

MAPPING DISASTER RISKS AND POLLUTION IN KAKANJ

Citizen Science Research



Acknowledgment

This report would not have been possible without the commitment, knowledge, and active engagement of the 127 citizen scientists who participated in the disaster risk and pollution mapping process. Through fieldwork, community meetings, focus groups, and online geo-mapping activities, they contributed their time, local knowledge, and lived experience to document risks and environmental challenges across the municipality of Kakanj. Their involvement demonstrates the power of citizen science as a tool for inclusive, evidence-based disaster risk preparedness and environmental governance.

We extend our sincere gratitude to our local partners and collaborators whose support was essential to the successful implementation of this initiative. Special thanks go to NGO Alternative, the KICK youth group, and the *Kakanj ustaje* citizen initiative for their outreach, mobilization of community members, and continuous engagement throughout the project. We also thank Gymnasium “Muhsin Rizvić” for its strong involvement and for encouraging youth participation in citizen science activities, as well as the Civil Protection Unit of the Municipality of Kakanj for their institutional support, technical insights, and cooperation.

Their collective contributions strengthened the quality, relevance, and impact of this report and laid the foundation for continued collaboration toward a safer, healthier, and more resilient Kakanj.

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Summary

This report presents a comprehensive, citizen-generated assessment of disaster and pollution risks in the municipality of Kakanj, one of the most environmentally burdened areas in Bosnia and Herzegovina. Based on participatory mapping conducted between June 2025 and January 2026, 127 citizen scientists documented 197 disaster risk and pollution sites, covering geological, hydrological, meteorological, climatological, biological, chemical, transport-related, and structural risks, as well as deforestation. The findings show that while Kakanj faces multiple, interconnected hazards, chemical risks emerge as the most severe, persistent, and system-wide threat, acting as a multiplier that exacerbates nearly all other risk categories.

Chemical risks are the most dangerous and pervasive hazard in Kakanj. Chronic air pollution—driven by coal combustion at the thermal power plant, cement production, household coal heating, and traffic—represents an ongoing, slow-onset disaster with acute peaks. During winter 2026, air quality indicators reached extreme levels (AQI > 400, with reported peaks far higher), placing Kakanj among the most polluted cities globally at specific moments. Prolonged exposure to PM_{2.5}, sulfur dioxide, nitrogen oxides, and industrial by-products is strongly associated with elevated rates of respiratory illness, cardiovascular disease, and cancer. Local health data show that Kakanj residents are disproportionately represented among oncology patients in Zenica-Doboj Canton, underscoring the long-term public-health burden of chemical exposure. Unlike sudden disasters, this risk is continuous, affects the entire population, and disproportionately harms children, older adults, and people with chronic illness.

Chemical risks also extend to water and soil contamination, creating cascading threats. Citizen reports and secondary evidence indicate heavy-metal leakage from upstream mining activities (notably cadmium, lead, and zinc) into tributaries feeding Kakanj's water sources. Untreated municipal sewage, illegal waste dumping, and legacy coal ash and slag deposits further degrade surface and groundwater quality. Incidents such as fish kills, visibly turbid drinking water, and pollution following heavy rainfall illustrate how chemical hazards intensify during floods and storms, turning hydrological events into compound disasters. The illegal Bare landfill—operating without permits and accepting household, animal, and medical waste—represents a persistent chemical and biological hazard near residential areas, highlighting systemic failures in waste governance.

Other risk categories are significant but often interlinked with chemical pollution. Geological risks, particularly landslides, are widespread (183 active landslides officially recorded), many triggered or amplified by mining, waste dumps, deforestation, and extreme rainfall. Hydrological risks—river floods, flash floods, and erosion—are recurrent and increasingly severe, with chemical pollution spreading more widely during flood events. Meteorological and climatological risks, including heatwaves, droughts, and wildfires, are intensifying due to climate change and are aggravated by air pollution and land degradation. Biological risks, such as COVID-19, zoonotic diseases, and vector-borne illnesses, reveal how environmental stress and pollution weaken public-health resilience. Structural collapse risks, especially those linked to mining and quarrying, remain high and historically lethal in Kakanj, with chemical releases often accompanying collapses of waste heaps or industrial infrastructure.

A central finding of the report is that environmental degradation and overexploitation of natural resources—especially coal, minerals, forests, and land—function as core drivers of disaster risk. Deforestation linked to mining infrastructure removes natural protections against landslides and

floods, while delivering minimal long-term economic benefit to local communities. Profits are concentrated among external actors, while environmental and health costs are borne locally, raising serious environmental-justice concerns.

The analysis concludes that without a strategic shift, Kakanj faces a future of compounding crises: recurring air-pollution emergencies, worsening health outcomes, increased landslides and floods, water insecurity, population decline, and rising poverty. Conversely, a gradual transition toward a regenerative and just model—centered on reducing chemical pollution, phasing out coal, restoring ecosystems, strengthening waste and water management, and embedding citizen science in governance—offers a credible pathway to reducing disaster risks while improving public health, environmental quality, and long-term economic resilience.

In sum, while Kakanj is exposed to many hazards, chemical risks are the most dangerous because they are chronic, cumulative, population-wide, and deeply entangled with all other disaster risks. Addressing them is therefore the single most critical leverage point for improving safety, health, and resilience in Kakanj.

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INTRODUCTION

Kakanj is one of the most environmentally burdened and disaster-prone municipalities in Bosnia and Herzegovina and the wider Western Balkans. Its long industrial history—anchored in coal mining, a thermal power plant, cement production, and heavy manufacturing—has generated persistent air, soil, and water pollution. Decades of extractive activity have also destabilized terrain through underground mining, increasing exposure to landslides and structural damage. At the same time, limited progress in energy transition and environmental remediation has prolonged health impacts on residents, including elevated respiratory and cardiovascular risks, while climate change has intensified floods, heatwaves, droughts, and wildfire conditions. The convergence of industrial legacies, slow decarbonization, and growing climate extremes makes Kakanj particularly vulnerable to both natural and human-induced hazards.

Against this backdrop, the Mapping Disaster Risks and Pollution in Kakanj initiative was launched to strengthen local preparedness through an inclusive, data-driven citizen science approach. Implemented from June 2025 to January 2026, through the support of [EU IMPETUS programme](#), the initiative engaged residents as co-researchers—especially youth, rural communities, local activists—to document hazards and vulnerabilities across the municipality. Rather than treating citizens as passive informants, the project positioned them as partners in co-designing methods, collecting geo-referenced evidence, interpreting findings, and advocating for policy change. By integrating lived experience with scientific guidance and open-source geo-mapping tools, the initiative grounded risk assessment in everyday realities while ensuring methodological rigor.

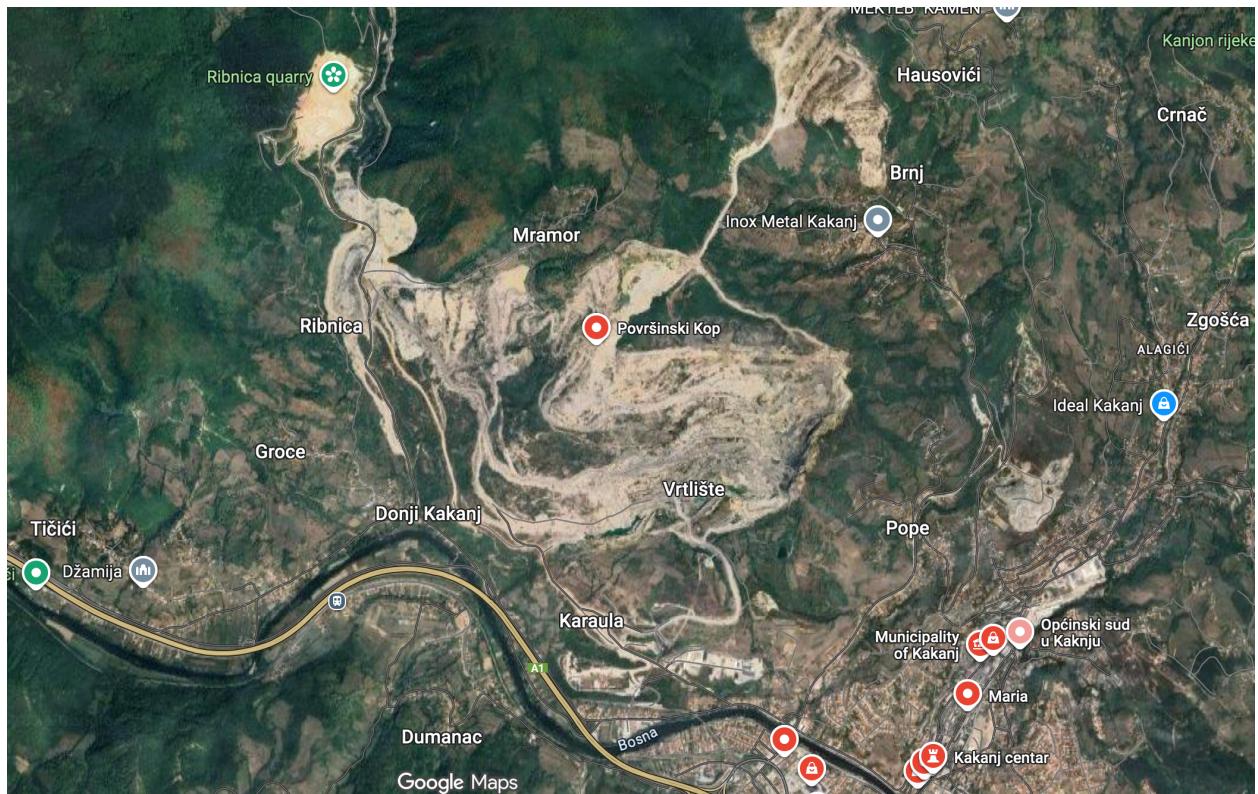


Image: Google map satellite view of Kakanj with clearly visible extensive extractive industries

Over the seven-month period, 127 citizen scientists participated in fieldwork and analysis, resulting in the mapping of 197 disaster risk and pollution sites. These included flooding hotspots, landslide-prone zones, industrial emissions and waste locations, damaged infrastructure, earthquake exposure, and other climate- and industry-related threats. Data were collected collaboratively with researchers, local NGOs, and municipal stakeholders, ensuring that technical assessment and local knowledge informed one another. The outcome is an open-access dataset that visualizes where and how risks accumulate, who is most exposed, and which vulnerabilities demand urgent attention.

The importance of this initiative lies not only in the evidence produced, but in how it reshapes disaster governance. By democratizing knowledge production, the project builds resilience as a shared capacity—strengthening environmental awareness, youth leadership, and trust between communities and institutions. The collected data directly inform policy recommendations for a local disaster risk reduction strategy, to be formally presented to the Municipality of Kakanj, while also supporting technical guidelines, advocacy materials, and a scientific publication shared through European open-science platforms. In doing so, the initiative establishes a replicable model for participatory resilience planning—one that transforms local concern into credible evidence and actionable policy, and positions Kakanj as a reference point for community-driven disaster preparedness in the region.

This report is structured to provide a clear, systematic overview of disaster risks and pollution in the municipality of Kakanj, moving from context-setting to analysis and conclusions. Following the Introduction, which outlines the local vulnerability profile and the rationale for a citizen science-based approach, the report presents thematic chapters on Geological, Hydrological, Meteorological, Climatological, Biological, and Chemical Risks, each examining the nature, spatial distribution, and local relevance of specific hazards. Dedicated sections on Transport Accidents and Structural Collapse address technological and infrastructure-related risks, while the chapter on Environmental Degradation and Pollution focuses on hazards arising from industrial activity, urban practices, and environmental degradation. The Methodology chapter then explains the participatory mapping approach, data collection tools, and analytical framework used throughout the study. Instead of a traditional conclusion, this report finishes with a set of future scenarios, reflecting the fact that it addresses risks with both immediate and long-term implications for Kakanj. These scenarios explore potential trajectories under the assumption that responses by local, cantonal, and federal authorities remain largely passive, outlining the likely consequences and impacts that citizens of Kakanj may face if existing risks are not adequately addressed.

GEOLOGICAL RISKS

Geological (or geophysical) risks arise from natural processes within the Earth's crust and surface that can cause sudden or progressive damage to people, infrastructure, and the environment. In the context of disaster risk assessment, these hazards are characterized by their physical origin, potential for cascading effects, and limited predictability at the local level.

Earthquakes are sudden ground movements caused by the release of energy along geological faults, which can result in building collapse, infrastructure failure, landslides, and secondary hazards. For earthquake risk assessment in this project, historical seismic data were used to understand past events, frequency, and spatial patterns relevant to the municipality of Kakanj.

Volcanic eruptions involve the release of magma, ash, and gases from the Earth's interior. Although Bosnia and Herzegovina has no active volcanoes, this hazard is included for completeness within standard geological risk classifications.

Tsunamis are large sea waves generated primarily by undersea earthquakes, volcanic eruptions, or landslides. While not locally relevant for inland municipalities such as Kakanj, tsunamis are recognized as a major geological hazard at the global level.

Landslides and rockfalls refer to the downward movement of soil, rock, or debris under the influence of gravity, often triggered by heavy rainfall, earthquakes, or human activities such as mining and deforestation. These represent a significant geological risk in Kakanj due to unstable terrain and historical underground mining.

Avalanches are rapid flows of snow and ice down steep slopes, typically occurring in mountainous regions under specific climatic and terrain conditions. Although spatially limited, they are included as part of the broader geological risk framework.

Kakanj lies in a seismically active region (the Dinaric Alps), but central Bosnia experiences moderate earthquake hazard compared to southern and northwestern parts of the country. Most local tremors are mild. For example, in August 2020 residents felt a magnitude 3.8 earthquake centered just 4 km from Kakanj; it caused some alarm but no reported damage. There have been no recent destructive quakes with an epicenter in Kakanj. However, the area can feel shocks from larger regional earthquakes. The 1969 Banja Luka earthquake (M6.4) in northern Bosnia – one of the country's worst quakes – was felt across the region (it devastated Banja Luka city, causing 15 deaths and thousands of injuries). Such events underscore the importance of preparedness even in Kakanj. Local authorities have incorporated earthquake response into their civil protection plans, and regular disaster drills are held.

There is no risk of volcanic eruptions in Kakanj. Bosnia and Herzegovina has no active or dormant volcanoes – any volcanic activity in the region dates back to the Triassic period (over 200 million years ago) and is long extinct. The geological record shows some ancient volcanic rocks in Bosnia's crust, but no volcano has existed in recorded history. Therefore, volcanic eruptions are not considered a hazard for Kakanj or the country as a whole. Likewise, tsunami risk is essentially nonexistent for Kakanj. Bosnia and Herzegovina has only a 20-kilometer coastline at the town of Neum on the Adriatic Sea, and Kakanj is a landlocked municipality about 200 km inland.

However, landslides are a major geological hazard in Kakanj, exacerbated by the local terrain and decades of coal mining activity. According to the information provided by the municipal Civil Protection service and their mapping efforts, there are 183 active landslides on the territory of Kakanj. The municipality has experienced several serious landslides in recent history. In late 2014, a massive slope failure occurred in the Bare neighborhood below a coal mine waste dump. This landslide tragically claimed one life and completely destroyed about 10 houses in Bare. Dozens of families were displaced, and the area remained unstable for months. Another catastrophe struck on February 24, 2017, when an enormous mine waste landslide from the open-pit Kakanj coal mine swept toward the villages of Ribnica and Mramor. More than 150 residents had to be evacuated as the slide threatened to bury the villages. The moving earth mass covered parts of a road, blocked a river (forming a temporary lake), and knocked out power lines. Mine officials indicated that many affected homes would likely be lost permanently, with compensation arranged for evacuees. Smaller-scale landslides and rockfalls are also frequent, especially after heavy rainfall or unregulated

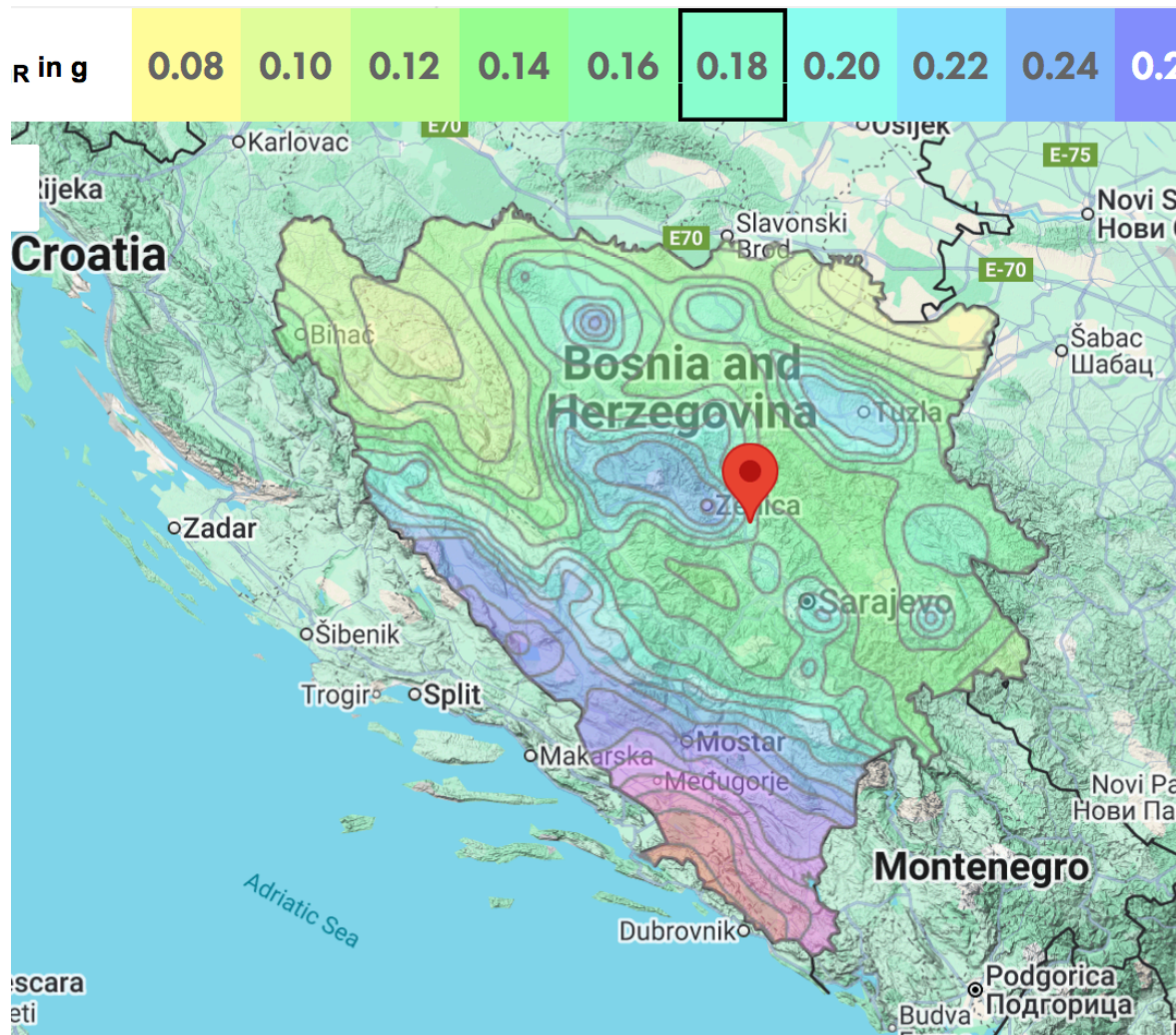


Image: Map of BiH's seismic load based on data for 475 years, Dlubal Software solutions.

construction. In 2016, a landslide in the Donji Kakanj area prompted emergency stabilization; in 2025 this slope was re-activated, apparently due to illegal dumping of material by a local company, again alarming residents. These incidents highlight the ongoing vulnerability of Kakanj's hillsides.

Mitigation efforts are underway to manage landslide risks. After the Bare landslide, geotechnical experts proposed engineering measures: removing excess waste material from the coal slag heap to lighten the load, and reducing the slope angle of dumps to prevent future collapses. The municipal Civil Protection service oversees slope stability studies, and some at-risk families have been permanently relocated out of hazardous zones. Public awareness has increased since the 2014–2017 disasters, and the local government now carefully monitors known landslide sites.

Avalanches are not a significant threat in Kakanj. The municipality's elevation is moderate and does not include the kind of high alpine terrain where large snow avalanches typically occur. Kakanj's winters do bring snowfall, and there is a small ski resort area (Ponijeri, about 20 km from town) that can accumulate heavy snow, but no major avalanche incidents have been recorded. Unlike Bosnia's

highest mountains (e.g. in Herzegovina or near Sarajevo) which have known avalanche paths, Kakanj's hills are mostly forested and of lower height, limiting avalanche formation. Local civil protection and mountain rescue teams do take precautions – for instance, joint avalanche rescue drills have been held at Ponijeri to ensure preparedness – but overall the avalanche risk to settlements is very low. Residents are affected by heavy snowstorms (which can block roads) than by any true avalanche.

Due to the high likelihood and recurring nature of slope instability in the municipality of Kakanj, the citizen science mapping initiative placed particular emphasis on landslides and rockfalls as a priority geological risk. Out of the 197 disaster risks and pollution sites documented during the project, 29 were identified as active or potential landslides, confirming that slope failure represents one of the most widespread and locally significant hazards in the area.

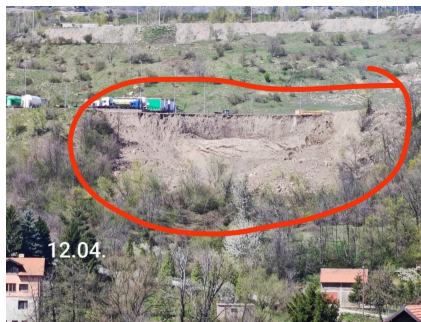


Image: Landslides in Kakanj, citizen science photos

Landslides were mapped across multiple communities, including Bilješevo, Bare, Vrtlište, Malješ, Donji Kakanj, Vukanovići, Donji Tičići, Povezice, and Tršće. Many of these locations are situated on unstable terrain shaped by decades of underground mining, quarrying, and road construction, often in close proximity to residential areas, local roads, and agricultural land.

The increasing occurrence and intensity of landslides in Kakanj is closely linked to climate change, particularly more frequent and intense rainfall events, rapid snowmelt, and winter storms that saturate soil and weaken slopes. These climatic drivers are further amplified by deforestation, uncontrolled logging, and extractive activities, including numerous quarries operating in and around the municipality. The removal of vegetation cover and disturbance of soil structure significantly reduce slope stability, making hillsides more susceptible to failure even during moderate weather events.

While emergency and short-term measures—such as clearing debris, stabilizing road sections, or installing temporary drainage—are often necessary to protect lives and infrastructure, they do not address the root causes of landslide risk. Long-term risk reduction requires an integrated approach, combining strict regulation of extractive activities, enforcement of land-use planning, improved surface and subsurface drainage, and continuous monitoring of high-risk zones.

Central to any sustainable solution is systematic reforestation and afforestation, particularly on degraded slopes and former extraction sites. Forest vegetation plays a critical role in stabilizing soil through root systems, regulating water infiltration, and reducing surface runoff. Investing in forest

restoration, alongside nature-based solutions and community-led land stewardship, is therefore essential for reducing landslide risk in Kakanj and strengthening the municipality's long-term resilience to climate-driven geological hazards.

HYDROLOGICAL RISKS



Hydrological risks arise from the movement, accumulation, or behavior of surface and subsurface water that can cause damage to people, infrastructure, ecosystems, and economic activities. These risks are shaped by natural hydrological processes but are often intensified by climate change, land-use change, urbanization, and inadequate water management. In disaster risk assessments, hydrological hazards are particularly important because they can develop rapidly, affect wide areas, and trigger cascading impacts such as landslides, pollution spread, and infrastructure failure.

Image: Map of flood risks in Bosnia and Herzegovina, Agency for Water Area Save FBiH

Floods occur when water overflows onto land that is normally dry. They can take several forms. River floods develop when rivers exceed their capacity due to prolonged rainfall or snowmelt. Flash floods are sudden, short-lived floods caused by intense rainfall over a limited area, often with little warning. Coastal floods result from elevated sea levels driven by storms or tides and are relevant mainly to coastal regions. Urban floods occur when drainage systems are overwhelmed by heavy rainfall, leading to surface water accumulation in built-up areas.

Glacial lake outburst floods (GLOFs) are sudden releases of large volumes of water from glacial lakes, typically caused by dam failure due to melting ice, heavy rainfall, earthquakes, or avalanches. Although not locally relevant for Kakanj, GLOFs are included as part of the standard hydrological risk classification and are increasingly important in mountainous and glacier-fed regions under climate change.

Storm surges are abnormal rises in water level caused by strong winds and low atmospheric pressure during storms, leading to flooding of coastal and low-lying areas. While primarily a coastal hazard, storm surges are recognized as a key hydrological risk at the regional and global level.

Erosion refers to the gradual or sudden wearing away of soil and land by flowing water. Riverbank erosion occurs when increased river flow undermines banks, threatening nearby land, infrastructure, and ecosystems. Coastal erosion involves the loss of shoreline due to wave action, currents, and rising sea levels. Erosion processes can significantly increase vulnerability by weakening natural and built defenses and by contributing to sedimentation and water quality degradation.

Kakanj faces several hydrological hazards primarily related to inland water systems. The town lies along the Bosna River (and its tributary Zgošća), making it vulnerable to riverine flooding. Over the past decade, extreme precipitation events have increasingly caused floods, while some associated phenomena like storm surges or coastal erosion are not applicable to this landlocked area.



Image: Map of flood risks in Kakanj, Agency for Water Area Save FBiH

Kakanj is prone to overflowing of the Bosna River during heavy rainfall and snowmelt. In May 2014, an unprecedented rainfall (the worst in 120 years) swelled rivers across Bosnia; Kakanj was among the towns inundated during this country-wide disaster. More recently, in November 2021, days of intense rain caused the Bosna River to burst its banks in Kakanj. Floodwaters surged into several settlements (notably the Doboј area of Kakanj) and reached homes and businesses. The municipal civil protection units responded with sandbags and machinery to reinforce embankments, limiting the damage, but numerous houses in villages like Doboј, Povezice, Malješ and Donji Kakanj were still flooded. Such river floods can devastate infrastructure and agriculture; Kakanj’s 2021 flood came with “great damage” and community alarm as residents recalled the catastrophic 2014 flood. Partial flood defenses (levees and floodwalls) do exist along the Bosna River in Kakanj, but they were built in a piecemeal fashion – often only on one riverbank or short sections – leaving some populated areas insufficiently protected. This incomplete protection means high flows can still overtop banks or erode unprotected segments. Plans have been identified to regulate and reinforce the Bosna’s banks in Kakanj (both left and right bank) to improve flood safety, although full implementation is pending.

Flood-prone areas are mostly along the Bosna’s banks, affecting low-lying settlements in Donji Kakanj (high flood risk index of ~245.8), Doboј (flood risk index of ~805.4, one of the highest in the region), Bilješevo (low flood risk index of ~5.5), Tičići (risk index ~0.48). Although Bilješevo and Tičići are classified as minor flood-prone spots, even small-scale flooding can impact local homes – recent plans note a handful of houses in Tičići are at risk and may require some protective measures. Kakanj is also affected by potential floods on its second-category watercourses – smaller rivers and streams that feed into the Bosna. Key tributaries include the Trstionica, Zgošća, and

Ribnica rivers. These waterways can overflow during heavy rainfall or when backed up by high Bosna levels, flooding adjacent communities. The following tributary flood zones are: Haljinići (Trstionica River), Zgošća (Zgošća River) with one of the larger and more populated second-category flood zones with a flood risk index of ~164.8 here, falling in Category III (significant risk), and Ribnica (Ribnica River) with low risk but localized flooding can occur where the Ribnica stream meets the Bosna or in low-lying parts of the village after intense rain.

Beyond river overflows, Kakanj frequently experiences flash floods from torrential rain. The municipality is hilly, and heavy downpours on steep slopes generate fast runoff and swollen streams. These bujični (torrent) floods can occur suddenly and cause urban flooding in low-lying neighborhoods or wherever drainage systems are overwhelmed. For instance, in early February 2019, intense rain combined with snowmelt led to flash floods across Kakanj's villages. Water from overwhelmed creeks and clogged storm drains inundated roads and yards, and dozens of families had to be evacuated as a precaution. The local authorities declared a state of natural disaster due to "numerous torrents and floods caused by the large volume of rain" that week. In that 2019 event, floodwater and saturated soil also triggered landslides on hillsides, blocking roads and threatening homes. Urban parts of Kakanj, though smaller, can likewise suffer flood pooling in heavy rain when sewers or collectors fail to cope (as happened in nearby Zenica's Tetovo suburb during the same 2019 storm). These flash flood incidents underscore how even areas away from the main river are at risk during extreme weather. Climate data indicate that while overall rainfall in Bosnia may be decreasing, extreme rainstorms are becoming more frequent, so flash flooding remains a significant hazard. Kakanj's residents have grown wary; local news reports note that "with each heavy rain, fear seeps in" due to the recurring floods and landslides in recent years.



Image: Floods in Kakanj, citizen science photos

Flood flows also bring the risk of erosion along riverbanks. During flood episodes, the Bosna's strong currents can eat away at unprotected banks in Kakanj, undermining roads, bridges or buildings near the water. The great 2014 flood, for example, caused widespread bank erosion and even altered river channels in the Bosna basin. In Kakanj, stretches of riverbank that lack robust embankments have periodically suffered scouring; there have been cases of minor bridge abutments getting eroded and farm fields along the Bosna losing soil after high waters. Local authorities recognize this threat: reinforcing the Bosna's banks in Kakanj has been prioritized as a mitigation measure. In fact, official flood management plans recommend regulating both the left and right banks of the Bosna in Kakanj (through gabion walls, levees, or rip-rap armoring) to prevent erosion

and contain floodwaters. Until such projects are fully completed, riverbank erosion remains a concern whenever flood levels rise.

In summary, Kakanj's hydrological risks are centered on inland flooding in its various forms. Major river floods on the Bosna – though not annual – have caused serious destruction (with 2014 as a historic peak, and significant floods in 2019 and 2021). Flash floods and heavy-rain-triggered landslides now hit the municipality almost every year to varying degrees. The community and authorities have responded by improving disaster readiness: Kakanj is listed among the high-risk municipalities in Bosnia and is actively involved in disaster risk reduction programs. Flood forecasting and early warning systems are being enhanced nationally, and Kakanj's civil protection service has been equipped for flood emergencies. However, the trend of frequent extreme weather means Kakanj must continually bolster its flood defenses and preparedness. Hydrological risk in this area will persist, especially as climate change can bring more erratic downpours. By reinforcing riverbanks, maintaining drainage infrastructure, and practicing vigilant emergency planning, Kakanj aims to mitigate these water-related dangers and avoid a repeat of disasters like the 2014 floods.



Image: Floods in Kakanj, citizen science photos

As part of the citizen science initiative, residents of Kakanj actively mapped hydrological risks, focusing exclusively on flooding events and flood-prone locations. Out of a total of 197 recorded risks and pollution sites, 20 were identified as hydrological risks, all related to floods. Some of these entries referred to earlier, historically recurring flood events, while others documented new and emerging flood risks that occurred during the lifetime of the project itself. A particularly important cluster of observations was recorded in autumn 2025, when prolonged and intense rainfall caused the Bosna River and several local watercourses to swell significantly, creating immediate flooding threats for residential areas. Citizens reported rising water levels, saturated riverbanks, and increased risk of overflow affecting houses and infrastructure in Zgošća, Doboje, Povežice, Modrinje, Kučići, and Lozančići.

METEOROLOGICAL RISKS

Meteorological risks arise from short-term atmospheric processes and extreme weather events that can cause significant damage to human health, infrastructure, livelihoods, and the environment. These hazards are often sudden, highly variable in space and time, and increasingly influenced by climate change, which is intensifying their frequency, severity, and unpredictability.

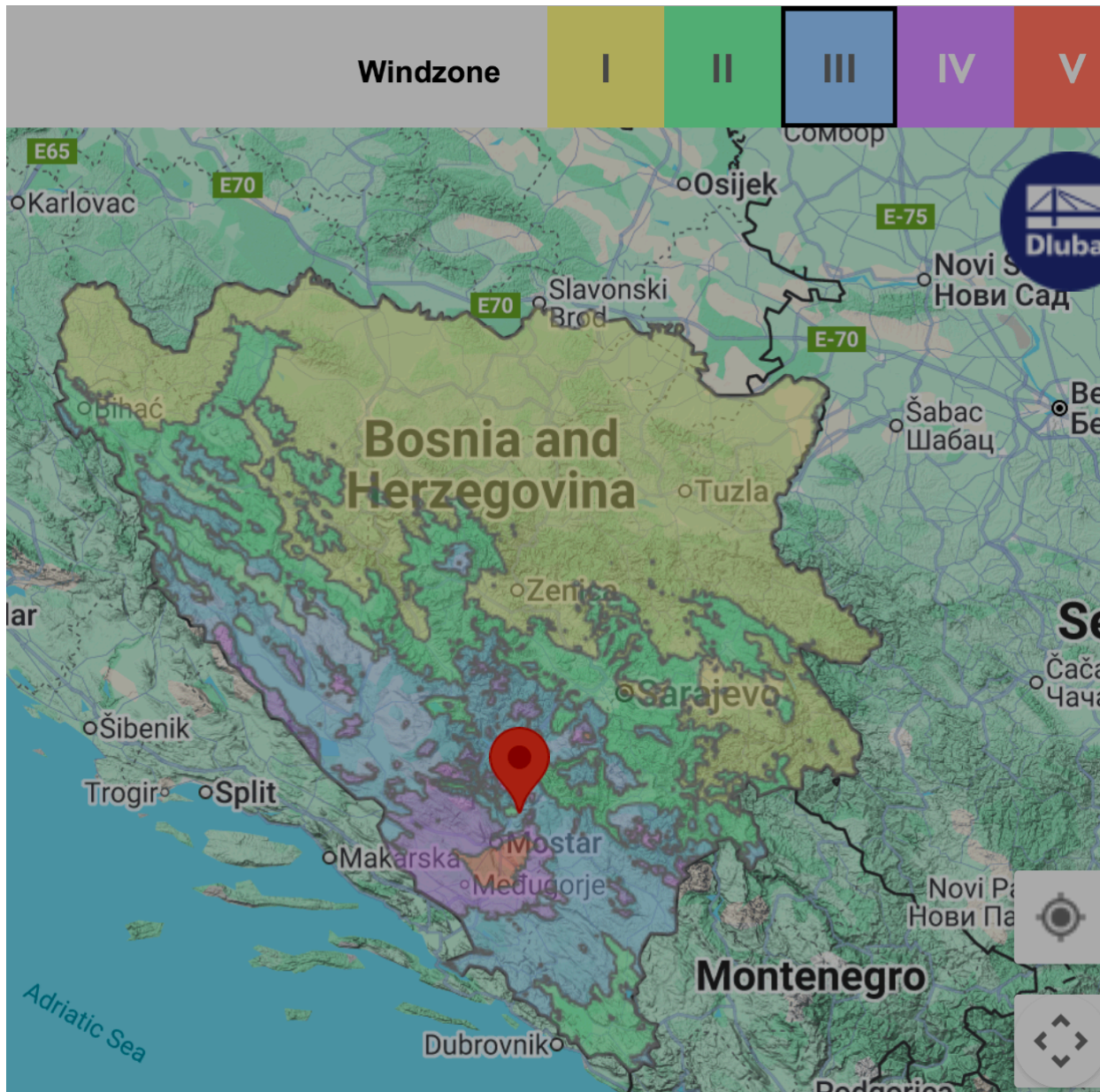


Image: Map of Bosnia and Herzegovina's wind zone risks, Dlubal Software solutions.

Storms are severe weather events characterized by strong atmospheric disturbances. Windstorms involve powerful winds that can damage buildings, forests, power lines, and transport infrastructure. Thunderstorms are accompanied by heavy rainfall, lightning, strong winds, and sometimes hail, and can trigger secondary hazards such as flash floods and landslides. Tropical cyclones, including hurricanes and typhoons, are large-scale storm systems with intense winds and heavy precipitation; while not locally relevant for inland regions such as Kakanj, they are included as part of the standard meteorological risk classification.

Extreme temperature events refer to prolonged periods of unusually high or low temperatures. Heatwaves can lead to heat stress, dehydration, increased mortality, and strain on health and energy systems. Cold waves are extended periods of extremely low temperatures that increase risks of

hypothermia, energy shortages, and infrastructure damage. Frost occurs when temperatures drop below freezing, causing damage to crops, water systems, and exposed infrastructure.

Hailstorms involve the formation and fall of ice pellets during strong convective storms. Hail can cause significant damage to roofs, vehicles, crops, and power infrastructure, and may pose direct risks to people and animals.

Lightning strikes are electrical discharges between clouds or between clouds and the ground. They pose serious threats to human life, can ignite fires, damage buildings and electrical systems, and disrupt communication and energy networks.

Kakanj's location along the Bosna River valley and surrounding hilly terrain makes it prone to various meteorological hazards, including severe storms (with heavy rain, strong winds, hail, and lightning), flooding and associated landslides, as well as extreme temperature events (heatwaves and cold waves). Climate change and local environmental factors (e.g. decades of mining activity destabilizing slopes) are exacerbating these risks, increasing the frequency and intensity of extreme weather and the town's vulnerability.



Image: Snow storm in Kakanj (January 2026), citizen science photos

Kakanj experiences severe thunderstorms and windstorms that can cause flash flooding, wind damage, and hail impacts. Intense short-duration rainstorms have led to dangerous flash floods and mudslides in the area. For example, in July 2018 an extremely strong storm struck the villages around Kakanj (Bilješevo, Gornji Lučani, Modrinje), bringing torrential rains and gusty winds. Local officials reported that water from the cloudburst flooded homes and even swept away several cars, injuring at least one person; fire crews were deployed to pump water out of inundated houses. The storm also triggered landslides and debris flows – soil and rock washed onto roads, forcing closure of the regional highway between Kakanj and Zenica until crews cleared the mud. Such convective storms are often accompanied by hail; hailstones can damage roofs, vehicles, and especially agriculture. According to Kakanj's risk assessments, hail (tuča) occurs frequently during the growing season and strips crops and fruit trees, typically affecting swaths ~500 m wide and a few kilometers long across the municipality.

High winds in some storms have downed trees and power lines – for instance, local news noted fallen trees in a 2018 squall that caused material damage to vehicles, though fortunately no injuries were reported. Lightning is another hazard during summer storms; cloud-to-ground lightning strikes in the area can cause fires or electrical outages (and pose a direct risk to anyone outdoors), though no major lightning-related disasters have been documented in Kakanj recently.

Kakanj's continental climate means it endures hot summers and cold winters, and occasionally these reach extreme levels that pose risks to health and infrastructure. In recent years, heatwaves have become more pronounced. During a July 2025 heatwave, Bosnia and Herzegovina saw record-breaking temperatures – daily highs climbed into the 40+ °C range. Forecasters showed that central parts of the country (including the Kakanj region) could reach up to 42 °C, with “tropical nights” offering little relief as temperatures stayed high even after dark. Such extreme heat can cause heat exhaustion or worse, especially among the elderly and those with health conditions, and it strains the electrical grid (due to heavy air-conditioning use) and water supply. Prolonged summer drought and heat also increase the risk of wildfires on the surrounding hills (though Kakanj itself is not heavily forested, regional forest/brush fires can degrade air quality and threaten remote hamlets).

Conversely, cold waves and heavy snowfall in winter have challenged Kakanj as well. In January 2017, an Arctic air outbreak (“Siberian winter”) hit the Balkans with some of the coldest temperatures in decades. Kakanj was not spared: nearby highland villages like Ponijeri recorded lows around –20 °C, and snow drifts piled up 2–3 meters deep in some areas. That severe cold snap caused dangerous conditions – an 87-year-old woman in BiH died of hypothermia during the freeze. In Kakanj town, such cold can freeze pipes, snarl transportation (snowy/icy roads), and force schools and businesses to close. On the other hand, late spring frosts occasionally threaten agriculture in the area, damaging fruit tree blooms or vegetable crops if temperatures dip unexpectedly. Overall, while not as dramatic as floods, temperature extremes do pose a risk – heatwaves directly affect public health and can even lead to fatalities, whereas cold waves can be life-threatening for those without adequate heating and can cause infrastructure breakdowns (frozen water lines, etc.).

Meteorological risks are likely to continue, and potentially worsen, in the future for Kakanj. Climate projections for the Western Balkans indicate more volatile weather patterns: heavier downpours, more frequent flooding, and an uptick in heat extremes. Bosnia and Herzegovina has already observed that in recent years “large floods have become frequent every year” even as summers tend to be very dry. On the extreme heat side, climate models project that average temperatures will keep rising and heatwaves will become longer and more intense. By mid-century, Kakanj may experience significantly more days above 35 °C each summer than it historically did. This will amplify heat stress on people and could affect industrial operations (e.g. cooling needs at the power plant). Conversely, warming winters might slightly reduce the frequency of extreme cold waves, but the possibility of polar vortex disruptions means occasional deep freezes can still occur.

CLIMATOLOGICAL RISKS

Climatological risks arise from long-term and large-scale climate patterns and processes that develop over months to decades. Unlike sudden weather events, these hazards evolve gradually but can have profound and lasting impacts on ecosystems, water availability, food security, public health, and

socio-economic stability. Climate change is significantly amplifying climatological risks by altering temperature regimes, precipitation patterns, and ecosystem resilience.

Droughts are prolonged periods of below-average precipitation that result in water scarcity, reduced river flows, declining groundwater levels, and soil moisture deficits. Droughts affect agriculture, drinking water supply, energy production, and ecosystems, and can exacerbate heat stress and wildfire risk.

Wildfires / forest fires are uncontrolled fires that spread through forests, grasslands, or shrublands, often during hot, dry, and windy conditions. Wildfires can cause loss of life, destruction of property, degradation of ecosystems, and severe air pollution, with long-term impacts on soil stability and water quality.

Desertification refers to land degradation in dry and semi-dry areas caused by a combination of climatic factors and human activities, such as deforestation, overgrazing, unsustainable agriculture, and poor water management. It leads to reduced soil fertility, loss of vegetation, increased erosion, and declining livelihoods, particularly in rural areas.

Long-term climate variability encompasses large-scale climate patterns that influence regional weather conditions over extended periods. Phenomena such as El Niño and La Niña can alter temperature and precipitation patterns, increasing the likelihood of droughts, floods, heatwaves, or cold spells in different regions. These climate oscillations can intensify existing vulnerabilities and contribute to cascading disaster risks when combined with local environmental and socio-economic conditions.

In Bosnia and Herzegovina (BiH) – and by extension the municipality of Kakanj in central BiH – rising average temperatures and more extreme seasonal fluctuations have increased the likelihood of prolonged droughts, intense wildfires, land degradation, and other slow-onset disasters.

Kakanj's climate is normally temperate-continental, with warm summers, cold winters, and about 861 mm of annual precipitation on average. However, climate records show increasing variability: five of the past twelve years in BiH were classified as very dry to extremely dry. This indicates a rising frequency of drought conditions. In dry years, Kakanj's rivers and springs (part of the Bosna River basin) experience low flows, affecting both hydropower and water supply, and local farms suffer reduced yields. For instance, BiH as a whole suffered a severe drought in 2012 that devastated crops – grain and vegetable yields fell by roughly 70%, causing about \$1 billion USD in agricultural losses and even reducing energy production (via hydropower) by ~25%. Such impacts extended to Kakanj's municipality, where agriculture and power generation (though mostly coal-based locally) are important to livelihoods. Indeed, drought in 2012 was described as the worst in half a century for the Balkans, illustrating how climate-change-amplified droughts can cripple local economies. The increasing temperatures observed (BiH's summer mean has risen over 1°C since the 1980s) combined with longer dry spells mean future droughts in Kakanj could be more frequent and intense. This raises concerns for food security and water availability in the area. To mitigate drought risk, local authorities are considering improved water management – e.g. upgrading irrigation infrastructure and protecting water sources – as current irrigation coverage in BiH is very low (under 1% of arable land).

Prolonged heat and drought, combined with dry vegetation, have led to more frequent wildfires in recent years, a trend also affecting central BiH regions including Kakanj. In BiH, hotter summers



Image: Mine waste landfills in Mramor and Donji Kakanj, citizen science photos

and recurring droughts have created more combustible environments. Statistics underscore this surge – the number of wildfire incidents in BiH increased 17-fold from 2011 to 2021, indicating a “staggering” rise in wildfire threat over the past decade. This trend is linked to successive dry years and heatwaves, which turn forests into tinderboxes. Kakanj, with its mix of rural areas and industrial zones, is not immune to this risk. According to the Kakanj Municipal Emergency Plan, “fires occur often in Kakanj Municipality”, and especially dry years have led to dangerous forest fires that were larger and longer-lasting than usual. The hilly, wooded parts of Kakanj can catch fire during summer droughts, endangering nearby villages and adding hazardous smoke to the already polluted air. Local fire authorities note that negligence (like agricultural burning or discarded cigarettes) on parched lands often ignites fires, which then spread rapidly in dry brush. Besides immediate loss of timber, wildlife, and occasionally property, wildfires leave long-term impacts: they degrade soil (increasing erosion and landslide risk on bare slopes) and impair water quality (ash and debris in rivers). They also contribute to air pollution and respiratory health issues over a wide area. Climate projections suggest that with warming, the fire season will lengthen and the wildfire risk zone could expand even into areas historically less fire-prone. Already, southern and eastern parts of the country see regular large fires (e.g. near Mostar, Trebinje), and central regions like Kakanj face periodic wildfires during summer droughts. To combat this, Kakanj’s strategy emphasizes preventive measures – e.g. clearing dry vegetation near settlements, improving firefighting capacity, and public awareness – aiming to reduce annual fire incidents (the goal is cutting them by over 75% by 2027).

While Kakanj (central BiH) has a wetter climate, it still faces soil erosion and degradation risks on deforested or mined lands. Desertification refers to the process of land degradation in arid, semi-arid, and dry sub-humid areas, driven by climatic factors (like prolonged droughts) and human activities (such as deforestation, overgrazing, and poor water management). It does not mean literal desert formation in the case of Bosnia, but rather the loss of fertile soil and vegetation cover, leading to an environment more prone to erosion and unable to support agriculture. In Bosnia and Herzegovina, approximately 40% of the country’s land area is considered degraded to some extent. The hilly terrain around Kakanj, combined with its industrial legacy (open-pit coal mines, quarrying, etc.), makes the soil vulnerable. Centuries of mining in Kakanj have left unstable ground and bare slopes; when heavy rains alternate with drought periods, it exacerbates soil erosion and degradation of these lands. Moreover, unsustainable agricultural practices (e.g. over-tilling, lack of crop rotation) and deforestation for fuel or development can degrade soil structure. Climate change amplifies these issues: the mountainous topography of BiH interacts with climatic extremes (flood downpours, drought, etc.) to worsen erosion and torrential runoff. During intense rainstorms, degraded hillsides in Kakanj suffer mudslides or gullyng, removing topsoil. During summer dry spells, pastures and

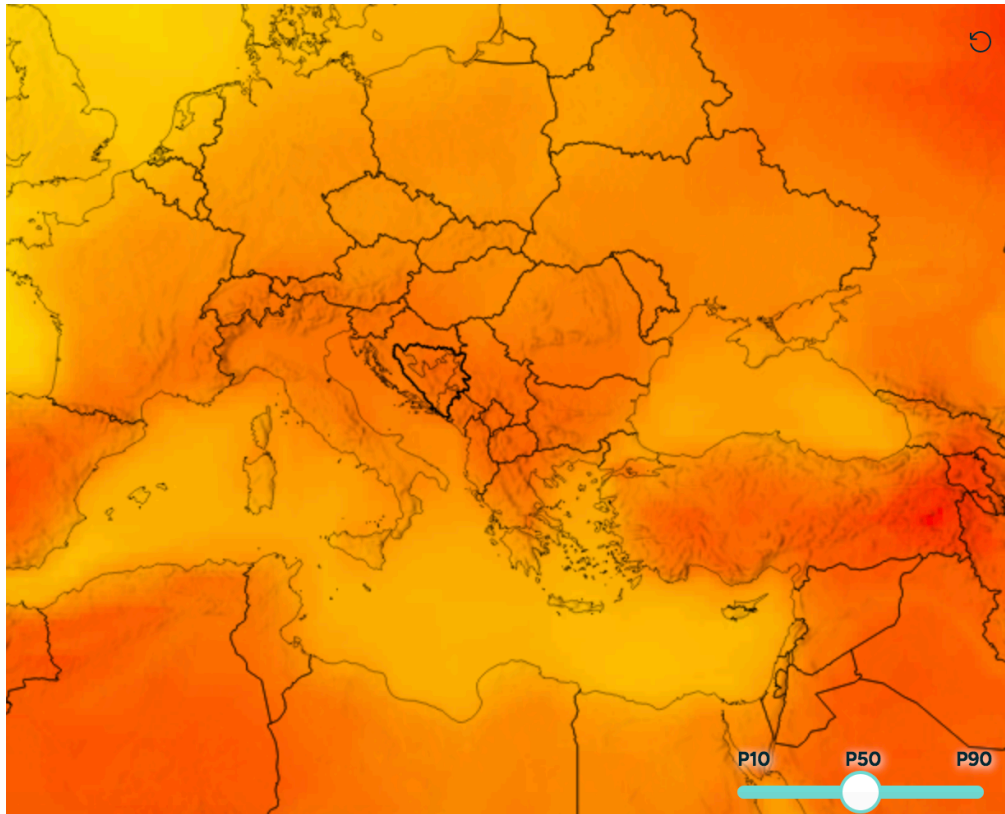


Image: Map of Projected Trend per Decade Change of Average Mean Surface Air Temperature, World Bank's Climate Change Knowledge Portal

croplands wither, leaving the ground exposed to wind erosion. The absence of vegetation cover is a major red flag – without plant roots to bind the soil, land becomes more prone to degradation. This is why preserving forests and grass cover is crucial. Wildfires (discussed above) also play a role: they can strip large areas of vegetation and the subsequent exposure leads to faster land degradation. While Kakanj itself isn't turning into a desert, pockets of land in the municipality (Mramor, Brnj, Donji Kakanj) are becoming unproductive “wastelands” if current trends continue – for example, spoil heaps from mines or overgrazed hillside meadows can lose all topsoil and vegetation. For Kakanj, integrating measures (planting trees on slag heaps, controlling grazing, improving irrigation where feasible) should be part of building resilience.

In terms of long-term climate variability, Bosnia and Herzegovina's climate can be subtly influenced by ENSO. Scientists note that during strong El Niño years, Europe often sees shifts such as milder winters in the north and potential summer heatwaves in the south, whereas La Niña years can bring cooler, stormier patterns to parts of Europe. In practical terms, this means that a global El Niño could increase the likelihood of unusual warmth and dryness in the Balkans, raising the risk of drought or wildfires in Kakanj's region for that year. Conversely, La Niña might contribute to a somewhat cooler, wetter summer pattern in the Balkans, potentially reducing drought risk but increasing flood or severe storm incidence. Indeed, in mid-2024 climate experts in BiH noted that with La Niña developing, they “did not expect an excessively hot and dry summer”, anticipating more frequent showers to break up heatwaves. Such forecasts highlight how global climate oscillations are factored into regional risk outlooks. Another important pattern is the North Atlantic



Image: Forest fire in Ponijeri, Kakanj (August 2024), citizen science photo

Oscillation – when in its positive phase, it can shift storm tracks northward (often yielding drier winters for southern Europe, including BiH), and in its negative phase, bring wetter conditions to the Mediterranean region. Over months to decades, these oscillations can thus create periods of heightened or reduced climatological hazard risk for Kakanj. For example, a decadal NAO trend could result in a run of drier-than-normal winters (hitting water supplies), or conversely a period of heavy winter rains (raising flood and landslide risks). It’s the combination of these large-scale patterns with local environmental factors that produces extreme outcomes. Crucially, climate change may be altering these variability patterns or at least exacerbating their impacts. Research suggests that ENSO’s influence on European weather might grow under global warming, and that when an extreme ENSO event coincides with warming trends, the resulting anomalies (droughts or heavy rainfall) can be more severe. In Kakanj, this means local authorities must stay aware of global climate signals. Seasonal forecasts from bodies like the World Meteorological Organization (WMO) are increasingly used to prepare for upcoming conditions – for instance, if an El Niño is predicted, water conservation campaigns and drought plans should be activated in Kakanj preemptively. Likewise, understanding long-term variability can inform infrastructure design (ensuring dams and drainage can handle the “worst-case” multi-year rainfall deficits or surpluses).

Climatological hazards – droughts, wildfires, land degradation, and the influences of global climate variability – pose significant challenges for Kakanj in the coming decades. These risks do not arrive overnight as a sudden crisis, but rather creep in gradually, as rainfall diminishes season by season, as summers grow hotter, or as forests and soils are subtly weakened year by year. Kakanj has already felt this through more frequent dry spells, occasional forest fires, and strains on its natural resources. Looking forward, climate change is expected to further amplify these trends – models project BiH’s mean temperature could rise by 2.4–4.9°C by the end of the century under high-emission scenarios,

alongside more erratic precipitation. This suggests that without adaptation, droughts could become longer, wildfires more intense, and land degradation more widespread, even as climate variability superimposes additional ups and downs.

Citizen-led mapping revealed that droughts are already occurring in Kakanj, particularly in rural areas. Reports from residents identified recurring drought impacts in the settlements of Vukanovići, Alagići, Pavlovići, Škomlići, and Haljinići. Several of these communities rely on local streams and small rural water supply systems, which are experiencing declining water availability and increasing shortages, especially during the summer months.

In response, the Municipality of Kakanj should undertake a comprehensive assessment of its water supply systems, with particular attention to rural and decentralized networks, to ensure that drought conditions do not compromise access to drinking water during dry seasons. This should include identifying vulnerable local sources, improving system resilience, and integrating additional or alternative water sources and streams into existing water supply systems.

BIOLOGICAL RISKS

Biological risks arise from the spread of diseases and biological agents that affect humans, animals, and plants, with the potential to cause significant health, economic, and environmental impacts. These risks are often influenced by environmental conditions, climate change, ecosystem disruption, global mobility, and weaknesses in public health and veterinary systems.

Epidemics and pandemics refer to the rapid spread of infectious diseases within a population (epidemics) or across multiple countries and continents (pandemics). Diseases such as influenza and COVID-19 can lead to high morbidity and mortality, overwhelm health systems, disrupt economic activity, and exacerbate social inequalities.

Vector-borne diseases are infections transmitted to humans through vectors such as mosquitoes, ticks, or fleas. Examples include malaria, dengue, and West Nile virus. The distribution and transmission of these diseases are strongly affected by climate conditions, water management, land use, and biodiversity, with warmer temperatures and changing rainfall patterns expanding vector habitats.

Locust swarms and other pest infestations involve the rapid multiplication and spread of insects that damage crops, forests, and natural vegetation. These events can severely affect food security, livelihoods, and local economies, particularly in agricultural regions, and may be intensified by climatic variability and ecosystem degradation.

Animal and plant disease outbreaks affect livestock, wildlife, and crops, leading to production losses, trade restrictions, and ecological imbalance. Such outbreaks can undermine food systems, threaten rural livelihoods, and, in some cases, pose risks to human health through zoonotic disease transmission.

Kakanj's most significant recent example of a biological disaster is the COVID-19 pandemic. The novel coronavirus (SARS-CoV-2) reached Bosnia in March 2020 via travelers from abroad and led to an unprecedented health crisis. In Kakanj, the first cases were recorded by mid-2020; by late July 2020 the local health authorities had confirmed 62 COVID-19 cases (with 30 active cases and 8 patients hospitalized in the Zenica isolation unit). Cumulative infections continued rising – for

instance, by August 2020 Kakanj had 95 reported cases (approximately 2.5 cases per 1,000 population). Bosnia and Herzegovina overall suffered one of the world's highest COVID-19 mortality rates by 2023. Over 16,000 people in BiH lost their lives to COVID-19 out of some 404,000 confirmed cases, a case-fatality ratio around 4%. The high death toll is attributed in part to strains on the health system – Bosnia had among the lowest testing rates in Europe and hospitals were overwhelmed during infection peaks. Indeed, analyses show the pandemic's indirect effects (e.g. delayed care for other conditions due to overburdened health services) contributed to excess deaths.

Beyond the raw numbers, COVID-19's impacts in Kakanj underscored how pandemics can disrupt daily life and expose social vulnerabilities. In spring 2020, authorities declared a state of emergency and imposed lockdown measures across BiH (including curfews, business closures, and mask mandates). These efforts initially slowed the virus, but loosening restrictions led to resurgence and repeated waves of infection. The health services in Kakanj (a small-town clinic with limited capacity) had to transfer severe cases to larger regional hospitals. Community programs stepped up to assist those in need; for example, during the crisis the EU/Council of Europe's ROMACTED program and local NGO "Romalen Kakanj" provided food and hygiene vouchers to hundreds of vulnerable Roma families in Kakanj and surrounding areas. Roma settlements like Varda (Kakanj) were also targeted for sanitation and outreach campaigns to prevent contagion. This highlighted pre-existing social inequalities – marginalized groups with poor housing and limited healthcare access were hit hardest by the pandemic. By 2021–2022, as the acute phase of COVID-19 passed, Kakanj and BiH entered a "post-COVID" recovery period with ongoing challenges. Vaccination rollout in the Federation of BiH started in early 2021. However, vaccination rates remained relatively low (under 30% of the population fully vaccinated by early 2022). The pandemic's economic impacts – from workplace disruptions to decreased industrial output – were felt in Kakanj's industries (mining, cement production) and small businesses. Schools gradually reopened, and public life resumed, but health officials noted the need to strengthen pandemic preparedness for the future. Studies of the COVID-19 response in BiH have urged improving surveillance (e.g. tracking excess mortality) and investing in healthcare capacity to ensure that future epidemics do not overwhelm the system. In sum, the COVID-19 pandemic in Kakanj demonstrated how a global infectious threat can swiftly permeate a local community, causing high morbidity and mortality, straining health infrastructure, disrupting the economy, and necessitating strong public health measures to contain the spread.

While COVID-19 is the recent example, other epidemic risks persist. Seasonal influenza epidemics hit Bosnia annually and could potentially reach pandemic scale if a novel strain emerges. Kakanj's public health officials participate in canton-level flu surveillance and vaccination campaigns, though uptake of flu vaccines is traditionally low. Past global outbreaks have also had local echoes – for instance, the 2009 H1N1 "swine flu" pandemic infected people across BiH (with several hundred confirmed cases in the Federation, including Zenica-Doboj Canton). Communicable disease preparedness remains a priority: Kakanj's civil protection and health services must remain vigilant for threats like measles outbreaks (given periodic vaccine lapses), food- or water-borne epidemics during natural disasters, and potential future pandemics.

Vector-borne diseases – those transmitted by mosquitoes, ticks, flies or other vectors – are emerging threats in the Kakanj region, especially as climate change and environmental factors expand vector habitats. Bosnia and Herzegovina's temperate climate has historically meant fewer tropical diseases, but this is changing. Warmer temperatures and altered rainfall patterns have been observed in BiH, including more hot summers and mild winters. These conditions allow certain disease-carrying vectors to proliferate and spread into new areas. A 2021 assessment warned that "wider spread and intrusion of new vector-borne diseases is very likely" in Bosnia's future due to climate change.

Notably, scientists have recently detected invasive mosquitoes like *Aedes albopictus* (the Asian tiger mosquito) in southern BiH. This species can transmit viruses such as dengue, chikungunya, and Zika. Its presence signals that diseases once confined to the tropics could pose risks if introduced by travelers. Similarly, ticks are active longer each year due to milder winters, raising the incidence of tick-borne encephalitis and Lyme disease.

One vector-borne infection already impacting Bosnia is West Nile Virus (WNV). WNV is carried by *Culex* mosquitoes that breed in warm stagnant water (e.g. ponds, flooded areas). The first human West Nile cases in Bosnia were recorded in 2012–2013. During a 2013 outbreak, Bosnia saw around 40 confirmed neuroinvasive WNV cases – a surprising emergence for a disease not previously seen in the country. (Neighboring Serbia and Croatia had reported West Nile in humans, horses, and birds a year earlier, indicating regional spread.) Many of these infections likely went undiagnosed, as surveillance was limited. By 2014, public health officials in the Federation of BiH were on alert: increased summer mosquito populations made WNV cases “not a surprise” should they occur. Since then, sporadic WNV cases have occurred in BiH most summers (for example, a fatal case was reported in 2018 in the Tuzla region), although Kakanj has not documented a human case to date. The risk, however, is present – the Bosna River valley and local wetlands near Kakanj provide mosquito habitat, and migratory birds (natural WNV hosts) pass through the area. Efforts such as mosquito control campaigns and public advice (using repellent, removing standing water) are important to reduce the threat.

Other vector-borne diseases of concern include Tick-borne diseases. Rural areas around Kakanj have populations of ticks (*Ixodes* species and others) which can transmit Lyme borreliosis and tick-borne encephalitis (TBE). Lyme disease (caused by *Borrelia* bacteria) is the most common vector-borne illness in temperate Europe. In Bosnia, hundreds of Lyme cases occur annually, especially from tick bites in grassy or wooded areas during spring-summer. Though often under-reported, residents of Kakanj who work or hike outdoors face this risk; wearing protective clothing and prompt tick removal are advised. Tick-borne encephalitis virus has been recorded in neighboring countries (like Slovenia and Croatia), and while Bosnia has not reported confirmed TBE outbreaks, the presence of the vector ticks suggests it could emerge if the virus encroaches.

Additionally, sandfly-borne leishmaniasis has occasionally been noted in the Balkans; however, there’s no known local transmission in BiH so far. Malaria, once endemic in the Balkans in the early 20th century, was eradicated in Yugoslavia by mid-century through mosquito control. With changing climate and global travel, imported malaria cases appear periodically (travelers returning infected), but the native *Anopheles* mosquitoes have not re-established malaria transmission. Still, vigilance is needed as warmer, wetter conditions could make even malaria re-emergence a future possibility in the region.

Overall, the expansion of vector habitats due to climate shifts, urbanization, and land-use changes poses a growing challenge. Floods and poor water management can create breeding grounds (for example, after the record floods of 2014 in BiH, concerns rose about mosquito-borne diseases in flooded communities). Meanwhile, public health systems must improve vector surveillance. Currently, Bosnia lacks an integrated monitoring program to map vector populations and the diseases they carry. For Kakanj, this means local authorities should collaborate with canton and national institutions to monitor vectors (mosquito trapping, tick surveys) and to educate the public on preventing bites. Proactive measures will be key to prevent vector-borne diseases from taking hold, especially as environmental changes push these risks northward into areas like Kakanj that historically did not face them.

Periodic explosions of agricultural pests – such as locust swarms or insect infestations – can devastate crops, pastures, and forests, thereby threatening food security and livelihoods. In the context of Kakanj (which has a mixed semi-rural economy with many small farmers), such biological hazards are important to consider even if not as frequent as in some tropical regions. Locust swarms are infamous in parts of Africa and Asia, but Europe too has seen locust infestations historically. The Italian locust and Moroccan locust are two species known to cause outbreaks in the Mediterranean and Eurasian region. In the late 19th century, Ottoman-era Herzegovina (southern Bosnia) experienced devastating locust plagues that consumed crops and impoverished villages. Today, large locust swarms are uncommon in Bosnia, but climate variability (hot dry springs followed by rain) could create favorable breeding conditions. Neighboring Albania, for instance, has had locust outbreaks requiring emergency control as recently as 2020. Should regional locust populations irrupt, Bosnia’s agriculture (maize, vegetable and pasture lands) could be affected. Kakanj’s direct risk from locusts is relatively low due to its more temperate climate and smaller crop area, but rural parts of the municipality could still suffer if a grasshopper or locust infestation moved through the Bosna river corridor. Thus, inclusion of locust monitoring in national contingency plans (through the Ministry of Agriculture and extension services) is warranted.

More pertinent for Kakanj are other pest infestations that can multiply rapidly and harm plant health. One example is the invasion of the Mediterranean fruit fly (*Ceratitis capitata*), an extremely destructive pest of fruit crops. This invasive fly was first detected in Bosnia’s Herzegovina region in 2005 and has since established itself in the warmer parts of the country. During its initial outbreak, a “large pest population and significant infestation of figs” was recorded in 2005 in the Neretva valley (southern BiH). Over 2005–2010, the medfly spread inland about 50 km from the coast, proving it can survive Bosnia’s climate. It attacks a wide range of fruits (figs, peaches, apples, etc.), causing them to rot from larvae, and can lead to complete crop losses if uncontrolled. While Kakanj is further north and has a cooler climate than Herzegovina, continued warming trends may allow pests like the medfly to extend their range. Even if Kakanj’s fruit producers haven’t yet faced medfly, they do contend with native pests (e.g. codling moth in apples, plum fruit moth, and various caterpillars). The implications for food security and local economies are serious: a major pest infestation can reduce yields, drive up produce prices, and require costly pesticide campaigns.

Another notable pest risk is to forests. Kakanj’s hillsides are partly forested, and in recent years Bosnia’s forests have been hit by infestations of bark beetles (notably after droughts and heatwaves). For instance, *Ips typographus* (spruce bark beetle) outbreaks in 2016–2017 ravaged conifer forests in the region, especially after trees were weakened by a dry summer. This not only affects timber resources but also can increase fire risk and erosion. Pests like gypsy moths can defoliate oak and other broadleaf forests; such outbreaks have occurred periodically in the Balkans.

It’s worth noting that climatic stress and ecosystem disruption often create conditions for pest surges – e.g. drought can reduce natural predators and increase pest insect reproduction rates. Additionally, global trade can introduce new invasive pests. Bosnia has had to remain vigilant against pathogens like *Xylella fastidiosa* (a bacteria killing olive and fruit trees in Italy) and *Drosophila suzukii* (spotted-wing drosophila fruit pest), which are not yet established in BiH but pose looming threats. The International Plant Protection Convention reports show Bosnia’s plant health authorities are monitoring such risks and reporting incursions. For Kakanj’s farmers, continued pest management – from monitoring fields to using integrated pest control methods – will be crucial. If a major infestation (whether locusts or another pest) does strike, coordinated response (spraying

programs, quarantine of affected areas, and possibly aid to farmers) would be needed to mitigate the damage.

Kakanj, being a mix of industrial town and rural settlements, has many households that keep livestock (cattle, sheep, goats, poultry) or rely on agriculture, so it is not immune to disease outbreaks in animals and plants. A prominent example in Bosnia is brucellosis, a bacterial disease (caused by *Brucella*) that affects sheep, goats, cattle and can infect humans who have contact with infected animals or consume unpasteurized dairy. Brucellosis causes miscarriages in animals and a severe flu-like illness in humans that can become chronic. Bosnia experienced a brucellosis epidemic in the 2000s following the disruption of the 1990s war. The first human cases in BiH were noted around 2000, and by 2008 the country reported an alarming 21,477 infected livestock and 994 human cases of brucellosis. The outbreak was nationwide, but notably concentrated in central and northern Bosnia (regions like Zenica-Doboj Canton, which includes Kakanj, were heavily affected). The causes of this crisis illustrate the “weaknesses in public health and veterinary systems” that amplify biological risks: after the war, animal vaccination and movement control were poorly enforced, livestock were imported without proper checks, and veterinary services were fragmented and under-resourced. Brucellosis spread among nomadic flocks and then to people (especially farmers, butchers, and veterinarians). In response, BiH’s State Veterinary Office launched a mass vaccination program for small ruminants in 2009. This led to dramatic declines in infection – by 2012, reported human cases fell to 68 for the year (from nearly 1000 a few years prior). However, inconsistent follow-through allowed a resurgence: by 2017–2018, a new brucellosis outbreak hit parts of the Federation, including dozens of human cases in Central Bosnia and Zenica-Doboj cantons. Experts cited gaps in the vaccination coverage (some sheep were never vaccinated or new animals introduced) and poor coordination between health and veterinary sectors. Kakanj, as part of Zenica-Doboj, saw cases during this period – local news reported several Kakanj residents hospitalized with brucellosis, likely contracted via infected sheep or dairy. The brucellosis saga underlines how animal diseases can become persistent public health issues if the veterinary infrastructure is weak. It also shows how trade and livelihoods suffer: during the outbreaks, thousands of livestock had to be slaughtered (over 75,000 sheep by 2011) with an economic loss estimated around \$9.8 million, and Bosnia’s ability to export animal products was severely curtailed. Even today, brucellosis remains endemic in Bosnia at lower levels, requiring continued surveillance in places like Kakanj where both farming and backyard animal keeping are common.

Another major threat is African Swine Fever (ASF), a viral disease fatal to pigs. ASF does not infect humans but it spreads rapidly among wild and domestic swine, with no cure or vaccine available, making it economically devastating. For years, Bosnia watched ASF outbreaks inch closer as it spread in Eastern Europe. In June 2023, Bosnia and Herzegovina confirmed its first ASF outbreak, on a small pig farm in Bijeljina (northeastern BiH). This outbreak, likely originating from bordering Serbia which had cases, prompted urgent containment measures. Authorities culled the affected pig and set up quarantine zones. However, within weeks ASF was detected on other farms, and by mid-summer 2023 Bosnia had to cull over 13,000 pigs in the span of one month to contain the virus. The Kakanj area, which has some backyard pig raising but is not a swine industry hub, fortunately did not see a local case in that wave. Nevertheless, to protect the national herd, Bosnia halted pig movements and received international aid.

Poultry diseases are another concern. Avian influenza (bird flu) outbreaks have sporadically occurred in the Balkan region. High-pathogenic H5N1 avian flu was detected in wild birds in Bosnia in 2006, and more recently some cases of H5Nx strains in backyard poultry in 2021, prompting culling of birds in affected villages. While no major avian flu outbreak has hit Kakanj specifically, the

municipality lies along migratory flyways, so local poultry farmers remain attentive to biosecurity during migration seasons. Plant diseases also pose risks: for instance, outbreaks of potato blight or wheat rust could affect crop yields in Kakanj's agricultural lands. In 2020, a fungal blight hit corn crops in parts of Bosnia after an unusually wet season, reminding farmers of the need for crop rotation and fungicides.

Underpinning these threats is the need for strong veterinary and agricultural health systems. The brucellosis situation exposed Bosnia's fragmented system: with two entity veterinary services and 10 cantonal offices in the Federation, coordination is challenging. Similarly, the human health sector has 13 ministries across state, entity, and cantonal levels. This complexity can slow down responses to outbreaks. In Kakanj's case, its local veterinary station and public health institute branch must coordinate with higher authorities for disease reporting and action. Improvements have been made – BiH now has an active disease notification system and has adopted EU-aligned laws on animal health. Yet, gaps remain in funding, staffing, and laboratory capacity. For example, confirming exotic diseases often requires sending samples abroad or to better-equipped labs.

The experiences with brucellosis, ASF, and other outbreaks underscore that early detection and rapid response are crucial. If an animal or plant disease can be pinpointed early (for instance, testing a sick animal and quarantining a farm), it can prevent wider community spread. Public awareness is also key: educating farmers in Kakanj to report unusual illnesses or sudden die-offs in their herds or crops can trigger timely interventions. Finally, these incidents highlight the interconnected nature of One Health – human health, animal health, and environmental health. A zoonotic pathogen spilling from livestock to people, or a pest infestation exacerbated by climate stress, shows that Kakanj's resilience to biological risks will depend on addressing environmental management and strengthening both medical and veterinary public health in an integrated way.

CHEMICAL RISKS

Chemical risks arise from the accidental or uncontrolled release of hazardous substances that can cause harm to human health, ecosystems, and infrastructure. These risks are closely associated with industrial activity, transport and storage of chemicals, agricultural practices, and inadequate safety or regulatory oversight. Chemical hazards can have both immediate acute effects and long-term cumulative impacts through environmental contamination.

Industrial chemical spills and leaks involve the release of hazardous substances during industrial processes, storage, or transport. Such incidents can contaminate soil, surface water, and groundwater, pose direct health risks to nearby populations, and require costly and complex remediation efforts.

Toxic gas releases occur when poisonous or harmful gases are emitted into the atmosphere, either accidentally or due to equipment failure, industrial accidents, or fires. Exposure to toxic gases can cause respiratory distress, poisoning, long-term health effects, and, in severe cases, fatalities, as well as necessitate evacuation and emergency response measures.

Illegal waste dumping involves the unauthorized disposal of household, industrial, or hazardous waste in natural areas, rivers, forests, or abandoned sites. Illegal dumping contaminates soil and water, threatens human and animal health, increases fire risk, and contributes to long-term environmental degradation.

Traffic pollution and accidents arise from road, rail, or industrial transport activities, including vehicle emissions, fuel leaks, noise pollution, and accidents. Traffic contributes to air pollution, greenhouse gas emissions, and localized environmental contamination, as well as increased risks of chemical spills during accidents.

Household heating pollution results from the widespread use of solid fuels such as coal, wood, or low-quality biomass in residential heating systems. Inefficient combustion releases particulate matter and toxic gases, contributing to poor air quality, respiratory illness, and increased climate impacts, particularly during winter months.

Sewage discharge into rivers or streams refers to the release of untreated or inadequately treated wastewater into surface waters. Sewage discharge degrades water quality, spreads pathogens, damages aquatic ecosystems, and poses serious risks to public health, especially in communities relying on downstream water sources.



Image: Air pollution in Kakanj, citizen science photos

By far the most acute and visible chemical risk in Kakanj today is its air pollution. Especially in winter, the town is frequently shrouded in smog – a mix of industrial emissions and smoke from household coal heating. Concentrations of fine particulate matter (PM_{2.5}) and toxic gases have soared to dangerous extremes. In January 2026, air quality monitoring in Kakanj hit an Air Quality Index (AQI) of 995 (on a scale where anything above 300 is “hazardous”), with PM_{2.5} levels many times above safe limits. This level of pollution “far exceeds all allowed limits and represents a serious risk to the health of the population, especially children, the elderly and those with chronic illnesses”. Local doctors have reported a noticeable increase in respiratory diseases and even cancers correlating with these pollution episodes. In fact, Kakanj has been noted for having an unusually high incidence of cancer – residents of Kakanj make up the largest number of oncology patients at the Zenica Cantonal Hospital – which health experts link to prolonged exposure to industrial pollutants and poor air quality.

Major polluters in Kakanj’s air include the coal power plant (emitting sulfur dioxide, nitrogen oxides, and dust) and the cement factory, as well as thousands of domestic coal furnaces and older vehicles.

The Kakanj Thermal Power Plant (450 MW capacity) began operation in the 1950s and consumes roughly 1.8 million tons of brown coal annually. A cement manufacturing plant Tvornica Cementa Kakanj also operates nearby, which utilizes some waste by-products (slag and ash) from the power plant as inputs. During temperature inversions in winter, a stagnant lid of cold air traps these emissions in the valley, leading to extreme smog events. Citizens describe evenings when “it is nearly impossible to go outside or even ventilate homes” due to the soot and sulfur smell; on bad days, “if you open the windows, cleaner air goes out than what comes in”. Kakanj’s air pollution has repeatedly hit emergency alert levels for SO₂ gas as well – for instance, monitoring has recorded sulfur dioxide concentrations above the regulatory “alert” threshold for days on end. A 2025 report by environmental NGOs identified Kakanj’s power plant as one of the ten largest SO₂ emitters in all of Europe, with pollution plumes that carry across borders. This chronic toxic exposure constitutes a slower-moving chemical crisis: while not an instantaneous disaster, it imposes a steady toll on public health. Respiratory ailments (asthma, bronchitis), cardiovascular diseases, and lung cancers are all exacerbated by such poor air quality, and Kakanj’s health statistics reflect this troubling trend.

LOKACIJA		AQI	SO ₂	NO ₂	O ₃	PM ₁₀	PM _{2.5}	CO	H ₂ S	
SARAJEVO	Vijećnica	●	18	●	72	●	79	●	2200	
	Bjelave	●	80	●	88	●	24	●	153	
	Otoka	●	56	●	131	●	3	●	161	
	SarajPolje	📄	41	📄	96	📄	#	📄	189	
	Ilidža	●	77	●	67	●	#	●	113	
	Vogošća	●	67	●	63	●	#	●	146	
	Ivan Sedlo	●	24	●	21	●	57	●	68	
	Hadžići	●	62	●	57	●	6	●	139	
Ilijaš	●	79	●	59	●		●	155		
VISOKO	Centar	●	353	●		#	●	137	126	
KAKANJ	Centar	●	766	●	66	●	●	210	●	196
	Općina	●	607	●	45	●	19	●	179	●
VAREŠ	Centar	●								
ZENICA	Brist	●	#	●	#	●	●	60	●	
	Tetovo	●		●		●				
	Centar	●	122	●	32	●	35	●	47	●
	Radakovo	●	78	●	45	●	18	●	58	●
MAGLAJ	Vranduk	●	58	●		48	●	42	●	38
	Maglaj	●	41	●		#	●	89	●	
TEŠANJ	Vatrogasni dom	●	18	●	12	●	38	●	45	#
GORAŽDE	Rasadnik	●	13	●	#	●	34	●	#	#
TRAVNIK	Centar	●	168	●	44	●	#	●	87	●
JAJCE	Harmani	●	32	●	11	●	#	●	34	●
BIHAĆ	Nova četvrt	●	#	●	5	●	52	●	13	●
LIVNO	Centar	●	#	●	96	●	2	●	87	●
MOSTAR	Bijeli Brijeg	●	30	●	60	●	79	●	34	●
	Kampus	📄						38	📄	35
ŽIVINICE	Centar	●	388	●	76	●	1	●		#
TUZLA	Trnovac	●								
	Skver	●	98	●	58	●	#	●		214
	Bukinje	●	63	●	53	●	#	●		162
LUKAVAC	BKC	●	102	●	57	●	#	●		#
	Centar	●	#	●	39	●	19	●		#

Image: Air pollution in Kakanj compared to other cities in BiH, January 2026 (Hydrometrological institute FBiH)

In mid-January 2026, Kakanj experienced an extreme air pollution event, with local air-quality monitoring reporting levels far above safe health thresholds and ranking it as the most polluted city in the world on certain days according to real-time air quality tracking. Local news outlets reported that on the evening of 15 January 2026, air pollution concentrations—especially fine particulate matter (PM_{2.5})—spiked dramatically, creating dangerous conditions and prompting headlines that Kakanj was the world’s most polluted city that night. Official air quality indices recorded values exceeding 400 AQI (Air Quality Index), which is considered hazardous and poses serious risks to the general population. These elevated levels were accompanied by heightened warnings for vulnerable groups, including people with respiratory conditions, children, and older adults. This episode was linked to the broader context of wintertime air-pollution issues across Bosnia and Herzegovina, where coal combustion for heating and industrial emissions frequently drive high pollution levels during cold weather.

Local authorities and Bosnia’s government have begun some mitigation (for example, projects to add desulfurization scrubbers at the power plant have been announced, and efforts to subsidize home heating upgrades are in discussion). However, residents and activists complain that responses are too slow and ineffectual. In January 2026, despite off-the-charts pollution readings, “the local government and Civil Protection did not even issue warnings or emergency measures. While we suffocate in smog from the cement factory, the power plant, and household stoves – the authorities stay silent,” frustrated Kakanj citizens told the press. The situation has spurred public protests, petitions, and even the formation of grassroots groups like “Kakanj Ustaje” (“Kakanj Rises”) demanding the right to clean air.



Image: Air pollution and mining landfills in Kakanj, citizen science photos

Beside industry, Kakanj’s frequent hazardous air quality, is also due to vehicle emissions as significant contributing factor, especially along busy routes and during winter smog episodes. Exhaust from traffic – particularly diesel trucks and older cars – builds up in these conditions. A leading air-quality specialist in BiH pointed out that outdated vehicles (many with no catalytic converters or low Euro standards) and a lack of cleaner public transport mean traffic in Bosnia and Kakanj emits excessive particulate matter (PM) and nitrogen oxides.

Local authorities have taken emergency measures to curb traffic pollution during severe smog. In January 2026, the Kakanj mayor declared an “Uzbuna” (alarm) episode due to dangerously high air

pollution. Under this alert, the town temporarily banned older polluting vehicles (those below Euro 3 emission standard) from main roads and made public buses free to reduce traffic. Similar restrictions on heavy trucks were also considered. These interventions mirrored those in Sarajevo, where trucks over 3.5 tons were barred from downtown during pollution peaks. While Kakanj's chronic air problems stem largely from its coal-fired power plant and household stoves, traffic is recognized as an important local source of NO₂ and PM_{2.5}. The rumble of coal and waste trucks through town – for example, hauling ash or garbage – further contributes to dust and diesel soot.

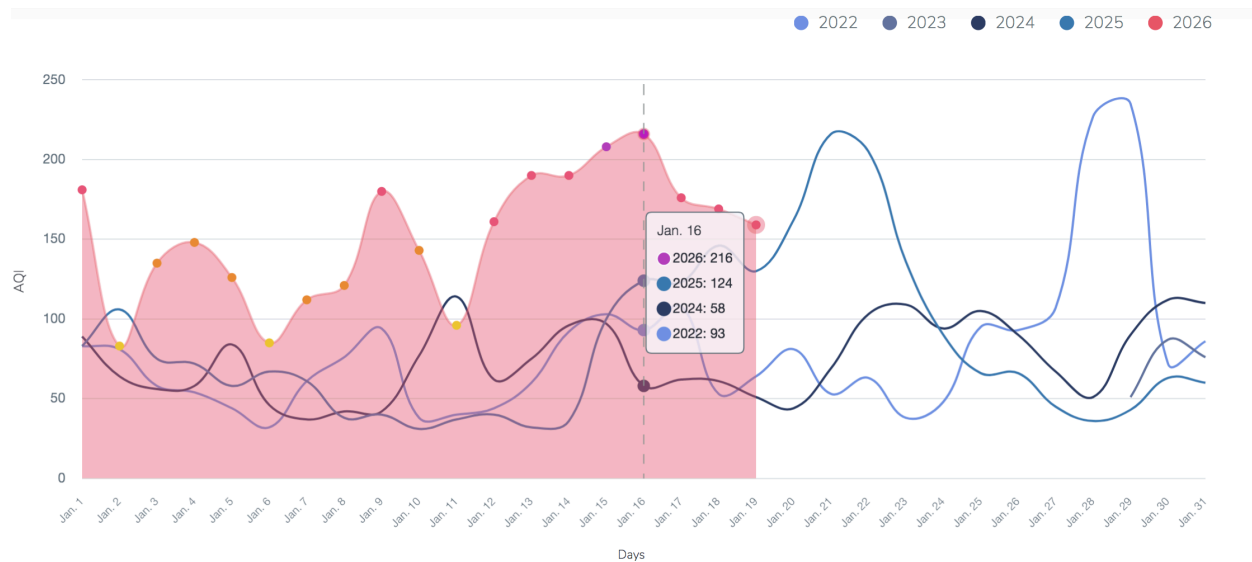


Image: Air quality in Kakanj for month January compared for 2022, 2023, 2024, 2025 and 2026 (AQI data)

These fumes, combined with smoke from home heating, often form thick smog in Kakanj's basin during winter. Residents report stinging eyes and respiratory troubles on days when tailpipe smoke and other pollutants hang in the air. Namely, household heating is another major driver of Kakanj's pollution crisis, especially each winter when thousands of homes burn coal or wood for warmth. Many families rely on inefficient coal stoves and boilers, often using low-quality lignite coal high in sulfur and ash, which releases thick smoke and soot into the air. On cold nights, a grey haze from household chimneys can blanket Kakanj's neighborhoods. The town's valley setting and stagnant winter air exacerbate the problem by trapping these emissions, creating intense smog episodes. Sulfur dioxide (SO₂) and fine particulate levels then spike far above health standards. The health impacts are very real: a 17-year-old Kakanj resident with asthma described coughing up blood on heavy-smog days and struggling to breathe whenever he went outside in winter. Unfortunately, such respiratory problems are common in Kakanj. Local clinics see increases in bronchitis, asthma attacks, and other pollution-linked ailments each heating season.

Authorities at both state and local levels have begun efforts to reduce pollution from home heating. Kakanj is among the communities to introduce programs encouraging a switch to cleaner heating technologies. In 2024 the municipal government offered financial incentives for residents to replace old coal furnaces – providing up to 30% subsidies for installing pellet-fueled stoves, heat pumps, or adding home insulation. This initiative aims to curb smoke emissions by making modern heating more affordable. A number of households have applied, though many others, especially in rural parts, still use firewood and coal due to cost. The town is also partly supplied by a district heating

system from the thermal power plant, which is less polluting per household; expanding that network is another strategy under consideration. While progress is very slow and gradual, the public is growing aware of the stakes. Media and NGOs have stressed that burning coal at home contributes significantly to Kakanj's toxic air.

Decades of coal combustion have left behind ash landfills and slag heaps containing heavy metals that leach into ground and surface waters. Failures in containing these materials – for instance, an ash slurry spill or a flood hitting waste piles – constitute a serious chemical spill incidents. Indeed, the region is dotted with sites where past improper waste disposal continues to pose long-term chemical hazards.



Image: Mining landfills in Kakanj, citizen science photos

On top of its legacy pollution problems, Kakanj is facing a new industrial project that many fear could introduce additional chemical and biological risks. In 2016, a Croatian company Agroproteinka (the leading animal waste processing firm in Croatia) announced plans to build a factory for thermal processing of animal by-products in Kakanj. The local subsidiary formed to carry out this investment is called Bioorganika d.o.o. Kakanj, and the plant – worth approximately 20 million Bosnian Marks – would be constructed in the hamlet of Modrinje/Bilješevo, just outside the town. The factory's purpose is to process animal waste (like carcasses, bone, offal from slaughterhouses or farms) into usable products such as animal protein meal and technical fat. From the outset, Agroproteinka and Bioorganika representatives tried to reassure the public about the safety of the project. They stressed that it would not be an incinerator burning animal remains on-site – “there are no new dangerous chimneys” – but rather a rendering facility using strict EU environmental standards. The processed output, they said, would be used for purposes like ingredient in pet food or biofuel, and the plant would operate under EU-compliant emissions controls. Despite these assurances, local residents and environmental groups grew alarmed as details emerged. It turned out that in the environmental permit applications, Bioorganika described handling animal waste in three risk categories – and that Category 1 waste (the highest-risk material, potentially infectious or unsafe for any recycling) would indeed ultimately be disposed of by incineration. Crucially, the permit draft stated that “final disposal is carried out in licensed cement production plants”, where the processed Category 1 waste would be used “as biofuel in place of fossil fuels”. In other words, the plant would sterilize and dry the worst animal waste into a combustible powder (known as meat-and-bone meal), and then that material would be burned in a cement kiln – a form of incineration by proxy. Kakanj happens to have a cement factory very nearby, and local observers found it “no coincidence” that a cement plant was close at hand. Citizens felt misled: although Bioorganika wouldn't have its own smokestack, the plan effectively meant

animal waste would be burned in Kakanj's vicinity (in the cement factory's kiln), releasing unknown pollutants into the air. Opponents of the project also point out that Kakanj has no significant livestock or meat industry of its own to supply such a facility. This means animal waste would be trucked in from elsewhere, bringing odor and biohazard concerns during transport and storage. The proposed site is in Bilješevo next to a creek that feeds into the Bosna River, raising fears of water contamination if any mishandling or wastewater release occurred. The rendering process itself can emit foul smells (a common issue with such plants), and any accidental release of gases like ammonia or hydrogen sulfide from decomposition could pose toxic inhalation risks for nearby communities. Kakanj's air is already overburdened; locals argue that adding the stench and emissions of an animal waste facility is untenable for a town "already over-polluted".

The Bioorganika project has therefore been met with intense community resistance. By late 2024, more than 2,400 residents had signed a petition against the plant's construction, demanding that authorities revoke or refuse its environmental permit. The Municipal Council of Kakanj held a special session in January 2025 and voted to issue a negative opinion on renewing Bioorganika's permit. Even the Mayor of Kakanj, Mirnes Bajtarević, shifted to an openly opposing stance (despite earlier local government approvals back in 2014 and 2019 when the idea first surfaced). The mayor filed formal objections and appeals to higher authorities, citing the community's overwhelming opposition and environmental worries.

However, in September 2025 the Federal Ministry of Environment and Tourism in Sarajevo – the national-level body in charge of environmental permits – surprised locals by announcing a draft renewal of Bioorganika's environmental permit, essentially paving the way for the project to proceed. This came "despite the negative stance" of Kakanj's council and many NGOs. The move fueled suspicions that high-level political connections were at play. Agroproteinka, the parent company, is majority-owned by the family of Gordan Grlić Radman, who happens to be Croatia's Minister of Foreign and European Affairs. This led to media scrutiny; in Croatia, Grlić Radman was controversially dubbed the "prince of the rendering plant" due to his wealth from Agroproteinka's business. Bosnian activists speculated that the project's approval might have been eased by political ties or seen as a favor to a neighboring country's official. (It didn't help public perception that Croatia itself lacks any animal-waste incinerator or continuously operating cement kiln – Agroproteinka has been shipping its Category 1 waste to Slovakia for incineration – so critics argue they wanted to use Kakanj as a convenient dumping/burning site).

As of the start of 2026, the fate of the Bioorganika plant remains contested. Protests and advocacy by groups like "Čist zrak" (Clean Air) and "Kakanj Ustaje" continue, aiming to halt the project. Citizens are concerned that if built, the facility could bring additional chemical risks: namely biohazards (pathogens from animal carcasses), foul odor pollution, and ultimately air pollution from the incineration of rendered waste. These would come on top of Kakanj's existing environmental burden. The investors maintain that modern technology will prevent smells and that only safe, treated outputs will be burned as fuel. Trust is low, however. Given Kakanj's past experience with industries that promised jobs and development while delivering pollution, residents are wary. The Bioorganika controversy highlights how new projects can reignite old worries about chemical safety and environmental justice – who bears the risks of pollution and who reaps the benefits.

Beyond air pollution and proposed new factories, Kakanj also grapples with persistent chemical hazards from waste and water contamination. One pressing issue is the town's municipal landfill, which has effectively been an illegal dumpsite for years. The landfill, called "Bare," lies only 1.5 km from Kakanj's center and a mere 100 meters from the nearest homes in the village of Plandište. This

dumpsite has been operating without any permit or proper environmental safeguards for 13 years – despite a 2012 federal order to shut it down for failing to meet minimum technical standards. The fact that it continued to operate “13 years later” in defiance of closure orders indicates serious regulatory lapses.



Image: City landfill in Kakanj, citizen science photos

Residents of the area have been living with the consequences. The Bare landfill emits “constant foul odor” and has experienced frequent smoldering fires, which release toxic smoke. Locals report that over the years an increasing number of neighbors have fallen ill with serious diseases, potentially linked to this pollution. Particularly alarming, the dump has not only taken household garbage but also animal waste and even medical waste – all without authorization. The mixing of rotting animal carcasses and biomedical refuse in an open dump presents a cocktail of chemical and biological hazards: it can generate ammonia and hydrogen sulfide gases, breed pathogens, and leach dangerous substances (like sharps or pharmaceuticals) into soil and water. The nearby population of 3,500 (including 500 children) has protested and petitioned for the closure of this dump, forming alliances with local environmental activists.

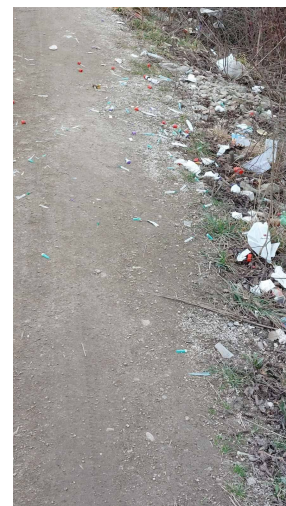


Image: Animal waste, oil spills and medical waste in the city landfill in Kakanj, citizen science photos

They've named the situation plainly: "Animal waste [and other trash] is poisoning Kakanj residents". The continued operation of the illegal landfill – run by the local public utility company – is seen by many as an example of putting cost savings over public health. (Officials claimed hauling Kakanj's trash to a proper regional landfill would be too expensive, while campaigners argue that the cost was exaggerated to justify inaction.) The result is an unmanaged chemical hazard on the town's doorstep. The municipal council repeatedly delayed action; in one case a citizen initiative to shut the dump was even removed from the council's agenda without discussion. Activists accuse local authorities and the utility (JP Vodokom) of ignoring higher-level orders and choosing a cheap dumping solution at the expense of residents' health.

Citizen reports and local monitoring show that illegal waste dumping remains a persistent environmental problem in and around Kakanj, with unauthorized disposal of household, industrial, and hazardous waste in natural areas and along local routes. Multiple community voices and informal monitoring have documented continuous dumping of waste in natural and rural locations, prompting municipal inspections and reminders of regulations against careless waste disposal. Despite new municipal rules that impose fines for improper waste dumping, unauthorized sites continue to appear, underscoring gaps in waste management services and enforcement. At the national level, Bosnia and Herzegovina faces a wider challenge of illegal dumps—estimated at over 1,400 sites across the country—which reflects shortcomings in organized waste collection and infrastructure and contributes to soil and water contamination and threats to local health and ecosystems.

Another vector of chemical risk is water pollution, particularly from industrial and mining activities upstream of Kakanj. The town's water supply comes partly from the Bukovica River, which has been impacted by mining in the region. In neighboring Vareš, an ore mine (operated by a foreign company, Adriatic Metals) has caused concerns of heavy metal contamination. Environmental tests and observations suggest that runoff from the Vareš mining area is polluting streams that feed into the Bukovica. An activist from Kakanj, Hajrija Čobo, explained that rainwater washes exposed, metal-contaminated ore tailings into the Trstionica and Borovički streams, which flow into the Bukovica River, "and then we have that same poison downstream in the Bosna watershed". By mid-2023, Kakanj's tap water had become visibly turbid (cloudy) with sediment. Locals worry it contains lead, arsenic, or other toxic metals from the upstream mine. "The water in Kakanj hasn't been drinkable since early spring [2023] and nobody officially warned the citizens," Čobo said, noting that if this continues "soon it won't even be usable as technical water". Activists have conducted their own small-scale water tests, fearing that heavy metals will reach levels "harmful to human and animal health". They warn that unless the mining practices are improved, Kakanj's water source may effectively be lost, forcing dependence on expensive alternative supplies. This scenario – chemical contamination of a town's water – is exactly the kind of slow-onset chemical disaster that often gets overlooked until it's advanced. The health stakes are high: heavy metals like lead or mercury in drinking water can cause neurological damage, organ failure, or cancer over time.

Compounding the issue, Kakanj's municipal wastewater infrastructure is underdeveloped. Industrial effluents and urban sewage have historically been discharged with minimal treatment. The Bosna River, into which Kakanj's waterways drain, has been burdened by high levels of pollutants, from both chemical (industrial) and microbiological sources. During the catastrophic 2014 floods in Bosnia, it was found that a significant portion of local water supply wells were contaminated beyond safe limits – partly due to overflow of industrial and waste facilities into waterways. Although Kakanj was not the only source, it exemplified the vulnerability of local environment to chemical contamination in disasters like floods.

Namely, Kakanj persistent challenges with wastewater and sewage pollution - municipality's sewage is released into local rivers without adequate treatment - exists due to a lack of a centralized wastewater treatment plant, so its main sewer system (which carries both households sewage and industrial effluents) discharges largely untreated water into the Bosna River and its tributaries. This has made sewage one of the dominant pollutants of the area's rivers. Nutrient overload from human waste (notably phosphorus and nitrogen compounds) has led to sections of the Bosna downstream of Kakanj being classified as sensitive to eutrophication, meaning the growth of algae due to excess nutrients is a concern. In practical terms, during dry seasons one can observe foamy, discolored water in the smaller streams as raw sewage from Kakanj's settlements trickles in. Aside from nutrients, pathogens and organic matter in the waste can deplete oxygen in water, endangering aquatic life. Local fishermen have long suspected that untreated sewage and runoff are partly to blame for periodic fish die-offs in minor waterways around Kakanj.

A dramatic incident in December 2022 underscored these dangers: a mass fish kill occurred in the Bukovica and Trstionica rivers on Kakanj's periphery. Residents were alarmed to find scores of dead fish, along with dead amphibians and stream invertebrates, over the weekend – an “ecological catastrophe” for those creeks. Investigators traced the cause to a release from a municipal water facility: an overflow of waste water from Kakanj's drinking water treatment plant had entered the streams, completely wiping out aquatic life downstream of the plant's discharge point. (Upstream of that outlet, the river was teeming with life, indicating the spill as the culprit.) The kill zone was near one of the town's water supply sources, raising extra concern, though authorities confirmed the tap water remained safe. This incident revealed how fragile local waterways are to any sewage or wastewater mishandling. In response, Kakanj officials and inspectors took water samples for analysis and pledged to reinforce monitoring of discharges. The municipality's development strategy now prioritizes building a proper wastewater treatment plant and extending sewer networks to villages. Until such infrastructure is in place, however, sewage continues to flow directly into Kakanj's rivers, posing ongoing risks of water pollution, ecosystem damage, and public health concerns (especially for communities downstream that rely on the Bosna River). The 2022 fish kill served as a harsh reminder that modern sewage management is urgently needed to prevent further environmental harm in Kakanj.

Additionally, there is clear and documented evidence that heavy metals are leaking from mining operations in Vareš into watercourses that directly affect Kakanj. Documentation and the application for the renewal of the environmental permit for underground mining at the “Rupice” site, reviewed by the Federal Ministry of Environment and Tourism in November 2025, indicate that expert assessments identified leakage of heavy metals into Vrući Potok, a stream that flows into the Trstionica River and further into the Bosna River. This hydrological system directly connects the mining area in Vareš with the Municipality of Kakanj, allowing contamination to be transported downstream. Such leakage poses a serious threat to drinking water quality, agricultural land, aquatic ecosystems, and public health in Kakanj, particularly given the cumulative and long-term effects of metals such as lead, zinc, silver, and other toxic elements.

Major oil spill in water incidents have been relatively rare in Kakanj, but a notable event in 2018 underscored the risk of industrial oils contaminating local waterways. In late May 2018, members of a Kakanj sport-fishing society noticed an oily sheen on the Bosna River near an outfall from the Kakanj Cement Factory. Investigators found that heavy rainstorms had overwhelmed the cement plant's oil separators, allowing a quantity of industrial oil used in cement production to wash into the river along with storm runoff. The plant's separators and settling basins could not handle the



Image: Metals and chemicals in Vruc Potok stream, ACT photos

unusually large volume of water during days of intense downpours, leading to oil mixing with rainwater and spilling into the Bosna. In response, the factory's management activated all resources to pump out and contain water from its basins, aiming to stop any further oil discharge until a permanent fix was in place. Thanks to the prompt action and high river flow, the spill's impact was limited, but it highlighted a vulnerability: extreme weather can trigger industrial runoff pollution.

In summary, Kakanj's chemical risk profile is multifaceted. The town faces acute risks like industrial accidents and chronic risks like ongoing air and water pollution. Its history as a coal and cement town has left a legacy of contaminated air, soil, and water that authorities are still trying to manage. New ventures like the Bioorganika animal-waste plant bring the prospect of additional hazardous exposure, prompting public vigilance. And lapses in waste management, such as the illegal landfill, show how regulatory failures can prolong an environmental health crisis.

Addressing these challenges requires robust environmental governance and investment in safety measures. Desulfurization units and particulate filters at the power plant, if fully implemented, could sharply cut SO₂ and dust emissions (in line with EU standards, which Bosnia & Herzegovina is obligated to meet). Upgrading home heating and banning the burning of trash in stoves would also reduce toxic smog. Properly closing and remediating the Bare landfill – as mandated back in 2012 – is critical to stop ongoing soil and groundwater poisoning. The Bioorganika project, on the other hand, poses a policy dilemma: while Bosnia does need modern facilities to safely dispose of animal waste, placing it in one of the country's most polluted valleys is, as citizens argue, “adding fuel to the fire.” If it proceeds, only the strictest operational controls and transparent monitoring might convince the public that it won't compound Kakanj's woes.

Finally, the Kakanj case underscores a broader point: chemical risks and environmental justice often go hand in hand. The people of Kakanj have for generations shouldered the toxic burden of

powering cities and producing cement, at the expense of their own health. They are now speaking up for a healthier environment, using protests, petitions, and legal channels to demand enforcement of regulations and a voice in development decisions. Their struggle is a reminder that managing chemical risks isn't just about technology and emergency plans, but also about governance, community engagement, and balancing economic gains with the fundamental right to a clean and safe environment.

In fact, this citizen science project emerged from civic-led responses to persistent environmental pollution and the associated risk of human-induced disasters where chemical pollution remains insufficiently regulated or mitigated.

TRANSPORT ACCIDENTS

Transportation accidents refer to incidents involving the movement of people or goods that result in loss of life, environmental damage, or disruption of critical infrastructure. When hazardous materials are involved, such accidents can escalate into complex technological disasters with wide-ranging health and environmental consequences.

Air crashes involve accidents of civilian or military aircraft during take-off, flight, or landing. Such events can cause significant casualties and environmental damage at impact sites. This risk category is not considered in the Kakanj assessment, as the municipality has no airport infrastructure and no significant exposure to aviation-related accident risks.

Train derailments occur when a train leaves its tracks due to technical failure, human error, infrastructure degradation, or external impacts. Derailments can cause injuries, fatalities, and major environmental contamination, particularly when trains transport hazardous materials such as fuels, chemicals, or industrial waste. This risk is relevant for Kakanj due to existing rail infrastructure and freight transport routes.

Maritime disasters, including oil tanker spills, involve accidents at sea that result in large-scale pollution of marine and coastal ecosystems. These hazards are excluded from the Kakanj risk profile, as the municipality is landlocked and has no exposure to maritime transport or coastal environments.

Road accidents involving hazardous materials occur when vehicles transporting dangerous goods—such as fuel, chemicals, or industrial waste—are involved in traffic accidents. Such incidents can lead to fires, explosions, toxic releases, and contamination of soil and water, posing serious risks to nearby communities and requiring rapid emergency response.

Kakanj, a landlocked municipality in BiH, faces transport accident risks primarily from railway accidents and road accidents involving hazardous materials. Other categories like air crashes and maritime disasters are negligible for Kakanj due to lack of exposure (no airport or seaport infrastructure).

Train accidents – especially derailments or collisions – are a significant technological hazard for Kakanj due to the existing railway infrastructure and regular freight transport through the municipality. Kakanj lies along a principal railway line (the Bosnian north-south corridor), so local authorities recognize that “large accidents in railway traffic” pose a risk to areas along the rail tracks



Image: Traffic accidents in Kakanj, citizen science photos

in the municipality. In fact, the municipal disaster plan lists rail accidents as a key risk, noting that communities situated near the railway and the highway are vulnerable. Many freight trains passing through Kakanj carry industrial materials – for example, coal for the local power plant, or potentially oil, gas, and chemical products for various industries. An accident involving such hazardous cargo could have severe outcomes: fires or explosions from flammable fuels, toxic chemical releases into the air, or leakage of pollutants into soil and waterways. A sobering regional example occurred in late 2022 in neighboring Serbia, where a freight train derailed near Pirot while carrying 900 tonnes of liquid ammonia. This accident released a large toxic cloud of ammonia gas and caused a local emergency: dozens of people were hospitalized with respiratory injuries, two people died from the fumes, and authorities had to declare a state of emergency. Such an incident illustrates how a train derailment with hazardous materials can escalate into a major health and environmental disaster. While Kakanj has not experienced a chemical spill of that magnitude, the possibility exists wherever dangerous goods are transported by rail.

In Bosnia and Herzegovina, railway safety has been a concern, particularly at level crossings where trains intersect with roads. Accidents involving trains and road vehicles or pedestrians have been distressingly frequent. (One 2024 investigative report noted that over past decades there have been hundreds of railway accidents in the country, leading to dozens of deaths.) Kakanj itself has seen several railway incidents in recent years, underscoring the ongoing risk. In July 2018 in Čatići, Kakanj, a passenger Talgo train operated by Željeznice FBiH collided with a van at a railway crossing. Fortunately, no one was injured in this accident, although the van and one of the train's carriages were heavily damaged. In February 2024 a tragic incident, a passenger train (no. 710) struck a car (Volkswagen Golf) on the railway at Doboj (a settlement in Kakanj municipality). The 27-year-old driver of the car was killed on impact. Police, firefighters, and medical teams responded, and the crossing was closed during the investigation. This fatal crash highlights the lethal consequences of a moment's error at an unprotected crossing. It also reinforced calls for improved warning systems or overpasses at railway-road intersections in the region.

Road traffic accidents are a common hazard everywhere, but those involving vehicles carrying hazardous materials are particularly dangerous. Kakanj is traversed by major roads – including the M17 highway (part of the Pan-European Corridor Vc) and regional routes – which carry significant heavy truck traffic. Many trucks transport dangerous goods such as gasoline, diesel, chemicals, industrial explosives, or toxic waste. If a vehicle carrying these materials crashes, it can result in fires, explosions, or toxic releases, and can contaminate the surrounding soil and water. In a populated area, a tanker explosion or chemical spill can threaten lives, necessitate evacuations, and require specialized HAZMAT emergency responses.

Recent history has justified these concerns, as there have been several notable road incidents. In December 2023 a fuel tanker truck and a car were involved in a serious collision on the regional Zenica–Kakanj road in the village of Tičići. The crash, which occurred around 11:00, caused the tanker (a cisterna owned by Delta Petrol) to slide off the road and overturn into a ditch. Emergency crews rushed to the scene. Miraculously, no one was injured in the accident. However, the situation was precarious – the overturned tanker had to be carefully extracted, and traffic was halted for hours amid fears of a spill or explosion. This accident underlined how a slight error can lead to a near-disaster; had the tanker ruptured or ignited, the consequences could have been much worse for the nearby community. In September 2024 on a mountainous regional road from Kakanj toward Vareš, on Lipničko Brdo an SUV carrying four people plunged into a ravine, killing all four occupants.

Citizen science mapping also documented widespread problems related to industrial and heavy-traffic routes passing directly through residential areas, resulting in increased dust emissions, air pollution, noise, and safety risks. These issues were repeatedly reported in Doboj, Donji Kakanj, Vukanovići, Obre, Čatići, Haljinići and several other local neighbourhoods. In the case of the Donji Kakanj local community, residents described a long-standing problem with the regional road that runs directly through the settlement and connects Kakanj with the Arnauti area. Intense traffic—particularly heavy goods vehicles—moves through narrow streets that were never designed for such loads, significantly endangering pedestrians and local residents. Inadequate road infrastructure and insufficient traffic signage further exacerbate safety risks, which are compounded by the presence of an active landslide identified more than 15 years ago. Residents also highlighted that when the road previously had local-road status, restrictions on heavy vehicle traffic provided at least partial protection. However, changes in road classification and unclear institutional responsibilities have eliminated these safeguards, leaving the community exposed to ongoing environmental pollution, infrastructure degradation, and serious safety hazards.

While the above examples in Kakanj luckily did not result in toxic contamination, they serve as warning signs. Other parts of Bosnia have experienced the full devastation of hazardous cargo accidents. One dramatic case occurred in Milići (eastern BiH) in September 2025: a tanker truck carrying motor fuel overturned into a drainage canal, spilling tens of tons of gasoline into the Jadar River. The spill caused an immediate environmental catastrophe – a massive fish kill was observed downstream as the fuel spread through the waterway. Local authorities declared an ecological emergency, and firefighters and environmental teams worked to contain the damage. This incident (though outside Kakanj) demonstrates the very real danger that a road tanker accident can pose: had a similar spill happened along the Bosna River near Kakanj, it could contaminate drinking water sources and harm ecosystems far beyond the crash site.

STRUCTURAL COLLAPSE

Structural collapse risks arise from the partial or complete failure of built structures due to natural hazards, structural degradation, human error, or inadequate design, construction, maintenance, or oversight. These risks threaten human life, safety, and livelihoods and can lead to significant social, economic, and environmental consequences. Structural collapses may occur suddenly or progressively and are often exacerbated by aging infrastructure, informal construction, and exposure to hazards such as earthquakes, floods, or landslides.

Building collapse refers to the partial or total failure of residential, commercial, public, or industrial buildings, resulting in the loss of structural stability and load-bearing capacity. Such collapses can be triggered by earthquakes, floods, landslides, fires, explosions, or extreme weather, as well as by poor construction quality, use of substandard materials, lack of maintenance, or unauthorized modifications. Building collapses can cause fatalities and injuries, displace residents, disrupt essential services, and generate long-term economic and social impacts for affected communities.

Dam failure involves the partial or complete collapse of a dam structure or its critical components, leading to the uncontrolled release of stored water and sudden downstream flooding. These events may result from extreme hydrological conditions, structural defects, foundation instability, insufficient maintenance, seismic activity, or operational failures. Dam failures pose severe risks to downstream populations, infrastructure, agriculture, and ecosystems, often causing widespread destruction, loss of life, and long-term environmental degradation.

Mining-related structural collapse refers to the failure of underground or surface mining structures, including tunnels, shafts, pit walls, tailings dams, or waste heaps. Such incidents are commonly caused by ground instability, inadequate support systems, water ingress, seismic activity, or unsafe mining practices. Mining collapses can result in worker fatalities and injuries, release of hazardous materials, ground subsidence, and environmental contamination, while also posing risks to nearby communities and infrastructure.

The community of Kakanj is not known for any high-profile building-collapse disasters in recent history; however, the town's exposure to moderate earthquakes and mine-induced tremors means that structural integrity of homes and public buildings remains an important concern. For instance, a 2014 earthquake in the region triggered a collapse in a nearby Zenica coal mine and shook buildings, underscoring that seismic events can precipitate structural failures. In Kakanj, ensuring building safety involves enforcing construction regulations, retrofitting older structures, and educating the public about avoiding unauthorized alterations that could weaken structural elements.

In the case of Kakanj, there are no large hydropower dams in the immediate vicinity of the town. However, the concept of dam failure is still relevant through the presence of mining and power-plant waste impoundments. The Kakanj coal mine and thermal power plant produce large quantities of waste rock, slag, and ash, which are often stored in slag heaps or tailings-like dumps. These artificial embankments can be viewed as earthen dams containing solid waste and slurry. If such a dump were to structurally fail (for example, a slag heap collapse after heavy rain), it could unleash flooding of ash or debris into nearby communities and waterways. Downstream of Kakanj runs the Bosna River, so any collapse of a waste storage site that blocks the river could act like a dam breach, causing flooding upstream until the blockage is cleared (such as in Donji Kakanj). Thus, even without a conventional dam, Kakanj must consider the stability of its industrial waste containment structures. Ensuring drainage and monitoring of these sites is critical, as exemplified in 2017 when a

massive landslide of coal waste at Kakanj blocked a river – fortunately drainage tunnels were deployed to prevent a flood wave.

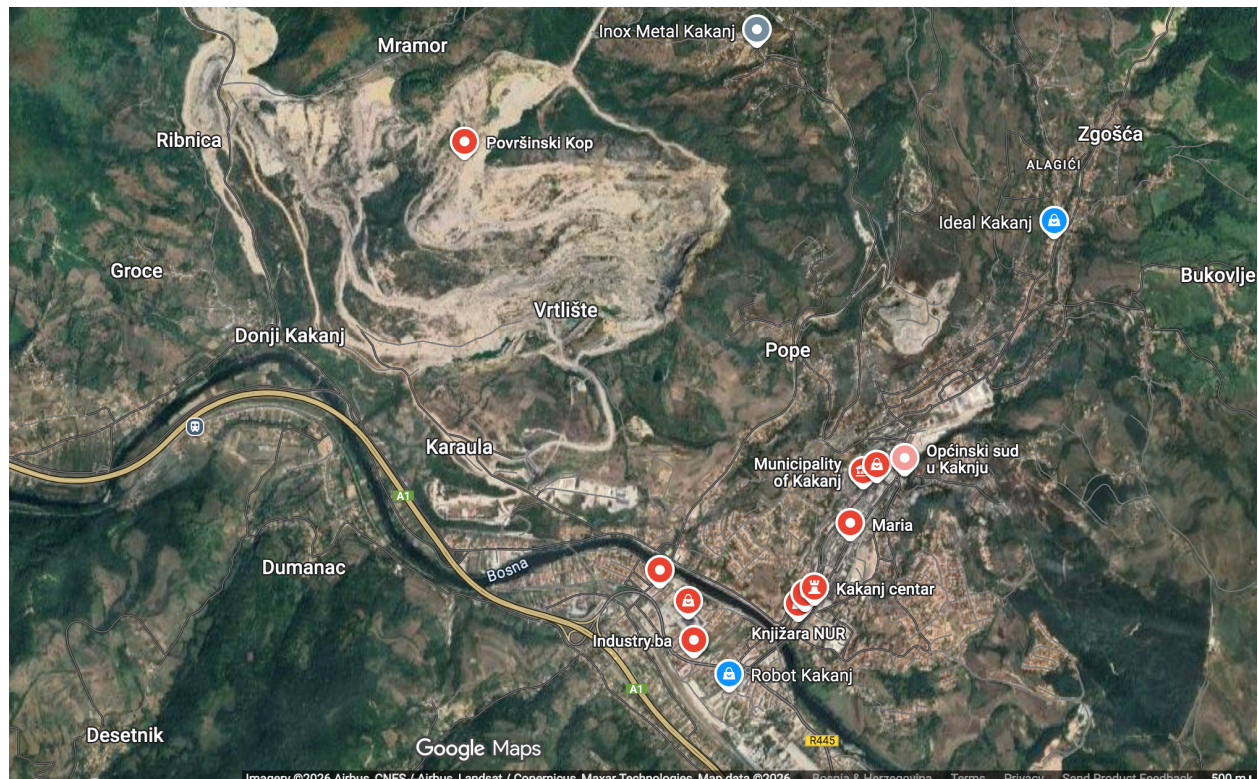


Image: Satellite map of Kakanj, with visible overground coal mining activities

Mining activities pose some of the most significant structural collapse risks for Kakanj. Mining-related structural collapse refers to failures of mine structures such as underground tunnels and shafts, the walls of open pits or quarries, and the collapse of spoil piles or tailings dams associated with mining. The Kakanj area has a long history of coal mining, and such activities inherently destabilize the ground by removing the support of coal seams and rock strata. Ground instability and subsidence are major concerns: as mined-out voids progressively collapse or settle, the surface above can subside, cracking buildings, roads, or even causing sudden sinkholes. Research in other coal regions has shown that the progressive collapse of underground voids leads to large-scale land subsidence, posing serious socio-economic and environmental risks to nearby urban infrastructure. In Kakanj, there are documented instances of subsidence and ground collapse linked to decades of coal extraction. Improperly supported mine galleries or “rooms” can suddenly cave in, which is a deadly hazard for miners and can also propagate to the surface if close to shallow depth. Multiple factors can trigger mining collapses: seismic tremors or blasts can destabilize rock pillars, water ingress can weaken pillars or cause roof falls, and unsafe mining practices (such as removing too much support or neglecting to backfill voids) greatly increase the risk of collapse. Unfortunately, Bosnia’s coal mines, including Kakanj’s, have suffered from chronic under-investment in safety upgrades since the 1990s. As a result, deadly accidents are frequent in these mines, and miners face elevated risks compared to global industry standards. Roof collapses or “rockbursts” underground can bury workers, and if the collapse is large enough, it may create surface tremors or cracks. Besides underground incidents, open-pit mines and quarries face the risk of slope failures: the steep

highwalls of a coal pit or a stone quarry can shear off in landslides, especially if loosened by blasting or heavy rain. Such slope collapses can inundate working areas and machinery with rock and debris.

When mining-related collapses occur, they can have compound effects: workers may be killed or injured, trapped below ground or hit by landslides above ground; hazardous materials can be released (for instance, a mine collapse might vent methane gas or liberate toxic runoff); and the local environment suffers (e.g., collapse-induced subsidence can disrupt groundwater or cause soil contamination if mine waste is exposed). Furthermore, communities near mines can be directly impacted – for example, a severe land subsidence might damage homes or a collapse in a waste pile could send a slide into a village.

Kakanj's mining operations date back to the late 19th and early 20th century, and the area has seen several major mining disasters due to structural failures underground. Notably, two of the worst coal mine accidents in Bosnian history occurred at Kakanj. In April 1934, a methane gas explosion in the "Stara Jama" pit of the Kakanj coal mine led to a catastrophic collapse of the mine galleries. This disaster killed 127 miners, one of the deadliest incidents of its time. Contemporary reports describe how an entire mile-long gallery was wrecked by the explosion and collapse, trapping workers inside. The tragedy had women and children waiting at the pithead in vain, underscoring the human toll of such structural failures. On June 7, 1965, another methane explosion occurred in the "Orasi" shaft of Kakanj's mine, causing a massive cave-in. This calamity claimed 128 miners' lives and injured about 20 others. It remains one of the worst mining accidents in the country's history. Investigations found that an accumulation of methane gas ignited (possibly from faulty electrical equipment or even a lit cigarette) and the resulting explosion knocked down ventilation bulkheads and support structures, leading to a progressive collapse through multiple corridors of the mine. The aftermath revealed inadequate safety measures – for instance, many miners did not use self-rescue breathing devices and chose wrong evacuation routes, contributing to the high death toll. The 1965 disaster prompted trials against mine management for neglecting safety rules, as they had knowingly allowed methane to build up and even erected a ventilation barrier that worsened the explosion's impact. These early catastrophes highlight how poor oversight and failing structural controls (like ventilation and support systems) can turn a mine into a deathtrap. In total, Kakanj's coal mine saw three major accidents in the 20th century (1916, 1934, 1965) that together killed 274 miners.

Unfortunately, accidents and structural collapses have continued into the 21st century, often attributed to outdated infrastructure and insufficient investment in safety. A poignant example occurred on October 13, 2015, when a roof collapse in the Kakanj coal mine killed 4 miners and injured 2 during the night shift. In that incident, a group of 28 miners was installing electrical equipment in a new gallery 105 meters underground when the timber and steel platform supporting the roof suddenly caved in, burying six workers under falling rocks. The victims were working on constructing a chamber for mining equipment (or a power substation) when the collapse happened, and one miner had just left the area moments before, narrowly escaping death. Bosnia's mining inspector noted that this particular pit had been renovated only two years prior, yet something caused its roof support to fail. The exact trigger remained uncertain (investigators examined whether there was a structural weakness or a minor tremor), but the broader cause is well-understood: Bosnia's coal mines had seen little modernization since the 1990s conflict, leaving them with antiquated and fragile infrastructure. An interview with the miners' union after this tragedy pointed out that many Bosnian mines had dilapidated structures and lagging modernization, making the job far more dangerous than elsewhere. In 2014 (just one year before the Kakanj collapse), an earthquake had struck the region and triggered a collapse at the Raspočje mine in Zenica, killing 5

miners. That event illustrated how even a moderate natural shock can exploit structural weaknesses in old mines – a scenario very relevant to Kakanj given its similar geologic setting.

Above ground, Kakanj has also grappled with the stability of its mining waste structures. On February 24, 2017, an enormous landslide of mine waste occurred at the open-pit section of the Kakanj coal mine. A massive pile of overburden (waste rock and soil extracted from the mine) and possibly ash from the power plant gave way after days of heavy rainfall. The failure was monumental in scale – satellite imagery suggested the slide was roughly 600 meters wide and 800+ meters long, involving an estimated volume of up to 10 million cubic meters of debris. This landslide surged downhill and blocked the Ribnica river, forming an impoundment of water. In response, authorities evacuated around 150 residents from the villages of Ribnica and Mramor that lay in the path of the slide. The scenario was perilous: had the impounded water built up too much pressure, it could have breached the debris in a flash flood. Fortunately, drainage tunnels were quickly put in place to channel the water and prevent a flood wave, and no casualties were reported in this event.

This incident highlighted a critical risk in Kakanj: the stability of slag heaps and tailings dumps. Residents and environmental groups had long warned that the excessive exploitation of coal and improper land use were creating unstable piles of waste around the town. The Center for Environment reported that some settlements, like Bare, had already suffered smaller slag heap landslides in prior years – one such dump collapse in Bare resulted in a fatality and forced several families to relocate. In another area called Mramor, people have been moving away due to a large slag disposal site encroaching on the village. These dumps, composed of ash and waste rock, are often not engineered with proper slope reinforcement or drainage; instead, they are left exposed to wind and rain. Over time, water seeps in and destabilizes the piles, especially as they grow larger and heavier without remediation. It has been recognized for 20-30 years that certain dump sites in Kakanj are high-risk for landslides, yet action was slow – only after the 2017 scare did authorities seriously consider rehabilitation measures. The recommended approach is to cease adding to the most vulnerable dumps and urgently stabilize or relocate them, otherwise further slides, fatalities, and house destructions are likely.



Image: Quarry Greben, citizen science photos

Aside from coal mining, Kakanj also hosts other extractive industries – notably a cement factory that exploits local limestone quarries. Quarry operations bring their own structural collapse concerns. The use of explosives to blast rock can trigger unexpected landslides or rockfalls from quarry highwalls. In a recent case elsewhere in Bosnia & Herzegovina (Bijela quarry near Mostar in 2024), a routine rock blasting caused a large landslide on an adjacent slope, which buried numerous cars and sent debris into a river. Two people were injured in that incident, and it was sheer luck that

no one was killed as the loosened rock mass slid downhill. This illustrates that quarry slopes, if not carefully monitored, can fail suddenly – especially when vibrations from blasting or heavy machinery destabilize existing cracks. In Kakanj’s quarries, though no major accident has been publicized, the risk is present. Any rock slope collapse could endanger quarry workers and equipment, and potentially affect nearby roads or buildings if the quarry is close to town. Moreover, illegal or informal mining (people scavenging coal from abandoned pits or waste piles) has been an issue in some Bosnian coal towns, leading to collapses that injure or kill untrained individuals. While Kakanj’s main mine is formal and operated by a state-owned company, the economic hardship has driven some to risk entering old mine portals to scratch out coal – these unmaintained workings are extremely collapse-prone. Indeed, across Bosnia, several of the mining fatalities in recent years have occurred in illegal diggings (for example, near Tuzla).

In Kakanj municipality the main active stone quarries include Greben (near the village of Barev Do) and Borovačka Stijena in the Bijele Vode area, plus limestone pits for the Kakanj cement plant (e.g. the Ribnica quarry). The Greben quarry is operated by Hidrogradnja d.d. Sarajevo (in bankruptcy but operating for years!), supplying stone to the Kakanj cement works. Local reports confirm Hidrogradnja holds permits from the Zenica-Doboj Canton for rock blasting (“rastresanje” of stone) at Greben. The Borovačka Stijena deposit is now under concession to Trgošped d.o.o. Kakanj – the municipal council approved granting Trgošped rights to explore and exploit limestone there in April 2024 (pending road infrastructure). The Ribnica quarry is an active limestone quarry serving Kakanj Cement (majority-owned by HeidelbergCement), and has been noted in biodiversity studies. Other small quarries exist in the area, but Greben, Borovačka and Ribnica are the largest stone extraction sites. All operate under official mining and environmental permits, though Borovačka’s expansion is currently restricted until a new access road is built.

Quarry operations in Kakanj pose documented collapse and disaster risks. Residents living ~50m below Greben report each blast feels “terrible, like an earthquake” and they have seen cracks in their homes. In September 2025 villagers blockaded Greben and demanded a halt to blasting, presenting photos of structural damage; Hidrogradnja claimed all permits are valid, but citizens insist only mechanical excavation be used. Similar concerns apply to slope stability: for example, in nearby Jablanica heavy rains in 2024 triggered a massive rockslide from a local quarry, where authorities reported “several thousand tons of rock” unleashed on the village. This incident – though outside Kakanj – highlights how unregulated quarry walls can collapse catastrophically. In Kakanj the Greben pit remains unrehabilitated and steep, so landslides or wall failures are a recognized hazard.

Local activism underscores environmental and health problems related to quarry mining. Citizens complain of quarry dust, noise and vibration hurting air quality and their homes. The municipal council held a special session in early 2025: officials agreed to press cantonal and federal inspectors to enforce limits on dust and blasting impulses. Importantly, civic groups and local neighborhood committees have mobilized – their 2025 initiatives warned that Greben quarry “poses a serious ecological and safety risk” if not remediated. A county-wide campaign against environmental licenses in Kakanj even cited the Greben issue as emblematic, noting that only “persistent and united action” by citizens and NGOs will compel authorities to address violations. In sum, dust, blast-induced vibrations and possible slope failure are active concerns for Kakanj’s quarries, and local communities continue to pressure regulators to tighten oversight and halt hazardous practices.

Kakanj lies in a seismically active region (though not the most active in Bosnia, it can still feel moderate earthquakes from regional faults). A future magnitude 5–6 earthquake centered in central Bosnia could test all structures in Kakanj – not just mines. In such a scenario, older buildings and

poorly-constructed houses might suffer partial collapses. Buildings that haven't been designed or retrofitted for seismic resistance could see walls or roofs give way. Kakanj's industrial structures (like the thermal power plant's facilities, factory buildings, and the towering smokestack) could also be vulnerable if not checked – for example, an earthquake might damage an older dam or embankment holding back water at the power plant (if any) or cause a section of a conveyor gallery or silo to collapse. In mines, as seen in Zenica 2014, a quake can collapse tunnels and trap miners. The risk to Kakanj from earthquakes is compounded by the presence of those loose waste piles; a quake could trigger a simultaneous landslide on an over-steep dump. The town's emergency planning must account for a multi-impact event (quake + landslide + building collapse). Strengthening public structures like schools, hospitals, and bridges in Kakanj is an important mitigation step for this scenario.

In conclusion, structural collapse risks in Kakanj are a serious concern shaped by the town's mining-centric identity. From the harrowing mine explosions of the past to the more recent waste landslides, Kakanj's experience vividly demonstrates how natural hazards and human factors intertwine to challenge structural stability. The lessons learned – at the cost of many lives – emphasize the need for robust engineering practices, vigilant oversight, and investment in safer infrastructure. By addressing the weak points (whether in a deep coal gallery or on a hillside of mine tailings), Kakanj can mitigate future collapses.

DEForestation

Deforestation (mass logging and forest destruction) refers to the large-scale removal of forest cover through legal or illegal logging, land clearing, or infrastructure development. Deforestation reduces biodiversity, destabilizes soil, increases surface runoff, and significantly raises the risk of landslides, floods, and long-term ecosystem degradation. Moreover, deforestation greatly amplifies all types of disaster hazards. In Bosnia experts agree that “commercial deforestation was a major contributing factor to the floods and landslides” during the 2014 disasters. Loss of tree cover destabilizes soil and riverbanks, leading to severe erosion and unchecked runoff. For example, in February 2017 a massive coal-mine waste landslide in Kakanj (~10million m³) forced ~150 people to evacuate and dammed a stream. This event shows how ground-clearing and mining debris on slopes can catastrophically fail. Such risks will only grow with further forest loss, as steeper, newly cleared hillsides are far more prone to landslides and flash flooding.

Kakanj is heavily forested. The municipality covers 22,548.5ha of forest (≈60% of its area). Most of this is state-owned (≈18,038.8ha, 80%), with the rest (≈4,509.7ha, 20%) private. Forestry surveys estimate ~3.46million m³ of standing timber stock in these woods, with an annual growth (increment) of ≈85,384m³. A municipal development plan (2021–2027) reports that over 2017–2020 about 117,949m³ of roundwood were harvested in Kakanj (an average ~29,487m³/year). These logs were sold on the market – roughly 114,276m³ of softwood and hardwood logs fetched about 11,026,705 BAM (≈€5.6M) in revenue over 2017–2020.

Kakanj has no major wood-processing industry (e.g. sawmills) of its own. The harvested timber is managed and sold by the cantonal forestry service, but value-added (furniture, panels, etc.) is minimal locally. Thus the forests' economic value largely appears only in raw log sales, not jobs or factories in Kakanj. Registered forestry enterprises in Kakanj are few: local data show just dozens of forestry holdings or self-employed farmers engaged in forestry (e.g. 188 natural persons in 2017, falling to 72 by 2020).

The key driver of recent deforestation near Kakanj is mining, not timber business. Since 2023, Adriatic Metals BH (formerly Eastern Mining) – a UK-listed firm – has been developing the Rupice open-pit mine at Vareš, adjacent to Kakanj. Although the concession and initial permits cover about 72.4ha (within Mehorić and Kraljeva Sutjeska areas), locals report wider illegal cutting of forest outside that zone. Cantonal forestry authorities repeatedly complained that Adriatic felled hundreds of trees without permit. For example, in August 2023 the company acknowledged it “accidentally” cut ~3,000m² of state forest (over 100 mature fir, spruce, beech, maple trees) on a mountainside. Instead of sanction, the company soon obtained a permit to clear 7.2ha of state forest (mostly within the approved mine boundary). Only a few months later, a court fined Adriatic ~€7,500 for illegally cutting “hundreds of trees” outside its authorization.

In practice, much clearing was done to build access roads for heavy mining trucks. Activists noted that Adriatic “turned forest paths...into gravel roads” and widened trails up the slopes near Kakanj. Insiders report that even before mining started, contractors illegally built a concrete plant and access road at Mehorić: a local forestry official found workers “clearing trees” and dumping spoil along the Borovički and Trstionica streams. These earthworks narrowed the stream beds and contaminated watercourses with mud and tailings. In short, cutting has not been limited to officially approved zones – it has expanded gradually to forge mine infrastructure, often without proper permits.

The rapid forest loss mainly benefits mining investors, not local communities. Investigative reports show the Vareš mine concession was granted very cheaply, allegedly shaving ≈€2.5 million from the state budget. Those profits largely go to the foreign company and its partners. By contrast, very few Kakanj residents have gained stable jobs: as of late 2024, Adriatic Metals employed only few people in Vareš. This is far fewer than the old coal industry jobs Kakanj once had. Local officials note that mining has added little payroll, while imposing huge environmental costs on many more people.

At the same time, numerous small forest users lose out. Farmers, woodcutter families and ecotourism operators lament the loss of forest land with no compensation. One wintertime example: a lone father who was jailed for cutting just 2m³ of firewood saw Adriatic cut 3,000m² of forest “nekažnjeno” (“unpunished”) around Vareš three years later. Meanwhile, enforcement is weak: despite documented illegal logging by the mining firm, prosecutions have stalled or been dismissed.

Taken together, the evidence from Kakanj demonstrates that deforestation is not a marginal environmental issue but a systemic driver of disaster risk, social injustice, and long-term economic loss. Extensive forest clearing—particularly linked to mining-related infrastructure—has weakened natural protective systems that stabilize slopes, regulate water flows, and reduce erosion, thereby amplifying the likelihood and severity of landslides, floods, and environmental degradation. At the same time, the current model of forest exploitation generates limited local economic benefits while concentrating profits among external actors, leaving communities exposed to heightened risks, degraded ecosystems, and declining livelihoods. Weak enforcement, unequal treatment of local residents versus large investors, and the gradual expansion of forest loss beyond formally approved zones further undermine trust in institutions and exacerbate vulnerability. Without urgent measures to strengthen forest protection, improve oversight, and align land-use decisions with disaster risk reduction and community interests, deforestation will continue to magnify hazards and impose growing social, environmental, and economic costs on the present and future of Kakanj.

FROM ENVIRONMENTAL DEGRADATION TO REGENERATIVE ECONOMY

It is evident from this reports that disaster and pollution risks in Kakanj are intensified by environmental degradation and the overexploitation of natural resources, which forms a critical link in the cycle of vulnerability. Overexploitation occurs when resources such as forests, water, minerals, and land are extracted or used beyond their natural capacity to regenerate. In Kakanj, this pattern has been most evident in mining, deforestation linked to infrastructure expansion, and the continued reliance on coal as a dominant energy source. These practices steadily erode ecosystem functions that normally provide natural protection against hazards, turning environmental stress into disaster risk.

When forests are cleared for mining access roads, quarry expansion, or unregulated logging, vegetation that stabilizes steep slopes and regulates water flows is removed. Soil becomes exposed, runoff accelerates, and hillsides lose their capacity to absorb intense rainfall. As a result, landslides and flash floods become more likely even during relatively common weather events. Similarly, mining activities disturb geological layers and leave behind unprotected tailings piles and waste deposits that are highly prone to collapse during heavy rains. These failures not only endanger nearby communities but can block streams, contaminate rivers, and trigger cascading hazards far beyond the initial site of collapse.

Overexploitation also undermines water security. Removing trees near springs and watercourses increases turbidity and accelerates the runoff of sediments and contaminants into rivers and reservoirs. At the same time, polluted or depleted water sources heighten the risk of water-supply emergencies, particularly during droughts. Climate change amplifies these effects: burning fossil fuels—especially coal—contributes to global warming, which in turn increases the frequency of extreme rainfall, prolonged droughts, and heatwaves. These climate-driven extremes compound local environmental degradation, making Kakanj more vulnerable to floods, landslides, water scarcity, air pollution crises, and public health emergencies.

This pattern raises a fundamental question of environmental justice: who benefits and who bears the costs of overexploitation. The primary beneficiaries are mining companies and, in theory, the state treasury. State-owned energy producers profit from coal-based electricity generation, while private mining firms benefit from access to mineral resources. Cantonal and municipal authorities receive limited concession fees and tax revenues, and some local residents gain employment in mines or related construction. However, these economic benefits are narrow, short-term, and unevenly distributed.

By contrast, the local population absorbs the long-term costs. Residents of Kakanj and surrounding villages face chronic exposure to air pollution, increased risks of water contamination, and loss of forests that once supported livelihoods, recreation, and ecosystem services. Farmers and herders experience declining soil quality, damaged crops, and reduced grazing land due to dust, runoff, and land degradation. Families displaced by landslides—such as those evacuated after major slope failures—have lost homes and security with limited prospects for recovery. Natural and cultural assets, including old-growth forests and river habitats, are being irreversibly damaged. At a national scale, Bosnia and Herzegovina loses renewable water resources, accelerates greenhouse gas emissions, and forgoes future economic options tied to sustainable land use and climate resilience. Investigative reporting has also highlighted governance failures, showing that mining concessions

have at times been granted far below their real value, depriving the state of millions while transferring environmental risk to local communities.

Taken together, overexploitation of natural resources in Kakanj functions as a multiplier of disaster risk. It weakens ecosystems, intensifies climate impacts, and undermines social resilience, creating conditions where hazards cascade rather than remain isolated events. Pollution, ecosystem loss, and climate stress reinforce one another, pushing the municipality toward a trajectory of recurring emergencies and long-term instability. Without a shift away from unsustainable extraction toward restorative land management and diversified local economies, Kakanj faces escalating risks—from water crises and landslides to public health emergencies and economic decline.

An additional and often overlooked driver of environmental risk in Kakanj is the near absence of effective recycling and reuse systems, which significantly increases pollution and generates secondary hazards. Most waste—household, industrial, and construction—ends up mixed, improperly stored, or illegally dumped rather than being separated, recycled, or reused. This accumulation of unmanaged waste contaminates soil and water, blocks drainage channels and riverbeds, and increases the risk of flooding during heavy rainfall. Open dumping and burning of waste release toxic substances into the air, worsening already severe air pollution and posing direct health risks to nearby communities. Waste deposited on slopes, in forests, or along roadsides can become unstable, contributing to erosion and localized landslides, while plastic and hazardous materials persist in the environment for decades. In the absence of circular waste practices, pollution does not remain a static problem but actively creates new hazards, amplifying disaster risks and placing additional strain on ecosystems, public health, and municipal infrastructure.

Breaking this cycle requires a deliberate transition from an extractive to a regenerative development model. A regenerative approach prioritizes restoring ecosystems, protecting forests and water sources, rehabilitating degraded land, and reducing dependence on fossil fuels. It aligns disaster risk reduction with economic renewal by investing in nature-based solutions, clean energy, sustainable forestry, circular waste systems, and local value creation. Such a transition is fully consistent with the European Green Deal and the EU's broader vision of climate resilience, biodiversity protection, and a just transition for regions historically dependent on extractive industries.

The findings of this report make it evident that a just energy transition is a crucial first step for Kakanj in addressing not only chronic pollution but also the growing risk of future natural and human-induced disasters. Continued reliance on coal and other fossil fuels drives severe air pollution, contributes to climate change, and sustains extractive practices that destabilize land, water systems, and ecosystems. Transitioning toward cleaner and decentralized energy sources would reduce emissions that intensify extreme weather events, lower public health vulnerability during pollution and heat episodes, and decrease pressure on forests and land used to support fossil-fuel infrastructure. A just transition—one that protects workers and communities while diversifying the local economy—would also strengthen social resilience, enabling Kakanj to better cope with floods, landslides, droughts, and air-quality crises. By reducing structural dependence on polluting energy systems and investing in sustainable alternatives, Kakanj can simultaneously mitigate disaster risks, improve environmental quality, and create a more resilient and equitable future.

A regenerative economy is not a completely novel or radical departure from existing development pathways, but rather a step-by-step transition away from an extractive economic model toward one that restores value from what has already been taken or discarded. Instead of treating waste, by-products, and degraded land as liabilities, a regenerative approach recognizes them as resources that

can be reused, recycled, or transformed into new economic and environmental value. For Kakanj, this transition is particularly relevant because decades of industrial activity, mining, energy production, and unmanaged waste have created large stocks of accumulated by-products—such as mining residues, ash, construction debris, organic waste, and degraded land—that can serve as inputs for circular and regenerative activities. These include land rehabilitation, material recovery, reuse in construction, biomass utilization, renewable energy production, and ecosystem restoration. Kakanj is especially well positioned for such an approach because it combines industrial heritage, technical skills, available land, and urgent environmental needs within a relatively compact territory. By gradually shifting from extraction to regeneration—starting with waste recovery, local recycling, restoration of mined and deforested areas, and clean energy solutions—Kakanj can reduce pollution and disaster risks while creating local jobs, retaining value within the community, and rebuilding natural systems that protect against floods, landslides, and climate extremes. This transition does not require abandoning the local economy, but reorienting it to turn existing environmental burdens into foundations for long-term resilience and sustainable development.

In this context, Kakanj’s future is not predetermined. The same landscapes that have been degraded can be restored to reduce hazard exposure, buffer climate extremes, and support healthier livelihoods. The choice lies between continuing a model that concentrates benefits while socializing risk, or embracing a regenerative path that reduces disaster vulnerability while creating durable economic and environmental value for current and future generations.

FUTURE SCENARIOS

Scenario analysis is a widely recognized tool for proactive risk mitigation. Integrating future scenarios into planning helps policymakers move from reactive crisis response to precautionary long-term planning. Including future scenarios in this report lets us imagine different “what-if” versions of Kakanj’s future – for example, how heavier rains, land subsidence or rising industrial pollution might change flood and landslide risks. Scenario thinking casts a wide net over possible conditions, helping planners prepare for a range of outcomes instead of banking on a single prediction. In practice, this shifts Kakanj’s disaster planning from reactive to proactive, because understanding multiple plausible futures makes it easier to craft robust mitigation strategies today. By exploring how choices made now could reshape vulnerabilities and resilience decades ahead, local authorities and community members can develop policies that prevent long-term harm. In short, thinking through future scenarios gives everyone a clearer picture of what might lie ahead and guides smart decisions to keep Kakanj safer over time.

The scenarios presented here are not predictions, but evidence-based trajectories derived directly from the risks, vulnerabilities, and trends documented through citizen science, historical records, and expert analysis. They aim to support informed policy debate by making visible what is at stake for Kakanj’s communities if current patterns persist—or if a gradual transition toward a regenerative model is undertaken.

Scenario 1: continued passivity and deepening extractive path (2026–2036)

In this scenario, Kakanj largely maintains its current approach. Authorities respond reactively rather than strategically, environmental enforcement remains weak, and the local economy continues to depend on coal, mining, heavy industry, and unmanaged waste flows. No systemic shift toward energy transition, land restoration, or circular practices occurs.

In this case, over the next ten years, pollution levels remain chronically high, with winter air quality crises becoming more frequent and severe due to continued coal combustion for power generation and household heating. Extreme smog episodes—similar to January 2026—become a near-annual occurrence, increasing respiratory and cardiovascular diseases and further elevating cancer incidence. Public trust in institutions erodes as warnings and emergency measures remain inconsistent or absent. Protests and social conflict will rise.

Landslides and slope failures intensify as deforestation, quarrying, and mining infrastructure expand without adequate rehabilitation. Heavy rainfall events increasingly trigger landslides near settlements such, periodically forcing evacuations and damaging homes, roads, and utilities. Flood risks along the Bosna River and its tributaries worsen as riverbanks remain insufficiently reinforced and illegal dumping continues to block drainage channels. Flash floods and erosion become more frequent even during moderate storms.

Water security deteriorates, especially in rural areas dependent on small streams and decentralized water systems. During summer droughts, water shortages become common in many villages and in the urban areas. Pollution from upstream mining and untreated sewage further compromises water quality, increasing reliance on emergency water supply measures.

If Kakanj continues on a passive, extractive path over the next decade, the cumulative impacts on population, health, and the local economy are likely to be severe and mutually reinforcing. Persistent air pollution, repeated environmental incidents, and declining living conditions accelerate population decline, particularly among young families, skilled workers, and healthcare professionals. Outmigration intensifies as residents seek cleaner environments and better opportunities elsewhere, while the remaining population becomes older and more vulnerable. By 2036, Kakanj risks a significantly reduced and aging population, with shrinking school enrollments and increased pressure on social and health services.

Public health outcomes deteriorate markedly. Chronic exposure to extreme air pollution—especially PM_{2.5}, sulfur dioxide, and toxic industrial by-products—leads to rising rates of respiratory and cardiovascular diseases, childhood asthma, and premature mortality. Cancer incidence continues to increase, reinforcing Kakanj’s already disproportionate burden of oncology patients within Zenica-Doboj Canton. Healthcare costs rise sharply, while productivity declines due to illness, disability, and early retirement. Periodic pollution peaks and climate extremes further strain an already limited health system, increasing preventable deaths during smog episodes, heatwaves, and floods.

Economically, the extractive model deepens structural weakness rather than delivering sustainable growth. While mining and energy production continue, they generate limited

local value and employment, and automation further reduces labor demand. At the same time, environmental degradation undermines agriculture, small businesses, and property values. Floods, landslides, and infrastructure damage impose recurring repair costs on households and the municipality, diverting public funds away from education, social services, and development. Poverty rates rise as health-related expenses increase, livelihoods are disrupted, and informal or precarious work expands. Social inequality deepens, particularly affecting rural communities and households already exposed to pollution and environmental risk. By the end of the decade, Kakanj risks becoming trapped in a cycle of declining population, worsening health outcomes, rising poverty, and permanent dependence on emergency interventions, with diminishing capacity to reverse course.

Scenario 2: gradual transition toward a regenerative and just model (2026–2036)

In this scenario, Kakanj begins a step-by-step transition away from the extractive model toward a regenerative approach. The shift is gradual and realistic, building on existing assets, accumulated industrial by-products, citizen engagement, and external support aligned with EU climate and resilience frameworks. A just energy transition becomes the entry point for broader transformation.

In this case, over the next decade, phased investments reduce dependence on coal through alternative energy sources, cleaner district heating, household heating upgrades, and energy efficiency measures. Air quality improves measurably, particularly during winter, reducing health burdens and emergency smog events. While legacy pollution remains a challenge, peak exposure declines and public health indicators stabilize.

Former mining and degraded lands begin to be rehabilitated through reforestation, slope stabilization, and nature-based solutions. This reduces landslide frequency and severity while restoring ecosystem services that regulate water and soil. Riverbank reinforcement, improved drainage maintenance, and reduced illegal dumping lower flood risks and limit cascading hazards.

A circular and regenerative economy emerges incrementally. Waste streams—ash, construction debris, organic waste, and biomass—are increasingly reused or processed locally, reducing pollution while creating new employment in waste management, land restoration, and environmental services. Recycling and reuse systems expand, cutting illegal dumping and reducing secondary disaster risks linked to clogged waterways and unstable waste deposits.

Water security improves as rural water systems are assessed, protected, and diversified, and pollution pressures are reduced. During droughts, shortages are less severe and better managed. Citizen science remains embedded in local governance, supporting early warning, monitoring, and accountability.

Under a gradual transition toward a regenerative and just model, Kakanj experiences measurable improvements in employment, public health, and long-term economic stability over the next decade. While extractive activities are progressively reduced, new jobs emerge

across a broader range of sectors, including renewable energy installation and maintenance, energy efficiency retrofitting, waste recovery and recycling, land rehabilitation, sustainable forestry, water management, environmental monitoring, and circular economy services. Importantly, many of these jobs are local and non-relocatable, helping retain skilled workers and providing alternative employment pathways for former mining and industrial workers through retraining and just transition programs.

Health outcomes improve steadily as air quality improves, pollution exposure declines, and green spaces and restored ecosystems increase. Reduced concentrations of fine particulate matter and toxic emissions lead to lower rates of respiratory and cardiovascular disease, fewer pollution-related hospital admissions, and a gradual stabilization—and eventual decline—of cancer incidence linked to environmental exposure. Improved water quality and reduced flood and waste-related contamination further lower public health risks. Over time, the health system shifts from crisis response toward prevention, easing pressure on healthcare services and reducing long-term public health costs.

METHODOLOGY

The project employed a participatory action research (PAR) design combined with mixed methods to ensure both scientific rigor and community ownership. Citizen scientists were engaged in data collection using geo-mapping applications, structured surveys, participatory workshops, and visual documentation. Their insights complemented by scientific expertise in disaster risk management, geography, and environmental policy to produce an integrated dataset that captures both technical risk indicators and lived community experiences. Qualitative methods (focus groups, interviews, and community mapping sessions) contextualized the spatial data. This methodological triangulation strengthens the reliability of the findings and ensures that they are actionable for local policy development.

The purpose of this methodology is to establish a scientifically robust, participatory, and replicable approach for identifying, mapping, and analyzing disaster and pollution risks at the municipal level through citizen science. The methodology is designed to address the absence of fine-grained, locally grounded disaster risk data in Kakanj and to bridge the gap between institutional risk assessments and citizens' lived experiences.

The methodology aligns with disaster risk reduction (DRR) principles, the Sendai Framework, and EU open science and FAIR data standards, ensuring both policy relevance and scientific credibility.

A survey capable of capturing geospatial data alongside visual evidence (photographs and videos) was developed using the KoboToolbox platform. To maximise accessibility and participation, citizens who were not directly involved in project meetings were also invited to submit geo-referenced materials through widely used communication channels, including WhatsApp, Viber, and Instagram. All collected inputs were standardised and consolidated into a central KoboToolbox geo-mapping database, where they were complemented with secondary environmental data and expert inputs to support contextualisation and validation.

The methodology integrates four primary data source categories to ensure triangulation and reliability:

- 1 Community-generated primary data

Data collected through in-person meetings, focus groups, and site visits with residents and representatives of local neighbourhood councils (mjesne zajednice) in: Novo Naselje Bare, Plandište, Obre, Kakanj I, Kakanj II, Dobož, Vukanovići, Donji Kakanj, Mramor, and Kraljeva Sutjeska. These communities represent urban, semi-urban, and rural areas, as well as locations predominantly affected by natural hazards or industrial pollution.

2 Civil society and citizen initiative data

Data and documentation provided by organized citizen groups and activists, including NGO Alternative, youth group Kick, Kakanj ustaje citizen initiative and the Foundation Atelier for Social Change (ACT), complemented by systematic mapping of publicly shared online materials related to disaster and pollution risks.

3 Youth-generated data

Geo-mapped data collected by a trained youth group from Gymnasium “Muhsin Rizvić,” who subsequently trained peers and coordinated additional youth participation.

3 Secondary and reference data

Publicly available environmental information, historical records, news reports and expert inputs from disaster risk specialists used for contextualisation and validation.

The methodology was piloted through a focused mapping exercise in Novo Naselje Bare. Feedback from participants informed refinements to data categories, instructions, and submission channels before finalisation.

Data analysis entailed data cleaning and validation where all entries were reviewed for completeness, consistency, and spatial accuracy. Visual materials were cross-checked against location data, and duplicate or unclear entries were resolved through follow-up with contributors where possible. Geo-referenced data were analysed using GIS tools to identify spatial patterns, clusters of risk, and areas of overlapping hazards. Qualitative inputs from focus groups, community discussions, and activist documentation were thematically analysed to contextualise spatial findings, capture historical trends, and identify locally specific vulnerability factors. Findings were triangulated across community data, civil society inputs, youth-generated data, and expert knowledge.

Following an initial literature review and analysis of available data on disaster risks and pollution, the international categorization of disaster risks was adjusted and refined for the citizen science project to reflect the specific context of Kakanj. This adjustment was informed by historical records and resulted in the inclusion of the following categories:

1. Geological Risks
2. Hydrological Risks
3. Meteorological Risks
4. Climatological Risks
5. Biological Risks
6. Chemical Risks
7. Transport Accidents
8. Structural Collapse
9. Deforestation

The following risk categories were excluded from the citizen science project as they fall outside the project's scope, objectives, and methodological capacity. These risks primarily require institutional, regulatory, or specialized technical interventions that cannot be reliably identified, monitored, or addressed through citizen-led data collection and community-based mapping approaches:

Socio-political risks – excluded due to their complex governance, security, and institutional dimensions, which extend beyond the project's focus on environmental and disaster-related hazards.

Economic and systemic risks – excluded as they relate to macroeconomic dynamics, market structures, and systemic vulnerabilities that cannot be meaningfully captured through localized citizen observations.

Cyber and information risks – excluded because they involve digital infrastructure, cybersecurity, and information systems that require specialized technical expertise and access beyond citizen science methodologies.

Public health and safety risks (human-induced) – excluded as these risks typically involve epidemiological, criminal, or behavioral factors that demand professional surveillance systems and are not directly observable through environmental or spatial citizen reporting.

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Association for Research and Social Innovation „Analysis, Design, Transformation“ is a non-governmental organization established in 2014 with commitment to creation of open and knowledge-based communities in Bosnia and Herzegovina that foster inclusive and sustainable development that protects the public interest and the common goods. The organization utilizes novel methods in social engineering and uses design thinking, mixed-method analysis and multistakeholder approach in fostering social innovations. One of its hallmarks is utilization of the feminist action participatory research method that ensures that organization’s programs, initiatives and activities are aligned with the needs of communities and stakeholders involved in the social innovation design and implementation. The organization works with diverse audiences, depending on the initiative. However, it always strives to include researchers, experts, entrepreneurs, civic activists, journalists and social media professionals, relevant governmental officials, students/youth and community representatives directly affected by a specific social intervention.

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