GEOGRAPHICAL REFLECTIONS OF MINE POLLUTION IN BOSNIA AND HERZEGOVINA AND CROATIA

Snježana Musa
PhD, full professor
Study of Geography
Faculty of Science and Education
University of Mostar
Matice hrvatske bb, 88 000 Mostar, Bosnia and Herzegovina
e-mail: snjezamusa@gmail.com

Željka Šiljković
PhD, full professor
Department of Geography
University of Zadar
Dr. Franje Tuđmana 24 i, 23000 Zadar, Republic of Croatia
e-mail: zs.zagreb@gmail.com

Dario Šakić
MA, senior assistant
Study of Geography
Faculty of Science and Education
University of Mostar
Matice hrvatske bb, 88 000 Mostar, Bosnia and Herzegovina
e-mail: dario.a.sakic@gmail.com

UDK: 911.9:355.58:914.971.5
COBISS: 1.01

Abstract
Geographical reflections of mine pollution in Bosnia and Herzegovina and Croatia
Numerous landmine fields cause an immense problem for the development of economy in rural areas of the Republic of Croatia and Bosnia and Herzegovina. Even twenty years after the Homeland War in Croatia, i.e. the same period after signing the Dayton Accord and war cessation in Bosnia and Herzegovina, huge areas are still contaminated with landmines. In Croatia are approximately 1.69 % of contaminated territory agricultural areas in the east part of country, forests and forestry land, i.e. pastures in highlands and the Mediterranean areas are most endangered. Bosnia and Herzegovina is one of the most landmine contaminated countries in the world. Severe landmine contamination in Bosnia and Herzegovina has been detected on pasture and forestry land, in the vicinity of the former war zone, in the central part of the country. Out of the total number of 1,366 landmine contaminated settlements in the Bosnia and Herzegovina territory, some 1,169 are rural communities.

Keywords
Mines, minefields, rural communities of Croatia and Bosnia and Herzegovina

Uredništvo je članek prejelo 10.12.2017

1. Introduction

In spite of the fact that twenty years have passed after the wars in Croatia and Bosnia and Herzegovina, both countries still face the problem of mines and mined land as the most severe consequence of war activities. The governments of Bosnia and Herzegovina and Republic of Croatia established national centres for demining, at first in 1998 and then in 2002. In addition to organization – Mine action centres also have the function of promoting and applying scientific research in practice. Croatian Mine Action Centre (CROMAC) has developed a Mine Information System (MIS) for all complex humanitarian demining procedures and thenweb application of MIS portal that provides clear insight into the current status of mine suspected area. The problem of uneven demining speed in Bosnia and Herzegovina and Croatia is the result of a number of factors. Some of them are a reflection of natural conditions, while others are a consequence of the social character of the war (three sides were in war in Bosnia and Herzegovina), which caused the existence of three types of minefields almost at the same place. In addition, minefield density is the problem in Bosnia and Herzegovina. Massive antipersonnel mine contamination (more than 100 sq km total per country) is believed to exist in Bosnia and Herzegovina and Croatia. Acording to Landmine Monitor (2016) in 2015 in Croatia is cleared 40,6 sq.km and destroyed 2,435 antiperslonnel mines. According to Bosnia and Herzegovina Mine Action Center (BH MAC) current size of mine suspected area in Bosnia and Herzegovina is 1,145 sq km or 2.3% of the total land area.

2. Minefields in Bosnia and Herzegovina and Republic of Croatia – spatial distribution

In Croatia, a mine action centre or CROMAC has been established in 1998, although the process of de-mining began earlier during the war, depending on the liberation of parts of the territory. Humanitarian demining continued after the military action "Storm" in 1995 when was found to have 13,000 sq km of mined territory. In the next six years 9,000 sq km of land, mainly contaminated with antitank mines, were cleared. Having in mind the overall state territory it might seem to be a small area but a problem arises from the fact that mines were registered in the area of 10 counties, 80 towns and municipalities encompassing the space populated by 700,000 inhabitants. As per the categorization of contaminated areas, majority belongs to forestry and agricultural land (Izvješće o provedbi plana humanitarnog razminiranja 2009), with more than 50 % in total share of space (Tab. 1). In total, 7 % (155,000 ha) of forests and forestry land is still mined or is mine suspected area (Mrkobrad 2009). Such a situation creates an obstacle in the renewal of economic activities since 20 million m^3 of wood has been inaccessible, numerous forestry roads are dilapidated due to impossibility of access while mining of forests presents a significant problem when extinguishing forest fires in the coastal part of the country. Current status of mine suspected areas in the Republic of Croatia amounts to 413.70 sq km and it is a result of humanitarian demining and general survey operations. Mine suspected area (MSA) covers 9 counties i.e. 60 towns and municipalities contaminated with mines and unexploded ordinances. It is assumed that the MSA is contaminated with 39,299 mines. Mine suspected area is also contaminated with large number of unexploded ordinances, especially in the areas of combat operations during the Homeland war. In line with the Law on Humanitarian Demining, the MSA is categorized into areas for mine search and demining. The entire MSA on the territory of the Republic of Croatia is marked with 13,498 mine warning signs. The current size of mine suspected area

in BiH is 1,091 km^2 or 2.2% in relation to the total area of BiH according to Bosnia and Herzegovine Mine Action Centre.

Tab. 1: Mine contaminated of land categories in Bosnia and Herzegovina and Croatia, 2009.

Category of mined land	Area in sq km		% out of total contaminated land	
	Croatia	B & H	Croatia	B & H
Forestry space	557,8	898	58.2	51.2
Agricultural land	269,2	645	28.2	36.7
Maquis and karst	109,7	36,7	11.5	2.1
Yards	4,7	33,7	0.5	2
Infrastructural facilities	0,2	74	0.02	4.2
Other spaces	12,9	68	1.4	3.8
Total	954,5	1755,4	100	100

Source: HCR, Zagreb (Plan humanitarnog razminiranja za 2010, 2009) and BHMAC, Sarajevo, 2010.

From the spatial aspect, the highest concentration of minefields is detected in the Easter regions of country, in the area of Osijek – Baranja County, 26.8 % or 4,165 of minefields, the most valuable agricultural land (Tab. 2). This area was the last that Croatia repossessed, only in 1997, so that demining has started late. The municipalities of Darda, Petlovac, Sodolovac and Markusica are characteristic by the highest number of minefields on one square kilometre of space. Darda municipality could be named as the most contaminated area in the country having 8.7 of minefields on one sq km, concentrated along the state road and the River Drava and in the area of Dardjanska Forest. In the area of the Petlovac municipality which is a boundary municipality with Hungary, the boundary line is mined but also a part of the territory belonging to neighbouring Hungary. Amongst most contaminated counties, Sisak – Moslavina County stands out with 5.3%, then Lika – Senj with 11.1 % and Zadar County with 11.1 % of minefields. In Sisak – Moslavina County areas along the pipeline and the agricultural land are still contaminated.One of the most contaminated areas is the Kotar forest near the town of Petrinja. (Report on implementation plan of humanitarian demining and funding for 2013). It is assumed that the territory of Croatia still has 15,439 minefields littered with more than 90,000 mines and ordnances. The National program of demining has given the priorities in demining to dwelling facilities, utility infrastructure at the state level, river channels, embankments, spaces along inhabited houses, spaces along state roads and the highway Zagreb – Split. Areas to be demined are divided into three categories of priority. First category, i.e. highest priority in demining includes educational facilities, hospitals, touristic destinations, known minefields, dwelling facilities falling under reconstruction program, agricultural first-class land as well as infrastructural facilities of state importance. This category also includes national parks and garbage wastes. Parts of National Park Paklenica are still contaminated exposing mountaineers to danger. The second category includes areas in the vicinity of settlements, parts of national parks and forests and agricultural second-class land. Amongst the parks, highest contamination has been detected in the Velebit Natural Park (area of Trulove Grede), which has been decontaminated in 2013, and after that Natural Park of Kopacki Rit. The third category includes forests along settlements as well as agricultural and forestry land of lower class (Nacionalni program protuminskog djelovanja Republike Hrvatske, 2010, Plan humanitarnog razmiravanja za 2010. godinu 2009). The problem with demining and the return of population is frequent occurrence of the so called “cluster” contamination, i.e. the fact that numerous combinations of mining have been observed in the areas of contamination. Most frequent clusters are in the combination of agricultural land (arable land + pastures), dwelling and infrastructural facilities, agricultural areas and roads and dwelling

facilities and water zones. In Bosnia and Herzegovina, the mine action centre (MAC) has been established in 2002, although the mining began immediately after the war. The United Nations established the Mine Action Centre of the United Nations - UNMAC in order to build local structures to manage the process of demining. As per initial assessment, 8.2% of the total territory or 4,200 km^2 was mine contaminated but demining has been going on under difficult circumstances since only a half of all minefields are accessible. The majority of minefields are dispersed along the separation line and along strategic facilities. Minefields are scattered in all vegetative communities of forests, grassland, the Mediterranean vegetation maquis and garrigue and on rocky lands. The distribution of population and settlements in Bosnia and Herzegovina is being of that kind that both lowlands and mountainous areas are almost equally contaminated. Out of the total number of 2,885 settlements in 142 municipalities, more than 60% were mine and ordnance contaminated.

Tab. 2: Most mine contaminated municipalities in Croatia and Bosnia and Herzegovina (Fig. 1).

Municipalities in Croatia	Area of municipalities in Croatia, in sq km	No. of minefields	No. of fields as per sq km	Municipalities in B&H	Area of municipalities in B&H in sq km	No. of minefields	No. of minefield as per sq km
Petrinja	380,1	868	2.3	Brcko	493	741	1.5
Darda	86,75	757	8.7	Zavidovici	540	607	1.1
Petlovac	93	665	7.1	Teslic	846	580	0.7
Glina	543	632	1.2	Travnik	563	556	1
Gospic	967	558	0.6	Bosanska	780	532	0.7
Sodolovac	78	504	6.5	Doboj	684	477	0.7
Markusica	73,45	485	6.6	Maglaj	384	474	1.2
Bilje	344	485	1.4	Gradacac	405	457	1.1
Benkovac	516,14	436	0.8	Ilidza	165	441	2.7

Source: HCR, Sisak 2011 and BHMAC, 2010.

As per data from 2007 (Operativni plan protuminskih akcija centra za uklanjanje mina u BiH za 2010, 2009) 1,631 settlements hosting almost one million of inhabitants were mine suspected. Bosnia and Herzegovina has been classified amongst the highly contaminated countries since 16.8% of its inhabitants fall under high risk category. In the period up to 2013, 214 settlements have been demined. The rest of 1,417 settlements have been divided according to the degree of threat in three categories (Report on antimine actions in Bosnia and Herzegovina for 2014, 2013): high threat - 136 settlements (10%), medium threat - 268 settlements (19%) and low threat - with 1,013 settlements (71%). The mine risk and the impossibility to deal with economic activities first of all agricultural ones have resulted in the slow return of its displaced population. By the beginning of 2008, mined area was downsized to 1,755 sq km or 3.4 % of state territory, presenting the downsize of 68.3 % compared to the situation in 1996. Demining priority has been in favor of urban centers and populated rural communities and is classified into three categories:

- Dwelling facilities, agricultural land, electricity–supply facilities and facilities of public importance (educational and health institutions)
- Industrial facilities, forestry areas, agricultural land in remote locations
- Touristic and forestry areas distant from settlements.

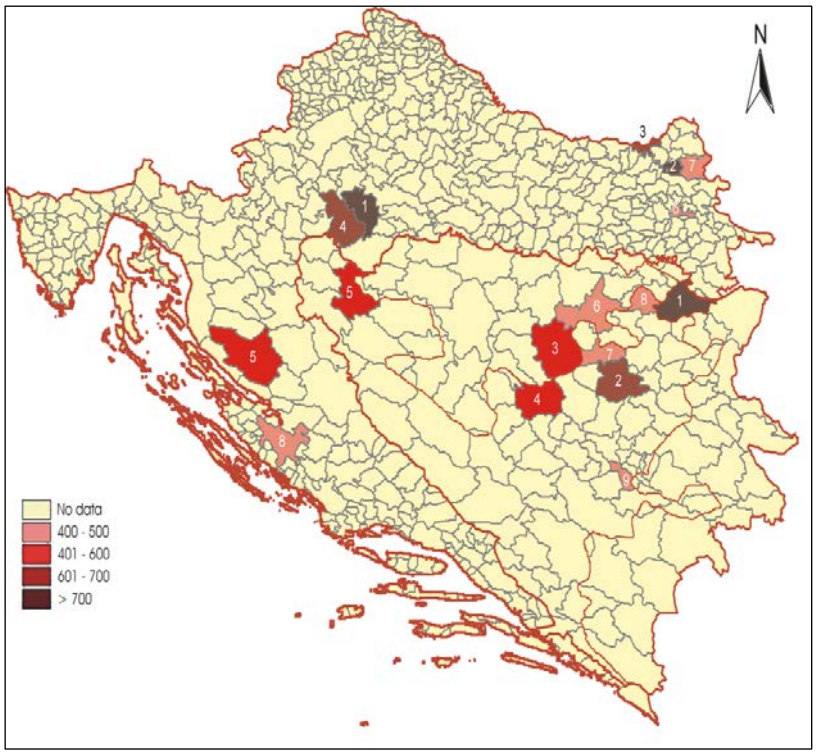

Fig. 1: Most mine contaminated municipalities in Croatia and Bosnia and Herzegovina
Source: Authors (by HCR, Sisak 2011 and BHMAC, 2010 data)
(Municipalities in Croatia: 1-Petrinja, 2-Darda, 3-Petlovac, 4-Glina, 5-Gospic, 6-Markusica, 7-Bilje, 8-Benkovac; municipalities in Bosnia and Herzegovina: 1-Brcko, 2-Zavidovici, 3-Teslic, 4-Travnik, 5-Bosanska Krupa, 6-Doboj, 7-Maglaj, 8-Gradacac, 9-Ilidza).

The distribution of population and settlements in Bosnia and Herzegovina is being of that kind that both lowlands and mountainous areas are almost equally contaminated. Out of the total number of 2,885 settlements in 142 municipalities, more than 60% were mine and ordnance contaminated (Tab. 3).

Tab. 3: Types of settlements exposed to minefields and suspected minefields, 2010.

Type of settlement	No. of communities	No. of inhabitants
URBAN SETTLEMENTS		
Urban	37	598 004
Suburban	111	236 383
Total urban and interim	148	834 387
RURAL SETTLEMENTS		
Densely concentrated	367	236 014
Scattered	798	298 161
Periodical	2	50
Nomad	2	8
Total Rural	1169	534 233
OTHER AND UNKNOWN		
Other (not populated, destroyed, military camp,	40	896
Unknown	9	6291
TOTAL	1366	1 375 807

Source: BH MAC, Final report, 2010.

It is impossible to assess the precise number of minefields and mines. Presumption is that some 18,322 fields have not been demined and are polluted with more than one million of unexploded mines. Especially endangered are the lowlands and the separation line of belligerent parties. The highest number of minefields has been detected in Brcko District – still 741 minefields, i.e. 1.5 minefield could be found on 1 sq km. Municipality Ilidza stands out by highest number of mines per sq km; 2.7 minefields as per square kilometre. Out of 142 municipalities, even 86 %, i.e. 128 are mine contaminated. An analysis of field work in Bosnia and Herzegovina has revealed an incomplete return of displaced population. Rural settlements still remain mine suspected.

3. The impact of landmines on the environment and economy

The natural features such as vegetation cover are a specific problem, especially in Bosnia and Herzegovina where forests dominate. Mines were placed on long and steep slopes, which makes demining difficult and challenging. Such areas are much more susceptible to erosion, which, along with slope gradient, causes very intense movements of minefields, so even demined areas can be contaminated again. Floods, torrents and subsidence are also mine risk sources because of possibilities of moving mines. Jebens (2013) states that in a dynamic coastal environment, the minefield is influenced by a number of physical processes on a daily basis, including erosion caused by wind and water, dune migration, marsh build-up and marsh and dune expansion. On the other hand, there is the social problem, i.e., a kind of society's lethargy in terms of solidarity among inhabitants in Bosnia and Herzegovina. The education about the problems of mines and minefields has ceased in schools and the media no longer regularly reports on the problem of mines. In contrast, there are continuous actions that call people to donate money for clearing potential mined areas in Croatia. NGOs, companies as the Croatian Lottery, domestic and foreign retail chains, and public and private television companies are involved in those activities under the slogan "I love Croatia". In Bosnia and Herzegovina such actions are not implemented. Therefore, every hiking trip, especially in the mountains and even those surrounding the capital Sarajevo (Bjelasnica, Treskavica, Trebevic), is connected with the risk of mines. A comparison with the situation in Croatia indicates that Bosnia and Herzegovina is a far poorer country than Croatia (GDP per capita in Bosnia and Herzegovina is 4,410 €, while in Croatia it is 10,129 €), thus allocations for these activities are far smaller. Croatia has up to 2014 spent 590 million euros on demining, but also on training deminers and scientific research. Another reason for the lag in demining in Bosnia and Herzegovina is its divided territory (Federation of Bosnia and Herzegovina, the Republic of Srpska and Brcko district) in which even the authorities are divided. In the reports of the international community it can be heard very often that the Bosnian donations for demining were eaten by its cumbersome administration, etc. (Overview of activities of donors 2009 – 2010, Document drafted upon financial and technical assistance of DFID Bosnia and Herzegovina, 2010). Humanitarian Mine Action (HMA) focuses its activities on the impact of mines and minefields on the social and economic development of society (Harpviken et al. 2003). According to the UN International Mine Action Standards (IMAS), four kinds of surveys are included: general surveys, impact surveys, technical surveys and hand-overdocumentation (Harpviken et al. 2003). In the economic analysis of the impact of the mine's, the emphasis is on the possibilities of future economic investment and the realization of certain incomes, while community analysis includes questions about the impact of mines on the return of displaced persons and their impact on cultural and religious issues. Mines have various detrimental effects on the environment,

social and economic development. The impact on the environment could be perceived through several categories: loss of biodiversity (during explosions or demining the vegetation on certain location is destroyed and animals are subjected to casualties as well). Detonations not only damage but also cause atrophy to the bark of trees and to the root systems of plants. Micro relief on mined location passes through a range of changes like the disorder of soil stability, the soil structure is being destroyed and the land is subjected to erosion. In explosions, surrounding land is exposed to chemical pollution since a mine contains the metals like iron, zinc, chrome, cadmium, nickel, lead and mercury. Many organic and inorganic compounds of explosives are waterproof, toxic (like TNT) and either directly or indirectly break through soil and underground waters subsequently accumulating in the bodies of animals and human beings. Minefields block access to existential sources for human life, such as water, farmland, roads, infrastructure. Mine are usually placed in rural areas, where agriculture and livestock are major industries. Many countries contaminated with mines are among the poorest in the world where agriculture and livestock farming is often the only source of income. Afghanistan, Ethiopia, Eritrea and Mozambique are among the poorest countries in the world (Harpviken and Isaksen 2004). Exploded and unexploded military waste scattered across the post-war landscape constitutes a serious concern on multiple scales (Henig 2012). In the areas where arable land and pastures are mined, forest becomes the only source of survival to its inhabitants which accelerates deforesting indirectly affecting the drainage system and the level of underground waters. From a sociological aspect, landmines in a certain area cause demographic drain, social instability for the return of its depopulated people and eventually demographic marginalization of the area.The presence of landmines may be only one of several factors that prevent refugees from returning to their community of origin. Landmines may interact with a lack of transport and a poor security situation (Harpviken et al. 2003). The Zemunik area, located in the hinterland of the coastal urban centre Zadar represents a typical rural region that experienced a major transformation from an intensively agricultural to a depopulated region with a significant share of landmine fields. The population of Zemunik Donji Municipality did not decline until as late as 1971 as a result of inhabitants emigrating to urban settlements. The most significant decline in the population number was the result of the Croatian War of Independence and it was registered in the population census in 2001. When compared with data from 1991, the total population decreased by 59.1%. A significant decline of agricultural economic activities occurred during and after the Croatian War of Independence and can be observed by closely examining the population structure according to the economic activity from 1971 to 2001. In 1971, 31% of the total economically active population living in the Municipality was engaged in agricultural activities. Based on information from the 1991 population census, the share of economically active agricultural population decreased to 12.8%.After the War, in 2001, the share of the economically active agricultural population in the overall economically active population was only 1.74%. In the Municipality, the total number of persons employed in the primary sector declined from 554 in 1971 to only 10 in 2001. One of the main reasons for such a distinctively negative change was the Croatian War of Independence. Despite the intensive demining process, the problem of mined arable land will not completely enable agricultural valorisation of land as it was the case before the 1990s (Šiljković et al. 2011). From the economic aspect, landmines varyingly affect; through diminished productivity resulting in the need for more investments into the improvement of quality and the manner of exploitation of resources. The socio-economic impact of landmines has been studied in works by Harris (2000), Elliot and Harris (2001) and Gibson et al. (2007). Taking into account the economics of landmine clearance, Harris (2000) and Elliot and Harris (2001) have

dealt with issues in Cambodia, Afghanistan and Mozambique, while Gibson et al. (2007) have provided a thorough analysis of the value of statistical life (VSL), and the economics of landmine clearance in developing countries. Huge mined zones in Croatia are located in forestry areas planted with the communities of beech and fir, in the area of Gospic, Osijek and Sisak as well as in karst area overgrown with marquis. Amongst forestry areas still being inaccessible, Prasnik forestry stands out, a special reservation of forestry vegetation of the community of Quercus robur being old up to 300 years. Another problem is a high ratio of contaminated agricultural areas as well as parts of the banks of the rivers Sava, Kupa and Drava. Bordering zones towards the neighboring country of Bosnia and Herzegovina along the River Sava and the river embankment of the River Drava towards the border with Hungary have not yet been demined. Mine contamination of these areas causes uncontrolled expansion of vegetation along the banks and channels and thus flooding of the agricultural land in rainy periods. It could be argued that landmines are an (albeit unwelcome) form of protection of peatland habitat as people and grazing animals are excluded and flora can get a chance to proliferate (McAdam 2013). Exploded and unexploded mines are considered to be a particular type of waste. Henig (2012) includes mines in military waste, while McGrath (2000) both mines and other unexploded ordnance (such as artillery shells, artillery munitions, bombs, missiles and rockets, hand grenades, mortars, rifles detonators) calls garbage of war. In rural Bosnia and Herzegovina, exploded ordnance means bullets and shrapnel embedded in buildings and, rather abundantly, in trees. McGrath (2000) defines unexploded ordnance (UXO) as any object containing explosive of any kind which has been deployed and failed to detonate, or has only partly detonated, or such objects which have been abandoned in any condition. According to UNEP (2013) mines are disaster waste together with other unexploded ordnance. Yet, between garbage and waste there are important differences. Therefore the authors have the opinion that unexploded mines should be classified as waste, while exploded mines as garbage. Military waste also entails complex issues of ownership and responsibility for risk mitigation and disposal. Great floods in Bosnia and Herzegovina during 2014 started landslides and caused ground erosion which included some mine fields. New mine fields appeared, and floods carried away the mine field markings.

The greatest threat is the area around Doboj, Maglaj, Olovo and Vitez, i.e. alluvial plains of the rivers Sava, Bosna, Krivaja and Spreča (Fig. 2). The floods had a similar effect on the mine fields in eastern Croatia, in the valley of the Sava River. The potential danger is that water swept away the mines to the areas that had already been cleared in previous projects CROMAC, because it is an area lower than the one covered with mines. The greatest danger is in the village of Gunja and Vrbanja (Fig. 3) where the flood affected the forest which had been previously established as the mine suspected area.

4. Use of Geographic Information Systems in managing landmine fields

The impossibility of a country to demine its own territory at its own expense brings it into the position of dependency on external assistance. The immense problem is the fact that not all minefields are registered. Other problems arose during the period of time, when documents on mining were lost, hidden or destroyed. Therefore it is important to additionally gather data by direct observation. The reduction of area contaminated by mines is multidisciplinary task in which its place take remote sensing and photogrammetry and GIS. The use of GIS in mine action has gained popularity in recent years. Landmine Action's operational staff uses GIS in Western Sahara to

record locations of mines and unexploded ordnance, and to delineate boundaries of minefields and cluster-strike areas and their associated details in the form of maps and databases. Maintaining this GIS is a challenging process that requires regular input and a systematic exchange of data between field teams and the GIS Officer. Owing to the nomadic population of Western Sahara, the threat of contamination poses a high risk, and it is therefore crucial to have detailed information on the exact locations of contamination (Caswell 2009).

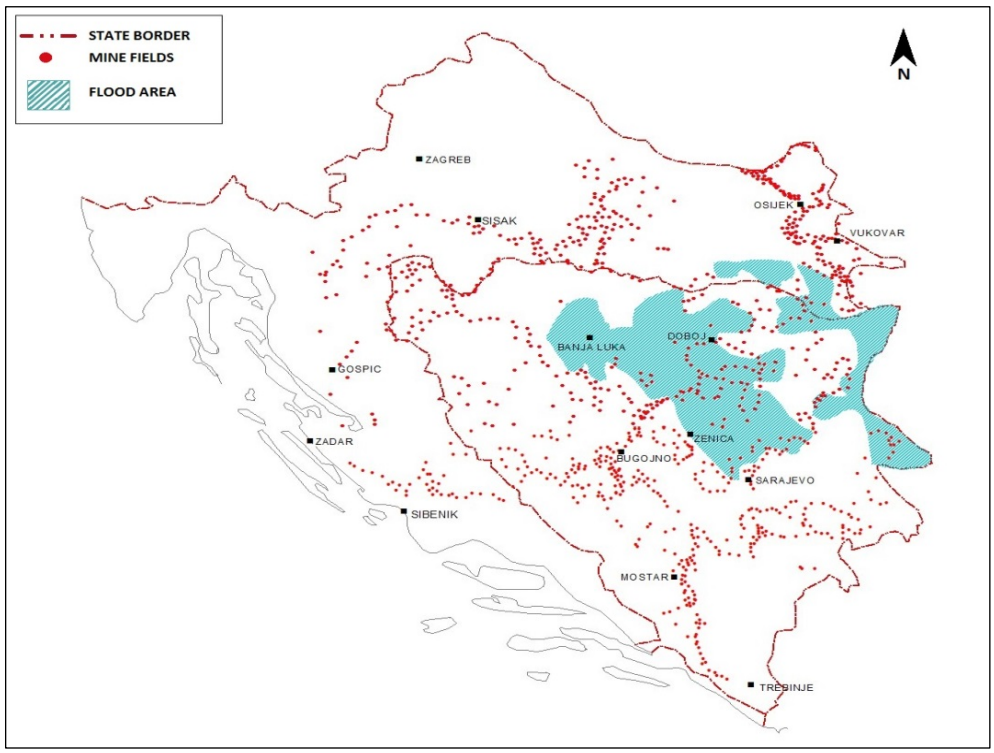

Fig. 2: Great floods during 2014 and mine fields.
Source: Authors (by MAC and CROMAC data).

The problem with gathering data is also insufficient preciseness of very information being the consequence of many reasons (Krtalić and Matić 2010):

- Uncertainty – whether collected information is true
- Impreciseness – at which extent the content of gathered information is true
- Incompleteness – whether gathered information is complete or only partial
- Contradiction – information obtained from the opposite side does not necessarily match to one's own information.

Gathered data are analysed through five phases: in the first phase cartographic data are processed by the usage of GIS and ortho-photo footage serving for detecting grid references of minefields. Then, the types and number of mines are to be determined in minefields and marked. Fifth phase refers to the comparison with previous data on mining and analysis of possible errors when locating them (Krtalić and Matić 2010).

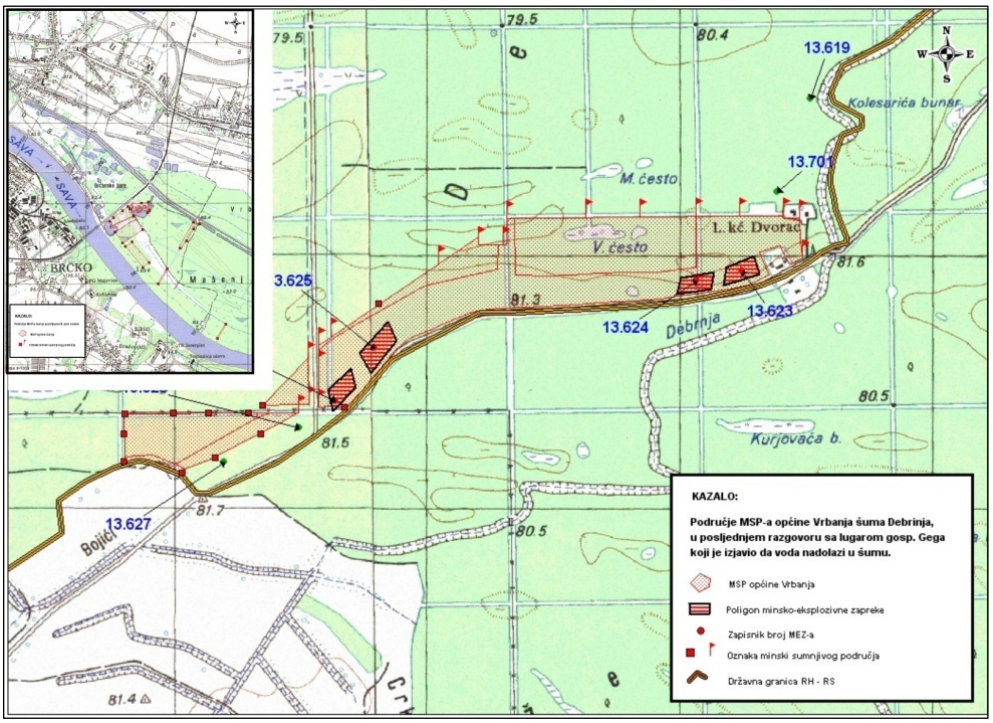

Fig. 3: Floods and mine fields in Gunja and Vrbanja area.
Source : CROMAC, 2014.

Important role in marking minefields belongs to remote researches using photogrammetry aimed at collecting reliable spatial data on terrain and position of minefields. Photogrammetry in this case used to obtain reliable spatial data about field and objects on it from a large number of images obtained with different systems of sensors. Applying the ARCOD system, the mine suspected area in Croatia has been marked in detail extensively downsizing the risk of sudden accidents and also enabling rapid demining of terrain (Bajić et al. 2009). ARKOD is the national system of identification of land parcels, i.e. registration of agricultural land usage in the Republic of Croatia. The goal of ARKOD is to provide farmers with easier and simpler manner of submitting their applications for direct payments as well as their transparent usage. Improvement in analysis and preparation of terrain for mine clearance is the DOF2 method whose preciseness is measured up to 20 cm and actuality of data up to several weeks at most. The GIS multicriteria model could indicate where are the potential erosion places.

According to the performed digitalised topographic map could estimate the slope angles, depths and lengths of more extensive gullies. These values can use to evaluate the erosive power of water (Valjarević et al. 2015). Topographic parameters representing the geometric properties of terrain surface are important for many applications related to environmental modeling and land use management (Mitasova and Mitas 1998). Assessment of soil erosion using GIS can be carried out according to the flowchart in Fig. 5.

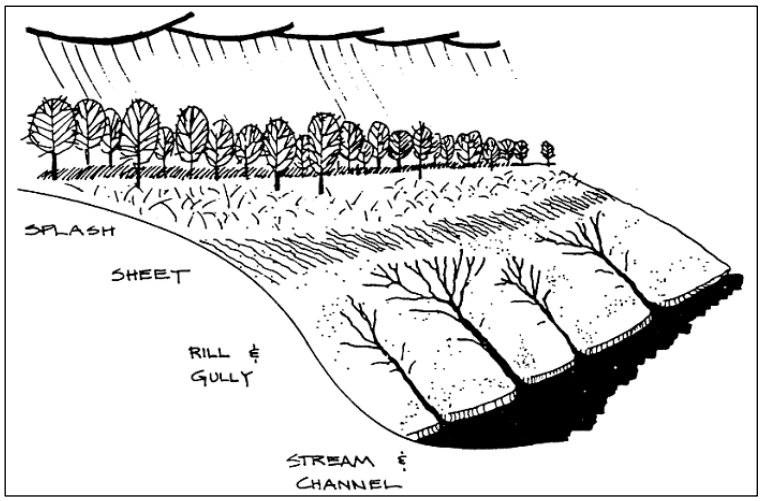

Fig. 4: Four types of soil erosion on an exposed slope.
Source: UNEP, 1994.

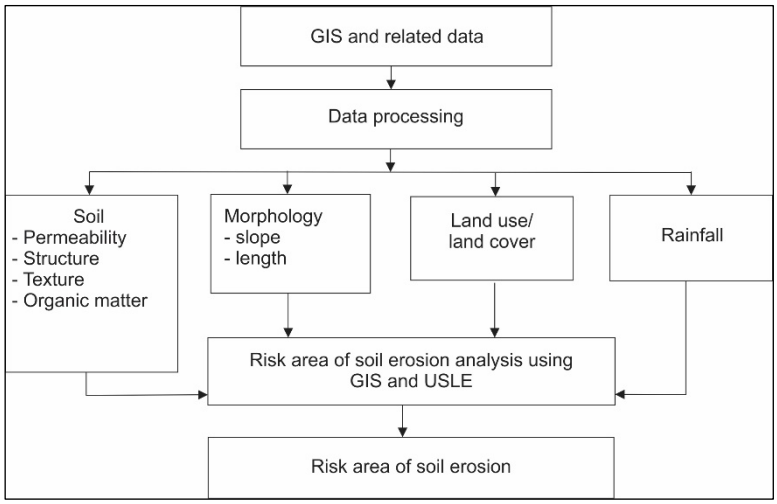

Figure 5: GIS-based soil erosion model.
Source: https://www.geospatialworld.net/article/using-gis-rs-for-soil-erosion-mapping/

The Universal Soil Loss Equation (USLE) is a widely used mathematical model that describes soil erosion processes (Hudson 1993). The USLE is composed of six factors to predict erosion: rainfall erosivity factor, the soil erodibility factor, the topographic factors and the cropping management factors. These mathematical operations and models could also be used to model the movement of minefields due to erosion.

5. Mine casualties in Bosnia and Herzegovina and Republic of Croatia

In many under-developed countries civilian casualties occur mostly in rural areas as people go about their daily activities, often driven by economic necessity to go into areas known tobe dangerous, as in Lebanon and Vietnam (Šiljković et al. 2011). For

2015, the Landmine Monitor (2016) recorded 6,461 mine casualties, marking a 75% increase from 3,695 casualties recorded for 2014. Casualties, the people killed and injured by mines, were identified in a total of 61 states and other areas in 2015 (including Bosnia and Herzegovina and Croatia). This sharp increase was due to more mine casualties recorded in armed conflicts in Libya, Syria, Ukraine, and Yemen in 2015, as compared with previous years. In 2015, there was also increased availability of casualty data for persons injured in some countries, particularly Libya and Syria. The casualty total in 2015 marked the highest number of annual casualties by victim-activated IEDs (also called improvised mines) recorded by the Monitor. There were at least 1,072 child casualties in 2015 in global. Child casualties in 2015 accounted for 38% of all civilian casualties for whom the age was known. (Landmine monitor, 2016). Except mine clearance experts constantly exposed to risk, the civil population frequently gets hurt. According to information from BH MAC for the period of 1997-2016 (20 years period), there were 79 demining accidents in BH, with the following consequences: 122 victims out of which 50 fatalities, 39 severely wounded and 33 lightly injured.

According to the Guide for anti-mine program (A Guide to socio-economic approaches to mine action planning and management, 2004), there are five categories of people exposed to mine casualties:

- Unaware individuals are persons not familiar with the risk
- Uninformed individuals do not know anything about safe conducts
- Careless people ignoring warnings
- Individuals that deliberately accept unsafe conduct
- Socially disadvantaged population trying to improve living standards by working in or exploitation some resources of mine-marked areas.

A comparison of casualties in Bosnia and Herzegovina and in Croatia has pointed at a positive trend of downsizing civilian causalities over the past several years (Tab. 4). The downscale could have resulted from intensively educating the population about the suspected areas, the involvement of media in education, school system role in the work with children as well as the diminishing of mined areas. Casualties reached the highest number in the period 1991-1997, i.e. in the war and post war period. Establishing demining centres and thoroughly marking minefields, the number of casualties has significantly downsized. Yet, the number of casualties in Bosnia and Herzegovina is higher than in neighbouring Croatia. Reasons could be found in the differences of economic valorisations of mined areas and in the need of poor population to exploit resources in mined areas. So, regardless of adequate actions on mine warnings and education on mine and ordnance risks, accidents with casualties and lethal consequences in Bosnia and Herzegovina occur very often although the number of casualties has been halved in 2010 compared with previous years. BHMAC stresses how the registered number of mine victims has been considerably lower in post-war period compared to the war time but at the same time the ratio between the deceased and injured has been increased for as many as 49%. Death rate has been increased by 49% compared to the war period when the so called “small mines” would more frequently explode. According to the data from BH MAC database, in the period of 1992-2016 there has been 8379 registered mine victims in BH, out of which 1751 victims registered once the war activities ended.

Tab. 4: Civilian mine casualties in Bosnia and Herzegovina and Croatia (1991 - 2013).

Year	Bosnia and Herzegovina			Croatia		
	Injured	Deceased	Index of deceased 1998=100	Injured	Deceased	Index of deceased 1998=100
1991-1997	5490	1375		1233	390	-
1998	75	50	100	56	36	100
1999	48	42	84	36	21	58.3
2000	39	42	84	13	10	27.8
2001	36	38	76	21	8	22.2
2002	48	25	50	19	6	16.7
2003	34	31	62	8	1	2.8
2004	35	24	48	2	14	38.9
2005	24	32	64	9	4	11.1
2006	22	28	56	10	1	2.8
2007	31	17	34	5	3	8.3
2008	29	34	68	5	2	5.5
2009	19	9	18	3	4	11.1
2010	8	6	12	0	1	2.8
2011	13	9	18	5	1	2.8
2012	3	9	18	1	2	5.5
2013	10	3	6	1	0	0.0
TOTAL	5964	1774		1417	504	

Source: HCR, BHMAC, 2011, 2012, 2013, 2014.

In both countries, the most risky group are mature-age males (19 – 39, 64.4 %), then children younger than 18 (8.1 %). McGrath (2000) reports similar data: 80 to 90 % of all mine victims in Bosnia and Herzegovina are male. More than 900,000 inhabitants of the Bosnian countryside are in potential danger of being injured or killed; nearly a quarter of the population (Henig 2012). Children are particularly vulnerable to mines and they very often get hurt while playing. While in adults individual victims are the most common, the children are group victims because of the causes of incidents (Kinra and Black 2003). The highest number of casualties appears in the summer time (period of picking forests fruits, agricultural works-the source of population living existence). Domicile population staying in their residence places during the war are most frequently the victims (64.7%), partly because of believing how minefields are known to them. Notably fewer casualties are observed amongst displaced persons (16%) and returnees (13%), being more careful when moving in suspected areas. Local population also increase the risk by tending to remove the minefield warning sign and placing it at some other location. Military operations in Kosovo in 1999 - 2000, caused the largest number of victims (77 % of the total 596), particularly among young people. In just one month (from 13 June to 14 July 1999) 150 people were injured or killed. Here is the largest number of victims younger than 24 years (71 %), while 95% of them were the male population (Krug and Gjini 1999).

6. Conclusion

Both countries, Bosnia and Herzegovina and Croatia face problems with mine contaminated areas especially in the regions being the sources of existence for their population. It is planned to demine the areas by 2019. For the time being only IPA funds are consistent in financing these activities. Demining is classified under high risk professions. One should be brave to work as a mine clearance experts, supported by the fact that so far in Bosnia and Herzegovina 96 mine clearance experts got injured out of which 41 died. Still, Bosnia and Herzegovina is among the ten most

vulnerable countries by the total number of mine victims, and the only country in the Western Balkans which has recorded mine incidents with casualties (2015). Natural features such as vegetation cover, steep slopes, slope gradient, floods, torrents and subsidence are all mine risk sources because of possibilities of moving mines. Geographic inforamtion systems could play enormous role in managing and mapping environtment effects on landmine fields. The use of GIS provides several benefits to mine action, including aiding clearance and decision making, identifying hotspots, providing visualization of contamination, and facilitating community handovers.

References

A guide to socio-economic approaches to Mine action planning and management, 2004, Geneva.

Bajić M, Krtalić A., Matić Č., Vuletić D.:Minefield indicators and analytical mine contamination assessment in scientific projects and practice. International symposium "Humanitarian demining 2009", 7-11, 2009.

Caswell P.: Insight into GIS Usage in Dangerous Area Survey, The Journal of ERW and mine action, Issue 13.3, 2009.

Elliot G. And Harris G.: A cost-benefit analysis of landmine clearance in Mozambique. Development Southern Africa, 2001.

Gibson J., Barns S., Cameron M., Lim S., Scrimgeour F., Tressler J.: The value of statistical life and the economics of landmine clearance in developing countries. World development, 35 (3), 512-531, 2007.

Harpviken K. B., Millard A. S., Kjellman K. E., Skara B. A.: Measures for mines: approaches to impact assessment in humanitarian mine action. Third World Quaterly, 24 (5), 889-908, 2003.

Harpviken K. B. and Isaksen J.: Reclaiming the fields of war: mainstreaming mine action in development, UNDP, 2004.

Harris G.: The economics of landmine clearance: case study of Cambodia, Journal of international development, 12 (2), 219-225, 2000.

Harris G.: The economics of landmine clearance in Afganistan, Disasters, 26 (1), 49-54,, 2001.

Henig D.: Iron in the soil: living with military waste in Bosnia and Herzegovina. Anthropology today, 28 (1), 21-23, 2012.

Hudson N.: Field measurement of soil erosion and runoff, Issue 68, Food and agriculture organization of the United Nations, 121-126, 1993.

Izvješće o provedbi plana humanitarnog razminiranja, Sisak, 2009.

Jebens M.: Analyzing Functionality of Landmines and Clearance Depth as a Tool to Define Clearance Methodology, The jornal of ERW an mine action, issue 17,2, 2013.

Kinra S. and Black M. E.: Landmine related injuries in children of Bosnia and Herzegovina 1991-2000: comparisons with adults, Journal of epidemiology and community health, 57 (4), 264-265, 2003.

Krtalić A. and Matić Č.: Statistical processing of minefield records, International Symposium "Humanitarian demining 2010", 78-80, 2010.

Krug E. G. and Gjini A.: Number of landmine victims in Kosovo is high, British medical journal, 450, 1999.

Landmine Monitor, International Campaign to Ban Landmines – Cluster Munition Coalition (ICBL-CMC), 2016

McAdam J.:The impact of the Falklands war (1982) on the Peatland ecosystem of the islands, War and peat conference procedings, Sheffield, 159-176, 2013.

McGrath R.: Landmines and unexploded ordnance: a resource book, 288, 2000.

Mitasova H. and Mitas L.: Terrain analysis and erosion modeling, GMS Laboratory, University of Illinois at Urbana-Champaign, 1998.
Mrkobrad M.: Šume pod minama, Hrvatske šume, 148, 3-8, 2009.
Nacionalni program protuminskog djelovanja Republike Hrvatske, 2010.
Operativni plan protuminskih akcija centra za uklanjanje mina u Bosni i Hercegovini za 2010., Sarajevo, 2009.
Overview of acitivities of donors 2009 – 2010, Document drafted upon financial and technical assistance of DFID Bosnia and Herzegovina, Sarajevo, 2010.
Plan humanitarnog razminiranja za 2010. godinu, Zagreb, 2009.
Report on antimine actions in Bosnia and Herzegovina for 2014, Sarajevo, 2014.
Report on implementation plan of humanitarian demining and funding for 2013, Zagreb-Sisak, 2013.
Šiljković Ž., Čuka A., Pejdo A.: Rural area transformation: from cropland to minefields – Zemunik Donji Municipality (Croatia) case study, Društvena istraživanja, 2011.
Valjarević A., Srećković-Batoćanin D.,Živković D., Perić M.: GIS analysis of dissipation time of landscape in Devil's city (Serbia), Acta Montanistica Slovaca, Volume 20, number 2, 148-155, 2015.
UNEP: Guidelines for Sediment Control Practices in the Insular Caribbean. CEP Technical Report No. 32 UNEP Caribbean Environment Programme, Kingston, Jamaica, 1994.

GEOGRAPHICAL REFLECTIONS OF MINE POLLUTION IN BOSNIA AND HERZEGOVINA AND CROATIA
Summary

In spite of the fact that twenty years have passed after the wars in Croatia and Bosnia and Herzegovina, both countries still face the problem of mines and mined land as the most severe consequence of war activities. The governments of Bosnia and Herzegovina and Republic of Croatia established national centres for demining, at first in 1998 and then in 2002. Current status of mine suspected areas in the Republic of Croatia amounts to 413,70 sq km and it is a result of humanitarian demining and general survey operations. Mine suspected area (MSA) covers 9 counties i.e. 60 towns and municipalities contaminated with mines and unexploded ordinances. It is assumed that the MSA is contaminated with 39.299 mines. Mine suspected area is also contaminated with large number of unexploded ordinances, especially in the areas of combat operations during the Homeland war. In line with the Law on Humanitarian Demining, the MSA is categorized into areas for mine search and demining. The entire MSA on the territory of the Republic of Croatia is marked with 13.498 mine warning signs. The current size of mine suspected area in BiH is 1,091 km2 or 2,2% in relation to the total area of BiH according to Bosnia and Herzegovine Mine Action Centre.

From the spatial aspect, the highest concentration of minefields in Croatia is detected in the Easter regions of country, in the area of Osijek – Baranja County, 26. 8 % or 4,165 of minefields, where is the most valuable agricultural land. Areas to be demined are divided into three categories of priority. First category, i.e. highest priority in demining includes educational facilities, hospitals, touristic destinations, known minefields, dwelling facilities falling under reconstruction program, agricultural first-class land as well as infrastructural facilities of state importance. This category also includes national parks and garbage wastes. Parts of National Park Paklenica are still contaminated exposing mountaineers to danger. The second category includes areas in the vicinity of settlements, parts of national parks and forests and agricultural second-class land. Amongst the parks, highest contamination has been detected in the Velebit Natural Park (area of Trulove Grede), which has been decontaminated in 2013, and after that Natural Park of Kopacki Rit. The third category includes forests along settlements as well as agricultural and forestry land of lower class (Nacionalni program protuminskog djelovanja Republike Hrvatske, 2010, Plan humanitarnog razmiravanja za 2010. godinu, 2009). The problem with demining and the return of population is frequent occurrence of the so called “cluster” contamination, i.e. the fact that numerous combinations of mining have been observed in the areas of contamination. Most frequent clusters are in the combination of agricultural land (arable land + pastures), dwelling and infrastructural facilities, agricultural areas and roads and dwelling facilities and water zones. In Bosnia and Herzegovina the majority of minefields are dispersed along the separation line and along strategic facilities. Minefields are scattered in all vegetative communities of forests, grassland, the Mediterranean vegetation maquis and garrigue and on rocky lands. The distribution of population and settlements in Bosnia and Herzegovina is being of that kind that both lowlands and mountainous areas are almost equally contaminated. Out of the total number of 2,885 settlements in 142 municipalities, more than 60% were mine and ordnance contaminated. The natural features such as vegetation cover are a specific problem, especially in Bosnia and Herzegovina where forests dominate. Mines were placed on long and steep slopes, which makes demining difficult and challenging. Such areas are much more susceptible to erosion, which, along with slope gradient,

causes very intense movements of minefields, so even demined areas can be contaminated again. Floods, torrents and subsidence are also mine risk sources because of possibilities of moving mines. Therefore, every hiking trip, especially in the mountains and even those surrounding the capital Sarajevo (Bjelasnica, Treskavica, Trebevic), is connected with the risk of mines. Micro relief on mined location passes through a range of changes like the disorder of soil stability, the soil structure is being destroyed and the land is subjected to erosion. In explosions, surrounding land is exposed to chemical pollution since a mine contains the metals like iron, zinc, chrome, cadmium, nickel, lead and mercury. Many organic and inorganic compounds of explosives are waterproof, toxic (like TNT) and either directly or indirectly break through soil and underground waters subsequently accumulating in the bodies of animals and human beings. Minefields block access to existential sources for human life, such as water, farmland, roads, infrastructure. Mine are usually placed in rural areas, where agriculture and livestock are major industries. Great floods in Bosnia and Herzegovina during 2014 started landslides and caused ground erosion which included some mine fields. New mine fields appeared, and floods carried away the mine field markings. Therefore it is important to additionally gather data by direct observation. The reduction of area contaminated by mines is multidisciplinary task in which its place take remote sensing and photogrammetry and GIS. The use of GIS in mine action has gained popularity in recent years. Important role in marking minefields belongs to remote researches using photogrammetry aimed at collecting reliable spatial data on terrain and position of minefields. Geographic inforamtion systems could play enormous role in managing and mapping environtment effects on landmine fields. The use of GIS provides several benefits to mine action, including aiding clearance and decision making, identifying hotspots, providing visualization of contamination, and facilitating community handovers.