Atlas on Erosion, Drought and Desertification of the Republic of North Macedonia

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Project

"Achieving Biodiversity Conservation through Creation and Effective Management of Protected Areas and Mainstreaming Biodiversity into Land Use Planning"

Project component 3.1.1.1.:
"Preparation of soil erosion and drought vulnerability map, and identification of high-risk zones and their impact to biodiversity"

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Cover photo: Mincev Ivan, 2020,
A view on Krivolak, Povardarie, Negotino municipality

INTRODUCTION

Land is an essential building block of civilization, it is essential for growing most of the food that the world's ever-growing population needs, and yet its contribution to our quality of life is perceived and valued in starkly different and often incompatible ways. While land degradation is a global problem, desertification is land degradation in dryland areas due to various factors, including climatic variations and/or human activity"

The United Nations Convention to Combat Desertification (UNCCD) recognized soil erosion by water and wind as the major cause for land degradation globally.

An existed Erosion Map of the country was developed using EPM through direct on filed mapping based on expert judgment 30 years ago. Erosion map using RUSLE has never been produced.

Drought and Aridity maps are necessary for delineation of the region vulnerable to desertification.

Maps of drought and desertification vulnerable areas have not been systematically analyzed over the whole territory of the country and there were no available maps up to now.

Desertification associated with biodiversity loss contributes to global climate changes through loss of carbon sequestration capacity and an increase in land-surface albedo.

These information are essential tool for evaluation of impact of the main drivers of land degradation and desertification in the country enabling reliable, easy and efficient quantification of the extent of land degradation and desertification processes.

Within this activity, main focus was given on development of the standard methodology for preparation of soil erosion, drought and desertification maps, in a contemporary approach using contemporary GIS/RS technologies and methodological approaches. It will be base for initial development of these databases and its further updating and maintenance. Moreover, these datasets were organized in a manner to be networked with other existing and future datasets related to desertification (soil, climate, land use, hydrology etc.) and become part of the decision-making process with wider environmental scope. The required information was provided through analysis of existing information and outreach activities.

Geographical scope of the study is the territory of the whole country with focus on the region vulnerable to desertification. The major outcomes are**:**

- erosion maps using EPM and RUSLE methodology and corresponding data arising from spatial analyzes;
- aridity and drought vulnerability;
- map of region vulnerable to desertification;
- maps of high-risk areas regarding erosion, aridity, drought and desertification;
- biodiversity in high risk areas.

Explanation of accepted terms:

- *Erosion map – map of erosion intensity (EPM), map of soil losses (RUSLE)*
- *Aridity map – map of areas with appropriate Aridity Index (threshold according to FAO-UNEP)*
- *Drought vulnerability map – Map of areas based on calculation (exposure + sensitivity) / adaptive capacity*
- *Region vulnerable to desertification – region under risk of appearance of desertification processes, based on aridity index by UNCCD*

EROSION

Various digital data was collected to be used further for erosion modelling as well as aridity, drought and desertification modelling.

Erosion modelling was launched using 2 methods – EPM (Erosion Potential Method) and RUSLE (Revised Universal Soil Loss Equation).

Model developed using EPM would be valid on country level with future validation and correction in the western part of the country. Model developed using RUSLE is valid for agricultural land.

For the erosion modelling using EPM, workflow consists of: desk-top analyses and filed work.

During the field work were directly mapped some necessary parameter later used for modelling as well as for validation of the final output of modelling. During this work, were made slight changes in original auxiliary tables for defining parameters γ and Xa.

According to Erosion Map using EPM, mean erosion coefficient on country level is Z = 0,31. Based on this map (preliminary and validated only for central part), total annual production of erosive material (sediment) is W = 12.900.832 m^3, or mean annual specific production Wsp = 519 m^3/ km^2.

These values are lower than those acquired in the previous map prepared 30-40 years ago using direct on-field mapping using expert judgment opinion as W = 17.000.000 m^3 and Wsp = 685 m^3/ km^2. About 33,6% of the country is affected by unacceptable intensity of erosion processes (I, II and III category), while 11,3% of the country is affected by high and very high erosion processes.

From erosion point of view, situation is improved today because of several factors especially in the hilly and hilly-mountain region as follow: decrease of rural population, land abandonment, overgrowth of abandoned agricultural land with woody vegetation, improvement of agricultural practices, decrease of livestock. But model was validated only for the central part of the country although this model is suitable for the eastern part of the country, but in the western part of the country this approach was not validated and the final results of modelling show lower results than expected.

Erosion control measures with high priority would be carried out on terrains affected by I and II category of erosion, while for terrains affected by II category of erosion are recommended measures with low to medium priority.

The erosion model using RUSLE methodology was done only with desk-top work. The working team followed the methodology modified by Panagos P. et al during preparation of erosion map of EU (2014, 2015). The only difference was in defining R – parameter, taking in consideration the absence of relevant data and because of that was used alternative approach based on annual sum of precipitations i.e formulas by various authors.

This map-model is focused on agricultural land. According to Erosion Map using RUSLE, mean annual soil losses on agricultural land is E= 4,1 t/ h. Total annual soil losses on agricultural land is calculated as 3,7 million tones.

It means that erosion control works should be carried out immediately with high priority on the terrain where soil losses are over 10 t/ha that cover 88.094 ha, but also on terrains were soil loses are between 3-10 t/ha that cover 340.394 ha with medium priority.

ARIDITY AND DROUGHT

For presentation of aridity on the country were developed maps of Aridity index by UNEP and Bagnouls-Gaussen aridity index (BGI). For further analyzes was accepted aridity index following UNEP adoption in 1992 where Ai is relation between potential evapotranspiration and average annual precipitation. For interpolation on a national level were used two methods: linear regression and kriging method.

Although according to UNEP, all region where aridity index is > 0,65 is assigned as humid, taking in consideration future climate changes and probably decrease of current values of aridity index, as well as some uncertainty in extrapolation because of insufficient meteorological network, part of the area with 0,65 < Ai< 0,75 is extracted from humid zone and set in a separate category.

The semi-arid climate is represented with 8% along Vardar River and south east part of the country. Dry sub-humid climate conditions with 20% is distributed mainly in the central and northern part of the country. Near to moderate humid climate conditions are 18,4% distributed mainly in Pelagonija region and less than moderate climate conditions are distributed manly in hilly-mountainous region with 53,6%.

Use of drought indices allows a quantitative assessment to be made of the climatic anomalies in terms of intensity, spatial extent and frequency, and favour the exchange of information about drought conditions. Large number of drought indices were calculated in a GIS environment as follow: Deciles, Standardized Precipitation Index (SPI), Rainfall Anomaly Index, Palmer Drought Severity Index (PDSI), Palmer Hydrological Drought Severity Index (PHDI), Palmer Moisture Anomaly Index (ZIND)

The drought vulnerability map of Republic of North Macedonia was prepared according to recommended procedure within the project "Drought Management Centre for South East Europe" (DMCSEE-OMSZ, 2011).

Regions which are moderately vulnerable to drought cover 51.79%. The vulnerable areas are distributed mainly in central and northern region, so as Pelagonija Region and cover 21.73%. The strongly drought vulnerable region is the central part of the country with only 1.14%

REGION VULNERABLE TO DESERTIFICATION

Region vulnerable to desertification according to the preliminary modelling based on FAO-UNEP approach cover 28% of the country. This area is located up to 600 m asl in several valleys and surrounding lower hilly region in: Skopje valley, Kumanovo valley, Veles valley, Ovche Pole, Shtip-Kocani valley, Radovish-Strumica Valley, Tikvesh valley, Valndovo – Gevegelija valley.

Additionally 18% of the country where Ai <0,75 are taken in consideration for future monitoring and analyzes because of uncertainty of current modelling as well as future forecast climate changes.

61 local municipalities in the country are within the Region vulnerable to desertification, part of them fully, part of them partially. The most affected municipalities are: Ilinden, Petrovec, Lozovo, Veles, Sv. Nikole, Gradsko, Negotino, Demir Kapija, Gevgelija, Valandovo, Vasilevo, Bosilovo, Novo selo, Strumica.

The greatest part of the area of RVD is under arable agricultural land (52,68%) or in total 376.941 ha. On the other hand, significant part of total area of agricultural land is within the region to desertification i.e. 72,71% of area with permanent crops, 57,65% of area of arable land and 47,24% of area of heterogeneous agricultural land. It means that agricultural arable land is the most affected by risk of desertification.

Area with unacceptable intensity of erosion (I, II and III category) cover 37,95% of the total area of RVD. Out of them, the highest categories where erosion control measures are with high priority (I and II category) cover 89.242 ha or 12,56% of the total area of RVD. Part of these area is within the army polygon.

BIODIVERSITY IN HIGH-RISK ZONES

Erosion causes various damages sometimes irreversible. Besides on-site damages as loss of soil and nutrients, water loss and disbalance of the water regime, degradation of the landscape, there are damages that occur far from the site of the erosion as torrential floods with a lot of sediment, deposition of sediment in downstream parts; mechanical and chemical pollution of water.

If an ecosystem has been very degraded due to soil erosion, it will take a very long time for its biodiversity to recover, if it even recovers in that area at all. Soil erosion decreases the soils potential to mitigate and adopt to climate changes and it causes loss of biodiversity. Then the soil impoverishes and natural succession of vegetation is logical consequence.

Finally, on the downstream sections, the sediment which is a result of erosion is deposed (in this region into the reservoirs but also everywhere on the agricultural land). Additionally chemical pollution is inevitable fact. Phosphates and nitrates as well as various pollutants reach the water bodies as a result of erosion (rinsing) of agricultural land, transport of sediments contribute to eutrophication of lakes and appearance of toxic alga-bloom.

Generally, the region vulnerable to desertification covers area up to 600 m asl. During the field work was noticed that everywhere in this region appear *Paliurus spina-christi*, commonly known as Jerusalem thorn, garland thorn, or on a Macedonian language – draka, chalija. This species could be bio-indicator for extent of the region vulnerable to desertification in current climatic conditions. Agricultural and rural landscape types cover 67,5%, dry grasslands 9,7%, woodlands and forest 20% of RVD. Dominant natural vegetation is *Querco-Carpinetum orientalis Rud.apud.Ht*, while in the southern part *Coccifero-Carpinetum orientalis Oberd.emend.Ht*.

Comparative analyzes of this phenological phase for the past thirty-year period versus more recent twenty-year period show changes in the average date of the beginning of flowering of natural vegetation i.e. selected analyzed species: *Robinia pseudoacacia, Quercus pubescens, Quercus cerris, Aesculus Hippocastanum.* It is noted that the average time of onset of flowering begins earlier, especially in the central part of the country. This change is mostly evident for *Robinia pseudoacacia.*

Land degradation and desertification are significant problem for economy and social status of people that are faced with this problem as well as for biodiversity. Taking in consideration forecasted climate change that are not favorable for our country, situation will worsen in future so the population and the Governmental and local institutions should pay more attention to it to adopt to new situation and mitigate the consequences of the desertification.

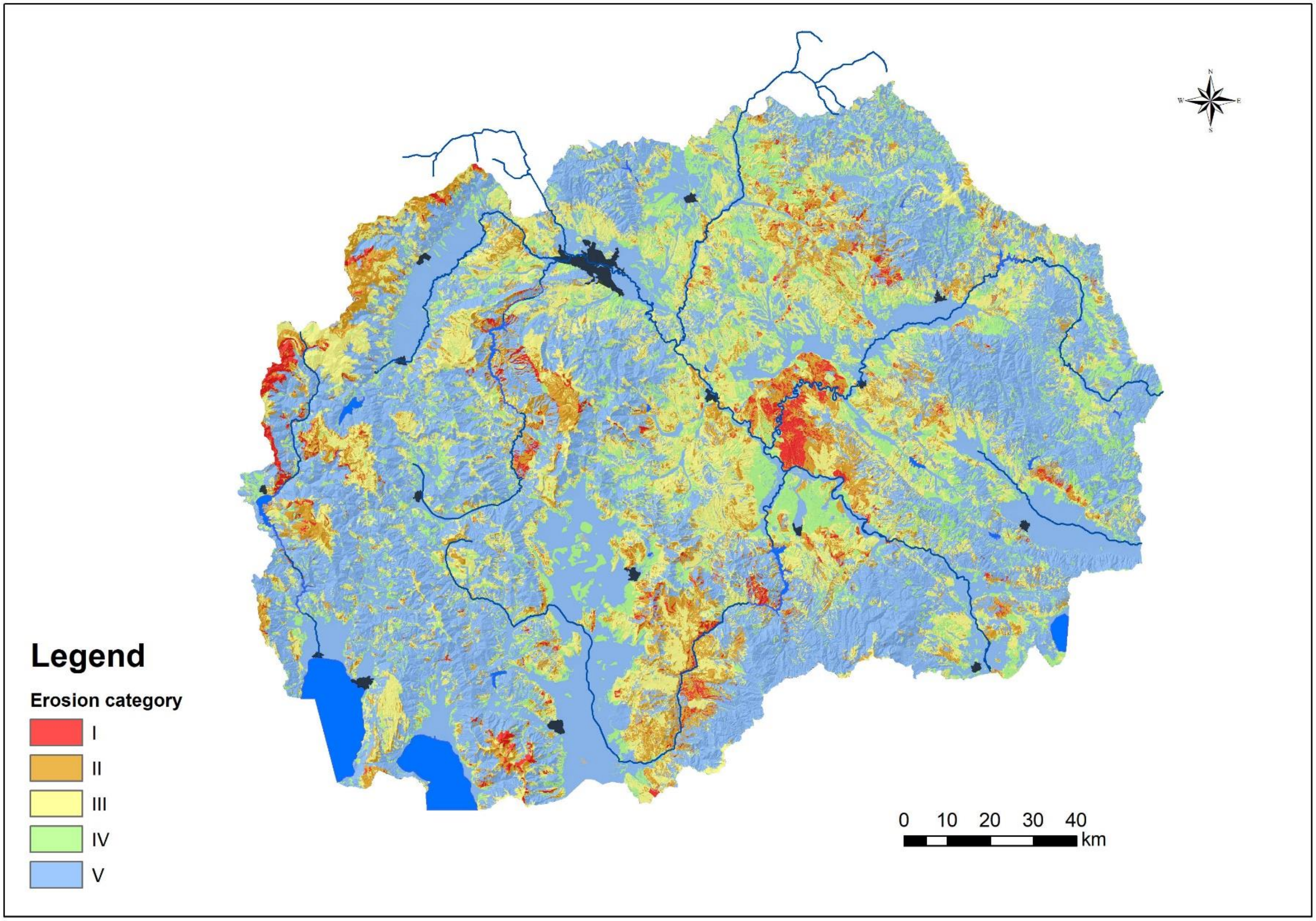

Figure 1 - Erosion Map developed using EPM - Erosion Potential Method

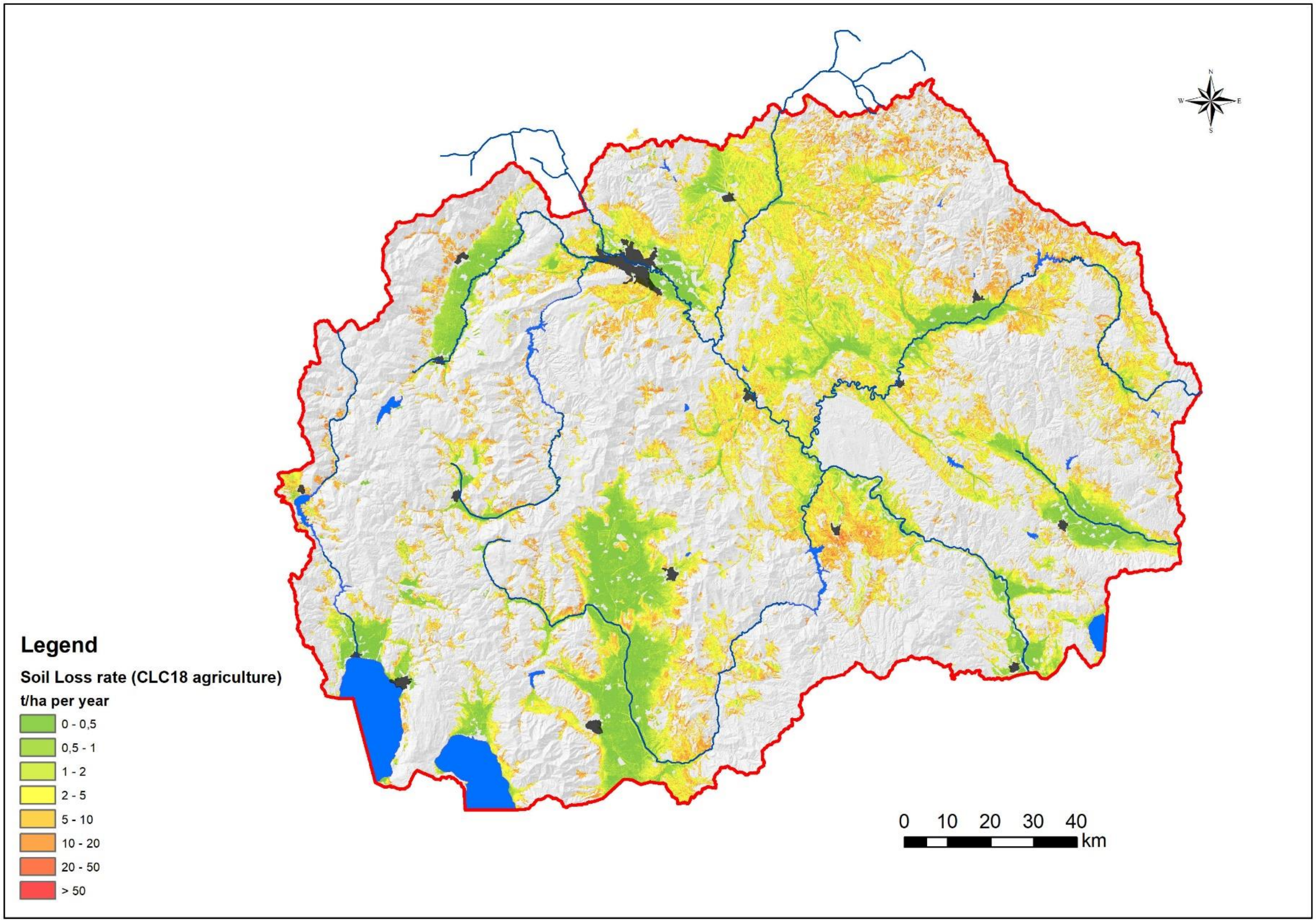

Figure 2 - Erosion Map of agricultural land developed using RUSLE (Revised Universal Soil Loss Equation)

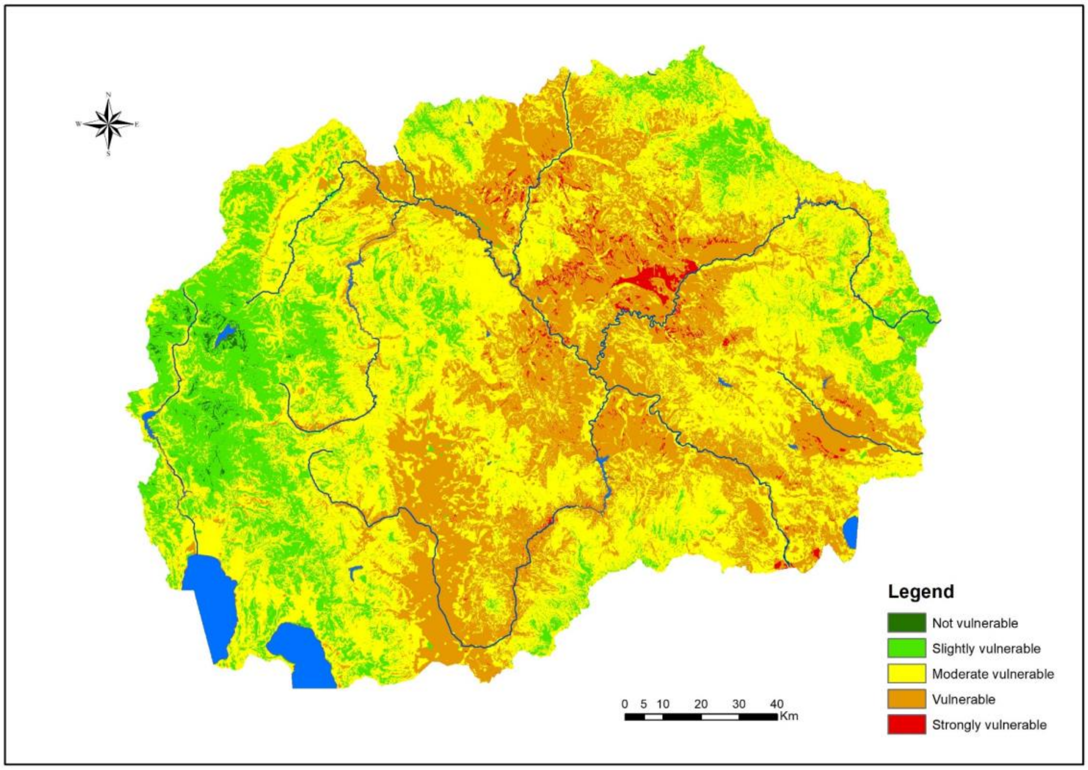

Figure 3 – Drought vulnerability map

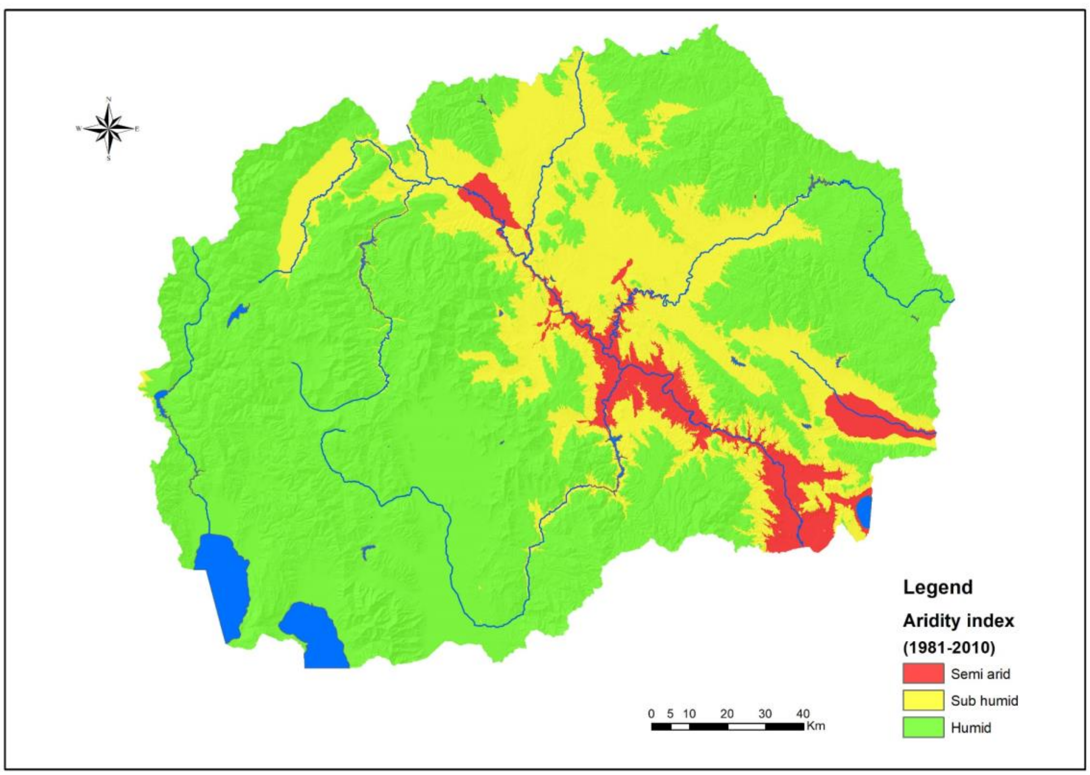

Figure 4 Aridity index

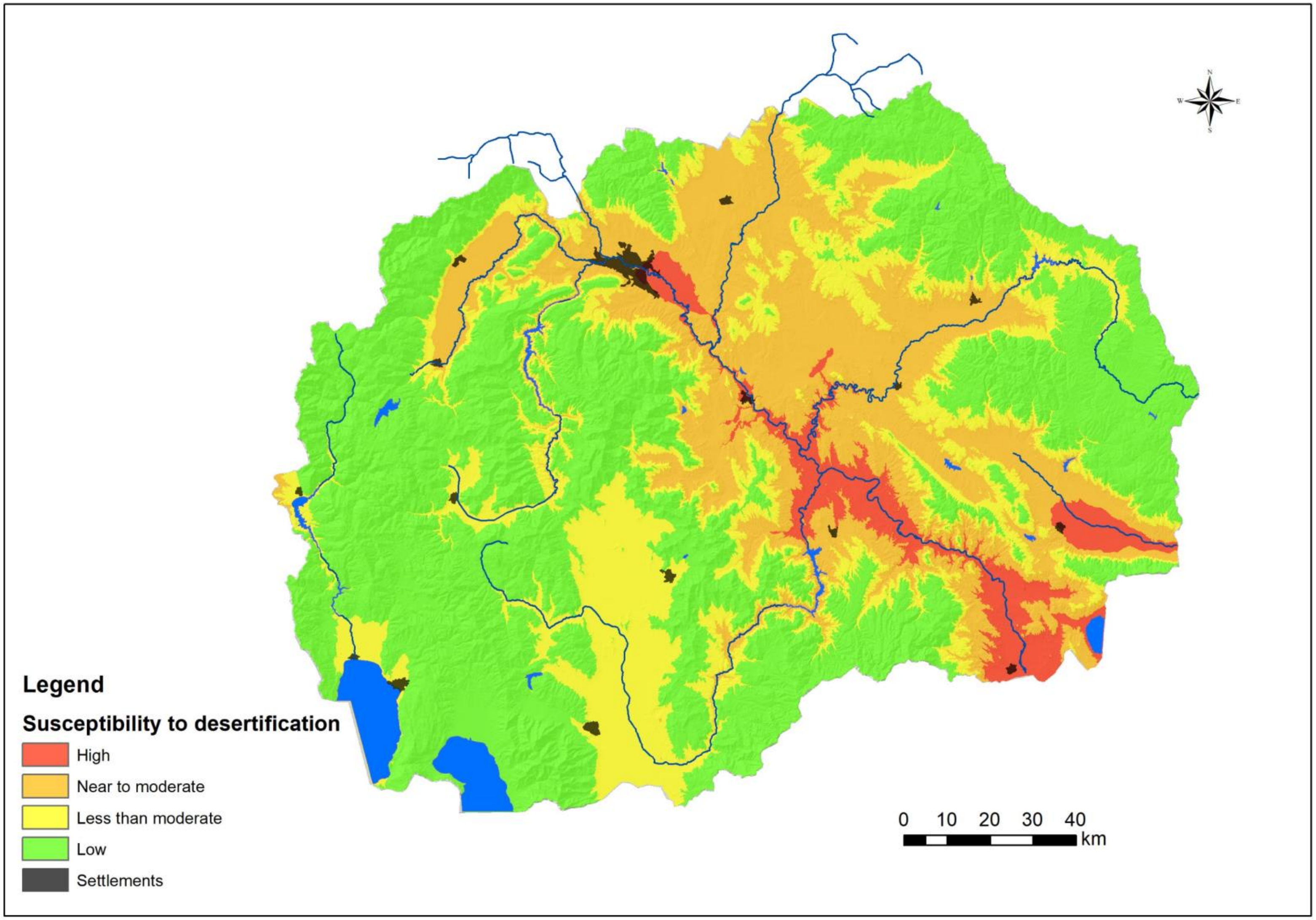

Figure 5 - Susceptibility (risk of appearance of) to desertification

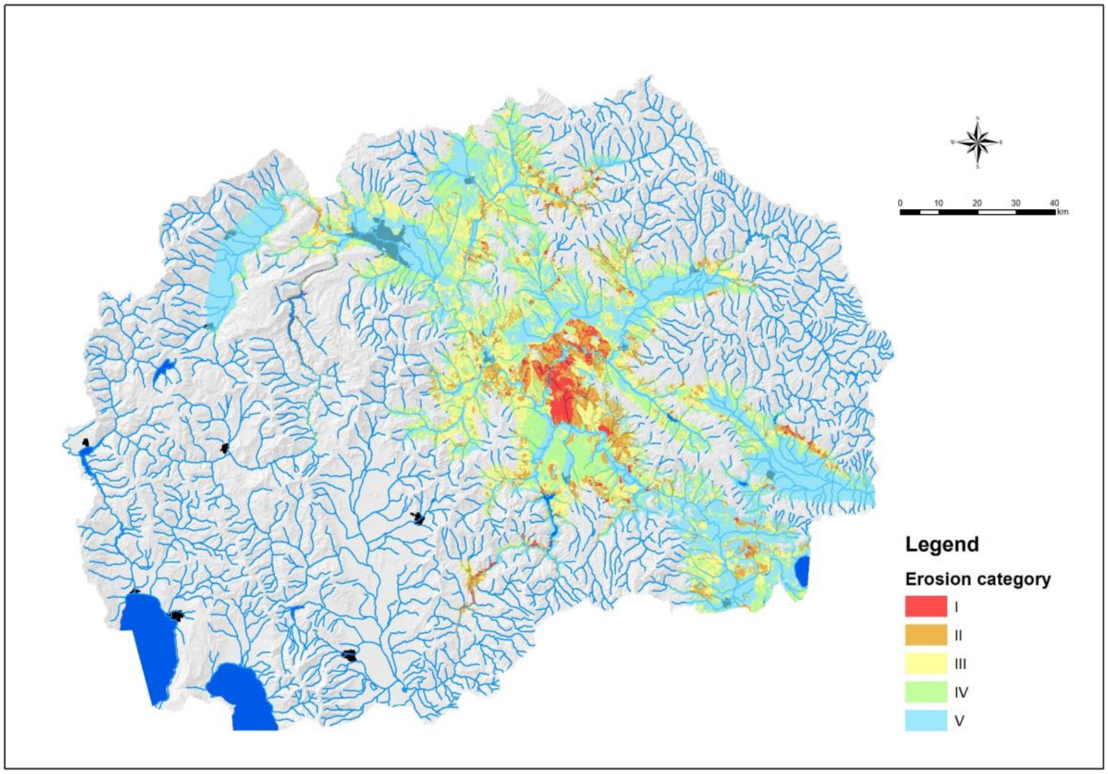

Figure 6 – Erosion intensity within RVD

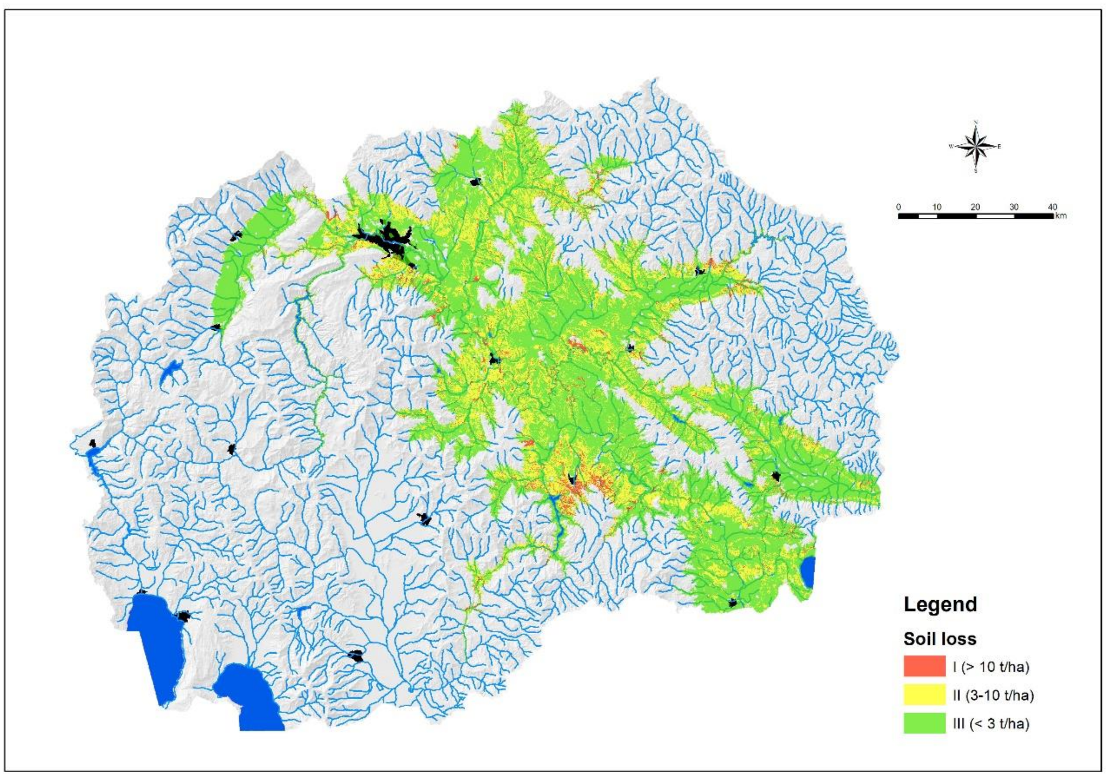

Figure 7 - Soil losses within RVD

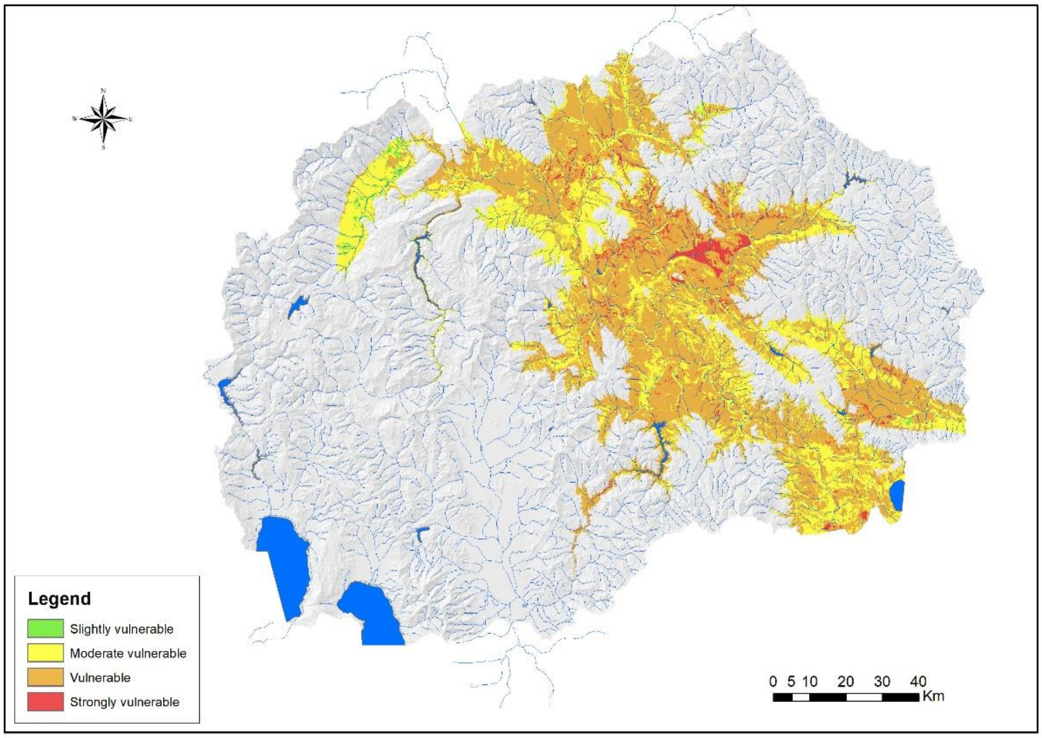

Figure 8 - Drought vulnerability within RVD

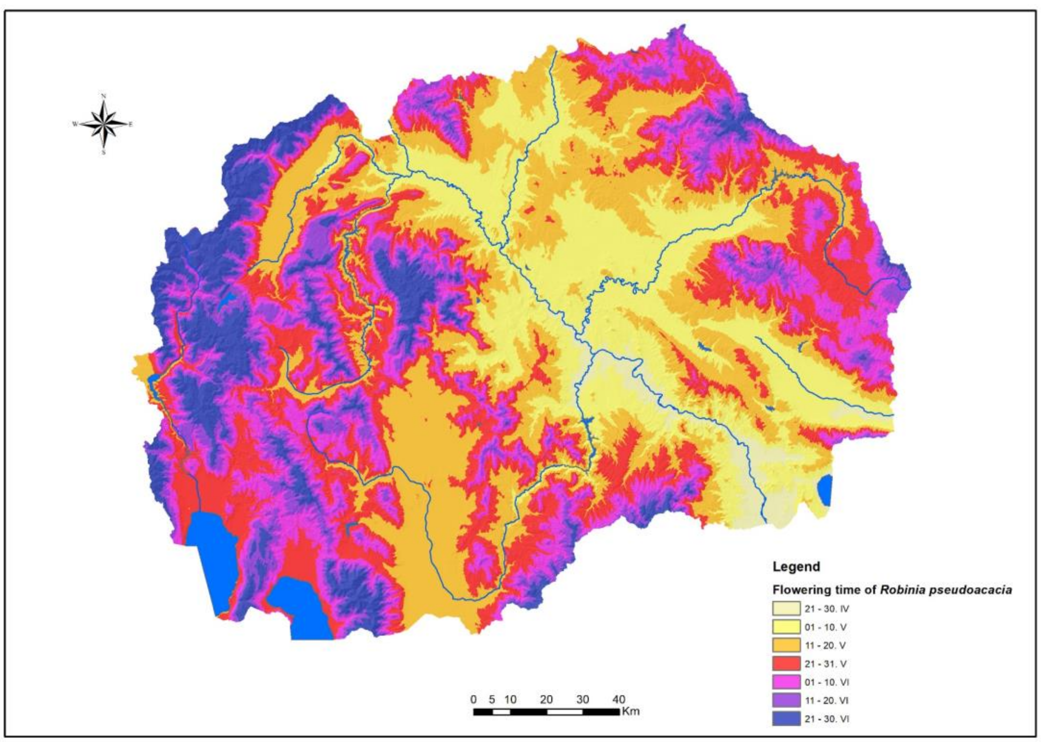

Figure 9 – Flowering time of *Robinia pseudoacacia* (Black locust) 1961-90

RECOMMENDATIONS

Climatological aspects

- Widening the network of climatological stations, especially at altitudes above 1000 m asl.
- Development of 30-minutes rainfall dataset as a necessity for modeling rainfall in RUSLE and EPM. There are some outdated datasets and they should be updated.
- Precipitation data for high mountain region is not certain and complete. Should be developed data for higher gauge stations to be included in modelling later
- Data for intensive precipitations is limited only on several meteorological stations
- Strengthening and providing continuity of meteorological measurements and observations at current meteorological measuring stations
- Additional measurement in regions with higher risk and inclusion of Satellite (remote sensing) monitoring
- Establishment of coordination mechanisms for use of meteorological data from other national sources

Erosion

- Taking in consideration that Erosion Map using EPM in this project was focused and validated only for extended region vulnerable to desertification, next phase should be validation of this model for the other region especially in the high mountain region in the western part of the country
- According to the Law on Water, each municipality and water economy unit are obliged to adopt erosive areas and areas prone to erosion (actual and potential risk areas) based on a technical project. At the moment they have no capacities to do this. Current map is only Erosion hazard map, but to become Erosion Risk map should be added the element of risk.
- Monitoring of siltation of reservoirs should be established as continual practice every 5 years in order to monitor the siltation regime and it can be used for validation of the results of the modelling

Desertification

Because desertification in this project was only tackled from erosion point of view, it is also necessary to develop projects about:

- Mapping environmentally sensitive areas to desertification
- Estimation of the risk for desertification, based on regional climate projection up to 2100 (based on different emission scenarios- RCP). This includes verification and adoption of a single aridity index, calculation and comparison using historical data from the beginning of measurement up to 1981.
- Desertification risk assessment taking in consideration socioeconomic parameters,
- Evaluation and Selection of Indicators for Land Degradation and Desertification Monitoring
- Setting a scene for preparation of risk management plan: as a first phase selection of several highest vulnerable sites, representatives of biodiversity species with regular monitoring and elaboration of periodical (annual, biannual or different period) assessment of the state of desertification impact.
- Socio-economic research in region vulnerable to desertification (agriculture, forestry, water economy, economic status of citizens including, poverty, etc.).

DESERTIFICATION

Delhi Declaration: Countries agree to make 'land degradation neutrality' by 2030, a national target for action

13 September 2019 | Climate Change

NEWS

Tackling desertification, land degradation, and drought for food security

June 16, 2020

Climate change: Land degradation and desertification

26 October 2020 | Q&A

Global soil erosion projected t worse than previously expect

Economy | Environment

Land degradation accelerates global climate change

Desertification or land degradation already affects more than 500 million people in the world's poorest countries.

Soil erosion must be stopped 'to save our future', says UN agriculture agency

JULY 16, 2019

Megadrought caused mega biodiversity loss

by Cass Erba, CSIRO

Desertification and Drought: The Big Challenge to the World

Guest Author | June 17, 2020