical activities, which are carried out outside the same urban area (Ijassi et al., 2022). In relation to the concentration of industrial facilities, cost also plays a role, where industrial facilities are located as close as possible to the urban area, or within it, to reduce transport and

communication costs (UN-Habitat, 2016). Several models are known for the position of industrial facilities in relation to the urban area, among them Burges's model, as well as Harris's and Ulman's. Burges reflects the position of industry in the urban area via the concentric circles model. The essence of this model is that the city expands from the center towards the periphery in a concentric fashion. Burges, in his model, identifies 5 areas. After area I, where the CBD (Central Business District) is located, area II appears as an area in transition and is an area of industrial activities (Nelson, 1969). The industry tends to be located as close to the CBD as possible, but at the same time, industry prefers to be located as close to the main roads as possible, as well as in the suburbs where the rent is the lowest. According to Burgess's model, industrial activity is concentrated in the transitional zone around the city center, while the subsequent division into light and heavy industry was elaborated by subsequent urban models (Spielman & Logan, 2013; Pacione, 2009). Light industry tends to be located near the CBD due to better connectivity to the city center. In recent times, light industry has been moving to the suburbs due to high rent (Pacione, 2009). According to Burgess's model, later supported by Harris and Ullman, heavy industry tends to move away from the city center as much as possible. This departure from the city center came about because of the demand for large spaces for factories, parking lots, and storage facilities (Lian et al, 2026; Pacione, 2009). Likewise, the "push" factor is of great importance in setting up the industry. This has to do with the impossibility of spatial expansion of industrial departments in the city, such as high land rent, high population density, environmental pollution, etc. (Ramadani, 2016). Another paper regarding the position of industrial facilities was written by Weber. Weber founded his theory, whereby the position of the industry is where the cost of transporting raw materials and the final product is minimal (Weber, 1929; Pacione, M. (2009). Weber explains that the position of industry in a country depends on several factors, together called the "location factor" (Weber, 1929). The location of the industry depends on many factors, such as topographical characteristics, sources of raw materials, market, workforce, infrastructure network, type of industry, etc. (Vresk, 2002).

Recent studies have increasingly focused on the transformation of industrial areas within cities, industrial brownfields, urban redevelopment processes, and the integration of industrial functions into sustainable urban development strategies. Contemporary research emphasizes the role of urban industry in circular economy models, sustainable land use, and industrial restructuring within metropolitan areas (Juraschek et al., 2018; Kreuz et al., 2020; Ijassi et al., 2022). These studies highlight the need to reassess the relationship between industrial facilities and urban areas, particularly in cities undergoing rapid spatial expansion and functional transformation. Gjilan, as a city, developed concentrically, especially on the western side, where residential districts and industrial areas developed around the city center (Pllana, 2015).

Data and methods

During the design for the selection of the location of industrial facilities in the urban area, many aspects should be considered, whether geographical or administrative regulations, for the preferred distance from some specific facilities, in order not to show implications around them and to enable a long-term and sustainable development. The city of Gjilan is taken as an example in this case study. The methods used in the realization of this work are statistical methods, deductive methods, graphic methods, GIS methods, and cartographic methods. For the collection of data and reports for this study, existing literature, fieldwork, and GIS assistance for digitization and mapping were used to analyze the existing situation. Also, the administrative regulations of MESP for the technical norms of spatial planning in Kosovo, for the adequate distances in accordance with this regulation, as well as population data from the Statistical Agency of Kosovo, were also used. Spatial proximity analysis and buffer zone analysis (300 m and 800 m) were employed to evaluate the relationship between industrial facilities and surrounding urban functions. GIS-based spatial analysis enabled the assessment of compliance with spatial planning regulations regarding the location of residential, educational and healthcare facilities. The analysis included the identification, mapping and quantification of facilities located within the designated buffer zones around industrial areas. All these have been displayed with maps and tables, from which conclusions and values have emerged for further analysis.

Study area

The Republic of Kosovo is a country with a relatively small area (10,908 km²). Kosovo borders four countries: Montenegro, Serbia, North Macedonia, and Albania. Kosovo is a hilly/mountainous country with great vertical and horizontal variation of the elevation. The main mountain areas: Bjeshket e Nemuna, Sharr, Karadak and Kopaonik, mainly extend in the peripheral parts of the country (Pllana, 2015). The territory of Kosovo has an average altitude of about 800 m and is characterized by pronounced vertical variation and different forms of elevation. The mountainous regions are mainly located in the peripheral parts and makeup about 63.5% of its territory. In the elevation of Kosovo, gently undulating and flat terrain is clearly distinguished, which makes up 36.5% of the territory of Kosovo. One of the lowland units of the field-pit type is the Kosovo Plain. Meanwhile, the Dukagjin Plain (Albanian: Rrafshi i Dukagjinit) appears in the form of a tectonic lowland (Kosovo Academy of Sciences and Arts, 2013). The city of Gjilan was taken as a study area for this purpose. The city of Gjilan is an urban and municipal center and the largest urban center in Anamorava Region and one of the seven largest regional centers of Kosovo. The city of Gjilan simultaneously represents the largest urban agglomeration of the eastern part of Kosovo, both in terms of surface area and population. The surface of the urban territory of the city of Gjilan is 1,435 ha, while with several settlements near the city: Livoç i Epërm, Livoç i Poshtëm, Velekincë, Malishevë and Shillovë, cover about 2,000 ha, and boast more than 70,000 inhabitants. The cadastral area of the city of Gjilan is 17 km², most of which is covered with residential buildings, infrastructure, and economic facilities, while the peripheral parts, and in particular those E and SW, are agricultural lands. The area of the territory of the municipality of Gjilan is 392 km², with about 90,000 inhabitants and with a density of 230 inhabitants/km², while the gravitating area of Gjilan with the other municipalities within this region: Viti, Kamenica, Novobërd, Kllokot, Ranillug and Partesh, cover 1,412 km², with 192 settlements and

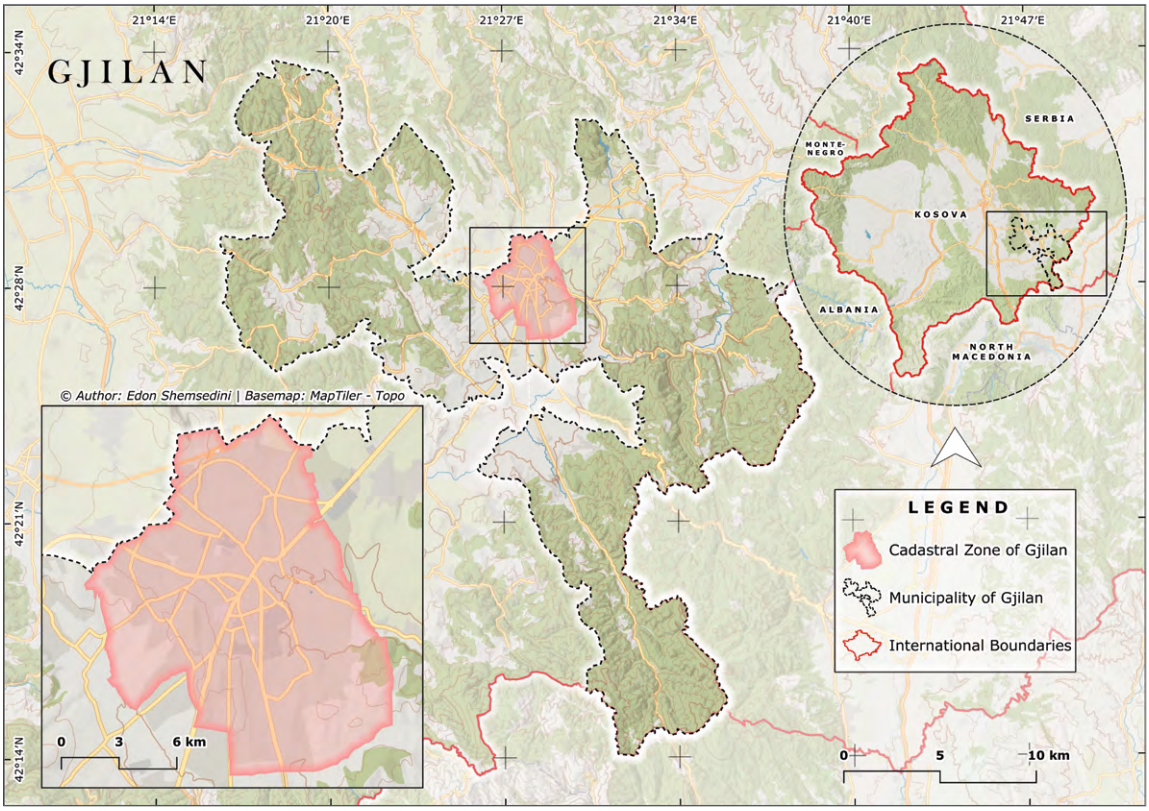

Fig. 1 The geographical position of the city of Gjilan in the Republic of Kosovo.
Source: authors, 2026

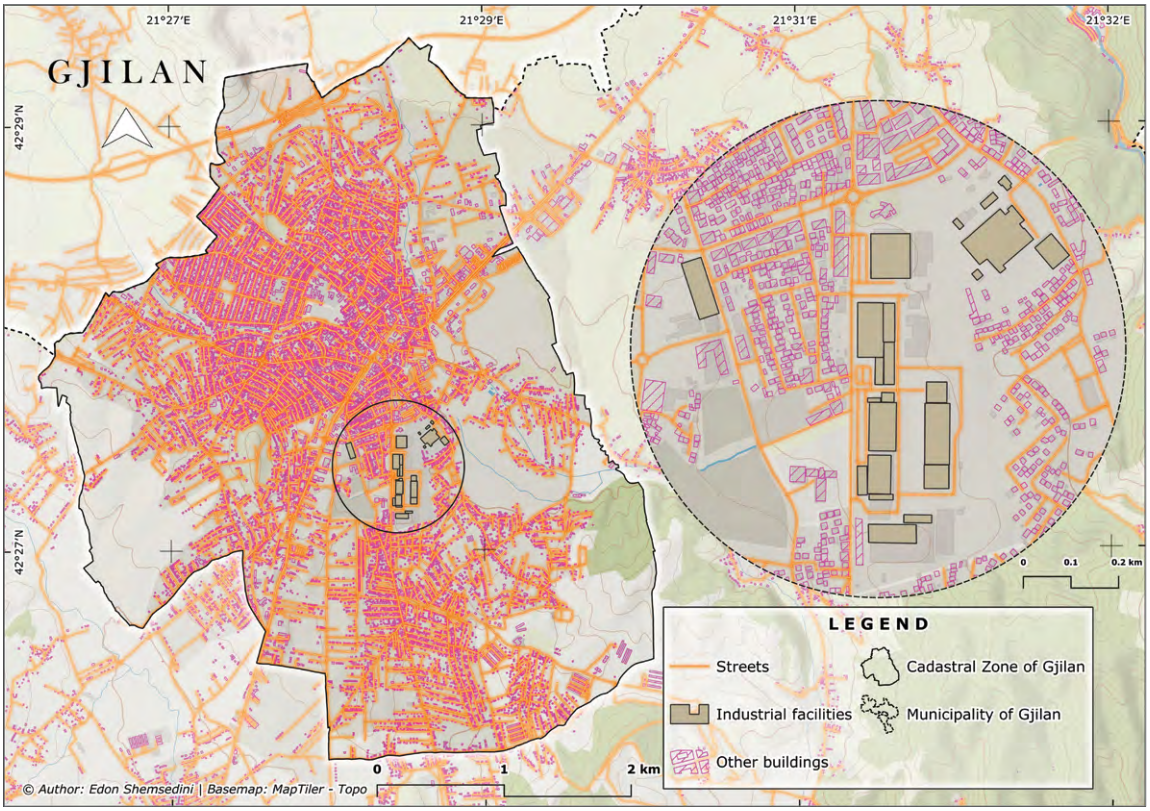

Fig. 2 Position of industrial facilities in Gjilan City.
Source: authors, 2026

about 180,000 inhabitants. Natural predispositions have determined the topographic and spatial development of the city. In addition to the favorable geographical-mathematical component, Gjilan is also distinguished by its important geo-communicative position, with the intersection of roads coming from the direction of Pristina, Ferizaj, and the Presheva Valley (Kosovo Academy of Sciences and Arts, 2018).

Results and discussion

The impact of the terrain on the location of industrial facilities is very large. In the hypsometric aspect, Gjilan stretches on different levels; the lowest point is in the E part with 488 m, while the highest quotas are found in the N part, near the Gllama hill with 652 m. The altitude in the center of the city is 500 m (Kosovo Academy of Sciences and Arts, 2018). These elevation data make Gjilan an ideal place for industry because this elevation has an impact on temperature, air pressure, transport accessibility, etc. The average annual air temperature in Gjilan is 10.1 °C, which is a suitable temperature for industrial facilities. The average annual rainfall in Gjilan is about 607 mm. In Gjilan, the most frequent air currents are from quadrant N, respectively N and NW (Kosovo Academy of Sciences and Arts, 2018. These favorable climatic and topographical conditions, the presence of raw materials, and good communication links with other cities of Kosovo, and also with other neighboring countries, make Gjilan a suitable place for the development of the industry. The facilities which are shown on map 2 (fig. 2) are related to industry: light products industry (tobacco factory, radiator factory), raw material industry (textile factory). Most of the industrial facilities presented in Figure 2 originate from the period of socialist industrialization, when Gjilan developed as an important industrial center in eastern Kosovo. These facilities include a tobacco factory, a radiator factory, textile production facili-

ties, and several smaller manufacturing and storage complexes. Following the economic transition after 1999, some industrial facilities continued their activities, while others were partially transformed into commercial, service or storage facilities.

In Figure 3, a buffer zone from the city center towards the suburbs is presented to analyze the proximity of industrial facilities to the city center. To make a more detailed analysis of the distribution and distance of industrial facilities within the urban area of Gjilan, we divided the urban area into 5 concentric areas expressed in meters, where the center of the buffer area is the city center. The selected distances are 300 m, 600 m, 900 m, 1200 m, and 1500 m. The distance of 300 meters between the concentric circles of the buffer is determined based on the *Guidance for reviewing new source construction permit applications under the national ambient air quality standards* from the American Environmental Protection Agency (EPA, 2010). Based on the detailed analysis regarding the distribution and distance of industrial facilities, it can be observed that there is no industrial facility within 600 meters of the city center. At a distance up to 600 meters from the city center, all the facilities are residential, with various services, recreation, etc. From 600 to 1500 meters from the city center is the area where most of the industrial facilities are concentrated. The industrial facilities in this area have a linear north-south alignment. The largest concentration of industrial facilities is located 600–900 meters from the city center. While at 900–1500 meters, the number of industrial facilities starts to decrease. Even some facilities that were industrial in the past have now been transformed into service centers (markets) or abandoned areas (derelict areas).

The population within the cadastral area of the city of Gjilan, according to the population census in 2011 by the Statistics Agency of Kosovo (ASK), is 54,239 inhabitants (Kosovo Agency of Statistics, 2011). All these residents are unevenly distributed along the city's borders. An extremely large amount of the population lives in the vicinity of these industrial facilities.

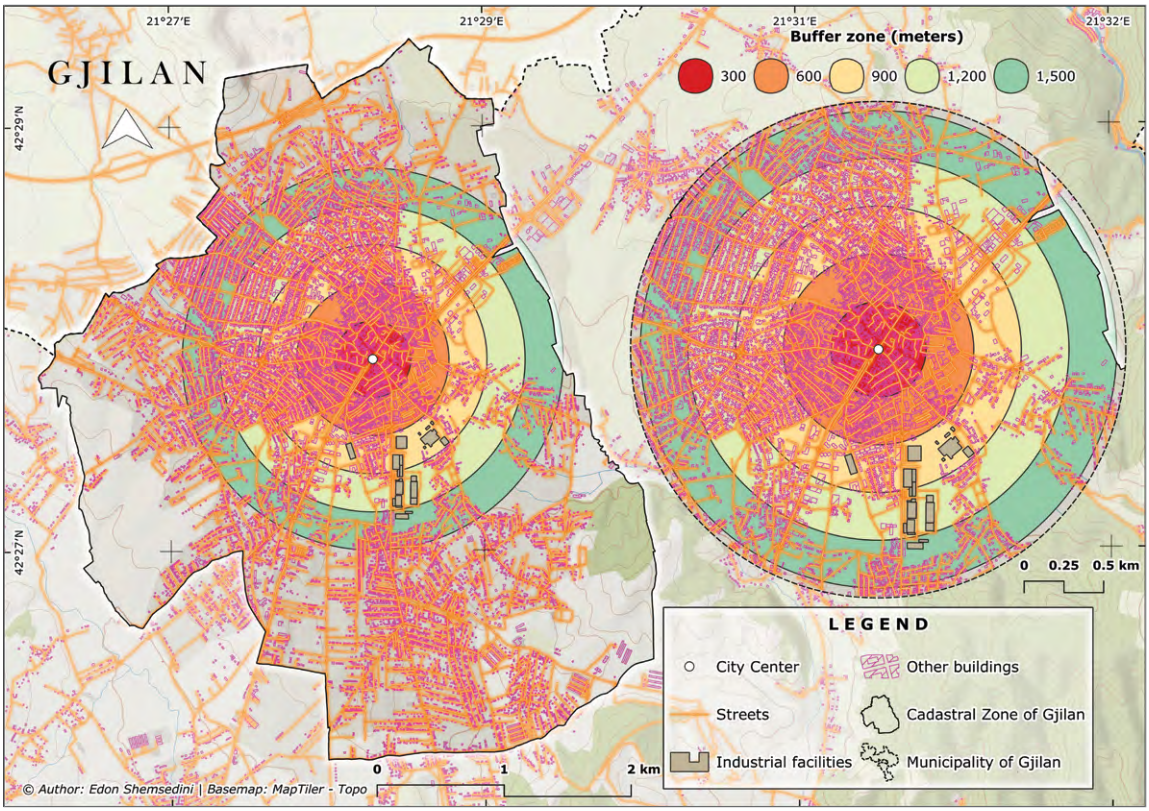

Fig. 3 Buffer zone from the center of the City of Gjilan.
Source: authors, 2026

According to the laws approved by the Ministry of Environment and Spatial Planning (MESP), the distance between an industrial and non-industrial facility (residential zone) must not be less than the maximum height above the ground of the tallest neighboring building (MESP, 2017).

According to international laws regarding the distance between residential buildings and industrial buildings, the distance between them varies depending on the type of industry, noise level, air pollution from industry, wind direction, and density of residential buildings (National Institute for Occupational Safety and Health, 1998; National Academy of Public Administration, 2003; WHO, 2010). The space occupied by these two industrial zones covers an area of about 29 ha. The distance between heavy industry facilities and residential facilities should be 500 meters, to avoid exposure to the risk. Likewise, the distance between light industry facilities and residential facilities of 200 meters has been deemed sufficient (National Institute for Occupational Safety and Health, 1998; National Academy of Public Administration, 2003; WHO, 2010). As shown in figure 4, it is clearly observed that within the buffer zone created at 300 meters from the area where the industrial facilities of Gjilan are concentrated, there are many facilities of various use, from residential to service.

Within this buffer, there are about 1,595 different facilities. Based on table 1, there are 1,458 individual and collective housing facilities, some of which are no further than the rules provided by construction law. But it is worth noting that the distribution of residential buildings is not the same throughout the industrial area. The northern and north-western parts are denser than the other parts, which confirms that the development of the city of Gjilan is oriented towards the west.

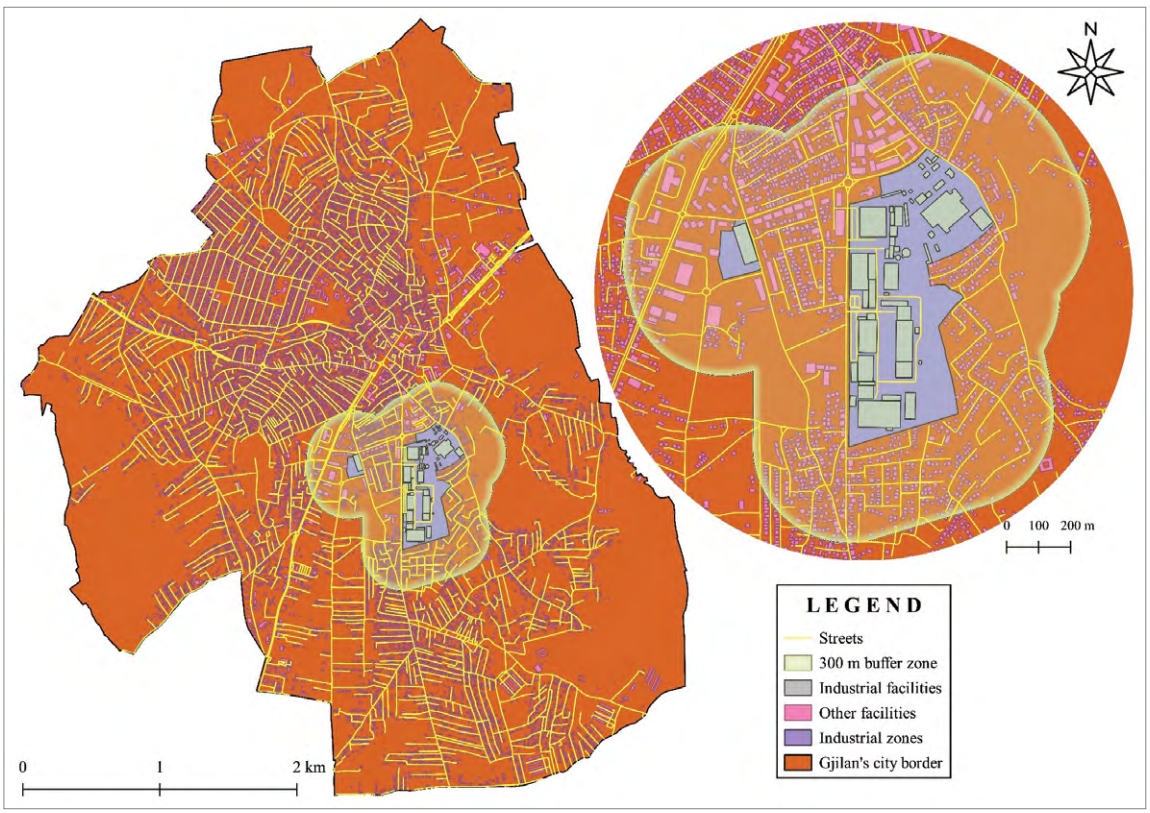

Fig. 4 Buffer zone 300 meters from 2 industrial zones in the City of Gjilan.
Source: authors, 2026

Tab. 1 Facilities within the area 300 meters from the 2 industrial zones in the city of Gjilan

Typologies	Frequency (Nr)
Individual housing	1,381
Collective housing	77
Commercial	43
Kindergarten	1
Primary school	2
Hospital	1
Emergency	1
Other	89
Total	**1,595**

Based on table 1: we note that education and medical care facilities are located within the buffer of the areas around industrial facilities.

Facilities intended for education are daycare centers and primary schools, while those for health treatment are the regional hospital of Gjilan and the emergency room. As shown in figure 5, it is clearly visible that these facilities are at a much closer distance than the technical norms of spatial planning approved by the Ministry of Environment and Spatial Planning allow. The Technical Norms of Spatial Planning state that educational facilities, such as nurseries, primary and secondary schools, and universities shall not be built at a distance less than 800 m from an industrial facility (MESP, 2017). In the case of the city of Gjilan, these rules have not been respected and educational facilities have been build closer than 800 m.

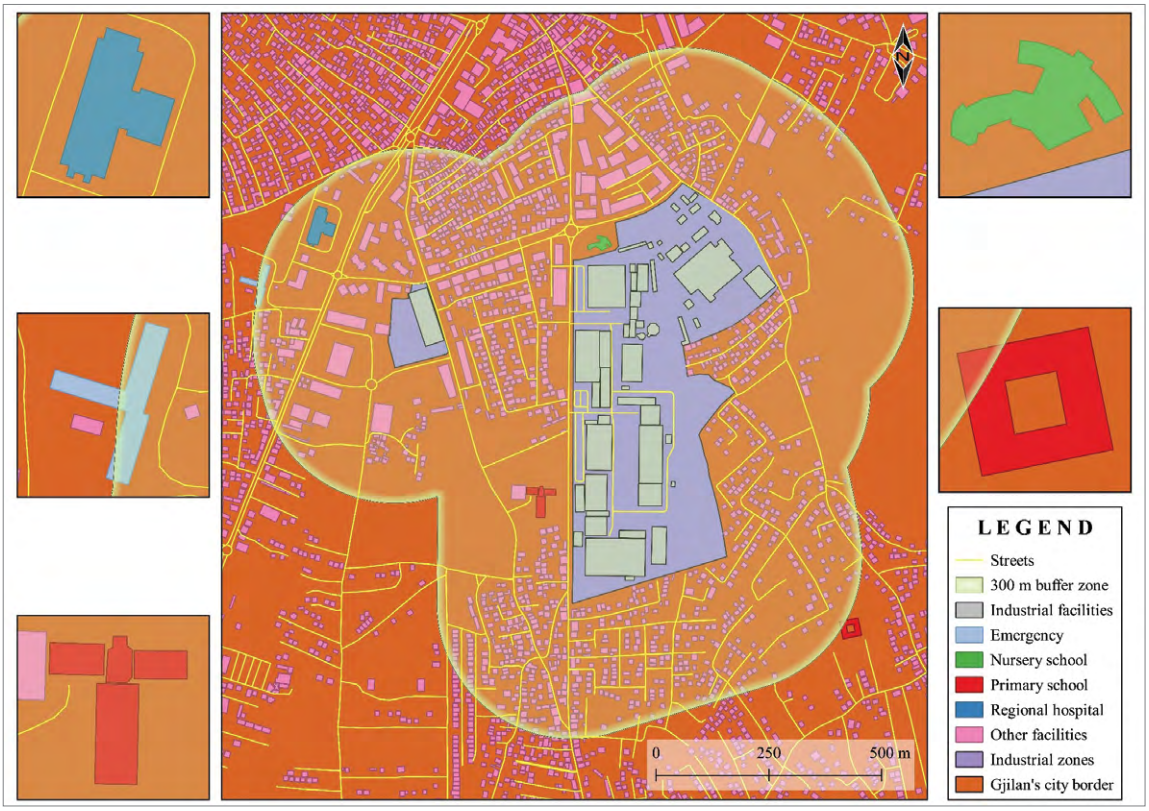

Fig. 5 The location of educational and medical facilities in relation to industrial facilities inside the 300 m buffer zone.
Source: authors, 2026

The case is similar for facilities for medical treatment. According to the Technical Norms of Spatial Planning, these facilities should not be built at a distance shorter than 800 m from an industrial facility (MESP, 2017). So, this distance has not been respected because the distance between health facilities and industrial facilities is much smaller than the laws of Kosovo allow.

In Figure 6, the buffer of 800 m is shown graphically. This radius of 800 m was taken based on the Spatial Planning Technical Norms approved by MESP. The values presented on the map show that within this radius there is a large number of facilities (that should not be there according to law), which according to technical norms is not preferable.

Based on table 2, a number of facilities are observed within this radius for various services, which include: 1 nursery school, 4 primary schools, 1 hospital, 1 emergency, and 1 ambulance station, which should not be in the radius, less than 800 m. The results indicate a significant mismatch between the current urban structure and the spatial planning standards prescribed by Kosovo legislation. The concentration of residential, educational and healthcare facilities within the protection zones surrounding industrial areas suggests that urban expansion has occurred without sufficient consideration of industrial land-use constraints. This situation reflects the gradual incorporation of formerly peripheral industrial zones into the urban fabric as a result of urban growth. Similar processes have been observed in many post-socialist cities, where rapid urbanization and functional transformation have altered the original relationship between industrial and residential land use. Consequently, the case of Gjilan highlights the need for more effective spatial planning measures to ensure compatibility between industrial activities and urban development.

Fig. 6 The location of educational and medical facilities in relation to industrial facilities inside the 800 m buffer zone.
Source: authors, 2026

Tab. 2 Facilities within the area 800 m from the two industrial areas in the city of Gjilan

Typologies	Frequency (Nr)
Individual housing	5,051
Collective housing	209
Commercial	43
Kindergarten	1
Primary school	4
Hospital	1
Emergency	1
Ambulance	1
Other	363
Total	**5,674**

Conclusion

In conclusion, the connection between industrial facilities and the urban area of the city of Gjilan is complex and requires careful management, including municipal spatial plans. However, in the case of the city Gjilan, the criteria and rules established by international rules and laws in force in the Republic of Kosovo have not been applied. Therefore, to ensure a positive connection between industrial facilities and the urban area, the city of Gjilan must take several steps.

First, it must be ensured that the new facilities (educational, health, residential) are placed in suitable areas with adequate distances, according to the criteria and administrative guidance of the Ministry of Environment and Spatial Planning on the technical norms of spatial planning in Kosovo. Based on this, the damage from pollution, noise, and other negative effects will be minimized. This can be achieved through zoning regulations and environmental impact assessments.

Second, the city should encourage the development of sustainable industrial practices and implement spatial planning regulations for these areas.

Third, in order to protect the urban area from pollution, the industrial facilities within this area should be equipped with facilities for the treatment of wastewater and industrial water. Also, for air pollution, industrial facilities must be developed in accordance with the criteria of *Directive 2008/50/EU* for clean air in Europe, and the laws in the Republic of Kosovo.

Fourth, the easiest access to traffic for the distribution of products from these industrial facilities should be ensured.

The current situation in these areas is changing day by day because, apart from those areas that are functional, some have begun to undergo transformations, while some do not show any industrial activity.

These transformations are turning industrial facilities into relic areas or derelict areas, while some of them have been transformed into large shopping malls. After these areas have undergone a transformation, conservation work should be undertaken, so that there is a sustainable development.

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