SETOF Soil Erosion and TOrrential Flood Prevention: Curriculum Development at the Universities of Western Balkan Countries

Co-funded by the Erasmus+ Programme of the European Union

WP1

Analysis of soil erosion state and torrential floods in Western Balkan Countries

Lead Organisations of WP1**: UNSCM; UB**

Participating Organisation: UNS;UNI; UBL; UNSA; INSZASUM; BOKU; UNIRC; FRI-BAS

Deliverable 1.2

Title : **Analysis of torrential floods in WBC**

Participating Organisation: UNSCM; UB; UNS; UNI; UBL; UNSA; INSZASUM

Project number: 598403-EPP-1-2018-1-RS-EPPKA2-CBHE-JP (2018 – 2579 / 001 – 001)
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PROJECT INFO

Project title	Soil Erosion and Torrential Flood Prevention: Curriculum Development at the Universities of Western Balkan Countries
Project acronym	SETOF
Project reference number	598403-EPP-1-2018-1-RS-EPPKA2-CBHE-JP(2018-2579/001-001)
Coordinator	University of Belgrade
Project start date	November 15, 2018
Project duration	36 months

DOCUMENT CONTROL SHEET

Ref. No and Title of Activity	1.1. **Analysis of torrential floods in WBC**
Title of Deliverable:	Report on Analysis state of torrential floods in North Macedonia
Institutions:	Ss. Cyril and Methodius University in Skopje, Faculty of Forestry in Skopje, North Macedonia
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Status of the document:	final

Project number: 598403-EPP-1-2018-1-RS-EPPKA2-CBHE-JP (2018 – 2579 / 001 – 001)
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4.1. Introduction

Average annual precipitation is 730mm unevenly distributed in space and time. Rainfall varies from 400 mm in the central and eastern to 1,400 mm in the westernpart of the country, and occurs mainly from October to December and March to May. In an average year the evapo-transpiration is higher than rainfall (see table 1 – PET), leaving crops with a water deficit of 250 mm in the west and 450 mm in the eastern part of the country. About 75 percent of the country is classified as a semi-arid region. The country is also very prone to droughts and some regions are significantly vulnerable to desertification (aridity index Ai<0,65).

Table 1 – Basic climatological elements (NAP DLDD 2015)

MS	t	P	PET	Ai	High intensity precipitations with various duration (20-1440')							
	°C	[mm]	[mm]		20'	40'	60'	90'	150'	300'	720'	1440'
Veles	13,2	443	772	0,57								
Kavadarci	13,3	467	781	0,60								
Štip	12,6	473	748	0,63	25	29	31	31	31	33	46	47
Radoviš	12,2	481	755	0,64								
Ergelija-Sv.Nikole	12,8	482	734	0,66								
Skopje –Zajcev Rid	12,4	507	725	0,70	30	37	41	42	43	50	57	63
Kočani	12,6	523	755	0,69								
Kumanovo	12,0	530	709	0,75								
Strumica	13,0	548	751	0,73								
Delčevo	10,8	548	668	0,82								
Prilep	11,0	555	684	0,81								
Demir Kapija	13,7	572	772	0,74	40	45	46	46	49	50	68	91
Bitola	11,1	612	687	0,89	39	55	69	78	90	93	93	113
Valandovo	14,1	614	794	0,77								
Berovo	9,2	628	602	1,04								
Nov Dojran	14,1	636	790	0,81								
Kriva Palanka	10,4	645	647	1,00	30	37	41	46	59	91	111	114
Gevgelija	14,2	679	797	0,85								
Ohrid	11,2	696	675	1,03	40	45	46	46	49	50	68	91
Kratovo	10,8	704	670	1,05								
Makedonski Brod	11,0	711	656	1,08								
Resen	9,8	714	622	1,15								
Tetovo	11,3	748	683	1,10								
Kičevo	11,0	771	679	1,14								
Solunska Glava	0,9	803	371	2,17								
Kruševo	8,3	808	590	1,37								
Debar	11,1	881	701	1,26								
Popova Šapka	4,5	996	481	2,08								
Lazaropole	7,0	1067	535	2,00	32	35	40	40	43	46	48	51
Average	**11,1**	**645**	**772**		34	40	45	47	52	59	70	81

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4.2. Status of the water resources

The hydrographic territory of the Republic of Macedonia is divided into four river basins: Vardar, Strumica, Crn Drim and Juzna Morava (figure 1).

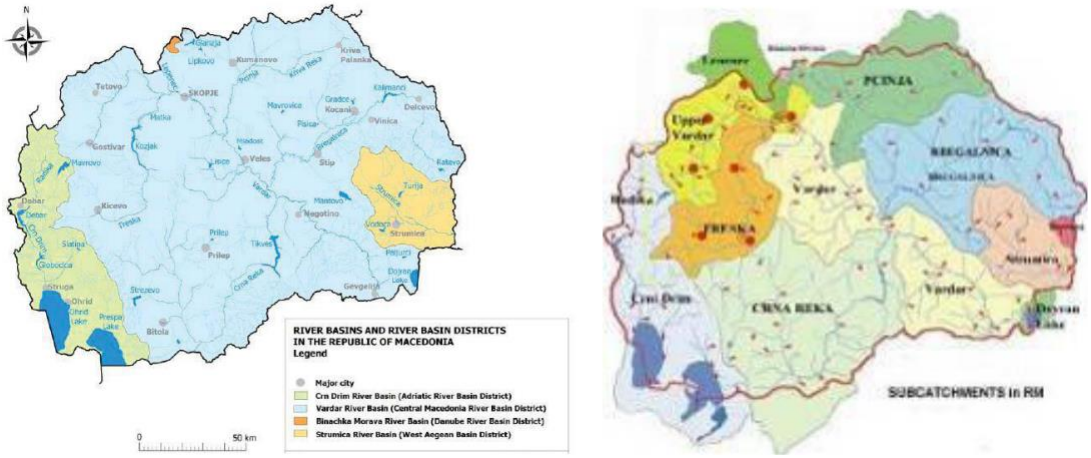

Figure 1– Basins and sub-basins

Vardar river basin is the largest (20.546 km2 or 79,9%) and gravitates towards Aegean Sea. Strumica river basin is on south-east part of the country (1.520 km2 or 5,9%), is a tributary of Struma River in Bulgaria, and gravitates also towards Aegean Sea. Crn Drim river basin is on west part of the country (3.355 km2 or 13%) and gravitates towards Adriatic Sea. Juzna (South) Morava river basin is on north part of the country, is the smallest one (44 km2 or 0,2%) and gravitates towards Black Sea. The surface inflowing waters are the rivers: Lepenac, Pcinja and Elaska and the out flowing waters are rivers Vardar, Strumica, Crn Drim, Cironska, and Lebnica. Mean annual sum of precipitation are as follow: in Vardar river basin 700 mm, in Strumica river basin it is 790 mm, and in Crn Drim river basin it is 980 mm.

The total water resources of the Republic of Macedonia are estimated at 6,37 billion m3 in a normal year and 4,80 billion m3 in a dry year, out of which 72,19% are carried in the Vardar basin, 25,74% in Crn Drim basin and 2,07% in Strumica basin.

There are 4.414 springs with total yield of 991,9 million m3/year, of which 58 have a capacity of over 100 l/s. Three natural lakes, Ohrid (358 km2, Macedonian part 229.9 km2 and with maximum depth of 285 m), Prespa (274 km2,Macedonian part 176.8 km2 and with maximum depth of 54 m) and Dojran (43 km2,Macedonian part 27.4 km2 and 10 m depth) have also great significance for the hydrographic characteristics of the Republic of Macedonia.

There are also 25 small lakes that are of glacial origin situated in the highest parts of the mountains. Beside it, there are 22 larger dams and reservoirs and over 100 smaller reservoirs. Total annual precipitation on the territory are 19,5 x 10^9 m3, External inflow – 1,014 x 10^9 m3 Total actual outflow is 6,322 x 10^9 m3.

In the latest 10 years (2004-2013), total mean annual discharge of rivers outflow from Macedonia vary from 55 m3/s (2007) up to 160 m3/s (2010).

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There are 44 wetlands (including lakes) in the country, having an area of 57.422 ha or 2,23 % of the total area of Macedonia. Groundwater on the territory of the Republic of Macedonia is generally divided in two kinds of lithological formations – Quaternary and Neogene formations with characteristic intergranular porosity and carbonate formations with karst porosity. Karst formations with porosity have minor importance for water distribution

Total annual available surface water resources in the country are assessed as 6,372 billion m^3 (Vardar basin – 4,6 - 72%, CrniDrim – 1,64 – 26%, Strumica 0,132 – 2%). The yearly average water availability from surface resources for a medium dry year accessed as 4,5 billion m^3.

Table 2 –Main hydrological parameters of the biggest rivers (Water strategy)

River	River basin	Catchment area (km^2)	River Length (km)	Average annual flow (m^3/s)	Average annual volume (10^9 m^3)	Specific run-off ($l/s/km^2$)
Vardar	Vardar	20.661	301	63-145 [a]	4,600	7,0
Treska	Vardar	2.068	139	24,2 [b]	0,764	12,9
Lepenac	Vardar	167 (*770*)	21(*75*)	8.7	0,271	11,2
Pcinja	Vardar	1893 (*2.841*)	83 (*137*)	12,6 [c]	0,400	4,6
Bregalnica	Vardar	4.344	..	12,2 [d]	..	4,1
CrnaReka	Vardar	4.985	228	29,3	..	5,1
Bosava	Vardar	468	52	23,4 [e]	..	..
CrnDrim	CrnDrim	3.359	45	52,0 [f]	1,640	12,3
Radika	CrnDrim	665	67	19,3	..	..
Strumica	Strumica	1.649	81	4,2 [g]	0,132	3,1
Binachka Morava	Bin.Morava	(44)	(5)	..	..	..

Legend: [a] 63 in Skopje; 145 in Gergelija; [b] at its confluence with the River Vardar; [c] at Katlanovska Banja; [d] in Shtip, [e] at Rasimbegov Most; [f] at Shpilje hydro power station; [g] at Novo Selo

Values represent situation in the North Macedonia, full area or length of river that enter in NM are with italic font

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4.3. Historical evidence of floods

Macedonia is a disaster-prone country that is particularly vulnerable to the risk of floods that are the dominant natural hazard. The key natural factors increasing the flooding risk, besides topographic and land characteristics, and a relatively dense hydrographic network in the most affected regions are heavy precipitations. In addition, the changes in the land-use/land cover structure are further modifying hydrological regimes, increasing the risk of extreme hydrological events. Additional causes of the growing flooding risk include: a) reduced conveyance respectively discharge capacity of existing regulated river sections (e.g., because of poor maintenance of existing river regulations, conversion of floodplains/river corridors); b) aging and poorly maintained hydraulic and/or flood control infrastructures (e.g., drainage systems, embankments and levees); and c) operating regimes of existing multi-purpose dams and reservoirs not optimized properly to enable better flood risk mitigation.

.Most river basins in the country experience dramatic periodic variations in water flow, and the risk of floods is further exacerbated by the country's mountainous topography and land structure. River floods in the major basins in the country are caused by long periods of rainfall and rapid snow melting. Torrential floods occur in smaller basins characterized by dominantly mountainous topography. In recent years, extreme weather events caused by changing climate conditions, including torrential rains, have heightened flood risk in the country; human factors are also at work. Damages and losses caused by floods have also been on the rise.

The number and intensity of floods in the country are rising. During the last three decades regional floods caused by the biggest rivers in Macedonia usually happened in the colder part of the year (November – February). River floods are caused by long periods of rains and intensive snowmelt or a combination of both. Beside them, there are very frequent flash floods caused by short and intensive rains (most frequently summer storms) in smaller basins especially mountain torrents Due to the geomorphology and climate, the Republic of Macedonia is very liable to both, river (regional) and torrential (local flash) floods.

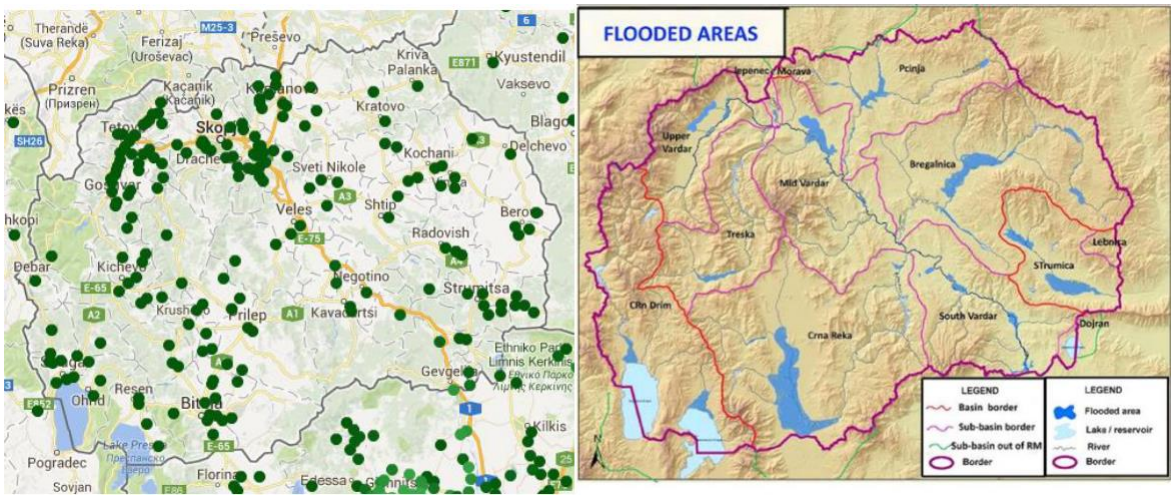

Figure 2- Flood events and flooded areas in the country (Blinkov I. 2016)

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As a result of intensive rainfalls and increase of level of groundwater combined with bad maintenance of channel beds and river outflow, there is appearance of floods in flat area especially on previously ameliorated former wetlands as: Pelagonija, Skopsko Pole, Strumichko Pole. Almost all rivers cause floods and over 102.000 ha could be flooded, considering 100-year return period. Rural areas were dominantly affected during the floods.

The floods of 1962 and 1979 resulted in economic losses of approximately 7,2-7,4% of GDP (for each year), while the floods in 1994 caused losses of 3.4% of GDP. Flooding in 2004 affected 26 municipalities. Floods participate with 50% of all registered natural disaster and 94,8% of estimated costs of damages. In the following table are presented mayor flood events (>10 ME damages).

Table 3 - Major flood events in the 2003-2018 period

Date	Affected municipalities.	Losses and damages ME	Affected population	Dead people	Type
January 2003	4			3	River
June 2004	26	15	100 000	0	R+T
February 2013	7		10 000	1	R+T
Jan. – Feb.2015	43	35,7	170 000	0	River
August 2015	3	25	10 000	6	Torrent
August 2016	10 - 2extremely	100	450 000 (20 000)	22	Torrent

Source: Blinkov, (2015, 2016) and http://www.emdat.be/country_profile/index.html

During the period 26th of January and 6th of February 2015floods and landslides affected the Republic of Macedonia. The bed weather conditions resulted with high level of the rivers and flooded 44 out of 80 municipalities in the country. The most disastrous flood happened in 2016 in the Skopje region when 22 persons died while total costs of damages haven't been estimated yet but achieve more then 100 MEs.

Landslides and rock falls are generally occurring in the several main engineering geological zones susceptible to different types of slope failure. More than one hundred larger landslides exist, with specific conditions and influences on surrounding media.

Exactly 1.539 torrents are registered in Macedonia (Gjorgjevic et al, 1993). Mudflow and debris flows are typical for this type of torrents. Normal consequence of these events besides flooding of the area and damages is the huge quantity of sediments deposed in the downstream section even big boulders rocks with volume up to 30 m^3. These torrents caused enormous damages and loses to the Macedonian economy. Beside this significant number of people died as a consequence of torrent flash floods.

The most vulnerable region to torrent debris floods is Tetovo-Polog region where in 2015 happened catastrophe. In the other regions dominate mudflow floods (f.e. Skopje region torrent floods 2016), Radovish flood (2008), Bogdanci flood (2004), Strumica(2010,2013) etc., various torrent through the country in 2010, 2013 etc. The most active torrent is Djepcishki Poroj that every year flood and block the regional road Tetovo - Jazince (Kosovo) and the agricultural land deposing huge quantity of sediment even big boulders and in 2015 cumulative volume of sediment form few years achieved more then 200 000 m^3.

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4.4. Preventions measures for torrential floods

The overview of measures and activities for achieving objectives for protection against floods and other harmful effects of water encompass the following measures: (i) construction of reservoirs and (ii) preparation of *good practice* guidance for sustainable river training.

Flood Protection

Administrative instruments	1. Preparation of program for protection from harmful effects of waters within the respective river basin as an integral part of plans for river basin management. 2. Improve of regional and urban planning (improve of rulebook for planners with flood hazard items) 3. Disabling of spatial construction work especially critical facilities and other activities that could increase exposure to flooding and damage. 4. Implementation of Floods Directive (Directive 2007/60/EC) (Preparation of preliminary flood risk assessment, flood hazard maps, flood risk maps and flood risk management plans according to Floods Directive) 5. Rising of public awareness. 6. Preparation of detailed flood plans for local/regional centres. 7. Preparation of integral international plans for flood protection.
Structural flood protection measures	1. Maintenance of water buildings (dams, reservoirs, protective embankments etc.) in a way that ensures acceptance of flood waves, as well as providing protection from natural disasters. 2. Providing preventive measures (construction of dykes, reservoirs, river regulation, check dams, retention channels, ponds, other erosion and torrent control works, afforestation, etc.). 3. Utilizing floodplains and wetlands as natural flood storage areas.
Rehabilitation measures	1. Removal of waste, rubble and barren from floodplains. 2. Non-structural flood protection measures. 3. Improvement of catchment level planning especially forest management planning on flood management measures. 4. Integration of rural land use and flood management policies and funding. 5. Improvement of hydro meteorological prognosis. 6. Preservation of retention areas (floodplain and wetlands). 7. Arrangements of integral urban development plan (avoiding from areas with flood risk). 8. Intense control over interventions on areas with flood risk. 9. Education of engineers and other water related workers

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Erosion Protection

Administrative instruments	1. Preparation of program for protection from harmful effects of waters within the respective river basin as an integral part of plans for river basin management. 2. Adopting actual and potential erosion risk areas on the national and municipality level 3. Proclaiming protective forest 4. Improvement of forest legislation related to erosion and torrent control (forest law and rulebook for preparation forest management plans) 5. Preparation and implementation of legal framework for protection of reservoirs from sedimentation. 6. Prohibition and restrictions for cutting of trees and shrubs and prohibition of cattle grazing in high erosion prone areas. 7. Prohibition on removing soil, sand, gravel and stone within erosion area.
Structural erosion and torrent protection measures	1. Considering of general rules against erosion in forest land (i.e. planting of trees must be done in a way that provides protection from erosion etc). 2. Considering of rules against erosion on agricultural land (appropriate ploughing and other "good agricultural practices" as cover crops, strip buffer, terracing, mulching …..). 3. Considering of rules against erosion on construction (roads, railway, pipeline,…….) sites f.e. adopting erosion and sediment control plan. 4. Considering of rules against erosion on mining sites. 5. Considering of rules against erosion on landfills, ash slag disposal sites. 6. Sustainable forest management (appropriate management of protective forests, appropriate management of other forests. 7. Afforestation and grassing of bare slopes. 8. Construction various cross structures (check dams..) and longitudinal structures into the torrent bed. 9. Various erosion control measures on the catchment (retention channels, retention ponds. 10. Usage of ecological friendly materials in erosion control on variosartificial slopes (blankets, hydroseeding or hydromulching, blown straw, straw blankets and wattles, coir logs and blankets, turf reinforcement mats (TRMs), filter and compost socks. 11. Construction appropriate erosion control structures on the artificial slopes in urban areas …..). 12. Maintenance of erosion/torrent protection constructions. 13. Appropriate planning, designing , construction and maintenance of forest roads.

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Irrigation and Drainage activities can contribute to flood management too.

Measures to **control torrents** were initiated in the early 1900's, aimed mostly at protecting rivers and reservoirs. About 65% of designed hydraulic structures within the designs was built, but only 25% of planed afforestation are realized in the period 1945-2014 more then 200 000 ha bare lands are afforested. The percentage of success is not known up to now, but estimated at reaching 70%. (Blinkov and Trendafilov, 2005)

The first written documents related to erosion and its control on the territory of North Macedonia is the King Dusan Law from the year 1349 (when North Macedonia was a part of the Dusan's kingdom). The article 123 (for Sasi) is a response tothe forest'sdestruction by the miners Sasi. "*Territory where Sasi cut the forest till this date, let it belong to them; If they illegally occupy land that belongs to any ruler, lest they be punished according to the king's Law.; from now to the future, Sasi must not cut the forest, if Sas cut the forest, they should leave the land, not to plough, not to settle, but let it empty, to allow forest growing….*"

After huge destroying of forests, in 1858 the so-called "Ramadan law", which refers to nature, forests, and water, was adopted. In 1869 the so-called "The Law of Chevalier", was proclaimed. These laws regulate the property -legal status. In addition, thesealso regulated the use for the forests, i.e., forests for cutting or not and if they are not available for grazing. All of this was planned to be implemented by 1905.

The organized measures to control erosion were initiated in the early 1900's, aimed mostly for protecting rivers and reservoirs.In 1913/14, i.e. after the Balkan wars and the end of the Ottoman rule, a special forestry commission evaluated the situation in North Macedonian forestry and concluded that was very unsatisfying: presence of waste bare lands, deforested, mostly by over-exploitation and over-grazing, problems with summer drought and forest fires, lack of planned management, deficiency of finances etc.

The first reforestation started already in 1914. Besides of poor financial situation, lack of experts and field experience etc., the reforestation for relatively small scale and on various terrains was performed even during the First World War (Kolevskaet al., 2017).

With the formation of the Kingdom of SCS, in 1922 the "Law on Forests" was adopted.
In the period 1919-1927 were drained 6000 ha in Skopje Valley. Significant activities were carried out for erosion and torrent control (GWD, 1928). In 1928 there was established a big forest nursery in Skopje, and part of the seedlings were used for first reforestation of the Mt. Vodno, to protect the Skopje city from erosion and torrents from the Vodno Mountain. In 1929, a law was passed on the administrative body of the kingdom, dividing it into "banovine" transferring rights and responsibilities for management the forests. The largest part of "Vardarska Banovina" was the present Republic of North Macedonia. Until 1929, the Yugoslav state assigned 15% of all finances in the country for torrent control in the Vardar Banovina. For afforestation of bare land in North Macedonia in the 1929were spent: 30 kg seeds and cca 600,000 seedlings. In 1931 a tax was introduced for the goats for the perceived danger of the goat in the forest. In 1931, Local people, on 1,000 hectares, planted 2,687,000 seedlings donated by government, with survival rate of 60%. In the year 1932/33, in Vardar Banovinawere planted 4 million seedlings (Kolevska et al., 2017; ex-cite Maksimović, 1934e).
The first written document (about torrent control is about training of river Dragor that attacked the city of Bitola.(Dolgij P., 1934) torrent Dragor à Bitolj) Activities were carried probably between 1927 and 1930.

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In 1946-7, the Law on Forests in the then FNRJ was adopted, under which forests were governed by thenational boards. With the establishment of forest holdings, forestry has been significantly regulated and improved that was positive for erosion control issues. IN the same time for established specialized institution for preparation torrent control designs that exists up to 1990 (Poroj proekt - Torrent design).

After successive approaches from 1946to 1950, the "Law on Afforestation"was adopted in 1951 to convert bareland in fertile lands and forest and protect the natural resources. After the catastrophe by torrents from Vodno Mountain that attacked the city of Skopje in 1951, was prepared separate law and on 3 July 1952, "Law on protection of steep lands from erosion" was adopted. The Government proclaimed erosive areas and depending on the degree of erosion, could plan technical measures, could expropriate the land, etc. In 1957, the Law was updated. Later in the same year, they issued a rulebook for the implementation of measures for protection of the land from erosion. In this period was established a Water development institute where exists department for erosion and torrent control but this institution was closed in 2010. They prepared various studies related to erosion and torrents, torrent cadaster, engineering designs and the crucial project – Erosion Map of the Republic of Macedonia.

In 1958 was adopted the Law on Hydromeliorative systems that enabled more finances for activities related to erosion and torrent control. After the adoption of the Law on Financing Melioration Systems (1958), these measures were strengthened, and as of 1985, 285 torrents were regulated. As part of the erosion control program an "Afforestation Fund" was established in 1970 and it existed until 1990, period when the erosion control measures and activities were on "higher level" and institutional support was higher. There were sections for erosion control in all regional water management enterprises and parts of the national budget aimed at erosion and torrent control.

Afforestation was significantly increased in the period between1971-90 during the existence of Fund for afforestation of barelands. In total more than 200,000 ha bare land were afforested in the past.

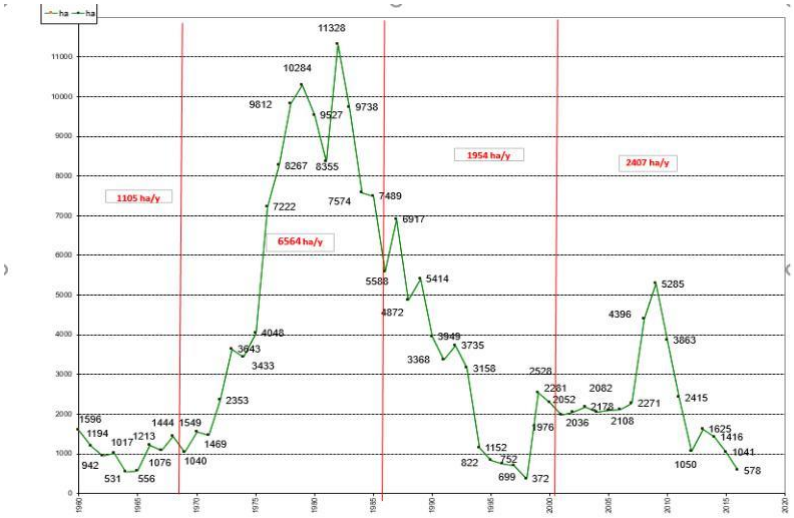

Figure 3 - Dynamic of afforestation of bare lands in the period 1960-2016

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For afforestation were used various species but dominantly *Pinus Nigra and Robinia Pseudoacacia,* while in the most arid region in central part of the country was used *Cupresus Arisonica*too. The central part of North Macedonia is a semiarid area where the total annual precipitation is less than 500 mm/a. The lowest measured annual precipitation in this area was 195 mm/a. This means that the region is vulnerable to the desertification processes. Afforestation in this region was a challenge for several generations of experts.

Figure 4 - Afforestation in central part of the country – *Pinus nigra* on cordons and results

Hydrauylic structures were made from different material but up to the 70's of the XIX century were classical stone in cement mortar check dams.

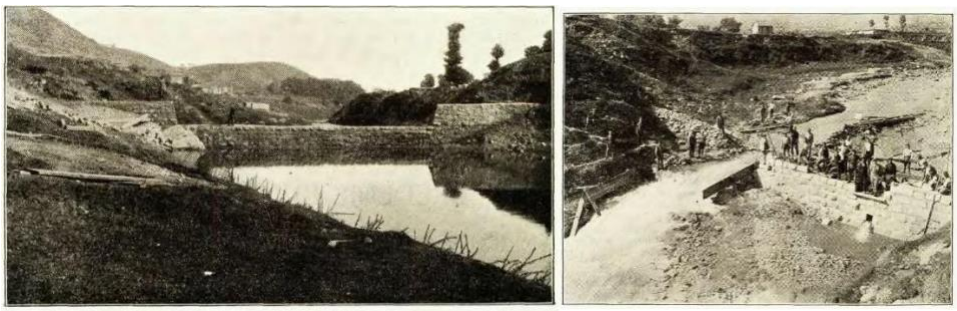

Figure 5 - Check dams in torrent Dragor (late 20's –early 30's of the XIX century)

Figure 6- Channel and check dam in torrents on VodnoMounatin (50's – 60's of the XIX cent.)

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After this period the building of concrete check dams began. The visual impact refers to the negative aspect altering the natural environment (the landscape), affecting the wildlife, impeding the establishment of natural floraand affect directly the tourism business. About 65% of the planned hydraulic structures were built, and only 25% of planed afforestation was done (Blinkov and Trendafilov, 2005). However the biggest part of the barrages are classical and in the 80's started construction of open check dams – "Herheulidze type". The most specific hydraulic structure in North Macedonia are screw check dams - Herheulidze type. These structures were built in the western part of North Macedonia where configuration type is Alpine. Erosion intensity is very high, weathering is significant and it results in rock fragments of huge dimension. These types of check-dams were built in a few torrents in the western part of North Macedonia (Blinkov et al., 2013).

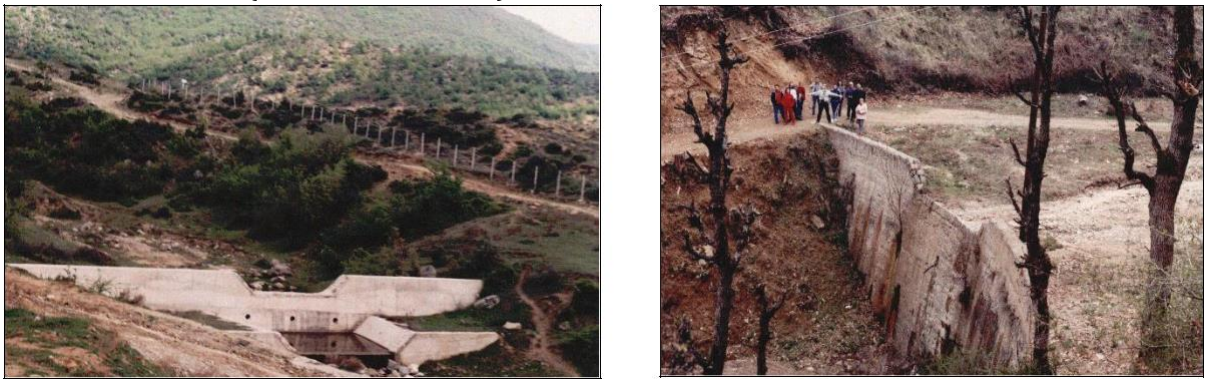

Figure 7 - Strait line check dam and arch line check dam - concrete

Figure 8 - Open check dam - Herheulidze type

Nowadays the situation is the opposite. Erosion is one the biggest environmental and economic problems in North Macedonia, but there are no special funds available for erosion control (Blinkov et al., 2017).

Beside it, after the independence started period of unconsciousness, decreasing of conveyance of already trained torrents with usurpation of surrounding land, throwing waste materials even construction in the bed, low maintenance of the structures, illegal logging in the forests, no existence of protective forests, etc.

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Figure 9 - Usurpation and narrowing of the bed, waste in the bed

Figure 10 - Illegal dike for crossing and total covering of the bed and directing the water on the street

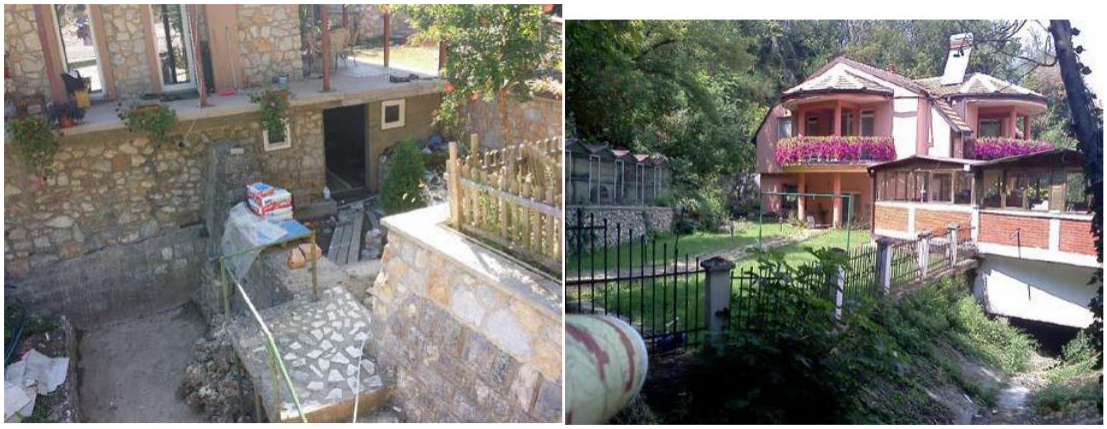

Figure 11 - Construction into the torrent bed (to the check dam) and on the channel

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With the latest changes in Law on Construction only civil engineers can got personal license for designing, revision and only civil construction companies can prepare designs for torrent control, although their capacities are very low because only on the master study programme hydraulic engineering, torrents are mentioned without detail explanation into the course river engineering. The crucial thing is disregarding the differences between rivers andtorrents, as well as river training and torrent management.

Taking in consideration tender procedures and incomplete designing team, because of lack of knowledge, it contributed to huge mistakes and increase of risk of flooding even great torrent flood damages somewhere.

Figure 12 - Torrent bed designed by forest engineers in the 60's and extract form design for covering of the channel by civil engineer 2017 (wrong calculated maximal discharge even few years ago channel was full with water)

a) b)

Figure 13 - a) New designed and constructed culvert in torrent bed (2017);
b) Small concrete Channel (2015) into the earth channel with cross structures from 70's.

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4.5. Flood risk management plans

Up to now, there are 3 flood management plan according to the needs of Flood directiveprepared for 2 out of 3 river basins: for the Strumica river basin, for the Crn Drim river basin and for Polog (Tetovo) region (sub-basin of Vardar river basin). For several basins or regions that were significantly flooded in the latest period especially in the January-February 2015, was prepared Preliminary Flood Risk Assessment: Strumica river basin, Pelagonia valley (part of the Crna Reka basin - sub-basin of Vardar basin) and Stip-Kocani valley (basin of Bregalnica river – sub-basin of Vardar river basin). For the Skopje region was prepared flood hazard and flood risk maps. The company "PointPro Consulting" - Skopje, realized all these projects. Beside this, there are flood management plans in a case of collapse of dams as well as plans for flood protection of the biggest cities but prepared according to the old Yugoslav methodology. Each municipality has adopted a document "An Assessment of endangerment of the municipality by natural and other hazards| according to the Law on protection and rescue, where flood hazard is significantly represented. Torrent are encompass in several of above document except in PFRAs for Crna Reka and Bregalnica valley.

Upper Vardar Flood Management plan

The frequency of flooding is higher in the Polog Region than anywhere else in the country.Based on outcome results of the modeling efforts, the following maps are developed: Flood Hazard Maps, ,Flood Risk Maps, Debris Flow Susceptibility Maps (preliminary) and Landslide Susceptibility Maps (preliminary).The study also includes assessment of the "social vulnerability" to floods, which is broadly defined as 'the characteristics of a person or group of people and their situation that influence their capacity to anticipate, cope with, resist, or recover from the impact of a hazard'. Flood event with medium probability of occurrence (100 years return period) for Vardar River and 19 tributaries, could cause cca 74 MEs costs of losses and damages, out of them 51MEs in residential objects.

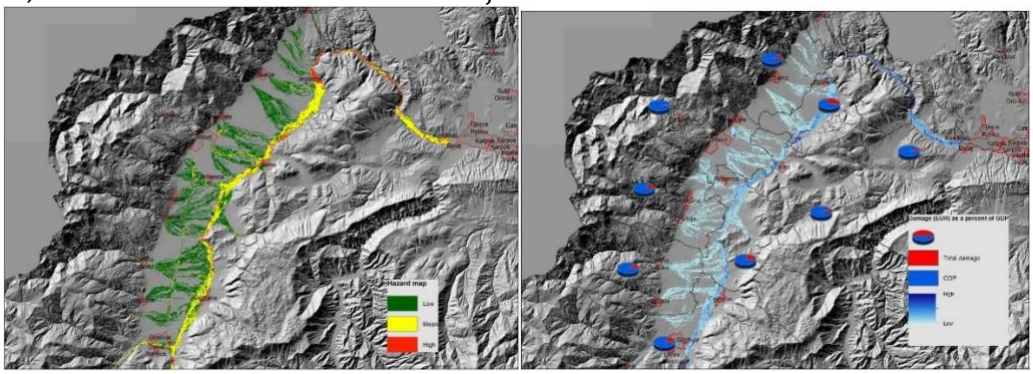

Figure 14 - Flood hazard and Flood risks maps (damages as % of GDP)

The method of D'Agostino&Marchi was selected for calculation of volume of maximum debris load and for Djepchishki Poroj (A = 16,15 km^2) is calculated as 243 000 m^3. Using Saint Venant's 2D equations was calculate debris flow discharge [m^3/s) and for Djepchiskiporoj

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are - Q_{25},(28) Q_{100} (59) and Q_{500} (86 m_3/s). The HEC-FIA (Flood Impact Analysis) software analyzes the consequences from a flood event.

Regarding susceptibility to debris flow, Flow-R (Flow path assessment of gravitational hazards at a Regional scale) was used to identifies potential source areas and delimits the zones in the path of the propagation. Regarding landslide susceptibility was used multi-criteria scenario with 4 parameters.

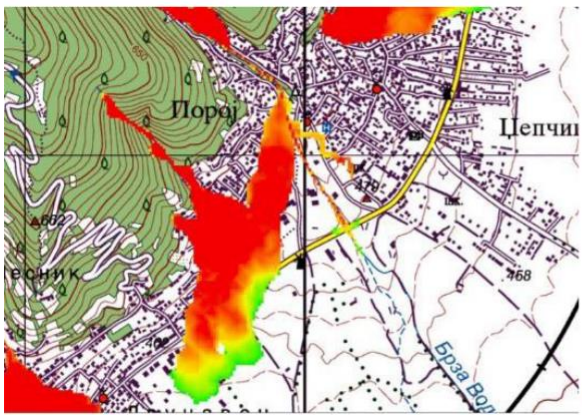
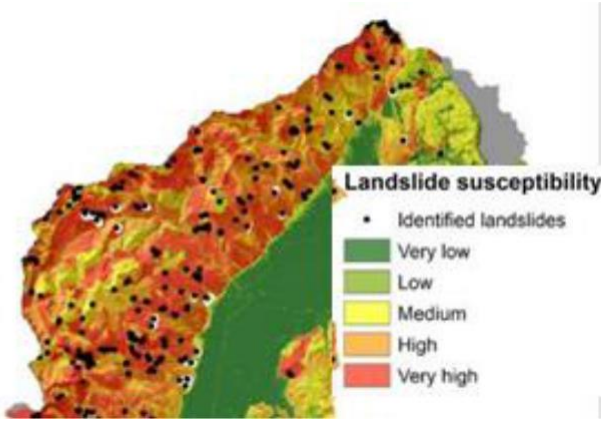


Figure 15 -Output Flow-R Map for Djepchishki Poroj**Figure 16** -Landslide susceptibility map



Measures to build resilience in Polog Region, in the plan are set according to the 4 priorities of the Sendai Framework.

Strumica PFRA

Figure 17 –Potential Q_{100} floods in Radovish city (by torrents Sushica, Radovishka Reka) and Radovis-Strumica valley (by river Strumica)

It is estimated that the total area at a medium flood risk (Q100) in the basin equals 14,450 ha, or nearly 9% of the total basin territory. In addition, the town of Radovish (risk category E3) and a big number of settlements (risk category E2) located in the lowland part of the upper Strumica valley sub-region are threatened. Important flood protection measures, mainly in the form of river bed regulation (structural), have been implemented throughout the basin territory in the past. However, the infrastructure is poorly maintained, as result of which the capacity for flood conveyance is significantly reduced, particularly in rural (farming) areas. The existing flood protection infrastructure is incomplete and insufficient for efficient protection of even frequent flood events.

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Skopje – Flood hazard and risk maps

Flooded area in the central part of the city is almost all on the right side while downstream form the central part of the city is on the left side of the river Vardar.

Figure 18 - Flood Hazard Map - Vardar Q_{500} and in a case of "Kozjak" Dam collapse

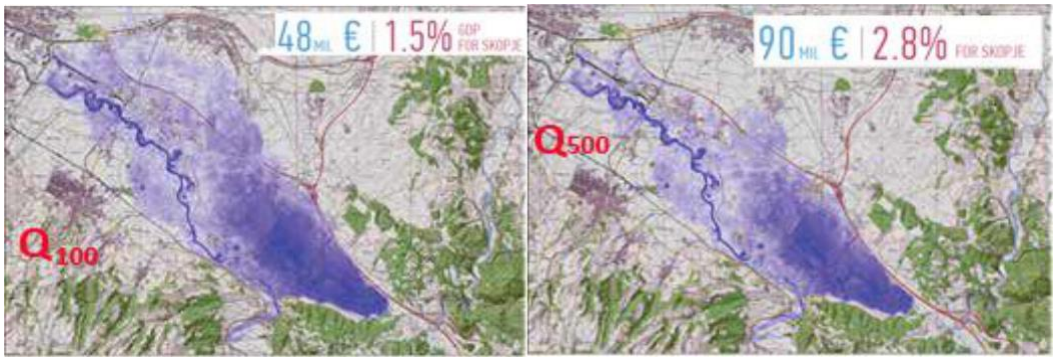

Figure 19 - Flood risk maps for Skopje city by river Vardar - Q_{100} and Q_{500}

Figure 20 - Q_{100} - Vodno torrents flood hazard maps (by torrents Murtinec and Priporskidol)

Vodno torrents directly attack central part of the city. In thepast, they permanently attacked the city but in the period of 50's up to 60's almost all of them were trained and their catchments were afforested. River Vardar was for the first time regulated in the end of the XIX century and the current regulation is from the 70's (after the biggest flood in 1962. With construction of the

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dam Kozjak, flood safety arise to 1/300 years discharge but latest constructions in the river bed in the center of the city (galleys, bridges, sculptures…) safety decrease.

4.6. Institutional and legal framework in field of erosion and torrent control

The provisions regulating flood management in Macedonia is comprised of several sector laws focusing on various aspects related to flood management. The system is encompassing elements of prevention of damage caused by floods, protection by taking measures to reduce the likelihood of floods, information system about flood risks and in event of a flood, as well as emergency response and mitigation of the impacts on the affected population. Without commenting on the relative advantages and disadvantages of this type of regulatory framework, this chapter aims to give an overview and analyses the key national legal documents applicable to flood management. Its final objective is to determine to what extent there is a consistent and clear national legal and policy framework and assessing the level of harmonization with the key EU *Acquis.*

Law on Waters -The core national legal instrument referring to issue of flood management is the Law on Waters (hereinafter: LW). It incorporates the basic principles and procedures of water resources management. In general the LW incorporates the flood management in the overall river basin district management principles:

- the planning and management is based on the river basin district as geographical unit for flood management,
- the river basin management plan encompasses the flood risk management and ensures efficiency of the implementation of measures and the development of programme for protection against harmful effects of waters should be carried out in coordination with and is integrated into reviews of RBMPs,
- acknowledges the extreme floods as an exceptional circumstances allowing deviation from the environmental objectives for a particular water body, and
- sets the competences for planning and implementation of the measures for protection against harmful effects of the waters within the same management body.

The most relevant is the Chapter V: *Protection against harmful effects of waters* that contains provisions on activities and measures for protection and defense against floods, defense against erosion and torrents, defense against freezing of surface water bodies, as well as elimination of the consequences from such harmful effects of waters, and competences thereof. The LW establishes references to other relevant *lex specialis* stipulating that relevant provisions of other laws determining the conditions, manner and procedures for protection against the harmful effects of waters shall be also applicable.

Law on Protection and Rescue - The law specifies the establishment and organization of a protection and rescue system, the construction of protection and rescue facilities, risk assessment for possible hazards, the creation of a protection and rescue plan and spatial planning.

Law on Crisis Management - The Law governs the crisis management system in the Republic of Macedonia such as: the organisation and functioning, decision-making and the use of the resources, communication, coordination and cooperation, assessment of the security jeopardy of the Republic of Macedonia, planning and financing.

Law on Hydro-meteorological activities -The law governs the functioning of the Hydro-meteorological activity and responsibilities of Administration for Hydro-meteorological

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activities. The Law establishes single meteorological and hydrological observation system of RM and also sets obligations for warning and notice of extreme weather conditions.

Law on Local Self-government - regulates inter alia the competencies of the municipality; organization and operation of the municipal bodies; municipal administration; acts of the bodies; property – ownership of the municipality; oversight over the operation of the municipal bodies; mechanisms of cooperation between the municipalities and the Government of the Republic of Macedonia; and other issues of importance to the local self-government. The Municipalities have inherent responsibility for execution of preparations and undertaking of activities for protection and rescuing of citizens and goods against war destructions, natural and other disasters as well as against the consequences caused by them. They also have other competences in flood management which are delegated by other sector laws.

Law on water economy - regulates the management, utilization, operation and maintenance of hydro-systems and irrigation and drainage systems by the entities acting as water management activity providers. It provides information on some institutional and operational competences related to the integrated flood management system.

Law on forests – regulates the management, utilization silviculture and protection of all forests in the country. Erosion and torrent control are not elaborated within the Law but some provisions for Afforesttaions or sustainable forest management significantly contribute to erosion and torrent control

Water Strategy (2011-2041). This document provides a direction for the Republic of Macedonia and sets the long term vision of where the water sector should be by 2040. Itis a document explaining the status of waters, inter alia the river training and protection against harmful effects of waters (river training, flood protection, erosion protection, irrigation, surface water drainage); water management objectives, inter alia, for protection against floods and other harmful effects of water (river training, flood protection, erosion protection, irrigation, surface water drainage);as well as programme of activities and measures, inter alia, for protection against floods and other harmful effects of water.

Institutional setup

The relevant national legislation assigns competent the authorities which are responsible for flood management. The main responsible body is the Ministry of Environment and Physical Planning, but also Local Self-governments and Water management enterprises. In a case of crisis situation, the legislation includes additional competent public and private entities.

The Ministry for environment, the council of the municipality, of the city of Skopje and of the municipalities of the city of Skopje and the water management enterprises adopt an operational plan for protection and defense against flood for affected areas.

The Government adoptthe „Assessment of the threats to the security of Republic of all risks and dangers“prepared by the CMC. Each LMA adopt „An assessment of the threats to the security of municipality of all risks and dangers”.

Crises management center collect data and do assessment of level of endangered of the municipalities, regions and the country by various natural hazard including floods, based on a potential flood intensity, exposure and vulnerability of the human and material goods.

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Crisis situation is declared to enforce the authorities to deal with crisis condition. The Government decides on the existence of a crisis situation, it determines the area affected by the crisis and consequently activate mechanisms for resolving the crisis. On the existence of this situation, the Government urgently notifies the Parliament and President of the Republic of Macedonia. The Government no later than 30 days after completion of activities, must prepare and submit written report to the Parliament and the President. In a case of prolonging the risk only Parliament can make decision for proclaiming crisis for longer than 30 days. In cases of crises, a crisis management system is established as Steering Committee (SC) and Assessment Group (AG),

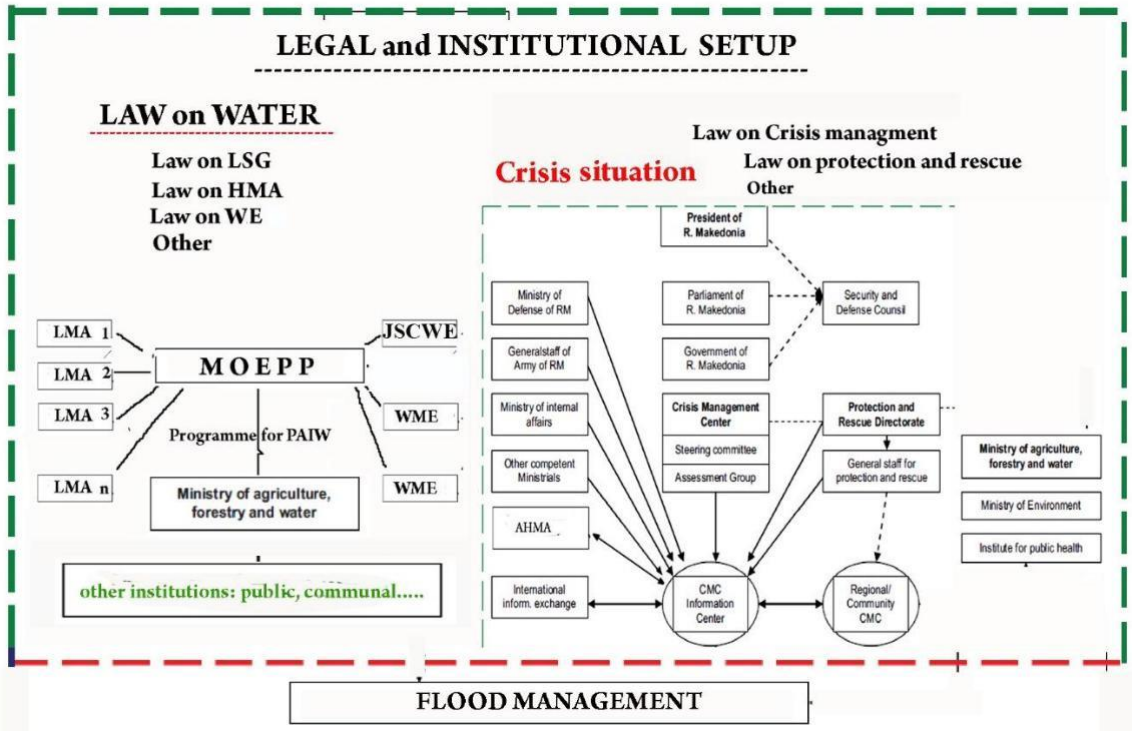

Figure 21 - Institutional responsibility in a case of flood and crises situation

Regarding torrent control, the Law on Waters is unclear regarding the responsibilities.

According to the LoW, municipalities are responsible in urban areas while water management enterprises out of urban area. For biggest rivers it is partially correct while for torrents it is absolutely incorrect taking in consideration responsibilities of entities in any torrent catchment. Usually greater part of the torrent basins are in the mountain regions that are under competences of Public Enterprise “National Forests”. Notorious fact is that torrents should be integrally treated on the whole catchment but thus misunderstanding by the politicians (local mayors etc) contribute to preparation of only design for regulating the torrent bed usually in the lowest section(near the settlement) and without measures in the mid section (cross structures etc or measures on the catchment slopes . It resulted even in destroying the new constructed channels.

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