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"All the world's a stage" – The Spatial Value of Destination DJ Videos

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KEYWORDS

- electronic dance music
- spatial value
- destination marketing
- destination management
- social media analysis

ABSTRACT

This exploratory article analyzes the contemporary trend in the music and event industry of organizing and filming electronic dance music (EDM) events at tourist destinations. These videos featuring DJ sets in attractive locations, referred to as destination DJ videos (DDJVs), accumulate a substantial number of views on social media platforms, primarily YouTube. Due to their widespread popularity, they represent an untapped source of online media content, holding potential for broader industry utilization and academic analysis of their spatial value, understood as an addition to the typically considered social, cultural, and economic values of music events. DDJVs combine the popularity of a music genre, an artist, a music streaming platform, and the destination featured in the video, offering various perspectives and approaches for assessing and evaluating them within the domain of tourism. The presence of datasets encompassing DDJVs stands as a noteworthy and substantial resource for novel academic explorations within the sphere of tourism research, expanding the scope of visual studies in tourism. Moreover, DDJVs have the potential to serve as valuable and pragmatic instruments for fostering innovation in the field of destination marketing. This exploratory study provides an early evaluation of research directions for DDJVs.

Introduction

Sets of electronic dance music (EDM) performed by Disc Jockeys (DJs) at characteristic landmarks and iconic places have become a popular trend among fans of this music genre (Mitchell, 2020). Videos of these events are what we will refer to as Destination DJ videos (DDJVs). DDJVs posted on social media attract high numbers of views, and as well as promoting music, they have a strong potential for destination promotion, like other forms of popular culture (Lexhagen et al., 2023). Thus far, the spatial value of DDJVs for destinations has not caught the attention of researchers.

There is a strong link between EDM and travel activities. For several decades, young people have taken vaca-

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tions to pursue their passion for EDM and follow their favorite DJs around the world, visiting famous nightclubs and festivals that host these DJs, and numerous specialist and non-specialist tour operators offer specially themed holidays centered around dance music (Sellars, 1998). Dancing to EDM has often been related to an experience of immersion of the dancers in the activity and a form of escape from mundane life (Peter, 2013). For example, as a hybrid of art and music, techno is ritualized in multimedia dance events known as raves or underground nightclubs in urban settings or as trance parties often in secluded rural areas (Della Corte et al., 2017). Over the past decade, fans of EDM have developed a thriving scene by attending festivals, local clubs, and large sporting venues and stadia to see their favorite DJs and EDM musicians perform (Adams, 2021).

Social media and online streaming services are among the primary channels for the promotion and distribution of mainstream electronic music. Online live music streaming has existed as a practice within the music industry since the late 2000s. Since then, it has grown via social media channels to include professional broadcasters hosting millions of viewers around the world. The largest of this live music streaming professional broadcasters operate largely within the world of EDM (Boyle, 2022).

DDJVs gain significant traction on social media platforms, particularly *YouTube* (Mitchell, 2020; Watson, 2019). The appeal of these videos lies in their combination of factors, including the popularity of the electronic dance music genre, the fame of the featured artists, the platform used for music streaming (Watson, 2019), and the visually captivating locations where the events take place (Stankov et al., 2019). Those videos primarily follow the DJ's performance and their interactions with the crowd (if present at a set), but the camera also frequently widens its focus to encompass the surrounding areas, employing appealing camera angles, often supplemented by visually striking drone shots. For instance, drone footage enhances the videos' attractiveness by offering dynamic and diverse filming angles, as well as a broader range of filming locations compared to terrestrial cameras (Vujičić et al., 2022). Deliberate consideration is given to the timing of these recordings, with a selection of moments that coincide with daylong periods or sunsets, thus augmenting the overall attractiveness and visual appeal of the resulting video content. This convergence of elements provides diverse perspectives and approaches for evaluating and assessing these videos (Dinhopl & Gretzel, 2016). As suggested by Zuo et al. (2023) destination management should shift its focus towards emphasizing the interplay of space, people and activities in destination videos, rather than merely showcasing physical settings.

As a result of their widespread popularity, these videos present a novel and unexplored form of online media content, offering potential practical and academic opportunities for investigation of their spatial value (van der Hoeven & Hitters, 2020), seen as an enhancement to the commonly recognized social, cultural, and economic aspects of music events (Ord & Behr, 2023; van der Hoeven & Hitters, 2019; Vujičić et al., 2023). Due to their specific nature, DDJVs have the potential to influence consumer segments and to be seen as management and marketing tools at the intersection of the music, event, and tourism industries together with social media. Thus, this research adopts a narrative approach to present the trend of DDJVs and explore potential future research directions. Conclusions are drawn from a blend of secondary data used for narrative review and primary exploratory research involving DDJVs' YouTube metadata. The article starts by showing reasons for the appeal of these videos by pinpointing a combination of factors, including the popularity of the electronic dance music genre, the fame of the featured artists, the platform used for music streaming, and the visually captivating locations where the events take place. This study further builds its arguments on the specifics of DDJVs based on the exploratory study of one of the most popular *YouTube channels* and culminates with clear delineation of research directions.

Literature review

The attractiveness of DDJVs could be related to popularity of particular DJs; the streaming platform (social media) used for sharing videos; the destination's image and the EDM genre's attractiveness.

The expected primary driver behind the viewership of EDM is typically the popularity of the DJs and the music they play, although audiences could also take non-musical traits of artists (e.g., physical attractiveness of a performer) into account during the music evaluation process (Schaap et al., 2023). The top 100 DJs earn an annual income of $352,500,000. Additionally, these esteemed DJs collectively amass an audience of 734,118,248 monthly listeners (InternetDJ, 2023). This data underscores the immense influence and widespread appeal that these DJs hold within the contemporary music landscape.

EDM artists are increasingly embracing social media as their avenue for accessible and budget-friendly marketing strategies (Boyle, 2021). This enables them to effectively communicate and establish connections with both their existing and potential audience members. In terms of user engagement EDM is relatively small on mainstream social media (*Facebook*, *Instagram*, and *Twitter*) compared to other genres. On the other hand, EDM's social following is more heavily reliant on *YouTube* than that of other genres, in terms of new content, uploads, subscribers, and activity, compared to *Twitter*, *Instagram*, and *Facebook* (Boyle, 2022). Most importantly, social video engagement is a strong point for electronic music.

Traditionally, major cities have been the epicenters of EDM, in part due to their attractiveness for visiting DJs and their followers (Garcia, 2016; Vujičić et al., 2020). For example, the so-called "techno-tourists" of Berlin are music fans who return repeatedly to the city to participate in the local EDM scene. More than one third of visitors to Berlin come because of the city's club culture (Clubcommission Berlin, 2019), where 40% of clubs play techno (Watson, 2019). However, while the association of EDM with tourist destinations like Berlin, Ibiza, or Miami is not a new phenomenon, DDJVs shared on social media could have potentially broader promotional impact, including a wider variety of destination and specific tourist attractions, and presenting these in novel and often visually dramatic ways (Dragović et al., 2019; Ritter, 2023).

EDM is the third most popular music genre in the world, after pop and rock music, with an estimated 1.5 billion listeners (Watson, 2019). According to a US study, fans of EDM have a higher propensity to attend live music events than those of any other genre (Nielsen, 2018; Watson, 2019). Moreover, the rising popularity of DJs is a contemporary trend. The highest-paid DJs usually perform over 100 shows every year. The EDM market was estimated to be worth 6 billion US dollars in 2021. This includes clubs and festivals, DJs' and artists' earnings, music sales, streaming services, hardware, software, and education about EDM (Watson, 2019). It must be noted that different EDM genres vary in popularity and appeal. Consequently, the choice of music genre in the DJ video can influence its attractiveness to a specific audience.

Methodology

The methodological section is based on the empirical study of the major provider of DDJVs, *Cercle*, who distribute content via their *YouTube* channel (https://www.youtube.com/@Cercle). *Cercle* is one of the most popular *YouTube* channels for DJ sets at tourist destinations and attractions. Cercle began live-streaming electronic music events in April 2016 and now streams one show weekly. The prime goal of *Cercle* is to showcase cultural heritage and other landmarks through the prism of electronic music and video. Their scope has broadened from unique venues in France to other locations across the world (Cercle, 2022). Cercle videos attract a young global audience, within which 5 out of 10 countries with the highest watch time are outside of Europe (Watson, 2019). In August 2023, the official *Cercle YouTube* channel had over 2.9M subscribers and had received more than 744M views.

In this study, we utilized the *YouTube* API to retrieve the metadata from the official Cercle channel. The YouTube API allows developers to retrieve metadata from a channel by making HTTP requests to the YouTube Data API endpoints, where they can access information such as video titles, descriptions, upload dates, and view counts. By using API keys for authentication, developers can query specific channel data and receive responses.

The time span of videos collected was from April 2016 to the end of October 2022. A total of 155 videos were analyzed, encompassing the following attributes: video title, description, duration, number of views, likes, comments, and the date of publishing. In total, 127 videos were included in the analysis, as 28 videos were excluded from the sample. Exclusions took place in cases where no location could be determined (in the initial period of Cercle's development, or in the case when videos featured a compilation of several videos) accounting for the exclusion of 9 videos, and another 19 were excluded because they were recorded in clubs, festivals, or in places that were not tourism destinations or attractions.

Results

Figure 1 shows geographical distribution of all videos in the sample. This shows that European destinations dominate, with 77.17 % of videos. It is followed by Asia (8.66%), South America (7.09%) and North America (4.72%). Africa (1.57%) and Australia and Oceania (0.79%) have the lowest frequency of videos. Here it must be noted that France is the leading country with 63,78% since Cercle is French-based entity and this is reflected in the fact that destinations in France dominated in videos from 2016 to the end of 2018, at the beginning of Cercle's growth. Following this, in the period from 2019, the ratio of French destinations fell to 27.78% due to an increase in the frequency of videos produced in other countries (such as Mexico, India, Italy, Brazil, Turkey, USA, Egypt, Croatia, and others). Figure 1 shows locations of DDJVs with a worldwide density-based clustering (showing areas where locations are concentrated and where they are separated by areas that are empty). The densest global cluster is in Europe, while closer inspection on the level of countries, shows that France is the epicenter, with sub-county clusters (e.g., around Paris or South France). This basic analysis demonstrates the existence of more interest of DDJVs creator for particular geographical regions.

All locations are classified into 25 subclasses based on the type of the attraction featured in the video and then are further reclassified into seven major classes (historical and archeological sites, natural attractions, museums,

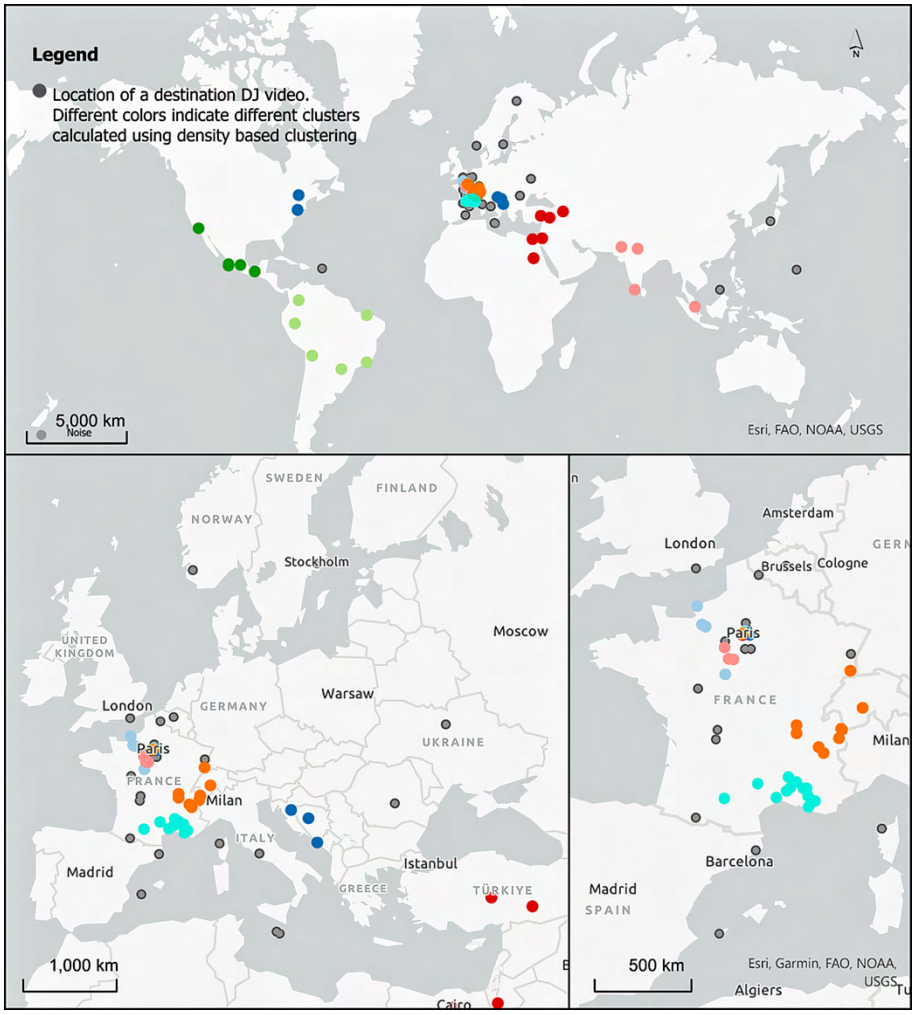

Figure 1. Spatial distribution of the sample videos with clustering based on location (the color of each location represents belonging to one cluster)

Source: Authors' own contribution

Table 1. Type of attractions featured in DDJVs

Major class	Subclasses	Frequency	Percentage
Historical and archeological sites	Castles, monuments, historical sites and archeological sites	30	23.62
Natural attractions	Parks, Geological sites, natural landmarks, mountains, rivers and beaches	27	21.26
Museums, cultural and religious sites	Museums, cultural institutions, exhibition halls and religious buildings	23	18.11
Event venues and sport facilities	Event venues, sport facilities, amusement parks	23	18.11
Infrastructure	Observation Decks, Skyways, Airports, transportation infrastructure	17	13.39
Other	Cities, embassy	4	3.15
Accommodation facilities	Hotels and restaurants	3	2.36
Total	-	127	100.00

Source: Authors' own contribution

Table 2. Top 10 DDJVs from the sample based on the number of views on YouTube.

Name of the artist	Featured location	Published	Views	Likes	Comments	Date of the last comment recorded on 27.07.2023.
Boris Brejcha	Grand Palais, Paris, France	13.06.2019.	45,357,833	428,374	15,334	27.07.2023.
Black Coffee	Salle Wagram, Paris, France	01.02.2018.	38,112,904	305,556	11,249	27.07. 2023.
Boris Brejcha	Château de Fontaineble, France	04.04.2017.	36,785,720	309,802	11,195	27.07.2023.
Fatboy Slim	British Airways i360, Brighton, United Kingdom	03.08.2018.	35,570,056	368,980	8,453	27.07.2023.
Deborah de Luca	Château de Chambord, France	08.09.2017.	29,585,399	248,982	6,948	26.07.2023.
ARTBAT	Bondinho Pão de Açúcar, Rio de Janeiro, Brazil	15.03.2019.	26,448,098	258,246	6,304	26.07.2023.
Ben Bahmer	Cappadocia, Turkey	10.10.2020.	25,294,844	270,429	12,316	27.07.2023
Solomun	Théâtre Antique d'Orange, France	24.04.2018.	23,037,840	211,552	6,556	22.07.2023.
FKJ live	Salar de Uyuni, Bolivia	28.02.2019.	22,669,560	387,056	10,899	27.07.2023.
Carl Cox	Château de Chambord, France	19.07.2018.	14,017,959	126,615	4,478	26.07.2023.
Stephan Bodzin	Piz Gloria, Mürren, Switzerland	26.07.2018.	13,499,414	152,331	6,247	27.07.2023.

Source: Authors' own contribution

cultural and religious sites, event venues and sport facilities, infrastructure and other). Man-made attractions account for around 80% of attractions, while every fifth video featured predominantly natural attractions.

The average duration of the video was 94 minutes. The standard deviation being around 15.2 minutes suggests that there is some variability in the values, but they are not too widely dispersed from the average duration of videos.

The average number of views was 5.125.611, with each receiving an average of 59.638 likes and 2167 comments. Table 2 shows the basic metadata of the 10 videos with most views. All of them have more than 10 million views. The overall analysis, as well as the specific metadata shown in Table 2, demonstrate high levels of user engagements, indicating the popularity of these videos.

Discussion and further research directions

The availability of datasets comprising DDJVs presents a significant and noteworthy resource for novel academic investigations, which can add to the growing field of video and broader visual research in tourism and geography (Arabadzhyan et al., 2021; Park & Kim, 2018; Volo & Irimiás, 2021) as well as part of system-wide shift in tourism theory and practice driven by technological and societal transformations (Lehto et al., 2022; Vujičić et al., 2022). Moreover, these datasets possess the potential to serve as a valuable and practical tool for innovation in destination management. Based on this exploratory analysis, several new research streams associated with DDJVs can be distinguished.

Destination marketing

Destination branding. In a similar manner to studies that examined the promotional effect of drone videos for destination (Jiang & Lyu, 2022; Stankov et al., 2019; Vujičić et al., 2022), DDJVs could have the same direct and indirect effect on destination branding. Research into direct destination branding could include analysis of explicit efforts to highlight and promote specific locations. This can be achieved through elements such as visual signatures (including iconic landmarks, recognizable symbols, or unique natural features of the destination prominently within the video frames), verbal references clearly mentioning the destination's name, distinctive attributes, and appealing aspects; branding materials (integrating official tourism logos, slogans, and official promotional materials in the video). Indirect destination branding research would involve a subtler approach. This can include further research of emotional storytelling trough EDM (analysis of narratives that evoke emotions and connect listeners to the destination's atmosphere, people, and experiences on a personal level), visual aesthetics including research, ana-

lyzing cinematography and editing techniques that capture the ambiance of the location (Dinhopl & Gretzel, 2016; Stankov et al., 2019). Another area for research could be thematic integration, which is aligning the destination's characteristics with specific themes (e.g., adventure, relaxation, cultural exploration) to create an association that lingers in the listener's mind (Ding & Hung, 2021; Stankov & Filimonau, 2021).

Travel motivation research. The correlation between music events and travel motivations has been firmly established (Cimbaljević et al., 2019), albeit with a predominant emphasis on participating in events within specific destinations. Exploring the potential impact of watching DDJVs on travel motivations (Parra-López et al., 2012) offers an intriguing angle, potentially unveiling video consumption as a distinct influential factor in its own. DDJVs could enhance the pre-travel experience by creating a vibrant and exciting preview of the destination, enticing potential visitors. Upon arrival, these videos can help travelers feel an immediate connection with the destination, recognizing familiar locations from the videos, thus enhancing their overall experience.

New consumer segments. With DDJVs, destinations could potentially access a new consumer base and leverage the existing trend of inclusiveness in EDM videos (Dhaenens, 2016). EDM events often create a platform for marginalized communities, offering chances to partner up for innovative musical ventures and enabling the exploration of novel sounds and experiences (Stankov & Gretzel, 2020). It also allows audiences to embrace diverse artistic expressions, such as fashion, music, and visual aesthetics (Mazierska & Rigg, 2021).

Further research could be directed into the analysis of the viral potential of DDJVs to determine the right blend of music and travel content that resonates with audiences and encourages them to share, engage, and discover the showcased destination. As suggested by Vujičić et al. (2022) this type of analysis could include analysis of thumbnails and titles that spark curiosity and convey the essence of the EDM event and destination, exploration of engagement with the opening moments that grab viewers' attention or integration of destination footage into the video's rhythm seamlessly with the music.

Spatial value and destination management

EDM events can bring new value to spaces and serve as a tool for the creation of new attractions, integration into various types of tourism attractiveness, and revitalization of less-recognized regions (Stankov et al., 2016). By strategically integrating EDM events into different aspects of tourism, destinations can create a unique and multi-dimensional appeal that resonates with a diverse range of travelers.

Location management and creation of new attractions. As seen from the results, apart from famous places, DDJVs sometimes utilize ordinary spaces and turn them into dynamic and vibrant settings, creating a novel attraction for both locals and tourists. Abandoned warehouses, open fields, and unconventional venues can be repurposed to host ad hoc events, breathing new life into these areas. EDM events can continue the trend of leveraging event tourism as a tool for the revitalizing or promotion of otherwise lagging areas and regions. Research can be carried out regarding effectively positioning EDM events in less-recognized destinations in pursuit of putting these regions on the map and attracting attention from a broader audience.

A tool for sustainable development. Set on mountain peaks and other natural wonders often not accessible to most tourists, DDJVs can convey messaging of protecting nature (Stankov et al., 2023). As opposed to electronic festivals that attract massive crowds (Kruger & Saayman, 2016) these events usually attract relatively small audiences. In some cases, the audience is not present at all, and videos exclusively show DJs and their immediate surroundings. The investigation of whether electronic dance music (EDM) videos featuring audiences yield superior performance compared to those devoid of such audiences holds a compelling avenue for inquiry. This proposition is particularly intriguing given the potential for human crowding (Stankov et al., 2017) to positively contribute to the tourist experience by engendering a vibrant and exhilarating atmosphere at music events (Kim et al., 2016; Radojević et al., 2023).

Research in cultural tourism. As seen from the data in Table 1, EDM events often fuse music and culture. Results from the example of *Cercle* show that frequent locations for hosting EDM events are castles, monuments, historical sites and archeological sites, museums, cultural institutions, exhibition halls and religious buildings. EDM videos often introduce visitors to the intangible culture of local music scenes and artistic works. More research could be directed into analysis and abilities of DDJMs to promote immersive cultural experiences. Indeed, more research could be focused related to exciting cultural values at EDM events and in videos, as EMD nowadays represent a multi-billion dollar culture industry that significantly moved from its subcultural roots (Conner & Dickens, 2023).

Collaboration with the music industry. EDM comprises various sub-genres allowing for different targeted audience engagement. Collaborations between EDM artists and mainstream musicians create cross-genre appeal and expand reach. In particular, destination managers should understand who influential DJs and producers are and what type of influence trends and fan engagement they attract. Collaborating with popular EDM artists can open avenues for cross-promotion, as the artist's fan base may develop an interest in the destination. At the same time, EDM events have disruptive potential, allowing direct-to-fan access for independent artists and bypassing the

conventional music industries' intermediaries (Ehlinger & Markey, 2022) offering possibilities for promotion of smaller or emerging destinations (Drakulić Kovačević et al., 2017; Vujičić et al., 2023).

Collaboration with event industry. Destination management organizations could explore ways of multi-stakeholders approach (Line & Wang, 2017) by closely with event industry and local governments to create supportive policies, streamline licensing processes, and improve infrastructure, making it easier to organize and promote events.

It is important to acknowledge that individuals attending EDM events may face an elevated risk of engaging in substance use and experiencing related negative outcomes (Palamar et al., 2021; Van Dyck et al., 2023). This underscores the necessity for destination management to take these factors into careful consideration (Bingöl, 2022). However, it's also worth considering that the level of risk could potentially decrease in professionally produced EDM videos showcasing destinations, especially when created in collaboration with music and event producers, as well as tourism authorities (Wright, 2019). Finally, future research could investigate if integrating cutting-edge technology and artistic innovation in DDJVs could position the destination as forward-thinking and attract tech-savvy travelers (Filimonau et al., 2022).

Social media analytics

The effectiveness of a media channel for the promotion of DDJVs would largely depend on the alignment between the platform's user base, its target audience characteristics (Gilstrap et al., 2021; Jovanović et al., 2019; Stankov et al., 2010, 2018), and DDJV content. For instance, EDM listening in the work environment may boost productivity (Jenkins, 2016), or at leisure time and social events, providing potential access to multiple listeners. The data shows a typical DDJV is longer than 1.5 hours, providing longer-listening sessions and thus longer exposure to destination footage.

Specifically, conducting additional research on *YouTube* metadata statistics, with a focus on user comments, may reveal how many videos are listened to solely for their music content. Our data indicates that videos are often listened to several years after being posted on *YouTube*. Most importantly, this suggests the potential of DDJVs to perform as long-lasting content with spillover effect to destination promotion. Here, research should account for a platform's video recommendation algorithms or trending algorithms as potential biases. Furthermore, it would be interesting to discover if DDJVs showcasing different destinations can boost each other's popularity through what is known as the "halo effect." This effect occurs when a well-liked video indirectly shares its viewers with similar content due to their proximity in search results and suggested videos, potentially leading to increased views for both videos (Liikkanen & Salovaara, 2015). Further analysis could also compare the performance of these music-focused videos against other *YouTube* channels, official promotional videos from destinations, or influencer videos. Finally, in-depth video content analysis could elucidate which parts of the videos garner the most user interest.

Further research could be directed to finding the most suitable channels to effectively promote destinations with EDM and staying adaptable to trends and user preferences. Additional research can include determining detailed characteristics of target audiences; exploration of social media platforms that are popular for sharing video content and engaging with niche communities (Wang et al., 2002) interested in music and travel. This research can be expanded into the analysis of EDM niche channels, opportunities for cross-platform promotion and the evaluation of advertising options.

A dedicated stream of research could explore what motivates viewers to create and share their own content inspired by DDJVs, and how destinations could leverage this influencer trend. This is in close connection to the need for analysis of networks within EDM communities (Cannon & Greasley, 2021). Leveraging user-generated content goes in line with current market trends since it can significantly amplify DDJV reach and consumer engagement.

Concluding remarks

With this exploratory article, our primary objective was to illuminate the significance of DDJVs as an emerging phenomenon that deserves greater recognition within the realms of both tourism practice and research. Positioned at the nexus of the music and event industries, the analysis of these DDJVs necessitates a multidisciplinary approach and is open to the application of diverse theoretical frameworks, particularly when applied in the context of tourism. Figure 2 provides a visual summary of the research directions that we have outlined in this exploratory article, establishing the foundations for future research into DDJV.

While prior research has examined the impact of music as a motivation for travel or as an integral facet of the tourist experience—be it through cultural heritage, music festivals, or as a design element in shaping memorable encounters—there remains a notable void in the scholarly landscape, specifically in addressing DDJVs' portrayal of destinations. The promotional influence wielded by these videos and their consequential effects on tourist moti-

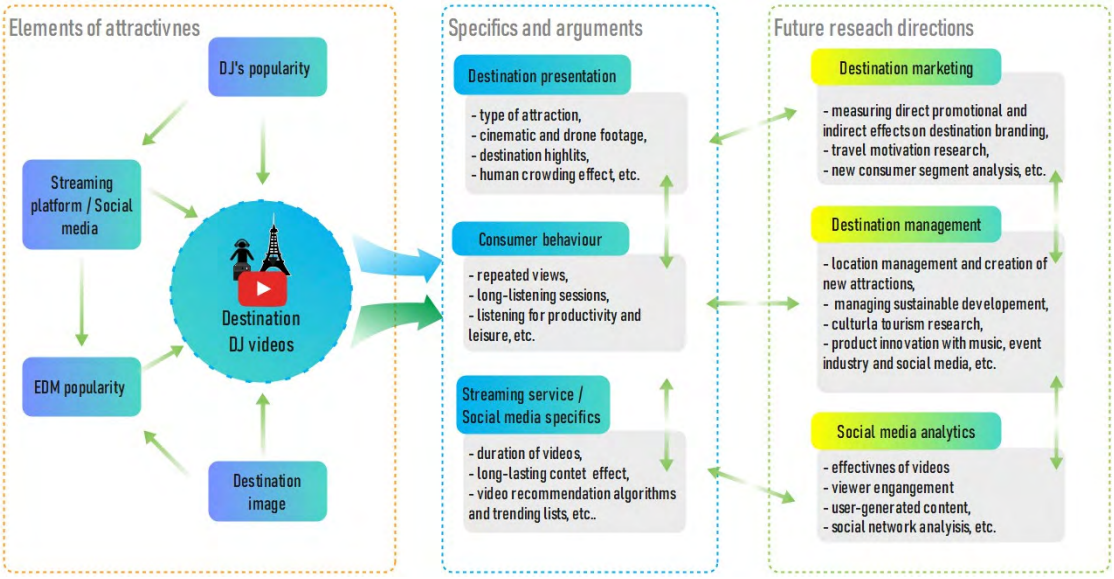

Figure 2. Research rationale for the future exploration of DDJVs
Source: Authors' own contribution

vation, the management of destinations, and marketing strategies have yet to be the focus of a dedicated research program.

The convergence of EDM and destinations possesses the potential to galvanize a novel research trajectory, one that could invigorate the discourse surrounding social media marketing. This uncharted territory not only harbors the prospects for insightful inquiries but also presents an array of challenges that warrant scholarly attention and further inquiry.

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Assessment of Surface Water quality in Highly Urbanized Areas: A Case Study of the Vladayska River in Sofia

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KEYWORDS

- water pollution
- urban river
- PCA
- water quality index
- Bulgaria

ABSTRACT

This study investigates the impact of Sofia's urban areas on the physicochemical parameters of water quality along the Vladayska River. Two sections of the river were analyzed: (1) an upper, relatively unpolluted section from the source to the Vladaya district, used as a reference due to limited data availability, and (2) a lower section (Kubratovo), downstream of Sofia, influenced by anthropogenic activities. Based on the results, significant changes in the physicochemical parameters were observed in the lower section. Principal component analysis (PCA) was conducted on data for 15 water quality indicators, precipitation, and river runoff under different hydrological conditions (high flow, low flow, and winter season) for the lower section (Kubratovo). The PCA results identified nutrient and organic matter pollution and mineral content as key drivers of water quality variability. Additionally, hydrological factors were found to indirectly influence water quality in the downstream section at Kubratovo. As revealed by the CCME WQI index, the Vladayska River's upper section also experienced poor water quality between 2013 and 2015, improving to good in 2016–2018, likely due to reduced pollution from tourism and residential sources. In contrast, the downstream section at Kubratovo consistently exhibited poor water quality from 2010 to 2021, reflecting ongoing urban pollution with no observed trend of improvement.

Introduction

River water quality is one of the current topics of theoretical and applied hydrology, ecological and urban hydrology, and one of the main problems in the planning and management of water resources. The chemical, physical, and biological characteristics of surface water, based on standards for its use, are related to human health, food production, wetland ecosystems, economic development and social growth in our communities (Jha et al. 2020). Questions about the protection of watercourses from the introduction of anthropogenic ingredients in undissolved and dissolved state have been raised for several decades. According to UNESCO's report (International Initiative on Water Quality, 2015), water quality problems pose new threats to water security and sustainable development and represent a major challenge in both economically developed and developing countries. The question of the quality of surface water in urban areas, where a combination of point and diffuse sources of pollution is registered, is particularly acute (Strokal et al., 2021). Rivers in cities perform important ecological and economic functions. They are a reliable source of water for various economic needs, an important element of na-

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ture and specific ecological corridors in the urban landscape (Przyjazny et al., 2006; Viji et al., 2014).

Many studies show that the state of urban rivers is strongly influenced by human activities, especially changes in land use and cover in the process of urbanization (Giri et al., 2016). Under the influence of urbanization, pollution from non-point sources, caused by the runoff of rainwater, has become one of the main reasons for the deterioration of the water environment in cities (Muschalla et al., 2008; Egodawatta et al., 2009; Van Der Hoek et al., 2011; Van der Sterren et al., 2013). Determining the relative influence of these factors on water quality remains a serious challenge for science and water management (Interlandi & Crockett, 2003).

The impact of urban areas on water quality is mainly due to two key factors – significant pollutant production and a reduction in the retention capacity of river basins as a result of an increase in impervious surfaces (Sun & Lockaby, 2012). The conversion of parts of water catchments from natural to urban cover increases the concentrations of sediments and nutrients from tens to hundreds of times in surface waters. The imperviousness threshold, at which changes in water quality and runoff regime occur, varies from 5% to 20% of the catchment area (Medupin, 2020). In addition to sediments and nutrients, urban waters often contain pharmaceuticals, pesticides, heavy metals, pathogenic microbial populations and organic pollutants (USGS, 1999; Paul & Meyer, 2001). The release of nutrients (especially nitrogen and phosphorus), which originate mainly from agriculture and domestic wastewater, can cause eutrophication of surface waters (Newman et al., 2006). Point sources are the main source of river pollution in cities (Medupin et al., 2020). Some point sources, such as domestic sewage, release pollutants at relatively constant rates, while others, such as leaks and accidental spills, are variable or intermittent. Wastewater treatment plants serving permanent populations contribute continuous nutrient discharges to watercourses, further impacting water quality.

Both organic pollution and heavy metal contamination remain unresolved issues facing the water resources management sector in Bulgaria. This concerns rivers in urbanized areas, which face significant environmental challenges, mainly related to urbanization, pollution and insufficient wastewater treatment infrastructure. Another form of pressure is hydromorphological, related to changes in the physical characteristics of river channels. A specific problem is also the rectification of river channels, which leads to the loss of their ecological functions and biodiversity. Instead of using environmentally friendly solutions, rivers are often treated as engineering structures, which limits their potential to support the ecology and living conditions of the city. In addition, frequent dumping of waste into river channels and lack of effective monitoring further deteriorate their condition.

To better understand these challenges, the objective of this study is to analyze the quality of river water in a highly urbanized area by examining the current physicochemical status of a small river course, the Vladayska River in Sofia. This is achieved by applying the water quality index and statistical analysis in R, considering both urbanized and non-urbanized areas of Sofia to identify the main pollutants and factors affecting the river water.

Materials and methods

Study area

The Vladayska River, with a drainage area of 151 km² and a length of 37 km, originates below Cherni Vrah and Selimitsa, draining the western Vitosha Mountain. Its basin comprises three sections: the upper part in the Vitosha and Lyulin Mountains, the middle part in the foothills, and the lower part in the Sofia Valley (Fig.1). Flowing through Sofia, Bulgaria's capital with over 1.2 million residents, the river passes neighborhoods like Knyazhevo, Ovcha Kupel, and Orlandovtsi before merging with the Perlovska River. Within Sofia, the riverbed and drainage network are heavily modified by human activity.

The river lies in a temperate-continental climate zone, with winter temperatures around 0°C and summer averages near 20°C. Peak precipitation occurs in May and June, with the lowest in February, increasing with altitude (Velev, 2010). Snowmelt, primarily in April, contributes significantly to peak flows, while torrential summer rainfall often causes rapid water level rises and localized flooding, which has intensified in recent years (Bocheva & Malcheva, 2020). The multi-annual average flow was 0.727 m³/s from 1961–2002, decreasing to 0.48 m³/s during 2010–2021. In the seasonal distribution of runoff, there is a pronounced spring high water period, during which up to 70% of the annual flow occurs, followed by a summer-autumn and less pronounced winter low water period.

Water quality and hydrological data

In this study, data from the Environmental Executive Agency's control monitoring were used. Monitoring was conducted at two points: before the city of Sofia (Vladayska River – Vladaya) and at its exit (Vladayska River – Kubratovo) (Table 1). The available data cover different periods: for the Vladaya station, monitoring was conducted from 2013 to 2018 before being discontinued, while the Kubratovo station has a longer dataset covering eleven years from 2010 to 2021. River Vladayska has been studied and evaluated for 15 physicochemical parameters:

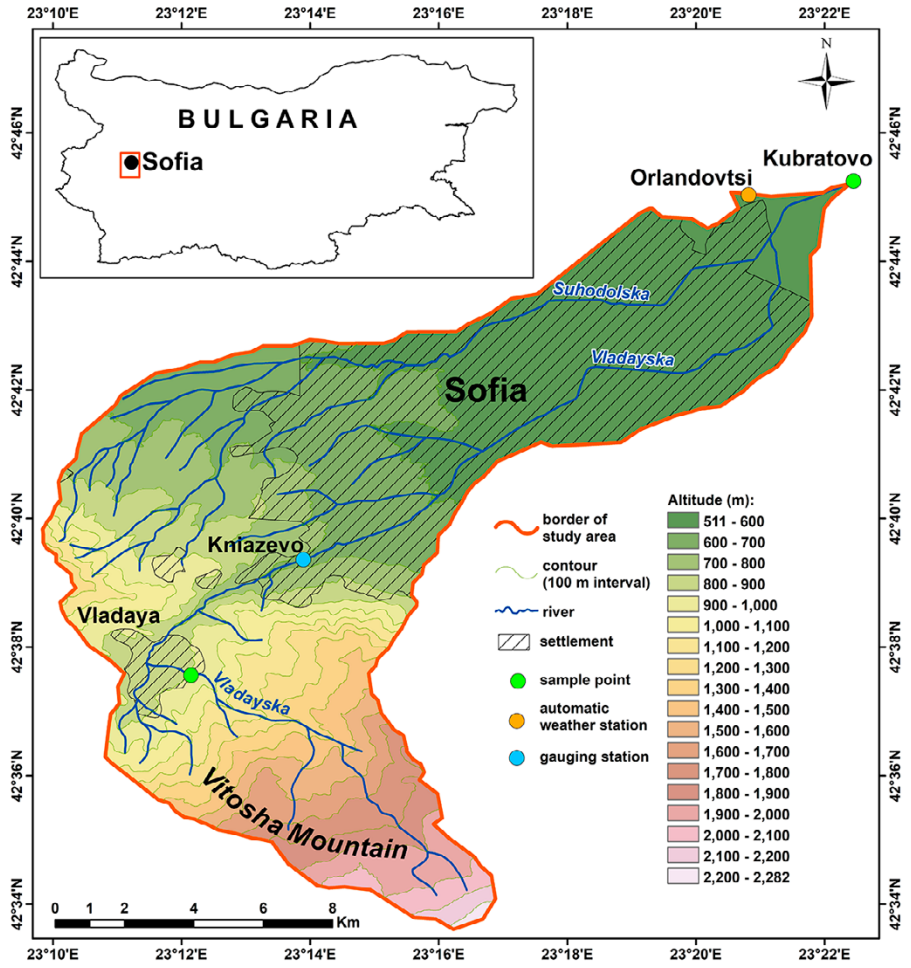

Figure 1. Study area with the location of the measuring stations.

1. General physicochemical parameters – temperature, dissolved oxygen, electrical conductivity, total hardness, total dissolve solids, chlorides and sulfates.
2. Indicators of organic pollution – ammonium nitrogen (N - NH_4^+), nitrite nitrogen (N–NO_3), nitrate nitrogen (N–NO_2), total nitrogen, total phosphorus, orthophosphates (P–PO_4), biochemical oxygen demand (BOD_5), and chemical oxygen demand (COD).

The data on river flow includes average monthly values for the period 2010-2021 at Knyazhevo hydrological station. The data was provided by NIMH (National Institute of Meteorology and Hydrology). Precipitation data are presented by monthly precipitation sum for the same period from the Orlandovtsi station. The station is located at 525 m above sea level, on the right bank of the Vladayska river, on a coastal slope above an extensive river floodplain. The station is automatic, model WS2816, and started operation in March 2015 (Table 1).

Data analysis and water quality analysis

In this study, correlations between water quality indicators were examined, and Principal Component Analysis (PCA) was applied to the Kubratovo monitoring station, located downstream of Sofia, to identify key factors influencing water quality. PCA was employed to reduce dimensionality and extract the most significant variance from

Table 1. Information about the Location of Water Sampling Points, Gauging, and Meteorological Stations

Location and description	Elevation (m)	Latitude (°)	Longitude (°)
Vladayska – Vladaya (upstream) - water sampling station	891.5	42.62609	23.20245
Vladayska – Kubratovo (downstream) - water sampling station	671	42.75417	23.37417
Kniazevo – gauging station	525.3	42.6563	23.2316
Orlandovtsi - meteo station	525.3	42.75056	23.34668

multiple water quality parameters. This site was selected for analysis due to its extended monitoring period (2010–2021) and the availability of a more comprehensive dataset, providing a robust foundation for statistical evaluation and interpretation.

PCA is a widely used method for identifying significant contributors to river water quality and potential pollution sources (Nasir et al., 2011; Olsen et al., 2012; Glińska-Lewczuk et al., 2016; Zeinalzadeha & Rezaeib, 2017; Tripathi & Singal, 2019). It is particularly effective for analyzing relationships among water quality indicators and assessing the importance of various factors under different hydrological conditions, including high-flow, low-flow, and winter periods. The PCA was conducted in the R environment using the prcomp function, with standardized data to ensure comparability. A scree plot (fviz_eig()) was used to visualize the contribution of principal components, while factor rotation was applied to improve interpretability. Additionally, a biplot (fviz_pca_var) illustrated the relationships between variables and their influence on the principal components. This approach facilitated the identification of the most significant factors contributing to water quality variability.

Furthermore, the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) was applied for an integrated assessment of the Vladayska River's water quality. The calculations were performed using nine physicochemical parameters, in accordance with regulatory requirements for achieving "good quality status", as well as the reference values for surface water bodies of type R2 (Vladayska River before Vladaya) and R5 (Vladayska River at Kubratovo), as specified in Ordinance No. H-4/14.09.2012 on the characterization of surface waters (Table 2).

Table 2. Reference threshold values defining the good state for water parameters in surface water bodies of types R2 and R5, as specified in Regulation 4/2012.

Code	Water quality status	Variables								
		EC	DO_2	$N\text{-}NH_4$	$N\text{-}NO_3$	$N\text{-}NO_2$	N	P	$P\text{-}PO_4$	BOD_5
		µS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
R2	Good	750	8-6	0.04 –0.4	0.2 –0.5	0.01 –0.025	0.2 -0.8	0.012- 0.03	0.01–0.02	1 – 2.5
R5	Good	750	8–6	0..04 –0.4	0.5 –1.5	0.01 –0.03	0.5 -1.5	0.025-0.075	0.02–0.04	1.2 – 3

The CCME WQI index consists of three significant factors: scope (F1), frequency (F2), and amplitude (F3). The final result of the CCME is a dimensionless number that describes the state of water quality from 0 (poor quality) to 100 (high quality) (CCME, 2003; Sutadian et al., 2016) (Table 3).

Table 3. Ranking system and interpretation of water quality based on CCME WQI (CCME, 2001)

Rating	WQI values	Interpretation
Excellent	95–100	Water quality is protected with a virtual absence of threat or impairment; conditions very closer to natural or pristine levels
Good	80–94	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels
Fair	65–79	Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels
Marginal	45–64	Water quality is frequently threatened or impaired; conditions usually depart from natural or desirable levels
Poor	0–44	Water quality is almost always threatened or impaired; conditions very often depart from natural or desirable levels

Results

Physicochemical Characteristics

The main statistical data on the water quality of the Vladayska River at two monitoring stations are summarized in Table 4, presenting the ranges, mean values, and standard deviations for the 15 physicochemical parameters analyzed. Temperature ranged from 2.5 to 23.8 °C, with conductivity values of 48–540 µS/cm before Vladaya and 213–933 µS/cm at Kubratovo. Water hardness ranged from 0.5 to 6.6 mg/L, and suspended solids averaged 8.38 mg/L before Vladaya, compared to 4–596 mg/L at Kubratovo. Dissolved oxygen (DO) varied between 4.2–9.82 mg/L before Vladaya and 1.6–10.8 mg/L at Kubratovo, while chloride concentrations ranged from 1.2–94 mg/L before Vladaya and 20.2–180 mg/L at Kubratovo. Sulfate concentrations

Table 4. Descriptive Statistics of Water Quality Indicators for the Vladayska River – Vladaya (A) and Kubratovo (B).

Parameters	Min		Max		Mean		Media		SD	
	A	B	A	B	A	B	A	B	A	B
Temperature	2.5	1.8	22.1	23.8	9.03	13.1	7.6	12.5	-	-
EC, (µS/cm)	48	213	540	933	193.8	471	133	480	90.7	113.9
Hardness, (mg/L)	0.5	1.3	3.1	6.08	1.67	2.95	1.77	3.0	0.67	0.86
TDS, (mg/L)	1	4.0	33.6	596	8.38	44.04	4	14.4	9.49	97.05
DO, (mg/L)	4.2	1.6	9.8	10.55	7.27	5.48	7.35	5.2	1.43	2.01
Cl, (mg/L)	1.2	20.2	94	180	30.4	43.7	15	35.8	16.6	28.5
SO_4, (mg/L)	4.23	20.5	31.8	52.7	17.6	33,56	15.5	33.1	6.36	8.661
$N - NH_4^+$ (mg/L)	0.05	0.7	4.03	18.3	0.97	6.17	0.59	5.19	1.07	4.19
NO_3, (mg/L)	0.01	0.01	0.96	1.68	0.34	0.66	0.25	0.62	0.14	0.44
NO_2, (mg/L)	<0.01	<0.01	0.12	0.23	0.03	0.09	0.025	0.08	0.03	0.05
Total N, mg/L	0.23	1.88	6.55	23.7	2.15	8.78	2.3	7.7	0.78	5.24
Total P, (mg/L)	0.004	0.19	1.37	4.99	0.30	1.21	0.21	0.85	0.42	0.99
P- PO_4, (mg/L)	0.003	0.11	0.98	1.67	0.17	0.65	0.12	0.58	0.32	0.39
BOD_5, (mg/L)	0.6	3.9	14.5	69	4.64	17.4	4.7	10.1	1.31	17.9
COD, (mg/L	8	17.2	79	200	22.5	57.2	21	39	7.5	44.1

were 4.23–33.6 mg/L before Vladaya and 20.5–52.7 mg/L at Kubratovo. Nutrient content showed significant differences, with higher organic loads downstream at Kubratovo. Ammonium nitrogen ($N - NH_4^+$), ranged from 0.05–4.3 mg/L before Vladaja and 0.7–18.3 mg/L at Kubratovo, facilitating nitrifying bacteria growth due to wastewater pollution. Nitrate nitrogen ($N–NO_3$) ranged from 0.01–0.12 mg/L before Vladaya and 0.01–0.68 mg/L at Kubratovo. Nitrite nitrogen ($N–NO_2$) was 0.01–0.12 mg/L before Vladaya and 0.01–0.23 mg/L at Kubratovo. Total nitrogen (N) concentrations before Vladaya ranged from 0.33 to 6.55 mg/L, with a clear improvement noted after 2017. However, total nitrogen values indicated significant pollution of river waters in the downstream section (1.88–23.7 mg/L at Kubratovo). The content of total phosphorus (P) and phosphates ($P–PO_4$) in the upper part of Vladayska River also varied, showing large fluctuations during the study period, with a significant reduction in concentrations after 2016 (PO_4 – 0.003 to 0.98 mg/L, and total phosphorus (P) – between 0.010 and 1.37 mg/L). Phosphate values exceeded the "good" status threshold in almost all samples during the study period at Kubratovo, ranging from 0.11 to 1.67 mg/L for PO_4, and from 0.19 to 4.99 mg/L for total phosphorus (P). The chemical oxygen demand (COD) before Vladaya ranged from 8 to 792 mg/L, while the biochemical oxygen demand over five days (BOD_5) varied from 0.6 to 14.5 mg/L, with improvements in water quality observed after 2016. COD values at Kubratovo varied between 17.2 and 200 mg/L, while BOD values ranged from 3.9 to 69 mg/l, indicating severe organic pollution of the river waters. Overall, Kubratovo showed significantly higher levels of ammonium nitrogen, nitrites, total phosphorus, orthophosphates, total nitrogen, BOD_5, and COD, reflecting strong anthropogenic influences such as untreated stormwater, industrial and domestic wastewater discharges.

Correlation matrix - physicochemical indicators

For the purposes of the present analysis, the correlation coefficients between the water quality indicators were calculated for the lower section (Kubratovo), presented in a correlation matrix (Fig. 2). Dissolved oxygen (DO) shows a negative correlation with temperature (r = -0.6), indicating lower oxygen levels as water temperature rises. DO also has a negative correlation with COD (r = -0.3) and nutrients like total nitrogen, total phosphorus, and NO_2, similar to trends observed in the urbanized part of the Pearl River estuary (Li et al., 2020). Temperature and electrical conductivity (EC) show a negative correlation (r = -0.4), likely due to groundwater inflow during summer low flow. Chlorides, sulfates, and electrical conductivity have a high positive correlation, with values of r = 0.9 and r = 0.6, respectively, indicating that as the concentration of these ions increases, so does electrical conductivity. Total phosphorus, total nitrogen, and orthophosphates exhibit very high correlations (r = 0.7-0.8), suggesting these ions often increase simultaneously due to common pollution sources. Ammonium ions ($N - NH_4^+$), strongly correlate with total nitrogen (r = 0.9), total phosphorus (r = 0.8), orthophosphates (r = 0.9), and both chemical and biological oxygen demand (r = 0.6). Orthophosphates (PO_4) positively corre-

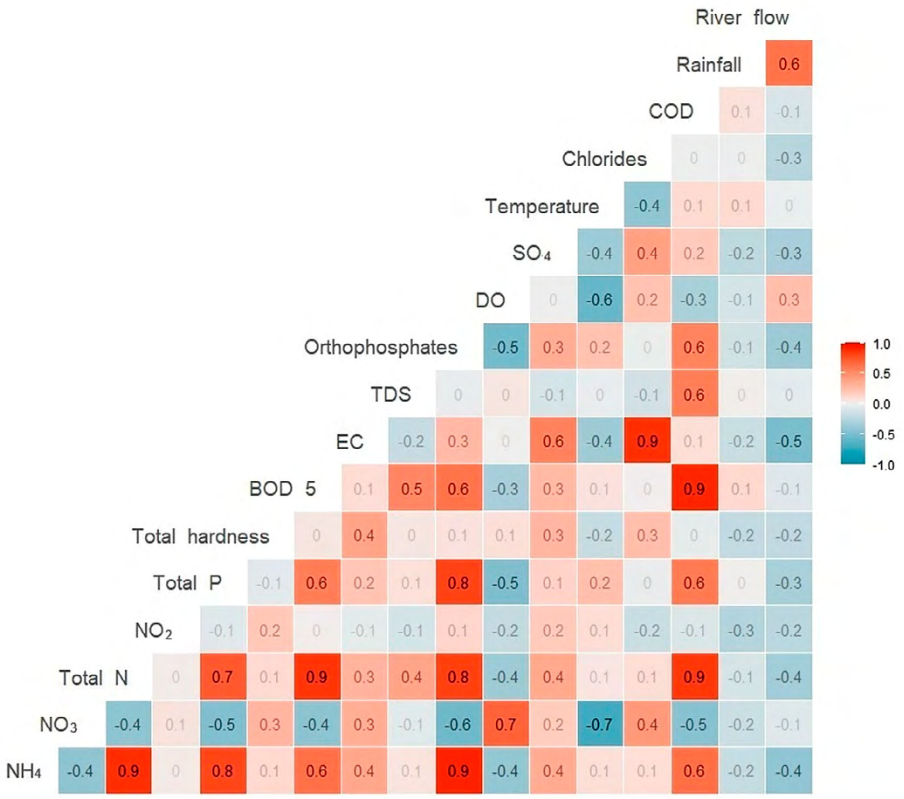

Figure 2. Correlation matrix of water quality indicators

late with total nitrogen and total phosphorus (r = 0.8) and with BOD_5 and COD (r = 0.6), while negatively correlating with NO_3 (r = -0.6) and dissolved oxygen (r = -0.5). Nitrates (NO_3) show a strong positive correlation with dissolved oxygen (r = 0.7) and a negative correlation with water temperature (r = -0.7), consistent with Kermorvant et al. (2023). BOD5 and COD have a strong positive correlation (r = 0.9), as noted by Lee et al. (2016), emphasizing their role in identifying organic and inorganic pollution. Dissolved oxygen correlates positively with NO_3 (r = 0.7), with NO_3 identified as a significant predictor for dissolved oxygen concentrations (Wen et al., 2013). Precipitation shows weak correlations with all indicators, while river flow negatively correlates with EC, total nitrogen, and orthophosphates due to dilution during high flows.

Principal Component Analysis (PCA)

In this study, three periods of annual variations in the Vladayska River at the Kubratovo station have been defined based on the hydrograph of the average monthly river runoff for the period from 2010 to 2021.The first period encompasses the river's high water, recorded during March, April, May, and June. The second period includes the low water phase during the summer and autumn months of July, August, September, October, and November. The annual distribution of river runoff also allows for the definition of a

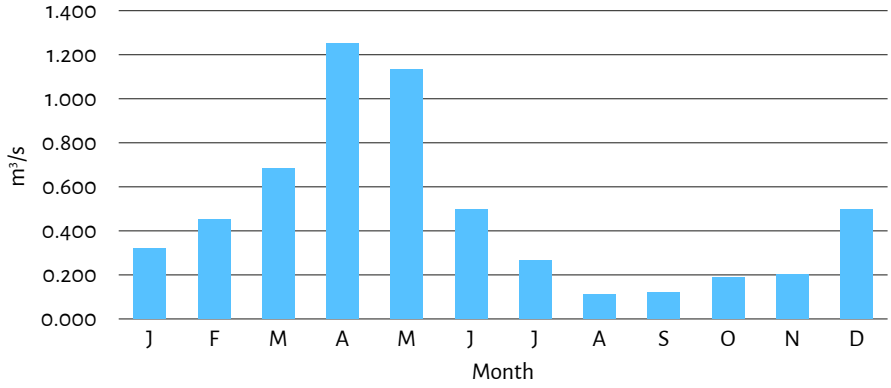

Figure 3. Hydrograph of average monthly water quantities for the period 2010–2021

third transitional period during winter, when a partial increase in water quantity is observed (Fig. 3). This period includes the months from December to February. Based on these defined periods in the river's annual regime, subsequent principal component analysis was performed to reveal differences in indicator loadings during each period.

The principal component analysis technique was used in this study to assess the seasonal variation of water quality parameters. Principal Component Analysis (PCA) was performed on standardized data for 15 water quality indicators, precipitation, and river runoff for the high-flow period, low-flow period, and winter seasons. In PCA, it is important to determine the number of principal components that enter the subsequent analysis. This is done by calculating the eigenvalues of the principal components (PC). A scree plot of the eigenvalues obtained in this study

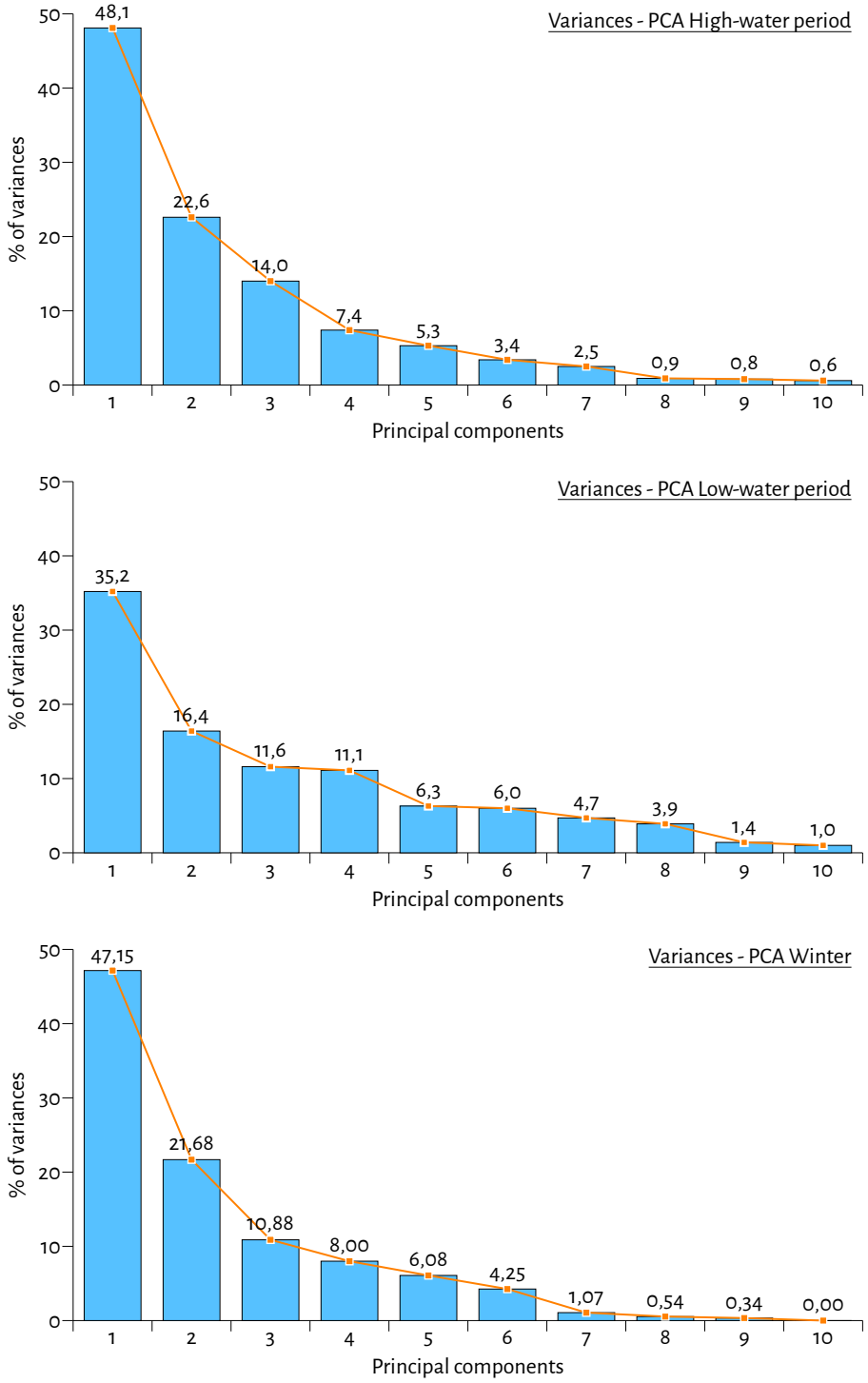

Figure 4. Scree plot of the eigenvalues of principal components in high-water, low-water period and winter

shows a distinct slope change after the third eigenvalue in the PCA for all three periods studied. (Fig. 4). As a rule, the post-slope component is also taken (Vega et al., 1998). Four components will be included in the subsequent analysis. For the high-water period, the first four components explain 92,1 % of the total variation of the information contained in the source data set (Fig. 4). In the low-water period, the first four components explain respectively 74.3% of the total variation. In the winter season, the first four components explain 87,7% of the total variation.

The first component (PC1) in the PCA for the high-flow period accounts for 48.1% of the total variance, with the highest loadings for (N - NH_4^+), total nitrogen, NO_2, BOD_5, total phosphorus, orthophosphates, and COD, all positively correlated. The second component explains 22.6% of the variance and includes indicators such as NO_3, EC, SO_4, and chlorides, all negatively correlated (Fig. 5). The third component explains 14% of the variance, characterized by positive loadings for TDS, DO, and precipitation, with a negative loading for temperature. The fourth component explains 7.4% of the variance and is associated with total hardness and river flow. The results indicate that during the high-water period, water quality variability is largely influenced by nutrient loading (e.g., ammonia, nitrogen, phosphorus), mineral content (e.g., nitrates, conductivity, sulfates, chlorides), and hydrological factors. Precipitation and river flow positively impact dissolved oxygen levels, while temperature has an opposing influence. TDS and total hardness were not significant factors during this period.

For the low-flow period, PC1 accounts for 35.2% of the variance and includes nutrient and organic pollution indicators, such as (N - NH_4^+), total nitrogen, total phosphorus, and orthophosphates, all positively correlated (Fig. 5). PC2 explains 16.4% of the variance, characterized by positive loadings for BOD_5, TDS, DO, and COD, and a negative loading for EC. PC3 accounts for 11.6% of the variance, with significant factors including NO_3, total hardness, SO_4, and temperature, all negatively correlated. PC4 explains 11.1% of the variance, with the greatest loadings for NO2, chlorides, rainfall, and river flow (Tab. 5). During the low-flow period, water quality variability is primarily influenced by nutrient and organic matter pollution, similar to the high-flow period. The first component highlights nutrient pollution as the main factor affecting water quality, while the second emphasizes the role of oxygen demand, dissolved oxygen, and ion content. Hydrological factors and mineral content have less influence, and water temperature shows a negative relationship with other indicators.

For the winter period, PC1 represents 47.1% of the total variation, including (N - NH_4^+), total nitrogen, total phosphorus, orthophosphates, NO_2, BOD_5, COD, and TDS. PC2 explains 21.7% of the variance (Fig. 5), with the highest loadings for NO_3, total hardness, EC, SO_4, chlorides, and

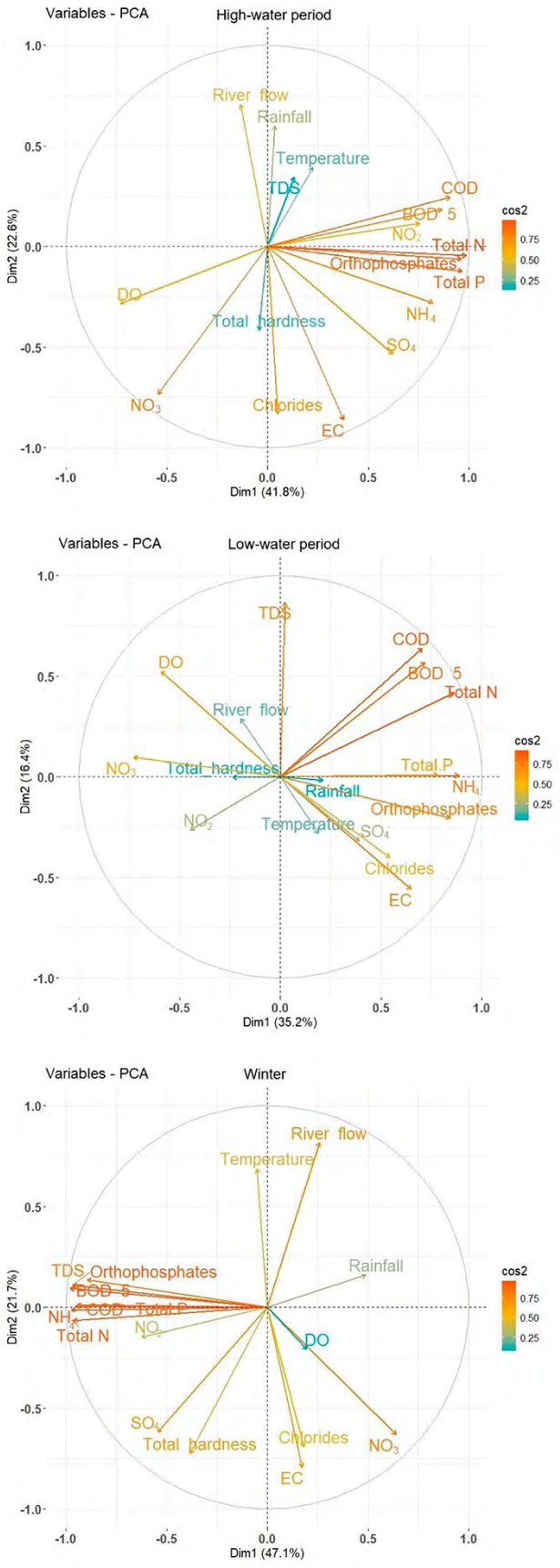

Figure 5. Results of principal component analysis performed with water quality data for a period of high water, low water, and winter seasons, Kubratoto station, Vladayska river

river flow. Unlike other periods, river flow is a significant indicator in the first two components. All significant indicators in PC1 and PC2 have negative loadings. PC3 accounts for 11% of the total variance, with DO and precipitation as key indicators. DO is not a significant factor for water quality during this season. PC4 explains 8% of the variance, with water temperature as the primary indicator (Tab. 5). While precipitation and temperature do not fall into the first two components, they have significant positive loadings. The indicators with the greatest loadings across the first and second components in all seasons include inorganic nutrients such as ($N - NH_4^+$), $N–NO^3$, $N–NO_2$, total phosphorus, total nitrogen, and orthophosphates. These are significant indicators throughout the year, with NH_4 serving as an indicator of domestic wastewater and industrial discharge (Furukawa et al., 2020). $N–NO_2$ reflects pollutants from household and land-use activities (Glińska-Lewczuk et al., 2016). BOD_5 and COD consistently have high loadings in all seasons, especially during high-flow and winter periods, due to organic and chemical pollutants that deplete dissolved oxygen and deteriorate water quality (Anh et al., 2023). Significant differences across the individual periods are observed in the influence of hydrological indicators and water temperature. The results indicate that river runoff has the highest loading during the low-water period, followed by the winter and high-water periods (Table 5). Precipitation, while not among the top two principal components in any of the analyses, shows the highest loading during the low-water period, followed by the high-water period. The prominence of these two indicators during the low-water period indicate their critical role in influencing water quality during dry conditions. Short-term intense rainfall and episodic increases in river discharge facilitate the entry of pollutants into the river, particularly in urban areas (Chow et al., 2019; Yang et al., 2021). During winter, precipitation and indicators related to nutrient and organic pollutants exhibit negative loading, likely due to lower precipitation levels and reduced temperatures. These conditions slow down biochemical self-purification processes, resulting in higher pollutant concentrations.

Water Quality Assessment Using Water Quality Index

The CCME WQI analysis for the Vladayska River was conducted as a summary assessment for each monitoring station providing an overall evaluation of water quality trends over time. The CCME WQI categorizes waters of Vladayska River in the upper section into two quality classes. Both applied indices confirm pollution of the Vladayska River upstream of Vladaya in the years 2013, 2014, and 2015, classifying the river water as being in poor condition. Notable improvement in water quality is observed in 2016, 2017, and 2018, reaching good condition. The main source of pollution in the studied section is pollution from human tourism activities or sewage from homes and septic tanks. Monitoring at this point was discontinued after 2018 (Fig. 6). The CCME WQI for the period 2010-2021 shows that the downstream section of the Vladayska Riv-

Table 5. The factor loadings after the varimax rotation of the water quality data

Parameters	High-water period				Low-water period				Winter			
	PC1	PC2	PC3	PC4	PC1	PC2	PC3	PC4	PC1	PC2	PC3	PC4
$N-NH_4^+$	**0.31**	-0.14	-0.06	-0.13	**0.36**	0.00	0.09	-0.11	**-0.34**	-0.01	0.00	0.16
NO_3	-0.20	**-0.37**	0.13	-0.03	-0.30	0.06	**0.37**	-0.02	0.23	**-0.33**	0.21	0.18
Total N	**0.37**	-0.02	0.08	0.02	**0.35**	0.25	0.11	-0.11	**-0.34**	-0.04	-0.03	0.13
NO_2	**0.28**	0.06	-0.19	-0.22	-0.18	-0.16	0.29	**-0.32**	**-0.22**	-0.08	0.30	0.18
Total P	**0.36**	-0.06	0.05	-0.02	**0.32**	0.01	-0.20	-0.02	**-0.33**	0.01	0.12	0.21
Total hardness	-0.02	-0.21	-0.11	**0.68**	-0.10	0.00	**0.39**	0.22	-0.14	**-0.38**	-0.19	-0.24
BOD_5	**0.33**	0.09	0.19	0.09	0.29	**0.34**	0.13	0.04	**-0.35**	0.05	-0.10	0.00
EC	0.14	**-0.44**	0.12	0.03	0.27	**-0.33**	0.26	0.10	0.06	**-0.41**	-0.30	0.28
TDS	0.05	0.18	**0.46**	-0.42	0.01	**0.52**	0.06	-0.04	**-0.32**	0.07	-0.21	-0.13
Orthophosphates	**0.36**	-0.03	0.03	0.10	**0.34**	-0.12	-0.03	-0.17	**-0.34**	0.06	0.03	0.05
DO	-0.27	-0.14	**0.31**	-0.18	-0.24	**0.31**	0.10	0.02	0.07	-0.11	**0.44**	0.44
SO_4	0.23	**-0.27**	0.03	0.12	0.16	-0.19	**0.47**	-0.15	-0.19	**-0.32**	-0.05	-0.27
Water temp	0.08	0.20	**-0.48**	-0.19	0.08	-0.17	**-0.43**	0.11	-0.02	0.36	-0.04	**0.45**
Chlorides	0.02	**-0.43**	0.26	-0.12	0.22	-0.24	0.22	**0.35**	0.06	**-0.36**	-0.35	0.36
COD	**0.34**	0.12	0.20	0.05	0.29	**0.38**	0.09	-0.03	**-0.34**	0.00	-0.13	0.15
Rainfall	0.01	0.30	**0.34**	0.20	0.09	-0.01	0.03	**0.61**	0.17	0.08	**-0.48**	0.28
River flow	-0.05	0.36	**0.37**	0.32	-0.08	0.17	0.04	**0.50**	0.09	**0.42**	-0.31	0.04

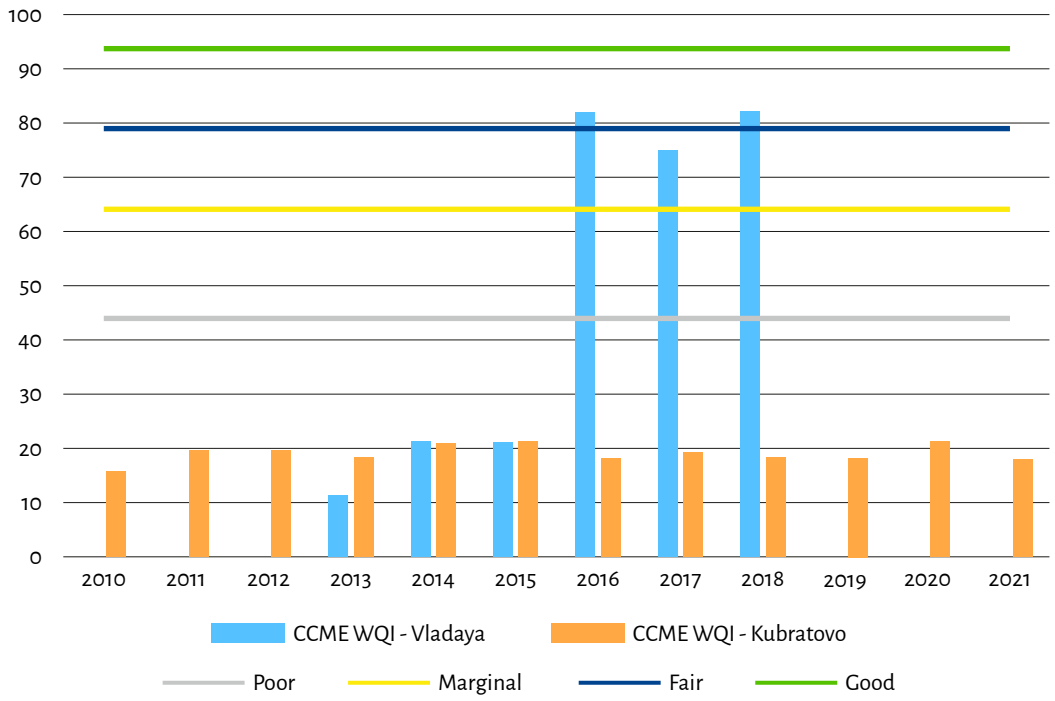

Figure 6. CCME WQI values for the Vladayska River before Vladaya and at Kubratovo monitoring points

er, influenced by the urban activities of Sofia, has consistently poor water quality, with no trend of improvement during the study period.

CCME WQI values remained below 44 for most of the study period, indicating that water quality in this urban-influenced section is almost always threatened or impaired, with conditions frequently deviating from natural or desirable levels (Fig. 6). The CCME WQI values for the Vladayska River – Kubratovo indicate consistently poor water quality, with only minor seasonal fluctuations across different hydrological conditions. The index remains critically low during high water, low water, and winter periods, suggesting that increased flow does not significantly improve water quality.

Discussion

Urbanization of the catchment is associated with significant water quality deterioration, particularly in smaller watercourses like the Vladayska River. The ecological status of these waters is influenced by both natural and anthropogenic factors, with chemical changes being more pronounced during low flow conditions. Smaller rivers, with reduced flow, are especially vulnerable to significant changes in chemical parameters, which amplifies the impact of pollutants (Hellwig et al., 2017) The PCA results indicate that nutrients and organic pollution are the primary contributors to water quality variability under different flow conditions. During high-flow periods, increased nutrient loading (e.g., ammonia, nitrogen, phosphorus) and organic pollution (BOD_5, COD) degrade water quality, likely due to higher runoff from urban areas. Mineral content (nitrates, conductivity, sulfates, chlorides) also plays a role, though its impact is mitigated by dilution. Hydrological factors, such as rainfall and river flow, influence dissolved oxygen, while temperature has an inverse effect. In low-flow periods, the effects of nutrient and organic pollution are exacerbated due to limited dilution capacity. The interaction between streamflow, dissolved oxygen, and mineral content is crucial for determining water quality during these conditions. In winter, nutrients and organic pollution continue to be key factors, with seasonal changes in river flow and temperature affecting dissolved oxygen and mineral content, resulting in distinct water quality dynamics. These findings highlight the critical link between urban development and water quality degradation, emphasizing the need to improve urban runoff management and wastewater treatment infrastructure. The results also indicate an improving trend in water quality at the monitoring point upstream of Sofia, while downstream water quality remains poor, showing no signs of improvement. CCME WQI for the Vladayska River at the Kubratovo monitoring point from 2010 to 2021 consistently indicates poor water quality, with no observed improvement trend. This suggests a gradual degradation of the aquatic environment in the Vladayska River. These observations are consistent with the study by Vyrbanov et al. (2021), which reported nutrient

concentrations exceeding regulatory limits by more than 25 times, and BOD5 and dissolved oxygen levels exceeding norms by 10 to 25 times. The primary causes of water pollution in the Vladayska River are as follows:

- Untreated wastewater from neighborhoods with incomplete or non-existent sewage systems. These waters contain high levels of contaminants such as coliform bacteria, nitrates, phosphorus, various household chemicals, pharmaceuticals, and other harmful microorganisms.
- Discharge of treated industrial wastewater.
- Leaky or damaged sewage systems.
- Rainwater runoff carries oils, rubber, heavy metals, and other pollutants from vehicles off the streets.
- Illegal dumping of waste into riverbeds and the use of unauthorized landfills.

The Vladayska River faces significant challenges related to wastewater management, particularly due to the inadequate or completely absent sewage systems in certain areas on the outskirts of the city. In the southern parts of Sofia, where urban expansion has been rapid, wastewater from households is often discharged directly into the river without proper treatment. As a result, a significant portion of untreated wastewater flows directly into the Vladayska River, contributing to its pollution and further degrading the water quality in this important urban waterway.

Conclusion

Based on the conducted water quality analysis of the Vladayska River using R and the Water Quality Index (WQI), several key conclusions can be drawn:

The PCA results showed that nutrient and organic pollution (eg ammonia, nitrogen, phosphorus, BOD, COD), mineral content (nitrate, conductivity, sulfate, chloride, TDS) and physical factors (dissolved oxygen) were the main indicators affecting the water quality variability of the Vladayska River under different discharge conditions. Factors such as river flow, precipitation, and water temperature affect water quality to a lesser extent and have opposite effects according to season.

The results show that among the 15 observed chemical parameters, the majority of them do not meet the requirements of Bulgarian Water Quality Standards for Surface Water Environmental Quality at the monitoring point downstream of Sofia, indicating the negative impact of urban activities on water quality.

The results from the CCWQI indicate an improvement in water quality at the monitoring point upstream before Sofia, where the river achieved good water status. In contrast, the monitoring point at Vladayska River – Kubratovo, located at the city's exit, consistently recorded poor water quality, demonstrating a lasting impact of urban pollution.

This study highlights that urbanization has a profound effect on the river's water quality. While relatively good water quality was observed in the peripheral areas of the urban environment, significantly degraded water quality was detected at the river's exit from the city. These findings underscore the urgent need for improved water management and pollution mitigation measures within the urbanized sections of the river. Detailed observation, consistent monitoring and comprehensive assessment are essential to improve our understanding of the impact of different urban areas and the dynamics of their pollutant inputs. Strict control of industrial and domestic wastewater discharge sources is urgently needed to improve the river's ecological status.

Acknowledgments

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Knowledge, Attitudes, and Practices Related to Heat Stress in the Climate of Koper and Ljubljana (Slovenia)

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KEYWORDS

- KAP
- climate adaptation
- heat stress
- climate change
- socio-economic impacts
- human perception of weather and climate
- Slovenia

ABSTRACT

This study examines the knowledge, attitudes, and practices related to heat stress among residents of two distinct urban neighbourhoods in Slovenia with different climate types: Olmo, Koper, and Zupančičeva jama, Ljubljana. The study explored the interplay of socio-economic indicators, demographic characteristics, and health status with heat stress KAP. While both locations demonstrated comparable levels of knowledge regarding heat stress, residents of Olmo exhibited significantly more positive attitudes towards adopting preventive measures and reported engaging in such behaviours more frequently. The findings suggest that targeted interventions must consider not only knowledge dissemination but also the unique characteristics of each community, including their specific climate, socio-economic profile, and cultural norms, to effectively enhance community resilience to the adverse impacts of heat stress.

Introduction

Climate change is a complex issue with socio-economic impacts that extend beyond environmental concerns. Adapting to increased heat waves and heat stress is crucial for public health. Heat waves should be recognized as a critical component of heat stress, as they exert detrimental effects on ecosystems, human activities, infrastructure, and well-being.

The cities of Koper and Ljubljana, where our sample neighbourhoods are located, exhibit distinct climatic conditions. Koper has a moderate Mediterranean climate (Cfa), characterised by hot, dry summers and mild, wet winters. In contrast, Ljubljana has a moderate continental climate of central Slovenia (Cfb) with warm summers—the warmest month is July, with a mean temperature of 21.8 °C —and cold winters, with January (1.0 °C) as the coldest month (Ogrin et al., 2023).

Besides climatic, our sample neighbourhoods also have notable topological and socio-economic differences. Zupančičeva jama (ZJ) is a densely populated urban area in Ljubljana, predominantly comprising residential buildings with commercial spaces on the ground floor. In contrast, Olmo has developed in a more dispersed and less systematically planned manner, lacking a defined urban centre. These differences could contribute to varying heat stress experiences and responses among the residents of the two cities.

Heat stress is not exclusively a consequence of extreme heat waves but can also emerge from moderately elevated temperatures that trigger physiological responses. This phenomenon is increasingly recognised as a socio-ecological challenge that benefits from applying the Knowledge, Attitude, and Practice (KAP) framework. Empirical studies among healthcare workers in Jian, China (Li et al., 2016;

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Figure 1. Orthophotography of the sample neighbourhoods Zupančičeva Jama, Ljubljana (left) and Olmo, Koper (right)

Xu et al., 2018), and Victoria, Australia (Ibrahim et al., 2011) indicate that while a basic level of heat-related knowledge is present, translating awareness into sustained behavioral practices remains a significant hurdle. In parallel, investigations into public awareness and risk perception (Franck et al., 2013; Bittner & Stößel, 2012; Nitschke et al., 2013; Zhou et al., 2014; Khare et al., 2015; Kunz-Plapp et al., 2016; Lam et al., 2018; Grothmann et al., 2017; Krüger et al., 2017; Nitschke et al., 2017; Cornes & Cook, 2018; Herrmann & Sauerborn, 2018) have documented considerable variability in risk perception and adaptive behaviors across different socio-demographic groups. Our research extends this literature by examining how socio-economic status, cultural context, age, and gender modulate these responses. In this study, we analyse the interplays between selected socio-economic and health variables and KAP related to heat stress in selected neighbourhoods with different climate in Olmo, Koper, and Zupančičeva jama (ZJ), Ljubljana. Residents of the sample are presumed to have similar formal knowledge but may exhibit divergent attitudes and behaviours related to heat stress, exposure, and sensitivity.

Data and Methods

KAP framework

This study's conceptual framework is based on the knowledge, attitudes, and practices approach (KAP), a quantitative approach used in public health and social sciences to analyse human behaviour in response to specific issues. KAP examines the interrelations between knowledge (awareness and understanding), attitudes (perceptions and beliefs), and practices (actual behaviours), providing insights into behavioural patterns and potential intervention strategies (Vandamme, 2009).

KAP was developed in the 1950s for demographic studies and has been extensively applied in health research, including disease prevention and environmental health. Its structured methodology enables the identification of knowledge gaps, the design of targeted interventions, and the assessment of behavioural responses. However, its limitations include a lack of standardized methodology, challenges in cross-study comparisons, and an oversimplification of behavioural determinants, as external sociocultural and environmental factors often influence individual actions beyond knowledge and attitudes alone (Vandamme, 2009; Chandler, 2018).

Knowledge refers to information people possess about an issue, such as causes, symptoms, and preventive measures. Attitudes encompass beliefs, perceptions, and feelings that shape willingness to act. Practices denote actual behaviours and actions in response to knowledge and attitudes. Examining the relationships between KAP can identify gaps between KAP components and develop targeted interventions (WHO & Stop TB Partnership, 2008). Knowledge arises from formal/informal learning personal experiences and is shaped by memory, cognition, and motivation. Knowledge, experiences, and interconnected factors like social environment, culture, media, and psychology form attitudes. The more knowledge someone has, the more likely they are to develop specific attitudes. Attitudes can guide how and what new knowledge is acquired and can affect behaviour, while behaviour could impact attitudes and knowledge. However, behavioural factors are complex, as behaviour is the most visible KAP component influenced by various factors beyond this study's scope.

This study integrates the KAP framework with a socio-ecological geographical approach to assess heat stress-related behaviours in Koper and Ljubljana. Exam-

ining the interplay between KAP components and socio-economic variables, facilitates a deeper understanding of public responses to heat stress and the development of targeted public health interventions to enhance urban climate resilience.

Study Design and Data

The questionnaire was designed based on the KAP framework and included socio-economic variables. Participants' responses were scored for each KAP segment. The knowledge segment had 42 possible points, with correct answers receiving one point and incorrect answers zero. The attitude category was scored using a 5-point Likert scale for four statements. Two theory-based questions were asked for practice, and participants evaluated their summer patterns on a 5-point scale. The KAP scores were used as variables in the statistical analysis.

For our research, we employed a KAP approach to investigate the influence of select socio-economic characteristics on urban heat stress in Koper and Ljubljana. The study was implemented in the autumn of 2020, focusing on the Olmo and Zupančičeva jama neighbourhoods. Data collection occurred immediately after summer to minimize direct heat influences on participants' perceptions. Residents in these neighbourhoods are presumed to have greater heat exposure. The questionnaire was administered in physical and digital formats, aligned with the KAP framework.

The researchers collaborated with local building administrators before the research, which occurred between the first and second COVID-19 waves. This partnership was most fruitful in Ljubljana, where administrators assisted in distributing questionnaires in Zupančičeva jama. In September 2020, physical questionnaires and flyers were disseminated, with posters and mailbox drops in Zupančičeva jama. Due to less support in Koper, the researchers used paid social media ads. In total, 750 physical questionnaires were distributed. Altogether, 168 responses were received by mid-October 2020, slightly higher in Olmo at 51.2%.

Results

KAP Descriptive Statistics

In our study, most participants were female (68.6%), as women predominated in both neighborhoods. The differences are higher in Olmo, where 27.4% of participants were male and 72.6% were female. According to the official data, the gender composition of the sample was more balanced compared to our sample (Olmo 52.0% and Zupančičeva jama 52.4% female).

Table 1. Selected socio-economic characteristics of the neighborhoods

	Olmo	Zupančičeva jama
Average household income	1.771.29 €	2.364.18 €
Average number of the household members	2.31	2.2
Income per household member	854.28 €	1,197.80 €
Health self-assessed	3.48	3.89
Sex		
Men	27.4 %	72.6 %
Women	36.0 %	64.0 %

The age composition of the participants showed that the largest group was aged 30-44 years, while the smallest group, at 7.6%, was young people aged 15-29 years, excluding one minor participant. Most respondents over 75 years old were from the retirement home in Olmo, which explains the higher proportion of this age group. In contrast, respondents from the Zupančičeva jama tended to be younger on average. The official age distribution data corroborate this. In Zupančečeva jama, 13.4% of residents were in the 0-14 age group, 69.9% were 15-64 years old, and 16.65% were over 65 (Zupančičeva jama, 2021). The Olmo had an older population, with 11.9% in the 0-14 age group, 62.3% aged 15-64, and 25.8% over 65 (Olmo, 2021).

Understanding these demographic differences is critical to our research. Age is a key factor in determining vulnerability to heat stress—older adults typically face more significant physiological risks due to age-related declines and a higher prevalence of chronic conditions. At the same time, younger individuals may respond differently to heat exposure. Additionally, the variations in age distribution across the study sites can influence the KAP outcomes; differing life experiences and risk perceptions are likely to shape adaptive behaviours in each age group. These insights enable us to tailor public health interventions and communication strategies more effectively, ensuring that strategies are sensitive to the distinct needs of younger and older populations.

The study participants exhibited relatively high educational attainment, with more than half holding post-secondary, higher education, or university degrees, including master's degrees. In contrast, just over 8% had incomplete or completed primary education, and these individuals tended to be in the oldest age group. Examining the key differences in educational attainment between the two neighbourhoods is crucial to verify our assumptions about the knowledge levels between the sample neighbourhoods.

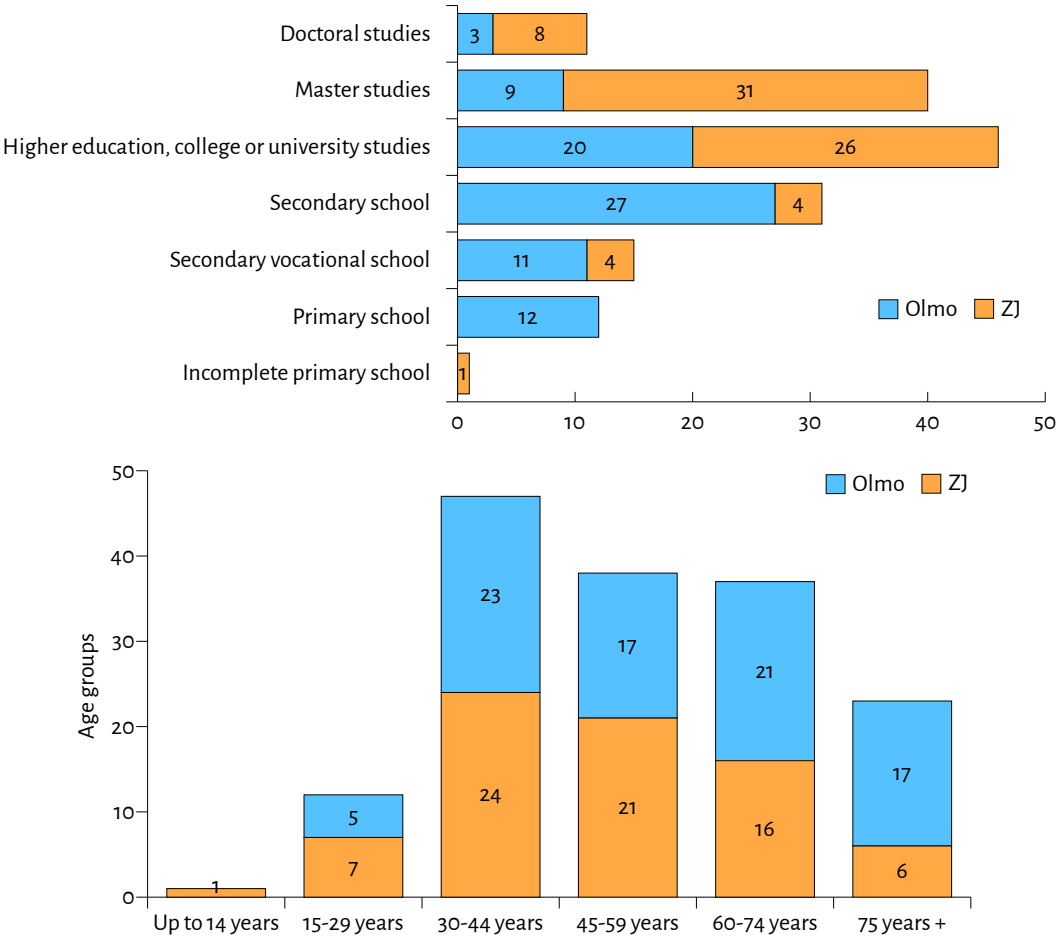

Figure 2. The overview of education levels (%, up) and age groups (below) by neighbourhood

Residents of the Zupančičeva jama demonstrated significantly higher educational achievement, with more significant proportions holding the highest levels of education. Conversely, the Olmo had a higher proportion of participants with secondary school and primary education backgrounds. This differentiation is important for our study because educational attainment may determine how individuals acquire, interpret, and act upon information regarding heat stress.

The educational attainment of the respondents was reflected in their employment characteristics. Only a small minority, just under one-fifth, engaged in predominantly physical labour. Conversely, most participants reported working in sedentary roles. However, about two-thirds of respondents had relatively diverse work responsibilities. Additionally, one-third were employed in workplaces with formal dress codes.

While 30.2% of participants indicated they could work from home, this finding should be interpreted cautiously. The study was conducted in 2020 at the outset of the COVID-19 wave in Slovenia when remote work had already become an established practice. Thus, many respondents likely selected the "work from home" option based on the pandemic context, despite the questionnaire's clarification that this did not refer to the COVID-19 period. Approximately half of employed respondents perceived their workplace as stressful.

The health self-assessment average was 3.68, indicating a status between moderately good and good. Notably, differences emerged between the neighbourhoods: participants from Olmo reported an average health self-assessment 0.41 points lower than those from Zupančičeva jama. As Nitschke et al. (2013) noted, participants who rated their health as fair to poor were at significantly higher risk for heat-related morbidity. Similarly, Grothmann et al. (2017) stated that high levels of occupational stress may reduce the capacity for effective adaptive behaviour during heat events. These insights underscore that poorer self-rated health and stressful, sedentary work environments can amplify heat stress vulnerability, highlighting the need for targeted interventions that account for these socio-economic and occupational factors.

Knowledge

As described, the knowledge segment of the questionnaire initially included statements that were either true or false, and participants responded with "yes," "no," or "don't know" based on their familiarity with the topic. Subse-

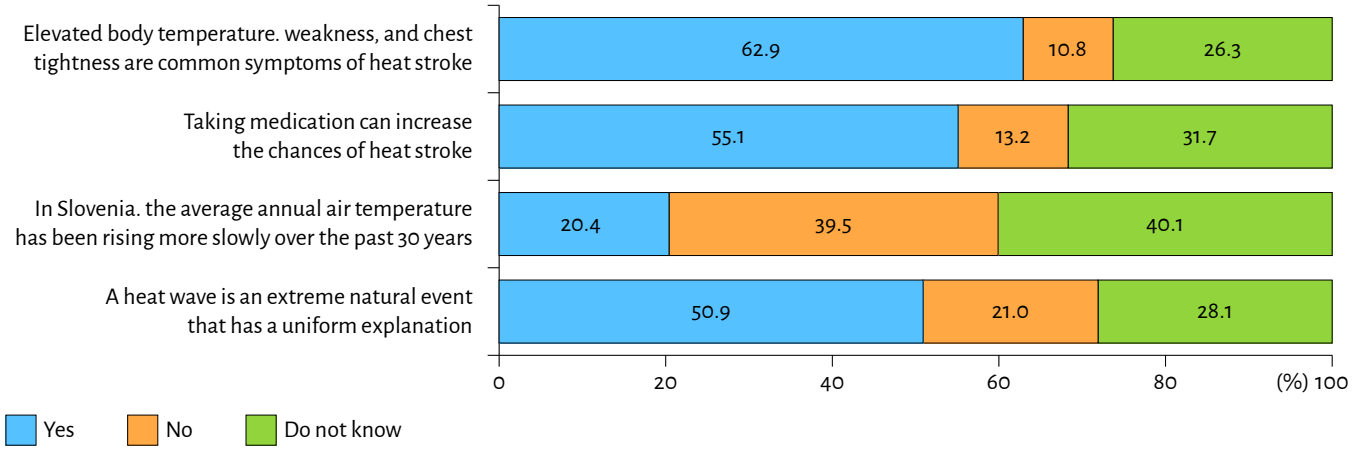

Figure 3. The participant's knowledge of climate change, heat waves, and health impacts. The bold shares represent the correct responses

quently, participants selected from the provided options in questions with multiple possible answers. The knowledge segment had 42 possible points; correct answers were scored with one point and incorrect with none. In this segment, participants achieved an average score of 30.2 points (out of 42 possible points), or 72.1% correct responses (Olmo 29.7 points; ZJ 30.9 points). Analysis of the knowledge segment revealed significant differences in the level of knowledge between the neighbourhoods.

The introductory questions revealed gaps in participants' understanding of heat waves and climate change trends. Only 21.0% accurately acknowledged that heatwave definitions lack uniformity, varying according to local climatic conditions. Similarly, knowledge about the rate of temperature increase in Slovenia compared to other regions was limited. As many as 40% of respondents could not assess the statement's validity regarding Slovenia's temperature trends, and an additional 20% believed the increase had been slower than elsewhere. However, most participants correctly identified that medication use can heighten the risk of heatstroke during hot weather and recognised common symptoms.

Participants' limited knowledge of climate change, heat waves, and associated health impacts may hinder the development of appropriate attitudes and practices, ultimately undermining the effectiveness of public health interventions. On average, respondents provided only 1.77 correct answers, indicating an overall lack of understanding that could impede adaptive behaviours during heat events.

Participants achieved better results in the second question related to more practical aspects of protection and health-friendly behaviour during the summer heat. Among the 15 suggestions, participants selected those they believed could effectively protect against the negative consequences of heat waves. Multiple answers were possible, including incorrect or unfavourable suggestions for prevention. Participants most frequently selected the correct answers, such as "drinking larger amounts of fluids," "ventilating living spaces in the morning hours," "wearing lighter and lighter-coloured clothing," "avoiding sun exposure between 11 a.m. and 4 p.m.," and "using head coverings and sunglasses. On the other hand, some misconceptions were also identified, with participants often selecting inadequate or even potentially harmful measures, such as "consuming alcoholic beverages."

Table 2. Participants' most common responses on effective measures to protect against heatwave impacts (multiple answers possible)

Activity	Frequency (%)
Drinking larger quantities of fluids (non-alcoholic)	164 (14,2 %)
Ventilating living spaces in the morning hours	160 (13,9 %)
Wearing light and loose-fitting clothing	159 (13,8 %)
Avoiding outdoor activities between 11 a.m. and 4 p.m.	159 (13,8 %)
Using hats and sunglasses	147 (12,7 %)
Ventilating living spaces in the evening hours	117 (10,1 %)
Using sunscreen	87 (7,5 %)
Drinking warm beverages	70 (6,1 %)
Drinking cold beverages	64 (5,6 %)
Ventilating spaces, regardless of time	10 (0,9 %)
Drinking caffeinated beverages	6 (0,5 %)
Wearing tight-fitting clothing	3 (0,3 %)
Other	7 (0,6 %)

Participants more frequently chose to ventilate living spaces in the morning than evening ventilation. This trend is expected since the effects of the UHI—where residents of the neighbourhoods live—persist in the evening hours, and temperatures remain relatively high. Nevertheless, evening ventilation is more appropriate for prevention

than midday, regardless of the time. Participants rarely selected incorrect answers, such as drinking caffeinated and alcoholic beverages and consuming fatty foods. Answers categorised as "other" included drinking alcoholic beverages, consuming fatty foods, and using synthetic clothing. The differences in proportions between correct and incorrect answers, according to the theory of preventive behaviour during heat, are evident in the sample.

Participants demonstrated relatively satisfactory knowledge in recognising key health indicators or examples of health problems associated with heat stress. The most frequently selected health consequences were "dehydration" and "heatstroke or heat exhaustion," followed by fatigue and dizziness. The list of health indicators included some options not directly related to heat waves. Among the incorrect options, respondents best recognised the causes of pneumonia, followed by the common cold, chosen by 10.7% of participants. Additionally, 22% of participants selected "itchiness," which is not primarily associated with hot weather. One of the most frequently chosen incorrect answers was "sunburn," which is related to UV-B solar radiation rather than air temperature. The frequent selection of this option may suggest that participants assumed heat waves are associated with clearer or sunnier weather.

Table 3. Health issues that respondents believe may be associated with heat waves (multiple answers possible)

Health outcome	Frequency (%)
Dehydration	157 (14,8 %)
Heat stroke	154 (14,5 %)
Fatigue	147 (13,9 %)
Dizziness	144 (13,6 %)
Sunburn	115 (10,8 %)
Worsening of chronic diseases	100 (9,4 %)
Vomiting	93 (8,8 %)
Diarrhea	50 (4,7 %)
Itching	37 (3,5 %)
Aggression	27 (2,5 %)
Cold	18 (1,7 %)
Pneumonia	13 (1,2 %)
Other	4 (0,4 %)
I don't know.	1 (0,1 %)

The final question in the knowledge segment of the questionnaire addressed the recognition of population groups most vulnerable to the adverse impacts of heat waves. Based on extensive research (e.g., Nitschke et al., 2013; Harlan et al., 2006; Kovats & Hajat, 2007), not all population groups are equally susceptible to heatwave and heat stress exposure. Nevertheless, 9.5% of respondents answered this question incorrectly by selecting that there are no differences in vulnerability among population groups; notably, most of these participants were from Olmo.

The study participants demonstrated adequate knowledge and correctly identified the elderly, individuals with chronic health conditions, outdoor workers, pregnant women, and young as the groups most vulnerable to the adverse effects of heat waves. These findings align with a broad body of research indicating that physiological factors, pre-existing health conditions, and social determinants amplify heat-related risks for specific populations (Heatwaves: A Guide for Health-based Actions, 2021). For instance, Kovats & Hajat (2008) underscore that older adults and those with chronic illnesses are disproportionately affected by extreme heat. Basu (2009) further reviews epidemiological evidence demonstrating heightened mortality risks for older individuals and those with comorbidities. O'Neill and Ebi (2009) emphasise how socio-economic variables—such as income and housing quality—compound these vulnerabilities. In a Slovenian context, Kajfež Bogataj et al. (2018) found that 79% of respondents recognised the elderly as a group susceptible to heat stress, alongside those on medication and young children. This study's observations thus reinforce existing evidence that targeted interventions for these high-risk groups—especially in urban areas—are essential to mitigate heatwave impacts.

However, the current study revealed that only 19% of respondents recognised the socio-economically disadvantaged as vulnerable. This is concerning, as socio-economic status significantly influences vulnerability and exposure to heat stress.

Table 4. Population groups perceived to be most negatively affected by heat waves (multiple answers)

Population group	Frequency (%)
Elderly (over 65 yrs)	150 (89,3 %)
Patients with chronic diseases	145 (86,3 %)
Outdoor workers	131 (78,0 %)
Pregnant women	119 (70,8 %)
Small children	104 (61,9 %)
Socially and economically disadvantaged	32 (19,0 %)
No differences between groups, we are all equally vulnerable	16 (9,5 %)
Men (40–50 yrs)	9 (5,4 %)
Women	5 (3,0,7 %)
Young people (15–29 yrs)	3 (1,8 %)
Others	1 (0,6 %)

The analysis of participants' knowledge across both neighbourhoods reveals that residents of Zupančičeva

jama exhibited a relatively stronger understanding of climate change, heat waves, and vulnerability. However, the data also suggests notable variations in knowledge levels within the individual survey questions. Furthermore, the study found no significant differences in the knowledge category between male and female participants.

Attitudes

The Attitudes section was based on participants' personal experiences, emotions, and past encounters. Unlike the Knowledge section, this part was not scored, as there were no right or wrong answers. Instead, participants expressed their attitudes using a Likert scale.

Most participants indicated concern about the potential consequences of climate change in Slovenia. According to their self-assessment, the majority followed preventive measures to protect against heatstroke during the summer of 2020. Conversely, participants did not feel particularly sensitive to heat and heat stress. Similar opinions were held regarding the dangers of heat waves to their health.

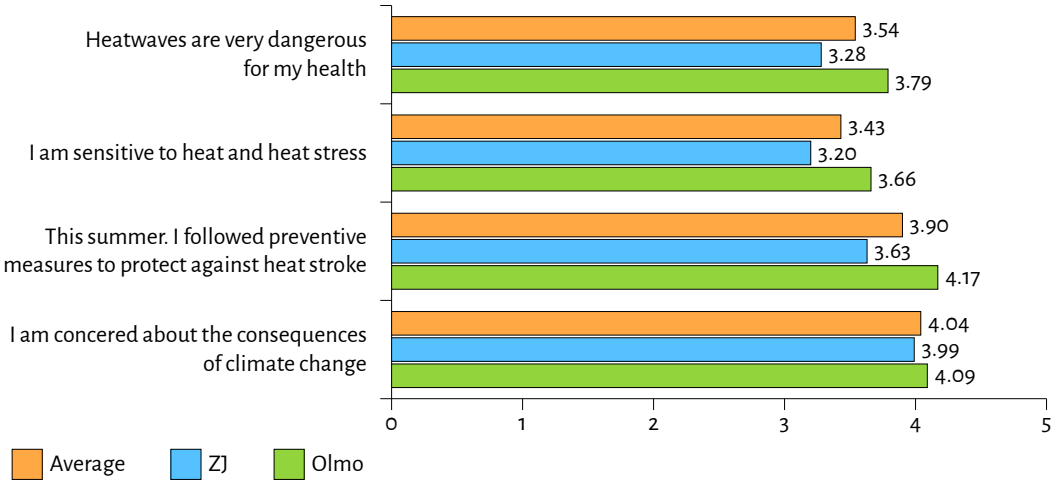

Figure 4. Respondents' average agreement with statements related to the perception of heat stress and understanding of climate change

The study found notable differences between the neighborhoods, with participants Olmo reporting higher average attitudes than those from Ljubljana. The most significant divergence emerged in their self-reported adherence to preventive measures against heatstroke. In contrast, the slightest difference was observed in their concern about the potential consequences of climate change, where residents of Olmo showed slightly higher agreement on average (0.09 higher).

Practice

This section evaluated participants' behaviours, actions, and preparedness for heatwave risks and stress. This final part of the KAP framework incorporated into the research aimed to assess the behaviours of participating residents during heat waves or weather conditions characterised by heightened heat stress. Through two questions in this segment, the study examined how participants changed their daily routines and behaviours in response to hot weather. Participants were presented with two statements and asked to respond "yes," "no," or "don't know."

Regarding the first statement, which focused on fluid intake, 79.5% of respondents reported drinking fluids during summer even when they did not feel thirsty. Just under 20% of participants disagreed with this statement. A similar proportion of responses was observed for the second statement, which pertained to increased attention and care for more vulnerable populations. While interpreting these responses, caution is warranted, as both statements may have elicited socially desirable answers. Additionally, the fluid intake question did not provide insight into the types of fluids the participants consumed, some of which may not have beneficial effects during heat stress. Interestingly, differences in participants' responses were observed when considering the neighbourhood. However,

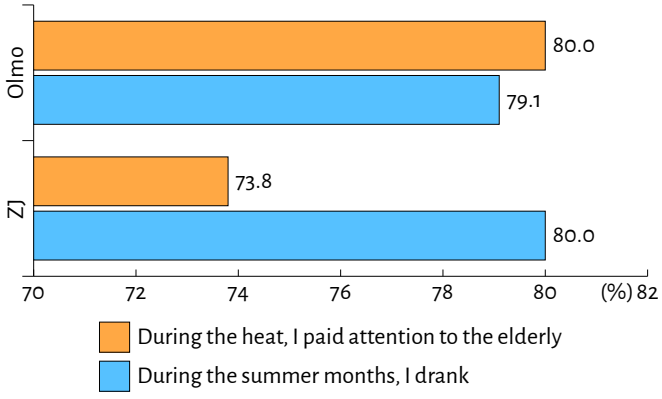

Figure 5. Proportion of respondents who are more attentive to hydration and care for the vulnerable during heat waves

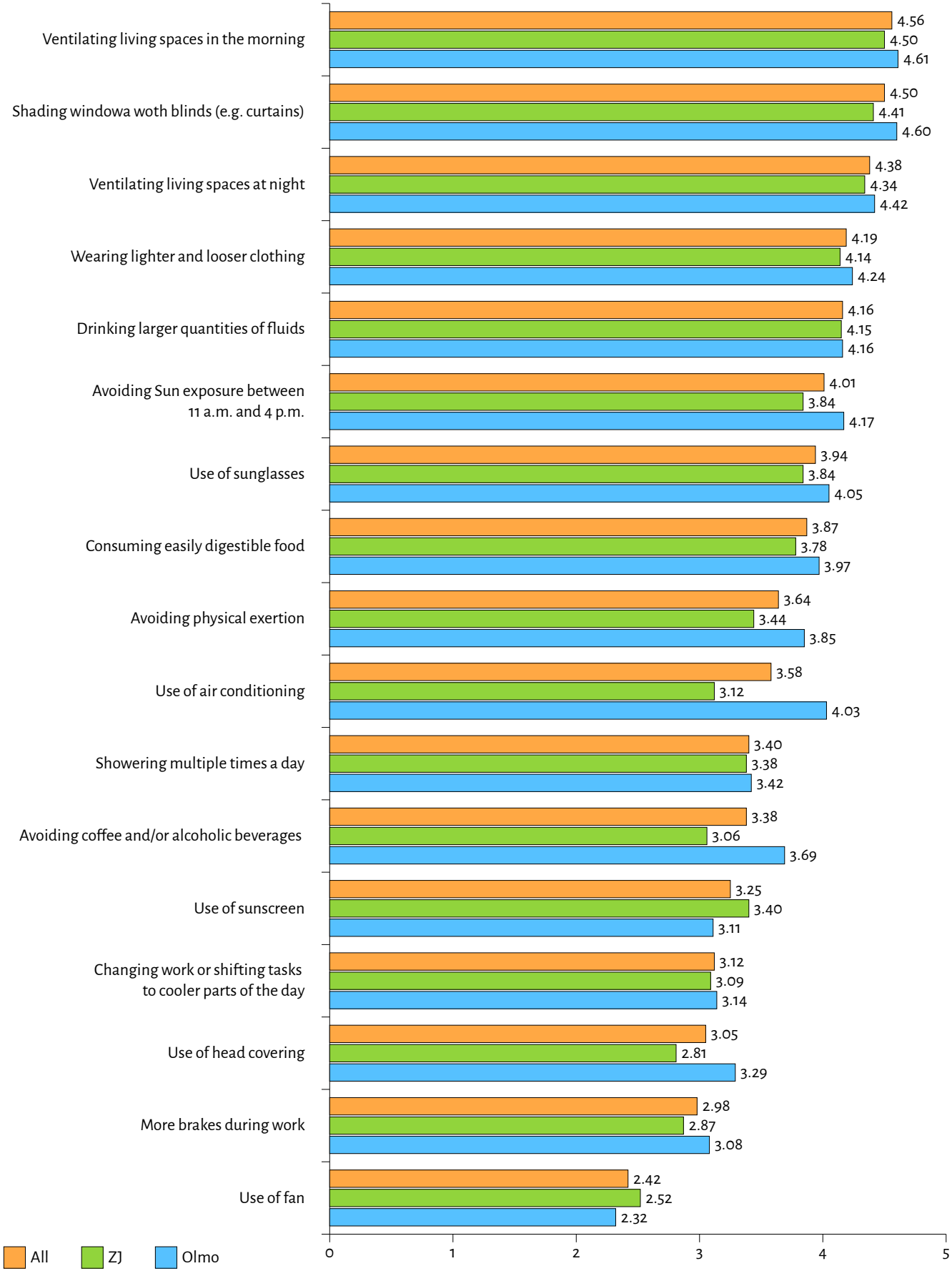

Figure 6. Frequency of use of preventive measures among survey participants in both neighbourhoods

these differences were evident only in the second statement, which was related to increased attention to the elderly, children, or weaker family members.

An interesting comparison between the neighbourhoods regarding preventive practices during extreme heat and heat waves reveals that the differences for the five most practised preventive measures are relatively small. The most significant difference is observed in shading windows with blinds.

Residents of Olmo more frequently used air conditioning than participants from Zupančičeva jama. Additionally, participants from Olmo exhibited a stronger tendency to avoid caffeinated and/or alcoholic beverages. Similarly pronounced differences were observed in measures such as wearing head coverings and avoiding physical exertion. Furthermore, the data suggests that Olmo participants generally practised preventive behavioural measures more often than their counterparts from Zupančičeva jama, with the latter only outpacing Olmo in two of the measures.

KAP Differences Between the Neighbourhoods

The study examined potential differences between Olmo and Zupančičeva jama based on the KAP framework. To analyse how heat stress interacts with socio-economic factors across the sample, the researchers used a non-parametric Mann-Whitney U statistical test to compare the average ranks of residents from Olmo and Zupančičeva jama for each KAP variable.

$$U_1 = R_1 - \frac{\left(n_1 \cdot \left(n_1 + 1\right)\right)}{2}$$

$$U_2 = R_2 - \frac{\left(n_2 \cdot \left(n_2 + 1\right)\right)}{2}$$

The Mann-Whitney U test of our sample revealed statistically significant differences between the neighbourhoods in the categories of attitudes and behaviour. The Olmo had higher average ranks in these categories. In contrast, the knowledge category did not show significant differences between the neighbourhoods. Although the Zupančičeva jama sample had a slightly higher average rank in knowledge, the difference was not statistically significant. This can be primarily attributed to the socio-demographic factors of age and education, as the participating residents of Zupančičeva jama were somewhat younger and better educated than the Olmo residents.

While the differences in knowledge between the neighbourhoods are not statistically significant, the differences in the categories of attitudes and behaviour are statistically significant (attitudes: $p = 0.017$; behaviour: $p = 0.044$), suggesting that Olmo demonstrated more positive attitudes and preventive behaviours related to heat stress in comparison to the Zupančičeva jama, despite the lack of significant differences in knowledge levels between the two samples.

The analysis reveals that knowledge levels did not differ significantly between the neighbourhoods. Olmo exhibited a statistically significantly higher average ranking in attitudes and behaviours related to heat stress than the Zupančičeva jama. This suggests that Olmo residents held more positive attitudes and engaged in more preventive practices to address heat-related impacts despite comparable knowledge levels across the two samples. According to the study, Olmo residents more frequently ventilated their living spaces in the morning and at night, shaded glass surfaces with blinds, wore lighter clothing, and consumed more significant amounts of fluids.

Table 5. Comparison of between Olmo, Zupančičeva jama and KAP categories

KAP		N	Average of ranks	Sum of ranks	Mann-Whitney U	p-Value
K	Olmo	86	78.94	6789	3048	0,128
	ZJ	82	90.33	7407		
	All	168				
A	Olmo	86	92.59	7963	2744	0,017
	ZJ	81	74.88	6065		
	All	167				
P	Olmo	86	90.74	7803.5	2817.5	0.044
	ZJ	80	75.72	6057.5		
	All	166				

Discussion

The findings provide valuable insights into the KAP related to heat stress. The analysis reveals that while knowledge levels did not differ significantly, the Olmo exhibited statistically significant higher average ranks in attitudes and behaviour compared to the Zupančičeva jama. This suggests Olmo residents held more positive

attitudes and engaged in more preventive practices despite comparable knowledge levels. Socio-ecological factors influenced these differences. Olmo participants were older, economically disadvantaged, less educated, and more sensitive to heat due to poorer health. Zupančičeva jama residents were more formally educated, but knowledge levels were relatively low across both samples. Respondents performed better on practical heat protection and health impact questions. They correctly identified key risks and vulnerable groups, though fewer included the socio-economically disadvantaged. Demographic differences were evident, with Olmo having more people who believed there were no differences in vulnerability. Gender did not impact knowledge. The results confirm that knowledge was comparable, but attitudes and practices differed significantly between neighbourhoods. This suggests that formal education is not the sole factor shaping the KAP related to heat stress. Other geographic, socio-economic, and cultural factors influenced perceptions and behaviours.

The analysis reveals statistically significant differences between the two neighborhoods in the attitudes and behaviors related to heat stress. Residents of Olmo generally held stronger perceptions regarding the impacts of climate change and heat waves on their health and well-being. They were more actively engaged in public health preventive measures during heat events. For instance, Olmo participants more frequently ventilated their living spaces, shaded glass surfaces, wore lighter clothing, and consumed more fluids. This heightened engagement in protective behaviours among Olmo residents can be attributed to their older age, poorer self-reported health, and higher heat stress sensitivity (Ye et al., 2018). These findings suggest that strong attitudes are influenced by formal education and informal knowledge and experiences accumulated over time, shaping their practices, particularly regarding economically feasible measures.

The results confirm that knowledge levels and prevention were relatively comparable across the neighbourhoods, but notable differences emerged in their attitudes and practices. Notably, the observed variations in formal education between the neighbourhoods do not appear to play a significant role. This aligns with the theoretical foundations, which suggest that knowledge as part of the KAP concept is shaped by formal and informal education about the natural and social environment and individual experiences. These factors vary according to the geographical characteristics of the neighbourhoods, ultimately influencing participants' attitudes and behaviours.

The level of formal education relates to the type of employment, which can influence individuals' exposure to heat stress and its impact on their health and well-being, adaptive capacities, and overall vulnerability. However, the study sample was diverse, including participants from various backgrounds, such as working residents, retirees, and young people, rather than a specific cohort disproportionately exposed to heat stress through their occupation. As a result, only a small proportion of the study participants engaged in physically demanding labour.

In addition to formal education, certain physical-geographic and socio-geographic factors can shape perceptions, experiences, and habits related to heat stress. The climatic differences between Koper's coastal region and Ljubljana's central area may influence residents' perceived need for preventive measures. The moderate Mediterranean climate in Koper could motivate Olmo residents to adopt more effective protective practices.

Furthermore, socio-geographic characteristics beyond socio-economic status can impact how residents respond to heat stress. For instance, the Mediterranean dietary patterns and cultural practices, such as afternoon breaks, common in the Slovenian coastal region, may contribute to the local population's heat wave coping strategies.

The findings indicate that despite high levels of concern and the adoption of some preventive measures, knowledge and awareness of specific heat wave risks and management strategies remain limited. Targeted educational and preventive programs and other measures are needed to address this gap. Additionally, it is important to devote special attention to understanding the impact of demographic and socio-economic factors on the vulnerability of specific groups.

This study has limitations that must be considered. The COVID-19 pandemic directly and indirectly impacted the research, though the influence of societal mindset and the epidemic on the outcomes is unclear. While randomised and diverse, the sample size may not fully represent the broader population. Environmental conditions during the study period, such as above-average precipitation in Olmo, average summer rainfall in Zupančičeva jama, and a relatively mild 2020 summer, may have shaped participants' perceptions.

This research provides insights for future studies. Expanding the sample size and geographic scope could enhance representativeness. Replicating the study during a non-pandemic period and under more intense heat wave conditions and testing the model in a third climate type would be reasonable. These findings are crucial for developing effective adaptation strategies, communication methods, and awareness-raising initiatives to mitigate the adverse impacts of extreme heat amidst socio-economic and health factors.

Conclusion

In conclusion, findings suggest similar knowledge levels about heat stress were comparable across the neighbourhoods; Olmo exhibited more positive attitudes and preventive behaviors (e.g., more frequent ventilation, shading, etc.) compared to the Zupančičeva jama. The analysis revealed a complex interplay between various factors, including demographic characteristics, health status, and environmental conditions, that shape the KAP of urban residents regarding heat stress. These differences highlight the influence of local context, including environmental conditions and potentially cultural norms, on heat-related responses. While formal education plays a role, demographic factors and health status also affect preparedness. Our study uniquely highlights how subtle climatic variations, socio-economic characteristics, and health within a relatively small geographic area can significantly influence heat-related attitudes and practices.

Although the COVID-19 pandemic and the conditions of summer 2020 may have influenced our results, this study provides a valuable baseline for future, wider-scope research. Replicating these methods in more varied environments and during more intense heat waves would further validate and refine these context-sensitive strategies for enhancing urban heatwave resilience.

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Waste Disposal Practices, Health Awareness and Challenges in Rapidly Growing Populations: A Case Study of Ede, Southwestern Nigeria

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KEYWORDS

- Waste disposal
- Health awareness
- Socio-demographic
- Populations
- Regression

ABSTRACT

Waste disposal and management have emerged as pressing challenges in urban areas, particularly in developing countries where rapid population growth exacerbates the situation. This study examines waste management practices, health awareness, and the associated challenges in Ede, Osun State, Nigeria. A structured questionnaire was distributed to 310 respondents using a simple random sampling method. The analysis revealed that waste disposal practices predominantly involve open burning (34.2%) and disposal in rivers/streams (26.8%), both of which pose significant environmental and health risks. Despite a high percentage of organic waste (74.2%), sustainable practices such as recycling (7.1%) and composting (3.2%) are minimally utilized. Using ordinal logistic regression, important predictors of waste disposal methods were found. These included lack of money, inadequate facilities, and low awareness. Additionally, dissatisfaction with waste management services correlated with poor waste disposal practices. The findings underscore the urgent need for enhanced public education, infrastructure improvements, and the promotion of sustainable waste management practices to mitigate environmental and health impacts in the study area.

Introduction

Waste disposal and management have emerged as critical issues in rapidly growing populations, particularly in urban areas where the surge in population density aggravates the challenges associated with waste generation and disposal (Gutberlet, 2018). As communities expand, the volume of waste produced increases, often exceeding the capacity of local waste management systems. This disparity can lead to significant environmental and public health concerns (Omang et al., 2021; Ichipi & Senekane, 2023). Improper waste disposal methods, such as open dumping, burning, and unregulated landfill use, contribute to pollution, spreading diseases, and degrading ecosystems. However, the health implications of improper waste disposal are profound, affecting both the immediate and long-term well-being of populations. In many developing countries, informal and unregulated waste disposal methods are prevalent due to inadequate infrastructure and limited resources. According to a study by Kaza et al. (2018) open dump-

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ing is common in lower-income countries, where landfills are not yet available. While just 2% of waste is disposed of in high-income countries, over 93% of garbage in low-income countries is burned or dumped in roads, open spaces, or rivers. Future waste increase will be greatly impacted by the fact that over two-thirds of waste is disposed of in South Asia and Sub-Saharan Africa. These practices pose severe risks to public health and the environment, contributing to air and water pollution and facilitating the spread of infectious diseases. Moreover, the lack of public awareness and inadequate infrastructure further complicate waste management efforts. Understanding the interplay between waste disposal practices and health awareness is crucial for developing sustainable solutions.

Recent studies on improper waste management globally, with a particular focus on Africa, reveal significant health and environmental implications. The mismanagement of waste, particularly in developing countries, has been linked to severe public health risks and environmental degradation. For instance, Sarkingobir et al. (2022) highlight that improper biomedical waste management can lead to soil and water pollution, which in turn affects agricultural productivity and public health through the contamination of food sources. This is echoed by Odonkor and Mahami (2020), who emphasize that improper disposal of healthcare waste in Ghanaian hospitals poses risks of infectious disease transmission, underscoring the urgent need for effective waste management policies. The COVID-19 pandemic has aggravated waste management challenges worldwide, particularly in developing countries. Fadhullah et al. (2022) note that the pandemic has complicated household waste management due to increased waste generation and the potential transmission of SARS-CoV-2 through municipal solid waste handling. This situation is further complicated in Africa, where inadequate infrastructure and governance hinder effective waste management practices. Godfrey et al. (2020) argued that good governance is essential for sustainable waste management, advocating for enhanced capacity in financial, institutional, and technological aspects to address the challenges faced by African nations. In Ethiopia, high levels of improper solid waste management practices, with significant portions of waste being disposed of in unauthorized locations, were reported by Lema et al. (2019). This finding is consistent with studies in other African countries, such as Ghana and Tanzania, where improper disposal rates are alarmingly high (Teferi, 2022). The implications of such practices are profound, as they contribute to environmental pollution and health hazards, including gastrointestinal diseases among waste workers and nearby residents (Adeyi & Adeyemi, 2019).

Solid waste management remains a critical issue in Ede and its surrounding areas in Osun State, Southwestern Nigeria, aggravated by rapid urbanization, population growth, and industrial activities. Omoge et al. (2021) in his study among residents of Buari Ishola Isibo in Ede North Local Government Area, reported that, currently, waste disposal in Ede involves a mix of informal practices such as open dumping and burning, alongside formal systems like municipal collection services. These practices pose severe risks to public health and the environment, contributing to the spread of various infectious diseases in the area. Hence this study therefore aims to investigate the current waste disposal practices, level of health awareness, and associated challenges in the entire Ede and its environ, with a view to identifying sustainable solutions.

Effective waste management strategies are crucial in addressing the challenges posed by improper waste disposal, which include environmental pollution, public health risks, and the depletion of natural resources (Omoge et al., 2021; Gupta et al., 2024). Implementing these strategies helps mitigate these issues and promotes sustainable development. Public awareness and education are critical components in addressing improper waste management. Ouma (2021) emphasizes the importance of training and awareness campaigns to foster responsible waste disposal practices among communities. Similarly, study in South Africa indicates that increased awareness of improper waste disposal correlates with better management practices among households (Raphela et al., 2024). This study entails grassroots and in-depth knowledge of the study area through the administration of questionnaires for valuable insights into waste disposal practices, socio-demographic influences, and public health awareness, randomly across the study area. The use of questionnaires serve as a vital tool for policymakers, environmental agencies, and researchers in developing effective waste management strategies tailored to the needs of rapidly growing populations.

Study Area

Ede is an ancient town in Osun State, Nigeria, located in the southwestern part of the country. It consists of Ede North and South Local Government Areas (comprising 21 wards). Ede is situated approximately 20 kilometers east of Oshogbo, the state capital. It is located between latitude 7° 35'00"N and 7° 47'00"N of the Equator and longitude 4° 18'00"E and 4° 36'00"E of the Greenwich meridian (Figure 1). Ede has an altitude of approximately 287 m above mean sea level and experiences a tropical savanna climate with two distinct seasons: wet (April-October) and dry (November-March). The average temperature ranges from 22°C to 32°C. The town is accessible via Iwo, Oshogbo, Ife, and Ara. The town covers an area of 330 km² with a projected population of approximately 314,738 as of 2022 by the National Bureau of Statistics. The town's economy is diverse, with residents engaged in trading, farming, and artisanal crafts. The presence of three (3) higher educational insti-

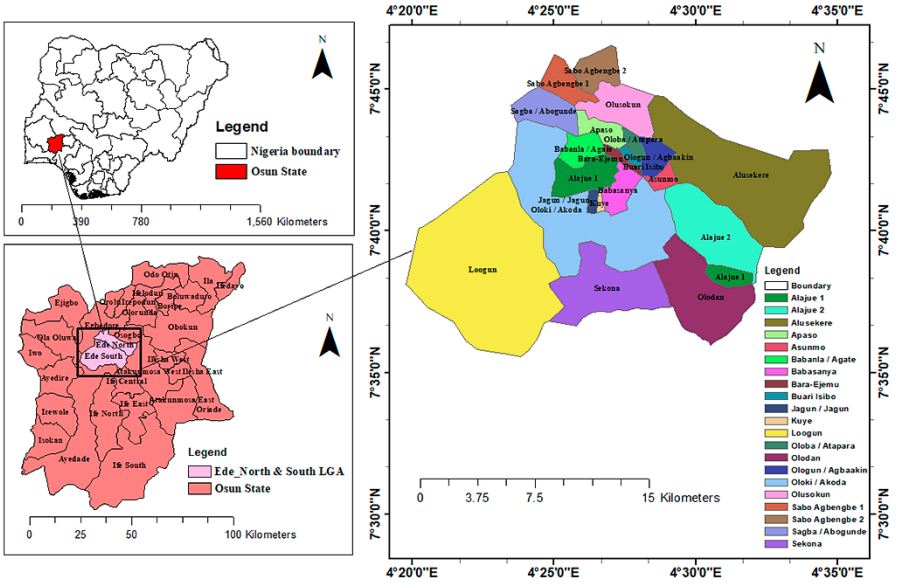

Figure 1. Location Map of the Study Area
(Source: Author)

tutions, i.e., Federal Polytechnic Ede, Redeemer's University, and Adeleke University, adds to the town's demographic dynamics, attracting students, staff, and visitors. Despite its historical and cultural wealth, Ede faces modern challenges, particularly in waste generation and management, necessitating sustainable solutions to maintain the town's environmental health and quality of life (Odeyemi et al., 2024).

Data and method

Sample Size

A structured questionnaire was employed as the primary research instrument to obtain comprehensive data on waste generation and management practices in Ede. To accurately assess solid waste generation and disposal methods in the study area, the study utilizes a simple random sampling method to capture the diverse waste production patterns across residential, commercial, industrial, and institutional sectors. The provided data represents a sample of 310 respondents gotten from simple random sampling distributed across the political wards in Ede and the surrounding area, Southwest, Nigeria, with various demographic and socio-economic variables. An adequate sample size was determined by employing the appropriate sample calculation procedure below. Sample size was determined based on the estimation method outlined by Israel (2012), with results provided below:

$$n = \frac{N \cdot Z^2 \cdot p(1-p)}{E^2 \cdot (N-1) + Z^2 \left(p(1-p)\right)}$$

Where

- n is the sample size
- N is the population size (314,738)
- Z is the Z-score (95% confidence level equivalent to 1.96 critical value)
- p is the estimated proportion of an attribute that present in the population (commonly 0.5 for maximum variability)
- E is the margin of error (0.05 or 5%)

$$n = \frac{314738 \cdot 1.96^2 \cdot 0.5(1-0.5)}{0.05^2 \cdot (314738-1) + 1.96^2 \cdot \left(0.5(1-0.5)\right)}$$

Estimation of respondent rate was $310/384 \cdot 100 = 81\%$
Non respondent rate was estimated as $74/384 \cdot 100 = 19\%$

Methods of Data Analysis

In this study, quantitative methods were used for the questionnaire analysis to present the collected data. Descriptive statistics was used to determine the socio-demographic variables, waste type and disposal methods, waste disposal practices, health awareness, and challenges in the studied area. The ordinal logistic regression was used to model the impact of waste type and health awareness and challenges on the method of waste disposal. The ArcGIS 10.8 software was used to generate various maps in the study.

Results and discussion

Socio-Demographic Variables

This section focuses on the socio-demographic status of respondents from Ede, Osun State, Nigeria, aiming to capture a comprehensive picture of the community. The data was collected from a sample of 310 individuals, encompassing various aspects such as age, gender, ethnicity, education, and occupation. Each of these variables plays a significant role in shaping the socio-economic landscape of the region. By examining these variables, a deeper understanding of the population's structure and the factors that influence their daily lives and opportunities was gained.

Table 1 presents the socio-demographic variables of the respondents in this study. The socio-demographic profile of respondents in this study reflects a diverse and representative sample of Ede, Osun State's population. A majority (45%) of respondents fall within the 18–30 age group, followed by 39.4% in the 31–45 age bracket, indicating a predominantly working-age sample. This aligns with recent findings by Chukwuone et al. (2022), who observed that younger populations in Nigerian urban centers exhibit higher waste generation rates due to increased consumption linked to economic activity. The gender distribution is balanced (slight female majority), mirroring trends in Nigerian waste management studies such as Adeoye et al. (2025), which emphasized gender inclusivity in environmental surveys to avoid behavioral bias. Ethnically, Yoruba respondents dominate (reflecting Ede's demographics), ensuring findings mirror local practices. This resonates with Nigeria's National Bureau of Statistics (2022) report, which highlights ethnicity as a key factor in shaping community-specific waste practices in southwestern Nigeria. Educationally, over half of respondents completed secondary education, a factor strongly correlated with waste management awareness, as noted in Adekola et al. (2021) for similar semi-urban Nigerian populations. Economically, most respondents are self-employed, students, or formally employed, suggesting varied waste generation

Table 1. Socio-Demographic Variables

Variables		Frequency	Percent %
Age	under 18	1	.3
	18-30	139	44.8
	31-45	122	39.4
	46-60	42	13.5
	above 60	6	1.9
	Total	310	100.0
Gender	Male	148	47.7
	Female	162	52.3
	Total	310	100.0
Ethnicity	Yoruba	285	91.9
	Igbo	14	4.5
	Hausa/Fulani	11	3.5
	Total	310	100.0
Education	No Formal	43	13.9
	Primary Education	55	17.7
	Secondary	113	36.5
	Tertiary Education	99	31.9
	Total	310	100.0
Occupation	Employed	54	17.4
	Self-employed	157	50.6
	Student	69	22.3
	Unemployed	17	5.5
	Retired	13	4.2
	Total	310	100.0

Source: Result from questionnaire, 2024

patterns. For instance, self-employed individuals (e.g., traders) may produce more organic or commercial waste, while students generate recyclables like plastics, as observed in Sahathu (2021) and Opusunju et al. (2024). These socio-demographic nuances underscore the need for tailored waste strategies, consistent with Wolff et al. (2021), who argued that localized interventions must account for economic diversity and cultural norms in sub-Saharan African communities.

Waste disposal, health awareness and challenges

Table 2 provides valuable insights into the community's practices and perceptions regarding waste disposal, health awareness, and related challenges in Ede, Osun State, Nigeria. The data reveal several key issues and trends that impact environmental health and waste management effectiveness. The types of waste present in a community and their disposal methods can significantly impact environmental and public health.

Firstly, the predominant type of waste identified is organic/paper waste, constituting 74.2% of the total waste, followed by plastic at 21.0% and glass/metal/electronics at 4.8%. This distribution aligns with findings from Noufal et al. (2020), who reported that organic waste often forms the largest component of household waste in various regions. The high percentage of organic waste suggests a potential for composting initiatives, which could mitigate the environmental impact of waste disposal and enhance soil fertility, as noted by Rani et al. (2022). To utilize the organic fraction of municipal solid waste (OFMSW) for soil ferti-

Table 2. Waste generation types, disposal and health awareness

Variables		Frequency	Percent %
Type of waste	Organic/paper: (Less harmful)	230	74.2
	Plastic: (harmful)	65	21.0
	Glass/Metal/Electronics: (very harmful)	15	4.8
	Total	310	100.0
Which of these do you notice in and around public waste bin or dumping land in your area?	Dark flowing water/odour/fire/smoke	241	77.7
	Mosquitoes/cockroaches	57	18.4
	Animal Presence	10	3.2
	Human scavenger	2	0.6
	Total	310	100.0
Did you ever hear of health problems due to solid waste in your area?	No	178	57.4
	Yes	132	42.6
	Total	310	100.0
How adequately informed are you about the potential environmental impact of improper waste disposal?	Uninformed	12	3.9
	Not well informed	108	34.8
	Well informed	115	37.1
	Very well informed	75	24.2
	Total	310	100.0
Have you ever received education or training on proper waste management practices?	No	205	66.1
	Yes	105	33.9
	Total	310	100.0
Waste Disposal Method	By road side	13	4.2
	open space in the compound	51	16.5
	In rivers/stream	83	26.8
	Open burning	106	34.2
	Public bin	17	5.5
	Recycling	22	7.1
	Composting	10	3.2
	Reuse for other purposes	8	2.6
	Total	310	100.0

Source: Result from questionnaire, 2024

lization through composting, primary waste segregation at the source is essential to ensure the production of uncontaminated, nutrient-rich compost suitable for agricultural use. Source segregation prevents contamination from non-biodegradable materials (e.g., plastics, metals) and hazardous substances, which can compromise compost quality and soil health (Adeoye et al., 2024). This step aligns with the waste management hierarchy (reduce, reuse, recycle), as emphasized by Pires and Martinho (2019), by prioritizing waste prevention and material recovery. Effective segregation at the household or institutional level enables the collection of organic waste (e.g., food scraps, garden waste) for composting, reducing the burden on landfills and minimizing environmental pollution (Policastro & Cesaro, 2023; Adeoye et al., 2024).

The data also highlights concerning observations in and around public waste bins, with 77.7% of respondents noting issues such as dark flowing water, odors, and smoke. These findings resonate with the research by Oruonye et al. (2018), which emphasizes the environmental degradation resulting from improper waste disposal, including contamination of water sources and air pollution. Such conditions not only affect the environment but also pose significant health risks, as improper waste management can lead to the proliferation of disease vectors like mosquitoes and cockroaches. Regarding health problems associated with solid waste, 42.6% of respondents acknowledged having heard of health issues linked to waste in their area. This awareness is crucial, as highlighted by the work of Marange et al. (2023), which discusses the public health threats posed by improper waste management. The lack of education or training on proper waste management practices, with 66.1% of respondents indicating they had not received such education, further exacerbates the issue. This lack of awareness is consistent with findings from Immurana et al. (2022), which suggest that education significantly influences waste disposal practices. The preferred waste disposal methods reveal a troubling trend, with open burning (34.2%) and disposal in rivers/streams (26.8%) being the most common practices. This aligns with the observations made by Ishaq (Ishaq, 2023), who noted that open dumping remains a prevalent waste disposal method in many urban areas. Such practices not only contribute to environmental pollution but also pose health risks, as highlighted by the potential for leachate and landfill gas emissions discussed by Ardiatma (2023). The low rates of recycling (7.1%) and composting (3.2%) indicate a missed opportunity for sustainable waste management, which could be improved through community education and infrastructure development.

Furthermore, the data reflects a critical need for enhanced public education on waste management practices, improved waste disposal infrastructure, and the promotion of sustainable practices such as recycling and composting. Addressing these issues is essential for mitigating the environmental and health impacts associated with solid waste disposal. The practice of separating waste at its source (e.g., households, businesses) into categories like recyclables, organics, and hazardous materials is a cornerstone of effective waste management. By prioritizing segregation at the point of generation, communities can drastically reduce contamination in recycling streams, enhance the efficiency of composting systems, and prevent hazardous materials from entering landfills or informal dumping sites. By emphasizing primary segregation, communities can directly address environmental degradation, reduce greenhouse

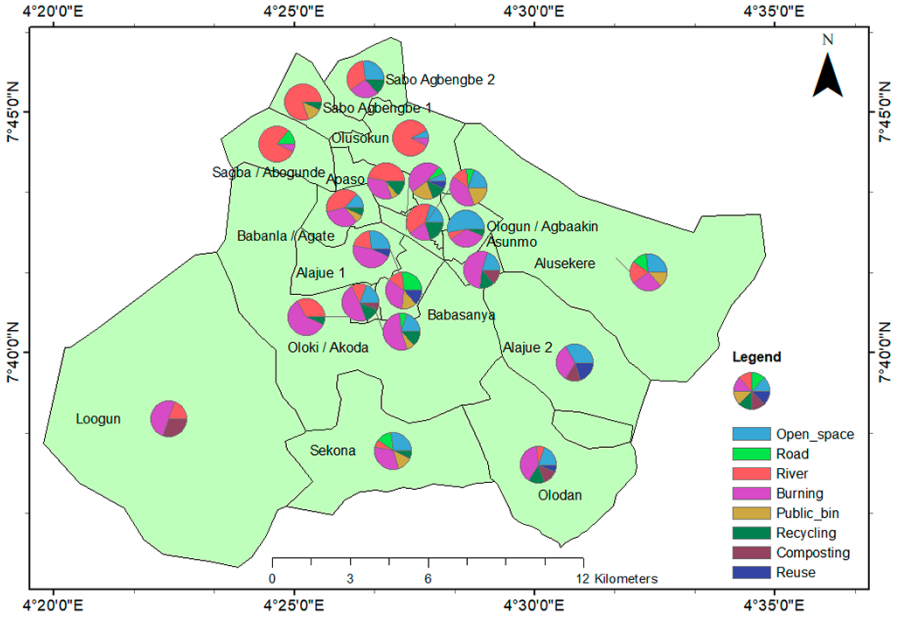

Figure 2. Distribution pattern of waste disposal methods across the political wards

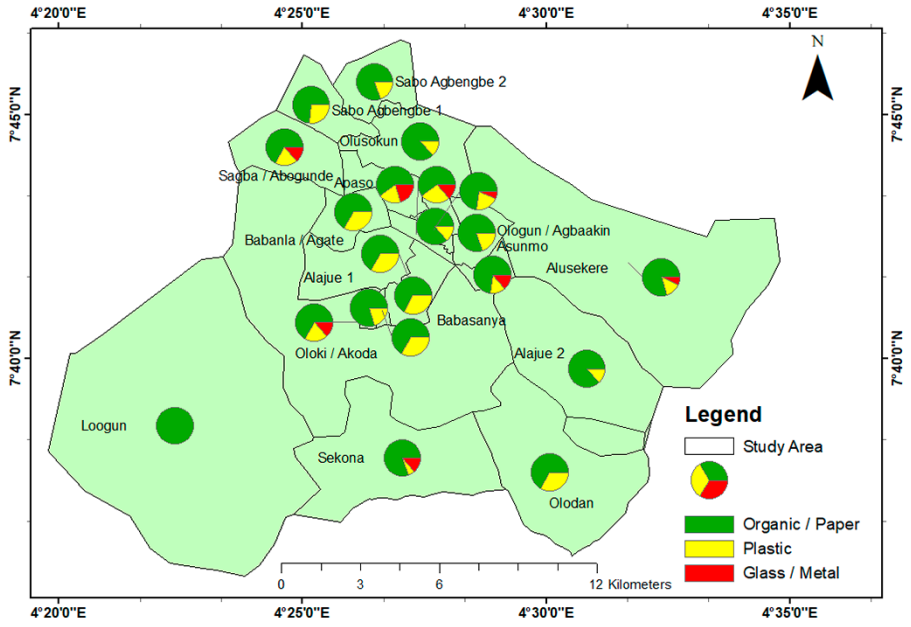

Figure 3. Distribution pattern of waste generation types across the political wards

gas emissions from landfills, and minimize public health risks linked to improper waste handling.

Ordinal Regression of Waste disposal methods on Waste disposal, health awareness and challenges

The analysis of the ordinal regression of waste disposal methods on various factors, including health awareness and challenges, reveals significant insights into the waste management practices in Ede and its environs. The results are discussed below, focusing on the interpretation of estimates and odds ratios and their implications on public health and waste management strategies.

The findings from this study offer critical insights into waste disposal behaviors and their determinants, contextualized within contemporary research on sustainable waste management. The strong preference for composting (OR = 13.343) and recycling (OR = 5.430) aligns with global shifts toward circular economies, where organic waste diversion and material recovery are prioritized to reduce landfill reliance (Kaza et al., 2018). The high odds for composting reflect growing recognition of its role in mitigating greenhouse gas emissions, as highlighted in a study linking organic waste management to a 47% reduction in methane emissions in urban areas (Chen et al., 2022; Manea et al., 2024). However, the lower odds for plastic

Table 3. Analysis of the ordinal regression

Parameter Estimates							
Variables	Categories	Estimate	Std. Error	Wald	df	Sig.	Odds Ratio (OR)
Threshold: Methods of waste disposal	By road side	-7.836	.927	71.450	1	.000	0.0004
	open space in the compound	-4.211	.703	35.916	1	.000	0.0148
	In rivers/stream	-2.047	.667	9.432	1	.002	0.1291
	Open burning	.243	.655	.137	1	.711	1.2751
	Public bin	.705	.659	1.146	1	.284	2.0238
	Recycling	1.692	.680	6.188	1	.013	5.4303
	Composting	2.591	.727	12.701	1	.000	13.3431
Waste Type	Organic/paper(Less harmful)	.036	.520	.005	1	.945	1.0367
	Plastic (harmful)	-.105	.557	.036	1	.850	0.9003
	Glass/Metal	0a			0		
What is your personal waste disposal assessment	Poor	-1.787	.271	43.468	1	.000	0.1675
	Fair	.557	.384	2.098	1	.147	1.7454
	Good	0a			0		

Parameter Estimates							
Variables	Categories	Estimate	Std. Error	Wald	df	Sig.	Odds Ratio (OR)
How often do you dispose of your household waste? How often do you dispose of your household waste	Monthly	-1.193	.761	2.456	1	.117	0.30331
	Bi-weekly	1.106	.555	3.972	1	.046	3.0222
	Weekly	.280	.234	1.430	1	.232	1.3231
	Daily	0a			0		
Are there any waste separation and recycling programs available in your community	No	.561	.262	4.599	1	.032	1.75242
	Yes	0a			0		
How satisfied are you with the waste management services privided in your community	Very dissatisfied	.098	.327	.090	1	.765	1.10296
	Dissatisfied	1.006	.468	4.620	1	.032	2.73464
	Satisfied	-.088	.563	.024	1	.876	0.91576
	Very Satisfied	0a			0		
How knowledgeable do you consider yourself about proper waste disposal practices	Not Knowledgeable	-.108	.475	.052	1	.820	0.897
	Not very knowledgeable	-.865	.389	4.958	1	.026	0.4211
	Somewhat knowledgeable	.178	.432	.169	1	.681	1.1948
	Very knowledgeable	0a			0		
Do you believe that the current waste disposal methods in your community are environmentally friendly	No	-.053	.257	.042	1	.837	0.9484
	Yes	0a			0		
Are there any challenges you face in managing household waste	Financial constraint	-9.025	1.017	78.737	1	.000	0.00012
	Insufficient waste disposal facilities	-2.702	.325	69.093	1	.000	0.0671
	Limited awareness about recycling options	-1.700	.284	35.829	1	.000	0.1827
	Lack of proper waste collection services	0a			0		
	No	-.449	.237	3.593	1	.058	0.63836
	Yes	0a			0		

waste management (OR = 0.900) mirror global challenges, with recent estimates suggesting only 9% of plastics are recycled globally, while 22% are mismanaged (d'Ambrières, 2019; OECD, 2022). This underscores the urgency of policies targeting plastic production and recycling infrastructure.

The persistence of open burning (OR = 1.275) despite health risks aligns with studies in low-resource settings where waste collection gaps force reliance on immediate, although harmful, solutions (Ferronato et al., 2021). For instance, a report by Cogut (2016) and Pathak et al. (2023) identified open burning as the source of 40% of airborne dioxins across the globe, exacerbating respiratory diseases. Similarly, river dumping (OR = 0.129) reflects systemic failures in waste infrastructure, a challenge amplified in coastal regions where 8 million tons of plastic enter oceans annually (Borrelle et al., 2020).

The modest use of public bins (OR = 2.024) compared to composting suggests infrastructure gaps, consistent with findings that 60% of urban residents in developing nations lack reliable waste collection (Kaza et al., 2018; Nepal et al., 2023). The preference for biweekly disposal (OR = 3.022) mirrors success in cities like Accra, Ghana, where tailored collection schedules improved compliance by 25% (Sarfo-Mensah et al., 2019). Severe financial constraints (OR = 0.00012) remain a critical barrier, echoing a 2023 global survey where 74% of municipalities cited funding shortages as the primary obstacle to waste management upgrades (Debrah et al., 2022; World Economic Forum, 2023).

The reduced likelihood of proper disposal among less knowledgeable respondents (OR = 0.421) underscores findings from Nigeria, where targeted digital campaigns increased recycling awareness (Osagwu & Nkamnebe, 2025). The marginal benefits of "somewhat knowledgeable" individuals (OR = 1.195) align with a 2021 behavioral study showing that even basic education can reduce contamination in recycling streams (Nurdin et al., 2023).

The preference for managing organic/paper waste (OR = 1.037) signals readiness for primary segregation, a strategy proven to reduce processing costs when paired with community training (Budihardjo et al., 2022). For example, Bandung City, Indonesia, achieved high waste diversion through neighborhood-level segregation programs (Lubis, 2018).

Conclusion

This study highlights the pressing challenges of waste management in Ede, Osun State, driven by rapid urbanization and limited infrastructure. Predominant reliance on environmentally detrimental disposal methods such as open burning and river dumping reflects a critical gap in sustainable practices. Financial constraints, insufficient facilities, and inadequate public awareness emerged as key barriers to effective waste management. The low adoption of recycling and composting practices suggests missed opportunities for mitigating waste impacts and fostering sustainability. Addressing these challenges requires a multifaceted approach, including community education, investment in waste management infrastructure, and policy reforms to promote sustainable practices. Global policy frameworks like the United Nations Sustainable Development Goals (SDGs) provide a critical roadmap for local municipalities to align their Municipal Solid Waste (MSW) management strategies with internationally recognized sustainability targets (Vaidya & Chatterji, 2020). By embedding SDGs into MSW management, municipalities can unlock resources, foster innovation, and contribute to a global sustainability agenda (Wang et al., 2018). This alignment not only addresses local challenges but also amplifies their role in achieving planetary health. Improved governance and active public engagement are essential for achieving environmentally friendly and health-conscious waste management solutions in Ede and similar urban settings. While this study provides valuable insights into waste management practices in Ede, several limitations should be acknowledged:

Limitations in this study reflected that while the study identifies infrastructure gaps and policy enforcement issues, it does not comprehensively assess the effectiveness of existing government regulations and waste management frameworks. Further research is needed to evaluate policy implementation and its impact on local waste management.

Although the study discusses the health risks associated with poor waste disposal, it does not include direct health assessments or epidemiological studies to measure the actual impact on community health. Future research could incorporate medical data to establish stronger links between waste disposal practices and health outcomes.

Addressing these limitations in future research could provide a more comprehensive understanding of waste management challenges and inform the development of more effective and sustainable waste management policies.

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Habits of Using Private Gardens and Green Spaces in Suburban Villages around Nitra

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KEYWORDS

- suburbanisation
- green infrastructure
- gardening
- attitudes of residents

ABSTRACT

The growth of suburbs alters the traditional villagescape due to increasing population and new housing developments. This not only affects the buildings but also alters the green spaces within the settlements. The amount of green space is decreasing as more densely populated developments are built. Additionally, most green spaces in villages are privately owned, with gardens making up the majority of these areas. Our study examines the attitudes of the population towards gardening and greening in four settlements near Nitra, Slovakia. Through questionnaires we explore how the attitudes of both newcomers and local residents differ and how this varies between the different settlements, to identify any differences in attitudes towards gardening.

Introduction

Central Europe's rural areas are undergoing a major transformation. The traditional rural way of life is in decline, and villages are becoming increasingly urbanised. This process is having a significant landscape-transforming impact on the entire rural space (Antrop, 2004). The majority of village dwellers work in the nearby cities and commute there. They do not have time in their daily routine to cultivate a traditional village-like garden. They are also less and less likely to produce their own food in the gardens. Svobodová et al. (2021) cite the work of several authors in their study that 10% of the population in Western Europe and 35-60% in post-socialist countries are engaged in some form of self-provisioning food production. Obviously, there is a wide variation between types of settlement and between the habits of different countries. In any case, the last decade and a half has seen a radical change in this respect. The size, share, and types of green areas on residential plots have apparently altered. This process is particularly intense in the suburban areas of our cities. Expanding residential and other built-up areas are usually created by the development of valuable

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agricultural land (Johnson, 2001). This is indeed an important, widely researched environmental impact of suburbanisation (Bürgi et al., 2017; EEA, 2006, 2016; Hardi et al., 2020; Hlaváček et al., 2019; Izakovičová et al., 2021; Kahn, 2000; Lennert et al., 2020; Repaská et al., 2017). Our study, however, focuses on the loss and change of the greens in the interior of residential areas.

In urbanised regions, green areas, green fields, parks, etc., are of decisive importance as they can improve the quality of human life, help adaptation to climate change, and generally provide several natural services for the residents: microclimate regulation, drainage, biodiversity, habitats, interconnected green corridors (Haladová & Petrovič, 2015; Izakovičová et al., 2017; Lennert et al., 2020; Zhou et al., 2022). That is why the term "green infrastructure" has emerged over the last decades. The quality and quantity of these services are dependent on the quality of the green infrastructure management. In cities and city centres, the management of green spaces is mainly in the hands of municipalities (parks, urban forests, green belts, etc.) (Bobáľová et al., 2024) or other public bodies. In the fast-growing suburbs, garden cities, and exurbs, the green infrastructure is provided mainly by the private gardens and green fields owned by the residents. It is, therefore, very important to know how the population manages its gardens and how the immigrating population and suburbanisation, in general, are transforming gardening habits (Cameron et al., 2012; Mahmoudi Farahani et al., 2018; Warhurst et al., 2014).

Our study investigates the attitudes of the population towards gardening in suburban settlements around Nitra (Slovakia). Through questionnaires, we measured the extent to which the attitudes of the population towards gardening, the green spaces on plots of land are moving towards a developed municipal green space and the extent to which the habits of new residents of suburban settlements differ from those of local residents.

The impact of suburbanisation on the transformation of green spaces in residential areas

In Central Europe, suburbanisation, i.e. the migration of urban residents and urban functions to nearby settlements, typically accelerated after the turn of the millennium (Antrop, 2004; Ehrlich et al., 2012). This triggered rapid growth first around capital cities and then also around smaller towns, where peri-urban villages were transformed into suburban settlements (Bürgi et al., 2017; EEA, 2006, 2016; Izakovičová et al., 2021; Lennert et al., 2020; Repaská et al., 2017; Taubenböck et al., 2019). This transformation does not only mean an increase in population but also a change in the structure of the settlement due to the increase in built-up areas (Hirt, 2012; Kazakov et al., 2024; Kovács, 2014), with smaller and smaller residential plots and denser built-up areas. In essence, the settlement landscape itself is changing from a traditional rural settlement to an urbanised suburb (Haase & Nuissl, 2007; Haladová & Petrovič, 2015; Hills, 1994; Izakovičová et al., 2017; Kubeš, 2015; Lennert et al., 2020).

Traditional peasant plots of up to several thousand square metres are being converted into plots of 600 to 1,500 square metres, and the newly created residential plots maybe even smaller. Obviously, most of these plots are occupied (Kubeš, 2015) by houses and associated buildings, but some of the remaining areas are also paved, as space is needed for cars (Warhurst et al., 2014). This has a number of environmental impacts. There is a significant reduction in the proportion of green space in residential areas and an increase in the extent and proportion of impervious surfaces, thus reducing the infiltration of rainwater into the soil and consequently increasing the proportion and volume of water run-off on the surface.

The last two to three decades have seen a major change in the nature of green spaces in our peri-urban villages. The traditional village lifestyle has been replaced by an urban lifestyle. On the one hand, this means that gardening is no longer one of the main activities of the inhabitants, many of whom cannot even devote time to it because of their commuting lifestyle. Most food is now more economical to buy than to grow at home. On the other hand, the size of residential plots is getting smaller and smaller, so there is less and less space available for gardening (Hall, 2010). In addition, the number of cars is increasing, with the highest number of cars in these settlements (4-500 cars per thousand inhabitants). The storage and moving of cars also takes up space, either in residential or public areas. Thus, it is typical of the population of the suburbs that the majority tries to maintain as simple a green space as possible, with a mown lawn, a few shrubs, hedges and a lot of paved surfaces. The ecological value of these green spaces is extremely low. At the same time, the people who move out often include owners who are pursuing their hobbies in their new homes. We often see special gardens with exotic plants, and the owners also use the public space in front of the house for decoration. Less often, we also see innovators introducing new types of food production using different organic gardening methods (Gangopadhyay & Balooni, 2012; Russo et al., 2017).

The aim is obviously not to market benefits but to provide the family with better quality, healthier food (Svobodová et al, 2021). In short, according to the urban ecology literature, moving outwards along the urban-rural gradient, the highest biodiversity is found in the suburbs, but it is also where the most significant environmental impacts are experienced (Forman, 2008). At the same time, it is important to see that urban dwellers who move out during suburbanisation often change their place of residence because they want to have their own garden or green space, but once settled, real life

will, of course, determine what becomes a reality. The extent and size of green spaces within settlements is important. The larger the green space, the greater the positive impact on microclimate (Graffigna et al., 2023; Liu et al., 2019; Matthews et al., 2015). In this respect, large, mature trees, extensive shrubs and hedges are the most valuable. Their placement requires awareness, as shading them can save significant amounts of energy (less air conditioning operation). They provide shade and evaporation while providing habitat for a wide range of organisms (Lagucki et al., 2017). The lowest ecological value is found in mown, single-species lawns. However, they are, of course, better than paved surfaces, which prevent rainwater infiltration. These gardens contribute to biodiversity in many ways. On the one hand, the varieties planted, as people prefer many, often exotic, species (Čepelová & Münzbergová, 2012). This becomes a problem when these include invasive species that, if released from the garden (most often through inappropriate disposal of green waste (Csontos et al., 2020)), can cause damage in natural or semi-natural environments close to the suburbs.

Biodiversity is also affected by the way the garden is managed, whether the owner creates an environment that is bird-friendly or insect-friendly. The connectivity of green spaces can also be an important factor. Interconnected green spaces (e.g. hedgerows, adjacent trees, shrub areas) can increase the size and thus the impact of a connected green space and can also create municipal-level eco-corridors, green belts and networks (Cameron et al., 2012; Forman, 2008). These can multiply the value of green spaces. In the suburbs, this can only be achieved with the involvement of the population since they manage most of the green spaces (Byrne et al., 2015).

Data and method

Description of the study area: suburban zone of Nitra city – the settlements examined

The suburban zone of the city of Nitra currently consists of 15 rural municipalities (Figure 1). In these municipalities, the share of immigration from the city of Nitra in the total number of immigrants is higher than the share of immigrants from other directions. The spatial growth of the city and its expansion into the suburban landscape is a long-term process of the city's development from its inception to the present. In the suburban zone of Nitra, new residential complexes are growing up, and new streets and localities with new construction of family houses are being created (Gajdoš & Moravanská, 2013; Haladová & Petrovič, 2015; Hardi et al., 2020; Repaská, 2012; Repaská et al., 2017). Residential suburbanisation in the area around Nitra does not achieve comparable proportions to the cities of Western Europe or the large Slovak cities of Bratislava and Košice (Baj, 2010; Bobáľová et al., 2024; Czaková, 2010; Izakovičová et al., 2017, 2021; Slavík et al., 2011), but from a qualitative point of view, it brings changes in the system of settlement and land use that are irreversible.

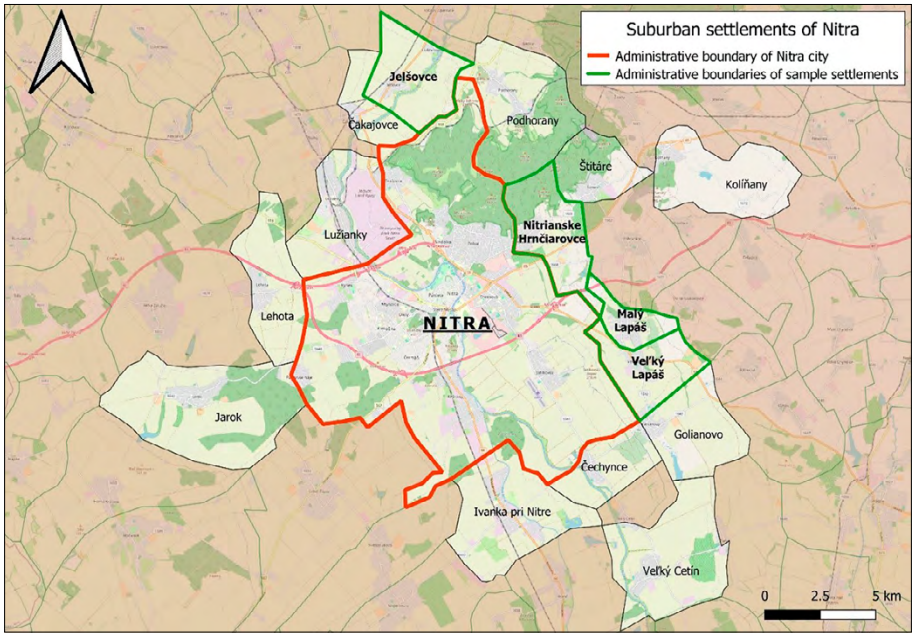

Figure 1. Suburban settlements of Nitra city (the sample settlements are highlighted)
Source: Authors based on OpenStreetMap using QGIS

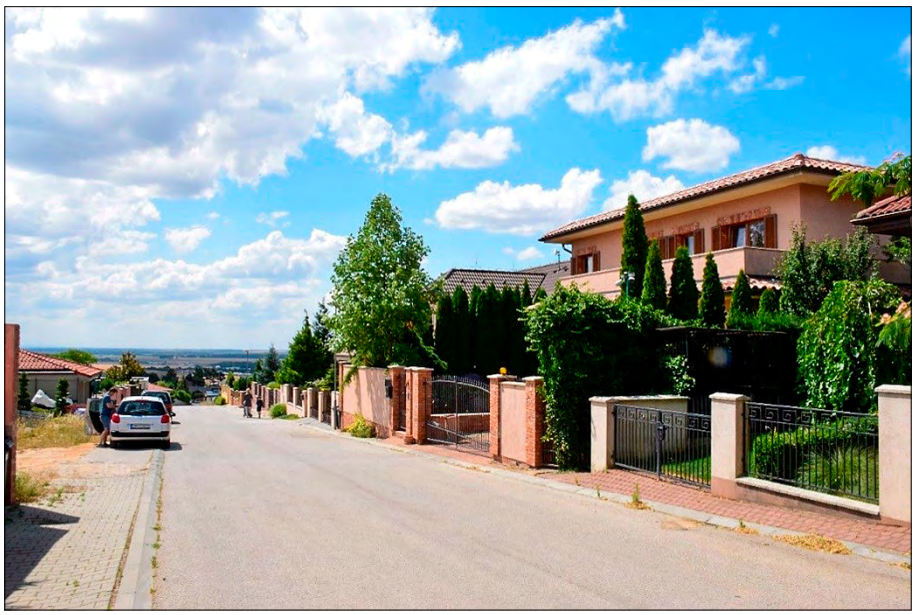

Figure 2. Higher prestige residences under Mount Zobor (Nitrianske Hrnčiarovce)
Source: Hardi T.

The village of Nitrianske Hrnčiarovce is the only one among all three villages located under the Zobor hill, which significantly increases its attractiveness. The share of migrants from the city of Nitra in the total number of migrants of the municipality averaged 70 % in the period 2001 - 2022. New locations of family and apartment houses were built in the municipality. The number of inhabitants is growing significantly, the municipality is one of the large municipalities with over 2000 inhabitants.

The municipalities Veľký and Malý Lapáš are neighbouring municipalities, which also intersect each other. Since they were one municipality called Lapáš until 1990, their buildings have common features. Suburbanisation started in these municipalities later, but has taken on significant proportions. The municipality Malý Lapáš is typical of all the municipalities in that old houses have been significantly revitalised and new houses are being built mostly on unused land between the old buildings. Later, new construction was built on vacant land in the northern part of the village, which the municipality gradually incorporated into its urban area. In Veľký Lapáš, suburbanisation began along the main transport route between Nitra - Vráble - Levice, but also on the 3rd class road between Veľký Lapáš and Golianovo. The location of the municipal-

Figure 3. Family houses on the edge of the forest (Malý Lapáš)
Source: Hardi T.

Figure 4. Small plots, dense development (Veľký Lapáš)
Source: Hardi T.

ity on the route Nitra - Vráble gives the inhabitants of the municipality the possibility of quick access not only to Nitra but also to the industrial town of Vráble.

Municipality Jelšovce belongs to the smaller municipalities of the suburban zone. It is exceptional among the three selected municipalities in that it represents a typical rural development with only detached houses, with which it wishes to preserve its rural character. It is attractive to migrants because of its proximity to the Jaguar Land Rover Industrial Park. It has good transport accessibility thanks to the R1 expressway which also allows residents access to Trnava or the Slovak capital Bratislava.

In the village of Veľký Lapáš, residents have the opportunity to build on a minimum of 600 m^2 of land, with a maximum buildable area of 30%. The remaining 70% of the land is green land. However, the inhabitants of the municipality do not respect these parameters as they build garden sheds or gazebos. The situation is similar in Malý Lapáš, Jelšovce and Nitrianske Hrnčiarovce; the difference is only in the minimum land area, which is 400 m^2 in these municipalities. The maximum number of storeys in the villages is two; the only exception is the village of Jelšovce, which is not interested in building so-called apartment buildings and is trying to preserve the character of the rural environment. In the municipalities, different properties are available, which developers sell to interested persons, or they build turnkey houses on them and sell them for private ownership.

Table 1. Main characteristics of the sample settlements

Indicator	Nitrianske Hrnčiarovce	Jelšovce	Velký Lapáš	Malý Lapáš
Population (2022)	2393	986	2052	1492
index of population growth (2001/2022)	43,0	3,1	82,4	323,9
average number of immigrants (2001-2022)	65	22	56	48
of which from Nitra (2001-2022)	44	11	32	30
of which from Nitra (2001-2022) in %	67,7	50,0	57,1	62,5
number of households (2022)	952	392	770	470
housing growth index (2001/2022) in %	44,9	9,5	90,1	282,1
area of the municipality (km^2)	9,95	10,44	8,16	3,22
distance from the centre (minutes by car)	15	10	13	13
distance from centre (km)	14	5	10	10
average plot size (m2)	800	600	650	750
land use changes	permanent grassland, forest land	arable land	arable land	permanent grassland, arable land

Source: Statistical Office of the Slovak Republic, own calculations

Residential suburbanization is also affecting the natural environment of the municipality, altering its greenery. Some municipalities now have their own local documents - general binding regulations - which allow them to regulate negative impacts on green spaces. At the same time, all municipalities have their own spatial plan.

Among the above-mentioned municipalities, a significant loss of forest, vineyards and meadows occurred in the municipality of Nitrianske Hrnčiarovce, where the mass construction of family houses was built in the above-mentioned areas. In the other municipalities of the suburban zone of Nitra, the affected land was arable land; in the vineyards there can only be garden houses (Veľký and Malý Lapáš).

One of the most frequent conflicts between citizens and local authorities is about parking in the municipality. Residents park their cars in front of their own houses or fences but on communal roads or plots of land. The municipalities of Malý and Veľký Lapáš also have a generally binding regulation on the parking of vehicles in public spaces, but in the other municipalities, this regulation is absent. According to this regulation, residents can only park in public parking spaces in the municipality; it is not possible to park in local communications, public green spaces, and sidewalks. This regulation is not respected by all residents, mainly because residents are unaware of the regulation or short-term parking in the said area, etc. Parking on public roads is a problem, especially in winter, when it is impossible to clear the snow on the road, which is solved by the municipality.

The municipality takes care of the village's greenery by mowing and planting new trees. The mayors agreed that mowing is very time-consuming. Therefore, they concentrate on mowing in playgrounds (children's playgrounds, football fields), cemeteries, church yards, and parks. Between residents' private fences and the public road, the municipality staff rarely mows; mostly, the residents of the municipality clean it up themselves or do not care at all. In the public areas near residents' houses, residents are not allowed to plant trees or plant shrubs, as the land does not belong to them.

With regard to the planting of new trees, the leaders of all the municipalities were in favour of enriching the municipal green spaces. In Veľký Lapáš, the municipality has planted 64 new trees (mostly maple lime) in Jelšovce 36 new trees (mostly ash), with plans to plant another 130 in the newly created park. In the village of Nitrianske Hrnčiarovce, mainly lime trees have been planted to replace poplars, and in the village of Malý Lapáš, old trees are also being replaced by new ones. By planting new trees, the municipality is also resolving conflicts in the municipality, as the inhabitants of the villages tend to complain about the trees that cause allergies to the inhabitants. The municipalities are replacing them with other trees. Municipalities do not have general binding regulations on what type of greenery they can plant. They are mostly standard hedges in the form of honeysuckle, bird's-beak and yews. Invasive species are not planted by people, nor do they have any knowledge of this type of plant.

With regard to fruit trees, the immigrant residents planted mostly columnar forms of fruit trees in low numbers. Their gardens are mainly dominated by ornamental plants, with some cash crops grown in plant beds. The fences of the inhabitants mostly extend up to 2 meters, despite the fact that the inhabitants do not have restrictions on fence construction. Higher fences can only be on the frequented road in the municipality of Veľký Lapáš. Complaints from inhabitants of the municipality are also directed at falling branches or leaves from trees on neighbouring properties. The municipality assesses the adequacy of the complaint, which it resolves either by consulting the actors and asking for the disposal of these branches and leaves or by not upholding the complaint (e.g. if family houses are built in the forest protection zone). The municipality of Nitrianske Hrnčiarovce also deals with vegetation on private land if citizens request it.

Due to the construction of new roads and the concreting of private land, there is a problem with stormwater drainage. Citizens tend to include ditches that drain rainwater. In villages, they can do this, but they have to maintain a channel under the concrete to allow the water to drain away. They are then able to park on the concrete. The municipality of Malý Lapáš is problematic in this respect, as there are no ditches, and rainwater runs down the roads. The inhabitants of the villages, mostly householders, collect rainwater in collecting containers, which they then use for watering. Residents who have moved in have a drainage pit on their land, into which they have runnels and thus drain the rainwater. Drainage of rainwater to the road is not allowed in the villages. The study villages of the suburban zone have plans to construct dry polders to catch the rainfall.

Characteristics of the sample

The sample covers the three settlements with an equal number of cases, with an adequate representation of different types of residential areas (traditional and newly built). Total number of valid items is 153, with households as basic units of analysis. Since selection principle was the equal number per municipality, there was no need to weight the sample. Due to the limited number of cases in the sample, the study is not suitable for drawing generalisable conclusions that can be applied to the entire Nitra agglomeration. However, the selected villages represent the different types of suburban settlements. Nitrianske Hrnčiarovce is a partially urbanising municipality that is also spatially merging with the city; Lapáš is a municipality with classical processes of suburbanisation and Jelšovce

is a municipality characterised as a transition between the suburban and rural zones. Also, with regard to the number of sample elements, it is important to note that the analyses that can be performed are predominantly descriptive, and the conclusions that can be drawn on the basis of statistical significance are limited to simple segmentation (villager-settler dichotomy).

Almost half of the respondents not lived in the municipality since birth; the proportion of settlers[1] is close to 40%. There is some variation in this respect between the three municipalities, with the highest proportion of settlers in Lapáš. Regarding type of suburbanisation, the effect of distance is evident; proportion of people moving out of Nitra decreases outwards (Table 2).

Examining the socio-economic status of households was important in order to investigate its impact on attitudes. The status index is composed of three items (subjective perception of financial situation, person with higher education in the household, car ownership). The zonal character is clearly visible by the items one-by-one; the most favourable indicators are found in Nitrianske Hrnčiarovce, which is considered to be the most suburban municipality (Table 3). This trend is even more evident by the values of the aggregate index (Figure 5).

Another important question is the difference in socio-economic status between original villager and settler households. Overall, the higher status of settlers is well reflected, with their status index being significantly higher than that of original villagers in all three settlements (Figure 6). Average age of the settler households (35.6 years) is significantly lower than that of the original villager households (44.8 years).

Table 2. Distribution of the sample by migration patterns (%)

	Lives there from birth	Moved to settlement		Moved from Nitra
		Anytime	After 2000	
Jelšovce	61.7	38.3	29.8	50.0
Lapáš	42.9	57.1	50.0	65.5
N. Hrnčiarovce	62.0	38.0	34.0	70.6
altogether	54.9	45.1	38.6	62.7

Table 3. Individual elements of socio-economic index, % of households

	financial situation			tertiary degree	have car
	well-off	average	poor		
Jelšovce	40.4	36.2	23.4	53.2	95.7
Lapáš	46.4	41.1	12.5	32.1	84.3
N. Hrnčiarovce	64.0	32.0	4.0	74.0	94.0
altogether	50.3	36.6	13.1	52.3	91.2

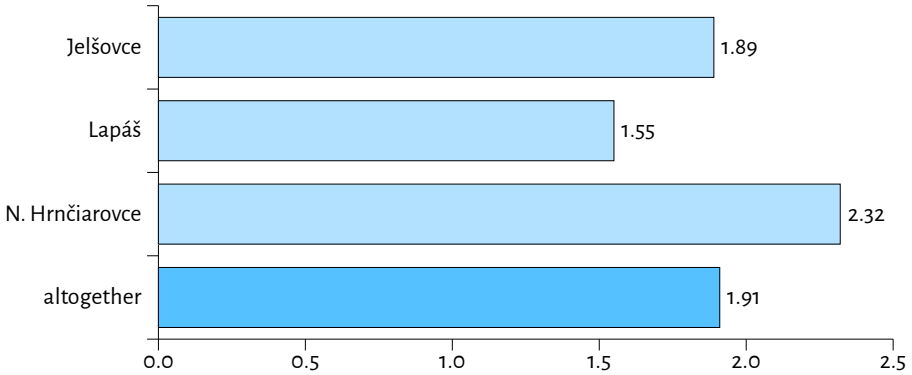

Figure 5. Average values of composite socio-economic indicator

[1] In the analysis, we refer to those who moved to the settlement after 2000 as settlers, those who have lived in the settlement since birth and those who moved there before 2000 as original villagers.

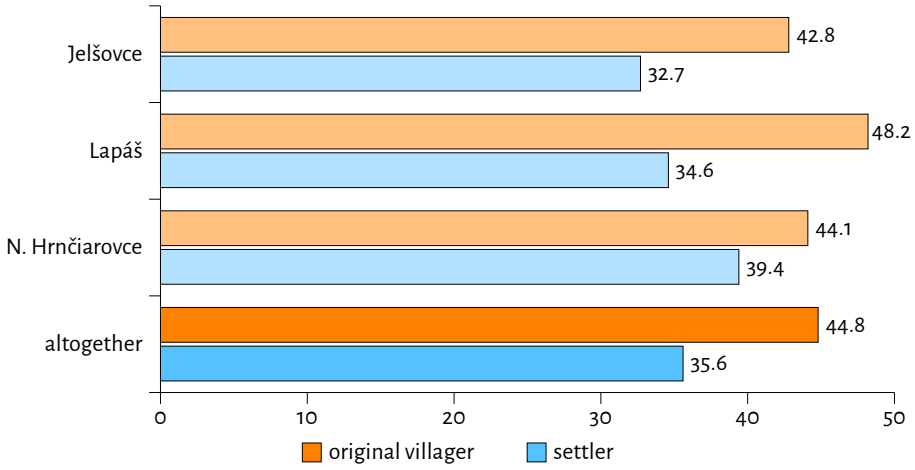

Figure 6. Proportion of households with high socio-economic status, %

Results

Motivations for move, evaluation of settlement

We looked at motivations of settlers for moving from three perspectives: in addition to the choice of settlement and plot, we also looked at how they valued the different characteristics of the settlement, with a particular focus on factors related to natural environment and green spaces.

Nitrianske Hrnčiarovce stands out in the case of differences between settlements in terms of motivational factors, where, with the exception of housing costs (their role is negligible here), the answers for the other factors were almost unanimous in that they were considered very important by the respondents (Table 4). Motivational factors can be divided into two groups based on whether they primarily reflect on the infrastructure or the environment. In the case of the two groups of factors, it can be said that importance attributed to "green" factors is slightly higher. In the case of the settlements, the difference between the evaluations of the factor groups is similar, and the gap that also characterized Nitrianske Hrnčiarovce in the case of the individual factors can be also seen (Figure 7).

Nitrianske Hrnčiarovce is also different by settlement selection factors; the picture is more polarized here compared to the agglomeration in general; factors related to the environment were considered important by everyone, while other factors (infrastructure, costs) have lower mention rate than of other settlements (Table 5).

Table 4. Motivations for move based on the proportion of those who consider the given factor to play a key role (%)

	Jelšovce	Lapáš	N. Hrnčiarovce	altogether
better quality of home	33.3	46.7	94.7	56.7
bigger house/flat	55.6	50.0	94.7	64.6
bigger plot	61.1	65.5	89.5	71.2
own garden	72.2	59.4	84.2	69.6
own green space	77.8	64.3	94.7	76.9
silence	27.8	46.9	100.0	56.5
natural environment	27.8	53.3	100.0	59.7
lower housing costs	22.2	17.9	10.5	16.9

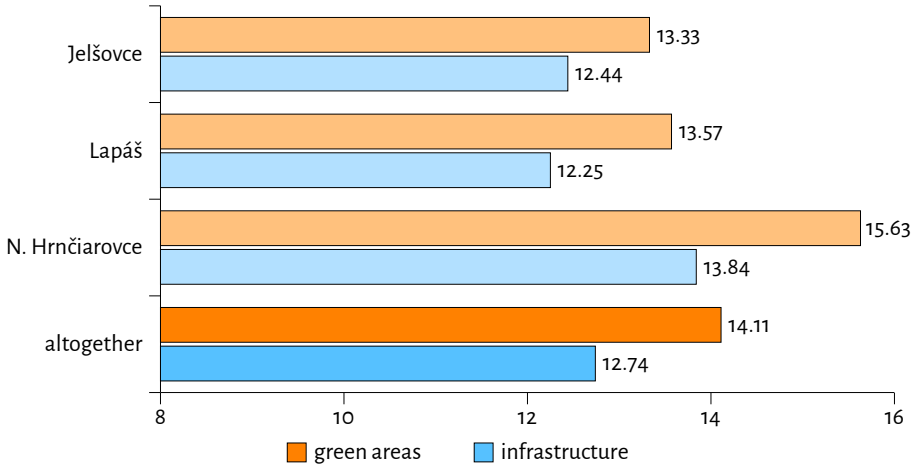

Figure 7. Average scores of merged motivational factors

Table 5. Factors of settlement selection, mention rates (%)

	Jelšovce	Lapáš	N. Hrnčiarovce	altogether
accessibility	77.8	56.3	52.6	60.9
property prices	88.9	65.6	10.5	56.5
family bond	27.8	28.1	5.3	21.7
village/street view	83.3	75.0	100.0	84.1
lots of green space	88.9	59.4	100.0	78.3
village atmosphere	88.9	65.6	100.0	81.2
urban character	5.5	9.4	0.0	5.8
good infrastructure	22.2	46.9	31.6	36.2
high prestige	5.6	37.5	94.7	44.9
natural environment	94.4	62.5	100.0	81.2
quality of life	94.4	71.9	100.0	85.5
living costs	61.1	59.4	21.1	49.3

Regarding whether respondents moved from Nitra or elsewhere, we can find significant differences by several factors. Among those who moved from Nitra, a significantly higher proportion mentioned rural character, village atmosphere and prestigious living environment, but adequate real estate prices and lower living costs played a lesser role for them. In terms of satisfaction with the settlement, Nitrianske Hrnčiarovce stands out, all factors have the most positive evaluation here (Table 6).

Table 6. Satisfaction with settlement, average score

	Jelšovce	Lapáš	N. Hrnčiarovce	altogether
quantity of green space	2.87	2.73	3.28	2.95
quality of green space	2.68	2.85	3.24	2.92
green space management	2.53	2.46	3.09	2.68
natural environment	3.06	2.98	3.91	3.30
tranquility	2.79	2.98	3.85	3.19
infrastructure	2.49	2.57	3.20	2.74
accessibility	2.74	2.78	3.26	2.92
services	1.83	2.09	3.24	2.38
leisure opportunities	1.96	2.45	3.72	2.69
townscape	2.70	2.96	3.98	3.20

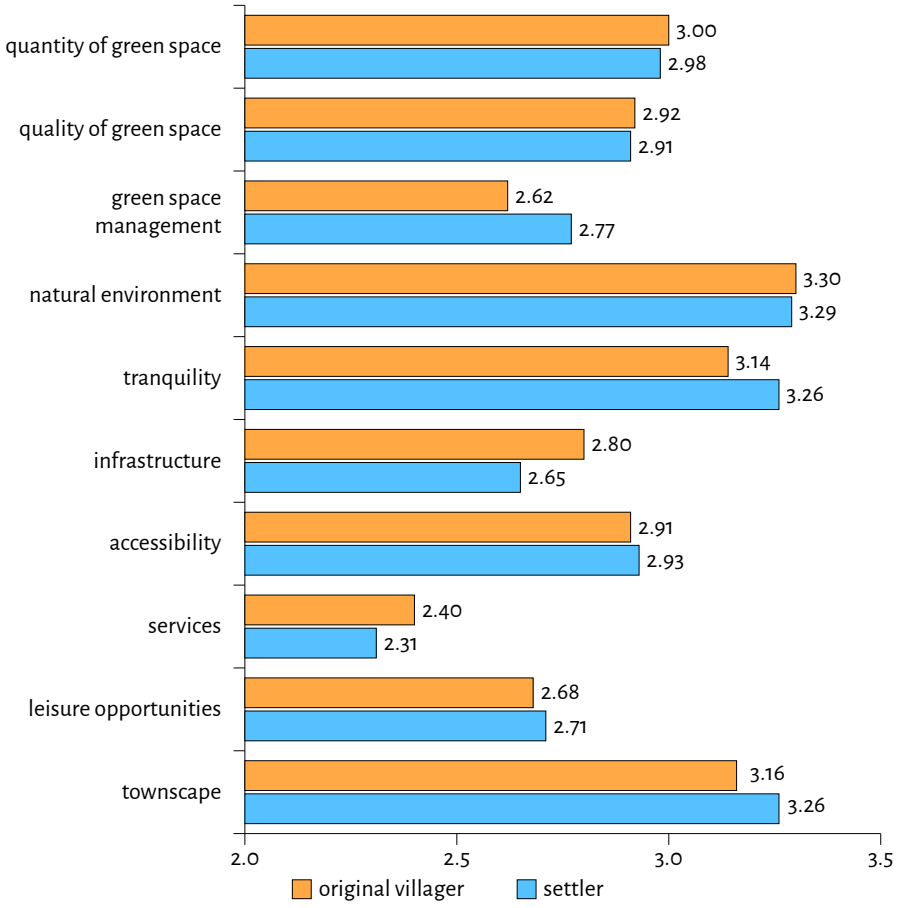

Figure 8. Satisfaction scores among original villagers and settlers

There are no significant differences in the assessment of the characteristics of the settlement between the original villagers and settlers, all that can be said is that among the settlers, the management of green areas, tranquillity, and the image of the settlement receive a slightly more favourable evaluation, while infrastructure and services are evaluated less favourably (Figure 8).

Regarding the selection of plot, it should be emphasized that the 'close to nature' factors, such as beauty of the landscape, proximity of natural areas, as well as the village-scape and atmosphere, played a particularly important role in moving.

Management of green spaces

Of the households interviewed, the vast majority (95%) have a house standing on an independent plot. Average plot is 1,158 square meters, and it is interesting to note that the smallest average size is characteristic of Jelšovce, which is farthest from Nitra. Difference between the three settlements - regardless of the difference in plot sizes - is primarily shown in the fact that the proportion of green space is much lower in Nitrianske Hrnčiarovce and the proportion of uncultivated land is much higher (Table 7).

Attitudes related to green spaces were examined primarily through expectations. Based on the importance of the various factors, differences between original villagers and settlers, as well as between settlements, can be examined. There are certain differences between the structure of factors considered important by original villagers and settlers. While factors related to the preservation of the environment and biodiversity (providing habitat, increasing green space, etc.) and production for supply of

Table 7. Size of plots and land use characteristics

	Size of plot	Ratio, %				
		built-up	green area	lawn	gravel	uncultivated
Jelšovce	900	15.5	51.0	14.0	1.7	7.8
Lapáš	1 050	19.2	52.8	9.1	1.3	3.5
N. Hrnčiarovce	1 515	19.3	34.1	6.6	2.3	21.8
altogether	1 158	19.4	46.1	9.8	1.8	10.8

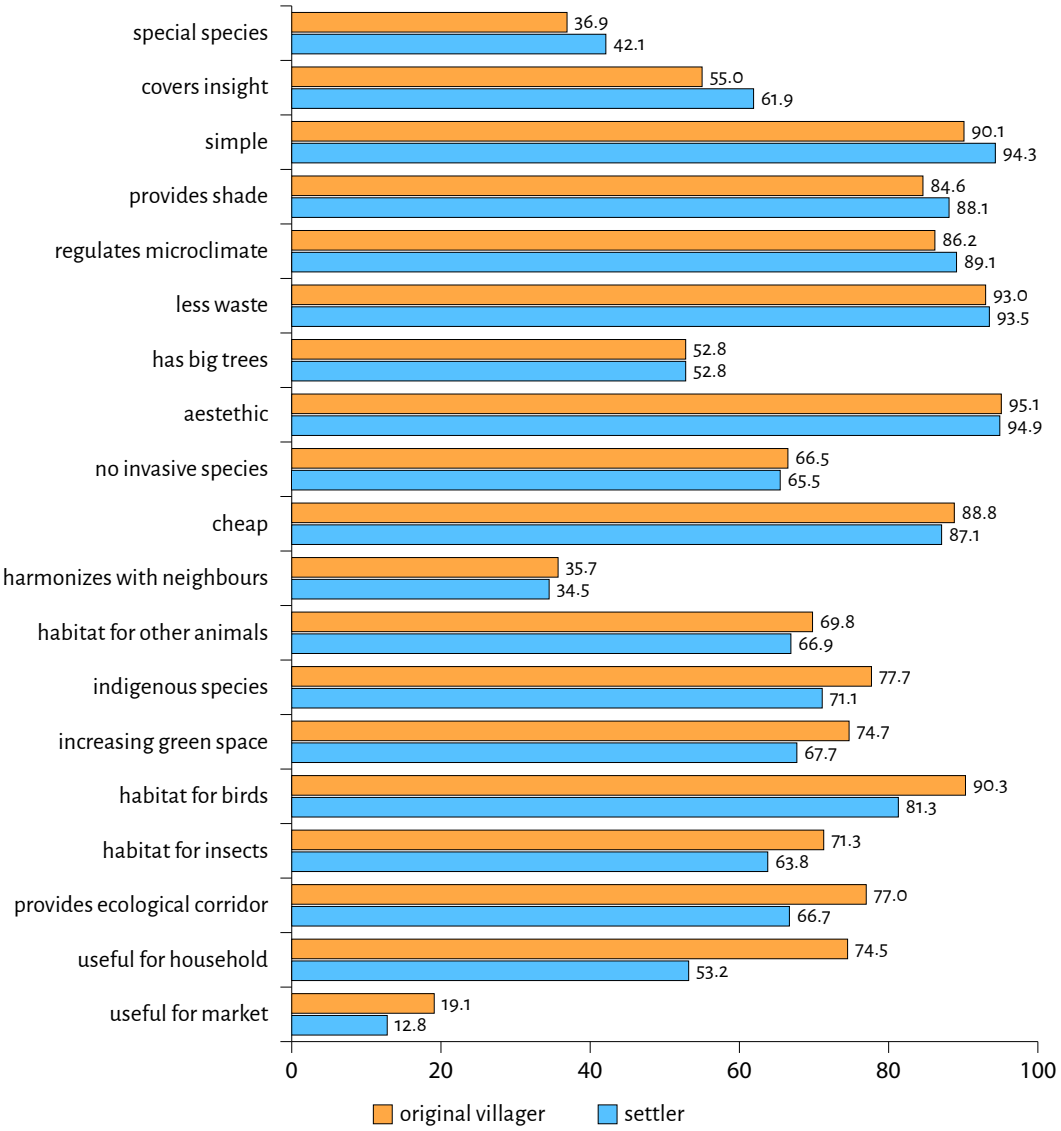

Figure 9. Assessment of factors deemed important among original villagers and settlers, mention rates (%)

households are considered more important for the original villagers, settlers mentioned only two factors in a significantly higher proportion; presence of special plant species, and that the design of the green areas harmonizes with neighbours (Figure 9).

Regarding differences in the importance of the factors between settlements, some factors correspond to the zonal structure. Moving from outside to inside, importance and presence of special species and covering of insight are clearly increasing, while as we move further from the city, utility for the household, increase of green space and provision of ecological corridor is more important (Figure 10).

Attitudes belonging to the listed factors were also examined in the form of thematic indices of six dimensions (utility, ecological awareness, convenience, biodiversity, native species, climate awareness). We computed variables based on factor scores, and also dichotomous variables for each dimension, indicating whether the respondent is generally characterized by compliance with the content of the given dimension. No significant differences can be found between settlers and villagers, except convenience, which is significantly more important for settlers. Differences between settlements are significant, with the exception of convenience and climate awareness, but directions are different. While Nitrianske Hrnčiarovce stands out in terms of biodiversity and the preference for native species, the situation is reversed in terms of usefulness and ecological awareness (Figure 11).

Regarding types of plants and cultivation of gardens, significant differences appear between villagers and settlers. In general, it can be said that the prevalence of different varieties and types of cultivation is higher in the case of villagers (lawn is the only exception to this, but the difference is not significant). Biggest differences in favour

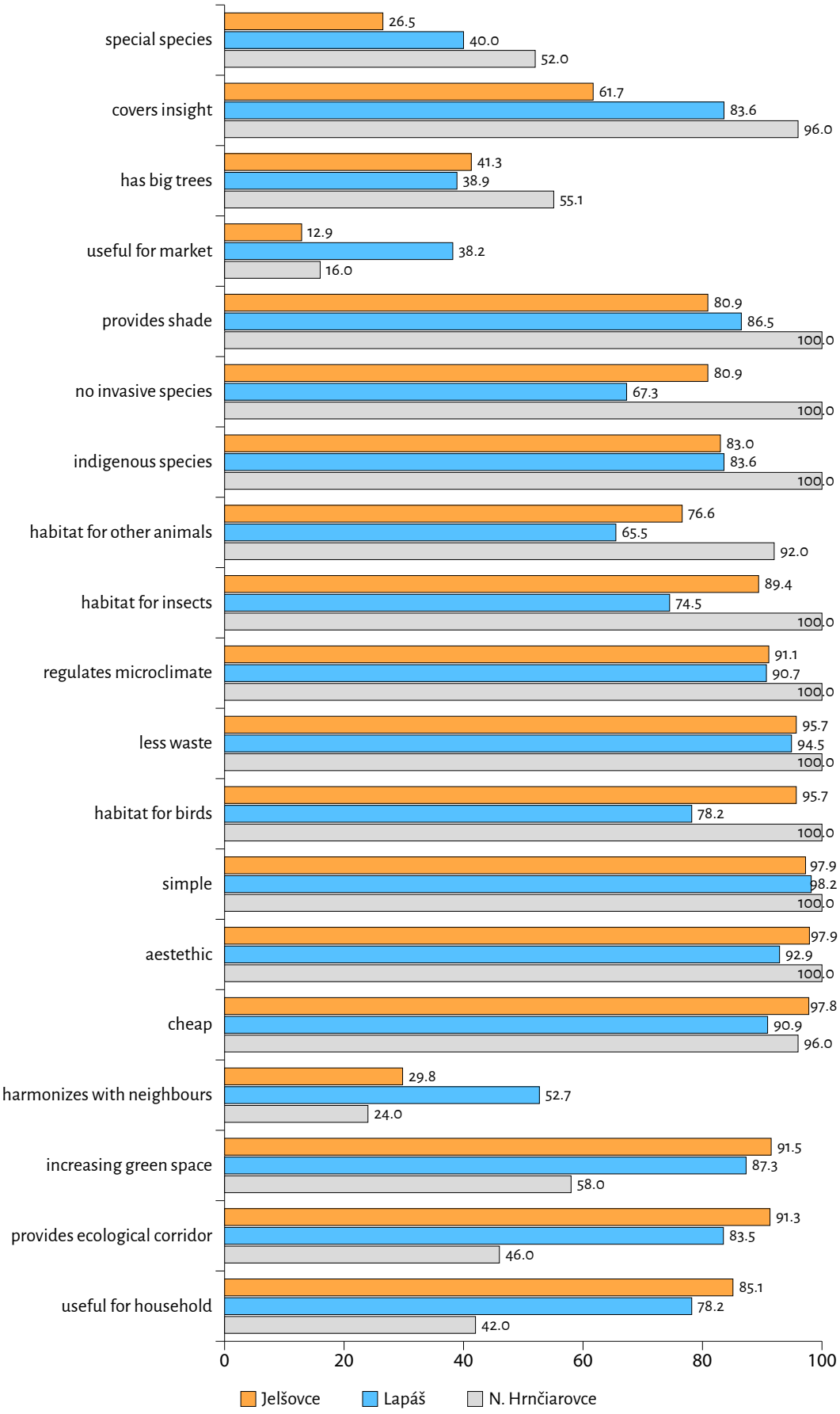

Figure 10. Assessment of factors deemed important by settlement, mention rates (%)

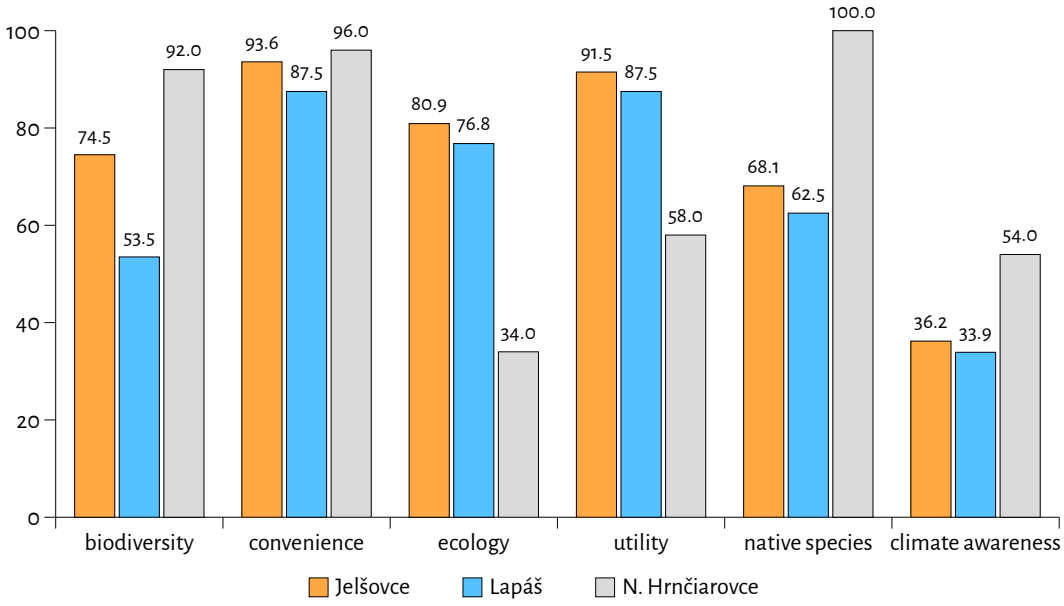

Figure 11. Differences between settlements based on the complex dimensions

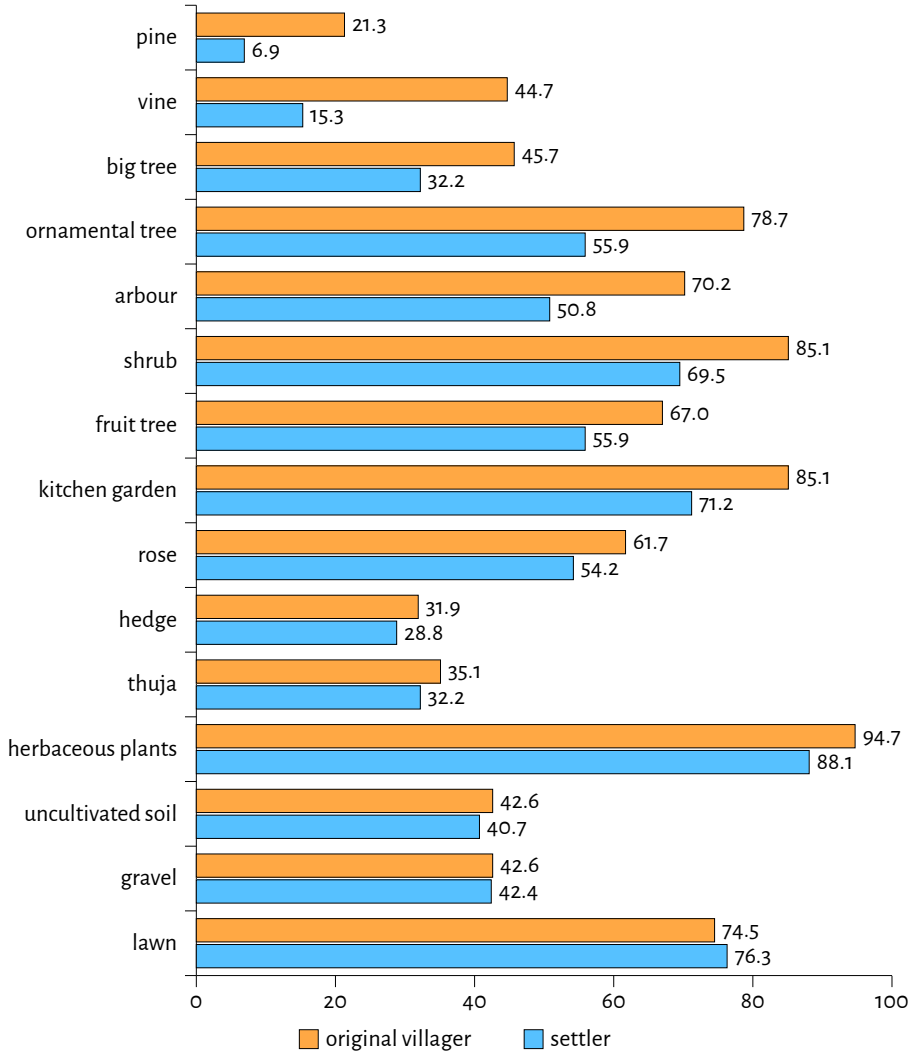

Figure 12. Presence of plant species and types of cultivation among original villagers and settlers (%)

of the original villagers are shown in the case of different trees and types that require a significant amount of care (vineyard, kitchen garden) (Figure 12). This also shows that villagers' gardens have a higher degree of biodiversity in general.

The qualitative dimension of the research, which was realized in the selected municipalities in the form of a questionnaire with the inhabitants, was complemented by interviews with the representatives of the individual municipalities. Based on the results of the interviews with the mayors, it can be concluded that all the representatives of the individual municipalities are introducing measures to regulate the negative impact of the residents on the green spaces and to enrich the municipalities with additional green spaces. Despite the fact that suburbanisation has reached significant proportions in the municipalities surveyed and has reduced the proportion of green spaces in the municipalities, all municipalities are taking the approach of planting new trees to replace damaged or allergy-causing trees. The attitude of the population towards green spaces varies according to the survey, and at first glance there are obvious differences between the different social groups of the population, as well as between the old settlers and the immigrants. While the old settlers prefer traditional fruit and vegetable cultivation, the immigrant population prefers ornamental gardens. In the higher income communities, spectacular and special gardens are also noticeable, with exotic trees, paved areas for cars and a swimming pool. Ornamental gardens with smaller usable areas are built in middle-income communities. According to interviews with mayors, this type of garden dominates in newly built sites, where owners plant hedges, columnar fruit trees, and shrubs that are not demanding in terms of soil composition and climatic conditions. Although traditional crop cultivation is gradually disappearing, the mayors agreed that the design of the individual gardens in the newly developed sites is harmonious within the neighbourhood, beautifies the village and the hedges have a beneficial effect on the microclimate. However, with different planting there are also conflicts between residents with each other and between residents and the village government. The mayors pointed out the most common problems. One of the main problems was mostly related to branches and leaves falling on neighbouring plots. Municipal officials consider each complaint individually, dealing with it mainly by asking for the disposal of these branches and leaves, or rejecting the complaint (e.g. if family houses are built in the forest protection zone). The other problem is parking in public spaces. The mayors agreed that residents should park on their own land in the first place, or then in constructed car parks, but never on grass areas. Some municipalities have drawn up a general binding regulations for the above. In those municipalities where there is no such regulation, the mayor's plan to draw one up in the near future. According to the mayors, one of the other major problems in the municipality is the care of the greenery between the public road and the residents' fences. This is a public space and belongs to the municipality. The vast majority of residents do not take care of this piece of green space as they do not own it. The mayors agreed that mowing is very time-consuming, and they do not have enough staff and equipment to cover the mowing of these areas. They concentrate on mowing playgrounds, cemeteries, parks or green areas located along the main road. These smaller areas are left unmowed, and residents are advised to groom them so as not to detract from the overall ornamental impression of the individual streets and locations in the municipalities.

Discussion

The results from our survey indicate that suburbanization is significantly changing the landscape and green spaces in settlements. It affects both their size and quality. As a result, living conditions and lifestyles are also being transformed, impacting the gardening habits of the population. This is particularly evident as newcomers have different attitudes and habits compared to traditional rural residents. These differences diminish as one moves outwards along the urban-rural gradient in more remote settlements. One key discovery is that differences exist between various suburban settlements. Municipalities closer to the city with beautiful natural surroundings (e.g. N. Hrnčiarovce) tend to attract higher-income residents. More distant municipalities draw in less affluent individuals, including those from rural areas, which makes their attitudes more similar to local residents than those who moved from the city.

Most of the literature treats suburban areas as a whole, making no distinction between zones. Our survey shows that the status of the settlement and its distance from the city are essential characteristics; the design of green spaces and habits differ somewhat. We can also detect an urban-rural gradient in this respect. This is illustrated by the tradition of food production. The literature shows that in Central Europe the proportion of people who grow food in their gardens for their own consumption is still 38%, compared with an average of 10% in Western Europe. In our experience, this activity is disappearing, with no more than 10-15% of food producers here. Of course, this varies from zone to zone, as we have seen.

One of the main features of suburbanisation is that higher-income out-migrants tend to seek out more naturally valuable places to live. At the same time, their own greening attitudes tend to attract them to more spectacular and special gardens. At the same time, the reality is that there is a growing preference for lawns and more secluded gardens. In contrast, in lower-income communities, the traditional approach tends to persist. The proportion of people who continue to use the garden to produce products for their self-consumption is relatively higher.

It may be interesting to note that we also see differences in the attitudes of the population across countries. Typically, the Slovak sample is closer to a Western European approximation than we thought before reading the literature. Aesthetics and environmental considerations are much more in the foreground. The specific features of the individual sub-elements include, for example, the strong role of vegetation in the Nitra pattern as a space divider and as an obstacle to the view of the plot. Already during our first field visit, we noticed that, especially in the case of higher-income plots, the owners were very concerned about the role of fences as an obstruction to the view (high, compact fences). This is much more prevalent than in other agglomerations studied. So, obviously, the need for hedges also arises.

Local authorities try to regulate the green management of the residents. Their most common tools are the village-scape, town-scape prescriptions, rules, and bans, which they are not able to control. Systematic advice on gardening and green infrastructure would be more helpful. Community events could be included to promote green solutions and increase eco-consciousness. Promote the spread of certain garden species, e.g. through free plant giveaways. Our research shows that the majority of people are interested in gardening. Knowing their habits, local authorities could organise targeted campaigns.

Conclusions

Suburbanisation is driven by various factors, one of the most significant being the desire of city residents to have their own green spaces and gardens. This influences their choice to settle in villages near the city. Additionally, rural inhabitants who relocate to urban areas for work often opt to live in suburban villages to maintain the values of their former homes. The preference for detached houses and more living space is also linked to a desire for gardens and greenery. In addition to this motivation, their attitudes seem to be influenced by the ecological knowledge of today, which appears in public discourse. Nevertheless, motivations and ecological attitudes are moderately realised. In fact, most owners prefer low-maintenance, sustainable plots. However, these plots often have limited ecological value as there are few large trees and hedgerows, preventing the development of necessary ecological green networks. This situation is not ideal for climate adaptation. To encourage appropriate gardening practices, local and national organisations need to emphasise and promote them, which would benefit the local community.

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