NATIONAL DROUGHT PLAN FOR THE REPUBLIC OF NORTH MACEDONIA

United Nations
Convention to Combat Desertification

Republic of North Macedonia
Ministry of Environment and Physical Planning

NATIONAL DROUGHT PLAN FOR THE REPUBLIC OF NORTH MACEDONIA

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Contents

Acknowledgements

ACRONYMS

AWS Automatic Weather Station
CMC Crisis Management Centre
CSO Civil Society Organizations
DEM Digital Elevation Model
DMP Drought Management Plan
DRR Disaster Risk Reduction
DRR/M Disaster Risk Reduction and Management
EC European Commission
EUMETNET Network of European Meteorological Services
FAO Food and Agriculture Organization of the United Nations
GCM Global Circulation Model
GEF Global Environmental Facility
GIS Geographic Information System
HMS Hydrometeorological Service
IDW Inverse Distance Weighting
IGOs Inter-Governmental Organizations
IPCC Intergovernmental Panel for Climate Change
LSGUs Local Self-Government Units
MAFWE Ministry of Agriculture, Forestry and Water Economy
MOEPP Ministry of Environment and Physical Planning
NARDS National Strategy for Agriculture and Rural Development 2014-2020
NCSA National Capacity Self-Assessment
NEAP 2 Second National Environmental Action Plan
NGOs Non-Governmental Organizations
NDVI Normalized Difference Vegetation Index
PAI Palfai Index
PaDI Modified Palfai's Aridity Index
PDSI Palmer Drought Severity Index
PEs Public Enterprises
PHDI Palmer Hydrological Drought Index
PRD Protection and Rescue Directorate
PWME Public Water Management Enterprise
SPI Standardized Precipitation Index
SWSI Surface Water Supply Index
UNCCD United Nations Convention to Combat Desertification
UNDP United Nations Development Programme
UNECE United Nations Economic Commission for Europe
WFD Water Frame Directive
WMO World Meteorological Organization
ZIND Palmer Z Index

1. Executive Summary

Drought management is the concept and practice to avoid, lessen or transfer the adverse effects of drought hazards and the potential impacts of disaster through activities and measures for prevention, mitigation and preparedness. It is a systematic process of using administrative directives, organizations and operational skills and capacities to implement strategies, policies and improving coping capacities. Meteorological and hydrological drought occurs frequently in South East Europe. Widespread meteorological drought with trans-boundary or regional impacts occurs every four to five years. Drought has become increasingly prevalent in the past decades, probably owing to a progressive aridization of the Western Balkans.

Droughts and water scarcity in North Macedonia should not be viewed only as a physical phenomenon or natural event, as they have significant negative impact on the economy, environment and the society in general. They have direct impacts on the citizens and economic sectors that use and depend on water, such as agriculture, tourism, industry, energy and transport. Droughts and water scarcity also have broader impacts on natural resources at large such as through biodiversity, water quality, increased risks of forest fires and soil impoverishment. The Republic of North Macedonia is among the most arid countries in Europe. The majorities of droughts occur in the rural areas of the southern and eastern regions of the country and adversely impact the agriculture sector. The most vulnerable agricultural zone is the Povardarie region, in particular the areas of the Crna, Bregalnica and Vardar rivers. The recent drought events in North Macedonia, in particular in years 1988, 1992/93, 2000, 2011, highlighted the vulnerability of the society to these natural hazards by reducing not only primary production of crops, grass and fodder, but also by affecting the constant supply of good quality water. Major droughts in North Macedonia have caused greater economic losses, particularly in the agriculture, energy, and municipal water sectors. Drought is very frequent and can occur with various duration and severity, causing frequent damages to agricultural sector, as a key sector in the Macedonian economy which contributes an estimated 12% to GDP.

Since the ratification of UN Convention to combat desertification and mitigation of adverse drought effects (UNCCD) in 2002, Republic of North Macedonia makes a lot of efforts in the strengthening the capacities of competent government bodies, including HMS, for carrying out the relevant tasks related to desertification and drought. In this context, “THE NATIONAL DROUGHT PLAN OF THE REPUBLIC OF NORTH MACEDONIA”, represent an overview of current state and opportunities for efficient and proactive drought management. The purpose of this national drought plan is to provide guidance and define specific processes to address drought and drought related activities, such as monitoring climatic conditions, defining declaration levels and triggers, developing impact assessments, mitigation measures, and response actions.

Guidelines for the preparation of this national drought plan were provided by the UNCCD as background document, which offered 10 steps and a draft outline for the preparation of the drought plan, with the supervision of the Ministry of Environment and Physical Planning as the UNCCD National Focal Point for North Macedonia.

This National Drought Plan has been developed in conformity with national legislations, policies, and strategies and also to relevant international protocols and agreements. The Plan provides definitions, types and characteristics of drought as natural phenomenon, as well as historical review of drought occurrence (1961-2010) in Republic of North Macedonia (that were identified according to various drought indices and using the meteorological parameters as input). Also, first estimation of the country drought vulnerability was elaborated, according to which, only less than 1% of the territory of North Macedonia is not vulnerable to drought. Slightly and moderately vulnerable is 8% and 51%, while vulnerable and strongly vulnerable is 39% and 1%.

The Plan considers both reactive and proactive approach for drought management, giving priority to improvement of drought risk management as proactive way for drought response. In a global changing climate and increase of temperatures in the country as well, the essential importance in the natural disaster reduction will have monitoring and early warning systems. Additionally, drought response activities should provide assistance in reducing the drought impact on life and safety, sustainable agriculture and other sectors.

The NATIONAL DROUGHT PLAN FOR THE REPUBLIC OF NORTH MACEDONIA, provide an overview of the institutional framework, the existing politics and regulations, as well as detected areas facing challenges for efficient drought response activities. The necessary interventions in various sectors have been addressed.

At the end, there is a necessity for regular revision and analyze of the undertaken measures in all sectors in order to their further improvement.

2. BACKGROUND

2.1 Drought as a hazard: concept and definitions

Drought differs from other natural hazards in various ways. Drought is a slow-onset natural hazard that is often referred to as a creeping phenomenon. It is a cumulative departure from normal or expected precipitation, that is, a long-term mean or average. This cumulative precipitation deficit may build up quickly over a period of time or it may take months before the deficiency begins to appear in reduced stream flows, reservoir levels or increased depth to the groundwater table.

2.1.1 Causes and determination of drought

Owing to the creeping nature of drought, its effects often take weeks or months to appear (Figure 1). Precipitation deficits generally appear initially as a deficiency in soil water; therefore, agriculture is often the first sector which is affected. It is often difficult to know when a drought begins. Likewise, it is also difficult to determine when a drought is over and according to what criteria this determination should be made. Is an end to drought heralded by a return to normal precipitation and, if so, over what period of time does normal or above normal precipitation need to be sustained for the drought to be declared officially over? Do reservoirs and groundwater levels need to return to normal or average conditions? Impacts linger for a considerable period of time following the return of normal precipitation. Therefore, is the end of drought signaled by meteorological or climatological factors, or by the diminishing negative impact on human activities and the environment? Another factor that distinguishes drought from other natural hazards is the absence of a precise and universally accepted definition.

There are hundreds of definitions, adding to the confusion about the existence of drought and its degree of severity. Definitions of drought should be region- and application specific- or impact specific-.

2.1.2 Other factors related to drought

Temperature, wind and relative humidity are also important factors to include in characterizing drought from one location to another. Definitions also need to be application specific because drought impacts will vary between sectors. Drought conjures different meanings for water managers, agricultural producers, hydroelectric power plant operators and wildlife biologists. Even within sectors, there are many different perspectives of drought because impacts may differ markedly. For example, the effects of drought on crop yield may vary considerably for maize, wheat, soybeans and sorghum because they are planted at different times during the growing season and do not have the same water requirements and sensitivities to water and temperature stress at various growth stages. Drought impacts are non-structural and extend over a larger geographical area than damages that result from other natural hazards such as floods, tropical storms and earthquakes. This, combined with drought's creeping nature, makes it particularly challenging to quantify impacts and even more challenging to provide disaster relief for drought than for other natural hazards. These characteristics have hindered the development of accurate, reliable and timely estimates of the severity and impacts, such as drought early warning systems and ultimately, the formulation of drought preparedness plans. Similarly, it is difficult for disaster officials tasked with responding to drought to deal with the large spatial coverage usually associated with its occurrence.

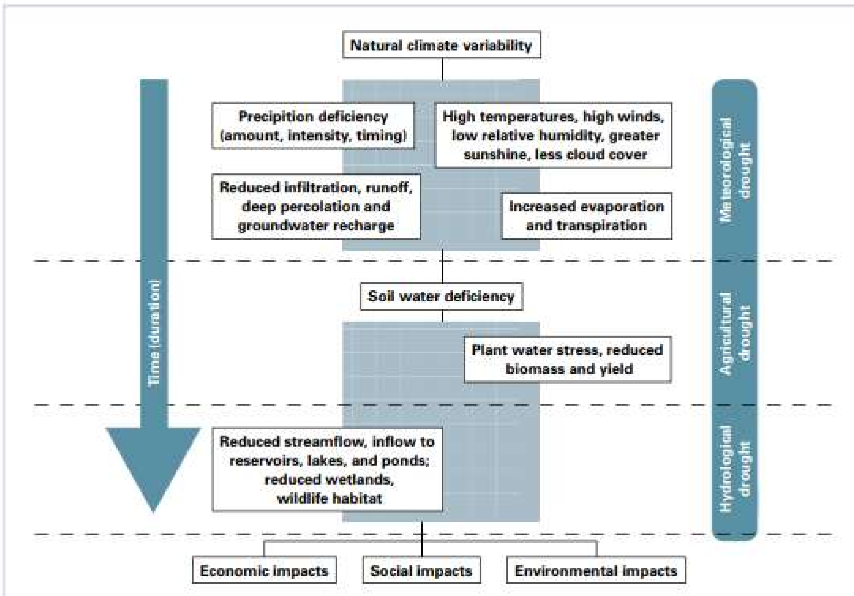


Figure 1: Sequence of drought occurrence and impacts for commonly accepted drought types. All droughts originate from a deficiency of precipitation or meteorological drought but other types of drought and impacts cascade from this deficiency (Source: National Drought Mitigation Center, University of Nebraska–Lincoln, USA)

2.2 Types of drought

Droughts are commonly classified by type as meteorological, agricultural, hydrological and socioeconomic.

Meteorological drought is usually defined by a precipitation deficiency threshold over a predetermined period of time. Meteorological drought is a natural event and results from multiple causes, which differ from region to region.

Agricultural, hydrological and socio-economic drought place great emphasis on human social aspects concerning the drought, highlighting the interaction or interplay between the natural characteristics of meteorological drought and human activities that depend on precipitation to provide adequate water supplies to meet societal and environmental demands.

Agricultural drought is defined more commonly by the availability of soil water to support crop and forage growth than by the departure of normal precipitation over some specified period of time.

There is no direct relationship between precipitation and infiltration of precipitation into the soil. Infiltration rates vary, depending on antecedent moisture conditions, slope, soil type and the intensity of the precipitation event. Soil characteristics also differ: some soils have a high water-holding capacity while others do not. The latter are more prone to agricultural drought.

Hydrological drought is even further removed from the precipitation deficiency since it is normally defined by the departure of surface and subsurface water supplies from some average condition at various points in time. Like agricultural drought, there is no direct relationship between precipitation amounts and the status of surface and subsurface water supplies in lakes, reservoirs, aquifer sand streams because these hydrological system components are used for multiple and competing purposes, such as irrigation, recreation, tourism, flood control, transportation, hydroelectric power production, domestic water supply, protection of endangered species and environmental and ecosystem management and preservation. There is also a considerable time lag between departures of precipitation and the point at which these deficiencies become evident in surface and subsurface components of the hydrologic system. Recovery of these components is slow because of long recharge periods for surface and subsurface water supplies. In some drought-prone areas, snow pack accumulated during the winter months is the primary source of water during the summer. Reservoirs increase the resilience of this region to drought because of their ability to store large amounts of water as a buffer during single- or multi-year drought events.

Socio-economic drought differs markedly from the other types of drought because it reflects the relationship between the supply and demand for some commodity or economic good, such as water, livestock forage or hydroelectric power, which is dependent on precipitation. Supply varies annually as a function of precipitation or water availability. Demand also fluctuates and is often associated with a positive trend as a result of increasing population, development or other factors.

2.2.1 Interrelation between different drought types

The interrelationship between these types of drought is illustrated in Figure 2. Agricultural, hydrological and socio-economic droughts occur less frequently than meteorological drought because impacts in these sectors are related to the availability of surface and subsurface water supplies. It usually takes several weeks before precipitation deficiencies begin to produce soil moisture deficiencies leading to stress on crops, pastures and rangeland. Continued dry conditions for several months at a time bring about a decline in stream flow and reduced reservoir and lake levels and potentially, a lowering of the groundwater table. When drought conditions persist for a period of time, agricultural, hydrological and socio-economic drought occur, producing associated impacts. During drought, not only are inflows to recharge surface and subsurface supplies reduced but demand for these resources increases dramatically as well. As shown in Figure 1, the direct linkage between the main types of drought and precipitation deficiencies is reduced because water availability in surface and subsurface systems is affected by how these systems are managed. Changes in the management of these water supplies can either reduce or aggravate the impacts of drought.

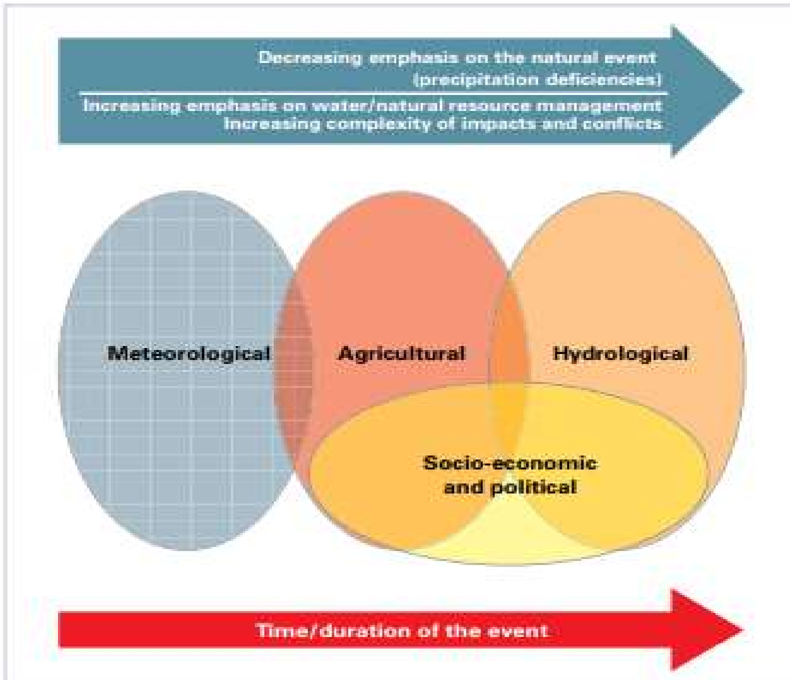


Figure 2: Interrelationships between meteorological, agricultural, hydrological and socio-economic drought. (Source: National Drought Mitigation Center, University of Nebraska–Lincoln, USA)

2.3 Drought in a changing climate

Examination of data from many diverse sources shows that the world is warming. According to global climate models, this will have a significant impact on the hydrologic cycle and, consequently, on the nature of drought in the future.

The hydrologic cycle describes the movement of water between the oceans, land, and atmosphere. Two important factors are relevant: (1) warmer air can hold more water vapor (moisture), and (2) warmer air causes more evaporation/ evapotranspiration. As the world continues to warm, the air will hold more moisture and more water will be evaporated, so there will be an increase in heavy rain events producing more frequent flooding. But more evaporation with hotter temperatures will dry out the soils more and increase water demand, which is one component in the water demand versus water supply drought equation. More demand translates to more frequent and intense droughts.

The climate warming scenario, an accelerated hydrologic cycle will result in more severe droughts (especially in the summer) interspersed with periods of intense flooding that will add extra stress to the agricultural and economic system.

Climate change increases the odds of worsening drought in many parts of Southeast Europe and the world in the decades ahead. Even in regions without changes in precipitation, warmer temperatures could increase water demands and evaporation, putting greater stress on water supplies.

Recent years have shown substantial methodological developments to monitor and assess drought in a changing climate, so the latest regional key findings of Intergovernmental Panel for Climate Change (IPCC) could be briefly summarized in:

- Low confidence in an observed global-scale trend in drought or dryness (lack of rainfall) since the 1950s, due to lack of direct observations, methodological uncertainties and choice and geographical inconsistencies in the trends;
- High confidence that the frequency and intensity of drought since 1950 have likely increased in the Mediterranean;
- High confidence for droughts during the last millennium of greater magnitude and longer duration than those observed since the beginning of the 20thcentury in many regions.

Projection of drought in the Mediterranean area, according to the RCP8.5 emission scenario shows that surface drying is likely with high confidence by the end of the 21stcentury.

In order to improve the resilience to drought, the historic drought examples should serve as guideposts to highlight vulnerability as we move into a warmer and, in some places, drier future.

In Annex 1 Are shown some results of climate change projections prepared for the National Communications on Climate Change, which Republic of North Macedonia regularly submits as an obligation of a Non-Annex 1 country to the UNFCCC.

2.4 Integration of gender concerns into all drought interventions

Drought can have economic, social, and environmental effects on women in less developed countries. Unequal power relations, gender inequalities and discrimination mean that women and girls are often hardest hit during a crisis and will take longer to recover. Women and girls experience vulnerability different to men. During times of crisis women`s access to, or control over, critical resources worsens, and can lead to exclusion from claiming basic services and rights. As a result, women’s and girl’s vulnerability can increase and under-mine their ability to cope with the impacts of droughts and other disasters.

As women are the hardest hit in times of disaster, and their very survival strategies impact on the environment, it is imperative that disaster management planning consider gender in all stages of planning and implementation to reduce the risks to droughts.

2.5 Purpose, Scope, Goals and Objectives

2.5.1 Purpose

The purpose of this national drought plan is to provide guidance and define specific processes to address drought and drought related activities, such as monitoring climatic conditions, defining declaration levels and triggers, developing impact assessments, mitigation measures, and response actions.

2.5.2 Scope

The drought plan will enhance national drought risk management institutional arrangements to coordinate information, identify ways to prepare for droughts, identify the different areas impacted by drought conditions, identify risks associated with drought conditions, and communicate the extent and magnitude of those drought conditions. Further, the plan will help to identify ways to mitigate the impacts of droughts.

2.5.3 Goal

The main goal of this drought plan is to asses current situation and give guidelines for establishing efficient and proactive drought management in the Republic of North Macedonia. In order to achieve this, there is need to strengthen drought early warning systems, promote drought preparedness; reduce vulnerability and risk; and boost resilience, with the following main objectives:

2.5.4 Objectives

- to strengthen drought disaster preparedness and institutional capacity of Government, NGOs, CSOs, and communities to address agricultural and related threats and disasters;
- to define a process to guide ministries, departments and agencies (MDAs), NGOs, CSOs, private sector to address drought-related activities, including monitoring, impact assessment, and the preparedness for various drought stages;
- to identify activities that may be implemented to coordinate drought assessment, response and impact mitigation;
- to identify government ministries, departments and agencies (MDAs), NGOs, CSOs, private sector entities that are primarily responsible for managing drought-related activities; and
- to promote effective mobilization of public and private resources to manage drought mitigation and response efforts;

One of the cornerstones of proactive drought management is the establishment of a drought policy and a drought management plan. This should address the whole drought management cycle (monitoring–impact assessment–response–recovery–preparedness) and help to improve decision-making processes in drought management.

3. DROUGHT MONITORING AND EARLY WARNING SYSTEM

Drought monitoring and early warning is the key factors for later operational management and determines the success of the overall drought management plan. The main objective of a monitoring system is to help decision-makers identify the drought warning conditions and to provide useful information for identifying the best drought mitigation measures on the basis of a continuous monitoring of the drought evolution in terms of meteorological and hydrological variables and water resource availability.

Early warning systems (EWS) can help to identify a drought as early as possible as well as monitoring existing droughts. Adequate rainfall stations throughout the country are therefore highly important, as well as there are challenges like the difficulty to determine the exact thresholds to define a meteorological drought, which would be appropriate in all situations and take certain factors into consideration to justify and initiate government intervention. Moreover, also when government support is provided to farmers and thereby helping them reduce the impact of the drought on their e.g. crops and livestock. The EWS helps to monitor various environmental and socio-economic indices and will trigger alerts when these indices are reached to identify various stages of drought status.

3.1 Monitoring system

3.1.1 Meteorological network

North Macedonia has different climatic characteristics caused by direct climatological influences from north by moderate continental and from south by Mediterranean, in the high mountain regions by mountain climatic influence.

The Hydrometeorological Service (HMS) of Republic of North Macedonia monitors surface and groundwater and performs climate- and agro-meteorological observations. Meteorological observations are carried out at 186 stations as follows: 19 main meteorological, 7 climatological, 24 phenological, 94 precipitation stations and 42 automated weather stations (AWS), which are shown at Map 1.

The following parameters are measured: air temperature and humidity, air pressure, insolation, wind speed and direction, evaporation, soil temperature to different depths, rain- and snowfalls, radiation, cloudiness and atmospheric conditions, soil moisture. Main activities are organization and management of the work concerning performance of complete meteorological and agrometeorological measurements and observations, processing, quality control, archiving, publishing and analysis of results of performed measurements and observations, the monitoring of climate system components and result application in science and economy. HMS uses CLIDATA which is Oracle based application with integrated geographical information system to perform the tasks of archiving, quality control, statistical processing and operating of meteorological data.

Map 1: HMS meteorological station network

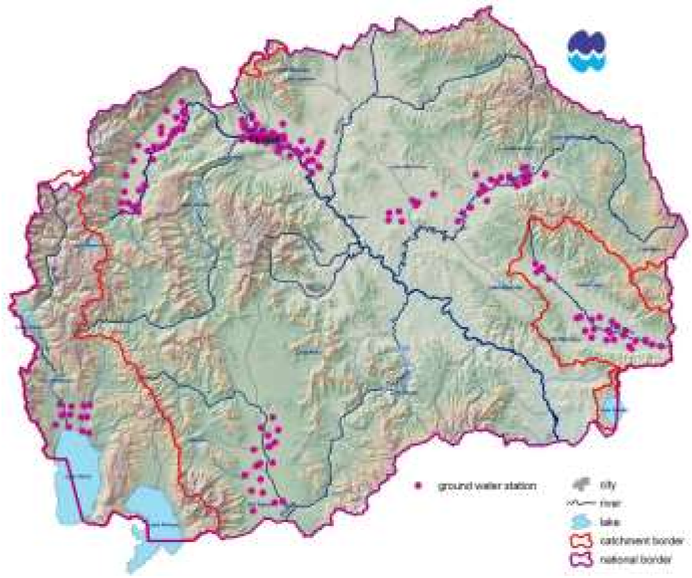
(Source: Hydrometeorological Service of Republic of North Macedonia)

Weather analysis and forecast Department of HMS makes permanent monitoring of weather conditions in North Macedonia and Europe, analyzing numerical models to make the forecast and finally preparing and distributing the weather forecast to the relevant Governmental institutions, media, public sector and private users. Maximal preparedness and reliability request a permanent operative work in shifts 24 hours a day for analysis of surface and upper air maps, operative monitoring of movement and development of atmospheric systems, and dangerous weather phenomena predictions, analyzing satellite and radar images, now casting and short-term early warning of dangerous weather phenomena and distribution to all relevant institutions and public users. Under the auspices of WMO in cooperation with EUMETNET, Republic of North Macedonia is part of the European project METEOALARM that is an integrated extreme weather warning system with the purpose of more prompt, more reliable and more precise severe weather information.

3.1.2 Hydrological network

Hydrological observations are carried out at surface water stations (66) and groundwater stations (38) which are shown at Map 2. Main activities in the Hydrological Department is hydrological investigation of surface water, ground water and springs (surface and ground water level, water temperature, direct measurements of hydrological parameters, water discharge, river bed cross-section with depth and width, water velocity along the whole profile, measurement of the decrease of water surface mirror, hydrological data receipt and processing, annual reports etc.), than hydrological information, balance, studies and water forecast and monitoring.

Map 2: HMS hydrological station network



(Source: Hydrometeorological Service of Republic of North Macedonia)

Regarding water pollution, ecological observation and research are carried out, including: monitoring of qualitative and quantitative characteristics of surface water at 20 measuring points; periodical control of domestic and industrial waste water; monitoring of chemical and toxicological water pollution, and; periodically carrying out radiological and biological analyses.

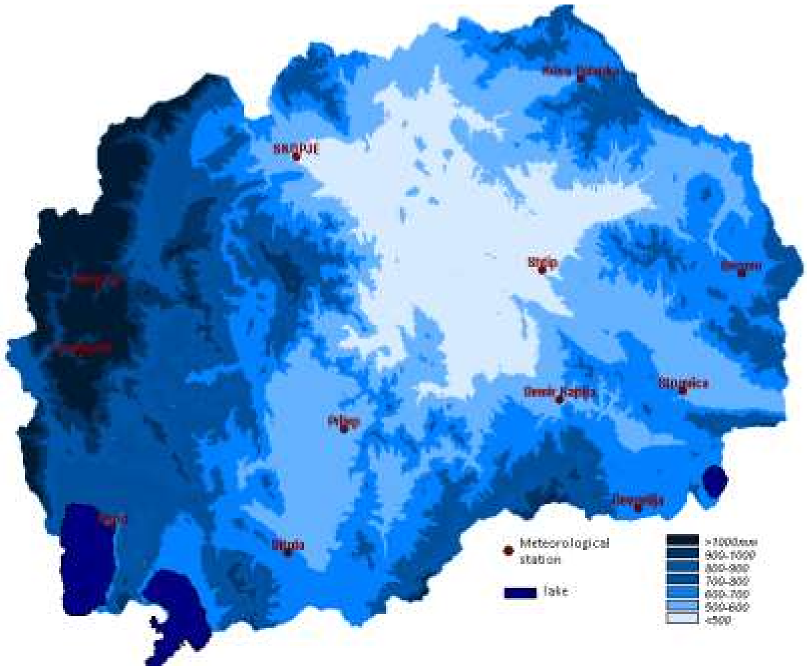
3.2 Drought analysis and historical review

Drought indices are essential elements for drought monitoring since they summarize the complex interaction between climatic variables and related processes (e.g. soil water moisture). Use of indices allows a quantitative assessment to be made of the climatic anomalies in terms of intensity, spatial extent and frequency, and favor the exchange of information about drought conditions among decision makers as well as the public. The availability of a large number of indices is mainly due to the difficulty in defining unequivocally a drought phenomenon.

Average annual sums of precipitation for the period 1981-2010 (Map 3) on the territory of Republic of North Macedonia are below 500 mm in the central part of the country. Mountainous western part is wetter with average precipitation sums higher than 1000 mm. It can be noticed a huge difference in the spatial and temporal distribution of types and quantities of precipitation.

Although the drought in Macedonia is “climatic fact” (Filipovski, 1948), the information and data on drought and drought impact in the country are very limited. Some individual activities at a scientific or professional level do not offer sufficient information to assess all aspects of drought. On the other hand, numerous data could be gathered out of numerous national assessments in other areas, but the problem is the communication among different stakeholders that have those data.

Map 3: Average annual precipitation sum for period 1981-2010y.



(Source: Hydrometeorological Service of Republic of North Macedonia)

Earliest investigation of drought provides analysis of the available meteorological elements from observation in North Macedonia in the period from 1927-1940 according to De Martonne aridity index. This aridity index was calculated for period 1927-1940 and shows values below 10 (5 to 10 indicates edge of desert and steppe) for summer months (July and August) for central (Veles) and eastern (Stip) part of the country. The analysis of the drought impact on the agricultural production 1945-1946 is given in Annex 2.

Agricultural production in Macedonia is strongly influenced by the drought that is caused not by the small annual quantities of precipitation, but mostly by the unfavorable annual distribution, especially emphasized in the central and eastern part of the country (Filipovski, 1948). Records of drought periods defined as number of consecutive days (more than 10 days) with precipitation less than 1mm for the period 1951-1975, show extreme long dry periods in 1953 (Feb-Apr), 1956 (Jul-Oct), 1961 (Jul-Oct), 1965 (Sep-Dec), 1969 (Sep-Dec), 1974 (Jul-Sep).

The most extreme dry period was registered in 1956 from July-October, over entire territory of the Republic of North Macedonia with recorded 88 days without precipitation (Lazarevski, 1982, 1993).

3.3 Drought indices

The latest archiving of drought data was done at the Hydrometeorological Service, providing the extension of the mentioned period until 2000, which shows prolonged dry periods in the period 1986-1989 (in the central part up to 54 days in Dec-Feb 1988), in 1992 (Stip 54 days from Jan-Mar), in 1997 (Prilep 40 days from Jun-Jul), in 2000 (Demir Kapija 47 days from Jul-Sep) (HMS Archive, 2010).

Different indices and methods have been proposed since the '60s to identify and monitor drought events. Some of the indices refer to meteorological drought and are based on precipitation series, while others are oriented to describe hydrological or agricultural drought or water shortages in urban water supply systems. Table 1 presents a summary of possible operational calculation of the main indices and indicators that can be applied to drought characterization and monitoring.

The most commonly applied drought indices include the Standardized Precipitation Index (SPI), the Palmer Drought Severity Index (PDSI) and Deciles due to their simplicity. It was concluded that the easiest index to be used for monitoring purposes is the SPI, which is based on a single meteorological parameter (precipitation). Recent advances in remote sensing provide products that have a large potential as drought indices like Normalized Difference Vegetation Index (NDVI) widely used for monitoring and forecasting crop production world-wide and by agricultural insurance companies in the world.

Table 1: Drought indices, indicators and their characteristics

drought index	Indicator	Category of use
Deciles	Precipitation	Meteorological
Standardized Precipitation Index (SPI)	Precipitation	Meteorological, used for monitoring and forecasting
Rainfall Anomaly Index	Precipitation	Meteorological, sensitive to extreme events
Run Analysis	Precipitation, Streamflow	Meteorological and hydrological, for spatial-temporal analysis of historical events
Palmer Drought Severity Index (PDSI)	Precipitation, Temperature, Soil Moisture (Available Water Content)	Meteorological, effective in agriculture, used in historical analysis and risk analysis
Palmer Hydrological Drought Severity Index (PHDI)	Precipitation, Temperature, Soil Moisture Conditions	Hydrological, effective in monitoring
Palmer Moisture Anomaly Index (ZIND)	Precipitation, Temperature, Soil Moisture Conditions	Agricultural
Surface Water Supply Index (SWSI)	Snowfall, Precipitation, Stream flow, Reservoirs	Hydrological, effective when snow is important

Because hydrometeorological parameters are measured at certain stations and decisions should be taken in most cases at basin level, spatial integration is required in the case of applications of the methodology for water and agricultural management decisions. Spatial integration at a level of a small basin or sub-basin may be implemented by calculating the weighted mean of the parameters involved. Weight in this approach is the area represented by each station. The spatial extent of drought is estimated based on comparisons of the affected area with a threshold referred to as "critical area". A promising method with the flexibility to use various area thresholds associated with each severity level of drought is based on plotting the percentage affected area against each level of severity of drought.

As far as the time step is concerned characterization of drought can be based on an annual time step accompanied by other shorter time steps (e.g. six months, three months) or any other time duration tailored for the specific application. The selection of the time step applied is a crucial element in the analysis as well as the selection of the threshold for each index.

3.3.1 Deciles

Deciles have been developed to be used instead of percent of normal. They are calculated from the number of occurrences distributed from 1 to 10 (Table 2). The lowest value indicates conditions drier than normal and the higher value indicate conditions wetter than normal. The deciles analysis for the annual precipitation sums for the main meteorological station for the period 1966-2015 is shown in Table 3.

Table 2: Deciles classification

deciles 1-2: lowest 20%	much below normal
deciles 3-4: next lowest 20%	below normal
deciles 5-6: middle 20%	near normal
deciles 7-8: next highest 20%	above normal
deciles 9-10: highest 20%	much above normal

Arranging monthly precipitation data into deciles is another drought-monitoring technique. It was developed by Gibbs and Maher (1967) to avoid some of the weaknesses within the “percent of normal” approach. The technique they developed divided the distribution of occurrences over a long-term precipitation record into tenths of the distribution. They called each of these category’s deciles. The first decile is the rainfall amount not exceeded by the lowest 10% of the precipitation occurrences. The second decile is the precipitation amount not exceeded by the lowest 20% of occurrences. These deciles continue until the rainfall amount identified by the tenth decile is the largest precipitation amount within the long-term record. By definition, the fifth decile is the median, and it is the precipitation amount not exceeded by 50% of the occurrences over the period of record. The deciles are grouped into five classifications. One disadvantage of the decile system is that a long climatological record is needed to calculate the deciles accurately.

Table 3: Deciles analysis for annual precipitation sums in mm for the period 1966-2015 for the meteorological station in Republic of North Macedonia

Deciles classification	*Demir Kapija*	*Berovo*	*Bitola*	*Gevgelija*	*Kriva Palanka*	*Lazaro-pole*	*Mavrovo*	*Ohrid*	*Prilep*	*Stip*	*Strumica*	*Skopje**
Much below normal	391.8	462.6	416.9	491.7	444.3	784.6	683.5	509.0	361.3	306.9	385.6	306.9
(1 -2 Deciles)	449.9	498.7	521.8	538.2	535.2	880.0	769.2	552.5	427.5	364.5	473.4	349.7
Below normal	499.1	570.5	549.3	567.0	577.2	924.7	817.0	604.0	466.6	428.1	514.3	376.2
(3 -4 Deciles)	540.1	581.0	584.9	631.4	619.7	988.4	905.6	649.1	503.3	443.6	539.0	445.8
Near normal	559.8	640.8	608.4	686.6	655.5	1034.9	997.3	693.2	520.9	471.6	587.6	491.5
(5 -6 Deciles)	594.7	662.8	633.3	757.0	667.6	1095.5	1077.5	721.1	564.2	502.1	600.2	511.4
Above normal	636.8	683.8	671.7	787.5	693.5	1153.7	1127.6	747.9	589.4	516.6	624.1	527.7
(7 -8 Deciles)	663.3	710.3	708.2	854.9	741.6	1252.1	1224.4	808.8	644.7	555.7	680.7	559.1
Much above normal	693.2	752.6	788.6	922.9	787.7	1317.3	1269.6	874.6	690.4	621.6	748.3	656.6
(9 -10 Deciles)	824.4	1034.0	884.7	1161.6	998.6	1566.5	1695.9	1145.1	832.7	799.4	887.9	782.9

* Skopje calculation period 1986-2015.

3.3.2 Percent of normal

Percent of Normal is a simple method to detect drought. It is calculated by dividing actual precipitation by normal precipitation –typically a 30-year mean and multiplying it by 100% for each location.

Table 4: Precipitation normals for period 1981-2010y for some meteorological stations in Republic of North Macedonia (mm)

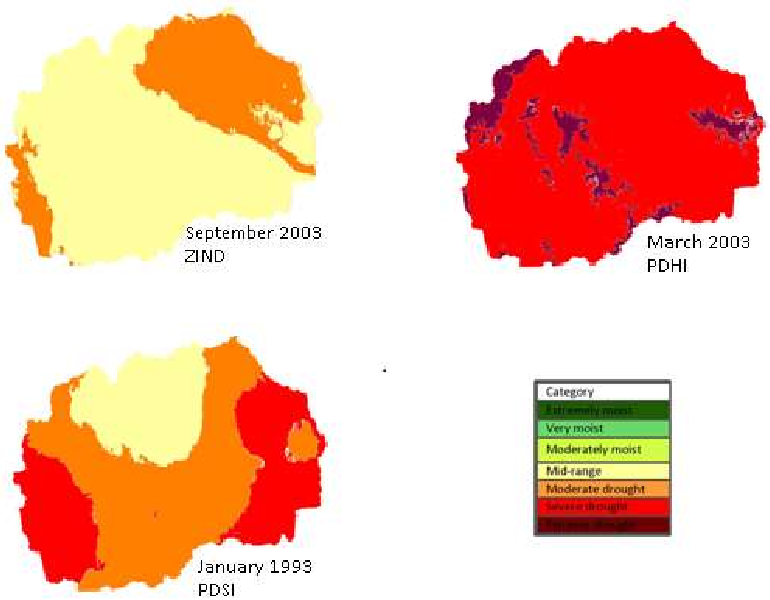
Meteorological station	***Skopje***	***Bitola***	***Stip***	***Prilep***	***Demir Kapija***	***Strumica***	***Ohrid***	***Gevgelija***	***Kriva Palanka***	***Lazaro-pole***	***Berovo***	***Mavrovo***
prec. normal 1981-2010	478.6	619.9	455.1	510.1	554.8	564.4	689.9	678.6	624.7	1060.4	611.1	993.5

3.3.3 The Palmer Drought Index

The Palmer Drought Index is one of the indices which are used for drought monitoring. There are three variants as follows:

- The Palmer Z Index (ZIND) shows how monthly moisture conditions depart from normal. It measures short-term drought on a weekly scale and is used to quantify drought's impacts on agriculture during the growing season.

- The Palmer Drought Severity Index (PDSI) attempts to measure the duration and intensity of the long-term drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during the current month is dependent on the current weather patterns plus the cumulative patterns of previous months. Since weather patterns can change almost literally overnight from a long-term drought pattern to a long-term wet pattern, the PDSI can respond fairly rapidly.



Map 4,5 and 6: Palmer drought indices variation

- The hydrological impacts of drought (e.g., reservoir levels, groundwater levels, etc.) take longer to develop and it takes longer to recover from. The Palmer Hydrological Drought Index (PHDI), another long-term drought index, was developed to quantify these hydrological effects. The PHDI responds more slowly to changing conditions than the PDSI.

3.3.4 The Palfai Index

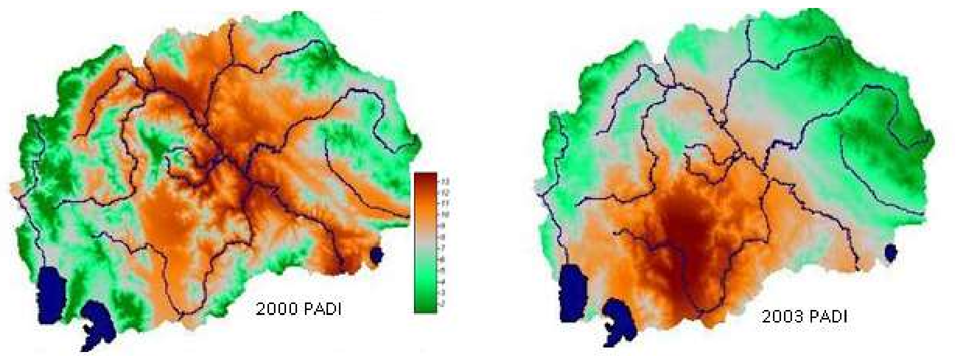
The Palfai Index (PAI) enables calculation of possible drought situation until the end of the year in case of the given spring conditions - its characteristic is that it produces one single value for each year. In the base-formula to calculate PAI the mean value of the air temperature of the period from April to August was divided by the precipitation depth summed up by the weighted monthly values of precipitation of the period of October to August, and multiplied by 100.

Since PAI is also absolute index based on ratio between temperature and precipitation, its long-term normal values can be interpreted as indication of dryness or aridity (Gregoric, 2011).

The fundamental goal of development of **Modified Palfai's Aridity Index-Palfai Drought Index (PaDI)** was to make data acquisition and calculation easier, thus to allow usage in Southeastern Europe region. For this reason, in calculation of correction factors we use another method. Instead of using daily temperature and precipitation values, as well as groundwater levels, so for calculations it is necessary to use monthly mean air temperature and sum of precipitation.

The driest years of examined period were 1988, 1990, 1992, 1993, 2000, 2003 and 2007. It is conspicuous that these years are all from the second part of examined period, which can be the sign of climate change, that it becomes drier (Kozak et al, 2001).

PaDI °C/100 mm	Classification
< 4	droughtless year
4 – 6	mild drought
6 – 8	moderate drought
8 – 10	medium strength drought
10 – 15	serious drought
15 – 30	very serious drought
> 30	extreme drought



Map 7: Modified Palfai Drought Index

3.3.5 The Standardized Precipitation Index

The Standardized Precipitation Index (SPI) - While Palmer's indices are water balance indicators that consider water supply (precipitation), demand (evapotranspiration) and loss (runoff), the Standardized Precipitation Index is a probability index that considers only precipitation. The SPI is an index based on the probability of recording a given amount of precipitation, and the probabilities are standardized so that an index of zero indicates the median precipitation amount (half of the historical precipitation amounts are below the median, and half are above the median). The index is negative for drought, and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. The SPI is computed for several time scales, ranging from one month to 24 months, to capture the various scales of both short-term (SPI 1, 2 and 3) and long-term drought (SPI6, 9, 12 etc.).

The 3-month SPI provides a comparison of the precipitation over a specific 3-month period with the precipitation totals from the same 3-month period for all the years included in the historical record. A 3-month SPI reflects short- and medium-term moisture conditions and provides a seasonal estimation of precipitation. It is important to compare the 3-month SPI with longer time scales. A relatively normal 3-month period could occur in the middle of a longer-term drought that would only be visible at longer time scales. Looking at longer time scales would prevent a misinterpretation that any "drought" might be over.

The 6-month SPI compares the precipitation for that period with the same 6-month period over the historical record. The 6-month SPI indicates medium-term trends in precipitation and is still considered to be more sensitive to conditions at this scale than the Palmer Index. A 6-month SPI can be very effective showing the precipitation over distinct seasons. Information from a 6-month SPI may also begin to be associated with anomalous stream flows and reservoir levels.

The 9-month SPI provides an indication of precipitation patterns over a medium time scale. Droughts usually take a season or more to be developed. SPI values below -1.5 for these time scales are usually a good indication that fairly significant impacts are occurring in agriculture and may be shown up in other sectors as well. Some regions of the country may find that the pattern displayed by the map of the Palmer Index closely relates to the 9-month SPI maps. For other areas, the Palmer Index is more closely related to the 12-month SPI.

A 12-month SPI is a comparison of the precipitation for 12 consecutive months with the same 12 consecutive months during all the previous years of available data. The SPI at these time scales reflects long-term precipitation patterns. Because these time scales are the cumulative result of shorter periods that may be above or below normal, the longer SPIs tend toward zero unless a specific trend is taking place. SPIs of these time scales are probably tied to stream flows, reservoir levels, and even groundwater levels at the longer time scales. In some locations of the country, the 12-month SPI is most closely related with the Palmer Index and the two indices should reflect similar conditions.

Table 5: Standardized Precipitation Index (SPI) scales and limits

Lower limit	SPI	Upper limit	Category
	SPI ≤	-2.326	Exceptional drought
-2.326	< SPI ≤	-1.645	Extreme drought
-1.645	< SPI ≤	-1.282	Severe drought
-1.282	< SPI ≤	-0.935	Moderate drought
-0.936	< SPI ≤	-0.524	Minor drought
-0.524	< SPI <	0.524	Near normal
0.524	≤SPI <	0.935	Slightly increased moisture
0.935	≤SPI <	1.282	Moderately increased moisture
1.282	≤ SPI <	1.654	Considerably increased moisture
1.645	≤ SPI <	2.326	Extremely wet
	SPI ≥	2.326	Exceptionally wet

SPI historical analysis involves 60 meteorological stations for the period 1961-2010 and showed the result of SPI 1, 3, 6 and 12. Calculated SPI 1 values for one of the affected regions in the eastern part (Stip) of Republic of North Macedonia for the period 1961-2010 is shown at figure 3, with associated map for the extreme values of the drought in April 2007. The lowest values for monthly drought (SPI1), showing extreme drought throughout the month are registered in Ovce Pole in April 2007, February 1992 and November 1969. Also, the extreme monthly drought was recorded in December 1992 in Pelagonija, in February 2008 and March 2003 in the Eastern part of the country. April 2004, November 1969 was driest in the south part of Macedonia and the western part experienced extreme monthly drought in December 1972.

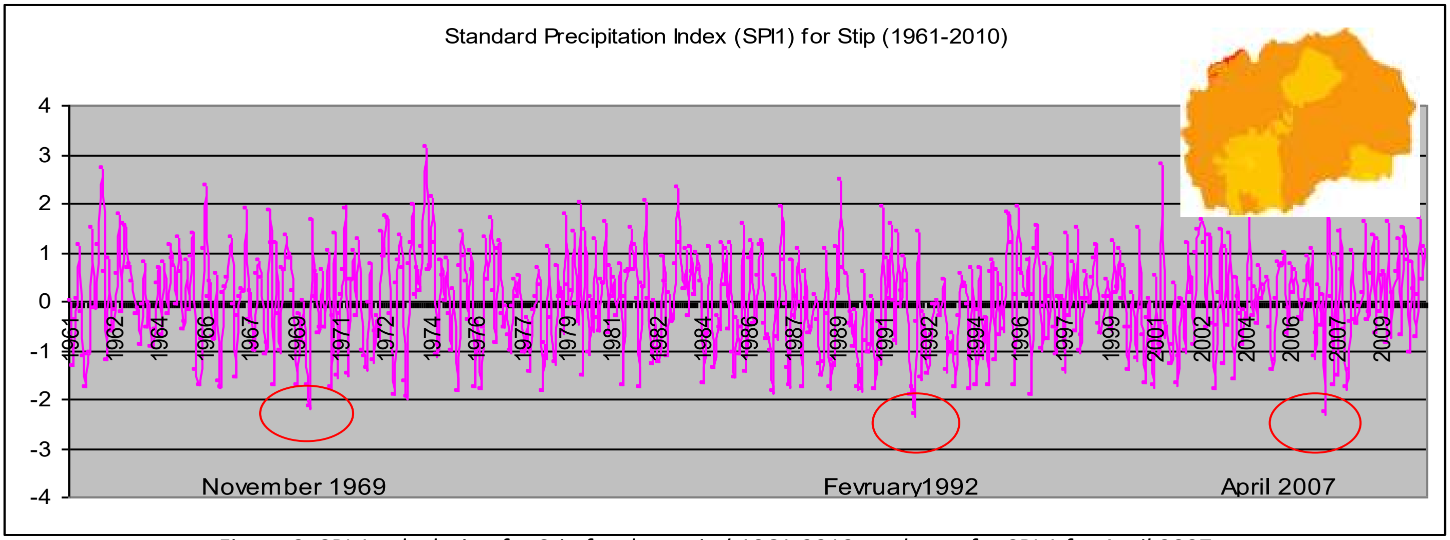


Figure 3: SPI 1 calculation for Stip for the period 1961-2010; and map for SPI 1 for April 2007

SPI 3 values for the same period calculated for the season show that winter 1992, autumn 1969 and spring 2005 the region of Ovce Pole recorded extreme drought.

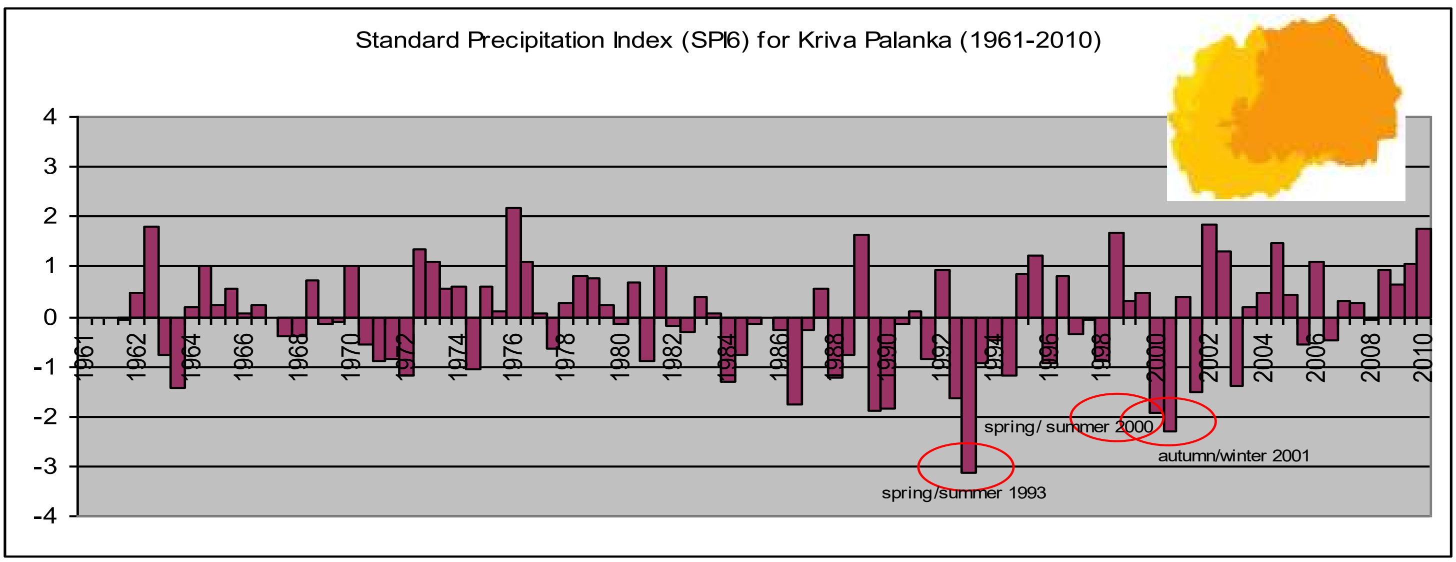
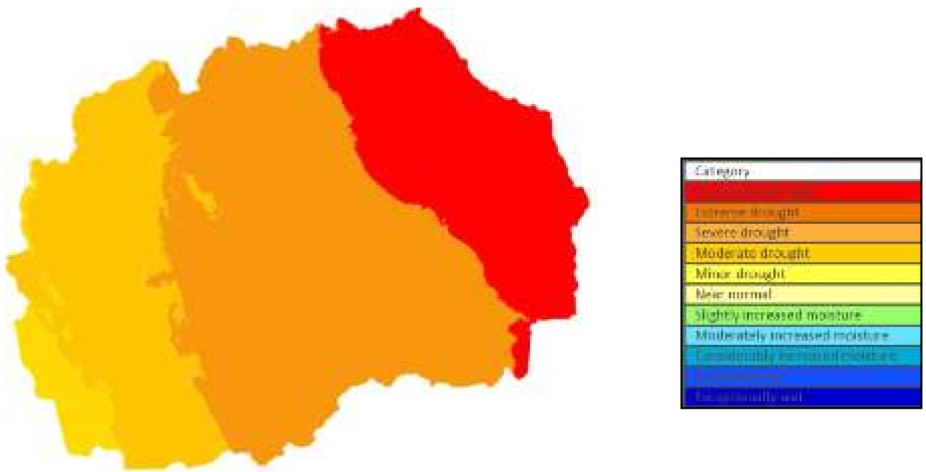


Figure 4: SPI 6 calculation for Kriva Palanka for the period 1961-2010; and map for SPI 6 for August 1993

Most extreme seasonal drought in Macedonia occurred during spring/summer 1993, with catastrophically low values of the SPI6 in the eastern part of the country (Kriva Palanka -3.12) (Figure 4). Pelagonia region was extremely dry during spring/summer season 1988, while severely drought occurred in southern Macedonia during spring/summer 2000. Autumn/ winter season 2001 was extremely dry for the territory of entire country, as well.

According to SPI12 calculated values (Berovo -3.12; Kriva Palanka 2.59; Gevgelija -2.47; Demir Kapija-2.27; Prilep -2.33 etc.), 2000 could be designated as a year with the most extreme annual drought in Macedonia (Map 8). Moderately, severely to extreme drought occurred in 1990, 1992 and 1993 in various parts of the country. In Pelagonia, Ohrid region, Skopje Valley and Gevgelija region 1977 and 1988 were also extremely dry.



Map 8: SPI 12 for N. Macedonia (December 2000)

For extended period, two-year drought in N. Macedonia occurred during 2000/01 on the entire territory, while in the eastern part, the most extreme drought was recorded during 1992/93. Three consecutive years with extreme dry conditions occurred in the period 1991/94 (Figure 5).

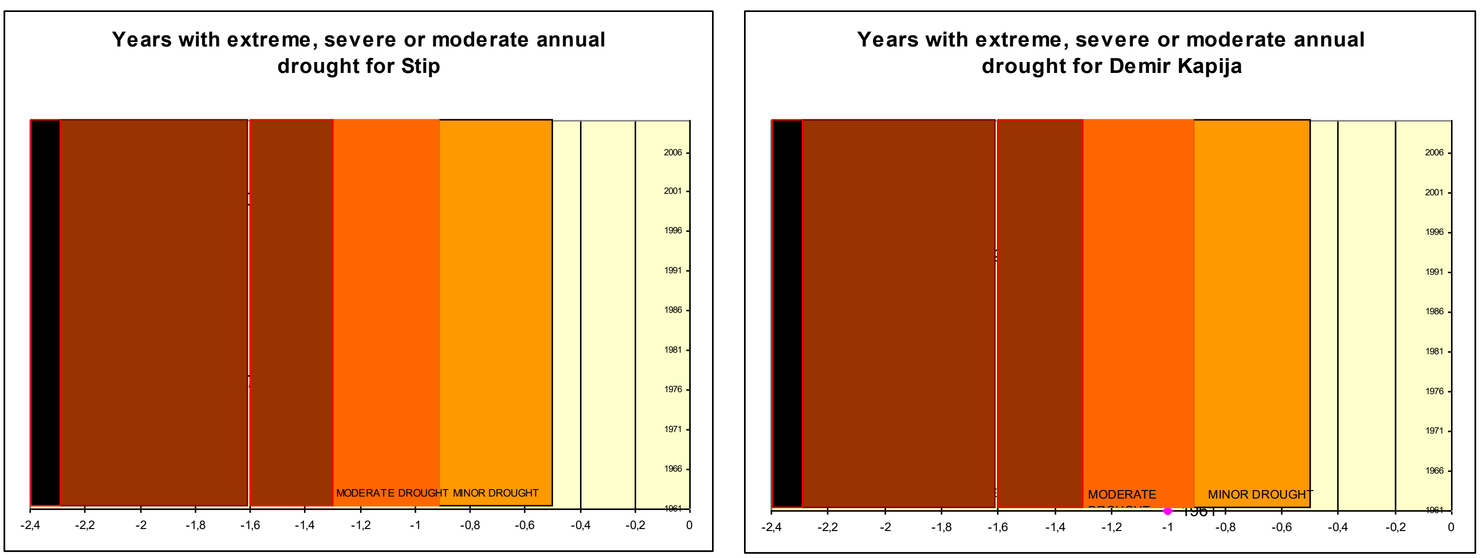


Figure 5: Annual drought overview for Stip and Demir Kapija for the period 1961-2010

SPI 36 for Stip has also very low values calculated for the periods 1990/93, 1989/1992 and the graph for the period 1961-2010 shows that severely dry period began in 1987 and lasted until the end of 1995 (Figure 6).

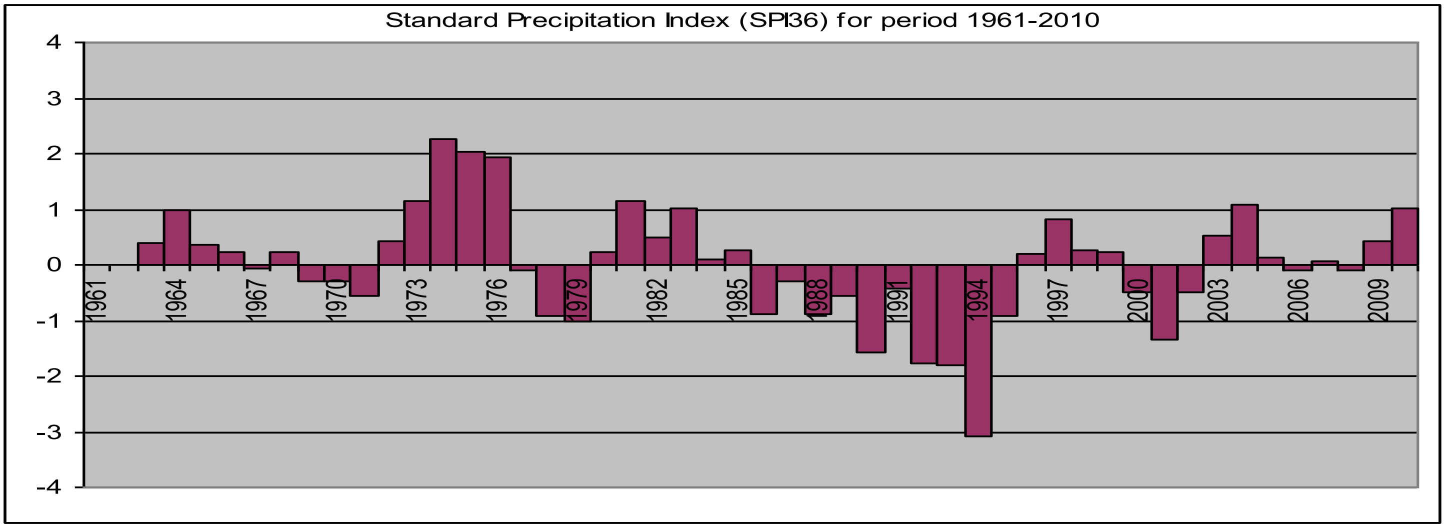


Figure 6: SPI 36 for Stip for the period 1961-2010

Recent SPI 12 analysis for period 1961-2017, for the reference period 1961-1990 presents the extreme annual drought and the top five years are given in Table 10. The overview of the drought for the period 1961-2017 for different stations which are representative for the regions in N. Macedonia is given in the Annex 3.

Table 10: Years with most extreme annual drought for different regions in N. Macedonia

Region	*Meteorological Station*	*Year*				
Skopje	**Skopje Airport**	2000	1977	2012	2001	1988
	SPI 12	-2.37	-2.24	-1.91	-1.42	-1.36
Eastern	**Berovo**	**2000**	**1993**	**1977**	**1990**	**1992**
	SPI 12	-3.87	-2.65	-1.91	-1.72	-1.7
	Stip	**1992**	**1990**	**1993**	**1977**	**2000**
	SPI 12	-2.49	-2.01	-2.0	-1.91	-1.83
Pelagonia	**Bitola**	**1977**	**2011**	**1965**	**2001**	**2000**
	SPI 12	-2.25	-2.07	-1.99	-1.93	-1.82
	Prilep	**2000**	**1988**	**1993**	**1994**	**1990**
	SPI 12	-2.56	-2.52	-1.99	-1.9	-1.78
Vardar	**Demir Kapija**	**2000**	**1977**	**1993**	**1990**	**2011**
	SPI 12	-2.2	-1.77	-1.7	-1.54	-1.45
Southeastern	**Gevgelija**	**2000**	**1988**	**2011**	**1993**	**1965**
	SPI 12	-2.79	-2.58	-1.84	-1.78	-1.65
	Strumica	**1993**	**2000**	**1992**	**2011**	**1977**
	SPI 12	-2.91	-2.8	-2.59	-2.42	-2.03
Northeastern	**Kriva Palanka**	**1993**	**2000**	**2011**	**1994**	**1990**
	SPI 12	-3.3	-3.2	-2.54	-2.22	-2.21
Southwestern	**Ohrid**	**1993**	**1988**	**2011**	**1992**	**1990**
	SPI 12	-1.81	-1.79	-1.76	-1.69	-1.58
	Mavrovo	**2000**	**2001**	**1993**	**1994**	**2003**
	SPI 12	-4.62	-3.99	-3.79	-3.77	-3.65

4. DROUGHT VULNERABILITY AND RISK ASSESMENT

4.1 Drought vulnerability and risk

Drought indices describe the duration, severity and distribution of drought. Therefore, they stress the drought effect potentially ready to damage different systems. The size of the damage depends on the impacted system as well, and the parameter which defines it is called vulnerability. Following are IPCC definitions concerning the drought and its impact:

- *Sensitivity* is the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct (e.g. a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g. damages caused by an increase in the frequency of flooding).
- *Adaptive capacity* is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities or to cope with the consequences.
- *Vulnerability* is a degree to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity.
- *Hazard* is anything with the potential to cause harm.
- *Exposure* is an extent to which the likely recipient of the harm is exposed to the hazard.
- *Risk* is the likelihood that a hazard will cause a specified harm to someone or something. Therefore, both hazard and exposure have to exist simultaneously to have a risk, otherwise there is no risk.

Vulnerability is composed of two basic elements and described by the following equation 1 (UNESCO, 2004):

$$Vulnerability = Risk \times Impact \quad (1)$$

That equation can include exposure as well but the role of exposure is not clear. Exposure can be considered both as vulnerability component as well as the relation that connects the examined hazard to the system of interest (Gallopin, 2003). In both cases, no hazard exposure means no vulnerability. Vulnerability is also connected to *risk* according to the following equation 2 and therefore vulnerability assessments are crucial parts of risk assessment.

$$Risk = Hazard \times Vulnerability \quad (2)$$

Drought risk is the probability of harmful consequences or likelihood of losses resulting from interactions between drought hazard (i.e. the possible future occurrence of drought events), drought exposure (i.e. the total population, its livelihoods and assets in an area in which drought events may occur), and drought vulnerability (i.e. the propensity of exposed elements to suffer adverse effects when impacted by a drought event) (Cardona et al., 2012). Expressed in another way, risk is determined not only by the amount of exposed entities and physical intensity of the natural hazard, but also by the vulnerability of society at a given moment in time – vulnerability is dynamic in response to changes in the economic, social and infrastructural characteristics of the locale or region (Wilhite et al., 2007). There are three determinants of drought risk, whose relations is find convenient to schematize in a mathematical form, as defined by Dao and Peduzzi (2003), Peduzzi et al. (2009) and Cardona et al. (2012):

$$\textit{Drought Risk} = \textit{Hazard} \times \textit{Exposure} \times \textit{Vulnerability} \qquad (3)$$

4.2 Drought risk management

Drought risk management is the concept and practice to avoid, lessen or transfer the adverse effects of drought hazards and the potential impacts of disaster through activities and measures for prevention, mitigation and preparedness. It is a systematic process of using administrative directives, organizations and operational skills and capacities to implement strategies, policies and improving coping capacities. The drought management consist two approaches: proactive and reactive (Figure 7).

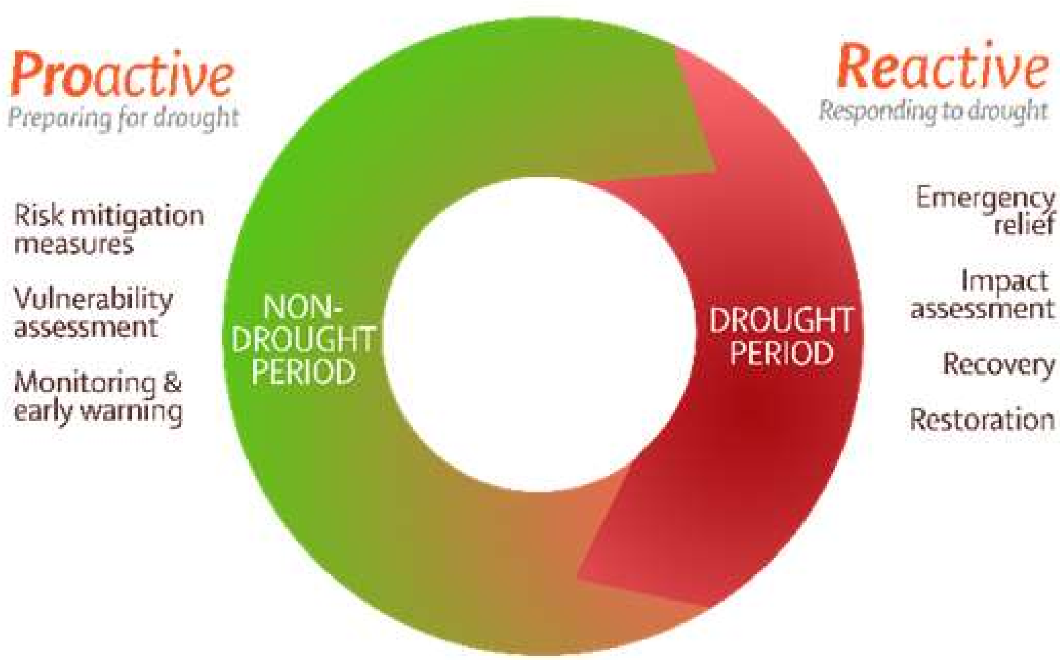


Figure 7: The drought management

4.2.1 Proactive approach

The *proactive approach* is based on both short-term and long-term measures and includes monitoring systems for a timely warning of drought conditions. So, it entails the planning of necessary measures to prevent or minimize drought impacts in advance. The proactive approach, preparing for the drought, emphasizes three components: monitoring and early warning, risk and impact management and mitigation and response. Little attention has been given to early warning actions that could reduce future impacts and lessen the need for government intervention in the future. Because of this emphasis on crisis management, society has generally moved from one disaster to another with little, if any, reduction in risk. A comprehensive, integrated national meteorological monitoring or drought early warning system is currently under discussion in the frames of the Multi-Hazard Early Warning Systems project. Risk assessment is important part of drought management. Risk assessment is a step in a risk management procedure. It is the determination of quantitative or qualitative value of risk related to a concrete situation and a recognized threat (hazard). Quantitative risk assessment requires the magnitude of the potential loss and the probability that the loss will occur. In the case of drought, the magnitude of potential loss is described by the drought indices and the probability is the exposure. Mitigation means to reduce the harmful effects and response actions and support the risks management activities.

Vulnerability and exposure are dynamic, varying across temporal and spatial scales and they depend on economic, social, geographic, demographic, cultural, institutional, governance, and environmental factors. Individuals and communities are differentially exposed and vulnerable and this is based on factors such as wealth, education, race/ethnicity/religion, gender, age, class/caste, disability, and health status. Lack of resilience and capacity to anticipate, cope with, and adapt to extremes and change are important causal factors of vulnerability.

A. Wilhelmi and Wilhite classified the largest effecting factors on a subjective basis, and the number of classes gives the vulnerability category. Some further development of the flow chart of vulnerability calculation was made by Szalai et al. (Figure 8).

Therefore, vulnerability to drought is the effect of the drought on the normal state of the environment and social activities. The impact on the plants depends on the environmental amplitude or how much pressure they can take in order to survive. The choice of the future crops will depend on the development of the vulnerability maps for the region.

Extreme and non-extreme weather and climate events also affect vulnerability to future extreme events, by modifying the resilience, coping, and adaptive capacity of communities, societies, or social-ecological systems affected by such events (high confidence). At the far end of the spectrum – low-probability, high intensity events – the intensity of extreme climate and weather events and exposure to them tend to be more pervasive in explaining disaster loss than vulnerability in explaining the level of impact. But for less extreme events – higher probability, lower intensity – the vulnerability of exposed elements play an increasingly important role.

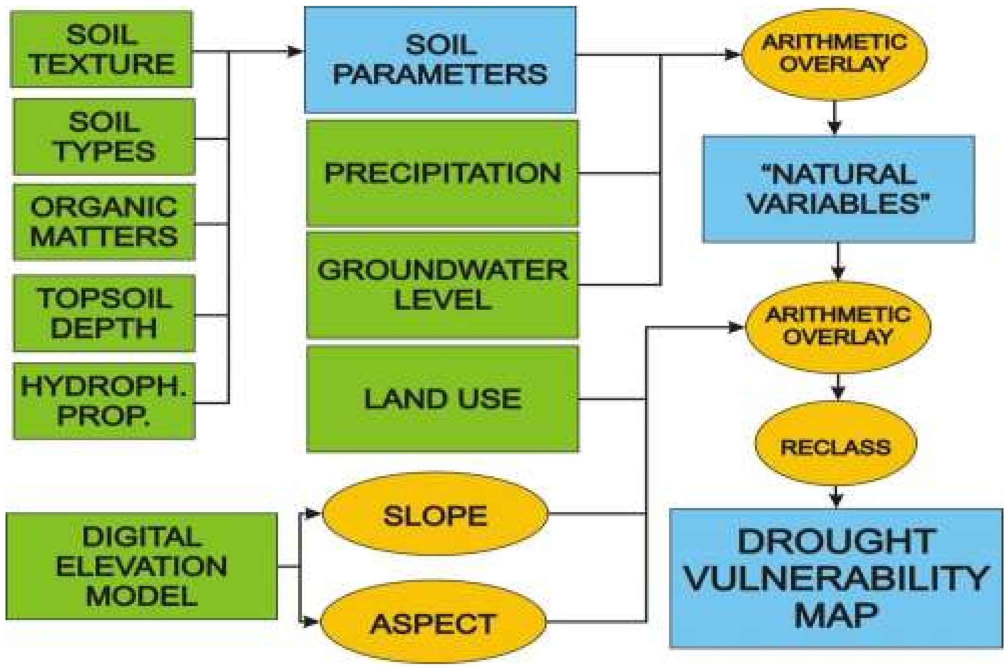


Figure 8: Flow chart of vulnerability calculation

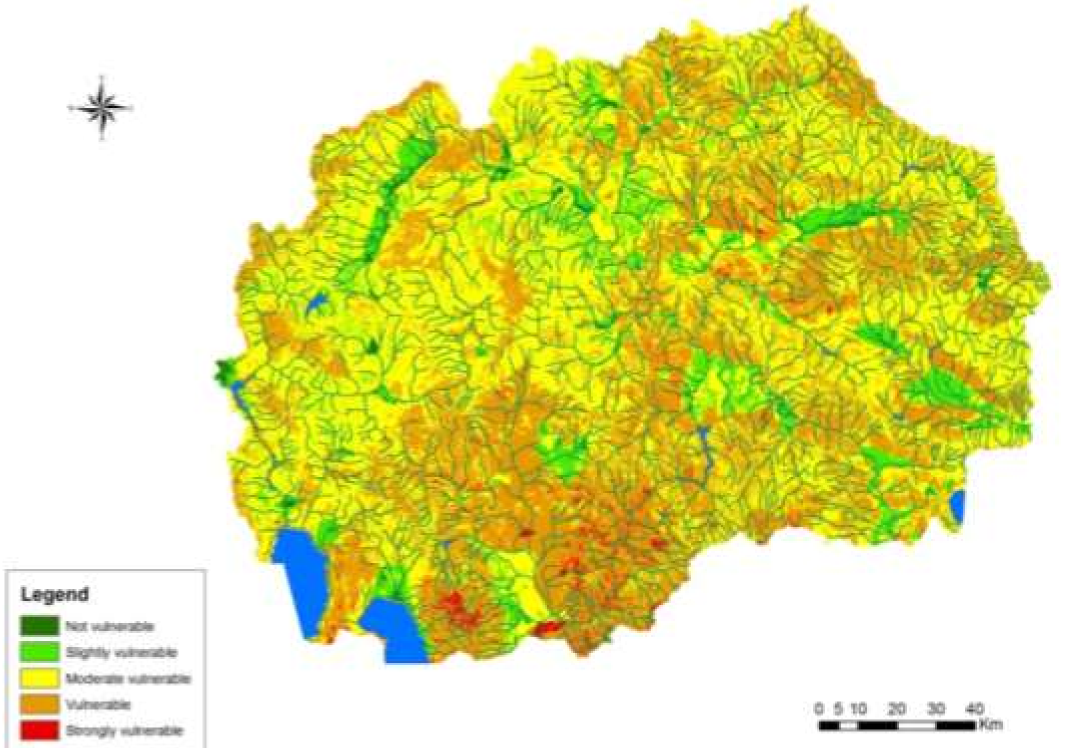
High vulnerability and exposure are generally the outcome of skewed development processes, such as those associated with environmental mismanagement, demographic changes, rapid and unplanned urbanization in hazardous areas, failed governance and the scarcity of livelihood options for the poor.

4.2.2 North Macedonia drought vulnerability overview

HMS analysis for drought vulnerability is described in Annex 4. Developed approach of WIlhelmi and Wilhite (2002) and further developed by Szalai et al. (2011) was used for determination of vulnerability. According to this methodology, the drought vulnerability maps were calculated from category maps which are made of different selected parameters. The development of the vulnerability maps was made in multicriteria GIS environment according to the established methodology, described in the Annex 4.

This developed model for estimation of the drought vulnerability is good starting point for estimation of large-scale studies for our territory. It is also a guideline for estimating the vulnerability. According to calculations, only less than 1% of the territory of N. Macedonia is not vulnerable to drought.

Slightly and moderately vulnerable is 8% and 51%, while vulnerable and strongly vulnerable is 39% and 1%.



Map 9: Drought vulnerability map
(Source: Hydrometeorological Service of Republic of North Macedonia)

4.3 Reactive approach

The *reactive approach* includes measures and actions after a drought event has started and is perceived. This approach is taken in emergency situations and often results in inefficient technical and economic solutions, because actions are taken with little time to evaluate optimal options and stakeholder participation is very limited. The response is the efforts such as the provision of assistance or intervention during or immediately after a drought disaster to meet the life preservation and basic subsistence needs of those people affected. It can be of an immediate, short-term, or protracted duration. The drought recovery, or the decisions and actions taken after a drought with a view to restoring or improving the pre-drought living conditions of the stricken community, while encouraging and facilitating necessary adjustments to reduce the drought risk. The severity of the impacts of extreme and non-extreme weather and climate events depends strongly on the level of vulnerability and exposure to these events. Understanding the multi-faceted nature of vulnerability and exposure is a prerequisite for determining how weather and climate events contribute to the occurrence of disasters and for designing and implementing effective adaptation and disaster risk management strategies.

4.3.1 Disaster risk management

Disaster management aims to reduce or avoid the potential losses from hazards, assure prompt and appropriate assistance to victims of disaster, and achieve rapid and effective recovery. The Disaster management cycle illustrates the ongoing process by which governments, businesses, and civil society plan for and reduce the impact of disasters, react during and immediately following a disaster and take steps to recover after a disaster has occurred (Figure 9).

Figure 9: The cycle of disaster management

The four disaster management phases illustrated here does not always, or even generally, occurs in isolation or in this precise order. Often phases of the cycle overlap and the length of each phase greatly depends on the severity of the disaster.

- Mitigation - Minimizing the effects of disaster
- Preparedness - Planning how to respond
- Response - Efforts to minimize the hazards created by a disaster
- Recovery - Returning the community to normal

4.3.2 National plan for disaster risk management

The overall responsibility for a disaster risk assessment in Republic of North Macedonia lies with the National platform (Figure 10), however both the Law on Crisis Management and the Law on Protection and Rescue are outlining the requirement of conducting risk assessments and are supported by the respective methodologies.

The Law on Crisis Management states that an assessment of all hazards should be undertaken by special methodology and is obligatory only for local municipalities. However, the Law on Protection and Rescue requests the development of risk assessments for natural and technological hazards, undertaken by a different methodology per type of entity and obligatory to all public and private institutions, including local municipalities. With a governmental decree the methodology for the assessment is prescribed, however as there is insufficient technical knowledge and expertise for all risks and hazards assessment, including those related to agriculture, as well as the lack of an integrated approach to disaster and climate risk management, both on national and local levels, the United Nations Development Programme (UNDP) provided North Macedonia with support in this area. Through this UNDP project implemented in 2011, the following, among others, were prepared:

- Guidelines for the development of methodologies for assessment of risks and hazards and impact assessment on the lives and health of the citizens and assets of the country;
- Historical databases for events that happened during the last 50 years;
- Guidelines for the preparation of a unified risk and hazard assessment and a preliminary risk profile of the country. Unfortunately, only very few municipalities have actually prepared a risk assessment, besides those prepared through externally funded projects.

However drought is not observed as a special threat so the need for comprehensive drought disaster management is necessary.

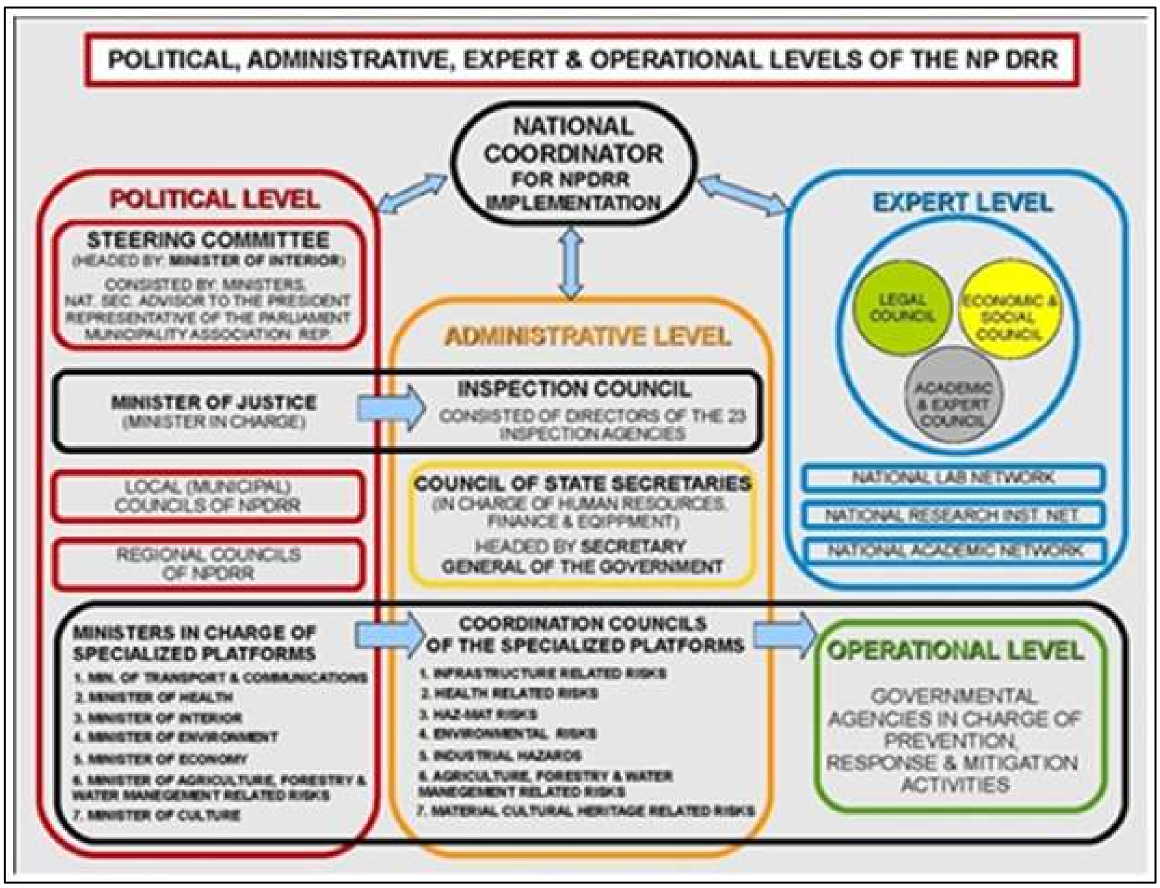


Figure 10: Levels of the National Plan for Disaster Risk Management

5. RELATIONSHIP TO OTHER PLANS, POLICIES AND LEGISLATION

Presently the Republic of North Macedonia does not have coherent and comprehensive policy regarding drought and drought management issues. Sectoral and medium specific policies merely mention drought in various policy documents and strategies.

5.1 Links with International Instruments

North Macedonia is a part to the three Rio Conventions: *UN Convention to Combat Desertification (UNCCD)*[1]*, Convention on Biological Diversity*[2] *and Convention on Climate Change*. A number of other conventions/international agreements (Kyoto Protocol, Air Pollution, Biodiversity, Endangered Species, Hazardous Wastes, Law of the Sea, Ozone Layer Protection, Wetlands, etc.) are signed and ratified. *Helsinki Convention*: trans-boundary watercourses and international lakes aim to prevent and control pollution of trans-boundary watercourses and international lakes by developing an international cooperation. The Convention establishes a framework for cooperation between the member countries of the United Nations Economic Commission for Europe (UNECE) by ensuring rational use of water resources with a view to sustainable development.

The Government has expressed the need for a common platform for reporting regional progress through the online Sendai Framework monitoring system. The Sendai Framework – the global roadmap for reducing disaster-related losses – highlights the need for action and cooperation on disaster risk reduction at the regional level through agreed regional and sub-regional mechanisms and regional Inter-Governmental Organizations (IGOs) have a core leadership role as a custodian of policy and guiding light of practice. It is expected to be implemented over the period until 2030.

The *United Nations Convention to Combat* Desertification (UNCCD) was ratified in March 2002 and came into force in June 2002. The Government of the Republic of North Macedonia has designated responsibility for the implementation of the Convention to the MOEPP and MAFWE in close cooperation with related institutions. North Macedonia is a country listed among countries of the UNCCD.

The UNCCD Operational Focal Point is within the MOEPP and a National Committee on Combating Land Degradation and Desertification and Mitigation of the Effects of Droughts in the Republic of North Macedonia has been established.

In the *National Strategy on Protection and Rescue* (OG 23/2009), drought is explicitly not mentioned, but is treated as other natural disasters. For several years, Macedonia is implementing civil protection and disaster prevention and management through two Governmental institutions: Crisis Management Center and Rescue and Protection Directorate, both under auspices of the Government of

[1] Official Gazette of RM

[2] Official Gazette of RM No. 54/97

N. Macedonia. The system encompasses national authorities (the Parliament, the President and the Government), National Army, capacities for Protection and Rescue and the Municipalities and City of Skopje. In the system also other national institutions, public enterprises, private companies, NGOs and CSO and other associations can be included. The Municipalities have an obligation to prepare risks and hazards assessment and plan for protection and rescue in the local level. The foundation of this system lies in the *National Concept for Security and Defense* (2003) and *National Platform for Disaster Risk Reduction* (2009), while the Law on Crisis Management (2005) and the Law on Protection and Rescue define its main aspects: organization and functioning, decision-making and use of the resources; communication, coordination and cooperation; assessment of all risks and hazards, planning and financing etc.

With the *"Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy"* or, in short, the EU Water Framework Directive of 23 October 2000 establishing a framework for Community action in the field of water policy, the European Union has established a Community framework for water protection and management. By this Directive the framework is provided for the management of inland surface waters, groundwater, transitional waters and coastal waters in order to prevent and reduce pollution, promote sustainable water use, protect the aquatic environment, improve the status of aquatic ecosystems and mitigate the effects of floods and droughts.

EU water regulation relevant for drought includes also the Communication on water scarcity and droughts - The document Commission Communication of 18 July 2007: *"Addressing the challenge of water scarcity and droughts in the European Union"* [COM (2007) 414 final] represents guidelines for addressing sporadic drought and medium- or long-term water scarcity. In the guidelines the content is related to water pricing, water allocation, drought prevention and rapid response in the event of a drought, as also high-quality information and technological solutions tackling water scarcity and droughts (The European Commission, 2007).

5.2 Links with National Instruments

The main water management objective, as defined in the *Water strategy for the Republic of Macedonia/ Draft Final Version (2010)*, is achieving an integrated and coordinated water regime on the territory of the Republic of North Macedonia. This includes not only location and construction of water systems but also quantity and quality state of water in a manner that best suits a particular location and certain period of time. By integrated water management in the Republic of North Macedonia it is necessary to:

- ensure sufficient quality of drinking water for public supply;
- ensure the necessary quantity of water of adequate quality for various commercial purposes;
- protect people and material goods from the harmful effects of water;

- achieve and preserve good water status of surface and groundwater bodies;
- protect aquatic and water dependent ecosystems and
- harmonize measures of water management with other sectors of space users.

A *National Disaster Risk Reduction Strategy with Action Plan* was prepared in 2014. The expected increase in frequency and severity of natural hazards, in particular droughts, heat waves and floods, due to climate change is mentioned as well as the expected adverse impact that climate change will have on the agriculture sector, which will lead to direct and indirect agricultural losses.

The current *National Strategy for Agriculture and Rural Development (NARDS)* 2014-2020, in contrast to the previous *Agriculture Strategy of 2007-2013*, recognizes the increased risk of extreme weather events and views climate change as a threat to the sector. It also acknowledges its adverse impact on agriculture subsectors, such as crop, livestock and forests. It envisages support for measures for reducing vulnerabilities of smallholder farmers, although not many measures are listed. It mainly mentions the need to enhance awareness and sustainable resource management as well as pledging support for climate change adaptation and mitigation.

Planning and strategy documents, such as the *National Development Plan 2007-2009* and the *2008 National Strategy for the Sustainable Development* do not mention disaster risk reduction or natural hazards as such. It focuses on sustainable development with regard to natural resources management and environmental protection, such as the prevention and control of pollution, protecting and exploiting nature sustainably.

Land use policy is formulated in the last *Physical Plan of North Macedonia* (2004). The issues of land degradation are not sufficiently covered in the document; neither has it given directions for development. The land use policy and poor implementation of spatial and urban plans up to now have induced resettlements, unfavorable changes in land use, such as loss of high quality arable land, changes of the natural habitat and landscapes, fragmentation of the landscapes, and weak management of natural resources.

Environment protection is one of the areas where significant efforts and developments were achieved in the last period. Policy documents regarding most of the issues of environment and nature protection exist or are being elaborated at the moment. Based on these strategic documents, as well due to number of ratified international conventions, with valuable bilateral and international support, numerous changes have been made in the legislation. Overall goal of the country, accession to EU, has promoted harmonization of national to EU legislation, and hence to main international environmental conventions and treaties regarding environment. A number of laws have been adjusted, amended and completely renewed. In the strategic document *Second National Environmental Action Plan* (NEAP 2), the issues of combating land degradation and desertification in the country have been properly addressed, due to the inputs from the GEF-UNDP, NCSA Project Thematic Reports and integration of some recommendations and key actions identified there.

A coherent and comprehensive policy regarding the use and protection of land and land resources in the country does not exist. The use and management of the so-called land-based–resources (forests, pastures, agricultural land, water etc.) is scattered among several public enterprises on national level and their respective branches on local level. A policy of integrated management (including both, utilization and protection, as well as integrated planning) does not exist, even though the MAFWE is responsible ministry for most of the sectors.

The national policy in agriculture is formulated in several strategies elaborated in the last few years. The process of harmonization and approximation to EU shall, in the foreseeable future, eventually lead to adoption of the EU Common Agriculture Policy (CAP). The MAFWE is not really involved in the problem land degradation and desertification, even though the majority of issues related to the UNCCD are topics within their responsibility. The awareness on drought exists within the Ministry mainly in the water sector and institutions linked with irrigation. However, due to changed roles in overall water management in the country since 2011, drought as a problem of water resources cannot receive comprehensive attention.

At the moment there is no national policy or formulated strategy for soil management and protection. Monitoring of soil is not established, and therefore reliable and updated data are scarce and unavailable.

One of the fundamental values of the constitutional order of the Republic of North Macedonia is the space humanization, and environment and nature protection and improvement. According to the *Constitution of the Republic of North Macedonia*[3], everyone has the right to a healthy living environment and duty to protect and improve the environment and the nature. In addition, the Constitution determines natural resources of the country, the flora and fauna, amenities in common use, as well as the objects and buildings of particular cultural and historical value determined by law, are goods of common interest enjoying specific protection. Although land is not mentioned directly, as an inherent part of the environment and an important natural resource it should enjoy specific protection.

For the purposes of integrated nature protection, implementation of the ratified international agreements and transposition of the relevant EU legislation in the area of nature protection, the Assembly of the Republic of North Macedonia adopted the Law on Nature Protection[4]. This Law has transposed the key legal acts of the EU concerning nature protection, such as the *Council Directive 1992/43* on the conservation of natural habitats. The protection of nature is carried out through biological and landscape diversity protection and natural heritage protection, in and outside protected areas.

[3] *"Official Gazette of RM" No. 52/91*

[4] *"Official Gazette of RM" No. 67/04*

The Law on Environment[5] tackles the issues of land degradation and desertification through provisions in Article 191 and 192 for preparation of *National Action Plan* and *National Action Programme* and their updating every three and six years, respectively. This can be considered as a big step forward which gives a good legal basis for planning and enforcing complete measures for combating drought and mitigation of land degradation and desertification in practice. However, implementation of this law and its provisions also lags behind.

The *Law on Agriculture and Rural Development*, established in 2013, does not include words like "drought risk" or "drought risk reduction". Although it is recognized that adverse climatic conditions can affect the agriculture sector mentioned in several articles, such as article 99 which focuses on the need to provide assistance to farmers whom incurred damages caused by natural disasters. Article 98 focuses on assistance for insuring agricultural assets from natural disasters and article 65 and 73 describe assistance for investments in agricultural infrastructure, which among other things assists in the protection of the agricultural assets from natural disasters. However, climate change as such and natural hazards linked to it, is not mentioned. Unfortunately, no link is made to natural hazards, such as that inappropriate land use and forest management can lead to increased vulnerability of risks to natural hazards, such as drought, floods, landslides, and forest fires.

The new Law on Water[6], mostly harmonized with EU WFD, does not pay much attention to drought, or drought management. It delegates most of the responsibility to the municipalities or the Water Management(s) organizations. The Law merely mentions drought in the provisions dealing with exceptions to normal situations management, namely in cases of natural disasters or unpredictable meteorological occurrences.

The important legislation of the Republic of North Macedonia in the field of water related subjects was established in line with the transformation process of the country. A number of respective regulations still in force dates back or is taken over unchanged from the years behind. Apart from the legislation dealing directly with water management there are important links with environmental or other sector or horizontal legislation, which affect the institutions and procedures in the field of water management. Law on waters of the Republic of North Macedonia defines water as a property of the state and thus gives the right and obligation to manage and preserve them in their natural condition and even improve. These responsibilities and obligations are implemented through appropriate governmental institutions. The Law on Waters (Official Gazette no. 87/08, 6 / 09, 161/09, 83/10, 51/11) provides a legal basis for water protection and management in the Republic of North Macedonia. It regulates the manner of water resources use and exploitation, protection against harmful effects of water, protection of water against exhaustive water extraction and pollution, water resources management, sources for and manner of financing water management activities, concessions, trans-

[5] *"Official Gazette of RM" No: 53/05*
[6] Official Gazette of RM" No. 87/08

boundary water resources, and other issues of relevance with regard to the provision of a unique water use regime. The Law on Waters has transposed the requirements of the main EU Directives in the domain of water resources management. It establishes legal grounds for the adoption of the relevant secondary legislation, which shall regulate in detail different conditions, procedures, standards and measures or on the basis of which the existing ones shall be revised, in order to achieve compliance with the new goals, standards and measures stipulated in the relevant EU Directives. According to the Law on Waters the basic set of documents for water planning and development shall include: *National Strategy for Waters*, *Water Management Master Plan of the Republic of North Macedonia*, and finally *River Basin Management Plans*.

Upon the Law on Waters, a Public Water Management Enterprise (PWME) 'Water Management of Macedonia' was founded in 1998. A Law on Water Management Enterprises ("Official Gazette of RM" No. 85/03) was adopted. This Law regulates the establishment, organization, performance, financing, control and termination of the operation of water management enterprises. 'Water Management Enterprise' is a legal entity sui generis, founded for the purpose of cost-effective management, use, functioning and maintenance of hydro-systems, irrigation systems and drainage systems. Another legal entity for management, operation and maintenance of irrigation schemes is established with the Law on Water Communities[7]. The term 'water community' means the association of owners or users of agricultural land associated for the purposes of the use, management, maintenance, construction, rehabilitation and extension of small scale irrigation and/or drainage systems.

The Law on Crisis Management (2005) establishes the two main institutions for disaster risk reduction, namely the Protection and Rescue Directorate (PRD) and the Crisis Management Centre (CMC).

The Law on Organization and Operation of the State Administration Bodies[8] defines the competence of the Ministries regarding issues of land degradation and desertification. The most relevant are the Ministry of Agriculture, Forestry and Water Economy (MAFWE) and the Ministry of Environment and Physical Planning (MOEPP). Other ministries also have responsibilities.

5.2.1 Institutional arrangements for drought management

The current complex institutional arrangements for water management are the result of a long history and of frequent ministerial restructuring and reallocation of responsibilities over the past years (Economic Commission for Europe, 2002; MEPP, 2007).

"Water competencies" are divided into six ministries: Ministry of Environment and Physical Planning, Ministry of Agriculture, Forestry and Water Economy, Ministry of Economy, Ministry of

[7] ("Official Gazette of RM" No. 51/03)

[8] Official Gazette of RM Nos. 58/00 and 44/02

Transport and Communications, Ministry of Education and Science, Ministry of Health and the Republic Institute for Health Protection.

The *Ministry of Environment and Physical Planning* (MOEPP) by current restructuring should take responsibilities related to the protection, improvement and planning in water management.

The *Ministry of Economy* has jurisdiction over abstraction of water needed for the industry and energy production (production of electricity and heat). Their responsibilities, the Ministry achieves through its energy sector and relevant units in the sector.

The *Ministry of Transport and Communications* has responsibilities related to supply drinking water, collection and drainage of urban waste water and responsibilities related by internal navigation

The *Ministry of Education and Science* through the Hydrobiological institute-Ohrid cares for physical and chemical composition of the water in natural and artificial lakes and the state of flora and fauna of aquatic life in them.

The *Ministry of Agriculture, Forestry and Water Economy* (MAFWE) manages with water for agricultural purposes as well as infrastructural facilities such as dams, reservoirs, irrigation systems. The *Hydrometeorological Service* is a part of the Ministry, and it is responsible for monitoring the quantity and quality of surface water and groundwater.

The *Ministry of Health* (MH) implements control of the state of the water in terms of potential epidemics that can spread through water and control of the water as a kind of food. Responsibilities are implemented through two bodies in own composition- State Sanitary and Health Inspectorate and Food Directorate.

Republic Institute for Health Protection has obligations in relation to communal hygienic in public facilities, quality control and hygienic-bacteriological correctness of the waters.

The MAFWE creates and implements the general agricultural policy in the country. The responsibilities of MAFWE are related to agriculture, forestry and partly water economy, namely utilization of agricultural land, forests and other natural resources, hunting and fishery, protection of livestock, large water infrastructure (dams and reservoirs) and irrigation and drainage. MAFWE has branches on local level in larger municipalities - regionally organized in regional centers. Irrigation is one of the few left responsibilities in the water sector within the auspices of MAFWE.

Land-based natural resources in Macedonia are mostly managed by *Public Enterprises* (PEs) – state owned public entities with authority delegated by the State to manage the resources. The relevant PE’s are the following:

- PE Macedonian Forests – responsible for forest management of the state owned forest;
- PE Macedonian Pastures – responsible for pastures management;

- PE Macedonian Water Management – responsible for water management

The organizational setups of the Public Enterprises in North Macedonia usually encompass a central office on national level and branches on local level varying in size and responsibility.

The MOEPP holds the legal[9] obligation to create and implement environmental policy in the Republic of North Macedonia, to lead the activities in the area of the environment and provide for rational use of space and natural resources. The MOEPP performs activities concerning: monitoring of the state of the environment; water, soil, flora, fauna, air and ozone layer protection against pollution; protection against noise and radiation; protection of biological diversity, geological diversity, national parks and protected areas; restoration of polluted segments of the environment; proposed measures for solid waste treatment; spatial planning; spatial information system; supervision within the scope of its competences; and performs other activities stipulated by law. Recently, MOEPP has also become responsible for the overall water management in the country: the Law on Water, adopted in 2008, has formally begun to be implemented from January 2011.

Other Ministries hold direct or indirect competences in the domain of land and environmental management. Apart from the MAFWE, regarding agriculture, forestry, pastures and water management, and MOEPP, which has the leading role in the area of the environment, the public administration bodies with direct competences include: the *Ministry of Defense* performing activities related to civil protection; the *Ministry of Interior* performing activities related to the implementation of the system of public security and the provision of aid in cases of natural disasters; the *Ministry of Economy* performing activities related to geological surveys and exploitation of mineral resources and energy; the *Ministry of Health* performing activities concerning health protection of the population through air, water, soil and foodstuff pollution monitoring; the *Ministry of Transport and Communications* performing activities related to communal services, including waste management, wastewater treatment, inland waterways, housing and public works.

The Hydrometeorological Service works according to the Law on Hydrometeorological Activities (Official Gazette of the Republic of Macedonia 103/08)[10]. The HMS provides meteorological, climatological, hydrological, agro-meteorological information, it performs special meteorological research within the meteorological station network, and it is responsible for monitoring of air, water and soil. This institution also performs basic data processing, research of climate physical basics, systematic observation of variations, and development of weather forecast methods.

Drought as natural hazard is mentioned in the strategic documents on natural and other hazards and disasters and in the documents on crisis prevention and management. The *Crisis Management*

[9] According to the Law on Organization and Operation of the State Administration Bodies ("Official Gazette of RM" Nos. 58/00 and 44/02)
[10] The old Law (OG nos. 03/1994 and 05/2003) is repealed with the new Law

Center and the *Directorate for Crisis Management* are responsible for related activities. The approach does not provide neither prevention, nor sustainable planning and implementation of drought prevention/mitigation activities. It mainly concerns with reaction a posteriori – namely after the drought has occurred.

State Authority for Geodetic Works is responsible for operations with regard to survey, cadastre and registering real estate entitlement, pursuant to the Law[11]. This institution implements its activities through its local/municipal departments/units in 84 municipalities. The State Authority for Geodetic Works maintains the public books, i.e. the *Land Cadastre* and the *Cadastre of Real Estate*.

The above-described setup indicates the existing fragmentation of competencies among bodies in the area of land and environment management. This may be partly overcome by actual implementation of current environmental laws. The Law on Water provides higher integration of environmental management also by the newly proposed setup. The MOEPP is planning to obtain full competence also in the domain of water management, while the Ministry of Agriculture, Forestry and Water Economy remains the responsible body in the domains of irrigation, forestry, hunting and fishing. Waste management, nature protection and air quality management have been transferred under the full competence of the MOEPP.

Decentralization is one of the key ongoing processes in the country. It encompasses transfer of responsibilities and resources from the central to the local government. Besides fiscal and governance changes, the process envisages changes in the environment and natural resources management by delegation of greater responsibilities to the municipalities. There are 84 municipalities in the country, varying in size and overall capacity to implement the planned reform and fully undertake the delegated responsibilities. Regarding drought, land degradation and desertification the capacity of the municipalities is even more questionable, according to the NCSA Thematic Report On Land Degradation/Desertification.

The local self-government units-*Municipalities,* according to the *Law on the Local Self-Government*[12] are responsible for regulating and performing activities of public interest of local importance, as stipulated by the law. The same Law defines the list of competences of the local self-government units, such as: environment and nature protection – measures for the protection and prevention of water, air and soil pollution, nature protection; public activities – drinking water supply; technological water supply; wastewater drainage and treatment; storm wastewater drainage and treatment; maintenance of public hygiene; collection, transportation and treatment of municipal solid and industrial waste; maintenance and use of parks, green areas, forest parks and recreational areas; regulation, maintenance and use of river beds in urbanized parts. Municipalities, or LSGUs, also have to prepare plans for Risk Assessment and Management and Disaster Risk Reduction.

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[11] Law on Organization and Operation of the State Administration Bodies ("Official Gazette of RM" Nos. 58/00 and 44/02)

[12] ("Official Gazette of RM" No. 5/02)

6. CHALLENGES IN INSTITUTIONAL SUPPORT AND MANAGEMENT SYSTEMS

The first need is establishment of drought management system in North Macedonia (umbrella document addressing drought, drought authority, drought plans), which will be coherent and integrated in the national policy.

6.1 National drought determination

There is no unified definition of drought in national legislation, so there is no clear distinguish from related terms such as water scarcity, desertification, dryness, etc.

There is a need to prepare sector-impact and region-specific drought definitions which form the basis for working on drought phenomena and its impacts. Furthermore, drought should be identified as risk in national legislation.

6.1.1 National legislation

Absence of a complex main (umbrella) document related to drought. Drought management is only partly mentioned and insufficiently included in different laws or regulations.

There is no law or regulation that can ask/trigger action from Ministries or other authorities. Drought related problems are solved in a diffuse way, both in content and institutionally; non-existent interdisciplinary approach.

Proactive (integrated) approach should be implemented in the entire drought management process, and close monitoring of action plans and measures implementation.

6.1.2 Drought monitoring

There is an absence of early warning system and drought monitoring needs improvement. There is no inter-connected, complex and integrated drought management. The national scheme of drought monitoring and management is missing including clear protocol to take action under specific conditions.

Besides the monitoring of basic meteorological elements in the meteorological station network, operated by HMS, only sparse researches were elaborated for calculation of various drought indices (mostly for DMCSEE Project). Some thresholds for different stages have been adopted, but not verified. HMS does not have sufficient human resources and technical capacities for operational calculation and does not have a reporting procedure on drought indices.

It is crucial to upgrade and modernize the national hydrometeorological monitoring, information exchange network and the forecasting system to provide sustainable organizational resources, human and technical resources and increase the budget available to HMS for efficient meteorological and hydrological disaster risk monitoring, forecasting and warning.

6.1.3 Drought management

There is no established drought authority responsible for organized drought management. There is no complex drought management tool defining competencies and responsibilities for drought monitoring, early warning and actions in the case of drought, especially having in mind sector specific aspects. There are no drought assessments and plans to adequately manage drought risks on national and local levels. Drought risk map for Republic of North Macedonia is missing. The drought risk map comparable with other countries needs to give base to elaborate drought management plan for N. Macedonia.

No unified concern on drought among meteorologists, hydrologists and soil, crop and forestry scientists. Most sectors show great interest in drought-related topics only when they are strongly affected by it. Evident “out of sight, out of mind” approach of most stakeholders.

There is a lack of investment plan in irrigation systems, creation of accumulations due to insufficient funding.

Drought impact data should be gathered on sectoral level in updated database and should be freely available at websites.

6.1.4 Drought communication

The communication between relevant institutions before, during and after drought event is very weak, mainly because there is no legal framework on procedures (protocols) to be undertaken. The most of the communication takes place during the drought episode, on a case to case basis.

There is a weak communication and cooperation between Governmental Institutions and Stakeholders (farmers, environmentalists, water companies, industry, fishery). Sometimes measurements and advises do not reach final users (all farmers).

Missing information system of communication to public, public is only informed of development of drought but given no accompanied recommendations for measures to reduce drought impact. When addressing to public, emphasis is mostly on impacts in agriculture and financial damage in this sector.

Much higher effort has to be given to create awareness of the raising campaigns. Natural hazards (also drought) are an issue, which deserve a regular public attention. The public have to be informed well by relevant information on every-day basis.

6.1.5 Impact evaluation

There is no post-drought-event briefings held to evaluate monitoring, reviewing of institutional response, communications flow etc. to sum up positives and negatives of procedures undertaken in practice and take notes for future cases. There is no drought database on a single site, leading to all the other drawbacks, the number of droughts, intensity and damage caused by droughts.

The drought impact data are rarely collected; even if so they are collected indirectly, e.g. in agriculture by assessment of crop yields every year but it is hard to determine what part of it was damaged due to drought.

The assessments of the municipal commissions for drought damages are not widely available, and procedures of national grants for drought-caused damage are very uncertain and long.

6.2 Actions for implementation

There is a need to introduce proactive approach for drought risk management that includes all of the measures being designed in advance, with appropriate planning tools and stakeholder participation. The proactive approach is based on both short-term and long-term measures and includes monitoring systems for a timely warning of drought conditions. This approach entails the planning of necessary measures to prevent or minimize drought impacts in advance.

6.2.1 Drought Task Force

According to the challenges in institutional report there is a need of forming a drought task force. The organizational structure for the drought plan reflects the three primary elements of the plan: monitoring, early warning and information delivery; risk and impact assessment and mitigation, preparedness and response.

The priority of the Government of Republic of North Macedonia should be establishment of the proposed Drought Task Force with Technical Expert Committee. The proposed scheme for the drought plan is detailed in Figure 11. The Drought Task Force should originate from the National Platform of the Disaster Risk Reduction.

Drought task force is responsible for the development and implementation of risk based drought policy. The main objective is to ensure that the process is coordinated by the government and that all key national authorities.

Technical expert drought committee should be established as a permanent committee with a strong mandate from the government and coordinating actions is the role of the national competent authority. The main tasks of the Committee are to:

- supervise and coordinate the national drought policy development process (during initial phase);
- be responsible for implementation of the drought policy at all levels (national, regional, local), including: DMP production and updating, design and operate a drought monitoring program, design and operate a drought early warning system, ensure a mechanism is developed for the timely and accurate assessment of drought impacts, provide accurate and timely information to the public, activate mitigation actions (measures) during drought occurrences according to the severity of drought stages (i.e. pre-alert, alert, emergency) taking into account priority needs, on-going and post-drought assessment, development and implementation of a drought mitigation programme during the normal drought stage;
- be responsible for cooperation on drought issues at the transnational (river basin) level, develop research, science, and educational programmes (drought experts, and stakeholder groups dealing with, or impacted by, drought are included in the Committee);

The work of the technical expert committee should also consider:

- Establishment of drought authority and organized drought management
- Link drought management with flood management instead of solving them separately (the same reservoirs can serve both for flood and drought prevention if properly conceived)
- Establish drought early warning system and statutory determine procedures when any of drought thresholds is exceeded
- Plan measures to mitigate the effects of drought in agriculture separately in the context of agricultural policy, and not in the wider context of natural disasters
- Set clearly measurable and time-bound objectives that the state wants to achieve in the field of prevention and elimination of the effects of drought
- Prepare provisions that would ensure the quality of water in case of drought event
- Establish tighter control over the implementation of all restrictions
- Responsible for regional cooperation
- Strengthen capacities in drought management both on individual and institutional levels

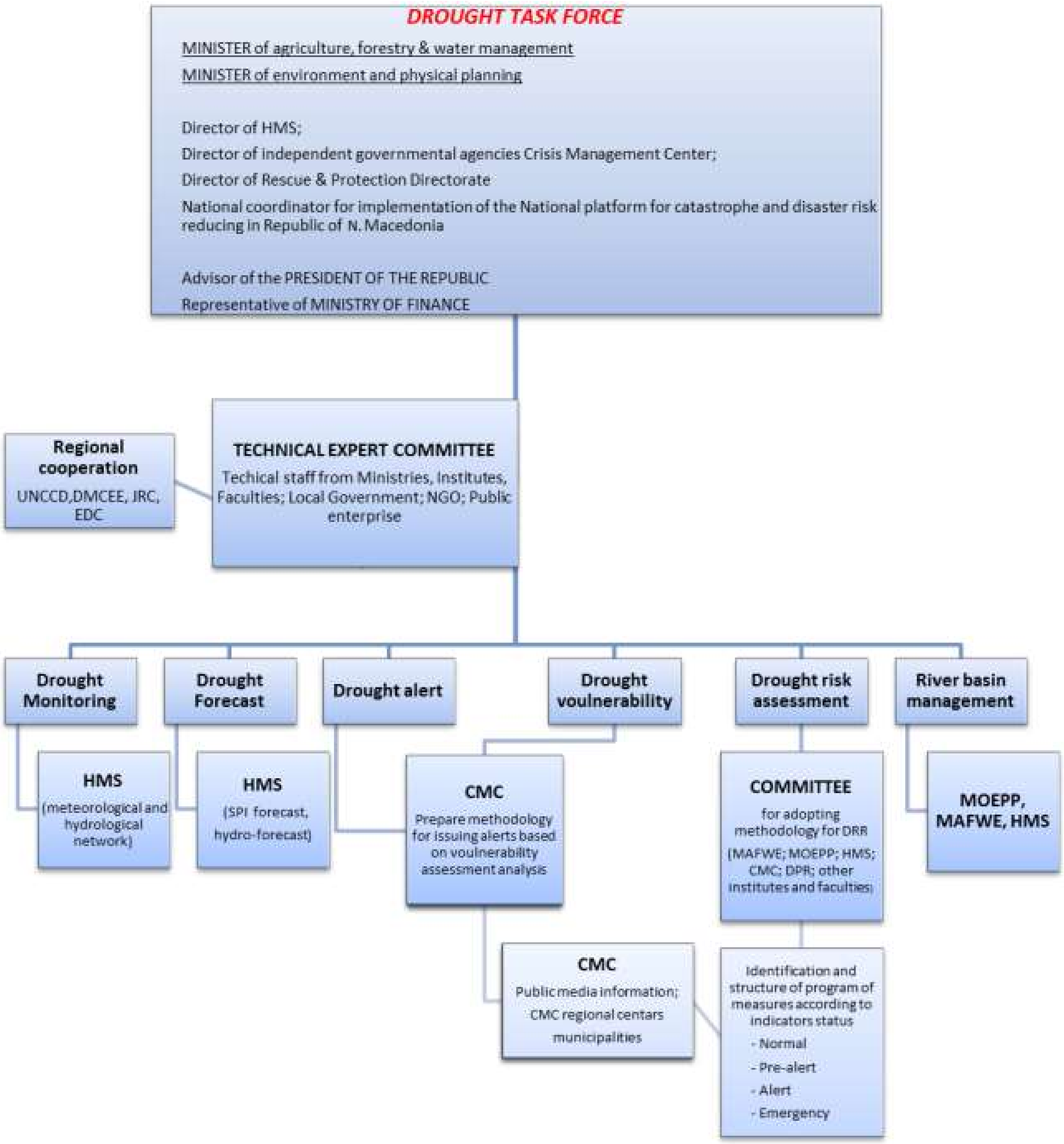


Figure 11: Organizational structure – National drought plan

6.3 Recommendations and Future Updates

The implementation of this drought plan will be done by Government of Republic of North Macedonia through its relevant ministries, departments and agencies, with support from donors, development partners, NGOs, and CSOs as well as well-wishers. A monitoring and evaluation system will be established through a consultative process with all stakeholders and sectors involved in the planning and implementation of this drought plan. This drought plan takes into account various interventions for various sectors, as well as cross-sectoral interventions.

Therefore, there is need for the Government of Republic of North Macedonia to regularly review for more thorough analysis of existing interventions and programs in each sector and of existing funding to avoid overlaps and the inefficient use of resources.

Regular updating and revising the drought plan will ensure the following:

- increased agricultural productivity and sustainability through irrigation and sustainable agricultural practices;
- strengthened resilience of water resource management and supply;
- improved food security, nutrition and delivery of health services;
- ensure enhanced drought resilience and preparedness by strengthening the capacity of institutions and drought affected communities to reduce their risks and vulnerability.

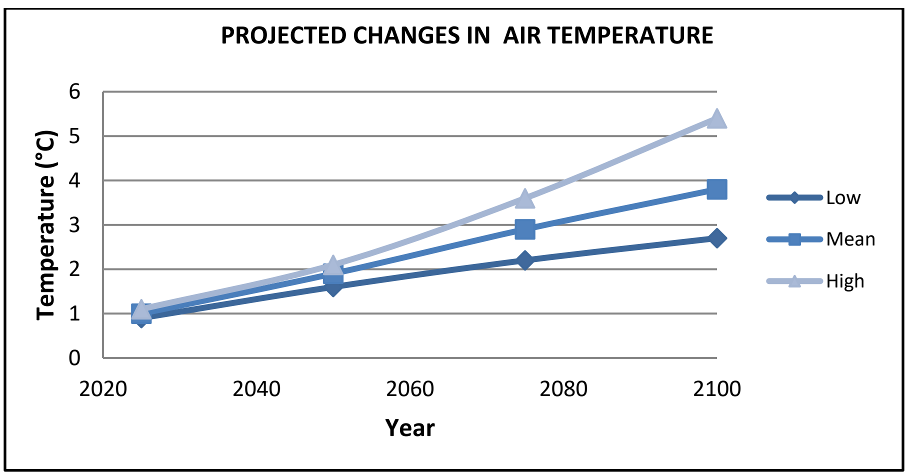
<u>ANNEXES</u>

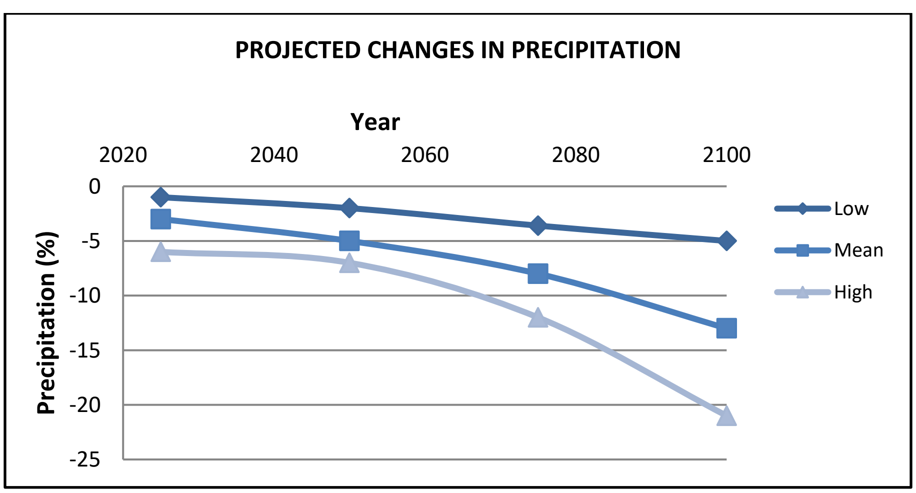
ANNEX 1

Basic estimates of climate change in the Republic of North Macedonia

Projected changes in average annual air temperature and annual sum of precipitation for North Macedonia based on direct GCM output interpolated to geographic location 21.5°E and 41.4°N (base period 1990).

	TEMPERATURE (°C)				PRECIPITATION (%)			
YEAR	2025	2050	2075	2100	2025	2050	2075	2100
Low	0.9	1.6	2.2	2.7	-1	-2	-4	-5
Mean	1.0	1.9	2.9	3.8	-3	-5	-8	-13
High	1.1	2.1	3.6	5.4	-6	-7	-12	-21





ANNEX 2

Drought impact in the Republic of North Macedonia

There is no drought database on a single site, leading to all the other drawbacks, the number of droughts, intensity and damage caused by droughts. The assessments of the municipal commissions for drought damages are sparse and not widely available. Due to such conditions, assessments of the drought impact are collected from occasional reports from MAFWE and the mostly on stakeholders statements in the media when trying to draw attention of the authorities on damages in their sectors.

Some analyses show a 50-60 % decrease in crop production in non-irrigated areas, as a result of drought, especially in eastern parts of the country. Forest drying and decrease of forest growth are current phenomena observed in the forestry sector. Drought has a directly harmful effect on water management. Long-term water shortages directly influence water resources of catchments areas, disturbing the water balance conditions. The drought periods are characterized by discharges under the annual averages at almost every river in N. Macedonia. In addition, drought causes lowering of the water level of natural lakes and artificial reservoirs. Besides the impact on the quantity, drought has an impact on the quality of water resources.

In N. Macedonia a prolonged drought occurred during 1993, damaging most of the crops. During 1993, 16 communities applied for refunds for the damage to crop production caused by the severe drought. The biggest yield reduction appeared in the communities of Stip, Sveti Nikole, and Kocani with up to a 70% reduction, compared with the averages from the previous three years. The total value of the yield reduction caused by drought was 2 669 451 000 MKD (about 80 million EUR). The loss of this income represented at least 5 % (and up to 21.2 %) of the gross income of each community. On a countrywide basis, the damage caused by this drought in decreasing agricultural production amounted to 7.6 % of the total national income.

The problems caused by drought are much more serious for the productivity of perennial crops (orchards and grape). The damage caused to perennial crops during one year is also expressed for several succeeding years. If drought is prolonged, serious damage can appear on the trees. North Macedonia has been exposed to prolonged droughts (ten successive dry years from 1985 to 1997). Fruit production during these years was seriously affected. Because of severe drought and other climatic changes (higher summer temperatures and frequent late spring frosts) more than 3 700 ha of fruit orchards became desiccated: 1 000 ha of apricot, 780 ha of sour cherry, 430 ha of pears. As a result of these droughts, the fruit growing area decreased from 23 900 ha in 1985 to 16 500 ha in 1997. The total fruit production rapidly decreased as follows: apricot from 12 000 tones to 2 000-3 000 tones, peaches from 16 000 tones to 3 500-5 000 tones depending on the year, sour cherries from 11 500 tones to 3 000-4 000 tones. The total fruit production decreased from 200 000 tones to 120 000-130 000 tones.

The impact of prolonged dry conditions with intensive and uncontrolled anthropogenic influence is evident on case of Dojran Lake, which is one of the three natural lakes in N. Macedonia, notable by its specific biodiversity and climate conditions. It is situated on the south border line of the Republic of North Macedonia and Greece, with a surface area of 41 km2 (63% belong to N. Macedonia and 37% to Greece). The lake has elliptic form with total accumulated water amount of 262 mil m3 and average depth of 10 m. It is very popular tourist resort and fishery region, unique by the method of fishing with birds' assistance.

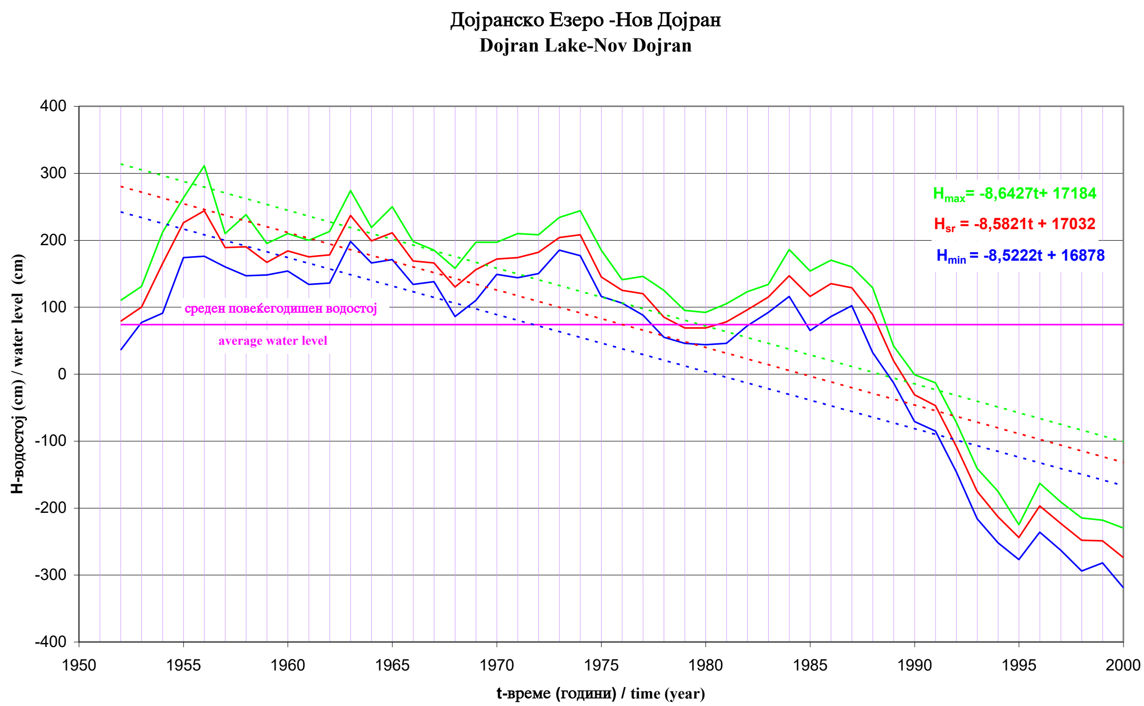


Figure 1: Decrease of Dojran Lake water level

Source HMS

During the last period of prolonged dryness, the lake suffered enormous decrease of the water level. The Hydrological Department at the Hydrometerological Service, responsible for operational monitoring of the hydrological parameters has recorded the oscillation of the water level since 1951 (Figure1).

Extreme drought on the whole territory of the Republic occurred 2001. Some data show reduction in agricultural commodities compared to 1999. The effect of drought also influenced reduced crop in 2002, due to delay of autumn planting (in Southeast region 43 % reduction of fields).

Impact archive shows that drought in 2001 caused 30% lower grape yield in Negotino (Vardar region), 30% lower tobacco production in Vardar region, destruction of 2.400 ha of barley and unsatisfactory wheat crop (reduction of 23 %). Damage was registered also in bee and honey production. Hydrological condition was extremely unfavorable, decrease of water level of natural and artificial lakes (Prespa Lake, Dojran Lake), drying of wells (East region) were registered. Energy production of Hydropower plants (Dosnica-Vardar region) was decreased and water supply in Southeast and East region was restricted. An overall damage caused by drought was estimated to 12.7 million euros.

Year 2007 also started with unfavorable hydrological conditions and developed as a year with severe and extreme drought especially in the western part of the country. In Pelagonia region due to drought 8500 ha of wheat, 4000 ha of barley and 1400 ha of ray were under threat . Losses of wheat amounted 32%. Valandovo plantations (Vardar region) were endangered by drought, cherries production was reduced to half in East region, as well as production of paprika in South east region. Both Prespa and Ohrid Lakes decreased in water level and Debar Spilje Hydropower plant reduced production of energy in the amount of 14%. Dry conditions were indirect cause of many forest fires that destroy 3200ha forest every year.

ANNEX 3

Drought categories according to calculated SPI12

	Skopje Airport	Lazaropole	Ohrid	Bitola	Prilep	D.Kapija	Gevgelija	Strumica	Stip	K.Palanka	Berovo
1961	EW	SW	SD	ED	MoD	MoD	MiD	N	MoD	SW	SD
1962	MW	VW	EW	MW	MW	EW	VW	VW	MW	N	EW
1963	N	EW	CW	SW	VW	SW	N	MW	N	N	VW
1964	MoD	N	SW	N	MW	MiD	SW	SW	N	N	N
1965	MiD	N	N	ED	N	SD	ED	MoD	N	VW	MiD
1966	N	N	MW	N	N	MW	VW	MW	N	MoD	N
1967	N	MiD	MiD	N	MiD	N	N	N	N	MiD	MiD
1968	N	MiD	N	MiD	N	N	N	N	N	N	N
1969	MoD	N	N	N	N	N	SW	MiD	MoD	SW	MoD
1970	N	VW	N	N	N	MiD	MiD	MiD	N	MoD	MiD
1971	N	MiD	N	N	N	N	N	N	N	N	N
1972	EW	N	N	MW	SW	N	SW	SW	SW	MW	SW
1973	N	N	N	N	MW	MW	N	N	MW	N	SW
1974	N	N	N	N	N	SW	N	N	EW	N	SW
1975	EW	ED	MoD	MiD	N	MiD	MiD	N	N	EW	N
1976	ED	N	MiD	SW	SW	N	VW	MW	SW	N	MW
1977	MiD	SD	MiD	ED	MoD	ED	MoD	ED	ED	MW	ED
1978	SW	MW	N	N	N	N	N	SW	MoD	SW	SW
1979	N	VW	VW	EW	MW	SW	N	SW	SW	N	SW
1980	VW	N	N	N	MW	MW	MW	EW	SW	SW	VW
1981	MiD	VW	MW	EW	EW	VW	N	N	SW	MoD	SW
1982	SW	MiD	MiD	SW	N	N	EW	N	MiD	N	N
1983	N	N	N	MW	SW	EW	SW	VW	VW	ED	MW
1984	N	N	N	MiD	MiD	MoD	MoD	ED	MoD	N	SD
1985	N	N	N	N	N	MoD	MiD	N	N	MoD	N
1986	N	SW	N	N	N	N	N	MoD	N	N	MiD
1987	SD	MiD	MiD	N	MoD	N	SW	N	N	MoD	N
1988	SW	MoD	ED	MoD	CD	N	CD	ED	ED	MiD	MoD
1989	SD	MoD	MoD	N	MiD	MiD	MoD	MoD	N	ED	N
1990	CD	SD	SD	MiD	ED	SD	MiD	N	ED	N	ED
1991	SW	N	N	SW	MiD	N	MiD	MiD	N	MiD	N
1992	MoD	MoD	ED	N	MoD	MoD	MoD	CD	CD	CD	ED
1993	MoD	SD	ED	ED	ED	ED	ED	CD	ED	ED	CD
1994	VW	ED	MoD	N	ED	MiD	SW	N	ED	EW	SD
1995	N	SW	N	N	MW	SW	SW	EW	MW	N	MW
1996	MoD	SW	VW	SW	N	N	MW	MW	N	N	SW
1997	N	MoD	MoD	N	MiD	N	MiD	N	N	N	SD
1998	N	VW	MW	N	N	N	N	SW	N	SW	N
1999	CD	MW	MW	MW	N	N	N	N	N	CD	N
2000	SD	ED	MoD	ED	CD	ED	CD	CD	ED	N	CD
2001	VW	ED	SD	ED	SD	N	SD	MiD	MoD	EW	N
2002	MoD	MW	SW	EW	MW	EW	EW	CW	VW	MiD	CW
2003	N	N	N	N	N	SW	MW	MW	N	VW	SW
2004	SW	MW	MW	SW	N	N	EW	N	N	SW	N
2005	MiD	VW	SW	N	N	N	MoD	N	N	N	SW
2006	N	N	N	SW	MiD	SW	VW	N	N	SW	MW
2007	SD	N	N	N	N	SW	MiD	N	N	N	N
2008	MW	MoD	MoD	MiD	MoD	MiD	N	MoD	MiD	VW	N
2009	VW	SW	MW	VW	SW	SW	EW	EW	SW	CW	MW
2010		CW	CW	VW	VW	SW	EW	EW	VW	CD	EW
2011	ED	ED	ED	ED	SD	SD	ED	CD	ED	N	SD
2012	N	N	EW	MW	N	N	SW	VW	N	N	EW
2013	EW	SW	N	N	N	MW	SW	EW	N	CW	SW
2014	N	MiD	N	EW	EW	EW	CW	CW	CW	VW	CW
2015	N	N	SW	SW	MW	MW	EW	N	VW	MW	EW
2016	MoD	MW	N	SW	N	N	N	N	N	N	SW
2017		MiD	N	MiD	MiD	SW	VW	SW	N		SW

Table 1: Standardization precipitation index- drought category

SPI category	
CD	Catastrophic (Exceptional) Drought
ED	Extreme Drought
SD	Severe Drought
MoD	Moderate Drought
MiD	Minor Drought
N	Near Normal
SW	Slightly Wet
MW	Moderately Wet
VW	Very Wet
EW	Extremely Wet
CW	Exceptionally (Catastrophically) Wet

ANNEX 4

Drought Vulnerability Assessment for the Republic of North Macedonia

Data & Methodology

Drought vulnerability estimate is based on climatological and geomorphological data.

Study area and dataset description

For the purpose of this study the following dataset was used:

- DEM (Digital elevation model) acquired from the Ministry of Environment and Physical Planning. Spatial resolution 80m, with spatial accuracy of 18.9m. The DEM was subsequently used to extract the slope of the terrain.
- Corine land cover/use map 2000. This land cover map was developed according the methodology of European Environmental Agency on the scale 1:100.000, minimal mapping unit of 25ha and with 3 hierarchical levels.
- Map of Irrigated land (source: Public Enterprise for spatial and urban plans of Republic of North Macedonia)
- Soil map of North Macedonia (source: Agriculture Institute-Skopje)
- Rainfall data (source: Hydrometeorological *Service* of the Republic of North Macedonia*)*
- *Solar radiation* (source: Hydrometeorological *Service* of the Republic of North Macedonia*)*

Methodology and development of the separate parameters

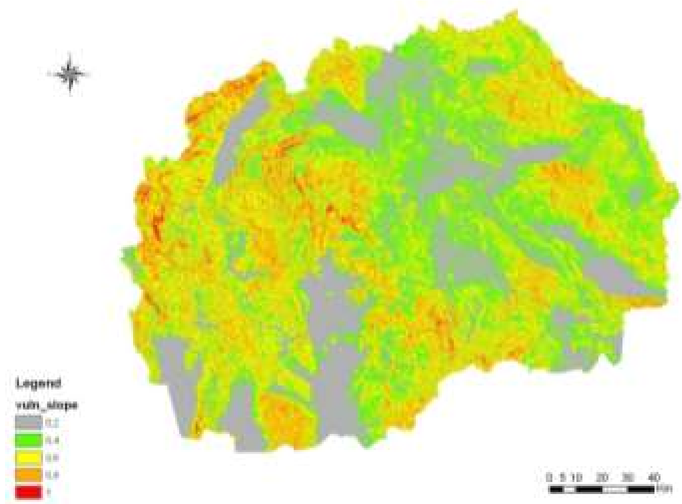
All of the aforementioned data were used as an input of the GIS based model for estimating the drought vulnerability of the area. The mapping unit of the developed model is 80x80m with approximation of the scale 1:100.000.

Slope

For the development of the parameter slope the acquired DEM was used. The DEM had 80m spatial resolution and spatial accuracy of 18.9m. The DEM was used as an input in the GIS algorithm creating slope output in degrees. Further on the slope was reclassified in five vulnerability classes (0, 2 - 1) Table 1. Finally a slope map was produced Map 1.

Table 1: Slope vulnerability classes

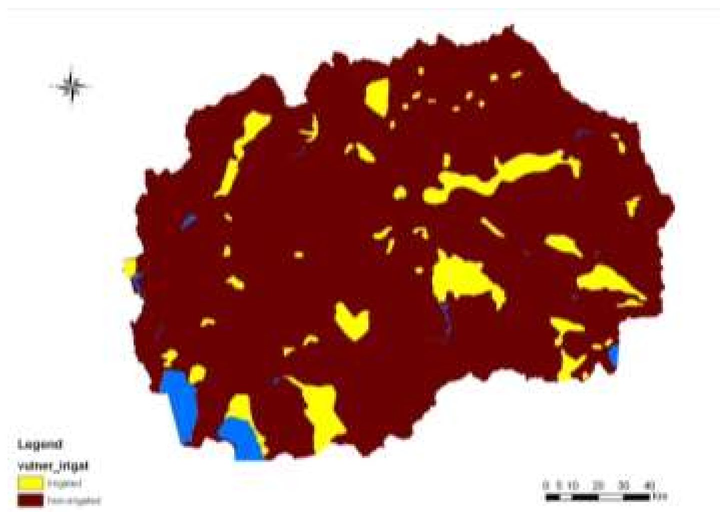
	Angle [°]	Vulnerability class
Slope	(0-5)	0,2
	(5-12)	0,4
	(12-20)	0,6
	(20-35)	0,8
	(35-90)	1



Map 1: Slope vulnerability map

Irrigation

This map was created by the Public Enterprise for spatial and urban plans of our Republic and it was acquired in hard copy format. First the map was scanned and georeferenced according the state reference system. Next, the irrigated land was vectorized and reclassified according the classification. Finally an irrigation map was produced Map 2.

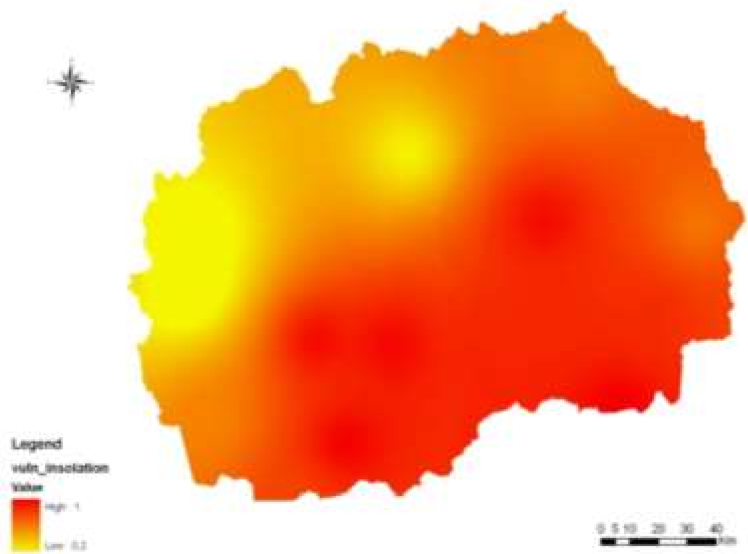


Map 2: Irrigation vulnerability map

Solar radiation

This parameter was acquired from the Hydrometeorological *Service* of the Republic of North Macedonia. The data were provided in table form. Most of the meteorological stations had continuous measurements for 30 years (9 out of 13). According to the provided methodology only the solar radiation from the vegetation months was taken (April through October).

Then this database was transferred in GIS environment. Each meteorological point was updated with the parameter for solar radiation. Using the data in the meteorological points, an interpolated map of the whole territory of North Macedonia was created using the IDW (Inverse Distance Weighting) algorithm. Finally this map was reclassified according to the given methodology in order to produce the vulnerability map for solar radiation (Map 3).



Map 3: Solar radiation vulnerability map

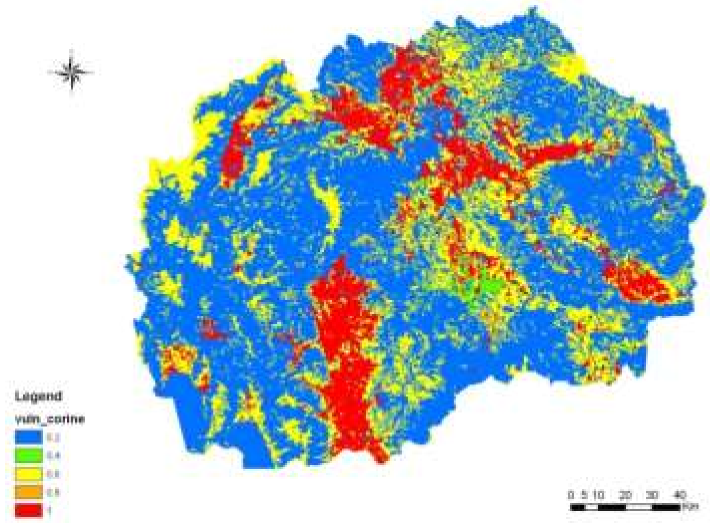
Land cover/use

For the development of the parameter Land cover/use (Map 4) the Corine land cover/use map 2000 was used. This land cover map was developed according the methodology of European Environmental Agency on the scale 1:100.000 with minimal mapping unit of 25 ha and with 3 hierarchical levels.

Table 2: Land use vulnerability classes

	Type of land use (CLC100)	Vulnerability class
Landuse	223, 243, 244, 311, 312, 313,324	0,2
	221	0,4
	241, 242, 321, 322, 323, 333	0,6
	222	0,8
	211, 212, 213 + hierachical class 1	1

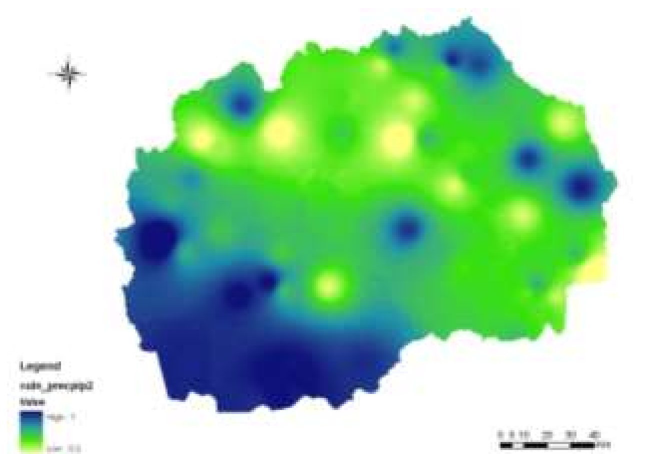
The provided methodology for classification of the vulnerability of the land use covered only the classes: agricultural areas, forest and semi natural areas. In order to obtain a map of the whole territory of the country also the other classes were included. Namely the class artificial surfaces were classified in the highest vulnerability class (1) and the class water bodies and wetland were classified in the lowest vulnerability class (0, 2) (Table2).



Map 4: Land use vulnerability map

Precipitation

This parameter was acquired from the Hydrometeorological *Service* of the Republic of North Macedonia. The data was provided in table form. For this model 51 meteorological stations from the national network were used, which had continuous measurements for 30 years (1971- 2000). The precipitations from each month were summed up in order to get the annual precipitation. Further on, average precipitations were calculated from the annual precipitation. Also this was done for the standard deviation for each meteorological station. Then the precipitations were divided with the standard deviation. This took care of creation of the database. Then this database was transferred in GIS environment. Each meteorological point was updated with the parameter for precipitation. Using the data of the meteorological points, an interpolated map of the whole territory of North Macedonia was created using the IDW (Inverse Distance Weighting) algorithm. Finally this map was reclassified according to the given methodology in order to produce the vulnerability map for precipitation (Map 5).



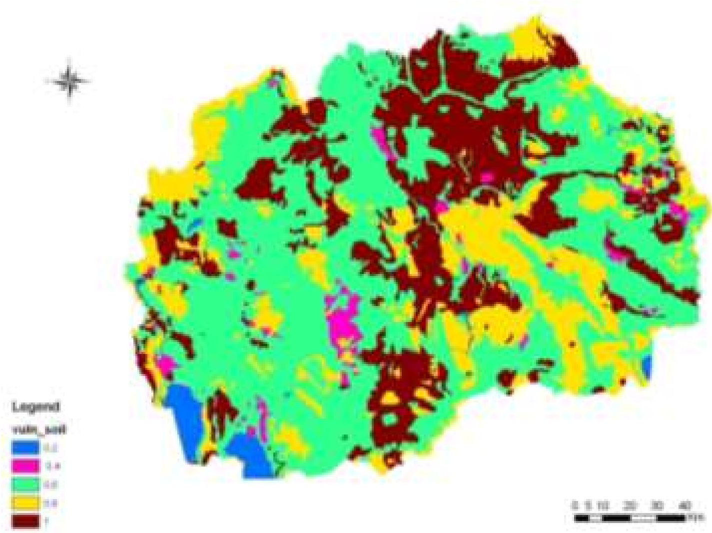
Map 5: Precipitation vulnerability map

Soil type

The Soil map of Republic of North Macedonia was acquired from the Agriculture Institute-Skopje in vector format. The soil type classes were reclassified according to the provided methodology (Table 3).

Table 3: Soil type vulnerability classes

	Soil type	Vulnerability class
Soil type	Histosols (HS)	0,2
	Gleysols (GL), Luvisols (LV)	0,4
	Cambisols (CM), Chernozems (CH), Fluvisols (FL)	0,6
	Phaeozems (PH), Solonetz (SN)	0,8
	Arenosols (AR), Leptosols (LP), Solonchaks (SC), Vertisols (VR)	1



Map 6: Soil vulnerability map

After the creation of the separate criteria/parameters the final vulnerability map of the area was developed. According to the provided methodology, the separate parameters were summed. Finally the vulnerability map was reclassified creating five equidistant vulnerability classes.

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