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3 WATCH OUT

ANALYSIS OF RISKS IN PROJECT AREAS (Albania, Montenegro, Italy)

Partnership for Development Foundation (2019)

This report was put together by Partnership for Development Foundation, with inputs and contributions from project partners from Albania, Montenegro and Italy.

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Table of Contents

1. INTRODUCTION ... 5
1.1. Background ... 5
1.2. Project objectives ... 6
1.3. The analysis of risks in involved project areas ... 7

2. ALBANIA ... 8
2.1. Introduction to Shkodra region ... 8
2.2. Flood Hazard Analysis ... 9
2.2.1. Geographical description ... 9
2.2.2. Water basins affecting Shkodra region ... 10
2.2.3. Overall climatic conditions and trends in Albania ... 11
2.2.4. Climatic conditions and trends for Shkodra region ... 14
2.2.5. Probabilities of flood occurrence and dimensional analysis ... 17
2.2.6. Main causes of flood hazard in Shkodra region ... 19
2.3. Vulnerability analysis ... 22
2.3.1. Experienced impact of recent flooding ... 22
2.3.2. Estimation of food risk in the region ... 27
2.4. Annexes ... 31

3. MONTENEGRO ... 36
3.1. Risk identification ... 36
3.1.1. Water area of Montenegro ... 37
3.1.2. Rivers in Montenegro ... 38
3.1.3. Flood Risk Management in Montenegro ... 41
3.2. Adriatic basin ... 46
3.2.1. Areas endangered by floods ... 47
3.2.2. Characteristics of floods in Montenegro ... 49
3.2.3. Land areas endangered by excess water ... 50
3.2.4. Possible future floods and planned flood protection activities ... 50
3.2.5. Long-term development perspective ... 52

4. ITALIA ... 54
4.1. Introduction ... 54
4.2. The Study Area ... 56
4.3. Main results of the analysis ... 58

5. BIBLIOGRAPHY ... 64

List of figures and tables

Figure 1. Location mapping and key figures about Shkodra region 8
Figure 2. Drin-Buna river basin, Shkoder....9
Figure 3. The Shkodra Lake Basin 10
Figure 4. The Drini River Basin....10
Figure 5. Annual Mean Temperature during the period 1961-1990 (in˚C)....12
Figure 6. Distribution of Annual Mean Precipitation during 1961-90 (mm) 12
Figure 7. Annual air temperature anomaly 14
Figure 8. Number of days with more than 110mm and maximum values 15
Figure 9. Map of wetlands and coasts of Albania with high flooding risks 17
Figure 10. Map of coastal and inland flood risk zones in Albania 17
Figure 11. Flood images in Shkodra history....18
Figure 12. View of flood situation in Shkodra region (December 6th, 2010) 20
Figure 13. Views of a flood risk area: mosque in Shkodra at three different stages....20
Figure 14. Calendar of main crop cultivated in Shkodra region 24
Figure 15. Map of protected areas in Shkodra plains affected by floods....31
Figure 16. Comparison of water extent between April 2009 and 9th January 2010....32
Figure 17. Flood extent and moist area on 11th January 2010 33
Figure 18. Competition between water extent between November 2001 and January 2010....34
Figure 19. Flood extent on 6th December 2010....35
Figure 20. Cartographic representation of the sub-basin areas in the water area of the Danube and Adriatic basins....38
Figure 21. geographic overview of the APSFR in the Drin/Buna River basin....40
Figure 22. Example of brief presentations of risk areas in Montenegro 44
Figure 23. Map of flooded area in the study reagion....58
Figure 24. Elements at risk in flooding areas for the four hazard scenarios of combined model. 60
Figure 25. Risk curve: Expected losses plotted against the related exceedance probabilities. 62

Table 1. Height quotas, inflows and discharge outflows for the three hydropower reservoirs established on the cascade of Drini River at 09:00, on 06.12.2010....21
Table 2. The flooded area and evacuated persons according to affected LGUs 22
Table 3. Number of families affected by damages and losses 23
Table 4. Affected families in most flooded areas 23
Table 5. Damages and losses in main agriculture crops 24
Table 6. Estimated value of damages and losses in main agriculture crops (in '000 USD)....25
Table 7. Damages and losses in main farm assets....25
Table 8. Estimated value of damages and losses in main farms assets (in '000 USD)....26
Table 9. Total value of estimated flood damages (in thousand USD) 26
Table 10. Assets at risk - regional overview (referred to the flood event in Dec. 2010) 27
Table 11. Rivers and their characteristics in the Drin/Drim – Buna/Bojana River Basin 42
Table 12. Main cities and villages along the rivers in the Drin/Drim-Buna/Bojana River Basin 42
Table 13. Overview of areas endangered by floods in Montenegro 48
Table 14. Land areas endangered by excess water 50
Table 15. Amount and economic value of exposed assets and overall consequences, for each element at risk category and flooding scenario, considering only the effect of storm surge. 61
Table 16. Amount and economic value of exposed assets and overall consequences, for each element at risk category and flooding scenario, considering the combined effect of storm surge and rainfall. 61

1. INTRODUCTION

1.1. Background

The Adriatic-Ionian Region area has a long history of vulnerability to disasters caused by natural and technological hazards, many of which transcend borders and exceed the management capacities of individual countries. Due to their high levels of vulnerability and the relatively small size of the countries in the Adriatic-Ionian Region, all national administrations would benefit from closer regional cooperation in disaster risk reduction, both technologically and organisationally. The cross border cooperation of 3 WATCH OUT partnership allows to share experiences and know-how and to exploit them in the implementation of the project's actions. The goal of the project is to implement a good practice example where the civil protection and mutual rescue shall hold a key position in the sustainable development of the involved Countries. The cooperation between involved Programme areas, directly represented by regional institutions, and with the involvement of different beneficiaries during the project implementation, such as volunteers, workers, stakeholders and so on, shall promote networking and collaboration among PPs, as well as exchange of information, experiences, acquired knowledge and best practices in the field of preparedness, prevention and response to risks and disasters. 3 WATCH OUT proposal enables not only to favour an active connections among all PPs, with the drafting of a trilateral model about civil protection, but also among other stakeholders involved in the protection processes, enhancing their experiences during workshops and exercises.

The main project result is the development of a joint and cross border strategy for risk prevention and reduction, in order to create conditions for establishment of the civil protection modules in accordance with EU standards in three Countries involved. It is linked to Programme results indicator, as it concerns the development of plans and integrated initiatives in the fields of coastal and inland environmental risks prevention and biodiversity safeguard. In particular, 3 WATCH OUT aims to: - share know-how about environmental management using as common WEB platform, that is interoperable with local and national bodies in the field of civil and environmental protection; - reduce the fragmentation in techniques, procedures and methodologies for environmental protection and safeguard, also in case of emergency and assistance among Countries; - increase the knowledge of using innovative techniques applied to environmental protection, with exchange of know-how and best practices.

The project is in line with the Community Civil Protection Mechanism, intended to facilitate reinforced cooperation in civil protection assistance interventions, including situations with an imminent threat of major emergencies. Moreover, the project is coherent with EU policies about environmental protection: Convention on Biological Diversity, the UNESCO Convention Concerning the Protection of the World Cultural and Natural Heritage, the Paris Declaration on Climate Change, the EU Strategy for sustainable development, and EUROPE 2020 A strategy for smart, sustainable and inclusive growth. At national and regional level the project complies to the following policies about civil protection and risk reduction: the Albanian National Strategy for Disaster Risk Reduction and Civil Protection 2014-2018 and the Action Plan of Region of Lezha; the Montenegrin National

Strategy for Emergency Situation; the Italian Law n. 60 of 2017 and the Regional Resolutions n. 255/2005 and 2181/2013.

1.2. Project objectives

Project objectives are as follows;

- Increase the protection of water landscapes through specific actions involving naturalistic interventions and with innovative techniques. Project actions want to test experimental model for the territory's hydrogeological safeguarding through the employment of bioengineering techniques adapted accordingly to the coastal Mediterranean context and oriented towards qualification and protection of the biodiversity. Moreover it wants to test techniques and networks for monitoring the environment and risks in the Programme area based on innovative protocols that interface with a WEB platform for data management and sharing. These instruments can facilitate assessments on monitoring models and intervention models for geographical risks management.
- Favour cross border cooperation and interoperability in the field of civil protection and risk prevention/reduction. A set of policy recommendations to deal with risk prevention and reduction in a sustainable way will be done during the project, as to encourage a cross-border interoperability plan for an efficient land and common risks management. Through the implementation of some specific project actions aimed at reducing, assessing and monitoring risks, PPs will realise some guidelines, that are a sort of recommendations based on the analysis of current and future practices to deal with different kind of risk (seismic, fire and hydrogeological). These instruments address at EU, national, regional and local levels and are the basis for the trilateral agreement about assistance among involving Countries in case of emergency. Moreover, the project aims to gather and disseminate the information related to risk prevention actions, through the exchange of best practices and experiences in the field of risk management capacities and through workshops and exercises modules based on a common methodology.
- Strengthen the civil protection culture, as an instrument for safeguarding individuals and the community. Highlight the importance of risks prevention with the promotion of public awareness and education on safety for civil protection represents the added value for the dissemination of project results. A good communication strategy aims to create awareness about the activities performed and the achieved results, obtain useful inputs and feedback from external experts and civil protection operators and organisations, while also fostering the implementation of the developed methodologies. For its strict relation with local communities and for the evident need of involving different organisations to be successful, project's dissemination need to be planned accurately in order to involve, create and reinforce the network of all relevant territorial actors, including citizens, and also to lay strong basis for a continuation and enlargement of the project after it closure.

1.3. The analysis of risks in involved project areas

In natural sciences, risk is function of the probability of occurrence of a hazard scenario and the related consequences that are expected on the exposed elements at risk. It is considered as a "human-centred concept that is applied when human or things that human value were adversely impacted". So, assessing exposed elements and their vulnerability are essential to risk analysis. However, the variety of potential exposed elements and their different characteristics (buildings, roads, people, etc.) leads to a complex and multi-level analysis. For the analysis of such dynamic topic as vulnerability, truly interdisciplinary research is necessary. In addition, different datasets of elements must to be taken into account (e.g. building structure and materials, number of inhabitants, infrastructures uses, traffic volume, among several others) to estimate direct and indirect costs within the quantitative risk analysis. As base of a complete risk assessment the location and number of exposed people, with a lower degree of uncertainty, is mandatory and demands a harmonization between the resolution of the hazard and detailed population data distribution. The assessment of risk consists of the combination of the probability of an event and its negative consequences. The level of risk is related to two different topics: (1) the hazard, that is the probability, frequency, intensity, warning and likely impact, and (2)the vulnerabilities and capacities of the affected people and communities. The risk assessment should contribute to an understanding of the range, impact and relative importance of all the major hazards affecting the population; how the community prioritises the risks it faces; the groups most likely to be severely affected and why. The following analysis is done in three Countries involved, selecting some specific areas affected by risks, mainly coastal or water landscapes.

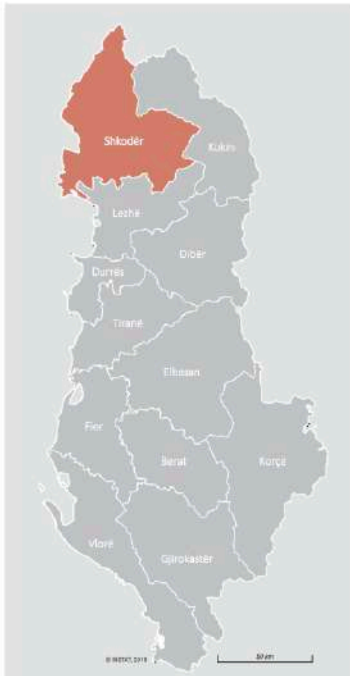
2. ALBANIA

2.1. Introduction to Shkodra region

Shkodra Region is situated in north-western Albania, about 120 km far from the capital (Tirana), and is 3,561.25 km2 in size or about twelve per cent of the 28,748 km2 of the surface area of the region. Its topography is very varied, ranging from the lowlands of the Adriatic coastline up to the Albanian Alps, with the third highest peak in the country of Radohima at 2,570 meters. The mountains are spectacular, while the lowlands, particularly around Lake Shkodra provide vast tracts of fertile land for agriculture. The region has both land and lake national border, 172 and 38 km in length, respectively, with Montenegro.

Figure 1. Location mapping and key figures about Shkodra region

Population	206,459
No. Municipalities	5
No. Administrative Units	33
No. Settlements	277
Largest settlement	Shkodra
Net internal migration	-1,288
Pupils	31,242
Employed persons (Administrative data)	74,589
Unemployment rate (%)	9.0%
Average bruto income (lek) (Average monthly payment in public sector)	55,690
Average expenditures per month (lek) (HBS 2017)	75,503
Regional PBB per capita (thousand lek)	384
No_Enterprises	11603
Entry of foreign citizens	968,914
Exit of Albanian citizens	659,225
Cars per pasenger (per 1,000 inhabitants)	191
Average useful floor space of the dwelling (m2) (HBS 2017)	88.5
Communal waste generated (kg per capita)	485
Dwellings (HBS 2017)	52,602



Source: INSTAT, 2018

Shkodra Region had about 7.2% of Albania's total population in 2017 (INSTAT). This population is spread over 5 municipalities out of 61 in the country. The region experienced a decrease from net domestic migration to -1,288 people, which is ranked third in the country after Vlora and Lezha. The average age of deaths was 75.2 years. The number of pupils attending primary-lower secondary and upper secondary education represents 7.1% of total number of pupils of Albania. The number of employed persons in the Shkodra region was 6.8% compared to the total employed persons in Albania, while the unemployment rate was 9%, remaining at average country level. According to INSTAT (2018) the average monthly income (average monthly gross wage in the public sector) were 55,690 ALL, while the average monthly consumption expenditures referred to the Household Budget Survey 2016 were 75,530 ALL per household. Shkodra contributed with 5.4% of GDP in Albania for 2016, contributing in real terms to 2015 by 0.21%, while GDP per capita was lower than the country-wide average of 384 thousand ALL. The number of enterprises in this region amounted to 11,603 or 7.1% of all enterprises in the country. Generated municipal waste was 485 kg per inhabitant. (INSTAT, 2018).

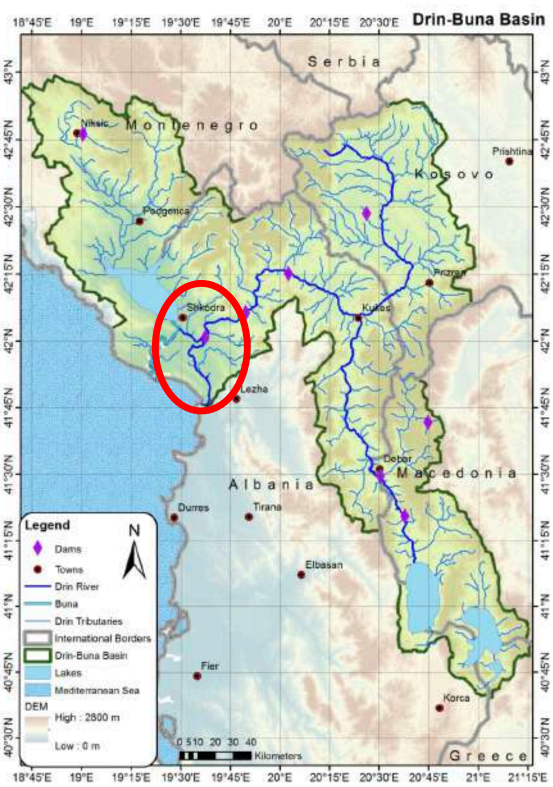
2.2. Flood Hazard Analysis

2.2.1. Geographical description

The Albanian hydrographic territory has a surface of about 44,000 km2, that is about 57% more than the overall country surface. The average perennial total inflow of all the Albanian rivers is about 1245 m3/s which turns the country into a vulnerable area affected by continuous inundation where Shkodra is the most affected region. According to statistics (figure 1), flood occurrences in the last twenty years report more than 40% of the natural disasters in our country.

The study area of Shkodra region which has the highest flood risk (surrounded with the red line in this map) is the Drin-Buna Lowland. This area is part of the extended trans-boundary Drin with the riparian countries of Albania, Kosovo, Macedonia and Montenegro. The total catchment area of the basin is approximately 20,380 km^2 (LWI, 2014) and it includes the Black Drin, White Drin and Buna River, as well as the Shkodra, Ohrid and Prespa lakes. The Black Drin originates from Lake Ohrid and flows up north crossing the border between Macedonia and Albania. The White Drin rises in Kosovo. The two streams flow into the Fierze reservoir. From there the Drin River passes the dam cascade of the three reservoirs Fierze (73 km^2), Koman (12 km^2) and Vau Dejes (25 km^2) operated by the Albanian Power Corporation. The dams have been constructed till 1975 (lowest dam Vau Dejës), till 1978 (highest dam Fierze) and till 1985 (Koman) (LWI, 2014). Hydropower production in the Drin River is highly important to Albania producing about 90% of the country's electricity. Further downstream the Drin joins the outlet of Shkodra Lake, the Buna River and losses its name.

Figure 2. Drin-Buna river basin, Shkoder



Source: GIZ, 2013

The area is characterized by the coastal floodplain of the rivers Drin and Buna, the surrounding mountains - foothills of the Albanian Alps - with heights up to more than 1,700 m (Mali i Cukalit, east of Shkodra) and Shkodra Lake, a large inland lake which is shared between the two countries Albania and Montenegro. Buna River at the south end of the lake is the only outflow discharging to the Adriatic Sea after joining with Drin River close to the city of Shkodra. Floods are frequent during the November-March period, when the region receives about 80-85 percent of its annual precipitation (Bogdani, 2006). This potential risk area in the Shkodër region is highest amongst the areas of Ana e Malit, Bërdicë, Bushat, Dajç, Gur i Zi, Rrethina, Shkodra and Velipojë.

2.2.2. Water basins affecting Shkodra region

Shkodra Region has abundant water resources[1] as it is supplied through two large water basins: (i) the Shkodra Lake basin, and (ii) the Drin basin, which includes the Drin River and the Buna River. Both basins discharge their water through the Shkodra lowlands either to the Shkodra Lake of to the sea.

Figure 3. The Shkodra Lake Basin

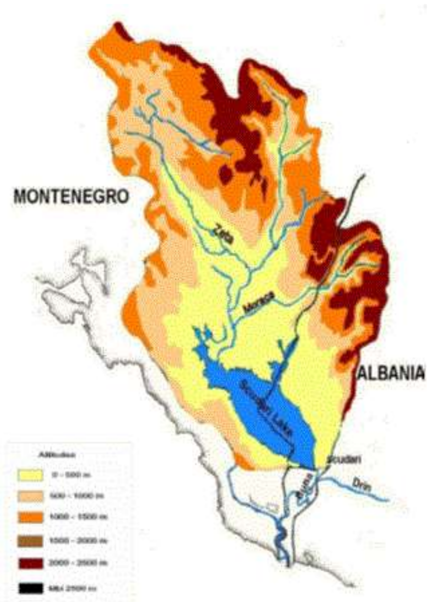
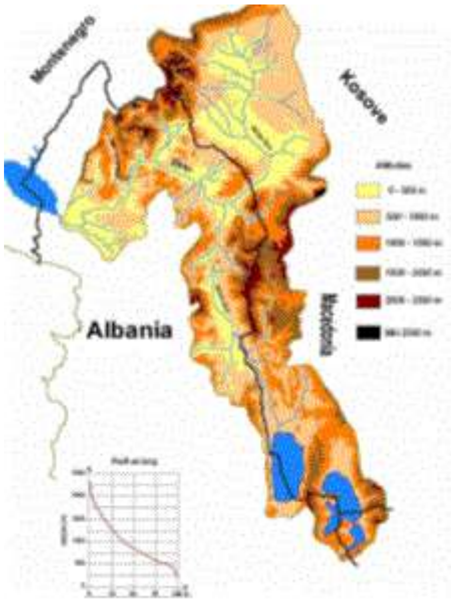


Figure 4. The Drini River Basin



Source: Water Resources in Albania. Hydro-meteorological Institute. 2009

The Shkodra Lake is about 368 km^2 in size and lies about 5 m above the sea level. This lake is fed by: the Dried River (Prroi i Thate), the Vraka River, the Rrjolli River, the Moraca River and the underground resource of Shegani River. The Lake's coast length is 150 km. The western coasts are rocky with a gradual lowering on the northeastern side. The basin is situated on carstic rocks: the rainfall quantity is about 2170 mm and their flow speed is about 355 m^3/sec. Shkoder Lake falls into the category of open lakes. It drains into the Adriatic Sea at the Bojana River with an average discharge of 332 m^3 per second resulting in a total water volume exchange occurring 2-2.5 times per year.

The typical geographic coordinates of the lake change to some extent during the year, depending on the water level and the lake's surface under different water level regimes. The water level of Shkoder Lake varies widely, with a height varying between 4.97-9.84 meters, due to the discharge capacities of the Buna River, and the surface varies between a minimum water level of 368 km^2, and a maximum of 542 km^2. The lake's surface under the mean water level of 6.59 meters is 475 km^2. In

[1] Adapted mainly from: "Shkodra Region SWOT Analysis. TEULEDA and Foundation for Local Autonomy and Governance (FLAG). 2008

the total inflow of water into the lake, the Moraca River is the most significant tributary. Its watershed area is estimated at 3,200 km^2, and the river brings 200 m^3 per second on average into the lake. The estimated outflow of Shkodra Lake is about 330 m^3 per second.

The hydrographic catchment of the Drini basin has a total area of 19,582 km^2 from which 14,173 km^2 belong to the Drini itself and 5,187 km^2 to the Buna river. The River Drin, which is 285 km in length, is the longest river in Albania. It is formed by two main tributaries: the Drini i Zi, with a catchment area of 5,885 km^2, flowing from FYROM, and the Drini i Bardhe, flowing from Yugoslavia. The Drini is the most important river in Albania, with the following characteristics: an annual discharge volume: 11,1 km^3, specific discharge: 24.8 $l/s.km^2$, one in 10 year high flow (about 13 times the river module).

The River Drin has three long and narrow artificial lakes distributed along its length created by the construction of dams in the 1970s and 80s. The one closest to Shkodra city is Lake Vau i Dejës. The second in the chain of lakes is Lake Koman and finally Lake Fierza, which lies outside of Shkodra County, in Kukës. Lake Vau i Dejës has a surface area of 24.7 km2 and lies 74 m above sea level. Lake Fierza is the largest artificial lake in Albania. It is 72 km2 in size and lies 295 m above sea level. This cascade of dams is extremely important for the Albanian economy as they produce 90 per cent of the country's electricity (installed power: Vau i Dejës, 260 MW; Koman, 600 MW; Fierza, 500 MW).

The River Buna drains Lake Shkodra, is 44 km in length, and slopes down to the Adriatic Sea with an average gradient of 0.11 metres per kilometre. The average flow of water as it leaves the lake is 300 m3 per second, while when it meets the River Drin the rate rises to 680 m3 per second, the third highest such figure in the northern Mediterranean. The river is still navigable in the lower reaches, but less than a century ago vessels were able to enter right into the heart of the city of Shkodra. The Buna has gradually silted up as a result of a major flood in 1858 that caused the Drin to breach through.

Based on various scholars, the chemical analyses of water samples taken from the Drini River have shown good quality water, with stable mineral composition along the river course. Metallic ions are present in small amounts except for iron in some cases. It appears that no restriction for the present uses (hydropower, irrigation) could arise from the water quality in the Drini River. A more difficult situation arises from the quality of the Kiri River water, affected and possibly contaminating the local groundwater resources also. Its effects on the lake of Shkodra have not been clearly assessed. The littoral zone of the Shkodra lake receive direct impact by the population living along the shoreline (many of which are illegal constructions, partly tourism purposes), the multiple disposal of solid waste and discharge of sewage.

2.2.3. Overall climatic conditions and trends in Albania

The climate of Albania is characterized by mild winters with abundant rainfall and hot, dry summers[2]. Depending on the season and region, Albania's climate is influenced by Mediterranean and Continental weather systems, which interact with the mountainous region across the north and east of the country to cause significant variations in temperature and rainfall.

Figure 5. Annual Mean Temperature during the period 1961-1990 (in° C)

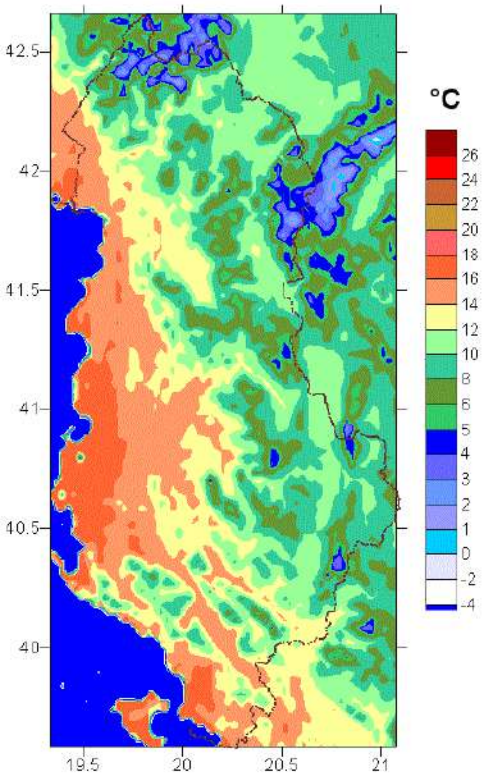
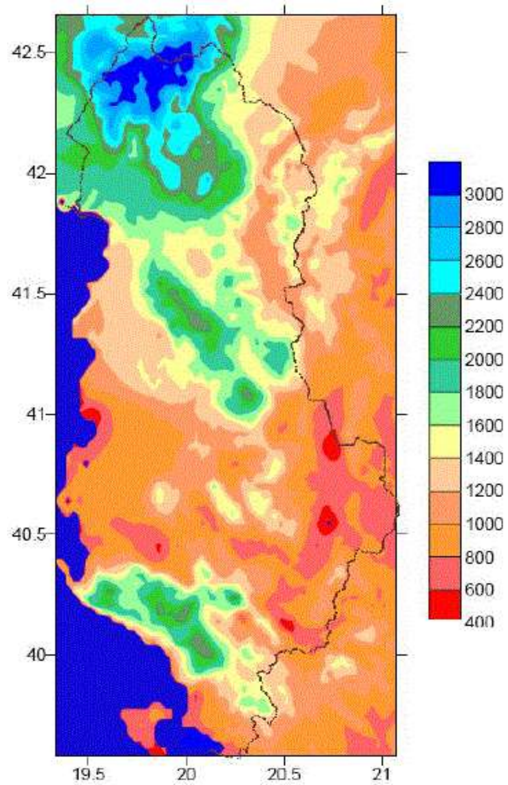


Figure 6. Distribution of Annual Mean Precipitation during 1961-90 (mm)



Source: Bruci, E. 2008 (in World Bank. 2009).

The influence of the mountainous zone in the east and north of the country is clearly apparent, with mean temperatures in this area ranging from 4-12°C (with temperatures going down to ranging from 1-10 °C in northern mountain areas of Shkodra region and eastern mountain areas of Dibra region), whilst the coastal plain with the influence of lower elevation and the proximity of the Adriatic and Ionian seas has mean temperatures ranging from 12-18°C.[3]

There is a significant north-south divide for mean annual precipitation with a clear lower rainfall band running east-west across the central and southern areas of the country, except the coastal south-west. Precipitation in this low rainfall band generally ranges from 600 to 1,000 mm. In contrast, the mountainous region in the north of the country has extremely high precipitation with averages up to 3,000 mm, especially the Shkodra region, ranging from about 1,750 mm in its plain areas up to about 3,000 mm in its northern highly mountainous areas. The majority of precipitation occurs during the cold autumn and winter months with approximately 70% of precipitation

[2] Bruci, E. 2008. Climate Variability and Trends in Albania, University of Polytechnics – Institute for Energy, Water and Environment, Tirana

[3] World Bank. 2009. Climate Change and Agriculture Albania Country Note (Draft for Discussion).

occurring from October through March[4]. The summer months are generally very dry with the lowest precipitation totals occurring in July and August.[5]The analysis of the climate trends from historic data is an important step in identifying the current and potential future impacts of climate change on communities The identification of the most important changes that have occurred in the past which could be used as leading indicators to highlight regions and communities that have been disproportionately affected by climate change and that may be at risk of being further affected in the future, hence increasing their vulnerability. Various analyses on general climate trends (for the whole territory of Albania) [6] from historic data indicate that there is clear evidence of climate variability. Although there is significant inter-annual variability, the temperature has increased by approximately 0.3°C on average across Albania, whilst precipitation decreased by 114mm during this time.

On a seasonal basis over the same time period, spring and summer temperatures have demonstrated the clearest increasing temperature trend, whilst winter and spring rainfall display the clearest decreasing precipitation trend on a national basis, although there are significant spatial differences for spring rainfall[7]. In addition, extreme events such as heavy rains, floods and drought are not rare phenomena for the area, and are part of this variability. According to the available analysis (IPCC, 2007 and Bruci 2008) the findings of this coarse resolution data are in broad agreement with actual data recorded on the ground in Albania. A Bruci's study (2008) that assessed the historic climate data of Albania made the following additional observations about climate trends for a number of weather station sites across the country:[8]

- Since the mid 1980's average temperatures have increased across the vast majority of the country. The number of days with the temperature above 35°C shows an increasing trend. Since the early 1980's it appears that such events are occurring every year rather than every second or third year. The number of days with the temperature less than -5°C has shown a decreasing trend since the early to mid-1980's;
- Measurement of runoff (in-stream hydrograph), both at an annual and seasonal temporal scale indicate a decreasing trend. This trend is most evident during the dry summer months, although the wet winter period also displays a decreasing trend. On an annual basis, all 18 measurement sites show a decreasing trend, with 10 sites showing statistical significance. No distinct trend is observed for the maximum amount of rainfall in a 24-hours period;
- Due to the lack of reliable drought indices, a proxy indicator for drought is the number and size of forest fires. Across Albania over the last three decades the number of forest fires and affected areas has increased, with a considerable increase in forest fire risk occurring since 1992;

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[4] Ibid (Bruci, E. 2008. In World Bank. 2009. Climate Change and Agriculture Albania Country Note (Draft for Discussion)

[5] Ibid (World Bank. 2009)

[6] Bruci, E. 2008. Expected changes of climate and some likely Impacts in Albania. South-Eastern Europe Climate Outlook Forum (SEECOF-1). June 2008, Zagreb, Croatia

[7] www.climatewiz.org (in World Bank. 2009)

[8] World Bank. 2009. Climate Change and Agriculture Albania Country Note (Draft for Discussion)

- A sea level rise of 48-61 cm would result in direct flooding of coastal area. Due to the increasing of the sea level, flooding will be intensified both directly by the sea and indirectly by changes in water tables.

2.2.4. Climatic conditions and trends for Shkodra region

As presented above, Shkodra region is influenced by its two main climatic zones: (i) the northern high mountainous and Alps areas, under the influence Continental weather system with lowest temperatures and highest precipitations in the country; and (ii) the plain/lowland areas, under the influence of the Mediterranean weather system, which highly interacts with the Continental weather system of the mountainous and Alps areas, causing significant variations in temperature and rainfall in the plain/lowland areas of the Shkodra region.

The annual potential of the sun radiation is 2054 kw/m^2, which is considered as a high amount, with a high importance as an ecologic factor for the area. The annual average number of sunny days on the lake is 116.4, while of the cloudy days is 73 – 106. Wind activity, predominately from east and south-east, is determined by cyclonic factors of the Mediterranean and Balkan, but also by the local factors. There are 15 types of winds, which are known on the Shkodra lake basin, of which Murlan and Shirok are the most important.

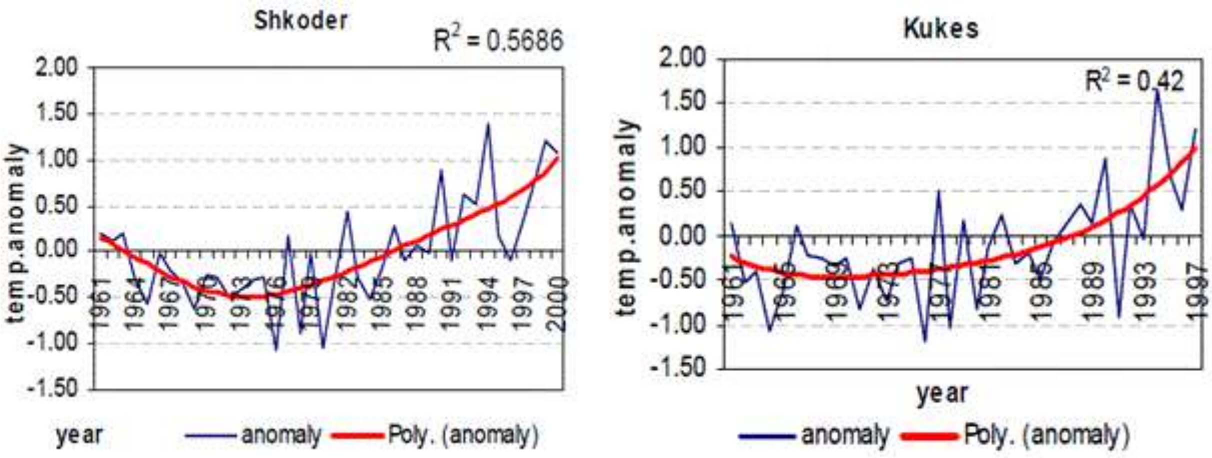
The temperature of the air varies significantly between the lowland and highland and Alps. The highest average temperature is usually recorded in August (21.4ºC – 27.5ºC) and the lowest average in January (0.5ºC – 6.5ºC). The highest values of air humidity are recorded in November (77%), while the lowest in July (55%). The maximum air temperature varies from 35°C to 40.0°C in entire zone.

The number of days with the air temperature exceeds the threshold 35°C is calculated for each year. The temperature over this threshold influences in the quality of human life as well as in the agriculture and other economy branches. Taking into consideration the threshold >35°C for the entire zone is found out that the bigger number of such days are observed in the low altitude (up to 9 days/year) and the lower one in the high altitude (1days/year).

It is obvious that the number of days with temperature > 35°C is more frequently during the last two decades. As far minimum temperatures, the absolute value varies from –10°C in the low part up to –24°C in the mountain one. The number of days with minimum temperature ≤-5°C is very low in the lowland, on contrary in high altitude the number of days ≤-5°C is higher, up to 20 days/year. In last decade a lower number with such temperature is observed.[9]

Figure 7. Annual air temperature anomaly

[9] Muçaj L, Mustaqi V, Bruci E. 2010. Meteorological Extreme events and their Evaluation Based on Climate Change Scenario Institute for Energy, Water and Environment, Tirana, Albania (in BALWOIS 2010 - Ohrid, Republic of Macedonia - 25, 29 May 2010)



Source: Bruci, E. 2008.

The average of the annual rainfall on the lake is between 1,750 mm and 2,500 mm, but within the Shkodra Lake basin and some areas nearer to the high mountains and Alps receive over 3,000 mm. The lowest rainfall is recorded in July (about 42 mm) and the highest in November (about 274 mm)[10]. By precipitation anomaly there are two different periods: the period 1951 – 1980 when predominate positive anomaly and period 1980 – 2008 when predominates negative anomaly. However, since 2000, the precipitation trend has started to increase up to the normal value. It is clear that the region is characterized by climate variability.

Extreme events such as heavy rains and drought are not rare phenomena for the main watershed basin of the region (Drini Basin). In general, the whole Shkodra region is characterized by heavy rainfall. According to to Radinović (1997)[11] in climatological practices, the maximum 24 hours precipitation with a return period once in 10 years is considered as a threshold for heavy rain estimation. Some of such heavy rains (most of which caused flooding in the Shkodra plains) with more than 300mm precipitation/day, have happened in Shkodra region in several cases (1946, 1963, 1969, 1970, 1995, 2002, 2009 and 2010). The figure below presents the number of days with more than 110mm precipitation within 24 hours in Shkodra region during 1951-2006.[12]

Figure 8. Number of days with more than 110mm and maximum values

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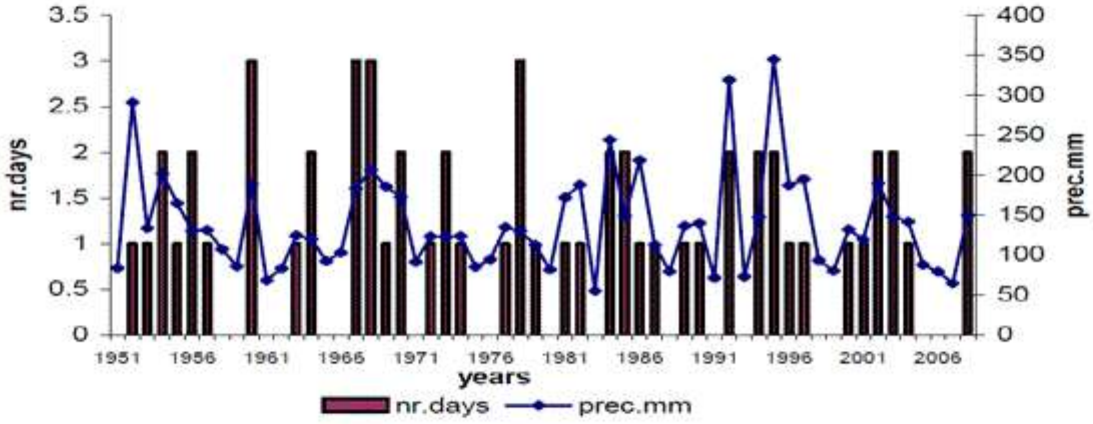
[10] Based on "Shkodra County SWOT analysis" (Foundation of Local Autonomy and Governance. 2009).

[11] Radinović, D. (1997): The basic concept of the Methodologies of Mediterranean Cyclones and Adverse weather Phenomena Studies. International symposium on cyclones and hazardous weather in Mediterranean. Palma de Mallorca (45-53) 1997

[12] Muçaj L, Mustaqi V, Bruci E. 2010. Meteorological Extreme events and their Evaluation Based on Climate Change Scenario Institute for Energy, Water and Environment, Tirana, Albania (in BALWOIS 2010 - Ohrid, Republic of Macedonia - 25, 29 May 2010)



Source: Muçaj L, Mustaqi V, Bruci E. 2010

According to recent studies (Mucaj et al. 2010) that period 1981-1990 has the maximum cases with drought in Shkodra and Lezha regions follow by the last period 2001-2008 and that the cases with drought have the increase tendency in the last decades. The same study identifies almost 16 years with extreme dry (years 1952, 1953, 1955, 1956, 1958, 1969, 1975, 1982, 2985, 1986, 1989, 1990, 1992, 2000, 2003 and 2007).

According to the climatic trends analysis and projection scenario for the future (developed by Muçaj et al. 2010)[13] for the main watershed basin of Shkodra region (Drini basin), it is expected an increase of mean temperature for the winter months up to 0.8°C, 1.7°C, 3.4°C and for the summer months up to 1.3°C, 2.8°C, 5.6°C for the time horizons 2025, 2050, 2100 respectively. Concerning the amount of annual precipitation, the scenario proposes a decrease up to 3.0, 6.1, and 12.4 % for the time horizons 2025, 2050, 2100 respectively.

Taking into account these increases temperature, suggested from the above mentioned scenario, a decrease of number of frozen day may occur. Referring to the number of days <-5°C recording during the period 1951-2000, in the lowlands this number may be very low (less than one day/year), while in inner parts of the region less than 15 days. An increase of days with the maximum temperature >35°C related to the period 1951-2000 is expected to occur for different time horizons. Respectively for the time horizon 2025 is expected an increase of 3 days, for the time horizon 2050 is expected 6 days and 10 days for the time horizon 2100 is expected too.

Concerning the amount of annual precipitation, the above scenario proposes a decrease up to 3.0, 6.1, and 12.4 % for the time horizons 2025, 2050, 2100 respectively. It is expected an increase of about 1-2 days with intensive rainfall by 2025 time horizons related to 1951-2000, of about 2-3 days by 2050 time horizons, and of about 3-5 days by 2100 time horizons with these hazardous rainfalls.

Because of the good relation between drought event and precipitation an increasing of occurrence of severing drought is expected. Respectively by the time horizon 2025 an increasing of 2 cases per decade, by the time horizon 2050 an increasing of 5 cases per decade and by the time horizon 2100 an increasing of 9 cases per decade is expected.

[13] Ibid (Muçaj L, Mustaqi V, Bruci E. 2010)

2.2.5. Probabilities of flood occurrence and dimensional analysis

According to the Disaster Inventory System (DesInventar[14]), which has an inventory of almost 4000 events from 1851 – 2013 in Albania, more than 95% of the communes have been affected by at least one flood event. Albania experienced major floods in 1962-63, 1970-171, 2003, 2005, 2009, 2010, 2013 and most recently in February 2015. EM-DAT shows that, during 1974-2006, floods accounted for the major share of disaster events (about 32%), followed by earthquakes (about 18%). Occurrence of different hazards over the period 1974- 2006 in the country shows that 62% are hydro-meteorological hazards: flood- and drought-related events[15]. Floods and flash floods account for 20% of the total events. The Districts with more floods and flash floods are Shkoder (160 events) and Lezhe (117 events) situated in the Northwest Albania. The most affected municipalities are Ana e Malit-Shkoder district (22 events), Velipoje, Shkoder district and Balldren i Ri (Lezhe district) (18 events). Floods and flash floods biggest impact has been in the agricultural sector, damaging on average 7,000 hectares of land each year. The average hectares damaged per event is around 300 ha with a maximum of 20,000 ha for a single commune in a single event[16]

According to various sources, Shkodra region seems to be vulnerable to a number of natural disaster risks, but mainly earthquakes and floods. Floods in Shkodra region seem to be a natural phenomenon at the lower parts of the Drini basin and at the border areas of the Buna River. Flooding in the lower part of Drini and border areas of Buna rivers started to become more often and important especially after year 1851 when these two rivers joined together. Several chronicles (*Hahn, in late XIXth century; Theodor Ippen, referring to one of his trips to Kiri valley (Shkoder) in beginning of 20th century; Oliver Shmitt, referring to various Venedician documents; etc*.) speak about significant floods in the lowlands of Shkodra in years 1837, 1854, 1858-59, 1860, 1863, 1905, 1937, 1952, 1960, 1963. The one in 1858-59 and one in 1963 are considered to have been the largest floods in Shkodra and Lezha regions until early 90'ies.

Figure 9. Map of wetlands and coasts of Albania with high flooding risks

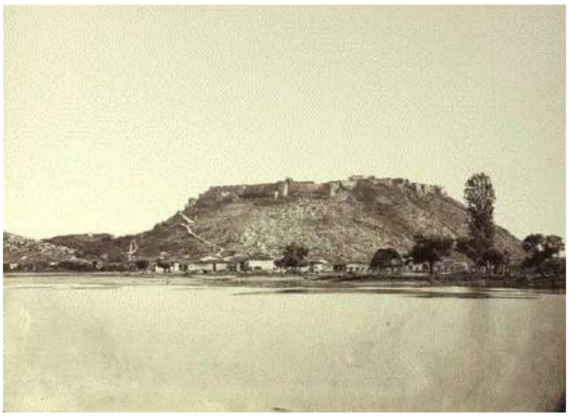
Figure 10. Map of coastal and inland flood risk zones in Albania

[14] http://www.desinventar.net/DesInventar/profiletab.jsp?countrycode=alb
[15] http://drace-project.org/index.php/map/albania
[16] Historical collection of Disaster Loss Data In Albania, by Toto, E, M. Massabo, 2014

Source: World Bank[17], ISDR, OCHA.2009 Source: U.S. Army Corps of Engineer.2006

Figure 11. Flood images in Shkodra history

Shkodra castle surrounded by floods, 1863 **A village of Shkodra flooded in 1963**



Source: www.wikipedia.org

During the communist system dikes were built along the major risky borders of Buna River, which reduced to a large extent the flood risk in the area. There have been some ten or more major floods since 1851: 1854, 1858, 1905, 1962-63, 1970-71, 1979, 1992-1994, 2003-2004, 2010 Jan and 2010 Nov-Dec. There is not much quantitative data for these floods, but some assessment can be made of the biggest historic flood in 1962-63 and the recent events in 2010. The countrywide floods of November 1962 – January 1963 are considered the largest (1 in 40-year (2.5%), where: (i) Drini and Buna rivers flooded the plains of Shkoder and Zadrima, 18,575 ha; and (ii) plains between rivers

[17] World Bank, ISDR, OCHA.2009. The Structure, Role and Mandate of Civil Protection in Disaster Risk Reduction for South Eastern Europe: South Eastern Europe Disaster Risk Mitigation and Adaptation Programme

Drini of Lezha and Mat, 3,122 ha. Also, a study on natural disasters from 2012 reported that flooding accounted for 40% of the natural disasters in the Shkodra region (Hysenaj, M., 2012).

2.2.6. Main causes of flood hazard in Shkodra region

The main causes of flood hazard in Shkodra region seem to be: urbanization (especially in the plain area), changing winter weather patterns, and the lack of proper maintenance of the hydrologic systems (such as insufficient maintenance of dikes in the borders of Buna river), changes in the frequency and importance of water flows and runoffs, difficulties in management of the water overflow in the three hydropower reservoirs (build before 90'ies in the Drini river) etc. As a result, floods have continued to be present in Shkodra region also after 90'ies and have led to floods that have caused significant economic damage to agriculture land, housing, etc. During this period certain lower areas of Shkodra (and Lezha) were flooded in winters of 1994, 1999, 2002 (about 5,400 hectares flooded), 2004 (about 3,800 hectares flooded), the two last flooding being the ones of late December 2009-January 2010 and November-December 2010.

During late December 2009 and early January 2010, due to the rainfall of recent days, accompanied with the melting of snow in the northern area of Albania, the Drini river flows increased very rapidly. Consequently, the levels of water in the three hydropower lakes of Fierza, Koman and Vau i Dejes which are built on this river increased too much, even though the maximum of water is used to produce electricity. In these conditions, in order to keep the level of water under control in the lakes, the relevant authorities were obliged to open the emergency gates of the dikes and release water from the lakes, reaching water runoff flow of up to about 2,450 m3/sec (as compared to a maximum usual capacity water runoff flow of about 800m3/sec). This water flow together with heavy rainfalls caused significant flooding on the lowland area of Shkodra region and some of the Lezha region. The authorities declared the natural disaster situation on 5 January 2010 for Shkodra and Lezha prefectures, and raging floodwaters forced the evacuation of thousands of people.

According to the figures reported by the Emergency Commission at Shkodra Prefecture on 8 January 2010, about 9,200 hectares of agriculture land were covered with floodwater and about 3,572 persons had been evacuated, of which, about 98% accommodated with their relatives. At the same period, the Red Cross reports about 2,200 affected families or about 8,800 persons affected.[18]

Due to the rainfall lasting four about 4 weeks (mid-November-mid December 2010) in the whole area of Shkodra Lake (covering partly Shkodra region and partly Montenegro) and Drini basins (covering northern part of Albania and parts of Kosovo and Macedonia), accompanied with the melting of snow especially in the Alps (in between Albania, Kosovo and Montenegro), the flows of water from the two main basins (Drini basin and the Shkodra lake basin) have highly increased. During the last 10 days of November and the beginning of December the level of water flows (both surface and ground water flows) in the Buna River had increased too much so caused high flooding especially in the Shkoder region. Although at a smaller extent compared to Shkodra region, heavy

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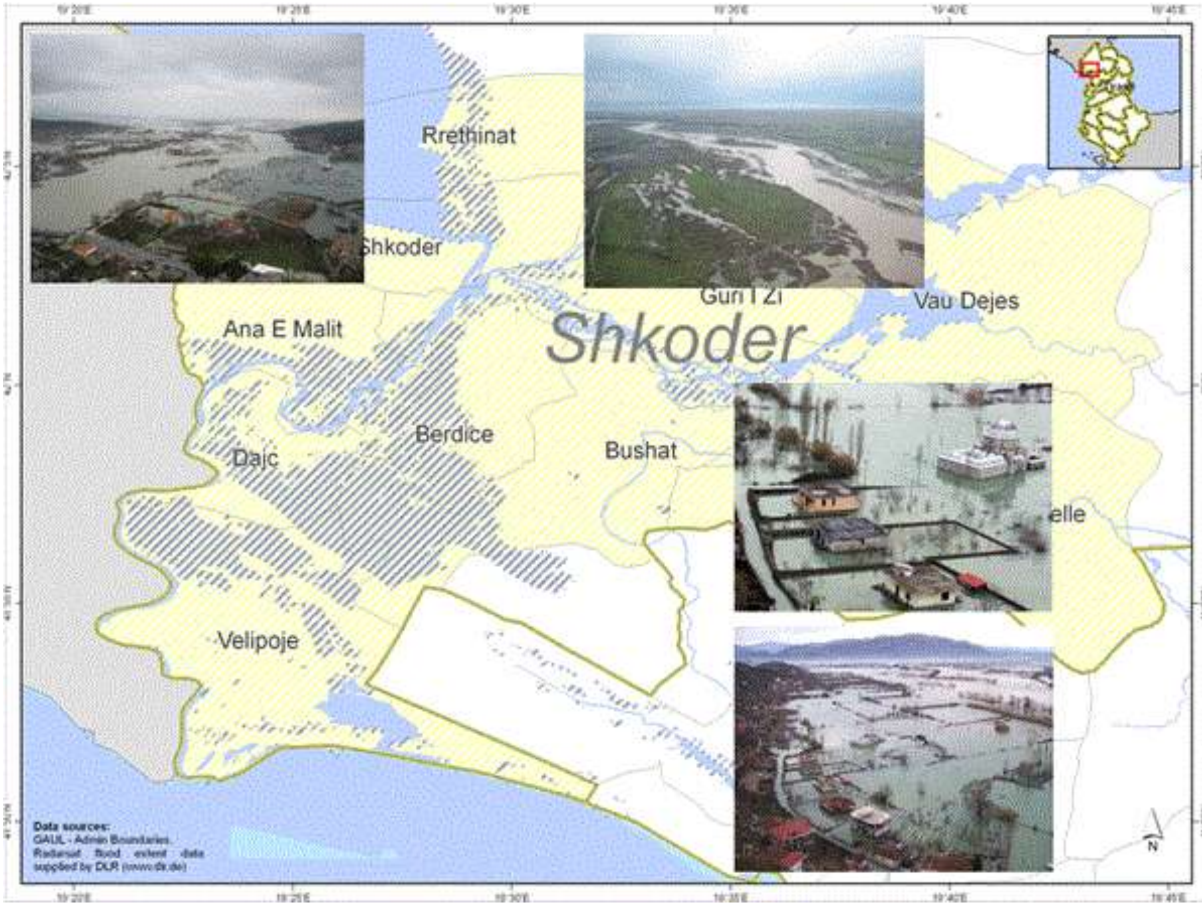
[18] Albanian Red Cross, 2010 Report

rains during this period caused also some flooding in few of the floodplains between Lezhe and the Adriatic Sea and in Durres region.

Figure 12. View of flood situation in Shkodra region (December 6th, 2010)



Source: MapAction and DLR (*www.dlr.de*) and our processing

The high flows into the Drini river had excessively increased the water levels in three connected dams near hydroelectric power plants (Fierza, Koman and Vau i Dejes). Consequently, in an effort to avoid damages of these dams, the authorities were obliged to open the emergency dam gates and release the extra water into the following Buna River, causing additional increase of the water level in this river, especially along the lowlands of Shkodra region. On December 6th, the three large dams in the north were releasing (discharging) water at average rates of about 1,500 cubic meters per second, while in normal situation the operative capacity of the last dam is 800 cubic meters per second, resulting in additional rapid increase of the flooding downstream.

Figure 13. Views of a flood risk area: mosque in Shkodra at three different stages


Table 1. Height quotas, inflows and discharge outflows for the three hydropower reservoirs established on the cascade of Drini River at 09:00, on 06.12.2010.

Hydroelectric Plants	Maximum Permitted Water height (m)	Actual water Height at (m)	Inflow of Water from The basin (m3/s)	Discharge Outflow (m3/s)
Fierzë Dam	296.00	291.54	1,092	1,092
Koman Dam	175.00	169.66	1,476	1,621
Vau I Dejes Dam	76.00	73.57	1,590	1,410

Source: General Directorate of Civil Emergencies, Ministry of Interior 2011.

In addition, the heavy rains increased the inflows into the Shkodra Lake from surface and ground waters of its basin (which is located in both Albanian and Montenegrin parts) the water level of Shkodra lace increased over its natural outflow capacity through the already overloaded Buna River to the Adriatic Sea. This situation resulted in additional flooding both in rural and urban areas of Shkodra. The area of Nënshkodrës was almost totally blocked by water on the Velipoja, Dajci, Oboti, Berdicës ana e Malit and Bushat. In addition, a large number of livestock was evacuated, but military forces and emergency teams using military vehicles and boats. The main road reaching Shkodra town from Tirana was flooded at the entrance of the city and the alternative road over hills is in use to reach the town.

As we can be shown from the 2010 flood example above, the severe flooding hazards in the area is the consequence of a combination of human and natural factors, leading to a crisis situation. These are as natural factors (including: (i) heavy and long lasting rainfalls in the winter season, often in combination with (ii) snowmelt in late winter / early spring causing overflow in the rivers of Buna, Drin, Kir and the lake of Shkodra) and/or as human factors (including: (i) the sudden release of huge amounts of water from the hydropower reservoirs and; (ii) the not properly working drainage system in the lowland.

In addition, the changes in the land ownership structure (farmland fragmentation) after the 1990's had led to serious damages in the irrigation and drainage schemes which are one of the components of the existing flood protection system. Due to the failure to maintain the systems especially the first and second level drainage channels are not functioning properly (e.g. channels are not cleaned or blocked by illegal building) - the drainage system is in a state of disrepair (Mott MacDonald, 2011). In the case of flood, the water may stay in the floodplain from only some hours up to several weeks. The first is the case if the inundation is caused by flash floods, when the flooding is generated by heavy rainfall concentrated in a small area. Then the runoff is very high but the water volume is comparing small. The latter occurs regularly from river flooding, especially during the winter and spring seasons, when the period of rainfall is longer or by snowmelt in the whole river basin. The water level of Lake Shkodra rises during flood season for up to 3 meters.

2.3. Vulnerability analysis

2.3.1. Experienced impact of recent flooding

This heavy rains of December 2010 followed by opening of the hydropower dams, highly overloaded both Drini river and Shkodra lake (all going down through Buna River to the same floodplain area of Shkodra), resulted on the 6th December 2010 with about 14,280 hectares of flooded land, about 2,580 flooded houses, about 4,610 house surrounded with waters. The situation in many plain areas became extremely problematic, with a water level going up in some of the places to 2 meters high.

Table 2. The flooded area and evacuated persons according to affected LGUs

Nr	Local Government Units	Flooded land (ha)	Persons evacuated	Flooded houses
1	Shkodër	830	2418	1800
2	Dajç	2900	2107	219
3	Ana Malit	1300	268	125
4	Velipojë	1600	350	6
5	Bërdicë	1850	3570	50
6	Guri Zi	1900	1300	140
7	Bushat	2900	2030	200
8	Qendër Koplik	100	-	-
9	Rrethina	500	102	40
10	V. Dejës + Hajmel	100	-	-
11	Kastrat	200	-	-
12	Gruemirë	100	-	-
	Total	14,280	12,145	2,580

Source: General Directorate of Civil Emergencies, Ministry of Interior. 2011.

About 12,145 persons were evacuated by military vehicles. of which, about 1,622 persons (or about 13% of total evacuated persons) were hosted in dormitories of various schools, hotels, university and various other public buildings, while the hosted by relatives and other families in non-flooded areas of Shkodra. The following table presents more in details the figures about flooded land and houses and the evaluated persons according to each of the affected local government unit in Shkodra region.

In order to provide necessary food for families (both evacuated and non-evacuated ones), fodder for livestock and other necessary things (i.e. cloths, beds, blankets, mattresses, etc.), at the beginning of December 2010, the government approved and made available an emergency fund of a total of about 600 million ALL (about 6 million USD) from the national budget. The fund was used by the Ministry of Interior to finance the most urgent requests coming from various local institutions in response to urgent needs of the affected persons during the emergency period. An additional financing of about 270 million ALL (about 2.7 million USD) was approved by the government to procure and provide to affected farms additional amounts fodder for the period January-March 2011.

Based on the data received from of the Regional Agriculture Directorate of Shkodra and our estimations, these floods caused damages and losses to about 7,656 families located in twelve communes of mostly of Shkodra district and few villages in Malesi e Madhe district. The largest number of affected families if found in Bushat (22%) Berdice and Dajc (with about 19% each) together with Ana e Malit and Guri i Zi (with about 13% each).

Table 3. Number of families affected by damages and losses

Nr.	Local government units affected	Number of families affected	Percentage of families affected
1	Shkoder	484	6.32
2	Bushat	1,684	22.00
3	Dajç	1,420	18.55
4	Velipojë	374	4.89
5	Bërdicë	1,451	18.95
6	Ana e Malit	1,023	13.36
7	Rrethina	160	2.09
8	Q. Koplik	40	0.52
9	Gur i Zi	964	12.59
10	Kastrat	8	0.10
11	Gruemirë	47	0.61
12	Vau Dejës	1	0.01
	Total	7,656	100.00

Source: Regional Agriculture Directorate of Degional Shkoder. 2011

The most heavily hit communes were the seven LGUs of Shkodra district (starting with Dajc with about 65% of total families, Ana e Malit and Berdice with 55-58% and then Bushat and Guri i Zi with about 27-28%, Velipje with about 17% and then Rrethina with about 3% of total families of the commune). Altogether, the total number of affected families in these seven LGUs represents about 92% of the total number of affected families in the region. About 46% of the total number of farms of these seven most hit communes were heavily affected by flood damages, while this share goes up to almost 80% in Dajc, about respectively about 73% and 67% in Ana e Malit and Berdice, with about one third of farms heavily affected in Bushat, Guri i Zi and Velipoje communes.

Table 4. Affected families in most flooded areas

	Local government units	Total number of families	Number of family farms	Number of flooded family farms	% of affected families/ total LGU families	% of affected families/total LGU family farms
1	Dajç	2170	1780	1,420	65.44	79.78
2	Ana Malit	1745	1522	1,023	58.62	67.21
3	Bërdicë	2593	1982	1,451	55.96	73.21
4	Bushat	5941	4996	1,684	28.35	33.71
5	Guri Zi	3448	2602	964	27.96	37.05
6	Velipojë	2238	1405	374	16.71	26.62
7	Rrethina	5745	3263	160	2.79	4.90

Source: Regional Agriculture Directorate of Shkoder. 2011

Out of a total of about 14,280 hectares of flooded agriculture land, heavy damages and/or losses of crops were caused to about 6,270 hectares cultivated with various field crops, to about 38,600 various fruit trees, olives and vineyards plants. A large number of ornamental crops (about 427 thousand) were heavy damaged or lost, especially in the Dajc area.

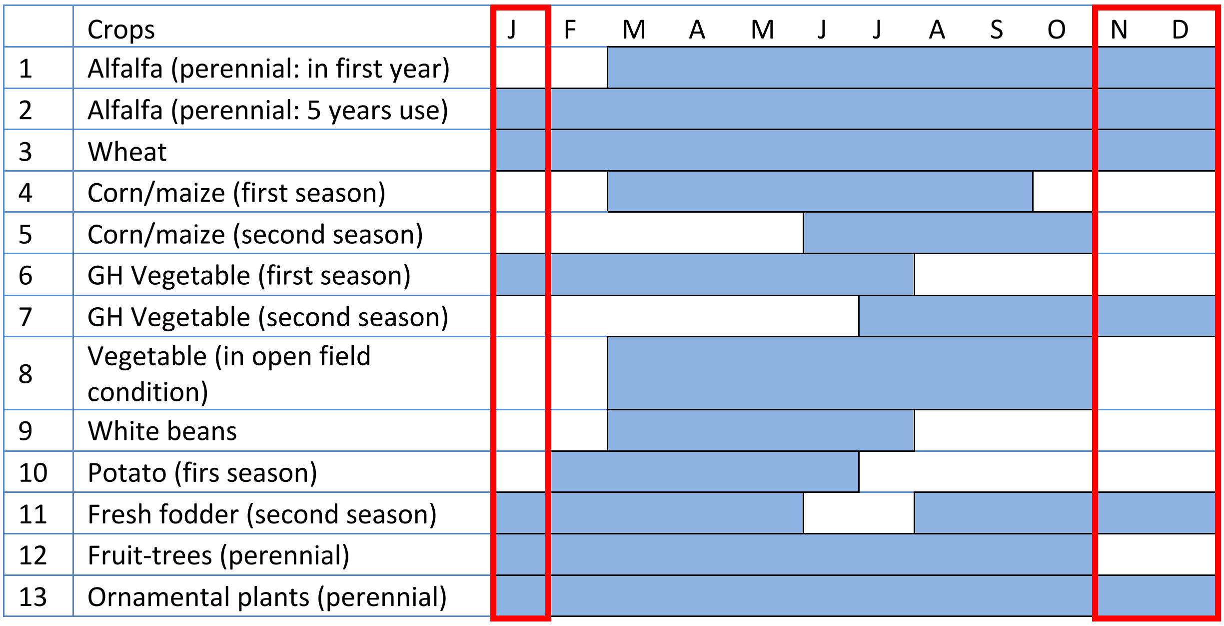
Table 5. Damages and losses in main agriculture crops

Nr.	Local government units affected	Field crops (ha)	Field crops (in %)	Fruit trees and, vineyards and olives (number)	Fruit trees and, vineyards and olives (in %)	Ornamental plants (number)	Ornamental crops (in %)
1	Shkoder	35	0.56	3,529	9.14	4,843	1.13
2	Bushat	1,583	25.25	6,433	16.66	0	-
3	Dajç	1,715	27.35	6,570	17.02	246,456	57.72
4	Velipojë	441	7.03	2,624	6.80	47,529	11.13
5	Bërdicë	982	15.66	6,781	17.56	24,154	5.66
6	Ana e Malit	872	13.91	12,021	31.14	103,141	24.16
7	Rrethina	88	1.40	219	0.57	854	0.20
8	Q. Koplik	9	0.14	0	-	0	-
9	Gur i Zi	517	8.25	432	1.12	0	-
10	Kastrat	5	0.08	0	-	0	-
11	Gruemirë	24	0.38	0	-	0	-
	Total	6,270	100.00	38,609	100.00	426,977	100.00

Source: Regional Agriculture Directorate of Shkoder. 2011

As we may see from the cropping calendar below, fodder crops (mainly alfalfa), wheat, fruit trees and ornamental crops were the most risked due to the correlation of their cropping season with the floods of November – December 2010 and late release of water during January 2011.

Figure 14. Calendar of main crop cultivated in Shkodra region



Source: Interviews with agriculture specialists

The total value damage/loss from field crops from these floods is estimated to be about 7.8 million USD, about 88% of which within the Dajc, Ana e Malit, Berdice and Bushat. Damages in fruit trees is estimated to be about 1 million USD, while damages in ornamental crops is estimated to be about 4.6 million USD, about 82% of the last being in Dajc area.

Table 6. Estimated value of damages and losses in main agriculture crops (in '000 USD)

Nr.	Local government units affected	Field crops	Fruit trees, vineyards and olives	Ornamental plants	Total damage on crops
3	Dajç	2,676	180	3,814	6,670
6	Ana e Malit	1,557	220	475	2,252
5	Bërdicë	1,303	197	106	1,606
2	Bushat	1,371	145	-	1,516
4	Velipojë	479	73	231	783
1	Shkoder	90	145	22	257
9	Gur i Zi	238	10	-	248
7	Rrethina	64	11	4	79
11	Gruemirë	22	33	-	55
12	Vau Dejës	-	-	-	0
8	Q. Koplik	8	5	-	13
10	Kastrat	6	-	-	6
	Total	7,813	1,020	4,652	13,485

Source: Regional Agriculture Directorate of Shkoder and our interviews and estimates

The estimated damages in livestock reach a total figure of about 32,311 animals of all types. Dajc commune was the most hit as regards livestock with about 67% of total livestock damages and losses in the region. Other heavily damages communes Berdice and Guri i Zi representing respective 13.5% and 11.5% of total livestock damages and losses in the region.

Table 7. Damages and losses in main farm assets

Nr.	Local government units affected	Nr. of animals (various types)	Animals (in %)	Agriculture buildings (m2)	Agriculture buildings (in %)	Nr. of farm equipment (damages fully/partially)	Farm equipment (in %)
1	Shkoder	74	0.23	0	-	0	-
2	Bushat	1,833	5.69	0	-	358	0.93
3	Dajç	21,566	66.95	120	3.78	1,198	3.12
4	Velipojë	448	1.39	0	-	200	0.52
5	Bërdicë	4,351	13.51	2,965	93.39	36,310	94.65
6	Ana e Malit	98	0.30	90	2.83	207	0.54
7	Rrethina	137	0.43	0	-	0	-
8	Q. Koplik	0	-	0	-	0	-
9	Gur i Zi	3,704	11.50	0	-	90	0.23
10	Kastrat	0	-	0	-	0	-
11	Gruemirë	0	-	0	-	0	-
12	Vau Dejës	0	-	0	-	0	-
	Total	32,211	100.00	3,175	100.00	38,363	100.00

Source: Regional Agriculture Directorate of Shkoder and our interviews and estimates

Damages in farm buildings were identified in three (Berdice, Dajc and Ana e Malit), however farm buildings damages in Berdice commune represent the majority of them, with more than 93% of total farm building damages in the region. In addition, a large number of various farm equipment and machinery (about 38,363, fully or partly damaged) was either lost or heavily damaged during by the flooding. Again here, Bercice commune was most heavily hit with about 95% of the total farm machinery/equipment damages of the region. The total estimated damage in farms assets represents about 2.48 million USD in the whole flooded are of the Shkodra region.

Table 8. Estimated value of damages and losses in main farms assets (in '000 USD)

Nr.	Local government units affected	Animals (various types)	Agriculture buildings	Farm machinery & equipment	Fishing	Total damages in farm assets
3	Dajç	708	3	430	64	1,205
6	Ana e Malit	25	2	58	-	85
5	Bërdicë	210	39	118	-	367
2	Bushat	107	-	166	-	273
4	Velipojë	37	-	65	95	197
1	Shkoder	99	-	17	17	133
9	Gur i Zi	66	-	41	-	107
7	Rrethina	10	-	1	52	63
11	Gruemirë	-	-	-	12	12
12	Vau Dejës	-	-	-	33	33
8	Q. Koplik	-	-	-	1	1
10	Kastrat	5	-	-	-	5
	Total	1,266	45	897	274	2,482

Source: Regional Agriculture Directorate of Shkoder and our interviews and estimates

The overall estimated damage caused by the November-December 2010 floods in Shkodra region is estimated to be almost 15,967,000 USD including crops and fruit tress (as presented in table 19), livestock, fishing and other farm assets (as presented in table 20). The table 22 below presents the summary of the estimated damages/losses per each Local Government Unit of the Shkodra region according to the main asset groups. The majority of these damages is caused in field crops (about 49%), followed by ornamental crops (about 29%), and then livestock and fruit trees (with about 7.9% and 6.4% respectively). Almost 50 of the estimated damage is caused in Dajc commune (mainly linked with ornamental crops), followed by Ana e Malit (about 15%) Berdice (about 12%) and Bushat (about 11%).

Table 9. Total value of estimated flood damages (in thousand USD)

Nr	Local government units affected	Field crops	Fruit trees and, vineyards and olives	Livestock	Agriculture buildings	Farm machinery & equipment	Ornamental plants	Fishing	Total value of damages	Total (in %)
3	Dajç	2,676	180	708	3	430	3,814	64	7,875	49.3
6	A.e Malit	1,557	220	25	2	58	475	-	2,338	14.6
5	Bërdicë	1,303	197	210	39	118	106	-	1,974	12.4
2	Bushat	1,371	145	107	-	166	-	-	1,789	11.2
4	Velipojë	479	73	37	-	65	231	95	980	6.1

1	Shkoder	90	145	99	-	17	22	17	390	2.4
9	Gur i Zi	238	10	66	-	41	-	-	354	2.2
7	Rrethina	64	11	10	-	1	4	52	143	0.9
11	Gruemirë	22	33	-	-	-	-	12	68	0.4
12	Vau Dejës	-	-	-	-	-	-	33	33	0.2
8	Q. Koplik	8	5	-	-	-	-	1	13	0.1
10	Kastrat	6	-	5	-	-	-	-	11	0.1
	Total	7,813	1,020	1,266	45	897	4,652	274	15,967	100.0

Source: Regional Agriculture Directorate of Shkoder and our interviews and estimates

2.3.2. Estimation of food risk in the region

As described in the chapters above, different types of risk assets were investigated within the risk assessment (infrastructure, buildings, transport infrastructure and further assets at flood risk). In the following table the number of risk assets and the respective number of risk assets affected by an extreme flood event (referred to the flood event in December 2010) are listed for each commune of the region. Based on the results of December 2010 flood impact, an estimation of risk has been made and included in the regional flood management plan (June 2015)[19], based on x/y, where: "x" number of affected risk assets and "y" is number of risk assets. The results of the risk assessments are highlighted in different colours.

no relevant risk assets	
≤ 5 affected risk assets	
≤ 10 affected risk assets	
≤ 15 affected risk assets	
> 15 affected risk assets	

Table 10. Assets at risk - regional overview (referred to the flood event in Dec. 2010)

[19] Flood Risk Management Plan. Shkodra region, 2015

Legend		Ana e Malit	Berdicë	Bushat	Dajç	Gur i Zi	Rrethina	Shkodër	Velipojë
Infrastructure at flood risk / *infrastruktura me rrezik nga përmbytjet*									
	power generation *prodhimi i energjisë*	0/0	0/0	0/1	0/0	0/0	0/0	0/0	0/0
	power distribution *shpërndarja e energjisë*	3/13	4/9	8/27	16/19	3/7	1/3	2/13	5/14
	gas station *stacion gazi*	0/1	3/6	1/2	1/1	0/5	0/8	6/21	0/3
	water supply *furnizim me ujë*	2/14	3/5	12/14	4/4	0/0	2/3	0/0	6/9
	wastewater treatment *trajtim i ujërave të përdorura*	0/0	0/0	7/7	0/0	3/3	0/0	1/1	3/4
	waste diposal *depozitim mbetjesh*	0/0	0/0	0/1	0/0	0/0	1/1	0/0	0/0
	communication *komunikacion*	2/2	0/0	0/0	0/1	1/2	0/0	0/0	0/0

Source: Flood Risk Management Plan. Shkodra region, 2015

Legend		Ana e Malit	Berdicë	Bushat	Dajç	Gur i Zi	Rrethina	Shkodër	Velipojë
Buildings at risk (hot spots) / *ndërtesa të rrezikuara (pika kritike)*									
	healthcare center *qender shendetsore*	1/3	0/7	3/11	4/8	2/4	0/2	0/6	0/2
	school *shkollë*	1/5	1/5	3/6	3/8	2/8	0/10	0/38	2/9
	kindergarten *kopësht*	0/0	0/0	1/1	0/0	1/1	0/0	0/1	0/0
	churches, mosque *kishë, xhami*	2/2	0/4	5/12	3/9	1/7	0/4	2/12	1/6
	cemetery *varrezë*	0/8	0/10	2/17	2/6	2/12	0/9	0/8	1/10
	retirement homes *azil*	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
	fire department *zjarrfikëse*	0/0	0/0	0/0	0/0	0/0	0/0	0/1	0/0
	police station *rajon policie*	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
	technical emergency, service *urgjenca teknike, shërbimi*	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/1
	other public buildings *ndërtesa të tjera publike*	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
Transport infrastructure at flood risk / *infrastruktura e transportuese në rrezik përmbytje*									
	important connections *lidhje të rëndësishme*	→ see flood risk map of Shkodra Region (Annex C)							
	bridges *urat*	23/16	20/12	88/41	18/18	37/03	10/03	10/06	18/04
	airport, airfield *aeroporte*	0/0	0/0	0/0	0/0	0/0	0/1	0/0	0/0
Further assets at risk / asete të tjera në rrezik përmbytje									
	cultural hot spots *pika kulturore*	0/0	0/0	0/0	4/4	0/0	0/0	1/2	0/2
	industrial hot spots *pika industriale*	0/0	1/1	1/1	0/0	0/1	0/0	0/0	0/0
	storage *depozita*	1/1	0/0	0/0	1/3	7/9	0/0	0/0	0/0
	livestock *blegtori*	3/3	0/0	6/7	6/6	0/1	2/2	0/0	5/5
	customs *dogana*	1/1	0/0	0/0	0/0	0/0	0/0	0/0	0/0
	dike *digë*	→ see flood risk map of Shkodra Region (Annex C)							
	dike breached *plasaritje e digës*								
	embankment *argjinaturë*								
	channel *kanal*								
	affected housing *shtëpi të prekura*	5	5	3	14	1	4	2	6

Source: Flood Risk Management Plan. Shkodra region, 2015

Infrastructure at flood risk: With regard to the infrastructure of the region the most flood affected assets are power distribution, gas station and water supply. In 2010 electricity cuts occurred especially in the housing areas of Dajç and Bushat. In contrast, the most potentially affected gas stations are located in Shkodër and Bërdicë (however, no environmental contaminations by leaking fuel have been reported in the last flood events). With regard to the water supply of the region (mainly wells) many communes are at risk. The percentage of potentially affected water supply stations is in Dajç at 100 % (4 of 4), in Bushat at 85 % and in Bërdicë, Rrethina and Velipojë higher than 60 %, see Table 5. Furthermore, the main water supply station of Velipojë is located in the flood risk area of Bushat and the main water supply stations of Shkodër are located in the flood risk area of Rrethina and Berdicë.

Buildings at flood risk: No buildings like retirement homes, fire departments or police stations and technical emergency services are at risk in Shkodër region. Common public buildings are healthcare centres, schools (including kindergarten), churches, mosques and cemeteries. Particularly important for the population of the region are functioning healthcare centres and schools. The strongest constraints during the flood event in December 2010 arose in the communes Bushat and Dajç.

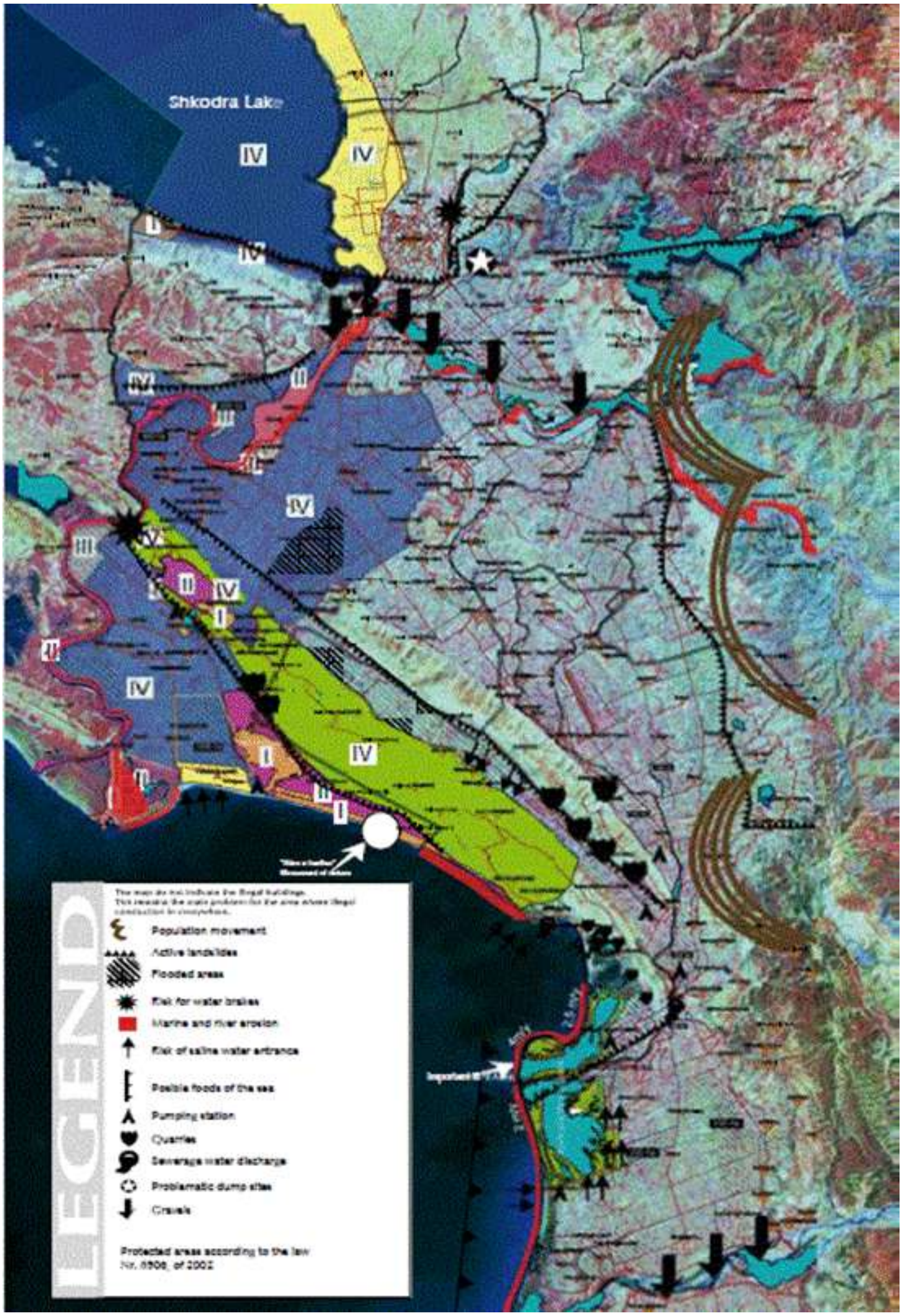
Transport infrastructure at flood risk: During the flood event in December 2010 most parts of the roads within the flooded area were not usable or only to a limited extent. The most important roads are the main road Shkodër –Tirana and the connection between Shkodër and Velipojë (passing through Bërdicë and Bushat). But also the cross connections to Dajç and Ana e Malit are potentially at flood risk. In addition, many bridges are affected by flood events.

Further assets at flood risk: Further assets at risk comprise cultural hot spots, industrial hot spots, storage, livestock and customs. In addition, the most affected housing areas and therefore the affected private buildings as well as affected inhabitants were investigated. In Shkodër region, cultural and industrial hot spots as well as customs stations (national border) are quite less relevant compared to storage and livestock. Especially in Gur i Zi is a high percentage of storages at flood risk. Bushat and Dajç are potentially most affected regarding livestock farming. Housing areas are more or less at flood risk throughout the region. The potential particular damage depends on the one hand on the flood extent and on the other hand on the topography and the consequent water levels. Moreover, in case of high water level of Shkodër lake parts of the City of Shkodër are flooded. With regard to the number of affected housing areas, the communes of Dajç, Velipojë, Ana e Malit and Bërdicë have to be mentioned as most affected.

Flood protection infrastructure: Dikes and dams along the Buna River and enforced embankments along Drin and Buna are partly in insufficient conditions for flood protection. In the 2010 events dikes were overtopped and partly destroyed, e.g. Belaj-Dajç-Shirq Dike (commune Dajç), Pentar-Luarz Dike (commune Velipojë) or Cas Dike near Murtemza Collector (Mott MacDonald, 2012a). Generally, the dike system has been improved in the last years but is still under risk in many stretches. The interventions in the rivers for embankments and dikes are done on ad-hoc basis. There is no detailed modelling for the rivers which would indicate the obsolete areas. After the flood in January 2010, the government took immediate measures and constructed embankments along Buna and Drin River, reinforced the Selmanaj dike and dikes along Buna River in Dajç.

2.4. Annexes

Figure 15. Map of protected areas in Shkodra plains affected by floods



Source: MoEFWA. 2006

Figure 16. Comparison of water extent between April 2009 and 9th January 2010

Figure 17. Flood extent and moist area on 11th January 2010

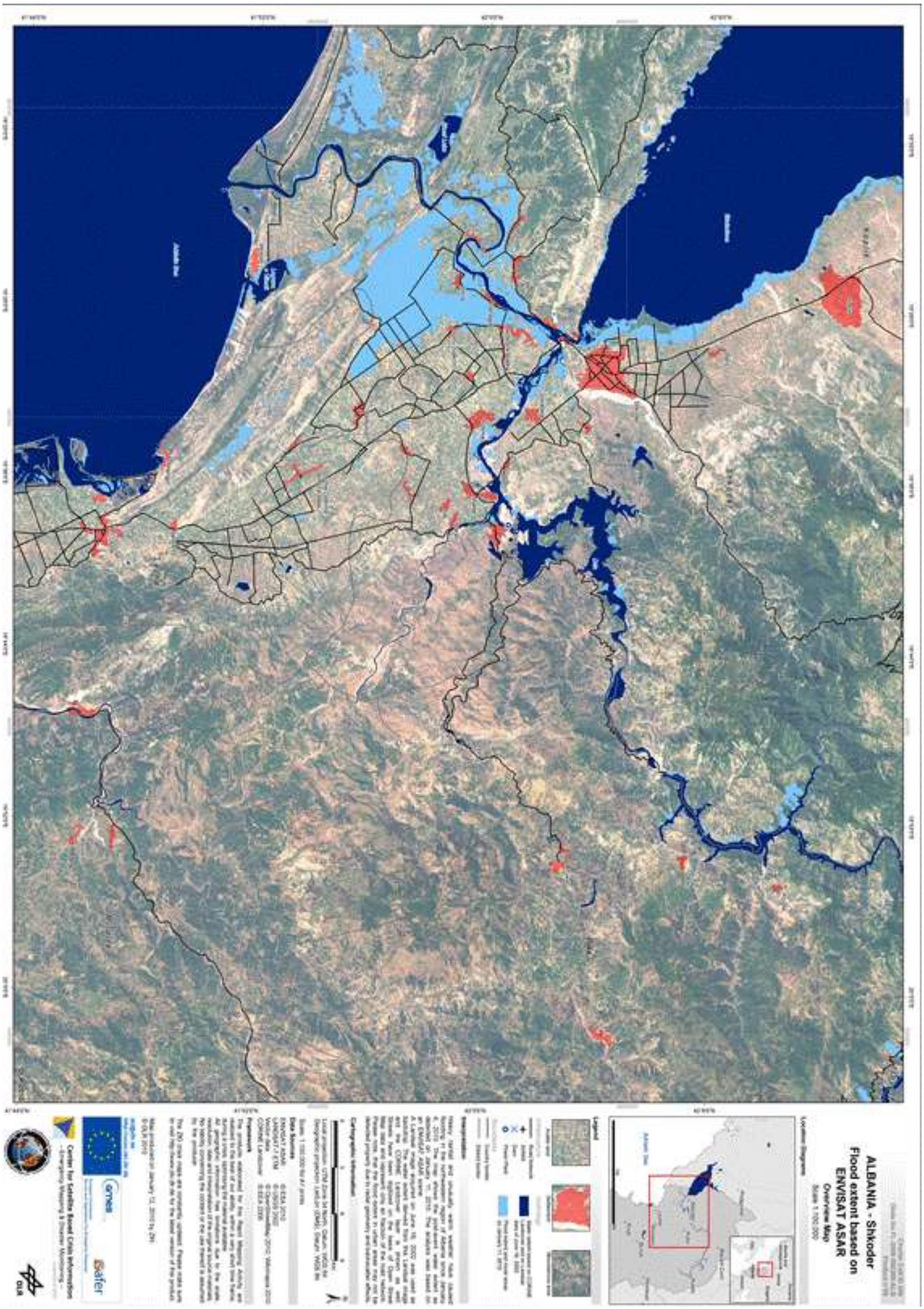


Figure 18. Competition between water extent between November 2001 and January 2010

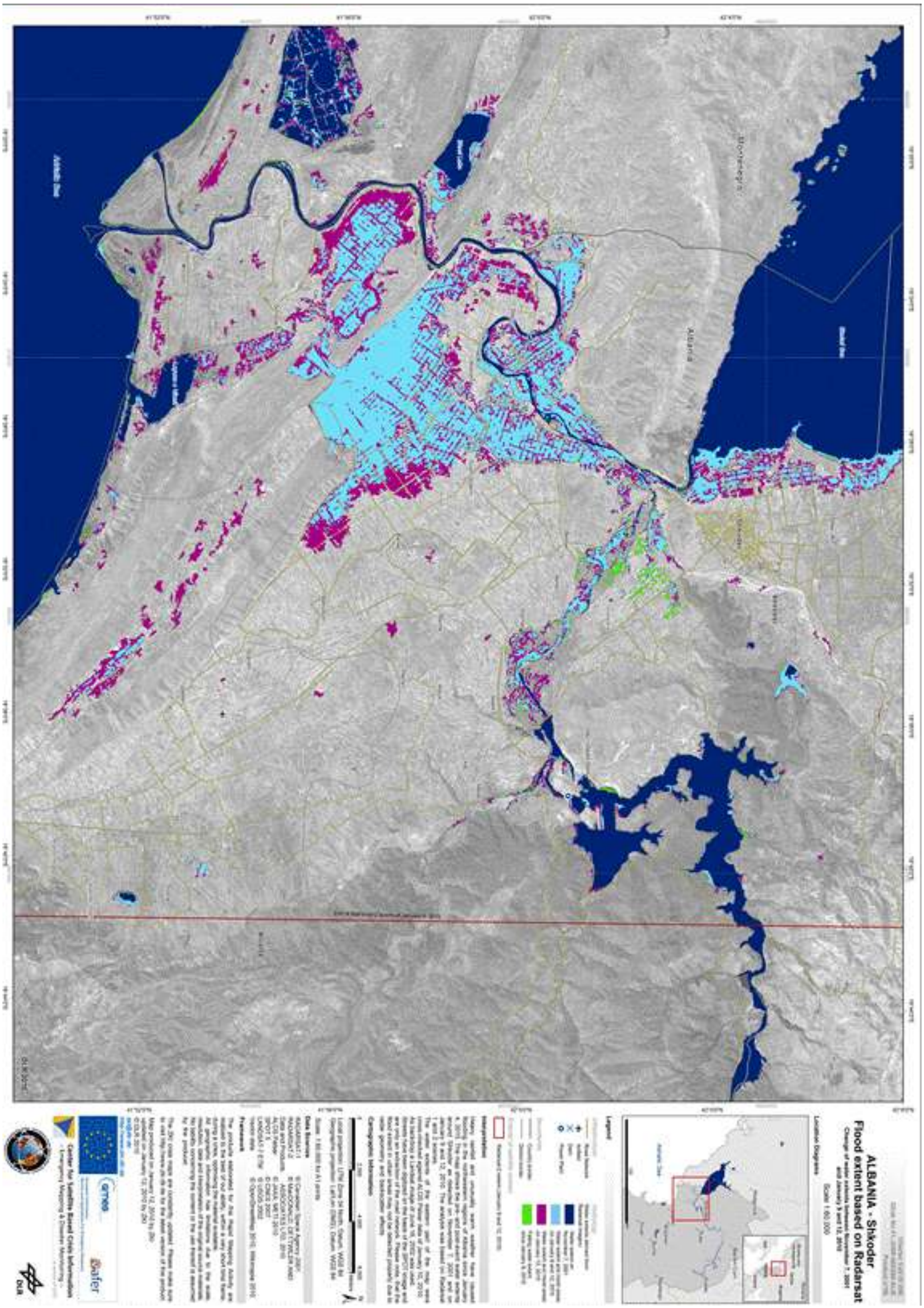


Figure 19. Flood extent on 6th December 2010

3. MONTENEGRO

3.1. Risk identification

Floods are of the most common risks in Montenegro, abetted by global warming and climate change, along with the negative human action or inaction. Floods cannot be avoided, but the risks can be reduced to a more tolerable measure by taking preventive measures (construction or non-construction). Water and water resources are managed, inter alia, in a way that contributes to mitigating the effects of floods and droughts.

EU Directive 2007/60/EC on the assessment and management of flood risks has been fully transposed into Montenegrin legislation through the Law on Waters and the Rulebook on the detailed content of preliminary flood risk assessment and flood risk management plan. Current legislation in this regard provides for the preparation of a preliminary flood risk assessment, identification of areas significantly affected by floods, development of risk maps and flood risk maps for areas significantly affected by floods in three return periods (small: T >> 100 years, medium: T = about 100 years, and highly likely: T = 10-50 years) and development of flood risk management plans for areas significantly affected by floods.

Given the fact that the implementation of the Floods Directive is at an early stage, that there is a lack of capacity (organisational, personnel and technical), that it is necessary to ensure public participation and information, as well as to collect the missing data, and taking into account that the Water Information System is yet to be established, Montenegro requested that it be granted a transitional period for the full implementation of the Floods Directive, with regard to the development of flood risk management plans, by the end of 2024.[20]

The most common direct causes of floods are: heavy precipitation in the basins of large rivers or lakes (rain and / or sudden snow melting), water level at the time of its rise, torrential floods of small watercourses due to short rains of high intensity, floods in karst fields due to heavy precipitation and insufficient permeability of natural abysses, formation of ice on rivers, floods caused by high sea levels, floods due to possible breakthroughs of dams and embankments, the occurrence of high water coincidence, watercourse meandering, landslides, inadequate construction and so on.

As for the indirect causes of floods, they can be of natural or anthropogenic origin. The most important ones are: size and shape of the basin, density of the river network, relief and its characteristics, soil water saturation, groundwater levels, afforestation and cultivation of agricultural land in the basin, human violation of certain regulations, fires that usually cause erosion, landslides and even climate change, inadequate cleaning of sediments in rivers and reservoirs, lack

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[20] Negotiating position of Montenegro for the Intergovernmental Conference on the Accession of Montenegro to the European Union for Chapter 27 – Environment and Climate Change (adopted at the session of the Government of Montenegro, 8 February 2018)

of defensive embankments, shores and fortifications, as well as climate change in more recent times.

3.1.1. Water area of Montenegro

As much as 95.3% of river flows in Montenegro are formed on its territory, i.e., their source and catchment area are located on the territory of our country. The territory of Montenegro is hydrographically divided into two almost equal parts. The Danube part of the basin accounts for 52.5% or 7,260 km2, while the Adriatic part of the basin covers 47.5% or 6,560 km2.

With a view to ensuring comprehensive water management, while respecting the hydrographic characteristics, uniqueness and integration of the water regime, water areas have been determined as basic units for water management in the territory of Montenegro, as follows:

- the water area of the Danube basin, as part of the international water area of the Danube on the territory of Montenegro, which includes the basins of Ibar, Lim, Ćehotina, Tara and Piva, with the corresponding groundwaters;
- the water area of the Adriatic basin, as part of the international water area of the Adriatic Sea on the territory of Montenegro, which includes the basins of Zeta, Morača, Skadar Lake, Bojana, Trebišnjica and watercourses of the Montenegrin coast, which flow directly into the Adriatic Sea, along with the corresponding groundwater and coastal sea waters.

Water areas are divided into sub-basin areas and small basin areas. Water areas can be formed through combination of small basins with larger ones or in connection with nearby small basins. At the proposal of the Water Administration, the Ministry of Agriculture, Forestry and Water Management adopted a new Rulebook on the boundaries of sub-basin and small basin areas (Official Gazette of Montenegro 18/2021).

Analysing the GIS data obtained through the process of drafting the Danube and Adriatic Basin Water Management Plans, the Water Administration concluded that the boundaries of water areas defined in the previous by-law (adopted in 2016) were not properly defined in the regulations or the management plans. In this regard, in 2020, corrections were started in terms of defining the boundaries of the water areas of the Danube and Adriatic basins, the boundaries of the sub-basin and small basin areas in the water area of Montenegro. 95

By implementing the above, Montenegro has created preconditions for more successful water management, and the institutions will have an official division of boundaries, ready for entry into the GIS database and the future functioning of the Water Information System.

Below are cartographic representations of the sub-basin areas in the water area of the Danube and Adriatic basins.

Figure 20. Cartographic representation of the sub-basin areas in the water area of the Danube and Adriatic basins

Land use	Total		Albania		Montenegro	
	km2	%	km2	%	km2	%
Urban fabric	214.90	1.85%	115.20	1.50%	99.70	2.20%
Industrial areas	12.30	0.12%	2.50	0.03%	9.80	0.21%
Transport Infrastructure	4.70	0.04%	2.90	0.04%	1.80	0.04%
Other urban land uses	6.60	0.06%	0.70	0.01%	5.90	0.10%
Agriculture	3447.20	30.70%	1466.20	18.70%	1981.00	42.70%
Forests	3804.60	31.00%	2263.40	28.80%	1541.20	33.20%
Non-forest vegetation	3764.80	27.95%	2866.60	36.50%	898.20	19.40%
Water bodies	449.30	2.95%	430.8	5.50%	18.50	0.40%
Other	778.80	5.30%	698.80	8.90%	80.00	1.70%
Total	**12268.3**	**100.00%**	**7847.10**	**100.00%**	**4636.10**	**100.00%**

3.1.2. Rivers in Montenegro

The Zeta River is the right tributary of the Morača River and springs on the territory of Nikšić municipality. Its length, with underground flow, is about 89 km and the surface of the basin is 1.547 km². It runs 29 km after which it enters underground. It re-enters the surface on Glava Zete and flows 56 km into the Moraca. The tributaries of the Zeta are the river Bistrica, Moštanica, Gracanica and Bratica in the area of the municipality of Niksic, as well as Susica and Matica on the territory of Danilovgrad municipality. The catchment area of the Zeta River covers an area of 1.597 km². The average flow of the Zeta River is 75,5 m^3/s, while the maximum reaches 463 m^3/s. Amplitude between low and high water levels is 10,26 m. Bistrica River is the left tributary of the river Zeta, whose source is at the foot of Tovic and consists of three groups of springs. In the river Zeta it is flowing through the Duklov Bridge. In the dry part of the year, Bistrica dries up, and in the rainy season Zeta gives significant amounts of water. River Mrkosnica has its spring in the southwestern foothills of Trebjesa.

The second branch of the same river flows out in the southern part of Niksic, and its riverbed is partially channelled. These two branches meet in Straševina and form river Mrkosnica, and they are poured into the Zeta River in the southern periphery of the field. All springs that feed the river Mrkosnica dry up during the summer period. Gracanica is a left tributary of the Zeta River. It springs above the village of Morakova and has a length of 29 km. The mean annual flow is 1,32 m3 /sec. This is an extremely periodic river, stopped by the dam and the accumulation of Liverovici. Through the Župa it flows in the direction of the southeast-northwest, after which it changes direction and flows to the south and flows into Zeta.

The Sušica River originates from many periodic sources, of which the most exquisite is the Blue Eye. It runs along the peripheral part of Mount Garač and, after a stream of 14 km, flows into the Zeta River. The Sušica River flows out of its riverbed during high altitudes and the blue surrounding area. The river Matica is located in the southern part of Danilovgrad municipality, in the area of Bandići, Koman and Zagarac. The largest tributary of this river is the periodic watercourse of the Crkovnica River.

The river Matica flows into the Moraca River near the village of Botun. During the December floods in 2010, the Crkovnica River, which is a tributary of the Matica River, flooded several facilities in Livade Bandićke. Rijeka Zeta is the most typical representative of karst hydrography and water of the richest river of Montenegro, after the river Bojana, but with great oscillations of water levels. It is the largest river sink with the largest drop in the underground profile (height difference of 563 m).

The hydro-geological river Zeta consists of Upper and Lower Zeta and about 4 km of underground stream. Lower Zeta is formed from the strong spring of the head of the Zeta and is 35 km long. Its water power was used by the implementation of a larger part of the Upper Zeta waters through a tunnel to the HPP Perućica (Municipality of Niksic) and two smaller hydroelectric power plants on the head of the Zeta and the Zeta Waterfall (Municipality of Danilovgrad). Important surface waters of Niksic Municipality are also artificial lakes that were created in favourable places where the land is watertight and where surface streams can be stopped for a longer or shorter period.

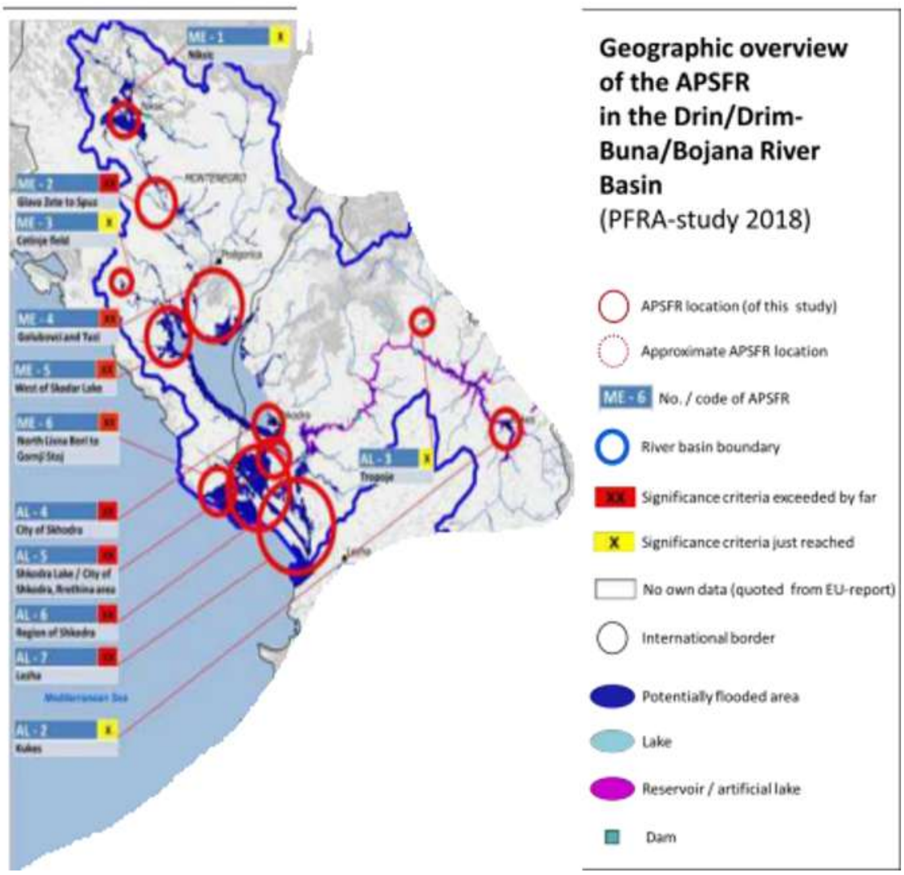
The water of larger accumulation lakes is usually used for the production of electricity, and less for irrigation or for water supply of the settlement. For the needs of HPP "Perućica", the following artificial lakes were created: Krupačko, Slansko, Vrtačko, compression basin Slivlje and Liverovići.

The Moraca River originates in northern Montenegro, under the Rzača Mountain. In its northern part, the Morača is a fast mountain river, and has cut a canyon north of Podgorica. After merging with its largest tributary, Zeta, just north of Podgorica, the Morača enters the Zeta plain. It flows through this flat area of Montenegro until it empties into Lake Skadar. The Moraca river flow is 97,1 km, the catchment covers an area of 3.200 km2 and is characterized by large oscillations in the water level. Tributaries of the Moraca River are Ribnica, Zeta, Sitnica and Cijevna. Ribnica runs its way through the Ćemovsko Field and flows into Morača in the centre of Podgorica. The river is about 10 km long. Its water level is directly dependent on the variable volume of the spring, so Ribnica almost dries out in the summer months.

The Cijevna River is formed in the high mountain massif of Prokletije. The length of 26,5 km runs through Albania, while in the territory of Montenegro it runs a length of 32,3 km. The most characteristic part is a deep, hardly accessible canyon that gives it a particularly attractive appearance. Sitnica is a river that springs near Podgorica. After a short flow, it flows into the Morača River between Podgorica and Skadar Lake. The current flow is often without water, because in that part of the river it dries up. Large areas around the Skadar Lake in Montenegro (mainly agricultural land) are affected by flooding. The lake is 50 km long, 14 km wide and the coastline is 207 km in the middle water.

Skadar Lake covers an area of less than 400 km2 at minimum water levels, up to 525 km2 at the highest registered water levels. It is primarily filled with the waters of the Morača River, and it is filled with Rijeka Crnojevića, Orahovštica in Montenegro and the river Kiri in Albania. The discharge is done by the river Bojana. The total flooded area on the shores of Lake Skadar is above the level of 6,5 m above sea level and amounted to 5.000 ha. The Bojana River (Albanian Buna) is 41 km long and located on the border of Montenegro and Albania. The Bojana River flows from Lake Skadar and into the Adriatic Sea. It runs in big curves with an average drop of 0,6%.

Figure 21. geographic overview of the APSFR in the Drin/Buna River basin



3.1.3. Flood Risk Management in Montenegro

The framework for management and protection of water resources in the country is set with the Water Law (WL), which is the main legal document transposing the Water Framework Directive. The Water Law is harmonized around 95% with the Water Framework Directive. The transition of the EU Floods Directive 2007/60/EC is completed (100%) but the implementation is at an early stage. The date of the full implementation has determined as following:

- Development of preliminary flood risk assessment until 2019,
- Determination of areas of potential significant flood risks until 2019,
- Preparation of flood hazard maps and flood risks maps until 2021, and
- Development of flood risk management plans until 2024.

According to the WL, the Ministry of Agriculture and Rural Development (MARD) has the leading role in the water management process. Water Administration (WA) as the administrative body within the Ministry of Agriculture and Rural Development is responsible for implementation of water management strategy and plants. Specific responsibilities and obligations are shared among several other ministries in their respective areas of competence. The Ministry of the Interior (Directorate for Emergency Services) is responsible for risk management and emergency situations response, including the event of floods, in cooperation with the Institute of Hydro-Meteorology and Seismology of Montenegro (IHMS). The institutions that are responsible for the management and implementation of FRM in Montenegro are:

- Ministry of Rural Development and Agriculture;
- Water Administration, under the Ministry of Rural development and Agriculture
- Directorate for Emergency Situations under the Ministry of Interior (MoI);
- Institute for Hydrometeorology and Seismology of Montenegro (ZHMS), under the MoI;
- Local Authorities – Secretariats involved in water management.

In accordance with the Montenegrin legislation, the Ministry of Agriculture and Rural Development (MARD), within which there is a separate Directorate of Water Management, has a leading role in water management process. The Directorate performs tasks related to proposing and developing flood risk management policies. The Water Administration (WA) is a body responsible for preparing and implementing a flood risk management plan as well as of all the steps preceding the adoption of the plan.

Montenegro is an active member of the International Commission for the Protection of the Danube River (ICPDR) and has the status of observer in the International Commission for the Sava River Catchment Area. Relations of Montenegro with its neighbouring countries Croatia and Albania are regulated by respective Inter-state Agreements. The Agreement between the Government of Montenegro and the Government of Croatia on mutual relations in the area of water management was made and signed on September 4, 2007 in Zagreb. The Agreement between the Government of Montenegro and the Government of the Republic of Albania on water-related problems was concluded on October 31, 2001 in Podgorica. The Framework Agreement on Water Management between Montenegro and Albania was signed at the joint session of the governments of

Montenegro and Albania which was held on July 3, 2018 in Shkodra. In addition to the Albania-Montenegro Agreement in the field of water management, the following are also signed: • Agreement between the Academy of Sciences and Arts of Montenegro and Albania in 2005; • Memorandum of Understanding between the Council of Ministers of the Republic of Albania and Montenegro for the "Intercultural Development of the Skadar Lake". In order to coordinate and harmonize the implementation activities, both short-term and long-term measures, both countries have been set up by the Commissions, which have elaborated an action plan and defined in detail the urgent measures that need to be taken

Table 11. Rivers and their characteristics in the Drin/Drim – Buna/Bojana River Basin

No.	Country – no.	Location	River / Lake	Type of flood	APSFR
1	AL - 1	Diber	Black Drin	River-flood 35	x
2	AL - 1	Kukes	Black Drin	HPP-reservoir managemen	x
3	AL - 2	Tropoje	/albona River (Drin tributary	Flash-flood	x
4	AL - 3	City of Skhodra	Kiri River	River-flood	xx
5	AL - 4	Shkodra Lake / City of Shkodra, Rrethina area	Lake Shkodra	Lake-flood	xx
6	AL - 5	Region of Shkodra	Drin, Buna / Bojana	River-flood	xx
7	AL -6	Lezah	Old (former) Drin River	River-flood	xx
8	ME - 1	Niksic	Zeta	River flood Heavily Modi fied Waterbody flood	x
9	ME - 2	Glava Zete to Spuz	Zeta	River flood	xx
10	ME - 3	Cetinje field	(groundwater and drainage channels)	Groundwater	x
11	ME - 4	Golubovci and Tuzi	Moraca and Skadar lake area		xx
12	ME - 5	North of Skadar Lake	Skadar lake area	River flood & Lake flood	xx
13	ME - 6	Lisna Bori to Gornji Stoj	Buna / Bojana	River flood	xx

Explanations:

XX	APSFR / Risk exceeds the value of 2 or more significance criteria clearly
X	APSFR / Risk exceed the value 1 or 2 significance criteria slightly
O	No APSFR / Risk does not exceed the value of the significance criteria
	Not assessed in this study; here quoted to complete the information (source: PFRA-report Greece; EEA, 2018)

Source: GIZ Report Meon; adjusted by national consultants based on national data

Table 12. Main cities and villages along the rivers in the Drin/Drim-Buna/Bojana River Basin

Country	River	Station	Basin [km²]	MQ [m³/s]	Mq [l/(skm²)]	MHQ [m³/s]	MNQ [m³/s]	HHQ [m³/s]
Montenegro	Bojana (see Buna)			640				
Montenegro	Morača	Pernica	441,0	27,5	62,0	339,0	3,3	747,0
Montenegro	Morača	Podgorica	2.628,0	148,0	56,0	1.167,0	15,1	1.893,0
Montenegro	Morača	Zlatica	985,0	61,0	62,0	718,0	1,7	1.173,0
Montenegro	Zeta	Danilovgrad	1.216,0	77,9	60,0	398,0	8,0	577,0
Montenegro	Zeta	Duklov Most	342,0	18,9	52,0	182,9	0,2	286,0

Country	River	Km	City / village
AL	Drini River (Fierza lake)	70 (from AL-MK border)	Village of Përbreg (Terthore commune)
AL	Drini River	175 - 250 (from AL-MK border)	Shkodër city and administrative units of Vau Dejes, Guri i Zi, Bërdicë, Dajç, Ana e Malit, Velipojë, Rrethina, and Bushat. Specific areas/villages within this area (Livadhe, Bahçallëk, Persash, Bahçja e Cakajve, Ajasëm, Kuç, Rrenc, Guri i Zi, Trush, Bërdicë e Sipërme, Bërdicë e Mesme, Bërdicë e Madhe, Beltoje, Belaj, Rrushkull, Shirq, Mushan, Samrish,Suka, Pentar, Obot, Oblikë, Muriqan, Baks-Rrjoll, Cas, Luarz, Pulaj, Fshat i Ri (Trush i Poshtëm), Mali i Jushit, Rranxa, Konaj, Hoten
AL	Kiri River	175 km	Villages of Bardhaj and Bleran
AL	Old Lezha Drin	175 - 250 (from AL-MK border)	Lezha city and villages of Mabe, Zojz, Gocaj, Torovic, Ishull Shengjin
ME	Zeta	65	Niksic-Poljica; Štedim
ME	Zeta	62	Nksic-Strasevina
ME	Zeta	60	Niksic-Klicevo
ME	Zeta	57	Niksic-Ozrinici
ME	Zeta	27	Danilovgrad
ME	Zeta	27	Pazici
ME	Zeta	9,5	Spuz
ME	Zeta		Podanje
ME	Zeta	15,5	Kosic
ME	River Matica	Tributary of River Zeta	Bandici
ME	River Susuca	Tributary of River Zeta	Strahinjici
ME	Zeta	31	Bogicevici
ME	Zeta	23	Curilac
ME	Zeta		Podkraj
ME	Zeta		Gorica
ME	Zeta	14	Martinici
ME	Zeta	40	Vis
ME	Zeta	34	Frutak
ME	Moraca	19,5	Botun
ME	Moraca	15	Ljajkovici
ME	Moraca	15	Mitrovici
ME	Moraca	16,5	Grbavci
ME	Moraca	19	Lekici
ME	Moraca	12	Vukovci
ME	Moraca	7,5	Ponari
ME	Sitnica River	19	Beri
ME	Moraca	12	Golubovci
ME	Moraca	11,5	Goricani
ME	Moraca	10,5	Susanja
ME	Moraca	14	Mojanovici
ME	Moraca	12	Golubovci
ME	Skadarsko jezero		Pothum I Vranj/ Tuzi
ME	Skadarsko jezero		Dodosi
ME	Skadarsko jezero		Zabljak Crnojevica
ME	Skadarsko jezero		Rijeka Crnojevica
ME	Skadarsko jezero		Plavnica
ME	Skadarsko jezero		Karuc
ME	Skadarsko jezero		Rogane /Bobija
ME	Skadarsko jezero		Poseljani
ME	Skadarsko jezero		Pevlaka
ME	Bojana		Lisna Bori
ME	Bojana		Fraskanjel
ME	Bojana		Sveti Djordje
ME	Bojana		Rec
ME	Bojana		Donji Stoj

Figure 22. Example of brief presentations of risk areas in Montenegro

Risk area	Country:	Montenegro	ME - 4
	Location:	Golubovci and Tuzi	

River-Food & Lake-Flood:	Moraca and Skadar lake area
River section:	The lower course of the Moraca river and the large area of land along the edge of the Skadar Lake.
River km:	**to km:**

Cities / villages of risk:

Botun, Ljajkovici, Mirovici, Grbavci, Lekici, Vukoci, Ponari, Gostilj, Vranjina, Beri, Golubovci, Bijelo Polje, Berislavci, Balabani, Kurilo, Goricani, Susanja, Mojanovici, Tuzi

Past events / years, damage:

Month/Year	Description of damage
Nov 2010 – Dec 2010	Floods in the municipalities of Golubovci and Tuzi are mostly endangering the large areas of land along the periphery of the Skadar Lake and in the lower flow zone of the Morača River. They w have posed risk to settlements, roads and agricultural land

Comments on past events:

Potential risks / assets in risk area

Risk area (in ha)	
Houses	982
Persons	15.857
Families	869
Companies at risk	
Industry (objects)	57
Infrastructure (objects)	3 bridges
Agriculture [ha] / objects	Large agricultural area
Protected areas	The flood zone is part of the National Park "Skadar Lake"
Other objects at risk	1.367 agricultural facilities

Risk assessment / significance of potential risks

Significance criteria	*value*	*limit*
A) Human health, economic values		
no. of houses	982	≥ 10
Settlement area (in ha)	~2.000	≥ 0,5
Industrial objects	57	≥ 1
Industrial area (in ha)	≥1	≥ 0,5
Critical agriculture aspects	xx	
B) Environmental risks		
B1) Water polluting substances / sites		
Contaminated sites	0	≥ 1
Locations with dangerous substances	0	≥ 1
B2) Protected areas (according to WRRL)		
Protected areas (e.g. Natura 2000 etc.)	1	≥ 1
Drinking Water supply areas	0	≥ 1
Bathing waters	0	≥ 1
C) Risk for cultural heritage sites		
UNESCO heritage sites	0	≥ 1
Other relevant cultural heritage sites	0	≥ 1

Location in the Drin – Buna/Bojana River Basin

Situation in the potential risk area:

Risk area	Country:	Montenegro	ME - 5
	Location:	West of Skadar Lake	

River-Flood & Lake-Flood:	Skadar Lake area
River section:	
River km:	**to km:**

Location in the Drin – Buna/Bojana River Basin

Cities / villages of risk:

- Municipality of Cetinje: Dodosi, Karuc, Rijeka Crnojavica , Zabljak Crnojevica
- Municipality of Bar: Virpazar, Boljevici, Dupilo, Krnjice

Past events / years, damage:

Month/Year	Description of damage
Nov 2010 – Dec 2010	Major damage was on orchards and vineyards, boats and fishing material and a part of livestock and food for livestock also disappeared. Infrastructure facilities were endangered by the Old Bridge on Rijeka Crnojević and three bridges on the road of Rijeka Crnojevića - Virpazar. Also, the pumping station of the Cetinje Water Supply in Podgora was endangered, from where Cetinje is supplied with water.

Comments on past events:

Potential risks / assets in risk area

Risk area (in ha)	
Houses	950
Persons	2.700
Families	600
Companies at risk	
Industry (objects)	1
Infrastructure (objects)	12; water supply infrastructure
Agriculture [ha] / objects	*ca. 185 ha*
Protected areas	The flood zone is part of the National Park "Skadar Lake"
Other objects at risk	Over 100 objects have been destroyed for agricultural production.

Situation in the potential risk area:

Risk assessment / significance of potential risks

Significance criteria	*value*	*limit*	
A) Human health, economic values			
no. of houses	950	≥ 10	
Settlement area (in ha)	13	≥ 0,5	
Industrial objects	1	≥ 1	
Industrial area (in ha)	0	≥ 0,5	
Critical agriculture aspects			
B) Environmental risks			
B1) Water polluting substances / sites			
Contaminated sites	0	≥ 1	
Locations with dangerous substances	0	≥ 1	
B2) Protected areas (according to WRRL)			
Protected areas (e.g. Natura 2000 etc.)	1	≥ 1	
Drinking Water supply areas	1	≥ 1	
Bathing waters	0	≥ 1	
C) Risk for cultural heritage sites			
UNESCO heritage sites	0	≥ 1	
Other relevant cultural heritage sites	0	≥ 1	

Risk area	Country:	Montenegro	ME - 6
	Location:	Lisna Bori to Gornji Stoj	

River-Flood & Sea water	Buna / Bojana
River section:	
River km:	**to km:**
Cities / villages of risk:	
Lisna Bori, Sukobin, Fraskanjel, Gornji Stoj, Sveti Djordje, Ada Bojana	
Past events / years, damage:	
Month/Year	**Description of damage**
Nov 2010 – Dec 2010	The biggest areas of land and private facilities near the river Bojana are endangered. It is primarily about ground-level houses and houses with a maximum of one to two floors, as well as large plantations of fruits and vegetables.
Comments on past events:	

Potential risks / assets in risk area	
Risk area (in ha)	940
Houses	658
Persons	475
Families	114
Companies at risk	
Industry (objects)	
Infrastructure (objects)	3
Agriculture [ha] / objects	Large agricultural areas
Protected areas	
Other objects at risk	At the mouth of the Bojana river, there is a huge complex with 390 facilities (fishing houses, cottages and restaurants) and the famous tourist center Ada (440 ha)

Risk assessment / significance of potential risks			
Significance criteria	*value*	*limit*	
A) Human health, economic values			
no. of houses	658	≥ 10	
Settlement area (in ha)		≥ 0,5	
Industrial objects	0	≥ 1	
Industrial area (in ha)	0	≥ 0,5	
Critical agriculture aspects			
B) Environmental risks			
B1) Water polluting substances / sites			
Contaminated sites	0	≥ 1	
Locations with dangerous substances	0	≥ 1	
B2) Protected areas (according to WRRL)			
Protected areas (e.g. Natura 2000 etc.)	0	≥ 1	
Drinking Water supply areas	1	≥ 1	
Bathing waters	1	≥ 1	
C) Risk for cultural heritage sites			
UNESCO heritage sites	0	≥ 1	
Other relevant cultural heritage sites	0	≥ 1	

Location in the Drin – Buna/Bojana River Basin

Situation in the potential risk area:

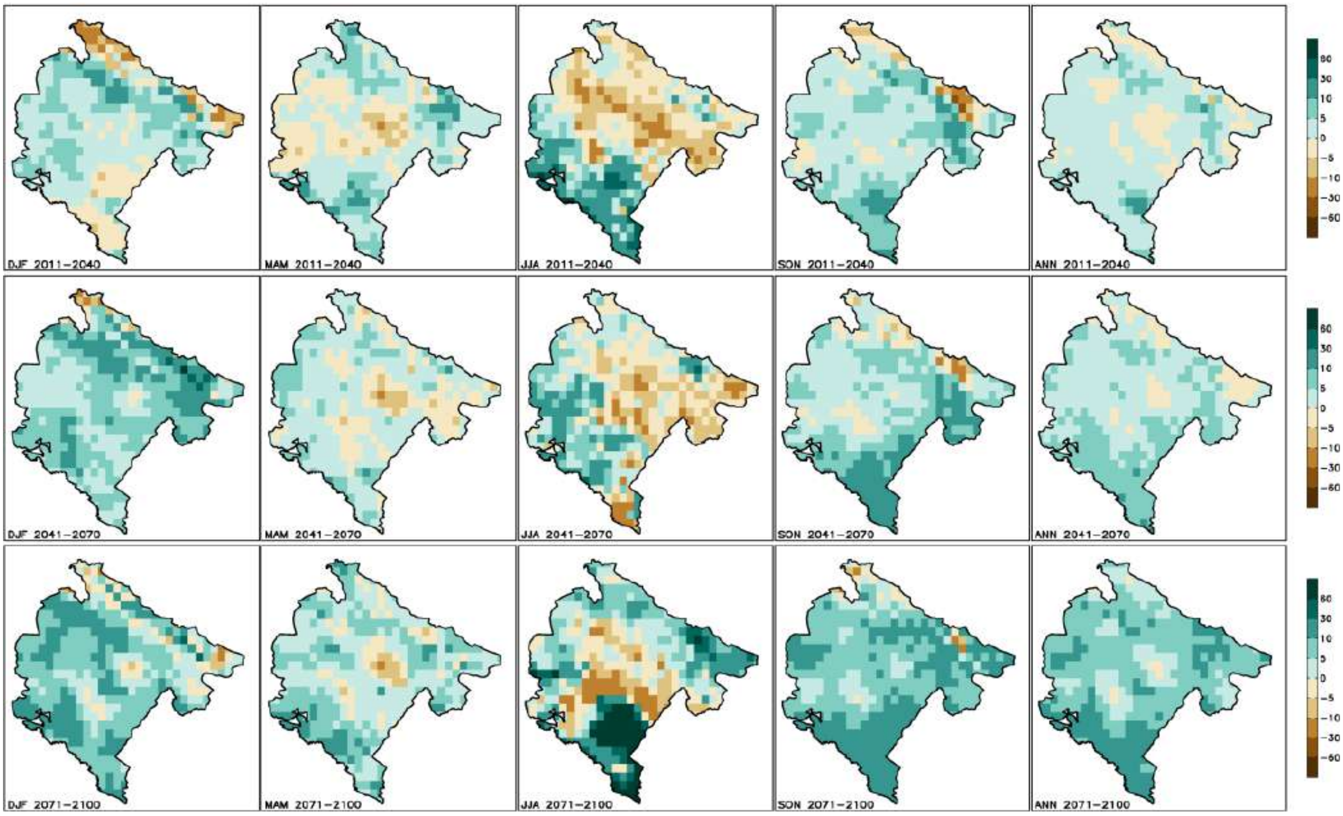
Map from Plan of protection and rescue of floods for the territory of the Municipality of Ulcinj

3.2. Adriatic basin

The hydrological complex of Skadar Lake, its main tributary Morača and the only distributary Bojana is very complex, especially from the aspect of floods. Morača, with its most significant tributary, Zeta, is the main inflow component. Apart from it, the larger tributaries of Skadar Lake are Rijeka Crnojevića and Orahovštica rivers in Montenegro and the Kiri River in Albania. All this is further complicated by the fact that downstream from Skadar, the Drin River flows into Bojana, whose waters at extremely high water-levels almost completely block the outflow of water from Skadar Lake, while part of the Drin water enters Skadar Lake. In such cases, the Lake, as a rule, is burdened by a large inflow of all its tributaries, so the inevitable outcome is the occurrence of floods in its shores. In the zone of Skadar Lake, significant agricultural areas have been flooded for a long period of time, and settlements along the edge of Skadar Lake are also endangered. Due to the duration of the floods, specific wetlands have formed in this zone. The zone of Ulcinj field is endangered by the high-level Bojana waters.

In terms of their significance, i.e., the size of the damage, the damage that occurs in larger and smaller karst fields should also be noted. In that respect, floods in the Cetinje and Nikšić fields are certainly the most common. In addition to floods caused by high waters on rivers and torrents, as well as very significant flooding caused by Skadar Lake, the occurrence of floods is caused by some specific causes, such as the combined action of surface and groundwater, the effect of karst and water overflow from one underground basin to another, with the characteristic occurrence of karst springs, as well as the superposition of the influence of tides and inflows of groundwater.

The following units can be singled out in the Skadar Lake basin: Zeta basin, Skadar Lake basin, Morača and Bojana basin, the Coastal Region and urban areas. Floods in city zones, i.e., urban areas, which are the result of heavy rains, are also a big problem, especially in those cities where unplanned construction and insufficient capacity of atmospheric sewage result in inability to drain excess water.



3.2.1. Areas endangered by floods

Large areas of land along the edge of Skadar Lake, in the zone of the lower course of the Morača River as well as next to Bojana, are most endangered by floods in Montenegro. In addition, floods in Polimlje from Gusinje to Zaton, near Kolašin and Mojkovac, as well as in the valley of Ćehotina near Pljevlja, are also of major importance.

Floods in Montenegro are manifested differently depending on the characteristics of the flood-causing watercourse. Along the valleys of most rivers, settlements, industrial plants and agricultural areas are endangered by short-term high-water waves. These flows are characterised by large longitudinal falls, high speeds in the event of flood waves, as well as significant amounts of suspended and drawn sediment. Canyons alternate along the streams, sometimes very deep, with extensions – valleys, where settlements and industrial facilities are located, as well as traffic infrastructure. Agricultural areas located in these valleys, although relatively modest in size, are of great importance for agricultural production, because the total agricultural land resources in Montenegro are rather scarce. Due to such a concentration of goods in the valleys, the damage caused by floods, even if relatively small in scope, can be significant. It should be noted that floods, which occur from high waters of the main stream, are very often superimposed with floods that occur from torrential tributaries, and that it is often very difficult, if not impossible, to separate these two phenomena. Also, the consequences of floods along these flows are accompanied by changes in the river bed, especially its meandering. This is why flood-prone areas change their position and size.

Table 13. Overview of areas endangered by floods in Montenegro

No.	Watercourse	Section	Characteristics
1.	Ibar	Near Rožaje	meandering
2.	Lim	Village Nedokusi	meandering
3.		Village Zaton	meandering
4.		Zaton – Bioče	meanderiNG
5.		Berane	settlement part endangered
6.		Berane – Vinicka	agricultural land flooding
7.		Plav	area endangered by torrents
8.	Lim tributaries	Bijelo Polje	area endangered by torrents
9.		Gusinje	torrents, settlement and infrastructure flooding
10.		Grnčar valley	meandering, flooding
11.		Vruja valley	meandering, flooding
12.	Ćehotina	Pljevlja field	meandering, endangered industry and agriculture
13.	Tara	Mojkovac	endangered urban area and agricultural land
14.		Kolašin	endangered urban area and agricultural land
15.	Piva	Šavnik	endangered settlement and infrastructure
16.	Morača	Village Botun – mouth	flooding, meandering
17.		Sitnica mouth – Botun	flooding, meandering
18.		Village Ponare –Sitnica mouth	flooding, meandering
19.	Zeta	Nikšić field	flooding
20.	Sitnica	Lješkopolje grove	agricultural land flooding
21.		Village Beri	settlement, agricultural land and infrastructure flooding
22.		Skadar Lake	settlement, agricultural land and infrastructure flooding
23.	Bojana	Vladimir-Sukobin field	agricultural land flooding
24.		Šas Lake zone	agricultural land flooding
25.		Ulcinj field	agricultural land and industrial capacities flooding
26.	Sutorina	Sutorina	agricultural land flooding
27.	Repaj	Repaj	agricultural land flooding
28.	Kuti	Kuti	agricultural land flooding
29.	Kotor	Kotor	groundwater flooding

30.	Sitnica	Grbalj field	area endangered by torrents

3.2.2. Characteristics of floods in Montenegro

Characteristic meteorological phenomena in the area of Montenegro are heavy precipitation, heavy rain series that last for several days with the absence of snow cover. It is not uncommon to have a combination of these rain series with melting snow, which can contain a large amount of water. This scenario usually leads to large-scale floods, which last for a long time. Floods of 2010 and 2011 are typical examples of this combination of factors.

The floods that occur in Montenegro result from the country's geomorphological characteristics, as well as the characteristics of the flood-causing watercourse. It is characteristic of most rivers in Montenegro that canyons and valleys alternate along their course.

River valleys, which are potentially endangered by floods, occupy a relatively small area of Montenegro. However, these areas are of great importance, because they contain the largest settlements, agricultural areas and important roads. Therefore, the protection of these areas from floods is of unquestionable social and economic importance.

The problem of flood defense in Montenegro is mainly related to the shoreline of larger watercourses: Gornja and Donja Zeta, Morača, Lim, Tara, Ćehotina, Ibar and Bojana, because almost all larger Montenegrin cities are located on their banks. These rivers threaten them with their overflow in times of great water levels.

Caused by high waters on the main streams, floods are very often accompanied by torrential floods of their tributaries. In addition to carrying large amounts of torrential sediment, these floods contribute to the sudden influx of large amounts of water and affect the rapid rise of water levels in the main riverbed. In addition to this, there are some specific problems of flooding in the territory of Montenegro – in the areas around Skadar Lake and the closed karst fields of Cetinje and Nikšić.

The high levels of the Skadar Lake, which endanger significant areas around the lake, result from complex hydrodynamic conditions in the lake basin itself, its distributary Bojana, as well as in the Drin River basin in Albania (cross-border impact). On the other hand, the flooding of the Cetinje field with inland waters endangers a large part of the urban zone of the municipality of Cetinje. In the Nikšić field, the land is mostly endangered by the overflow of rivers and streams and where the superposition of the action of surface and groundwater is common, which leads to large floods.

Floods in urban areas, which are caused by high-intensity rains and which, due to the large concentration of the population in a relatively small area, often cause great material damage, are also a significant problem. The effect of these floods is increasing due to the undeveloped drainage system, as well as its insufficient capacity.

Occasional flows that flow through urban areas and whose basins cover the borderline parts of the high mountains get "activated" due to heavy rains, further complicating the situation. The intensity of these floods increases with the occupation of the watercourse area by both legal and illegal construction, unprofessional sewerage, waste disposal, which reduces the capacity of the riverbed and leads to floods.

Torrential floods pose a special danger, primarily due to the speed of formation and propagation of the flood wave, high flow velocities which very often have a destructive character. These floods are mostly present in the coastal part of our country, but also occur in the Danube basin. Prominent examples also occur in the Ibar basin in Rožaje area.

An integrated approach to flood management requires interaction, synergy, mutual communication and coordination of all actors involved and recognised in this process, both at the national and local level and internationally. The prerequisite for this is to strengthen professional and financial capacities in institutions responsible for the implementation of this policy.

3.2.3. Land areas endangered by excess water

Along with high-level groundwater and "upper" groundwater, constant or periodic floods endanger the land area of about 26,000 ha. Land areas that are occasionally or constantly endangered by these waters during the year are potentially high-yield. However, their adaptation to cultivation purposes requires appropriate hydro and agricultural-technical land amelioration. First, they need to be protected from floods, which are common in the shoreline zone of Skadar, Plav and Šas lakes, as well as next to Bojana, Morača, Zeta, Lim, Tara and Ćehotina rivers. Land that is protected from floods needs to be drained as well, and the same applies to land with high-level groundwater and "upper" groundwater. If these and other agricultural-technical measures were applied to the land, the arable land amount would be significantly increased.

Table 14. Land areas endangered by excess water

No.	Area	Area size (ha)	Type of excess water
1.	Skadar Lake (shoreline area)	14,000	Floods and groundwater
2.	Ulcinj fields	4,500	Floods, groundwater and external waters
3.	Other coastal fields	1,000	Groundwater and external waters
4.	Bjelopavlići plain	2,400	"Upper groundwater" and floods
5.	Lješkopolje meadows	800	"Upper groundwater"
6.	Nikšić field	1,000	Flood waters
7.	Plavs-Gusinje valley	1,500	Flood and external waters and partly groundwater
8.	Maoči field	300	Groundwater and external waters
9.	Other smaller areas	400	Groundwater and external waters
Total		26,000	

3.2.4. Possible future floods and planned flood protection activities

Unwanted effects of potential future floods in Montenegro are expected in endangered unprotected areas, but could be even more pronounced in areas where there are infrastructure facilities for flood protection. This is especially so because many years of negligence and neglect of investments in regular maintenance of protective facilities built in the fifties and eighties of the last century have led to a significant reduction in the safety of facilities, and thus the degree of the protection they provide. In particular, due to inadequate maintenance and use of riverbeds, the banks of torrential watercourses are endangered. Such a situation also stems from the irresponsible attitude of individuals, and often the community, towards flood protection facilities (inadequate buildings are built in riverbeds and inundations, embankment materials are often stolen, riverbeds are used as landfills, there is unplanned exploitation of material from riverbeds and inundations, etc.). In this regard, the most important preventive measure in the coming period must be regular monitoring, control of the condition and maintenance of water facilities. Before that, it is necessary to provide preconditions for adequate management of water resources, water protection and protection against harmful effects of water, first and foremost in terms of strengthening administrative and financial capacity in institutions responsible for this area, but also in strengthening mutual cooperation between all actors involved in this process, as well as through implementation of watercourse regulation and flood protection, which includes integrated regulation at the basin level.

Certain works were performed in 2011 in order to repair the effects of the catastrophic floods that occurred in 2010 and to prevent future floods. Since 2011, the Public Works Directorate has been implementing the project “Emergency Flood Relief and Prevention”, which is financed from the credit funds of the European Investment Bank. Within this project, in the period from 2011 until today, 61 projects have been implemented. In addition to the construction of three bridges on the Lim River, the reconstruction of the main city bridge in Berane and the bridge on the Marsenića Rijeka river, riverbeds were regulated, i.e., stone bank fortifications extending for approximately 10 km were built.

Given the geomorphological disposition of river basins and steep relief forms, the processes of erosion production of sediments and the formation of surface runoff are very intensive and have specific dynamism. Torrential waves, with large amounts of sediment, reach the main watercourses and have a very negative effect on the performed regulation works, forming deposits and reducing the drainage capacity of the riverbed. Therefore, a complex approach to river regulation and flood protection is necessary, which implies integrated regulation throughout the entire river basin. In this regard, in 2014, the implementation of the project “Regulation of the Morača River from the mouth of Sitnica in Botun to Ponari” began. These works will define the riverbed on a 7.5 km section, with bank fortifications for high and medium waters, preventing further collapse of the banks of the Morača riverbed, flooding of surrounding agricultural areas and endangering facilities of interest to the wider community and the state (bridge, railway, etc.). Another important project is “Regulation of Lim (with Grnčar) with a view to combat climate change and provide for integrated management of natural resources.” The project is implemented by the Ministry of Agriculture, Forestry and Water Management in cooperation with the World Bank, and is funded by grants from the Global Environment Facility (GEF) and the Special Climate Change Fund (SCCF). The municipalities covered by the project are: Gusinje, Plav, Andrijevica, Berane and Bijelo Polje. This project will create conditions for the implementation of capital infrastructure works on the construction of multi-purpose bank fortifications on Lim and Grnčar.

Companies and other legal entities managing reservoir and retention basins are obliged to maintain and use them in a way that ensures the attenuation of flood waves. Furthermore, legal entities are obliged to prepare operational instructions for the management of reservoirs intended for flood protection, and especially for multi-purpose reservoirs. In 2018, the Ministry of Agriculture and Rural Development adopted the Rulebook on the content of operational instructions for the management of reservoirs intended for flood protection (Official Gazette of Montenegro 3/18 of 19 January 2018). As for the Adriatic basin, the following reservoirs have been formed in the Nikšić field so far: Liverovići, Krupac, Slano, Vrtac, as well as a smaller reservoir "Grahovo" in Grahovo field. The complete system of HPP Perućica in Nikšić field should play the role of active flood protection in the Bjelopavlići plain. As for the Danube basin, large reservoir "Piva" has been formed on the Piva River, as well as the reservoir "Otilovići" on Ćehotina. Existing reservoirs are now used mainly for single purposes, although they have mostly been designed as multipurpose.

3.2.5. Long-term development perspective

Water management in Montenegro must be based on continuity in long-term planning of the water sector functioning, in line with the principles of sustainable development, i.e., performing water activity in its basic areas (regulation and use of water, protection of water from pollution and regulation of watercourses and protection from harmful effects of water). Water protection is just one of the areas where the impact of global climate change is manifesting. Climate change has become an integral part of our daily lives. In recent times, due to climate change, efficient and sustainable flood protection is becoming an increasingly important issue worldwide, including in Montenegro, which is facing a major challenge in the necessary improvement of flood protection, early warning system for floods and readiness of the state and society to respond to the possible occurrence of extremes in the form of floods. Changes in the pattern of distribution, duration and intensity of precipitation and dry periods indicate changes in the water balance. According to the data available to date, the annual precipitation has not changed to a greater extent, but its extremes have become more pronounced and more frequent. Therefore, the impact of climate change should in no way be ignored or seen as irrelevant. As a result of global climate change, along with the impact of some anthropogenic activities on rivers (regulation, water use for various purposes, etc.),

we can expect extreme hydrological events to become even worse, i.e., high water levels during floods will increase and low water periods will get longer. In order to stop the increasing trend of potential damage, these phenomena require increased implementation of active protection measures (reservoirs, retentions, reconstruction of canal protection systems in valleys), as well as consistent application of non-investment protection measures. The spatial plans must preserve all locations that are planned for the construction of reservoirs in the frontal parts of the basin, as well as the areas of planned retentions for mitigation of flood waves in extreme hydrological situations.

Climate change requires continuous information and education of the entire population, with an emphasis on children of school and preschool age, as well as the adaptation of lifestyles to the expected climate change.

Reducing the risk of floods throughout the country is a permanent task and goal, while improving the protection of the most common flood-affected targets (cities, settlements, companies, traffic infrastructure, etc.) and works and measures on interstate watercourses are priority activities. The Water Management Strategy of Montenegro identifies projects whose implementation would have an extremely significant positive effect in terms of flood protection. These are:

- Regulation of Ćehotina River on the Ševari-Židovići section, municipality of Pljevlja (5.4 km);
- Regulation of Grnčar River through Gusinje and construction of an embankment (1.3 km), municipality of Gusinje;
- Regulation of Lim River on the Zaton section, municipality of Bijelo Polje (6 km);
- Rehabilitation of the embankment on Bojana, municipality of Ulcinj (12 km);
- Regulation of Kutska River on the Krkori-Kamena luka section, municipality of Andrijevica (3 km);
- Regulation of Gračanica River on the Halda-Gračanica canal mouth section, municipality of Nikšić (9 km);
- Regulation of Zeta River on the Brezovik-Slivlje section, municipality of Nikšić (9 km);
- Regulation of Tara on the territory of the municipality of Mojkovac (sections: Podbišće 2.7 km, Gojakovići 3.2 km and Polja 4 km);
- Regulation of Zeta River on the territory of the municipality of Danilovgrad upstream from Spuž (25 km)
- Regulation of Sušica River on the Oraška jama-mouth into Zeta section, municipality of Danilovgrad (5km)
- Construction of a flood-defense embankment on Skadar Lake;
- Regulation of locally important rivers.

According to the calculations made, it will be necessary to provide about EUR 120 million over the course of next 20 years for the implementation of these priority works and measures.

Protection against erosion and torrents, which implies the construction of new facilities and the execution of necessary protective works, requires significant resources, given their complexity and high cost, as well as the fact that a significant area is still subject to erosion processes. It is estimated that at least EUR 280 / ha should be invested in regulation of land with a lower erosion coefficient, where no additional afforestation is required, while in the case of higher degree of erosion the specific costs reach even up to EUR 2,000 / ha. In the territory of Montenegro, biological works on an area of about 100,000 ha are necessary. These works include afforestation, forest reclamation and grassing (within this framework, a change in the purpose of certain areas should be envisaged). As for technical (masonry) works, their volume can be estimated at approximately 800,000 m3. In order to achieve a satisfactory condition, around EUR 200 million should be invested in the anti-erosion regulation of endangered areas in the next twenty years. The entire flood risk management mechanism in Montenegro needs to be constantly upgraded and improved in accordance with the financial possibilities available either through the EU funds, other international funds and / or under the national budget

4. ITALIA

Flood Risk Evaluation in Ungauged Coastal Areas: The Case Study (Apuglia Region - Southern Italy)

4.1. Introduction

The growing concentration of population and the related increase in human activities in coastal areas require numerical simulations to analyze the effects of flooding events that might occur in susceptible coastal areas in order to determine effective coastal management practices and safety measures to safeguard the inhabited coastal areas. The reliability of the analysis is dependent on the correct evaluation of key inputs such as return period of flooding events, vulnerability of exposed assets, and other risk factors (e.g., spatial distribution of elements at risk, their economic value, etc.). This paper defines a methodology to assess the effects of flooding events associated with basin run-off and storm surge in coastal areas. The assessment aims at quantifying in economic terms (e.g., loss of assets) the risk of coastal areas subject to flooding events. The methodology proposed in this paper was implemented to determine the areas subject to inundation on a coastal area in Southern Italy prone to hydrogeological instability and coastal inundation. A two-dimensional hydraulic model was adopted to simulate storm surges generated by severe sea storms coupled with intense rainfalls in order to determine the areas subject to inundation in the low-land area along the Adriatic coast object of this study. In conclusion, the economic risk corresponding to four different flooding scenarios was assessed by correlating the exceedance probability of each flooding scenario with the potential economic losses that might be realized in the inundated areas. The results of the assessment can inform decision-makers responsible for the deployment of risk mitigation measures.

Urban development that occurred in the last decades is considered one of the key reasons determining an increase in occurrence and intensity of flood events with consequent social and economic damage in the affected areas [1]. Increase in flood occurrence has been recorded especially in small catchments where an increase in land use has had an impact on flooding areas [2–4]. In general, floodplains are areas characterized by the presence of stream channels developed by the combined effects of floods of variable scales and geomorphologic processes [5]. These areas are often mentionedas riparian regions or buffers [6,7] and are easily recognizable from adjacent areas due to variances in hydrological storage [8–10] and other environmental aspects [11]; therefore, an accurate flood mappingis particularly important to identify such areas. In fact, flood mapping is a crucial element of flood risk management. Furthermore, in small ungauged catchments, the lack of observed discharge data makes flood mapping very difficult as these data are required to calibrate hydrological and hydraulicmodels [12–14].

The increase in human activities due to global population growth requires the employment of numerical simulations to determine the effects of flooding events with the objective of informing riskassessments and management practices to be adopted in the affected coastal areas [15]. Coastal risk isstrictly connected to erosion phenomena and marine inundation [16–18]. Several studies have been conducted to investigate coastal flooding areas in recent years [19,20].

With regards to the Adriatic Sea, for example, several coastal inundation maps have been produced [21–23]; however, most studies have only focused on storm surge contribution.

Nevertheless, even though flood risk has been studied for a long time with the developmentof numerous numerical approaches [24], several aspects have not yet been completely investigated such as the influence of contemporary event of river floods and marine inundation, which all require further analyses.

Other studies [25,26] focused on floodplains located in hurricane-prone areas subject to heavy rainfall and storm surge have been carried out. These employ coastal hydrodynamic models coupled with topography-based hydrologic methods. These studies adopt a high-resolution modeling approach which requires high spatial/temporal resolution data sensitive to natural hazard characteristics such as storm intensity, track, and topography. This approach results computationally demanding, thus can be hardly applied to large areas.

Ray (2011) [27] and Torres (2015) [28] analyzed the combined effects of storm surge andinland rainfall using HEC-RAS, a widely used flow model, and generated floodplain maps under hurricane scenarios.

Heavy rain and sea storms, in the context of global sea level rise, increase the probability of coastal flooding in areas such as the Mediterranean Sea [29,30]. Recently, both Adriatic and Ionian sides of Apulia were flooded for thousands of square meters due to sea level surges generated by severe storms in connection with intense rainfalls [31].

As a consequence of the recorded sea level rise and the increased probability of extreme events,in recent years, there has been a growing interest in determining the economic consequences floods and erosions risk along coastal areas [32–34].

In line with the latest development made in recent years in this area of study, the purpose of this paper is to provide a methodology to assess the economic risk associated with four flooding hazard scenarios generated in a low-lying area by storm surges coupled with intense rainfalls.

Existing flooding maps in the test area have been generated using only rainfall as input to hydrodynamic models without taking into account the contribution of storm surges [35]. However, an economic assessment of inundation risk has never been carried out.

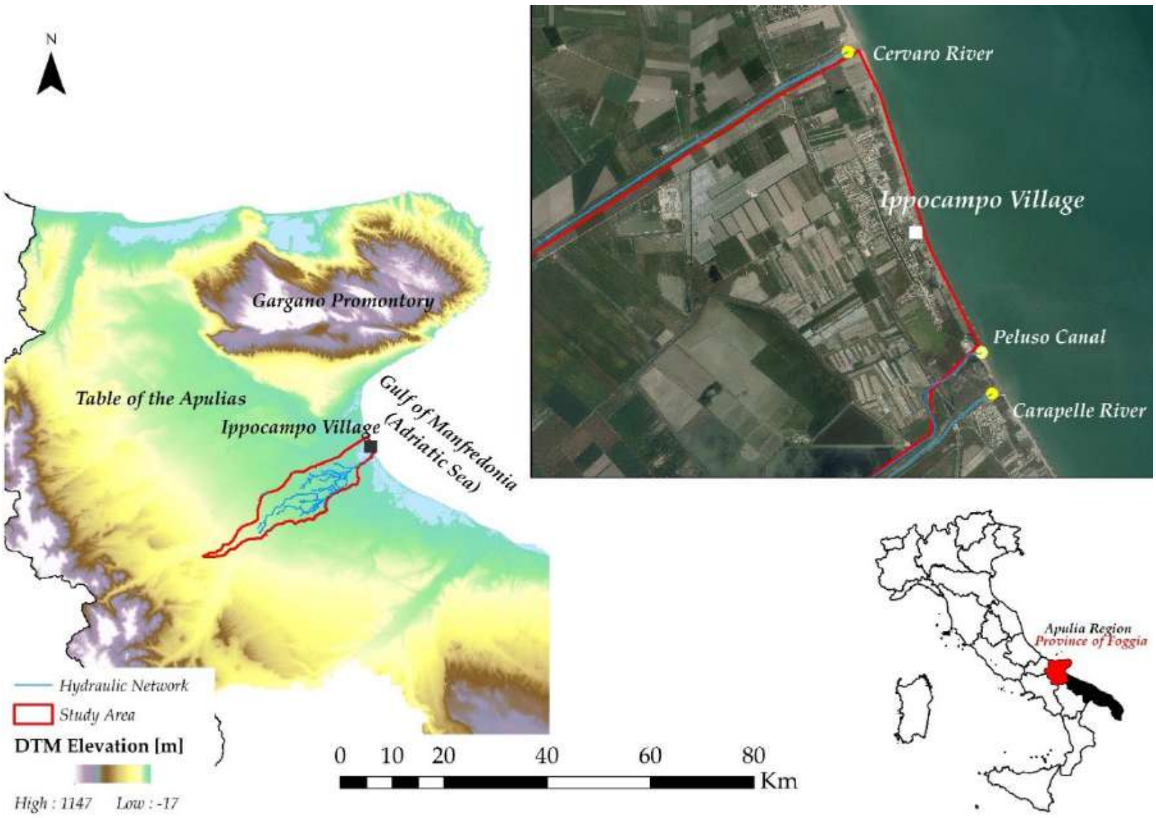
FLO-2D model has already been used to simulate storm surge inundation [36] and marine ingression coupled with intense rainfall [37]. Unfortunately, due to the lack of validation data, thesestudies have only conducted a qualitative analysis. In contract with previous attempts, a past storm surge event was simulated using the FLO-2D model at a small spatial scale and validation was carriedout with the aim of assessing the model accuracy in flooding prediction.

Hence, 1-, 30-, 50-, and 100-year return period predicted floodplains were used to perform an economic assessment. The economic consequences were determined by multiplying the economic value of elements at risk involved in each flooding scenario by their vulnerability, i.e., the percentage of damage associated with each typology of the element at risk [38,39]. The vulnerability was obtained through flood damage functions which are dependent on the damage of each element at risk with flooding water levels and flow velocity [40,41].

In the present paper, a "combined hydraulic modeling" is presented, whereas, in most studies, the risk assessment in a coastal area takes into account only storm surge contribution, even though, in low lying areas with the presence of water channels, the classical approach could provide an underestimation of economic risk (as shown in the "Results and Discussion" section). Moreover, the FLO-2D model output was validated by employing real data, proving the model to be an effective tool in identifying coastal areas exposed to storm surge inundation. In addition, it is very important to highlight that the geographical object of this study, despite being a flood-prone area, has not beenthe subject of similar studies in the past and therefore this study improves the knowledge around theidentification of the most vulnerable areas at a local scale under the guidelines provided by the 2007/60 Flood Directive.

4.2. The Study Area

The examined area is located within the Gulf of Manfredonia in the Adriatic Sea (Apulia Region, Southern Italy) and the coastline is oriented north–south with a narrow sandy beach backed by salt marshes and cultivated crops.The study area is crossed by an important hydrographic network and is bounded on the north bythe Cervaro River, on the south by the Peluso canal and the Carapelle River, and on the east by the Adriatic Sea.



The rainfall regime is Mediterranean with an average rainfall of 442.1 mm per year and an average of 63.4 rainy days per year. The maximum rainfall occurs in the autumn–winter period, with a strong dryness during the summer months [42].

Elevation is lower than 15 m above mean sea level and the area also includes a large part of the ancient Salso Lake. This area has historically been mostly uninhabited and wild, being naturally rich in marshes and swamps, and it is classified as a SIC (Site of Community Importance for the European Commission Habitats Directive—92/43/EEC) [43] (SIC IT9110005 "Capitanata wetlands").

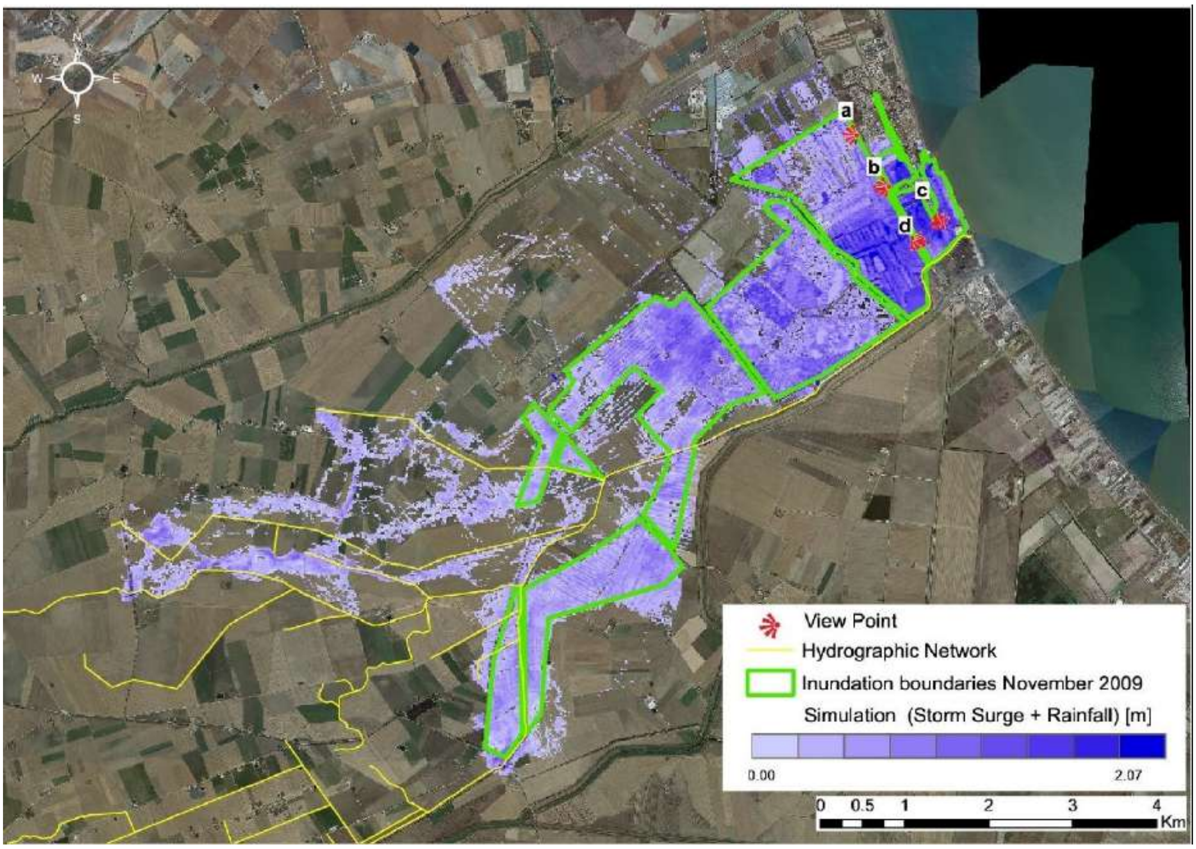
Starting from the 1970s, some local landowners gave impetus to an extensive reclamation of the area, which had already begun since the early twentieth century, transforming a highly natural landscape into intensively cultivated agricultural land and built-up areas. A large network of reclamation channels, currently in a poor state of conservation, was specifically built. The expansion of the cultivated land, to produce vegetables close to the coastline, destroyed the coastal dune cordon reducing it to a narrow embankment to protect crops. In that period, the Villaggio Ippocampo tourist complex was also built and further developed in the following years and nowadays in the summer period, there are more than 15,000 residents.

Since the mid-20th century, the long sandy beaches of the Gulf of Manfredonia have suffereda significative shoreline retreat due to a massive anthropic action [44]. At present, the retreating coastline extends from Margherita di Savoia to the Ippocampo tourist village and the erosive process is progressing towards the port of Manfredonia [31]. Due to the hundreds of protection structures builtin the past 40 years, the examined area has especially been observed in the last decades, becoming a "case study" [18].

In addition to coastal erosion issues, the study area is also aggravated by flooding hazard [35] because, due to the presence of low-lying and depressed areas, coastal flooding occurs also during ordinary storms. Furthermore, sea storms are often associated with significant meteoric events with consequent river overflow. However, it should be noted that, despite the twentieth-century anthropization, half of the territory to be examined can be classified as "natural area". About 50% ofthe natural areas are listed as habitats indicated in the Habitats Directive 92/43/EEC [43].

Trying to analyze the land-use, it is evident that the area, as already mentioned, is characterized by a strong anthropization, which totally transformed, in the last decades, the natural environments. Specifically, the construction of the "Ippocampo" tourist complex took place on brackish moist soils characterized by halophilous vegetation, which was recognized by the European Community as a habitat of community importance. The phenomenon of anthropization has also affected the beaches and the entire dune system, both for the construction of the shores and the cultivation of the land. Together with the total obliteration of the dune cordon to make way for the bathing structures, various degrees of transformations of coastal dunes are found, ranging from the construction of an embankment to protect the internal spaces with the planting of exotic species (e.g., *Carpobrotus acinaciformis*), to the reduction of the original dune and its typical dune vegetation (e.g., *Ammophila* sp.). These data highlight the importance of the examined area from the point of view of environmental conservation.

Figure 23. Map of flooded area in the study reagion



4.3. Main results of the analysis

The first set of simulations was run to check the reliability of the inundated areas and the accuracyof the simulated flooded areas had been checked by comparing the model outputs with the effects of an observed event.

In November 2009, a severe meteo-marine event struck the examined area, causing flooding and considerable damages. In the hours following the disaster, a quick field survey was carried out in the area to detect inundated regions and numerous photographs had been taken (Figure 5). Initially, following the common practices for the evaluation of the risk on the coastal areas [21–23], a FLO-2D model based only on storm surge input was defined exploiting the water levels and wave data collected in the area. However, it proved unable to fully return the observed floodplain, because only the areasclosest to the coast were flooded.

Therefore, a combined model that included both storm surge and flood input was run and the accuracy of the simulated inundation areas was tested comparing the model results with the observedflooded areas. Quite good accordance was found, as shown in Figure 6, even if some differences, especially in the agricultural area, can be explained considering that observed inundation boundarieshave been collected during an expeditious survey along the damaged roads in the days following the event. In the urban zone, where the post-event flooding area was detected with extreme detail, the numerical results perfectly overlap.

After the model results validation, the FLO-2D [45] model processed for each selected scenario (T_R = 1-, 30-, 50-, and 100-year return period) two flooding simulations, one considering only the storm surge contribution and one using the storm surge combined with the rainfall.

Storm surge and rainfall depth were modeled considering the same return period, since in the case of a small catchment, mostly located in the coastal areas, the same synoptic weather system may induce extreme sea level and heavy rainfall [83]. Moreover, Bevacqua et al. [84] and Moftakhari et al. [85] confirmed a substantial decrease in return periods if the joint occurrence probability of sea water level and river discharge is considered. Hence, in these cases, in favor of safety, it could be appropriate to consider the probability distribution of the extreme events of the two random variables substantiallycoincident, because the meteorological forcing is the same. Therefore, the presented combined modelrepresents the worst-case scenario and could be a useful tool for coastal area management.

The simulation provided results in the form of flood maps in terms of flow depth and velocity. These maps presented zones affected by values of both flow depth and velocity that were negligible for the realistic evaluation of the connected hazard distribution. Technical literature called these areas "marginals". The delimitation of the "marginal inundation areas" was carried out following the methodology suggested by the River Tevere Basin Authority [86].

The applied methodology conservatively considers a water depth above 0.2 m and a velocity flow greater than 0.3 m/s as the limits of danger, whereas the flooded areas with smaller values are definedas marginal areas. In particular, all water depth values >0.2 m were considered to identify flooding areas, regardless of velocity values. At the same time, all velocity values >0.3 m/s were considered, regardless of depth values.

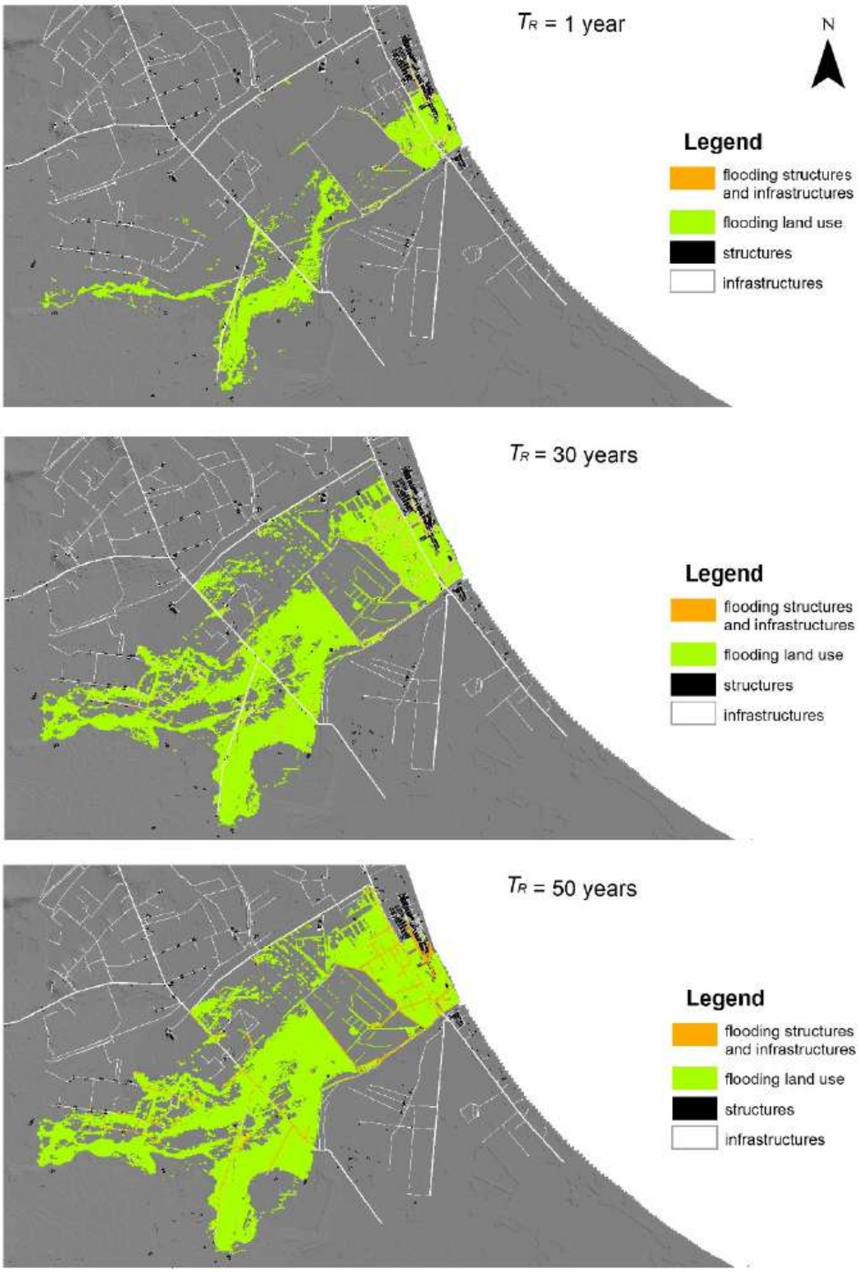
Following this approach, all flooded areas resulting from the hydraulic simulations were mapped (see Figure 7 for the storm surge model and Figure 8 for the integrated model). To develop hydraulic modeling, FLO-2D is preferred, for which the numerical stability was preliminarily verified. This aspect made possible simultaneously modeling both the storm surge input and the flood hydrographs for the different return periods, in a more detailed calculation domain. The inundation contours simulated with the FLO-2D model (see Figure 8) highlight the presence of large areas at risk of marine ingression in all the investigated scenarios and the flooded areas increase further if the rainfall is included in the model.

The zone most affected by flooding includes built-up areas, wetlands, and agricultural land, constituting a potential hazard for people, facilities, and viability. The presence of channels and rivers heavily affects the result of the analysis. The water channels, in fact, constitute a preferential way of marine ingression directing water inland for hundreds of meters and in the case of combining with heavy rain, due to the increased water depth in the channel, the flooding event involves a greater area. The extension of flooded areas increases as the year return period increases, but it is important tohighlight that even a one-year return period event will inundate the urban area. Consequently, this scenario was also considered in the risk assessment of the study area.

The output of flooding simulations, in terms of flooding hazard maps, was combined with the distribution in the study area of elements at risk to carry out the exposure analysis according to Figure 4.

This procedure was applied for both flooding simulations, i.e., both considering only the storm surge contribution and using the storm surge combined with the rainfall (combined model). In Figure 9, the elements at risk, subdivided into structures, infrastructures, and land use, involved in flooding areas derived from the four combined models are highlighted.

Figure 24. Elements at risk in flooding areas for the four hazard scenarios of combined model.



Subsequently, for each of flooding scenarios and each category of elements at risk, the amount of exposed assets potentially involved in the flooding events and their economic values were computed.Therefore, the consequences were obtained by multiplying the economic values of the exposed assetswith vulnerability values, deduced from the damage functions in Table 3. Finally, the total economic losses associated with each flooding scenario were computed by summing the consequence values of the five categories of elements at risk. The results of exposure and risk assessment are synthesized inTables 4 and 5. The first one is related to modeling with only storm surge input, while the second one refers to the combined model (storm surge and rainfalls). The final values of risk, or economic losses,corresponding to a different return period of flooding events are also shown in Figure 10 in the form of risk curves.

Table 15. Amount and economic value of exposed assets and overall consequences, for each element at risk category and flooding scenario, considering only the effect of storm surge.

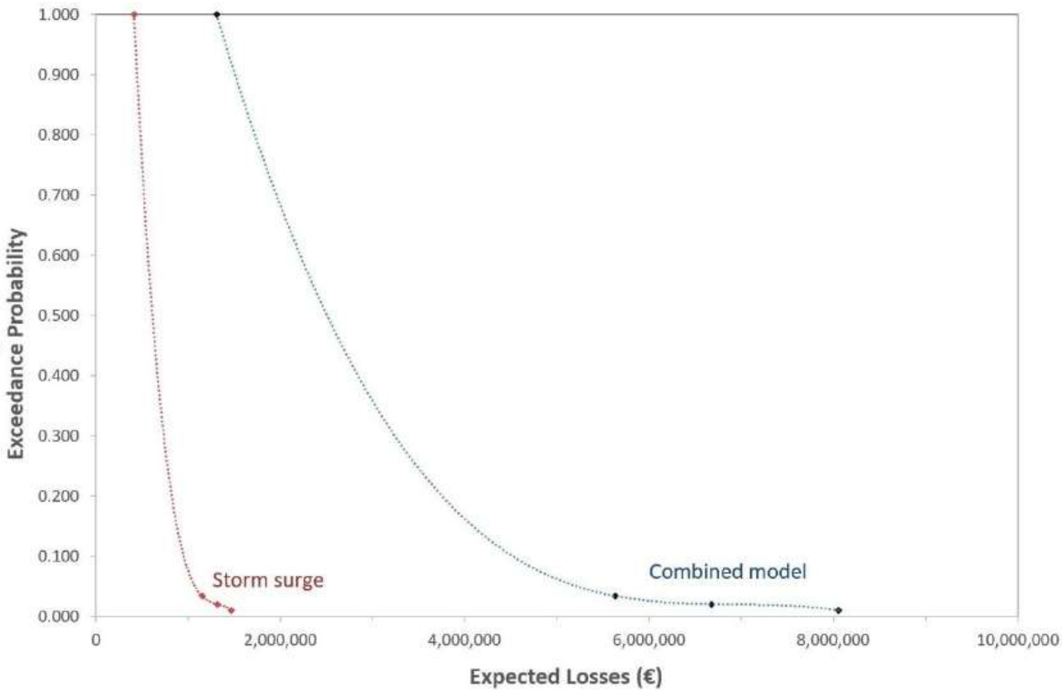
Elements at Risk	T_R	Exceedance Probability	Amount (sqm)	Economic Value	Consequences	Total Economic Losses
Buildings	1	1	163	€891,831	€163,634	
Other structures	1	1	365	€35,470	€4661	
Road	1	1	36,762	€1,028,209	€207,380	
Specialized land use	1	1	1903	€4563	€1783	
Unspecialized land use	1	1	585,449	€315,691	€34,665	€412,123
Buildings	30	0.033	1864	€3,432,475	€633,715	
Other structures	30	0.033	632	€61,271	€13,060	
Road	30	0.033	57,393	€1,604,410	€414,963	
Specialized land use	30	0.033	1903	€4563	€4080	
Unspecialized land use	30	0.033	728,335	€421,024	€84,052	€1,149,870
Buildings	50	0.02	2234	€4,379,509	€774,118	
Other structures	50	0.02	632	€61,271	€13,640	
Road	50	0.02	59,299	€1,657,620	€435,358	
Specialized land use	50	0.02	1925	€4616	€4212	
Unspecialized land use	50	0.02	739,636	€427,151	€88,295	€1,315,623
Buildings	100	0.01	2407	€4,721,521	€880,093	
Other structures	100	0.01	632	€61,271	€14,794	
Road	100	0.01	64,811	€1,811,336	€474,252	
Specialized land use	100	0.01	1,925.01	€4616	€4319	
Unspecialized land use	100	0.01	759,036	€441,781	€96,043	€1,469,500

Table 16. Amount and economic value of exposed assets and overall consequences, for each element at risk category and flooding scenario, considering the combined effect of storm surge and rainfall.

Elements at Risk	T_R	Exceedance Probability	Amount (sqm)	Economic Value	Consequences	Total Economic Losses
Buildings	1	1	917	€1,777,765	€271,608	
Other structures	1	1	365	€31,210	€3689	
Road	1	1	98,534	€2,703,967	€517,629	
Specialized land use	1	1	56,000	€127,087	€49,089	
Unspecialized land use	1	1	4,050,000	€6,241,545	€466,578	€1,308,593
Buildings	30	0.033	5967	€10,291,706	€1,867,053	
Other structures	30	0.033	633	€61,568	€13,090	
Road	30	0.033	270,945	€7,408,776	€1,592,121	
Specialized land use	30	0.033	316,000	€559,501	€251,005	
Unspecialized land use	30	0.033	12,780,000	€21,062,380	€1,912,155	€5,635,423
Buildings	50	0.02	7030	€11,999,597	€2,233,376	
Other structures	50	0.02	633	€61,568	€13,759	
Road	50	0.02	302,982	€8,278,693	€1,817,806	
Specialized land use	50	0.02	400,000	€683,770	€319,958	
Unspecialized land use	50	0.02	14,440,000	€23,938,683	€2,291,826	€6,676,725
Buildings	100	0.01	7931	€13,425,906	€2,678,795	
Other structures	100	0.01	633	€61,568	€14,847	

Road	100	0.01	350,619	€9,558,971	€2,125,702	
Specialized land use	100	0.01	524,000	€861,115	€412,420	
Unspecialized land use	100	0.01	16,680,000	€27,819,598	€2,826,192	€8,057,956

Figure 25. Risk curve: Expected losses plotted against the related exceedance probabilities.



Tables above show that economic losses corresponding to the first scenario, flooding at one-year return period, are already relevant if compared with the other three scenarios. Therefore, it representsthe risk scenario to be considered to plan mitigation measures. Moreover, the amount, in square meters, of structures (buildings and other structures) undergoes slight variations among the last three scenarios (T_R = 30, 50 and 100 years). This is due to the configuration of flooding areas, which, as shown in Figure 9, are nearly similar for these scenarios. This effect is even more evident for the storm surge modeling (in Table 4), observing the values of total economic losses for 30-, 50-, and 100-year scenarios. Land elevation in coastal areas subject to inundation from storm surge is below mean sea level and, hence, a low return period event is sufficient to completely flood the urban area.

Furthermore, the elements at risk mostly affected by flooding events are agricultural areas and roads, which represent preferential flow paths. Finally, the risk curves in Figure 10 highlight that the combined flood modeling provides more complete results in terms of potential economic losses. This aspect is confirmed in Figure 7, which shows that the storm surge alone could not sufficiently justify the flooding areas.

Quantitative risk estimation methods are often limited by the lack of data on calamitous events, information on damages, and related costs, although an increase availability of data is lately being recorded in the technical literature with regard to risk related to natural hazards.

In this paper, a "combined hydraulic modeling" is proposed to identify the hazard map in an ungauged coastal area. In contrast with most studies, in which the risk assessment in a coastal area only takes into account the storm surge contribution in adherence to the classical approach, this study shows that in low lying areas with presence of water channels the classical approach would lead to an underestimation of the economic risk. To improve the estimate of the economic risk, a two-dimensional hydraulic model was adopted to assess the coastal inundation risk zones in the area along the Adriatic coast. The model enabled the simulation of a storm surge approaching a low sandy beach simultaneously affected by river flooding.

Firstly, the output of the model was validated by employing real data to demonstrate its effectiveness in identifying coastal areas exposed to storm surge inundation.

Secondly, the output of flooding simulations was combined with the distribution of the elements at risk in the study area to determine the level of exposure. This procedure was applied for both flooding simulations, i.e., in the presence of only storm surge contribution and in combination with rainfall. Subsequently, the amount of exposed assets potentially involved in the flooding events and the related economic values were computed for each flooding scenarios and for each category of elements at risk.

Finally, the total economic losses associated with each flooding scenario were computed by summing the consequence values of all categories of elements at risk.

The results show that economic losses corresponding to the first scenario analyzed are already relevant when compared with the other three scenarios for floods of one-year return period. These results represent the risk scenario to be considered to plan mitigation measures. The results also showthe surface area amount, in square meters, of civil structures subject to slight variations in the last three scenarios considered with return periods of 30, 50, and 100 years. This becomes even more evident forstorm surge modeling when observing the values of total economic losses for the 30-, 50-, and 100-year return period scenarios. The particular trend of the risk curves determined can be explained by the peculiar topography of the flooded area are characterized by negative elevation respect to the medium sea level. This is the reason a low return period event can also be sufficient to completely flood the urban area.

The risk curves for the flood combined modeling provide more complete results in terms of potential economic losses. This was confirmed by the necessity of the combined hydraulic model which is proposed in present work.

The approach adopted in this work can deliver a concrete support to decision-makers responsiblefor the identification of measures aimed at reducing the flood risk and for the implementation of flooding protection policies detailing safety interventions. A further development of this work will account for the indirect and intangible losses at basin scale in accordance with the 2007/60 Flood Directive.

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3 WATCH OUT

ANALYSIS OF RISKS IN PROJECT AREAS
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