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

WP1
Analysis of soil erosion state and torrential floods in Western Balkan Countries

Analysis state of soil degradation/soil erosion in the Republic of North Macedonia

Report developed by Ivan Blinkov

Contribution: Aleksandar Trendafilov and Ivan Minčev

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

Introduction

- The Republic of North Macedonia having an area of 25713 km^2 is land-locked country situated in the central part of the Balkan Peninsula. It extends between 40°50' and 42°20' north latitude, and 20°27'30'' and 23°05' east longitude.
- Large and high mountainous massifs with emphasized vertical (dividedness) characterize the country's topography. Mountainous and hilly mountain region encompasses almost 3/4, whilst valleys only 1/4 of its territory The average elevation is 829 m above sea level and vary from 40 m asl near Greece border up to 2764 m asl (peak Golem Korab situated on the Albanian border).
- Mountains in the Western part are continuation of Alps-Dinarides range while mountains in the eastern continue to Rila-Rhodpes massif.
- Geology and soil patterns are very heterogeneous. The mountainous region is generally composed of compact (solid) rocks which are of eruptive or metamorphic origin and only a small part of mountains is consisted of clastic sediments. The valleys consist mainly of clastic mechanical sediments and only a very small part of the valleys consists of recent compact stones (vulcanite).

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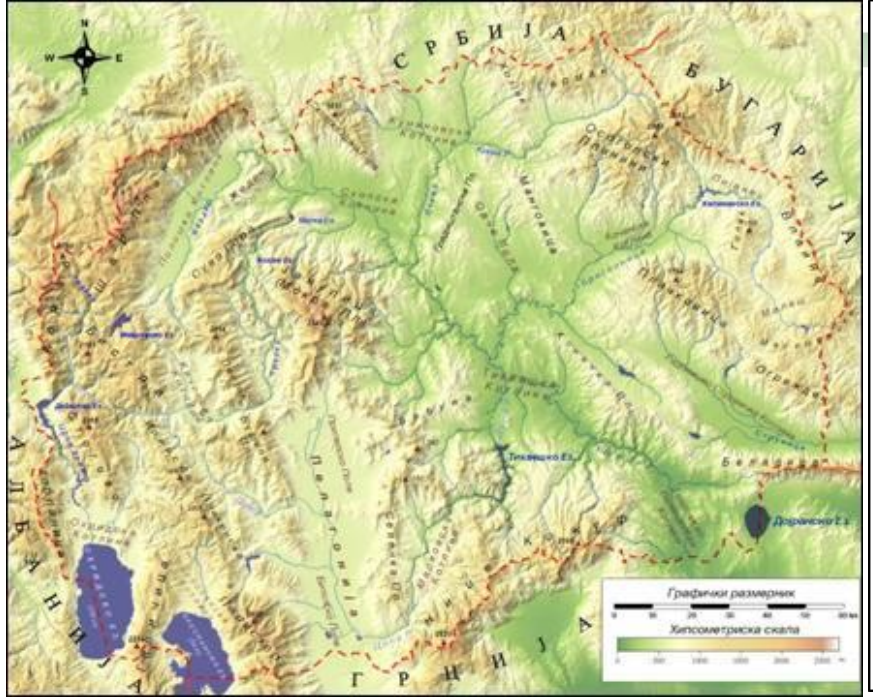
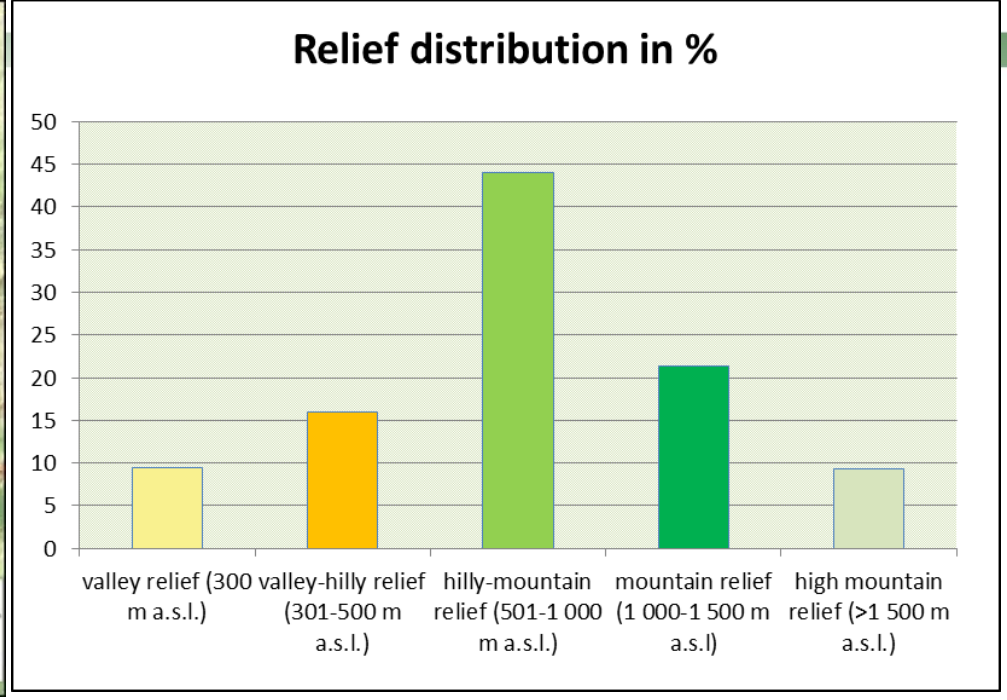
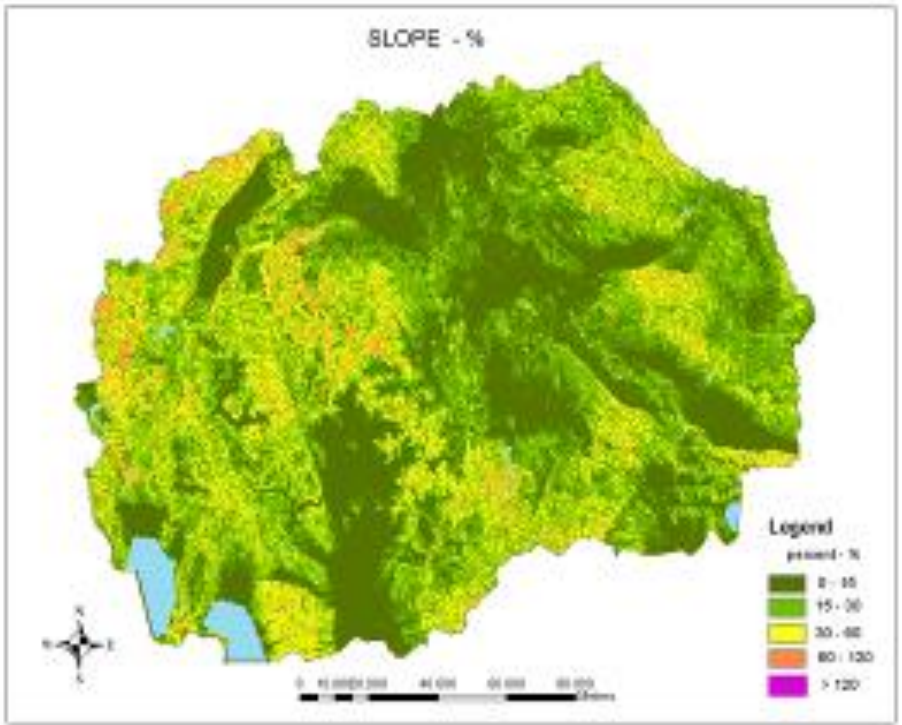
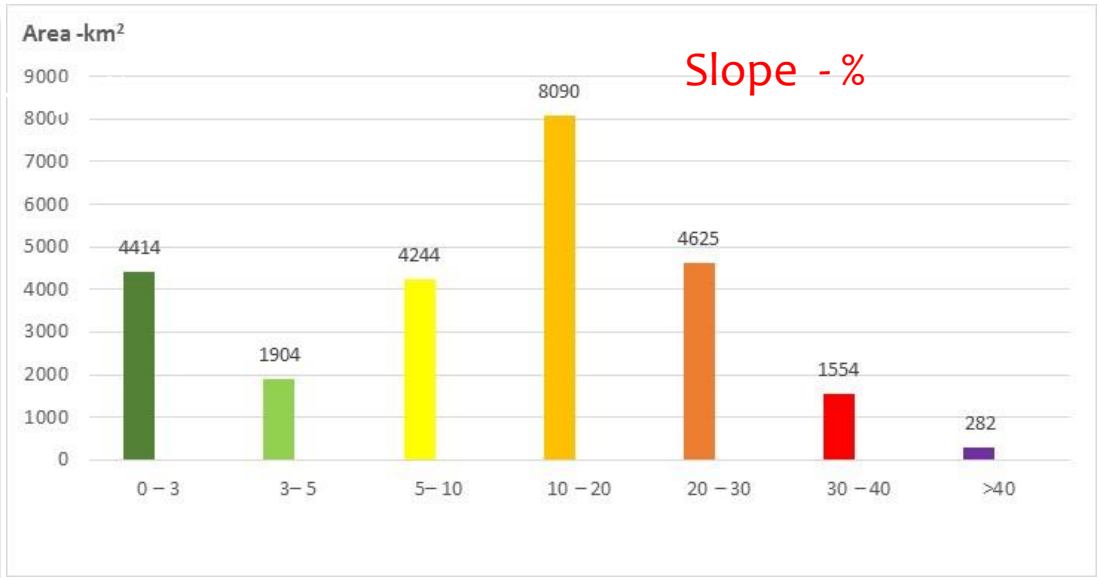




Altitude :
40 – 2764 m asl





19 284 km² (80%) - mountain, hilly mountain and hilly region

76% of the country with slope > 10%

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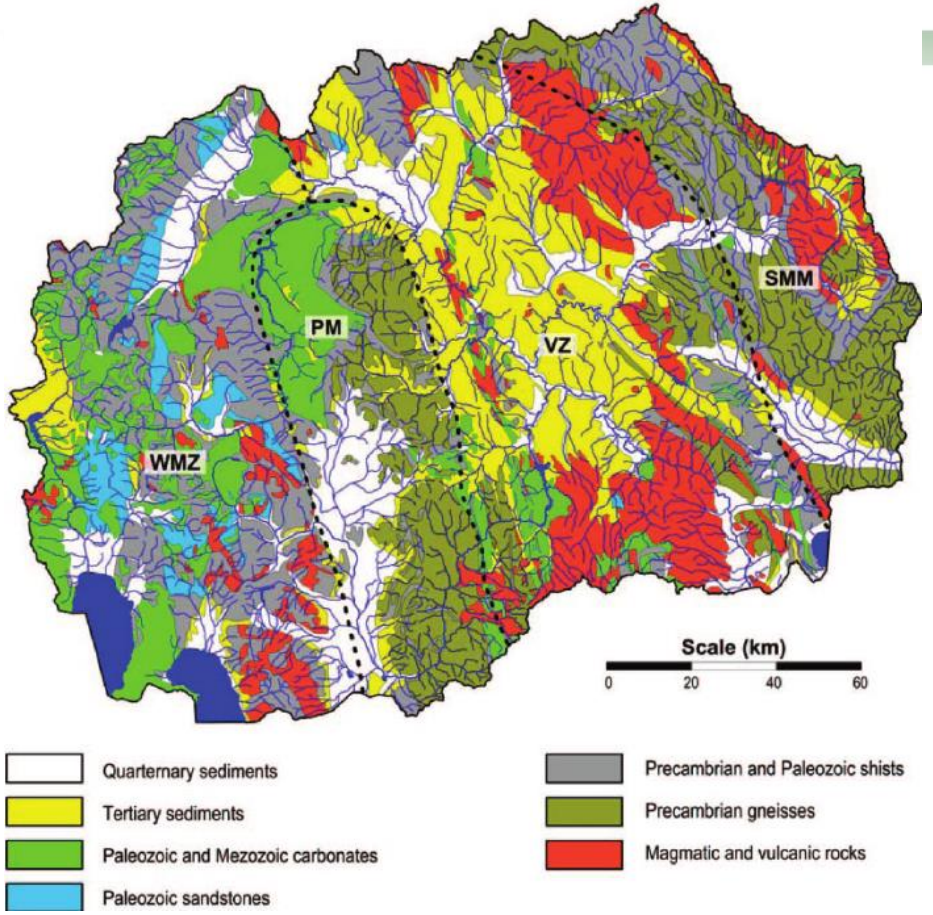
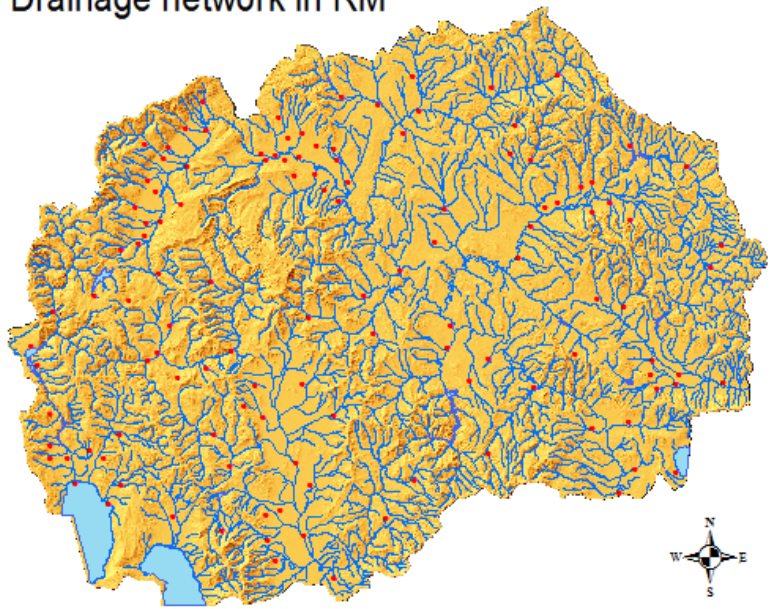


Geology and soil pattern are very heterogeneous. The mountainous region is generally composed of compact (solid) rocks which are of eruptive or metamorphic origin and only a small part of mountains consists of clastic sediments. The valleys consist mainly of clastic mechanical sediments and only a very small part of the valleys consists of recent compact stones (vulcanite).

Drainage network in RM



The total water resources are estimated at 6.37 billion m^3 in a normal year and 4.80 billion m^3 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 a total yield of 991.9 million m^3/year. Three natural lakes, Ohrid, Prespa and Dojran Lakes have also great significance for the hydrographic characteristics of the country. There are 22 larger dams and reservoirs and over 100 smaller reservoirs.

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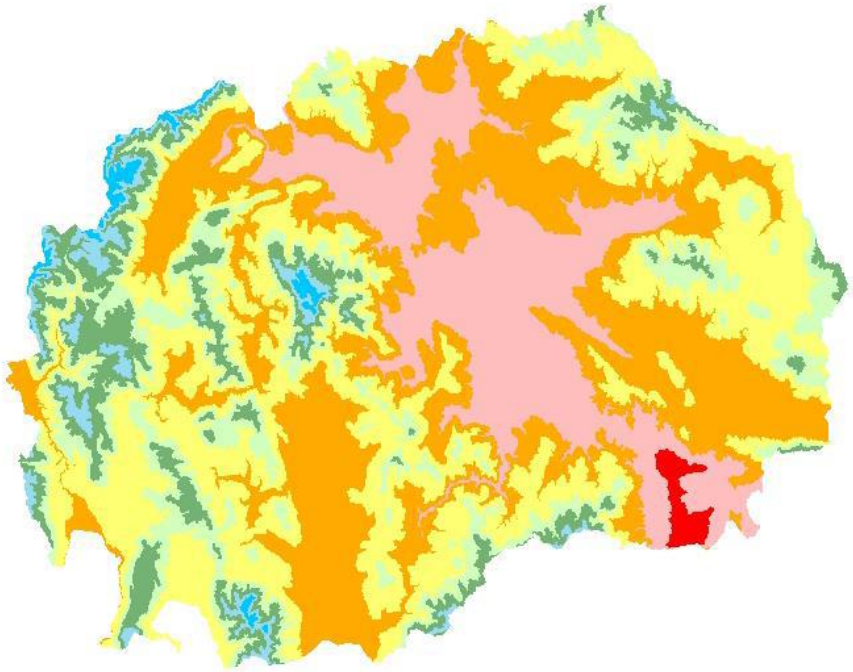
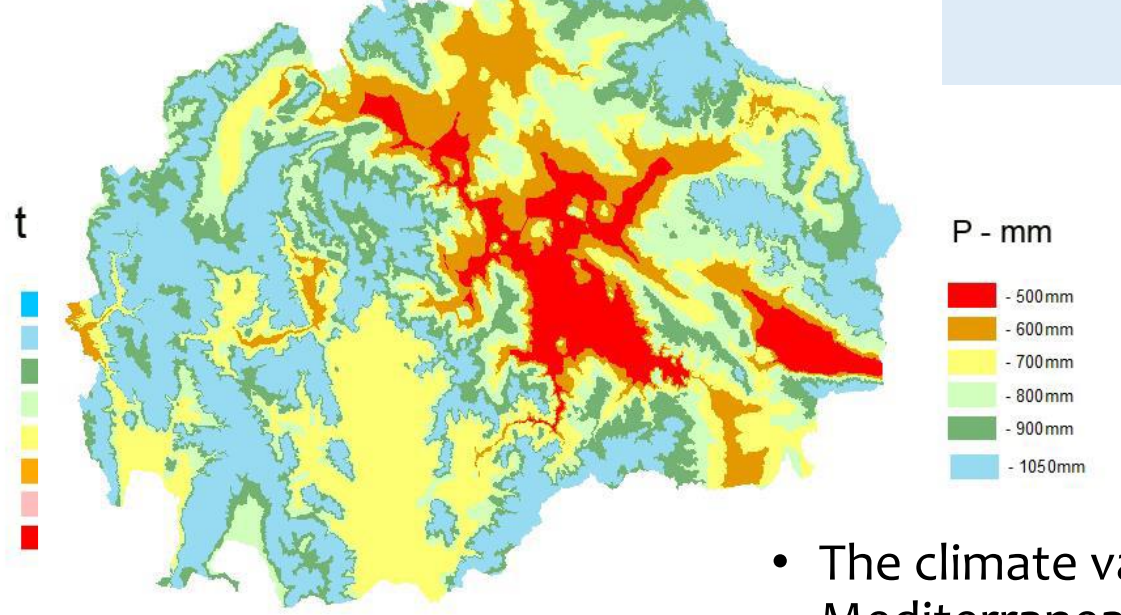
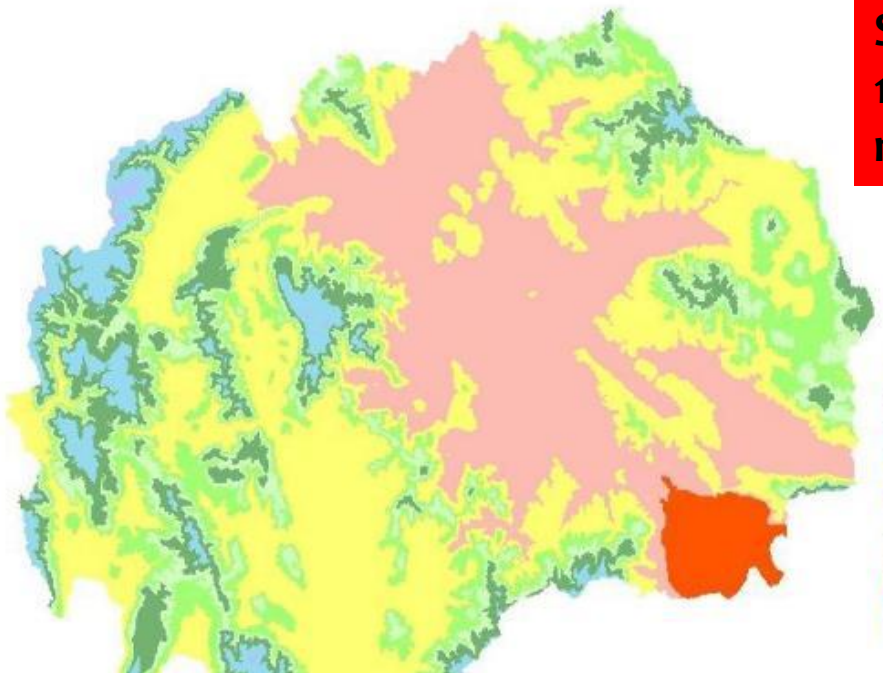
CLIMATE





Drought is not a rare occurrence and then sudden intensive rainfalls Skopje 100 mm /4 hours, Negotino 175/165 minutes, Valandovo 205 mm, few hours…..

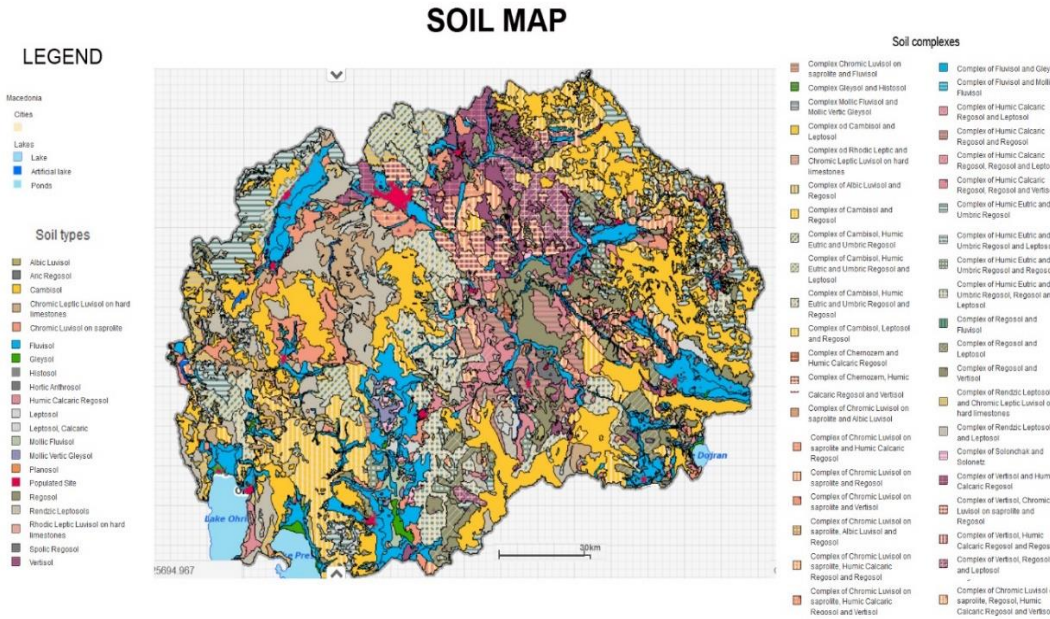


- The climate varies from sub-Mediterranean, moderate continental/ sub-Mediterranean to continental and alpine on the highest mountains. The mean annual precipitation is also quite diverse and it vary from 450 mm (central part) up to 1200 mm (mountains in the western part). Mean annual temperature vary from 4,8 – 14,2 °C. The total annual precipitation on the territory is 19.5 x 10^9 m^3, with the external inflow being 1,014 x 10^9 m^3.

Status of soil data

Soil survey and soil mapping in the Republic of Macedonia started soon after the World War II in 1947. This process started with the survey of soils of Strumica valley, i.e soil survey study, including a soil map of this valley in a scale of 1:50 000. (Filipovski Gj., 2016). This process continue up to the finalization in 2015. In the period 2012-2015 was launched FAO-financed project for finalization of the soil maps of the Republic of Macedonia. All previous collected data and maps were reclassified, according to the WRB (The World Reference Base that is the international standard for soil classification system endorsed by the International union of soil scientists). Then, all paper maps were scanned, digitized and was prepared attribute database so a Soil Information System was produced. In addition, 11 soil studies have been published: 10 studies for particular regions and one for the whole territory of the country comprising 1028 pages in total. (Filipovski Gj., 2016)

As digital output additionally were created the following thematic maps: Maps on spatial distribution of: pH, CaCO, organic matters, clay, dust and sand and Initial maps on soil suitability for cultivation.



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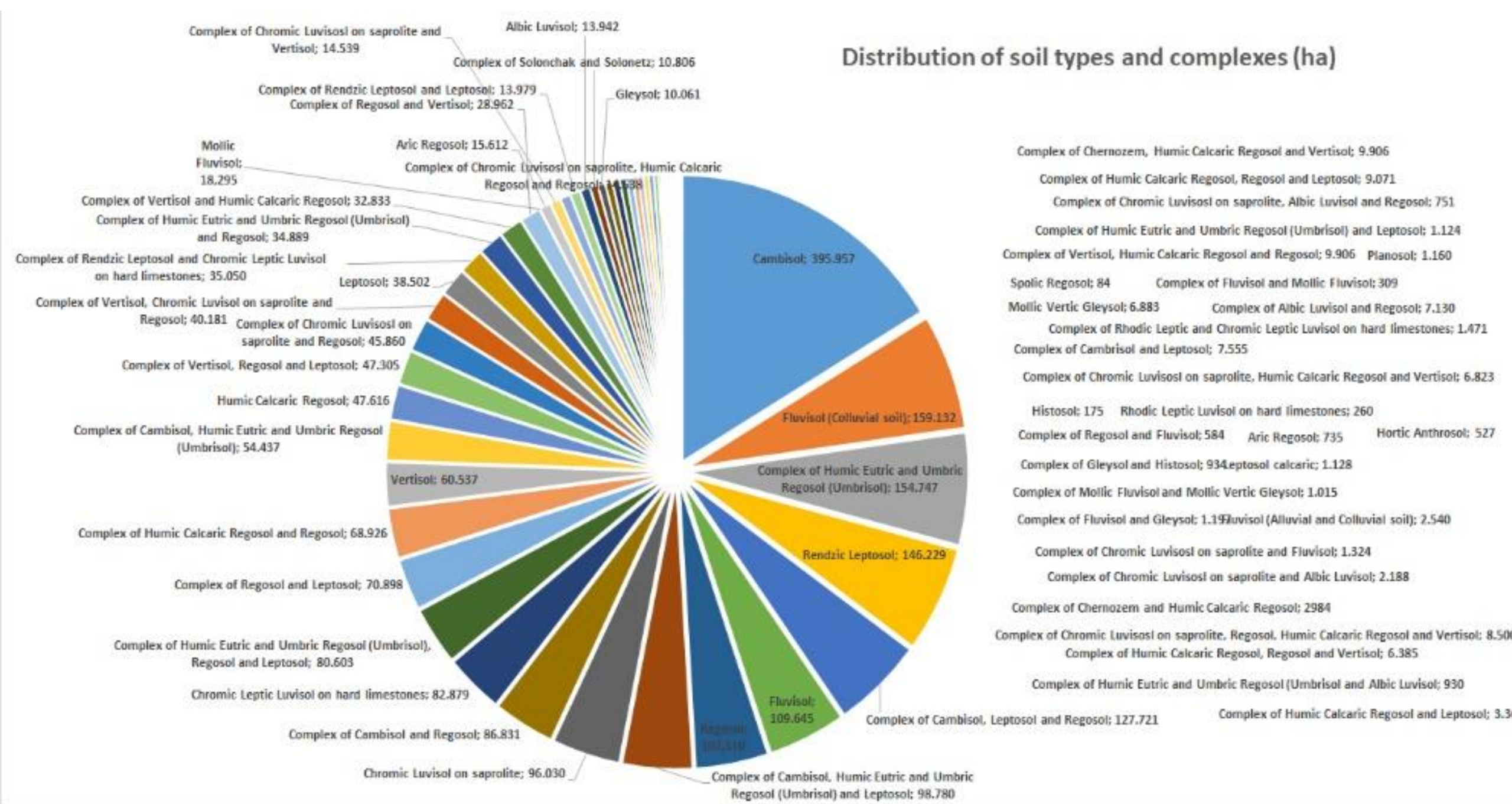
Distribution of soil types and complexes (ha)



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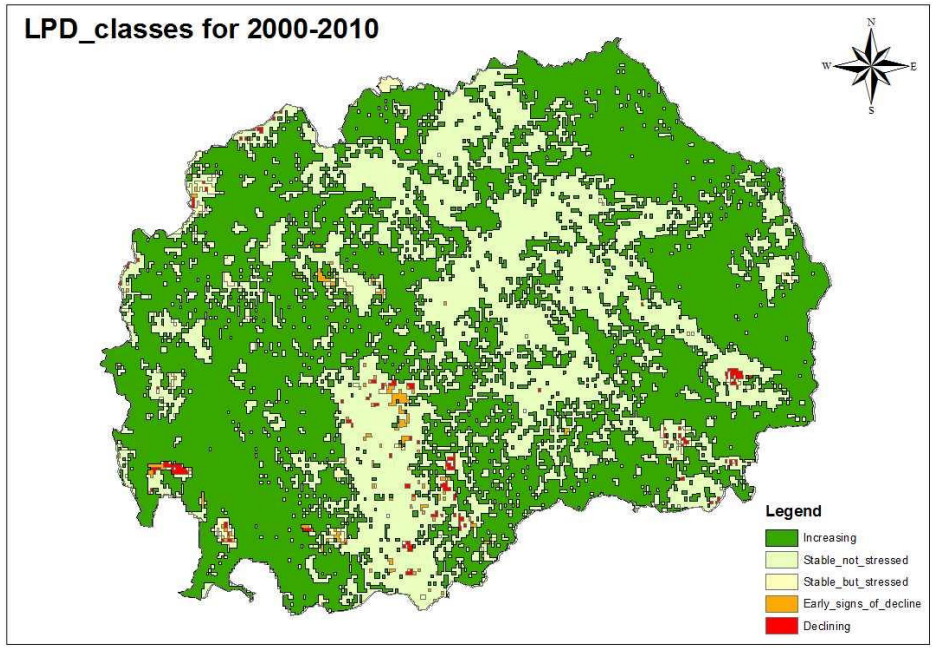
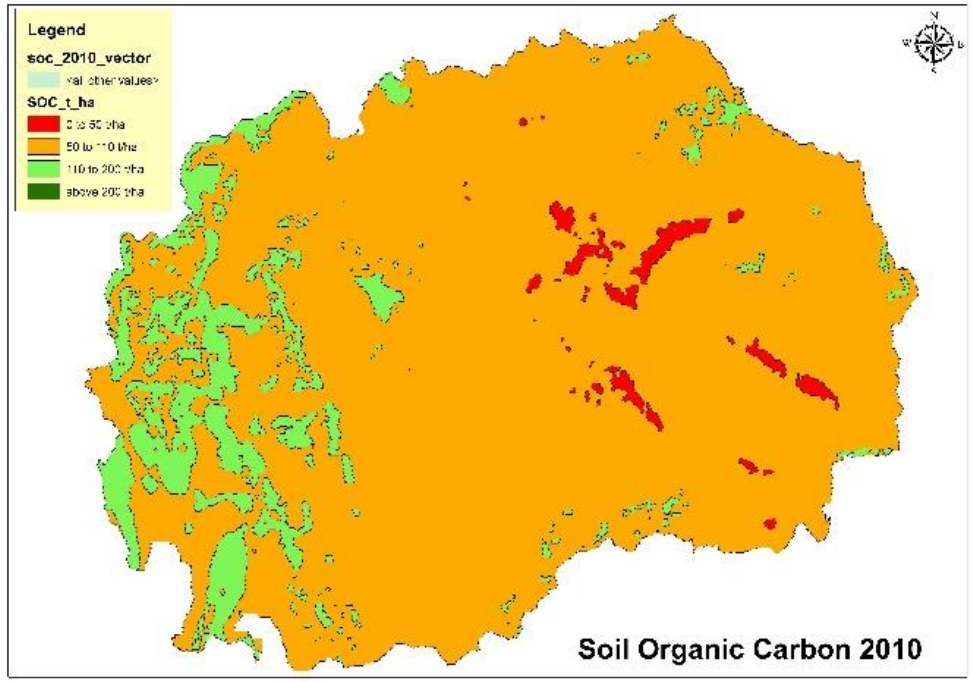
Land and Soil Degradation

The ESA-CCI data base recognizes a total loss of 6, 5 sq. km, out of which 3,9 sq. km are converted to shrubs, grassland and sparsely vegetated areas and 2, 9 sq.km to cropland. (Mukaetov and Blinkov 2017)

According to the calculations, total area of **land productivity dynamic** for the period 2000-2010 (according to the Global data) defined as unacceptable are only 2,35% of the territory of the country and it seems as to be very small area, but in reality there are 58 500 ha with negative land productivity dynamic. The available global data sets gives a modeled **SOC** levels for the period 2000-2010. **According these data, the total loss of SOC in our country is estimated on 3951 *t*.** (Blinkov and Mukaetov 2017).

According to the ESA CCI data, the total degraded area is 588,6 km^2 (LPD – 585 km^2 and SOC loss – 2, 6 km^2). Total degraded area (negative status in dynamic of LPD +SOC) in the country cover 589 km^2 out of which 585 km^2 from LPD and 3,5 km^2 with SOC losses.





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Soil degradation

- For soil alkalization and salinization, and soil compaction as well as loss of organic matter and biodiversity, there is **no exact data**.
- Similar is the situation with the soil sealing. There is no data on national level, only studies on few areas around the biggest cities.
- Desertification is a new recognized natural hazard in the country. Drylands cover central part of the country and wide to the eastern part. Climate conditions are the main reason for desertification, in the central part of the country, mean annual sum of precipitation is bellow 500 mm, while mean annual temeperature is higher then 11°C. Water deficit is high. The last two decades of the XX century were very arid and in this region the mean annual sum several times was bellow 300 mm even bellow 250 mm.

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SOIL EROSION

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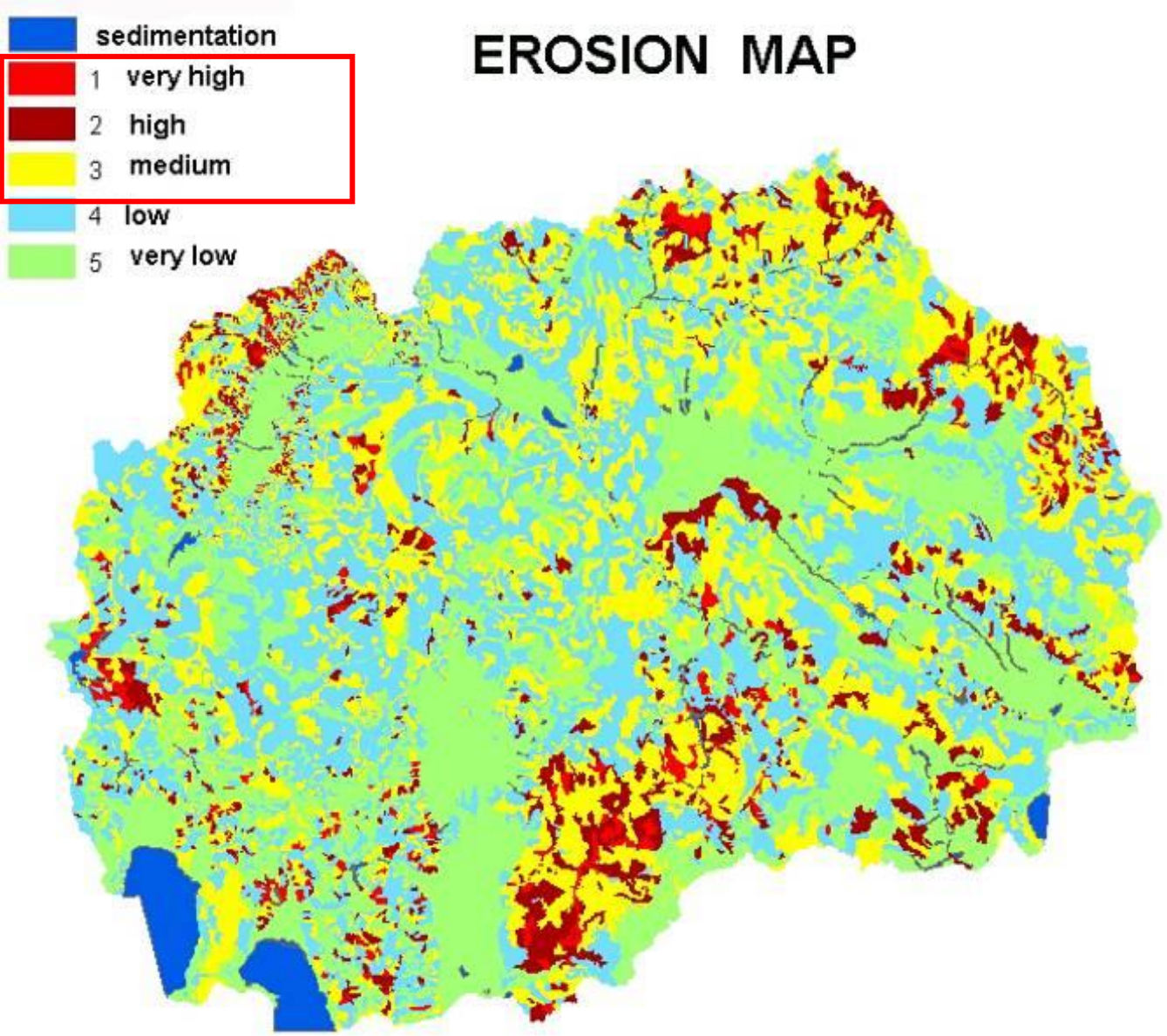
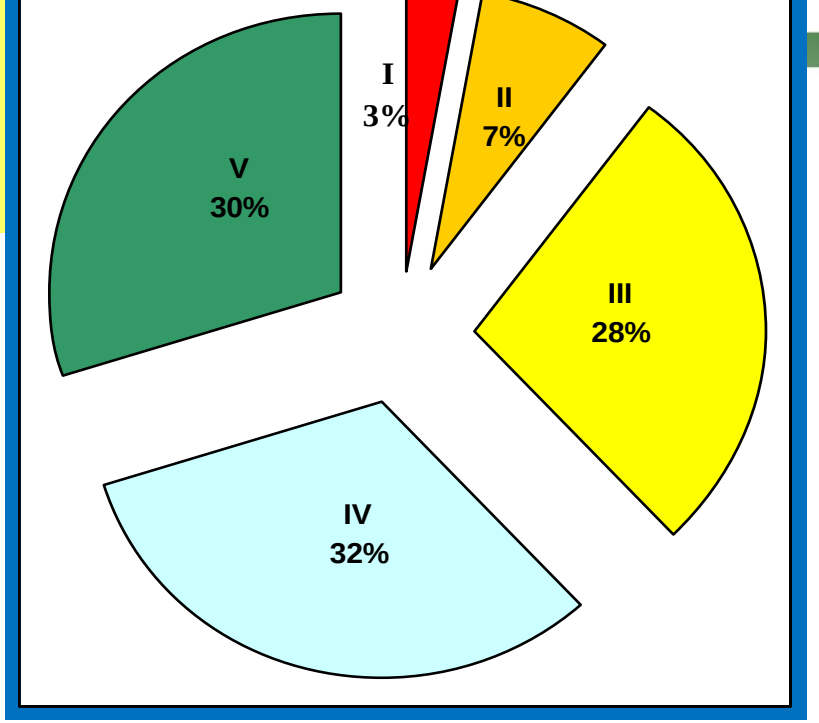
Map of Erosion intensity – WDI, 1993





Degr. Categ.	Erosion intensity	Erosion intensity ($m^3\ km^2\ y^{r-1}$)	Area endangered km^2	%
I	Very high	> 3000	698	2,71
II	High	1500 – 3000	1832	7,12
III	Moderate	1000 – 1500	6893	26,81
IV	Low	500 – 1000	7936	30,86
V	Very low	70 – 500	7463	29,02
Sedim.			891	3,47
	Total		25 713	100.00

- Due to the natural conditions as well as human activities, various type of erosion processes can be defined in the country as follow:
- water erosion (dominantly), wind erosion (mostly in central part), karstic and glacial erosion on the high mountains, etc.

By type, there are present: sheet erosion, rills, shallow and deep gullies, streambank erosion, fluvial vertical erosion, mass movement erosion (landslides and landfalls). Rock weathering are significant in the mountain region and are significant contributors of sediment.

- **The most characteristics erosive processes will be elaborated per 3 different high erosive zones in the country: western part – Shara – Korab massif, central part of the country along the river Vardar and eastern part of the country near Kalimanci reservoir.**

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- The main mountain range in the **western part of the country** is continuous of are the Dinaric Alps, the Shara-Korab - Jablanica massif which spreads along the border between Albania and Macedonia. It is generally composed of Paleozoic metamorphic complex, with volcanic and sedimentary formations in the lower parts, and carbonaceous formation on top. The creation of this massif, as we know it today, probably originated from Eocene about 40 million years ago, and throughout that period, the mountain significantly changed its appearance.

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- These mountains usually have narrow, sharp ridges and peaks and deeply incised valleys. The highest peaks are Korab (2764 m asl) and Titov Vrv (2747 m asl). There are 17 peaks with height more then 2600 m asl. Slopes are very steep (in a some parts even mean slopes of torrent beds achieve more then 20% or f.e. Djepcishki poroj in the highest part - slope of the torrent bed achieve 50%). The terrain is rough. Drainage net is very dense. Various erosion processes by type and intensity can be seen.
- **Erosion intensity in the region is at least 2 times higher then the average value for the country.**

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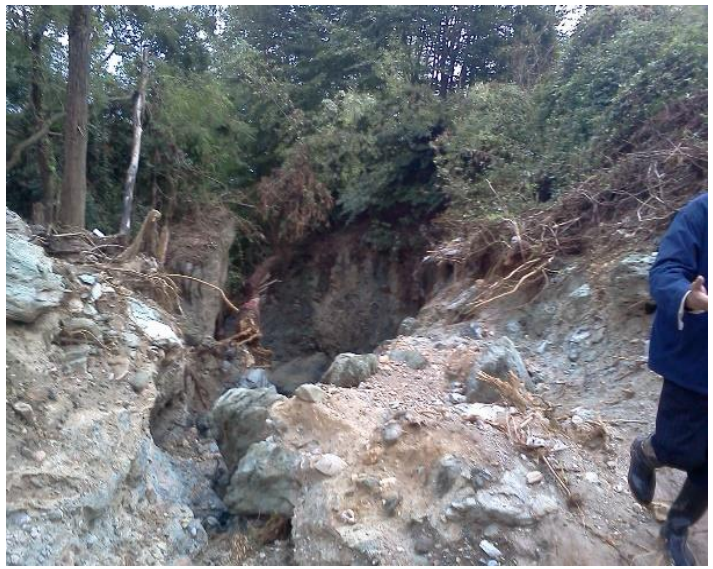

Talus cones, weathering

Deep gullies and landslides

Sedimentation by torrents and rivers

- **Central part of the country** (along the river Vardar and lowest parts of its tributaries Bregalnica and Crna Reka) on the altitude < 450 m asl., characterized with semiarid climate.
- Geologically dominated by various Paleogene and Neogene sediments.
- River Vardar is the main river in Macedonia and the main communications pass along this river. According to Turkey chronicle E. Cheleby (XVII AC) this area was cover with dense woodland and forest. Later was proclaimed "res nullius" for the forests that means nobody is owner and everybody can cut it. Forest along the river was cut and transported through the river to Thessaloniki. After the forest devastation, erosion processes filled up the river bed. Today on that territory, part of Vardar left side in Central Macedonia is desertified (Krivolak).
- Low education level, lack of consciousness, social structure and low financial level in past, were reasons for large forest destroying around the settlements too. Although sum of precipitations is low, rare sudden high intensity rainfall caused intensive erosion processes on the slopes forming even deeper gullies.
- Beside typical sheet, rill and gully erosion, taking in consideration the lithological structure, in this area there is appearance of landslides and the Mokliste landfall is the biggest in the country (10-15 million m^3 earth material slided in the valley and barraged the river Luda Mara forming a lake.)

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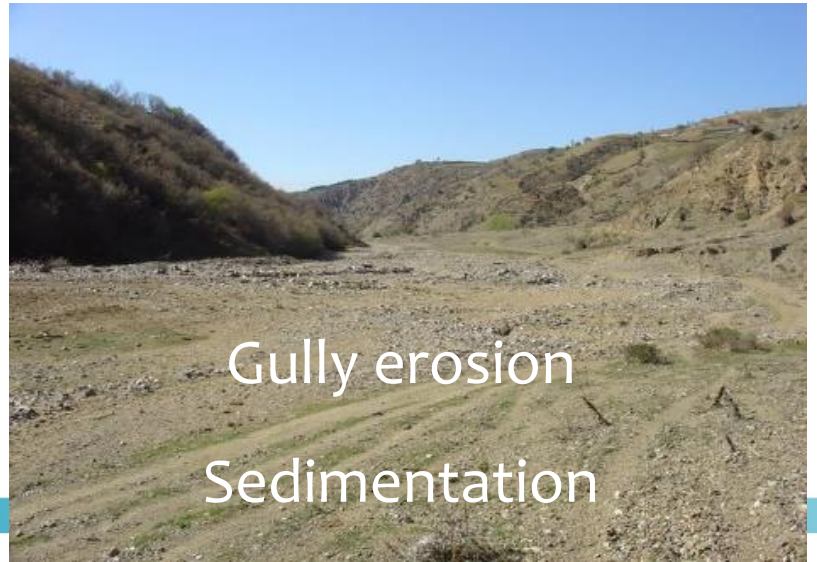
Sheet erosion

Desertified area



Gully erosion

Sedimentation

Landslides Timjanik, Moklishte

- The **eastern region** i.e. in the Kalimanci reservoir catchment the erosion processes are various.
- These mountains belong to Serbo-Macedonian Massif that's characterize by the domination of very old Precambrian and Cambrian lithological complexes: gneisses, mica-schists, amphibolite, and green-schists that are high erodible. Intensive volcanic activity contribute to the landscape. Mountains are with subdued relief, rounded ridges and peaks, and less deeply incised valleys. Lower parts of the mountains consist of sediment rocks sandstones that are highly erodible. Precipitation is higher then country average values.
- Depp gullies U and W type and pyramidal forms are characteristic and intensity of erosion is extremely high.
- Natural conditions combined with human influence contribute to high erosion processes. In the XIII-XIV century German miners (Sasi), arrived to Macedonia and started with mining activities especially in the East and Northeast part of Macedonia. They cut the forests in that area and used the wood for fuel or for mining. This area (especialy Kamenicka river catchment) is still one of the most erosive part in the country besides huge erosion control works.

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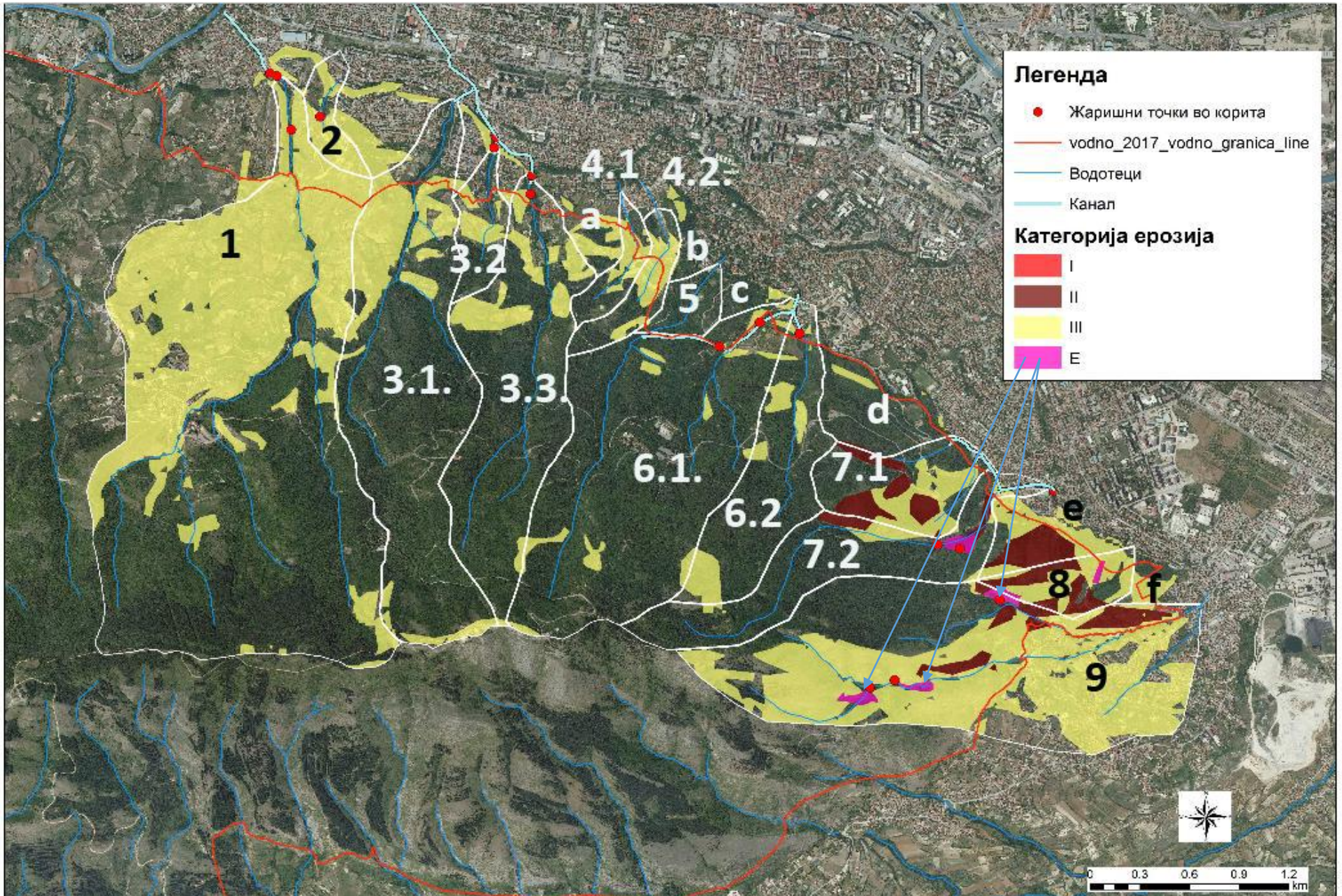
Deep gullies, pyramidal forms on sandstones

Sheet erosion, gullies, sediment cones

Sedimentation (Kalimanci reservoir)

additionally

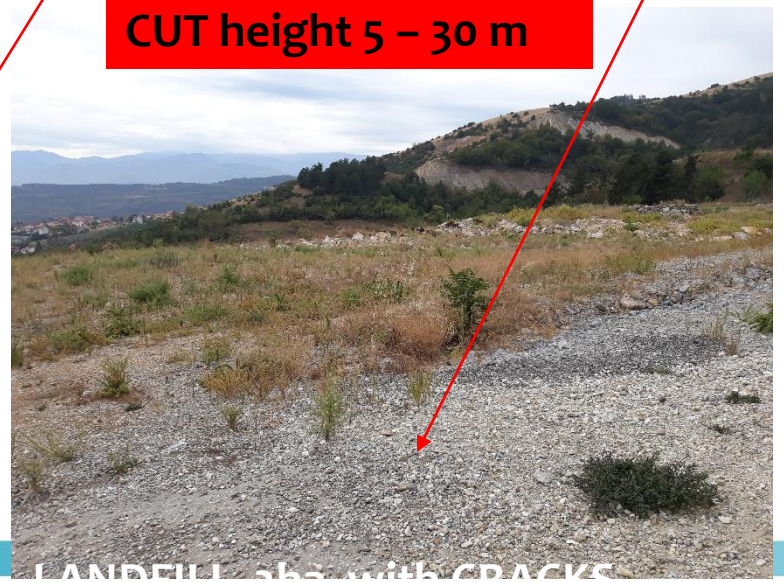
EXTREME EROSION - CATEGORY - E

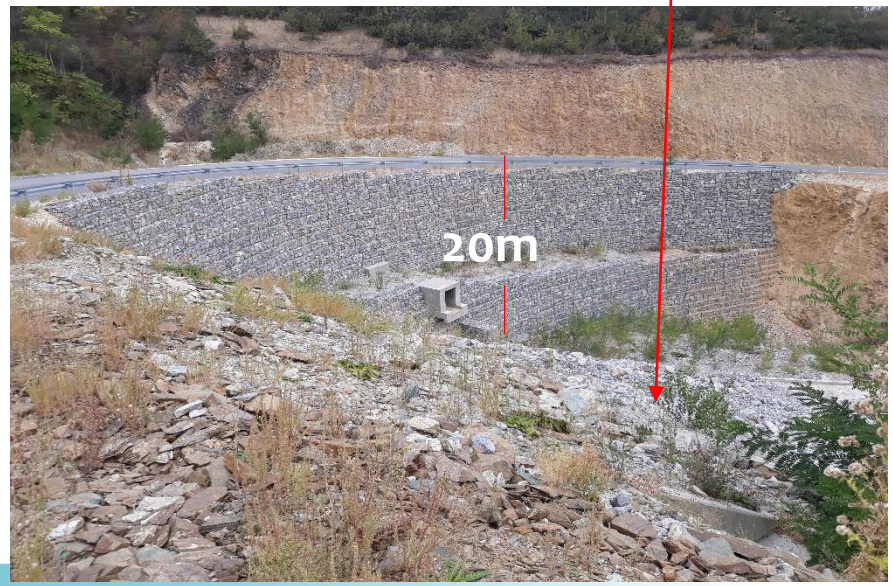


VODNO – road to "Soncev Grad"

Erosion intensity on construction sites is 100 times higher then on agricultural land, 1000 times higher then on forest land

CUT height 5 – 30 m





R E S U M E

- Of the total area 96% is affected by processes of erosion. An amount 9423 km^2 or 36.65% of the total state territory is in the highest categories (I – III).
- The total annual production of erosive material on the whole territory is about $17*10^6\ m^3y^{-1}$ or 685 $m^3\,km^{-2}.y^{-1}$, which of $7.5*10^6\ m^3\,y^{-1}$ or 303 $m^3\,km^{-2}.y^{-1}$ are carried away.
- Significant part of these deposits, about $3*10^6\ m^3\,y^{-1}$ is not carried through the downstream sections of the rivers to the exit of the state territory, but deposed in natural lakes and reservoirs. For example, the rates of annual sediment yield in the biggest reservoirs in Macedonia are: Tikves ($1,3 * 10^6\ m^3$ or 497 m^3/km^2), Kalimanci ($0,42*10^6\ m^3$ or 970 m^3/km^2).
- Exactly 1245 torrents are registered over the whole country territory. Torrential flows (flash floods) endanger infrastructural facilities (roads, bridges …), cover agricultural land with sterile sediments (stones, gravel, etc.) and caused causalities in the settled areas.

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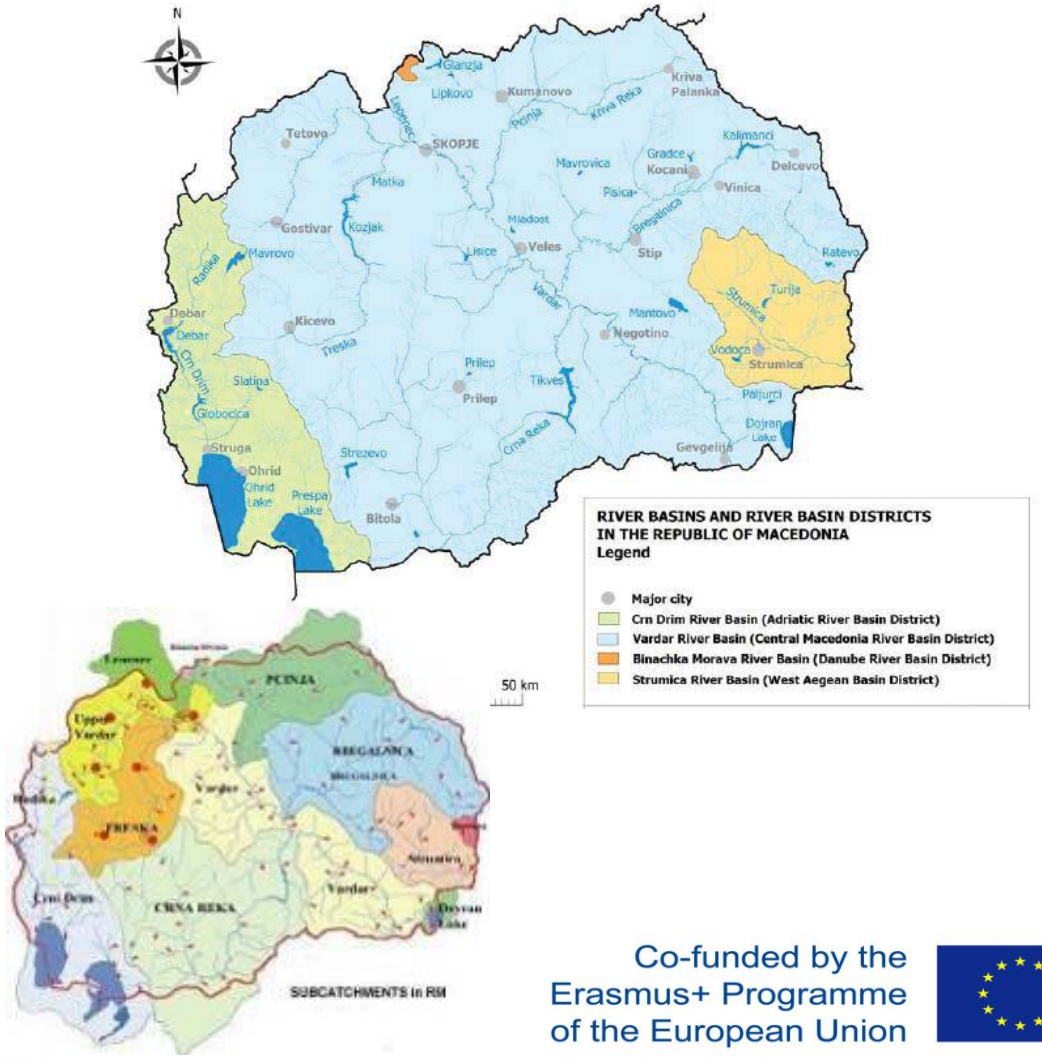
Status of the water resources

- The total water resources of the Republic of North Macedonia are estimated at 6,37 billion m^3 in a normal year and 4,80 billion m^3 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 m^3/year, of which 58 have a capacity of over 100 l/s. Three natural lakes, Ohrid (358 km^2, Macedonian part 229.9 km^2 and with maximum depth of 285 m), Prespa (274 km^2,Macedonian part 176.8 km^2 and with maximum depth of 54 m) and Dojran (43 km^2, Macedonian part 27.4 km^2 and 10 m depth) have also great significance for the hydrographic characteristics of the Republic of North Macedonia.



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Main hydrological parameters of the biggest rivers (Water strategy)

River	River basin	Catchment area (km2)	River Length (km)	Average annual flow (m3/s)	Average annual volume (10^9 m3)	Specific run-off (l/s/km2)
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**
Crna Reka	Vardar	4.985	228	29,3	..	**5,1**
Bosava	Vardar	468	52	23,4(e)	..	**..**
Crn Drim	Crn Drim	3.359	45	52,0(f)	1,640	**12,3**
Radika	Crn Drim	665	67	19,3	..	**..**
Strumica	Strumica	1.649	81	4,2(g)	0,132	**3,1**
Binachka Morava	**Bin.Morava**	(44)	(5)	..	..	..

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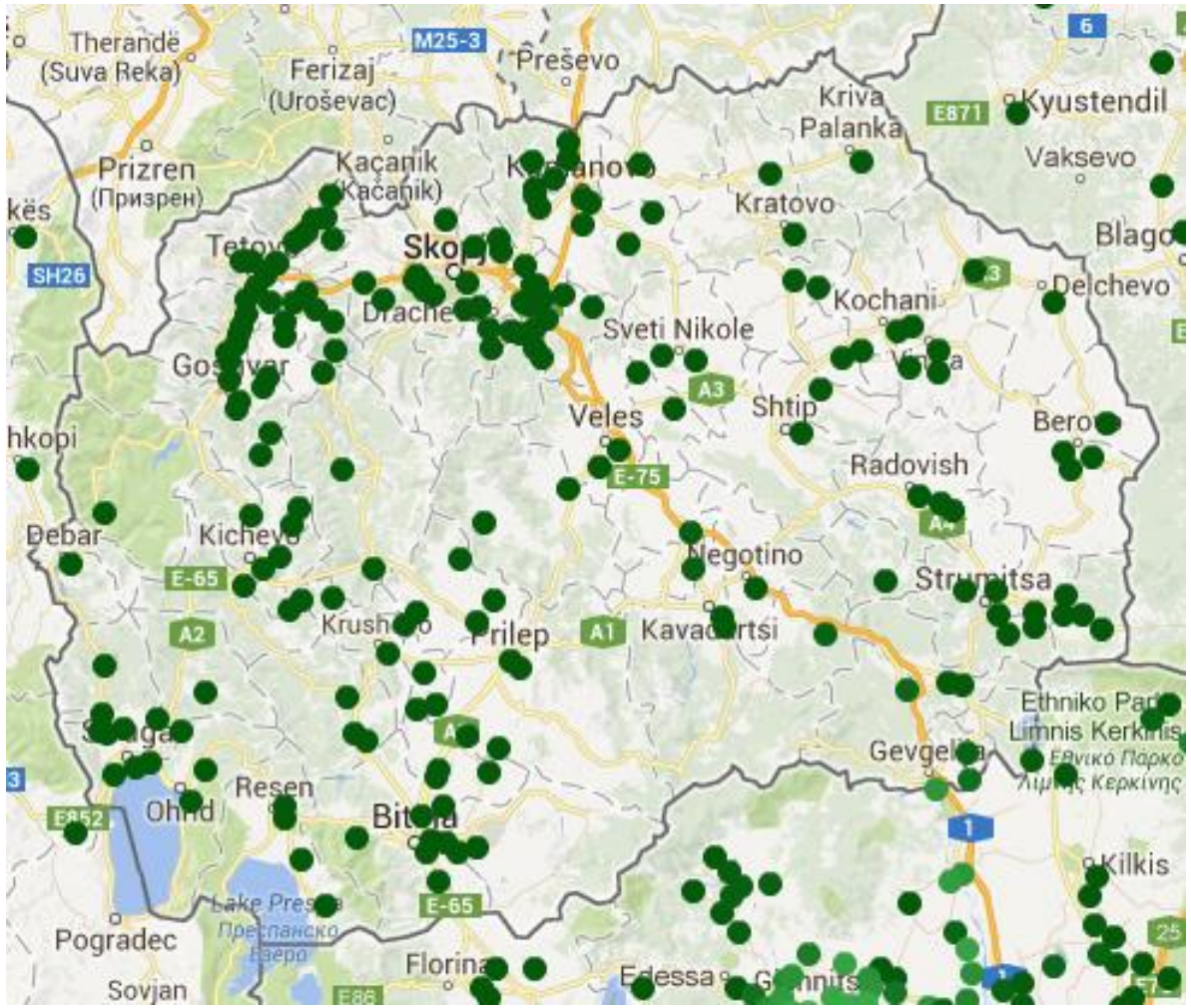
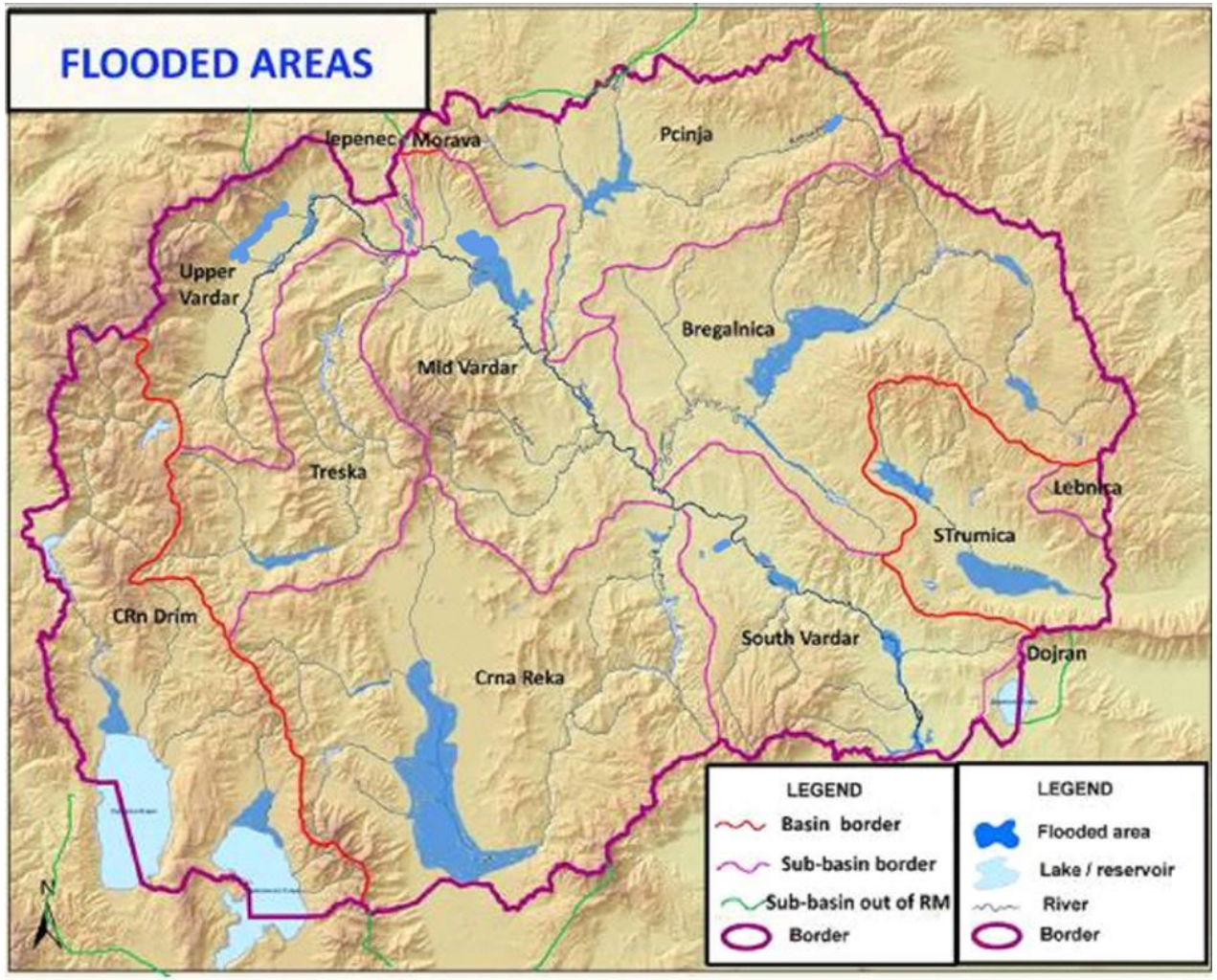
Historical evidence of floods





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Floods in the last 15 years

Date	Affected municipalities.	Losses and damages ME	Affected population	Casualties	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 - 2 extremely	100	450 000 (20 000)	22	Torrent

Preventive measures for torrential floods

- 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 barelands are afforested. The percentage of success is not known up to now, but estimated at reaching 70%. (Blinkov and Trendafilov, 2005)

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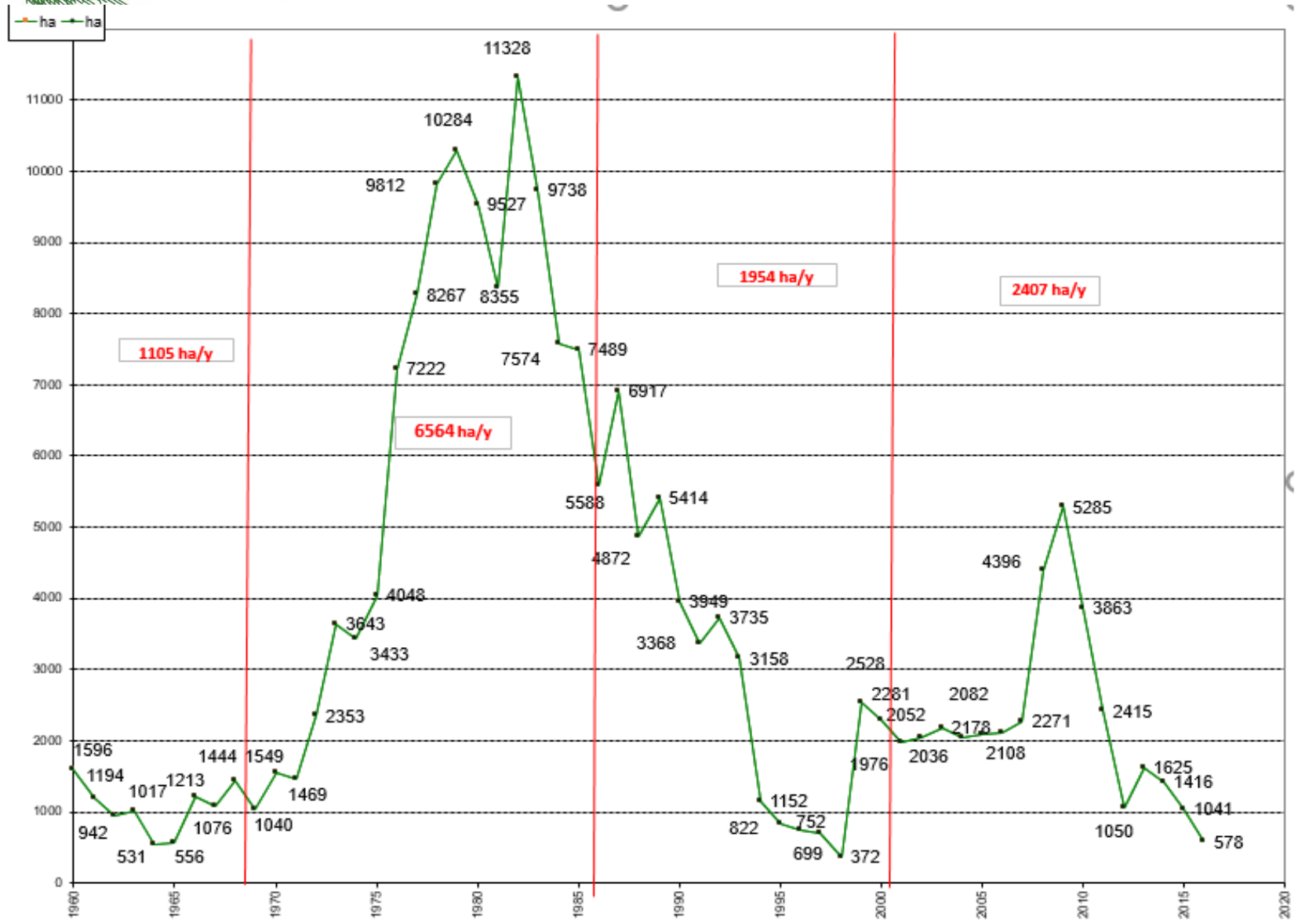

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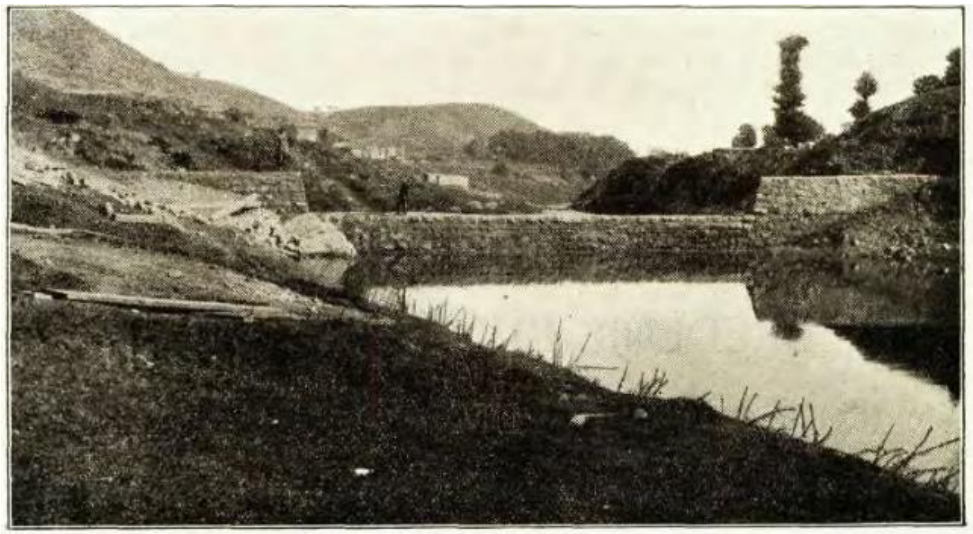

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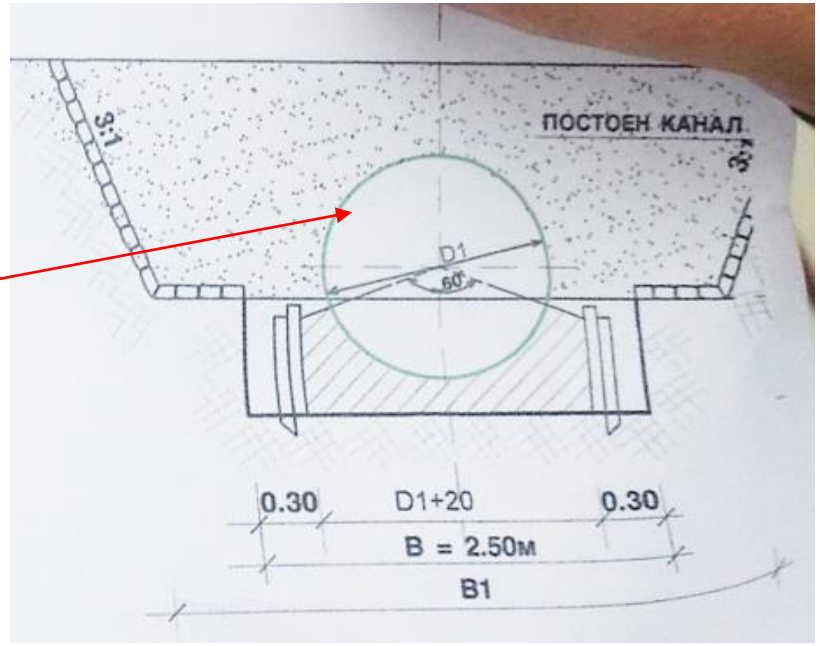
Inappropriate activities



Flood risk management plans

- Up to now, there are 3 flood management plan according to the needs of Flood directive prepared 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.

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

Institutional and legal framework in field of erosion and torrent control

- **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.

- **PROBLEM: There is no separation between riverine and torrent floods.**
- **Flood protection is under competence of municipalities while greater part of catchment areas are under competence of PE National Forest**

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Other Laws

- Law on Protection and Rescue –
- Law on Crisis Management –
- Law on Hydro-meteorological activities -
- Law on Local Self-government -
- Law on water economy –
- Law on forests
- Water strategy …..

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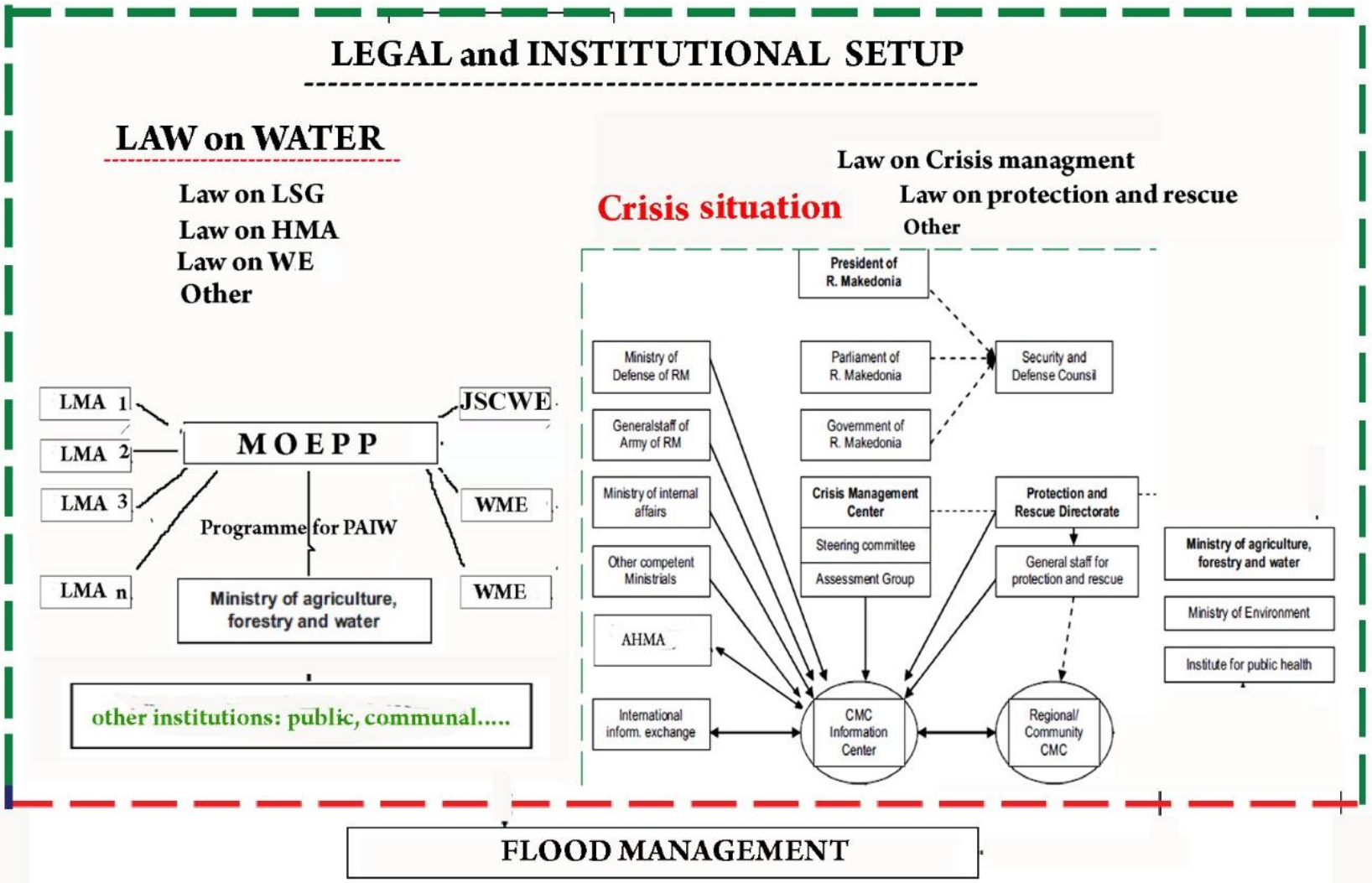
Institutional setup

- 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.



- 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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Thank you for your attention!!!

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