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SECURITY RISKS OF LANDMINES AND EXPLOSIVE ORDNANCE IN BOSNIA AND HERZEGOVINA

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Abstract: Various security risks have persisted in Bosnia and Herzegovina even after the cessation of the armed conflict. Mines and explosive remnants of war continue to constitute a significant source of security threats to both the population and the environment. The loss of human lives, the infliction of severe bodily injuries, the inability to utilize agricultural land, the deterioration of soil quality, and the degradation of groundwater represent some of the adverse consequences of the presence of mines and explosive ordnance in Bosnia and Herzegovina. The absence of comprehensive documentation regarding mines, coupled with persistent financial constraints, further complicates and delays the process of land decontamination.

Keywords: landmines; explosive ordnance; human security; threats; vulnerability.

Introduction

From today's perspective, human society is exposed to a wide range of security challenges, risks, and threats. Given the importance of human security, such risks and threats have attracted substantial scholarly attention. At the core of human security lies the individual as the primary referent object of protection (Лалић, Ћеранић, Башкало, 2023). Human security represents the foundational level of security upon which national, regional, and global security subsequently rest. The absence of human security, therefore, undermines all other levels of security. Human security encompasses several interrelated dimensions: health security, environmental security, personal security, economic security, food security, community security, and political security. Mines and explosive remnants of war exert a negative impact across each of these dimensions, thereby significantly jeopardizing human security.

The concept of explosive ordnance (EO) refers to all types of bombs, mines, shells, and other devices containing explosive or related non-explosive material or a detonator, which, under external or internal influence, result in the sudden release of energy and fragmentation (Сл. гласник Републике Србије, 20/2015, 10/2019, 20/2020, 14/2022). Depending on their area of application, explosive ordnance may be classified into devices intended for civilian use and those designed for military purposes (Мићин, Малиновић, 2023).

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From the perspective of threats to human security and the environment, a particularly severe danger is posed by military-grade explosive ordnance left behind after the cessation of armed conflicts in specific geographic areas. Depending on their mode of use, various types of mines can be distinguished—most notably antipersonnel and antitank mines—alongside a wide range of unexploded (inactive) ammunition, including bombs, shells, rocket projectiles, and other ammunition of different purposes. Classification based on manufacturing methods differentiates between standard and improvised explosive ordnance. Due to their widespread deployment, the large areas of land contaminated, and the significant adverse effects they cause, mines represent the most prevalent form of unexploded remnants of war. Mines may occur in different forms of deployment, such as minefields, clusters of mines, or individual devices.

Available data from the end of 2024 regarding land contamination at the global level indicate that areas contaminated with explosive ordnance have been identified in 58 states and 2 "other areas." This highlights the fact that explosive ordnance contamination constitutes a serious global security threat. The extent of contaminated land is further confirmed by the *International Campaign to Ban Landmines* (ICBL) data for 2023, which report the presence of explosive ordnance contamination across 58 countries worldwide (ICBL-CMC, 2024).

Between 2009 and 2023, more than 3.5 million mines of different categories were cleared worldwide (Mine Action Review 2009–2024, 2024).

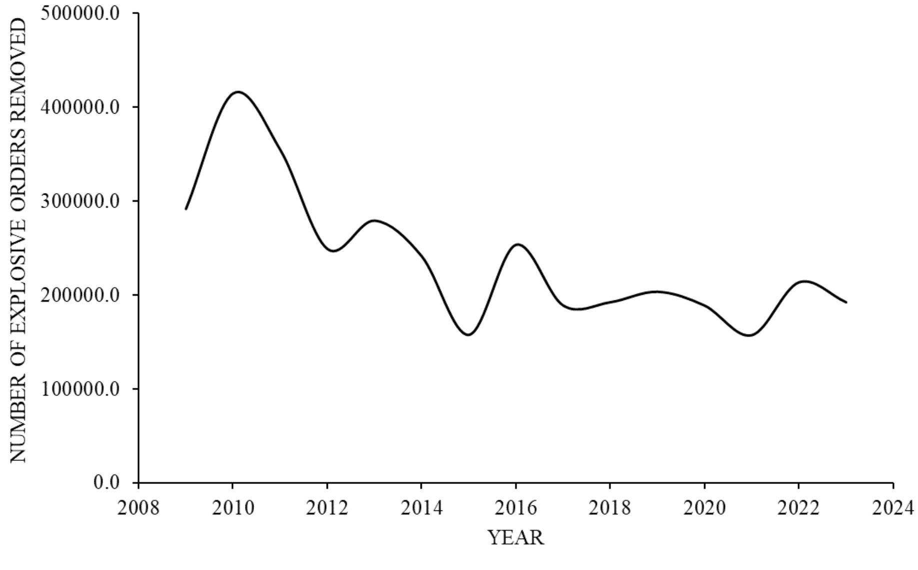


Figure 1. *Number of explosive ordnance cleared between 2009 and 2023 at the global level.*

Between 2009 and 2023, the total area of land cleared globally amounted to 2,641.9 square kilometers (Mine Action Review 2009–2024, 2024).

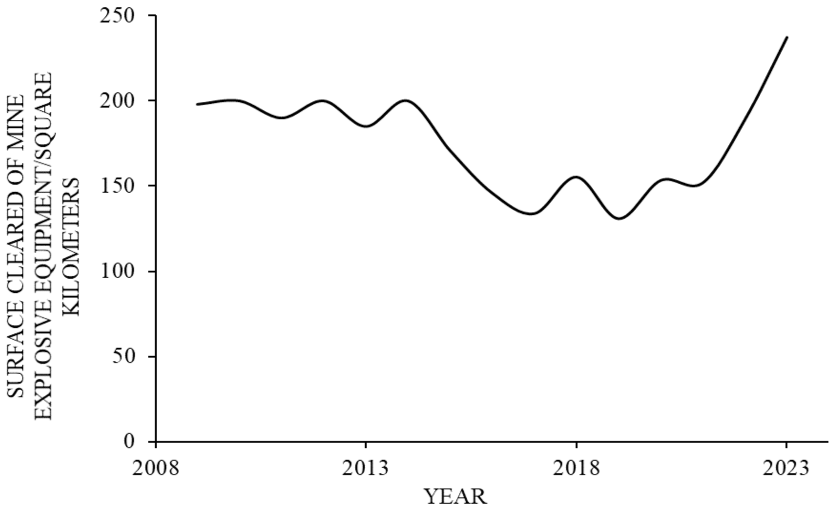
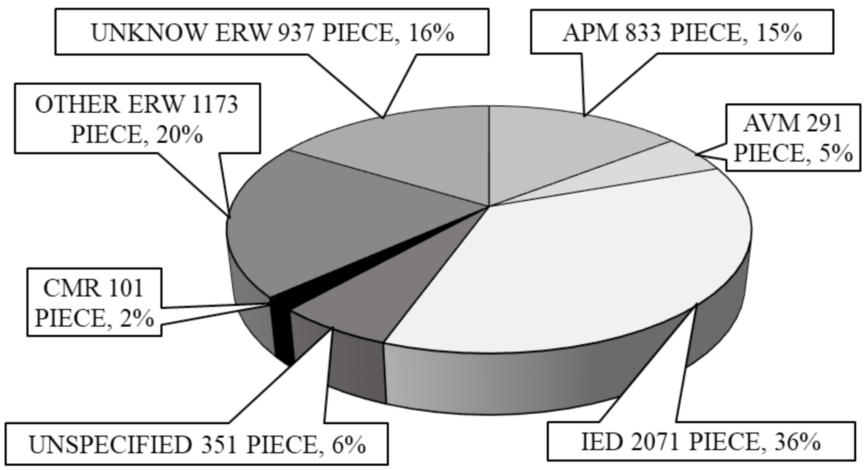


Figure 2. *Areas of land cleared worldwide between 2009 and 2023.*

Data indicate that between 1993 and 2023, a total of 159,445 individuals worldwide were affected by mines and other unexploded ordnance. Of these, 45,959 people were killed, while 109,270 were injured. The vast majority of casualties were civilians (80%), followed by military personnel (19%) and deminers (2%). Among civilian victims, 43% were children or young persons (ICBL-CMC, 2024).

An analysis of casualties by type of explosive device classified according to construction method reveals that improvised explosive devices accounted for the largest number of victims (Figure 3).



APM-antipersonnel mines; AVM-antivehicle mines; IED-improvised explosive devices; ERW-explosive remnants of war

Figure 3. *Number of casualties by type of explosive ordnance.*

One of the main characteristics of improvised explosive devices lies in the specificity of their technical design and their relatively low level of safety with regard to clearance.

The aforementioned data unequivocally indicate a high degree of security threat to human safety on a global scale.

The impact of explosive ordnance remnants is manifested through both direct and indirect adverse effects on the environment, including human populations. Direct effects are reflected in the immediate consequences, changes, and disturbances within the environment or its particular segments at the moment of activation of explosive devices at a given location. Indirect effects comprise those consequences, changes, and disturbances that occur within a different temporal or spatial framework from the initial site or explosion. From a temporal perspective, indirect impacts may be continuous or delayed, spanning short-, medium-, or long-term periods. Continuous indirect impacts include physical and chemical effects associated with the degradation of explosive devices. Delayed negative impacts become apparent only after a certain period of time. The physical degradation of flora and fauna, the disruption of the physical and chemical properties of soil, and the persistence and bioaccumulation of toxic substances present in explosive materials—or generated in the process of detonation—are among the manifestations of the negative environmental impact of explosive devices (Nachon, 2004).

In general, the structure of a mine consists of the mine body, the explosive charge, and the detonator. In more recent types of mines, the body is made of polymeric materials, while older models are characterized by metallic casings. The explosive charge belongs to a class of energetic materials known as secondary explosives. Used either individually or in mixtures, the most common secondary explosives are 2,4,6-trinitrotoluene (TNT) and 1,3,5-trinitroperhydro-1,3,5-triazine (RDX).

Trinitrotoluene is classified as a nitroaromatic compound, which is distinguished by its relatively high solubility in water (200 mg/L), which imparts a pink coloration to the solution (Taylor et al., 2009). This indicates a high level of toxicity to humans, whereby even minimal concentrations persisting over longer periods may cause health problems (US EPA, 2014). Similar compounds from the class of nitroaromatic explosives, such as 2,6-dinitrotoluene (DNT), tetranitro-N-methylaniline (Tetryl), trinitrophenol (picric acid), and 1,3,5-trinitrobenzene (TNB) (Akhgari et al., 2015), as well as degradation products (e.g., 2,4-dinitrotoluene, DNT), exhibit comparable adverse characteristics. DNT is highly toxic due to its ability to transform hemoglobin into methemoglobin even at very low concentrations (0.13 mg/L) (GICHD, 2021). RDX is characterized by a higher degree of stability (solubility 30 mg/L), which increases its mobility through soil and facilitates its migration into groundwater (Khan et al., 2012). The maximum permissible concentration for drinking water is 0.61 µg/L (Meyer et al., 2005). Due to its low solubility, RDX demonstrates high persistence over extended periods (Tucker et al., 2002). HMX (1,3,5,7-tetranitro-1,3,5,7-tetrazocane) exhibits similar properties to RDX, though with lower solubility and reduced toxicity.

During the detonation process—whether occurring during the activation of a mine or in the course of clearance operations—unreacted explosive particles are dispersed into the surrounding environment and deposited on the soil surface. Previous studies have shown that the proportion of fully reacted explosive material ranges between 99.0 and 99.9%, while the concentration of unreacted secondary explosive particles in soil is on the order of micrograms per kilogram of soil (Hewitt et al., 2005).

Research findings also indicate elevated levels of heavy-metal contamination at the soil surface. Within a radius of up to six kilometers, significant mean concentrations of mercury (101 µg/kg), cadmium (0.45 mg/kg), chromium (23 mg/kg), manganese (888 mg/kg), nickel (35 mg/kg), and lead (27 mg/kg) were measured (Berhe, 2000).

Explosive ordnance in Bosnia and Herzegovina

During the previous armed conflicts in Bosnia and Herzegovina, the opposing sides made extensive use of diverse types of explosive ordnance. Throughout the hostilities, most of these devices were not cleared, resulting in a substantial presence of explosive ordnance remnants, particularly in areas of land that once constituted the frontlines between the warring parties.

Prior to the conflict, approximately six million mines of different categories were stored in the stockpiles of the former Yugoslav People's Army (JNA) (ICBL-CMC, 1999). Due to the impossibility of obtaining precise data, initial estimates were made regarding the quantity of explosive ordnance remnants in Bosnia and Herzegovina. According to Berhe (2000), the number of explosive ordnance remnants ranged between 2 and 3 million items of various types. According to a report by Friends of the Earth Flanders and Brussels, based on a visit to the Bosnia and Herzegovina Mine Action Centre (BHMAC), the number of explosive ordnance remnants including landmines and unexploded ordnance, exceeds one million (Friends of the Earth Flanders & Brussels, 2007). The United Nations High Commissioner for Refugees (UNHCR) estimated that approximately 750,000 of different types of explosive ordnance were located in Bosnia and Herzegovina, which were grouped into 30,000 minefields (UNHCR, 1998). According to the BHMAC database, 19,000 minefields have been recorded, which is estimated to represent 50–60% of the actual total (BHMAC, 2017).

Following the end of the conflict, in accordance with the peace agreement, efforts were undertaken to destroy the stockpiles of mines held by the warring parties. Table 1 presents the quantities of destroyed anti-personnel mines, which are classified by mine type and the entity in which they were stored (ICBL-CMC, 2000).

Table 1: *Type and quantity of destroyed anti-personnel mines in Bosnia and Herzegovina following the end of the conflict*

Mine type	Republika Srpska	Federation of BiH	Total
PROM-1	14569	2869	17438
PROM-1P	760	-	760
PROM-KD	33	-	33
PMR-1	-	1664	1664
PMR-2	890	-	890
PMR-2A	99905	11953	111858
PMR-S1	2560	-	2560
PMR-S3M	16224	-	16224
PMR-3	5980	207	6187
PMR-4	8778	62	8840
PMA-1	103103	7868	110971
PMA-2	59936	23225	83161
PMA-2A	-	135	135
PMA-3	57106	32818	89924
PMA-4	1146	-	1146
MRUD	-	4025	4025
PPM (various)	-	70	70
PPM-VM	-	354	354
Improvised	-	4487	4487
TOTAL	370067	90660	460727

The spatial distribution of explosive ordnance remnants and the extent of contaminated areas are largely influenced by the characteristics of minefields and the manner in which the ordnance was deployed. A relatively small number of mines used in the establishment of minefields, as well as the frequent use of grouped mines or individually placed devices, represent the primary features of deployment patterns. Unknown mine placement and incomplete records of the locations of mine groups or minefields present an additional challenge when defining the extent of contaminated land.

According to available data, initial mapping of contaminated areas was conducted (Figure 1), revealing that a significant number of explosive ordnance were located along the frontlines of the warring parties. Considering that the frontline extended approximately 1,100 kilometers with an average width of 4 kilometers, the estimated contaminated area amounted to 4,400 km^2 (ICBL-CMC, 1999).

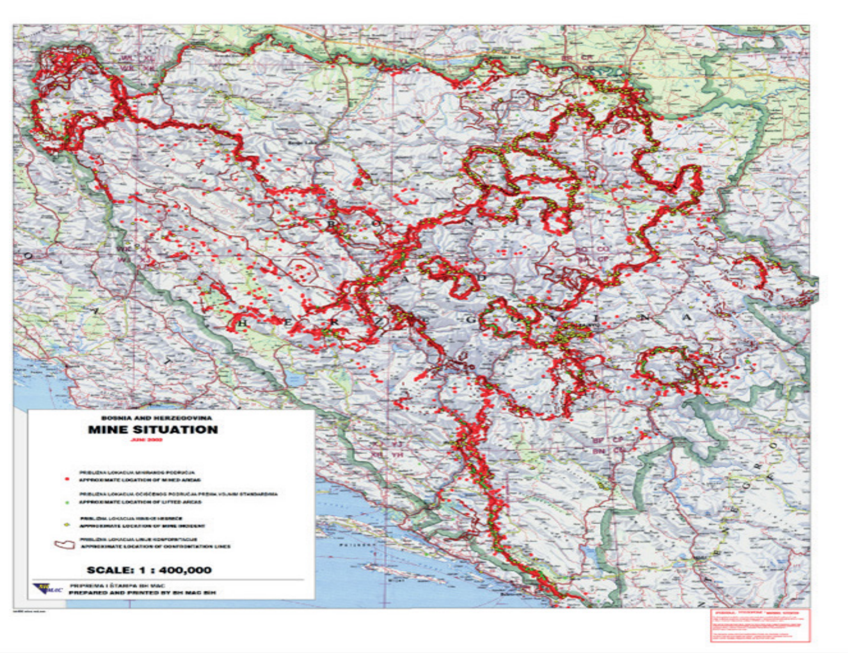


Figure 4. *Map of the initial condition of contaminated areas (2001) (GICHD, UNDP, 2022)*

The decontamination of contaminated land began following the end of the armed conflicts. According to data reported in the annual Mine Action Review *(*Clearing the Mines*)*, between 2009 and 2023, a total of 20.09 km^2 of land containing identified explosive ordnance in Bosnia and Herzegovina was cleared (Figure 5). Between 2013 and 2023, 22,686 various explosive ordnance were removed (Figure 6) (Mine Action Review 2009–2024, 2024).

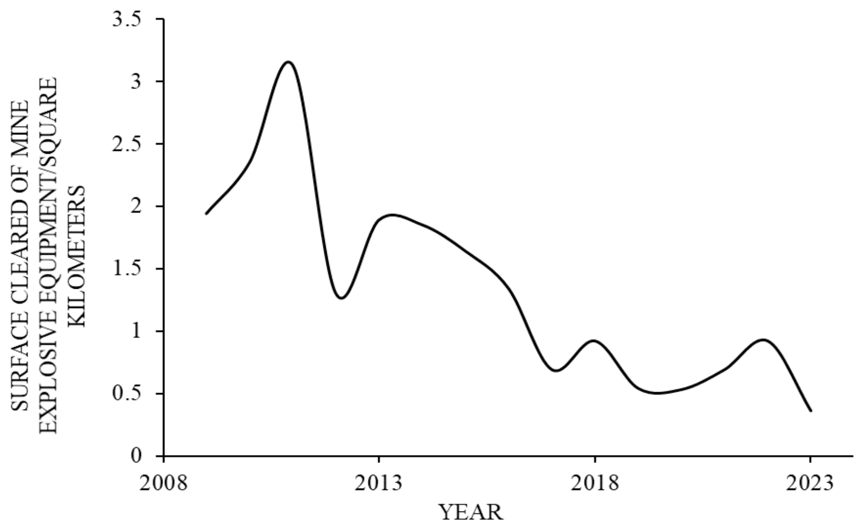


Figure 5. *Areas of land cleared in Bosnia and Herzegovina, 2009-2023.*

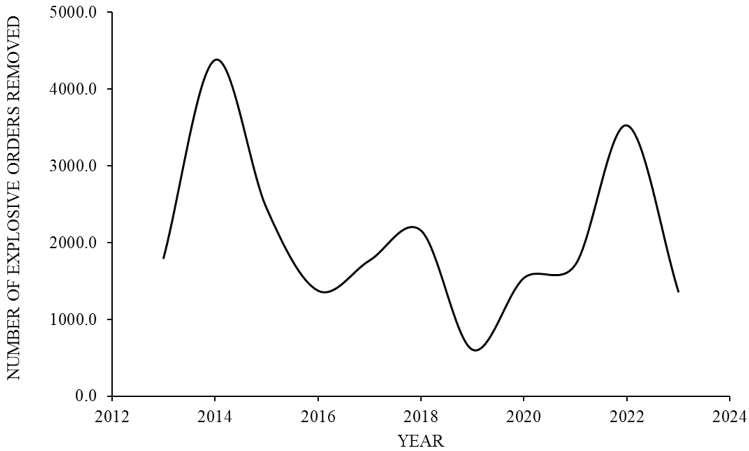


Figure 6. *Number of explosive ordnance cleared in Bosnia and Herzegovina, 2013–2023.*

Based on data from the Mine Action Centre (BHMAC), between 1996 and 2023, technical survey and mine clearance operations released a safe area of 3,343 km^2, representing 75.9% of the estimated contaminated land. By the end of 2024, the remaining suspected hazardous areas amounted to 826 km^2. During the same period, 155,167 explosive ordnance items were removed, including 75,232 antipersonnel mines, 8,813 antitank mines, and 71,122 explosive remnants of war (BHMAC, 2025).

Discrepancies in the published data arise from the use of different methodologies in assessing both the extent of land clearance and the number of various types of explosive ordnance cleared. Figure 7 demonstrates the status of contaminated areas in 2021.

Figure 7. *Map of contaminated areas in Bosnia and Herzegovina in 2021 (GICHD, UNDP, 2022).*

In late October, in 2024, the remaining suspected hazardous areas in Bosnia and Herzegovina amounted to 826 km^2 (1.6% of the country's total territory). Of this, 189 locations were categorized as high-risk mine-suspected hazardous areas, 275 locations as medium-risk mine-suspected hazardous areas, and 15 locations as low-risk mine-suspected hazardous areas (BHMAC, 2025).

Human security and landmines in Bosnia and Herzegovina

Regard landmines, Bosnia and Herzegovina is among the most affected countries in the world. According to the criterion of contamination extent by antipersonnel mines, until 2019 Bosnia and Herzegovina belonged to the small group of countries (Afghanistan, Cambodia, Bosnia and Herzegovina, Iraq) with massive contamination (area >100 km^2). Since 2019, Bosnia and Herzegovina has been categorized in the second group, with severe contamination (area >20–100 km^2), alongside Angola, Thailand, Turkey, and Yemen (Mine Action Review 2009–2024, 2024).

Even three decades after the cessation of armed conflict, incidents with fatal outcomes caused by explosive ordnance remnants continue to occur in the country. One example is the fatal incident in 2023 in the Tešanj area, where an individual entered a minefield while searching for raw materials. Another case occurred in late August, in 2025, when a young man was killed in a minefield near Doboj (Независне новине, 2025).

Based on analyses covering 145 municipalities, mine-contaminated areas were identified in 118 municipalities (1,398 communities), representing a serious threat to human life. It is estimated that 259 communities face a high level of threat, 212 communities a medium level, and 950 communities a low level. In these areas, 264,011 households comprising 845,163 people are at risk. Of this number, 32,109 households with 132,803 people are considered to be at direct risk (BHMAC, 2025).

The most evident direct consequence of explosive ordnance remnants in Bosnia and Herzegovina manifests itself in the number of individuals killed and injured by their detonation. Since 1996, a total of 1,781 people have become victims of landmines and other explosive devices, 624 of whom lost their lives. Of the overall number of post-war casualties, 185 were women, while 251 were children, representing 14% of the total. During humanitarian demining operations in Bosnia and Herzegovina, 134 deminers were injured, while 53 were killed (BHMAC, 2024).

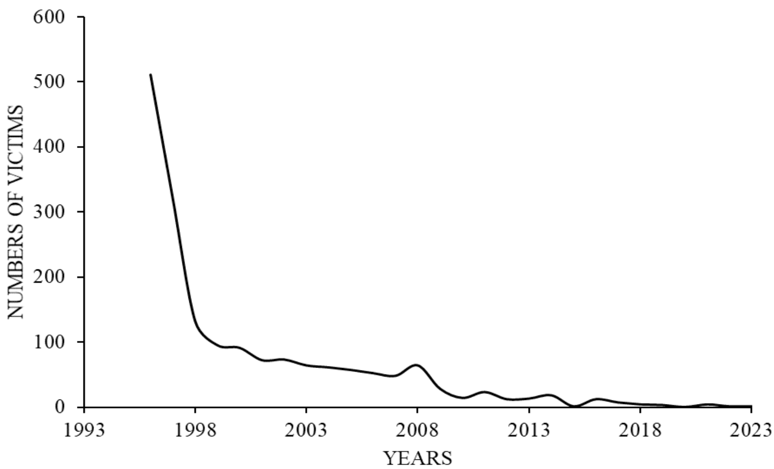


Figure 8. *Graphical representation of fatalities and injuries in Bosnia and Herzegovina, 1996–2023.*

Beyond posing a direct threat to human life, explosive ordnance remnants also affect broader aspects of human security. From an economic perspective, this is illustrated by the fact that, in 2024, 1.63% of Bosnia and Herzegovina's territory (838.29 km^2) was classified as suspected hazardous areas. A substantial portion of these areas comprises economically valuable land—such as forests, meadows, and riverbanks—which points to the negative impact of explosive ordnance remnants from an economic perspective.

From the perspective of the negative impact of explosive ordnance remnants on the economic aspect of security, the financial resources required for clearance operations and related activities aimed at returning land to safe use represent a significant factor. Available data indicate that, between 2013 and 2023, approximately 153.6 million dollars was spent on demining activities. Of this amount, 85.4 million dollars (55.6%) was financed from various domestic sources within Bosnia and Herzegovina, while international donations accounted for 68.2 million dollars (44.4%) (Mine Action Review 2009–2024, 2024).

Furthermore, the return of refugees and internally displaced persons, particularly in rural areas, has been considerably hampered by the continued presence of explosive ordnance in resettlement zones.

The ecological and health dimensions of human security in Bosnia and Herzegovina are also affected by the presence of contaminated areas. In the past, no systematic studies were conducted on soil contamination by heavy metals originating from explosive ordnance or their potential impact on the environment. A particular concern arises from the use of depleted uranium ammunition by NATO forces during the bombing of certain areas of Republika Srpska in 1995, including the use of the same munitions for training purposes at the Barbara military range near Glamoč. Approximately three tons of depleted uranium ammunition were used, which are characterized by long-term radioactivity (with a half-life exceeding 2×10^5 years) and the potential to migrate into ecosystems in contact with contaminated sites. Measurements and analyses at specific locations have shown levels of radioactive exposure up to 400 times higher than natural background radiation (Сарачевић et al., 2003). It is also notable that local Serb populations in these areas exhibit significantly higher rates of malignant diseases compared to other parts of Republika Srpska (Ђеранић, Башкало, 2019).

Conclusion

Based on the data presented, it can be concluded that the threat posed by explosive ordnance remnants to human security persists at a global level. Bosnia and Herzegovina ranks among the countries with the highest risk to human security. The negative impacts are reflected in a large number of injured and killed people, representing the most severe direct consequences for human security. The inability to utilize contaminated land, combined with compromised ecological and health conditions, hinders the return of refugees and internally displaced persons. From an economic perspective, the financial burden associated explosive ordnance remnants clearance further underscores its impact on security. Based on the available data, it is unlikely that the problem of explosive ordnance remnants clearance will be resolved in a short period of time (1–3 years). Given the multitude of other threats to human security in Bosnia and Herzegovina—such as terrorism, organized crime, illegal migration, and corruption—the clearance of minefields in the observed areas should remain a primary priority for the relevant institutions.

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