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Tourism Impacts on the Air, Light and Noise Pollution

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Abstract: *Various activities in the tourism sector, especially transportation, have a negative impact on the atmospheric complex. The paper aims to research tourism's impact on global carbon dioxide emissions, the generation of photochemical smog, and noise and light pollution. Various tourism industry activities have been identified, as well as tourist transport factors on which the intensity of air pollution depends. To demonstrate the harmful effects, statistical indicators and other results of modern scientific research were used, including the consequences of pollution on the living world. The paper provides current knowledge in the field, highlighting the risks of mass tourism, and the global need for more rational planning of sustainable tourism development.*

1. INTRODUCTION

According to IUCN (2015), various tourist activities affect air quality: transport; construction and facility power; sound (noise); and lighting. Examples of potential consequences, through the studied literature, include air and noise pollution from vehicles; increased carbon dioxide emissions from fossil fuel combustion, which contributes to global climate change; light pollution can distract reproduction and cause growth crisis (e.g. birds or turtles); noise pollution from vehicular traffic can affect behavior (e.g. bears) and breeding success of nesting birds. „One of the most negative impacts of tourism is on climate through Greenhouse gas emissions, in particular CO_2. In the tourism sector, energy consumption at destinations and the related GHG emissions strongly depends, e.g., on the infrastructure of the accommodation, particularly installations for heating, cooling and hot water“ (Serrano-Bernardo et al., 2012). Müller (2004) used Switzerland as an example, where hotel accommodation and tourist transportation contribute to air pollution, with tourism accounting for 0.7% of SO2 emissions, 3.2% of NOx emissions, and roughly 28% of COx emissions. „Almost 70% of the carbon emissions generated by the tourism industry originates from the combustion of fuels used for accommodation, transportation, and land use“ (Zhang & Lu, 2022). “The analysis of the carbon footprint of tourism worldwide shows that the greenhouse emissions are due to: transport (particularly air and motor vehicle) 82%, accommodation 4.5%, retail 3.4%, and other activities 8.6%. The transportation of visitors to the destination plays an important role in contributing to the carbon footprint” (Serrano-Bernardo et al., 2012).

According to Table 1, tourism accounts for 5% of all worldwide energy-related CO_2 emissions, with transportation accounting for three-quarters of all GHG emissions. “Transport to and on destinations represents a high percentage of energy consumption (currently about 30%), and a large fraction of it is represented by travels for tourism. If we consider that almost all transport vehicles are fuelled by liquid fuels, travel is certainly responsible for large quantities of GHG emitted into the atmosphere” (Serrano-Bernardo et al., 2012).

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Table 1. Global CO_2 emissions and tourism contributions from various sectors

	Millions of tones	Share of tourism (%)
Air transport	515	40
Car transport	420	32
Other modus of transport	45	3
Accommodation	274	21
Other activities	48	4
Total tourism	1302	100
World	26400	/
Share of tourism in global CO_2 emissions		**4,9**

Source: Author adapted according to the WTO data at Serrano-Bernardo et al., 2012

2. METHODOLOGY

The aim of the paper is to identify tourism impacts on air, light, and noise pollution and their potential negative effects on humans and wildlife. The paper's objectives are: a) to analyze tourism transportation's impact on CO_2 emissions and effects on human health; b) to analyze tourism activities' impact on noise pollution and identify its negative consequences on wildlife; and c) to analyze the role of tourist destinations' lights in forming light pollution and its impact on living creatures (birds). Primary and secondary sources were used (relevant literature, official data from corresponding organizations, terrain data, and maps). Identification, analysis, and terrain observations are the main methods in this paper.

3. THE IMPACT OF TOURIST TRANSPORT ON CO_2 EMISSIONS AND AQI

Emissions of CO_2 and other GHG in the tourism transport sector depend on several factors: mode of transport; efficiency of transport means; the size and the state of the transportation network; number of passengers; number of trips; distance traveled; idling (if longer than 10 seconds, it consumes more fuel and emits more CO_2 than restarting the engine); tourist seasonality.

"Air travel accounts for 76% of overall traffic worldwide during the summer vacation season" (IATA, 2020). "Air travel is the most prevalent in global tourism in 2019 (59%), while, for example, in Bosnia and Herzegovina road transport is more prominent than air transport. The aviation industry accounts for around 8% of global final oil consumption, while road transport (passenger and freight vehicles) accounts for the majority of global final fuel consumption (49.3%)" (Žunić, 2023). Serrano-Bernardo et al. (2012) stated that the entire contribution of emissions from airplanes to total anthropogenic CO_2 emissions is rather small- around 2%. However, airplanes use 10-30% kerosene, which is as hazardous as diesel and has a severe impact on the air and the health of living creatures. „The comparison showed that at very high contamination levels (10 and 15%) kerosene was 1.3-1.6 times more phytotoxic than diesel fuel and 1.3-1.4 times more toxic than crude oil, and at low (1 and 2%) and medium (3 and 5%) levels the toxicity of these contaminants was close differing by a factor of 1.1-1.2" (Sharonova & Breus, 2012). „ An aircraft can produce up to 4% of the global CO_2 emissions each year. Burning kerosene produces pollutants like carbon dioxide, nitric and nitrogen oxide, sulfur oxides, and soot. The hotter the inside temperature of the engine, the more efficiently fuel is burned. These higher temperatures increase the NOx emissions that harm the ozone. This results in additional emissions that contribute to air pollution and the warming of our climate" (NASA, 2007). "However, airplanes transport a substantially greater number of passengers. The energy intensity of automobile transportation is 57% higher than that of air transportation; a car emits more CO_2 than an average airplane because it requires more energy to transport

the same number of passengers. As a result, air travel is more environmentally sustainable than car travel. On the other hand, UNEP advocates for reducing flights and promoting domestic tourism" (Žunić, 2023). "According to EPA, a typical passenger vehicle emits about 4.6 metric tons of carbon dioxide per year. One long flight releases the equivalent of nearly 14% of the annual emissions from a car. When comparing the number of emissions per person, flying is better than driving" (Sunkara, 2022). „In short travels, the contribution of LTO to fuel consumption and CO_2 emissions is very high. This is the reason why flights covering long distances become more convenient in terms of the amount of CO_2 emitted per km" (Serrano-Bernardo et al., 2012).

The summer tourist season is the most pronounced on a global level due to the use of annual vacations in that period of the year, which significantly contributes to traffic congestion and air pollution. "Only two summer months (June and July) account for 44% of all foreign arrivals" (UNWTO, 2022). In Sarajevo, for example, traffic congestion is increased during the peak tourist season (summer), due to both the influx of tourists and enhanced seasonal transport on roads and rails, primarily towards the Adriatic (in the southern route through the Neretva valley); there are also a greater number of flights (charter, etc.).

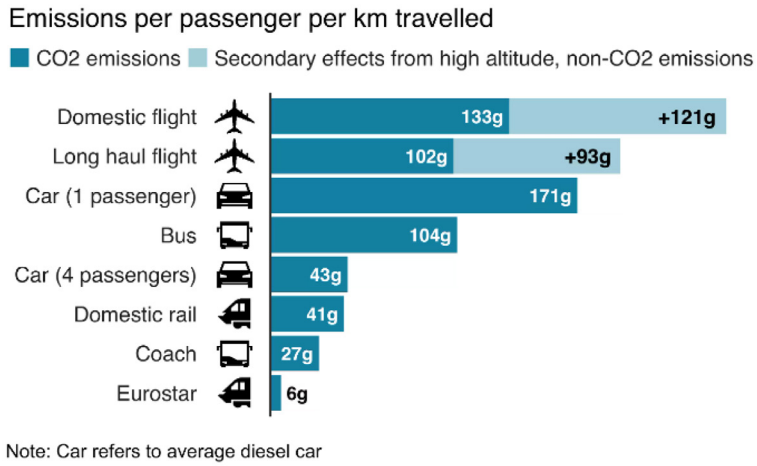


Figure 1. Emissions of CO_2 by different modes of transport - economic class
Source: BBC, 2019

According to Ritchie (2020b), driving a small Mini car emits 111 g CO_2eq per km, while a large 4×4 car emits ~200 gCO_2eq per km. Adding one additional passenger traveling to the same location would halve emissions per passenger-kilometer. A car would produce over 100 kilograms of CO_2eq on the 500-kilometer journey, while flying would raise emissions by nearly one-third (128 kg CO_2eq); taking the train would be 80% lower (21 kg CO_2eq). At moderate distances (1000 kilometers), flying has a higher carbon footprint than a medium-sized car. If the distance is longer (>1000 kilometers or an international flight), then flying would actually have a slightly lower carbon footprint per kilometer than driving alone over the same distance. Sunlu (2003) stated that one transatlantic flight releases about half of the CO emissions produced by all other sources (lighting, heating, car use, etc.) that the average individual consumes annually.

From the Figure 2, there is a positive growth in CO_2 emissions from aviation (passenger air travel, freight, and military operations) with an annual rate of 4–5% since 2010. Global aviation emitted 1.04 billion metric tons of CO_2 in 2018. Ritchie (2020a) stated the increased CO_2 emissions from air travel have been accelerated by the swift development of air traffic and global tourism. Global aviation (domestic and international; passenger and freight) accounts for: 1.9%

of GHG emissions (which includes all GHG, not only CO_2); 2.5% of CO_2 emissions, 3.5% of 'effective radiative forcing'- its impact on warming (CO_2 accounts for less than half of this warming, while contrails from aircraft exhausts account for the largest share).

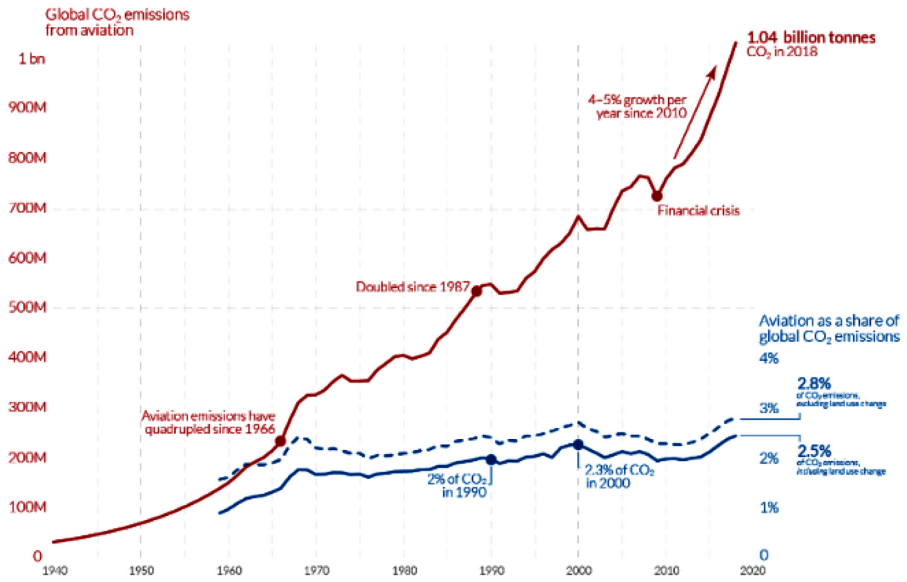


Figure 2. Global CO_2 emissions from aviation 1940-2020.

Source: Ritchie, 2020a

Tourist transportation and certain tourist activities contribute to global and local air pollution. Tourist buses, for example, leave their engines running for hours while tourists go on adventures and want to return to a comfortable air-conditioned bus; traffic congestion during the tourist seasons also contributes to this. "Fuel use and CO_2 emissions are always greater for idling over 10 seconds. If each car idles for just 6 minutes per day, about 3 billion gallons of fuel are wasted annually, costing drivers $10 billion or more" (Gaines et al., 2012).

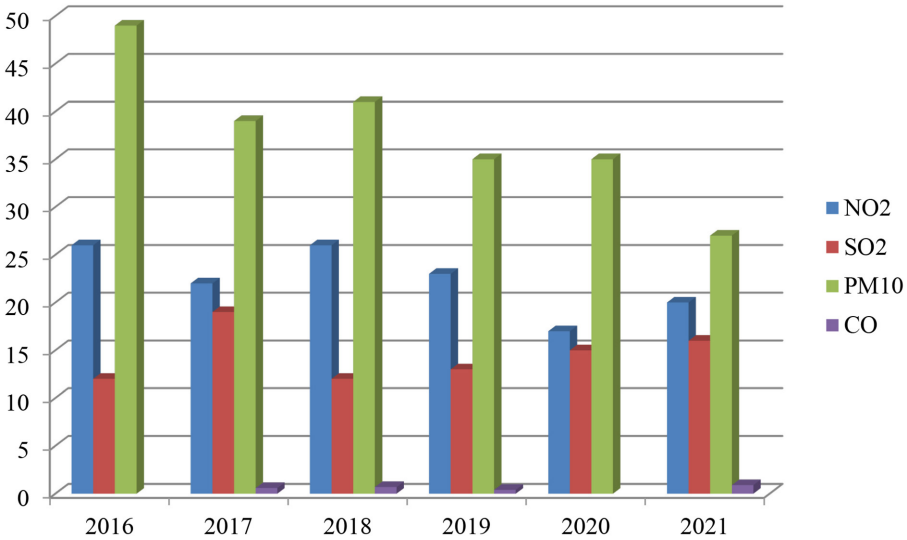
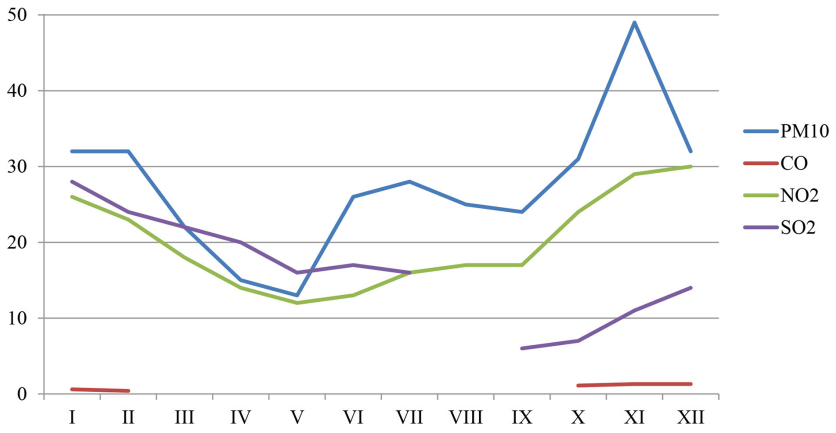


Figure 3. Growth of the Sarajevo air pollutants (average annual concentrations in mg/m3) (monitoring Vijećnica) for the period 2016-2021.

Source: Author (adapted according to the reports from the Federal Hydrometeorological Institute (2022) and Institute for Public Health of Canton Sarajevo, 2022))

An example of Sarajevo AQI related to tourism impacts, according to the average annual concentrations for the period 2016–2021 (figure 3), demonstrates a positive growth for four air pollutants (excl. 2019–2020 bcs. of COVID movement restrictions), in particular NO2 and PM10, which come mostly from tourist vehicles and traffic congestion, including increased idling on the city's narrow roads during the peak tourist season.

Sarajevo's air pollution is growing along with the country's tourism blooming, posing new hazards to human and wildlife health. There's a popularly known *"Syndrom of Sarajevo Lungs"* as the lower AQI negatively affects human health; e.g., respiratory diseases are among the five main causes of population death in 2020. "WHO estimates that Bosnia and Herzegovina's air is the most polluted among European countries" (Sivac, 2022), which can be easily attributed to expanding tourism.



Note: *the broken line - "no available data for the year" (N/A)*

Figure 4. Average monthly values (mg/m3) of monitored parameters during 2021.

Source: Author (adapted according to the Institute for Public Health of Canton Sarajevo, 2022)

The values of air pollutants (Fig.4) are demonstrably higher during the summer and winter seasons. Apart from the physical-geographical factors that contribute to this, especially in the cold months (basin location and temp. inversions), tourism is a significant source of increased air pollution during the winter and summer seasons; mountains near Sarajevo are crowded in the winter with both domestic and foreign tourists, as well as diaspora visitors, while the city (as well as the country) is generally mostly visited during the summer.

4. TOURISM IMPACT ON NOISE POLLUTION AND WILDLIFE DISTURBANCE

"Noise pollution from airplanes, cars, and buses, as well as recreational vehicles such as snowmobiles and jet skis, causes disturbance, stress, hearing loss, and disturbance of wildlife, especially in sensitive areas" (Sunlu, 2003). Arbor (2020) stated the effects of noise pollution on the reproductive success of 58,506 nests from 142 species across North America include delayed nesting, no reproduction, and no mating and breeding due to the non-transmission of the "seduction" song. According to Thomas (2018), noise pollution delays nesting for birds whose songs are at a lower frequency and thus more difficult to hear through low-frequency, human-caused noise. Mating decisions are made based on the male's song, and in some cases, females need to hear the male's song to become physically ready to breed. According to Halfwerk et al. (2011), many species rely to some extent on auditory contact for reproductive success. Anthropogenic noise has a detrimental impact on bird breeding density and reproductive output, with particularly negative effects for species vocalizing at low frequencies (e.g., pigeons and cuckoos).

"Main effects of coexistence with humans for bears are increased disturbance, human-bear conflicts and human-caused mortality; behavioral alterations; reduced fitness and genetic diversity; and physiological alterations" (Morales-Gonzalez et al., 2020). In the example of Sarajevo, there has been spotted a rare phenomenon - annoyed bears in the suburban zone, who escaped from quad noise presented in the mountain surroundings *(Vratnik/ Old town of the city)*. The bear was seen by locals and rangers, who observed that he was frightened by the sound of the jeeps driving near their forest habitat.

Figure 5. Sarajevo's picnic and quad spots
Source: Author (based on Google My Maps, 2023)

Figure 6. Annoyed bear in the suburban area of Sarajevo
Source: Informative portal Klix, 2023

The map shows quad spots near Sarajevo (Bukovik, Čavljak, Barice, D. Biosko, Vraca, and Bjelašnica), in which anthropogenic activity rises, the building of roads and recreational sites

(e.g. quad tourism); bears, disturbed by the noise of motor vehicles, descend from the surrounding forests to the suburban village of Vratnik, which is only a 5-minute drive from the most visited tourist site of Baščaršija in the old town.

5. TOURISM IMPACT ON LIGHT POLLUTION AND MIGRATING BIRDS

Photochemical smog and light pollution have negative effects on the life, migrations, feeding, breeding and reproduction of living organisms (e.g. birds). "Photochemical smog is a mixture of pollutants that are formed when nitrogen oxides and volatile organic compounds react to sunlight, creating a brown haze above cities; it tends to occur more often in summer" (EPA, 2004), while "light pollution is brightening of the night sky caused by street lights and other man-made sources, which has a disruptive effect on natural cycles and inhibits the observation of stars and planets" (Oxford Dictionary). City lights have a confusing effect on the birds' migrations, resulting in potential wandering, colonization near cities, and other negative outcomes (fatigue, disease, injury, and death). UD study of North American birds (Thomas, 2018) revealed problems with south migration and increased bird density near metropolitan areas due to the city lights. City lights mislead migrating birds on their way to their final destination. Arbor (2020) stated that the effects of light pollution on the reproductive success of 58,506 nests from 142 species across North America include premature nesting and unavailability of food. City lights attract migrating birds (geese, cerulean warblers, etc.), throwing them off course. "Autumnal migrant stopover density increased at regional scales with proximity to the brightest areas but decreased within a few kilometers of brightly-lit sources. This finding implies broad-scale attraction to artificial light while airborne, impeding selection for extensive forest habitat" (McLaren et al., 2018). "Most birds migrate at night through increasingly light-polluted skies. Bright light sources can attract airborne migrants and lead to collisions with structures, but might also influence the selection of migratory stopover habitat and thereby acquisition of food resources" (McLaren et al., 2018). They are also more likely to perish or be wounded when they come into contact with urban hazards such as highways and buildings. "Migratory animals have an impact on ecosystems throughout their entire range, which for some birds can extend over 10,000 kilometers" (Thomas, 2018). "Given that high-quality stopover habitat is critical to successful migration, and hindrances during migration can decrease fitness, artificial lights present a potentially heightened conservation concern for migratory bird populations" (McLaren et al., 2018). There's an example of Sarajevo's seagulls in the urban center with a pre-mountain climate, potentially affected by illumination in the tourist-crowded coastal Adriatic area, but also because of the active airspace noised by numerous tourist flights during extended tourist summer-fall season.

Although the majority of seagulls are migratory birds to warmer climates *(European gulls migrate to Africa or South and Southeast Asia),* they settled down in Sarajevo during the last decade (Birdfact, 2022). Despite some sources claiming their presence here has resulted in food supplies from wild dumps, climate change and light pollution shouldn't be neglected as potential causes of their lost navigation. Settlement in the urban continental environment with insufficient supplies of food is an intriguing phenomenon to investigate; seagulls prefer to fish in open seas rather than in polluted city rivers (e.g. Željeznica). Bosnia and Herzegovina is situated on the migratory route of seagulls, with congested Mediterranean destinations (e.g., Neum, Adriatic Sea), followed by the overall tourist expansion of the country; "BiH had the third highest tourism growth rate in the World in 2019" (USAID, 2020). The light and noise pollution from tourism traffic and lights could be a reasonable explanation for seagulls' stopover in Sarajevo.

Figure 7. Seagulls on the city river Željeznica, Sarajevo, BiH
Source: Author

6. FUTURE RESEARCH DIRECTIONS

As tourism's impact on air, light, and noise pollution with negative consequences for humans and wildlife presents an associated occurrence in growing destinations, tourism-focused places will need to tighten their tourism and environmental policies. The primary task of mitigating the detrimental impacts of tourism is to monitor changes in nature and behaviors. Radar tracks and other advanced methods should be implemented to expand knowledge regarding the impacts of tourism on the environment. This study clarifies the environmental risks of tourism expansion in the case of Sarajevo, and other relevant world examples, while also encouraging more sustainable tourist activities beneficial to humans and other living creatures; some are discussed in the paper's conclusion.

7. CONCLUSION

The tourism industry contributes to air, noise and light pollution, producing a variety of crises for humans and wildlife, including health, reproduction, and breeding issues. Animals' unpredictable behavior can be triggered by different threats, e.g., Sarajevo' annoyed bears leaving their mountain habitat and descending into the calmer suburban areas due to the noisy adventure tourist activities (e.g. quad tours), or the lost seagulls due to the tourist Mediterranean lights and illuminated noisy sky by increased air traffic. Tourism seasons (winter and summer) are followed by decreased AQI (e.g., Sarajevo, Bosnia's most visited destination). Environmental monitoring should be established in expanding tourism destinations, with a focus on lowering GHG emissions while simultaneously preventing additional threats. Accounting for the fact that long flights have a higher impact on air pollution, encouraging domestic tourism could be a reasonable solution, as well as practicing more environmental activities through other sustainable forms of tourism (nature and eco-tourism). Alternative modes of access to popular tourist attractions: walking, carriage transport, or bike routes, should be preferred over traffic roadways.

For instance, Amsterdam is „the bicycle capital of the world", because „the city is equipped with an elaborate network of cycle-paths and lanes as the easiest mode of transport" (Van der Zee, 2015), while famous Bosnian eco-tourist site (e.g., protected area of "Springs of Bosnia" near Sarajevo), is accessed by horse-drawn carriage. Group-organized tours are more sustainable than individual trips. "Most of the emissions from the transport sector are produced by private cars; many cities have successfully managed to reduce CO_2 emissions by as much as 50% by reducing or limiting the flow of private cars" (RIDANGO, 2022). "By eliminating one car and taking public transportation instead of driving, a saving of 30% of carbon dioxide emissions can be realized" (KCATA, 2023). Ecological hotels can contribute with their saving concepts: e.g., LED lights reduce carbon emissions by 6 tons per year; green roofs reduce urban heat; resort gardens create natural shading; "net cooling effect of a young healthy tree is equivalent to ten room-size air conditioners operating 20 hours a day" (USDA, 2021).

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