Global Water Partnership
Central and Eastern Europe

INCEPTION REPORT

Inception report for the GWP CEE part of the WMO/GWP Integrated Drought Management Programme

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Section 1: Introduction

The Regional Council of the Global Water Partnership for Central and Eastern Europe (CEE) presents this Inception Report for the WMO/GWP Integrated Drought Management Programme to be implemented in the region of Central and Eastern Europe (see Fig. 1.1). This document is the first result of an intensive about five months long process in which IDMP Task Force[1] established by the GWP CEE Regional Council and eight GWP Country Water Partnerships (CWPs) worked together on addressing national and regional drought management challenges. Going from South to the North of the region, these countries are Slovenia, Bulgaria, Romania, Hungary, Ukraine, Slovakia, Poland and Lithuania. The remaining four GWP CEE countries of Moldova, Czech Republic, Latvia and Estonia are expected to join the WMO/GWP Integrated Drought Management Programme at the later date.

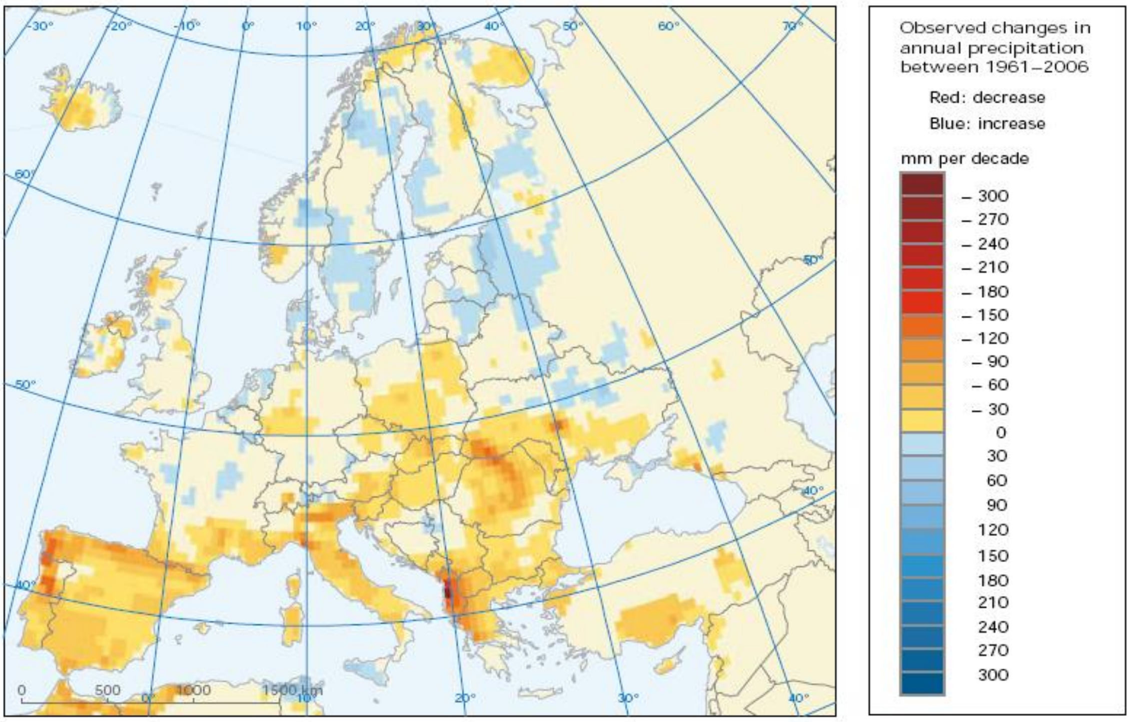
The GWP CEE region

Fig. 1.1: The GWP CEE region

[1] Prof. Pavol Bielek (CWP Slovakia), Prof. Elena Mateescu (CWP Romania), Prof. Gintas Stankunavicius (CWP Lithuania), Prof. Janos Tamas (CWP Hungary) and Prof. Janusz Kindler (CWP Poland – Task Force Leader)

Drought events are widely recognized as being a major cause of natural disasters. They have large adverse consequences on the socio-economic condition of people living in drought-prone areas through their impact on water scarcity, land degradation, agricultural and energy production as well as on ecosystems degradation. Whether due to natural climate variability or climate change, there is an urgent need to develop better drought monitoring and management systems, as well as broader social response to manage the drought risks.

Addressing the challenge of water scarcity and droughts in Europe[2], Fig 1.2 shows that reduced precipitation, being one of the key phenomena leading to drought, is a recurrent feature of the European climate that is not restricted to the Mediterranean.



Note: Data are in mm per decade, blue means an increase, red a decrease. The observations indicate that large decadal scale variability in precipitation amount is superposed on the long time scale trends described above. This variability is partly related to the decadal scale variability in atmospheric circulation anomalies (see Box 5.1). Calculating trends over shorter time periods may therefore lead to different results.

Source: The climate dataset is from the EU-FP6 project ENSEMBLES (http://www.ensembles-eu.org) and the data providers in the ECA&D project (http://eca.knmi.nl).

Fig. 1.2: Observed changes in annual precipitation between 1961 – 2006

Droughts can occur as well in high and low rainfall areas and in any season. Although Mediterranean countries are particularly affected by water scarcity and drought episodes, the consequences of drought also cause damages in other European countries. Recent severe and prolonged droughts have highlighted Central and Eastern Europe’s (especially the South-eastern parts of the region) vulnerability to this natural hazard and alerted the public, governments, and operational agencies to the many socio-economic problems accompanying water shortage and to the need for drought mitigation measures.

The CEE region comprises countries that are EU member states and non-EU countries. All GWP CEE countries are actively involved in implementation of the EU water directives, foremost the Water

[2] According to EEA “drought” means a temporary decrease in water availability due for instance to rainfall deficiency, while “water scarcity” means that water demand exceeds the water resources exploitable under sustainable conditions.

Framework Directive and Flood Risk Management Directive which are to be accompanied soon with Water Scarcity and Drought Directive.

Also, the region lies in two hydro geographical areas of Baltic Sea and Danube River basins. In the past, the Danube and Baltic Sea regions have been considered as two independent areas. The adoption of EU Strategy for the Danube Region was a significant outcome supported by the GWP CEE activities in years 2008-2010. A main focus of CEE GWP intervention was to persuade and finally to get the inclusion of water issues into regional economic development strategy as a prerequisite of economic and sustainable development.

The GWP CEE has also an observer status in both international Basin Commissions of Transboundary Conventions: International Commission for Protection of Danube River (ICPDR) and Helsinki Commission (HELCOM). GWP CEE was also recognized by UNECE to have a key role in mobilization of stakeholders regarding Integrated Water Resources Management, assessment of transboundary basins, including activities to promote cooperation under the Water Convention.

Moreover, all of these countries are signatories of the ***United Nations Convention to Combat Desertification*** (UNCCD) and made an effort to transpose the Convention into their national legislation. The particular conditions of the CEE region are addressed by the Convention's regional implementation Annex V. They include:

- specific problems and challenges related to the current process of economic transition, including macroeconomic and financial problems and the need for strengthening the social and political framework for economic and market reforms;
- the variety of forms of land degradation in the different ecosystems of the region, including the effects of drought and the risks of desertification in regions prone to soil erosion caused by water and wind;
- crisis conditions in agriculture due, inter alia, to depletion of arable land, problems related to inappropriate irrigation systems and gradual deterioration of soil and water conservation structures;
- unsustainable exploitation of water resources leading to serious environmental damage, including chemical pollution, salinization and exhaustion of aquifers;
- forest coverage losses due to climatic factors, consequences of air pollution and frequent wildfires;
- the use of unsustainable development practices in affected areas as a result of complex interactions among physical, biological, political, social and economic factors;
- the risks of growing economic hardships and deteriorating social conditions in areas affected by land degradation, desertification and drought;
- the need to review research objectives and the policy and legislative framework for the sustainable management of natural resources; and
- the opening up of the region to wider international cooperation and the pursuit of broad objectives of sustainable development.

In order to support the Annex V countries, a Regional Coordination Unit (RCU) was established in 2011 by the UNCCD secretariat, and located in the secretariat's headquarters in Bonn.

The countries under regional Annex V are advancing in building up the regional cooperation for several years. In 2006 the Secretariat of the UNCCD Convention in cooperation with World Meteorological Organization (WMO) organized a workshop for national experts and representatives of National Meteorological and Hydrological Services where they agreed on ***Drought Management Centre for South Eastern Europe*** (DMCSEE) within context of UNCCD. Five GWP CEE countries (Bulgaria, Hungary, Moldova, Romania and Slovenia) are among the founding national members of the Centre. The Environmental Agency of Slovenia was selected to host DMCSEE once its functions will be established through the execution of the kick-off project. It was agreed that this kick-off project will be co-financed by EU South East Europe Transnational Cooperation Programme. The duration of DMCSEE Project was to be 36 months (2009-2012). Altogether 13 countries of South Eastern Europe (SEE) are involved in the Programme[3].

The principal aim of the DMCSEE project was to coordinate development and application of drought risk management tools and policies with the goal of improving preparedness and reducing drought impacts. It was to provide now missing regional information on drought situation. Since definitions and thresholds for drought differ on country/region levels today, the partners' countries were to agree upon an integrated approach combining outputs of meteorological services and information from agricultural institutions. Using common methodology in drought analysis and impact assessment, the project was to obtain regionally comparable results enabling better overview of drought situation for sectors economically dependent on water availability, such as agriculture, energy and tourism. Quality assessments of drought occurrence risk and possible drought impacts provided by DMCSEE and disseminated to decisions makers and general public were to allow effective and timely decisions to reduce drought related damages.

One of the specific objectives of the project was "to set-up Drought Management for SEE for drought preparedness, monitoring and management and to coordinate and integrate drought related services of National Meteorological and Hydrological Services (NHMSs) and other relevant institutions in participating countries and broader SEE region".

The final conference on the Drought Management Centre for South Eastern Europe project was held in Ljubljana on May 14-15, 2012. Introducing the conference, the organizers stressed that South Eastern Europe is among areas which are largely exposed to drought. In the past decades the drought-related damages have had large impact on the economy and human welfare. Several papers were presented on the advances made in the area of drought monitoring process, risk assessment of drought in agriculture, drought indexes and mapping of drought vulnerability using GIS technique. In addition, there was a round table discussion on future development of DMCSEE.

There are also several drought-related initiatives of the European Union. In 2007, the European Commission worked out a Communication "***Addressing the challenge of water scarcity and droughts in the European Union***" (Com, 2007). The Communication presented an initial set of policy options at European, national and regional levels to address and mitigate the challenge posed by water scarcity and drought within the Union. The Commission remained fully committed to continuing to address the issue at international level, through the UNCCD and the UN Framework Convention on Climate Change (UNFCCC). The 2007 Communication identified seven main policy options to address water scarcity and drought issues:

1. Putting the right price tag on water
2. Allocating water and water-related funding more efficiently
3. Improving drought risk management
4. Considering additional water supply infrastructures
5. Fostering water efficient technologies and practices
6. Fostering the emergence of a water-saving culture in Europe, and
7. Improve knowledge and data collection.

[3] Albania, Bosnia and Herzegovina, Bulgaria, Croatia, FYROM, Greece, Hungary, Moldova, Romania, Slovenia, Turkey, Montenegro and Serbia

The Environmental Council was supportive of the 2007 Communication and invited the Commission to review a further develop the evolving strategy for Water Scarcity and Drought by 2012. Since 2007 a number of studies, research and other activities have been launched and the progress of work on the above seven policy options has been assessed on an annual basis. In 2010 EU Environment Commissioner announced a new Commission initiative, a ***"Blueprint to Safeguard Europe's Waters"*** comprising a review of the Strategy on Water Scarcity and Droughts, a review of the implementation of the Water Framework Directive, and a review of the vulnerability of water and environmental resources to climate change and other man-made pressures. At that moment it was acknowledged, however, that a number of knowledge gaps still exist as regards water scarcity and droughts in the EU (EC, 2010). In reaction, the European Commission launched a study to look into the current state of play regarding water scarcity and droughts, to check the adequacy of existing measures, identify gaps and suggest new measures where gaps are identified. The studies addressed above all the following issues:

1. Water efficiency activities
   - Buildings and water efficiency
   - Leakage reduction in water distribution networks
   - Activities to halt desertification in Europe
2. Water use in agriculture
   - Water pricing in agriculture
   - Water saving in agriculture
3. Instruments for better planning

The 2010 Follow-up Report of the Commission confirmed that water scarcity and drought is not limited to Mediterranean countries. Apart from some sparsely-populated northern regions with abundant water resources, this is a growing issue across the EU. Some of the earlier Follow-up Reports indicated that more effort is needed on drought risk management.

As pointed out by one of the recent State of the Environment reports developed by European Environmental Agency (EEA), the achievement of EU water policy goals stated in the Water Framework Directive appears far from certain due to a number of old and emerging challenges. The "Blueprint to Safeguard Europe's Waters" planned to be released by the end of 2012, will be the EU policy response to these challenges. It will be accompanied by a series of impact assessments o understand better the potential environmental and socio-economic impacts of its policy options as well as by a number of reports covering the major strands.

The more recent European initiatives on drought-related issues are the ***European Drought Centre*** (EDC) and the Drought and Science-Policy Interfacing (D&SPI) project to be implemented within the framework of the 7th EU Framework Research Programme. The EDC is a virtual centre of European drought research and drought management organizations to promote collaboration and capacity building between scientists and the user community. The long term objective is to enhance European co-operation in order to mitigate the impacts of droughts on society, economy and the environment. Although the EDC primarily has a European dimension, it also links with other international projects, organizations and experts outside Europe.

The EDC is based on the EU funded projects WATCH and XEROCHORE (in Greek it means "dry land"). The core group comprises individual research scholars[4] including International Hydrological Programme (IHP-UNESCO) and the EU Institute for Environment and Sustainability (Ispra, Italy).

4 Italy (Department of Civil and Environmental Engineering, University of Catania), United Kingdom (Centre for Ecology and Hydrology, Wallingford), Norway (Norwegian Water Resources and Energy Directorate and Department of Geo Sciences,

The D&SPI project is managed by the above mentioned Hydrology and Quantitative Water Management Group from Wageningen University. The project is to enhance the understanding of: (1) Drought as a natural hazard, including climate drivers, drought generating processes and occurrences, (2) Environmental and socio-economic impacts, and (3) Vulnerabilities, risks and policy responses, including the further development of drought management plans in support of EU and other international policies, e.g. UN/ISDR-HFA. The project will address the past and future climate, link science and science policy dialogue across scales and across a range of affected sectors. Project duration is October 2011 to October 2014.

1.1 Rationale for the Integrated Drought Management Programme

At the background of the above presented drought-related initiatives in Europe, the GWP CEE recognizes the important issue of serious eco-social problems caused by drought and wants to contribute to the ***Integrated Drought Management Programme (IDMP) of WMO/GWP***. At the Consultation Meeting on the proposed Integrated Drought Management Programme held at WMO in Geneva, Switzerland on 15-16 November 2010, the participants unanimously agreed, among others, to the following principles:

1. Proactive approaches have priority over reactive approaches. Proactive approaches were defined as preparedness and drought risk management strategies such as: prediction, early warning, developing preparedness strategies, and mitigation through early recognition of factors contributing in drought. On the other hand, relief of drought through drought crisis management is a reactive approach and treats the symptoms during or after the drought, but not necessarily the causes. Impact assessment, reconstruction, and recovery are examples of reactive or crisis management.
2. Definition of drought risk: Risk = Hazard * Vulnerability.
3. Hazard can be recognized by scientific analysis such as: calculating severity, duration, frequency, spatial extent, trend recognition, impacts, and early warning. Vulnerability can be evaluated by social analysis such as: assessing the contributions of population growth, population shifts, urbanization, technology, land use/change, environmental degradation, water use trends, government policies, and environmental awareness.
4. There is a necessity of horizontal and vertical integration over all sectors impacted by drought. The meeting participants agreed on the importance of a "bottom-up" approach by participation of communities in an integrated drought risk management programme for moving from policies to practices. They have agreed also on the necessity of effective dialogue with stakeholders at all levels for capacity building and knowledge development to build political commitment, competent institutions, and an informed constituency.

According to GWP CEE Strategy for 2009-2013, Strategic Goal 2 "Addressing critical challenges", 2.1 "Regional level intervention to disaster risk reduction", output of CEE IDMP shall be recommendations for CEE countries on coordination of the drought monitoring, its assessment, terminology used by individual national weather services, methods used for prediction and early warning of stakeholders involved in drought management, and respective interface as basis for the integrated drought management (IDM) at the regional level. The outcome will be that institutions in the CEE countries dealing with drought monitoring, assessment and its prediction, together with stakeholders involved, recognize the need of IDM coordination at regional level. The policy and decision makers in these countries will have tools to manage droughts in an integrated manner.

University of Oslo), the Netherlands (Hydrology and Quantitative Water Management Group, Wageningen University and Germany (Institute of Hydrology, University of Freiburg)

GWP CEE will build on the previous outcomes regarding management of flash floods. The ***Guidance on Flash Floods*** (GWP CEE and APFM/WMO, 2007) was well received and applied in 7 countries in GWP CEE region.

To complete this introduction following is a brief presentation of the contents of this Inception Report. Concerning drought situation and the related risk **(Section 2)**, it is shown that significant part of the CEE region is vulnerable to frequent occurrence of droughts that have adverse consequences on the people living in drought-prone areas through their impact on water scarcity, land degradation, agricultural production and ecosystems degradation. Climate variability is high in the region both temporally and spatially. In addition, climate change already amplifies the frequency and severity of droughts in the region.

The common feature across the CEE countries is that all of them are especially sensitive in respect to both the variability and change in precipitation. The most probable future climate development in CEE region is directed towards warm and slightly drier summers, warm winters with a rather unchanged average level of annual rainfall and an increased frequency of extreme weather events. If these changes persist, they will clearly result in the increase of drought hazards. Another common feature of CEE countries is that in all of them, the sector most vulnerable to drought losses is agriculture. However, in the severe drought situation shortages, water supply to population and industry may also be affected.

To illustrate how complex and severe drought risks can be, the report mentions several impacts the current droughts are creating in the CEE countries. The drought's most apparent, immediate impact is a reduction in crop yields across the affected areas. Reduced yields and the threat of outright crop failure have immediate impacts that stretch far beyond farmers and the communities that rely on crops for their livelihoods. The threat of reduced crop yields has an immediate impact on agricultural commodity prices. These rising prices often have far-reaching implications across today's inter-connected markets. For example, increases in grain price are correlated to increases in price for essential fertilizers such as potash – demand for fertilizers grows as farmers try to meet the increased demand for grains. While the threat that drought poses to agriculture is often the one most discussed, no rain can contribute to devastating wild forest fires and seriously hinder power generation. The drought risks facing governments, businesses, investors, communities, and others are undeniably severe.

Concerning current policies regarding drought monitoring and management in the CEE countries **(Section 3)**, in the past few decades it has become evident that in all of them there is a clear need to improve national drought monitoring and management policies with the goal of improving preparedness and reducing drought impacts. Better coordination of national policies is also needed due to the regional character of drought processes, as shown by experience of the Drought Management Centre for South Eastern Europe. But current definitions and thresholds for drought, as well as monitoring and management arrangements differ considerably on country levels today.

Although most CEE countries have well developed meteorological and hydrological monitoring, these systems are not translated into concerted efforts to support decision makers in other sectors of the national economy (such as agriculture and energy sector). Some countries (with a strong tradition of agriculture production) also have developed a sound agro-meteorological monitoring and drought warning system. It should be confirmed that several countries undertake serious attempts to adopt a more comprehensive and integrated approach towards drought mitigation across various sectors.

Having in mind that drought episodes have local and regional character, there is not a suitable mechanism to share information and knowledge among countries. This is in spite of the fact that several basins in the region are of a transboundary character, regional integration of drought monitoring and early warning is not at the level desired. Transnational integrated approach is needed for successful tracking of drought, comparing its impacts using common methodology and assessing vulnerability of various sectors to drought occurrence. At present, all countries of the CEE region need to improve their both short-term and long-term responses across sectors to meteorological, agricultural and hydrological droughts.

It should be underlined that this Inception Report is based on information obtained directly from the GWP CEE Country Water Partnerships and it represents situations in the specific countries rather than in the entire region. Thus, the following five categories of national and regional GWP CEE initiatives are proposed for IDMP **(Section 4):**

1. Drought preparedness measures (investment and non-investment measures, like for example drought insurance systems,
2. Enhancement (and/or development) of drought monitoring and early warning systems;
3. Development of capacity building programs for water managers and farmers;
4. Integrated drought management including design of real-time operational systems of different complexity;
5. Development case studies to document good practices in application of integrated drought management (including transboundary basins).

The conclusions and recommendations for the IDMP initiative **(Section 5)**, envisage four types of principal outputs:

1. Knowledge base on recorded practices in drought planning and management,
2. Guidance on tools and institutional arrangements to support increased risk responses,
3. Advocacy through regional and country dialogues, and
4. Improved early drought warning services, building upon existing regional initiatives.

To organize these anticipated outputs, it is recommended:

- To collaborate closely with WMO on the drafting the workplan on Integrated Drought Management Program (2013-2015);
- To invite the DMCSEE project , the European Drought Centre, and the Drought and Science-Policy Interfacing project being implemented within the framework of the 7th EU Framework Research Programme, to conduct the proposed activities and seek synergies;
- To invite and inform national secretariats of UNCCD of all CEE countries to contribute to specific case studies dealing with degradation of land caused by desertification;
- To seek an appropriate mechanism and cooperation with agriculture and other appropriate sectors at national levels;
- Having in mind a transboundary context of drought risk management it is recommended to invite the UNECE and its Task Force on Climate Change Adaptation to coordinate and share achievements in IDM program in CEE region and seek a potential of the program replication in other signatory UNECE countries (specifically those in Central Asia, where GWP has also its partners).

It is also recommended to establish a web-based ***Integrated Drought Management Platform*** for detection, monitoring, forecasting and information exchange. Section 5 ends with GWP CEE Workplan 2012.

To start the GWP CEE part of the WMO/GWP IDMP, it is proposed to embark on two principal activities (August-December 2012):

1. Organization of the **Regional Workshop on Integrated Drought Management Platform** comprising regional drought experts in GWP CEE Country Water Partnerships together with representatives of WMO, DMCSEE, EC (DG Environment), UNECE, UNCCD regional focal points. The main objective of the workshop is to formulate and commit to the IDMP initiative. Decision makers of agriculture sector of selected countries should be also invited.
2. Implementation of the regional study on "**Increasing soil water holding capacity; an example of best practice in drought mitigation".** The soil water holding capacity is a key attribute of soil quality. Water holding capacity is determined by several factors, some of which are beyond our control but some of which can be managed. Management practices designed to improve soil structure are the main way to improve water holding capacity and contribute to increase resilience to drought risks. The target group is agriculture sector.

1.2 Literature

Com (2007), Addressing the challenge of water scarcity and droughts in the European Union, Communication from the Commission to the European Parliament and the Council, 414 final.

EC (2010), Water Scarcity & Droughts – 2012 Policy Review – Building blocks, Non-Paper.

Lehner B., Doll P., Alcamo J., Henrichs T. and Kaspar F. (2006), Estimating the impact of global change on flood and drought risk in Europe: A continental integrated analysis, Climatic Change, 75:273-299.

GWP CEE/APFM-WMO (2007), Guidance on Flash Flood Management - Recent experiences from Central and Eastern Europe

Section 2: Drought situation and the related risks

2.1. Slovenia[5]

2.1.1. Climate situation in Slovenia

In the past, Slovenia was not considered to be an area where drought had a significant bearing on hydrological conditions and agriculture. The country is climatically diverse; orographic influence causes differences in the yearly precipitation in western part (3200 mm) and the eastern parts (900 mm) of Slovenia; the maximum precipitation is reached at Dinarides-Alps barrier. The average annual rainfall (1567 mm) in long-term average exceeds evaporation (650 mm). The water quantity distribution is well-depicted in the charts of annual precipitation, evaporation, runoffs and specific runoffs. With specific runoffs, the ratios between the most and least water-abundant river basins can reach 1:10 or more (Fig. 2.1.1). A long term average water balance is shown at Fig. 2.1.2.

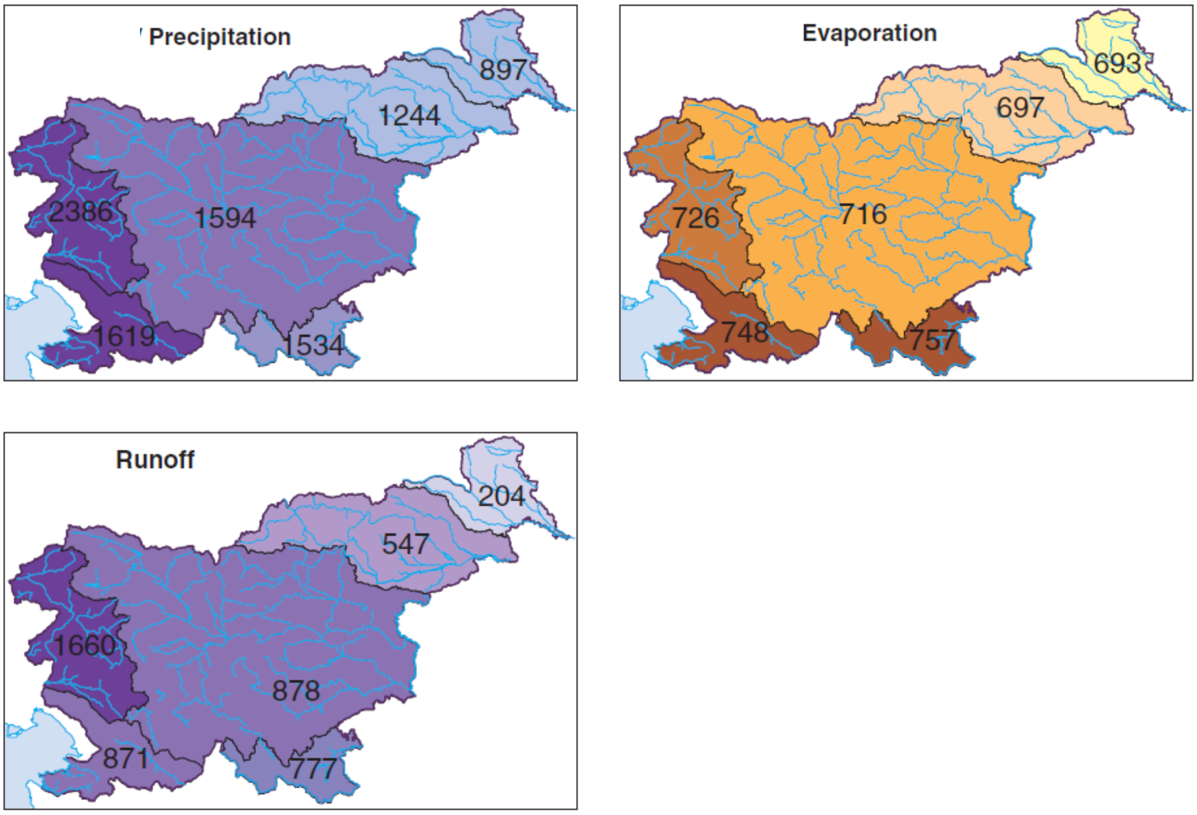
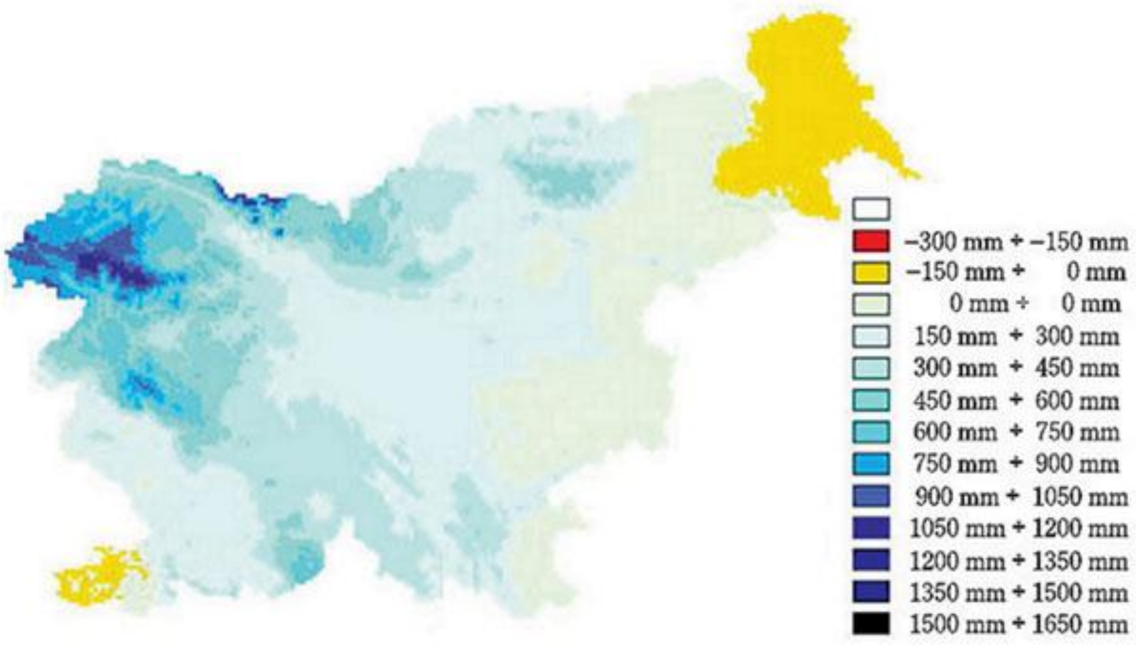


Fig. 2.1.1: Elements of the water balance in the territory of Slovenia (precipitation, evaporation and runoff) by river basins in mm

[5] Prof. Lucka Kajfez Bogataj, Biotechnical Faculty, University of Ljubljana, Slovenia



source: Kajfež-Bogataj, Bergant, 2005

Fig. 2.1.2: The difference between precipitation and potential evapotranspiration in the warm half of the year (April-September) for the period 1961-1990

Over the past decades, Slovenia, like most of Europe, experienced an increase in temperature at a level higher than the global average. The average increase in the observed annual mean temperature across the European continent is 0.8°C. Slovenia is among the most sensitive areas to changes in temperature, and more broadly to climate change, especially in regards to changes in precipitation variability.

Vulnerability to climate change is spatially inhomogeneous due to complex orography and substantial microclimatic differences. Based on the results of General Circulation Model, the data from the period 1961-1990 indicate that Slovenia can expect 1-4°C increase in temperature and a change in the amount of rainfall (from –20% to +20%) in the first half of the 21st century (Bergant, 2003). In addition, Slovenia is likely to experience warmer and slightly drier summers, warmer winters with a rather unchanged average level of annual rainfall, and an increased frequency of extreme weather events.

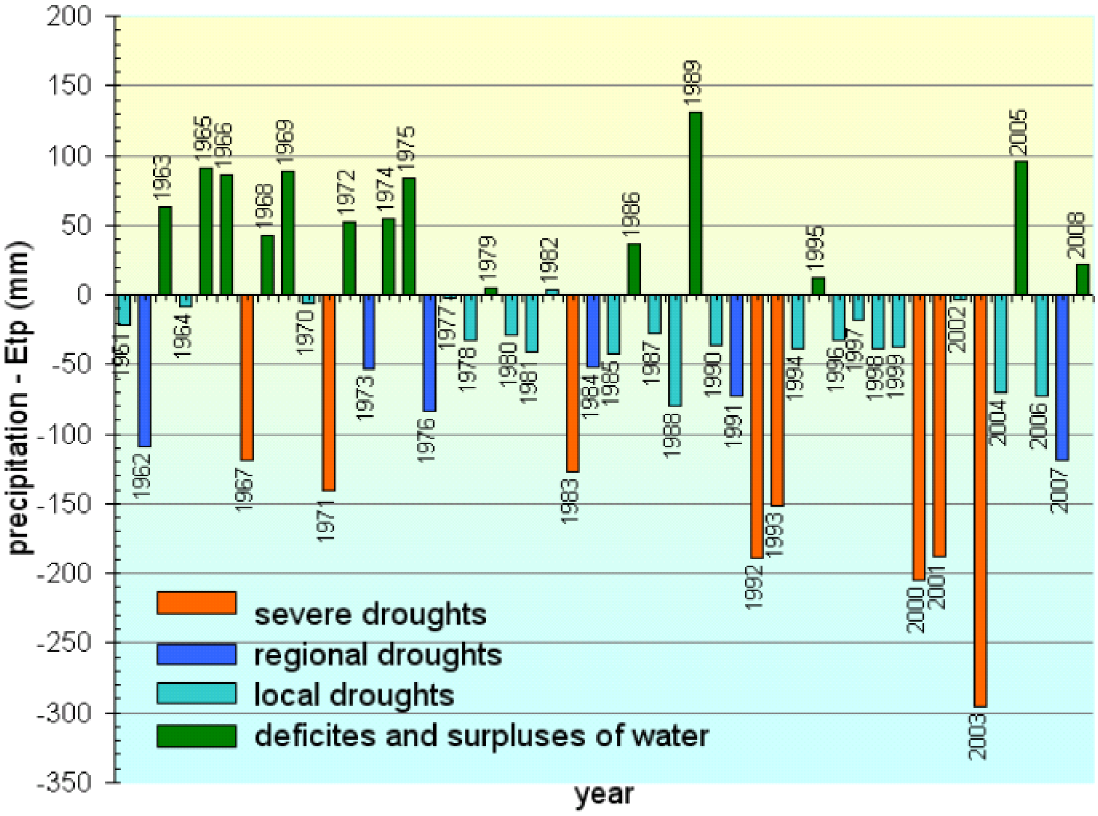


Fig. 2.1.3: Droughts in Slovenia during 1961 to 2008, based on the rate of water deficit in 8 main agricultural areas in Slovenia (modified from Sušnik and Kurnik, 2005).

2.1.2. Meteorological drought in Slovenia

Figure 2.1.4 represents spatial averages of Standard Precipitation Index (SPI) on time scales of 1, 3, 6 and 12 months. Several dry periods were recorded on all time scales. The most extreme drought conditions on a 3-months time scale were observed in January 1989, when precipitation was extremely low. Extreme drought events on shorter time scales also occurred in the years 1993, 1997 and 2003. Extreme drought events on longer time scales have occurred more frequently after 1990. The most extreme drought conditions occurred in 2003, which had a significant impact on agriculture and water resources in Slovenia. Severe and persistent drought events occurred also in 1993, 1997, 2001 and 2007. A negative and significant trend was observed from 1974 to 2010 for SPI on longer time scales. The mean duration of droughts was 5 months for SPI3 and 13.3 months for SPI12. Nevertheless, extended dry periods, identified by SPI3, were recorded between 1974 and 2010, with 9 consecutive months of drought conditions between February and October 2003 and between January and September 1993. 10 consecutive months with drought conditions were recorded between January and October in 2000.

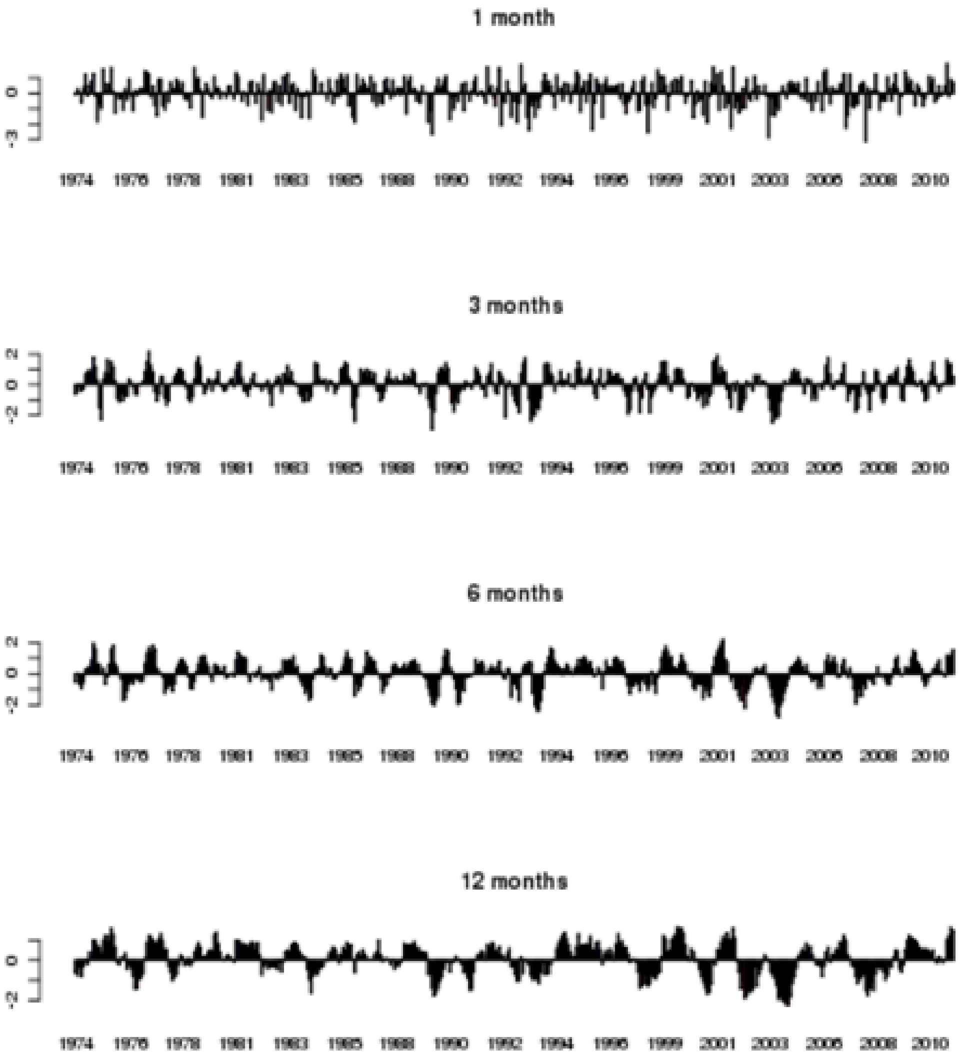


Fig. 2.1.4: Average 1-, 3-, 6- and 12-month SPI for Slovenia from the EDO, GPCC and Slovenian datasets

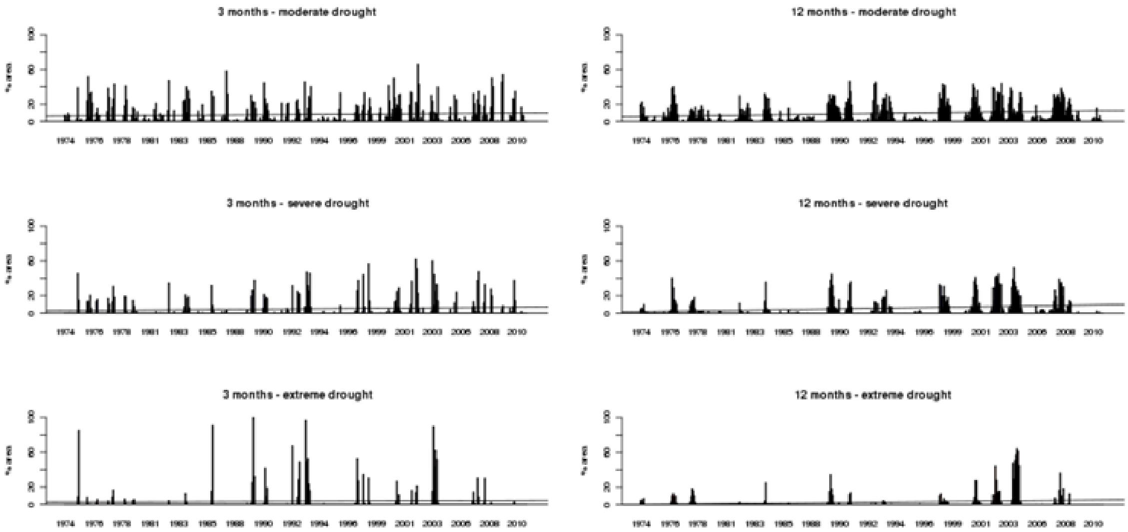


Fig. 2.1.5: The evolution of surface area affected by droughts on time scales of 3 and 12 months

The evolution of surface area affected by droughts on the time scales of 3 and 12 months is shown in Figure 2.1.5. For this purpose, three different thresholds have been used: SPI=-2 (representing extreme drought events), SPI= -1.5 (representing severe drought events) and SPI=-1 (representing moderate drought events). Extreme droughts on shorter time scales occurred more frequently after 1990. Almost the entire area has been affected by extreme drought conditions in 1989, 1993 and 2003. When considering agricultural drought on longer time scales, usually no more than 60% of area was affected, with the highest proportion in 2003 (Fig. 2.1.6). This observation indicates that drought intensity can be highly diverse spatially; while extreme droughts can be recorded in some areas, other areas may experience moderate or severe drought for the same period. The areas affected by droughts showed a significant increased sensitivity for severe and extreme drought on longer time scales (12 months), whereas no significant trend has been recorded for SPI on shorter time scales. This indicates that the negative and significant trend of SPI12 is driven by an increase in the intensity and frequency of severe and extreme drought events. If seasonal trends are considered, using SPI3, significant wetting can be observed for parts of northern and north-western Slovenia in the autumn, whereas the summers for parts of central and western Slovenia are drying. No significant trends can be observed for winter and spring.

Precipitation patterns are expected to change in the near future in Slovenia. Simulations from IPCC 5 climate model shows that precipitation could increase in winter but decrease in other seasons. Simulations of changes in daily precipitation intensity are more uncertain, but nevertheless indicate a slight increase in precipitation for the winter months.

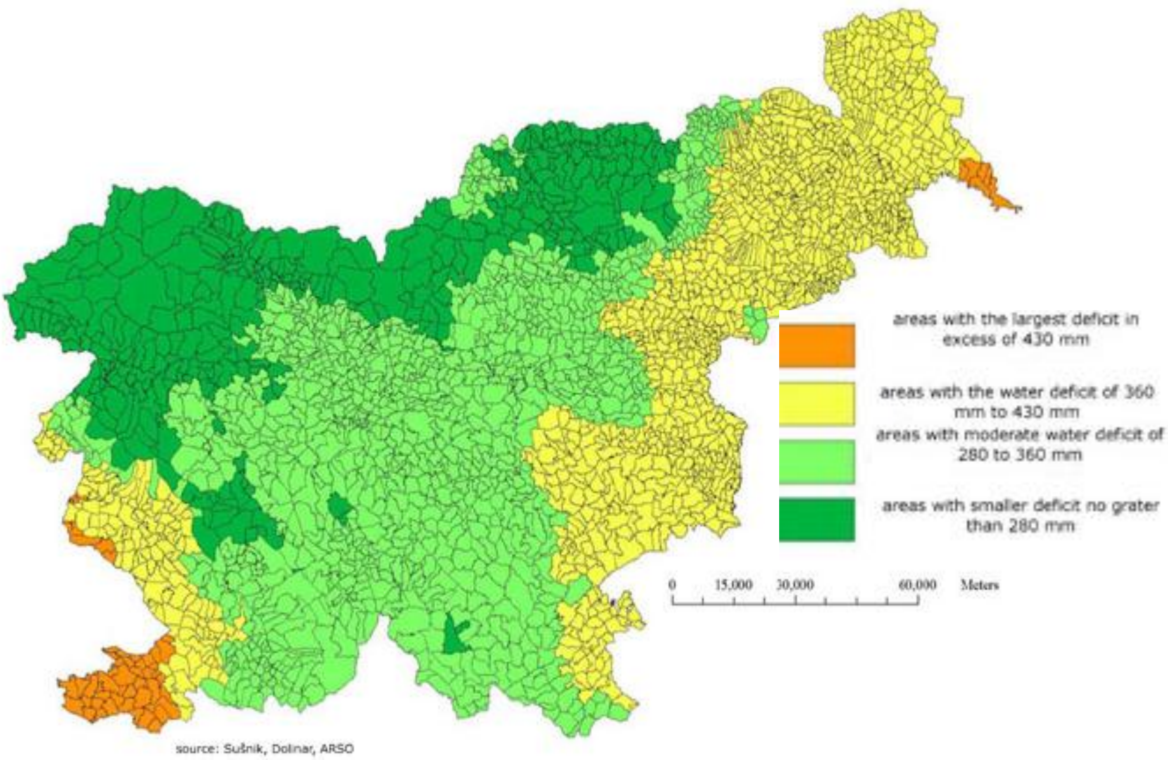


Fig. 2.1.6: Areas with agricultural drought in Slovenia in summer 2003
(Source: www.drought.si/index.php?page=map2003)

SPI has also been used to simulate meteorological drought conditions in future climate, using 1971-2000 as a reference period. The average duration and intensity of meteorological droughts in Slovenia is expected to increase (Figure 2.1.7). Most droughts are expected to occur in the summer.

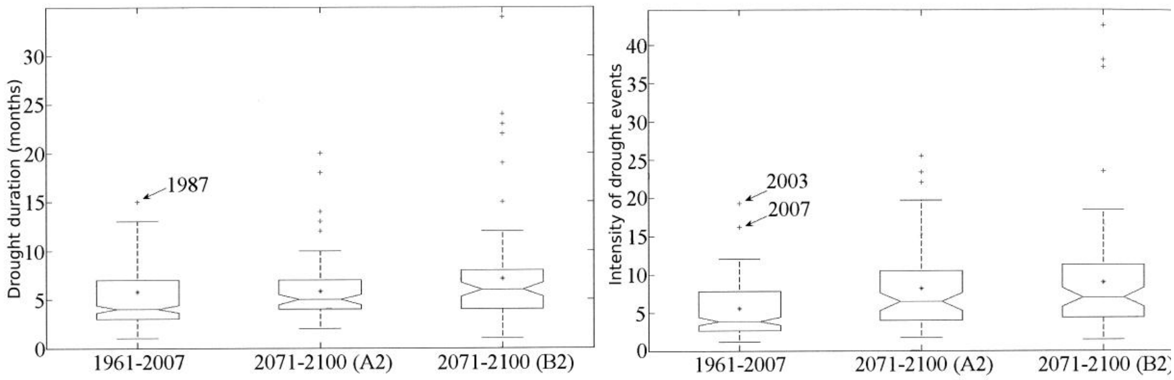


Fig. 2.1.7: Boxplots for drought duration (left) and intensity (right) in current and changed climatic conditions at the end of the 21st century. Climate model simulations of the PRUDENCE (PRUDENCE, 2008) project were used to calculate the SPI in changed climatic conditions, using scenarios A2 and B2.

As demonstrated by Fig. 2.1.3., Slovenia has experienced several summer droughts in the last 50 years, causing damage to agricultural production. However, there are only a few prevention programs aiming to reduce or eliminate the effects of drought in affected sectors. In the years when droughts has been particularly severe (2000, 2001, 2003, 2006 and 2007), the estimated agricultural losses were refunded to farmers by the Slovenian government. The Slovenian Court of Auditors estimates that these repayments resulted in a 26 times higher use of national financial sources. In this context, it is necessary to highlight that whereas the effects of drought occurrence on the agricultural sector in Slovenia are recognized, effects on the water level, groundwater table and biodiversity remain unknown.

The fundamental problems arise from a lack of an umbrella legislation to curb the effects of drought on affected sectors. This includes also unclear administrative and institutional competencies.

2.1.3. Literature

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2.2. Romania[6]

2.2.1. Mapping of droughts in Romania

Romania's climate is temperate-continental with varying influences: oceanic influences are present from the west, Mediterranean influences are coming from the southwest, and continental influences are present from the northeast. Average yearly temperatures are latitudinal different in the range of 8°C in the north and 11°C in the south, and also altitudinal variable with values of 2,6°C in the mountain areas and 11.7°C in the plain areas. Yearly rainfall decreases in intensity from west to east, from 800 mm in the northern Tisa Plain to 500-600 mm in the Romanian Plain, and to under 400 mm in Dobrogea (Mateescu et al., 2009).

Drought greatly affect the agricultural sector; 48 % of the agricultural area (14.717 thou. ha) is affected by drought, with areas in the South, South Eastern and Eastern parts of the country being most affected. The drought phenomenon, although without a strict cyclical pattern, generally shows repeatability at 15 to 25-year intervals. Within such cycles, there are extremely dry years, but also short-term interruptions of about 1-3 years with rainfalls above the normal amounts. These interruptions do not modify the general features of dry periods; water scarcity still characterizes the ground water resources, in the groundwater, and the surface hydrographic network. Average yields of various crops during dry cycles are only 35-60% of the potential yields.

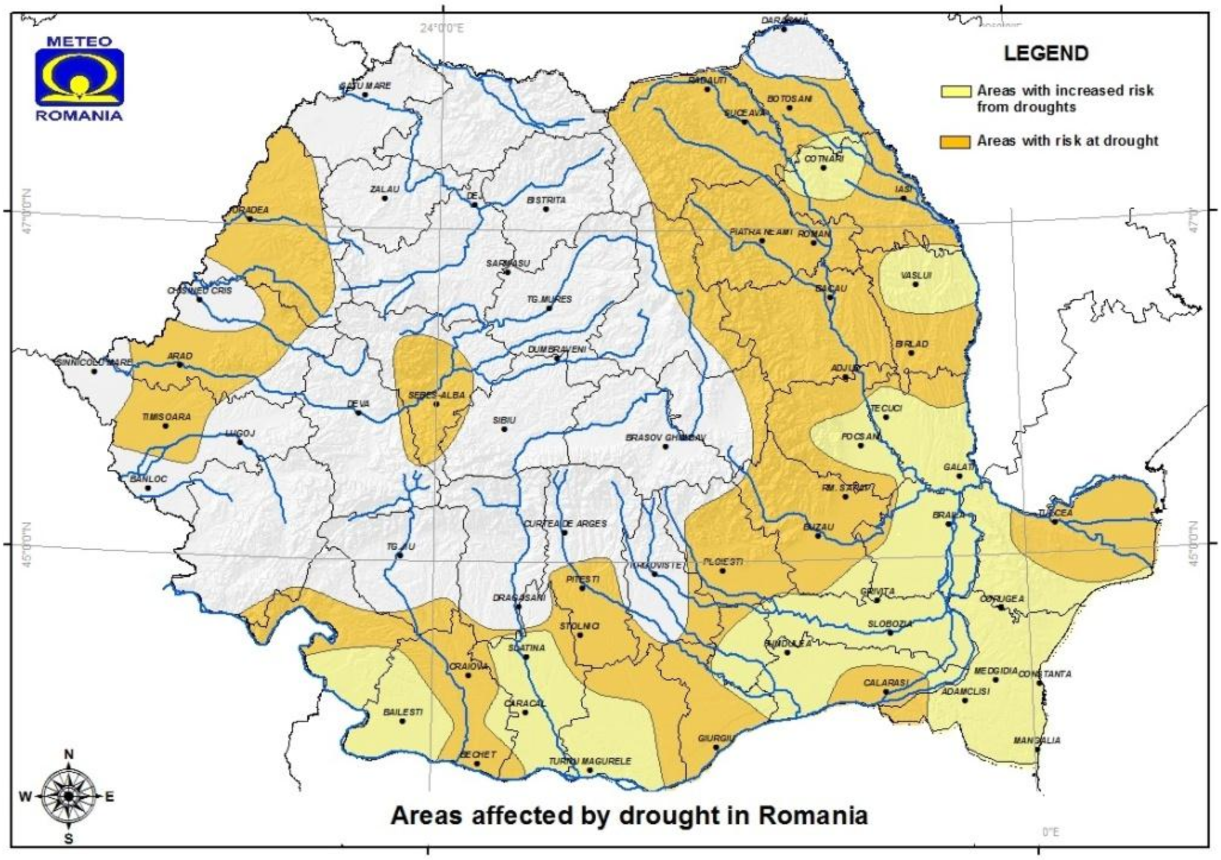

Fig. 2.2.1: Areas affected by drought in Romania

6 Prof. Dr. Elena Mateescu, Executive Director of National Meteorological Administration in Bucharest, Romania

In the past century, numerous episodes of extremely intense and extensive droughts were recorded (1907-1908, 1917-1918, 1923-1924, 1927-1928, 1934-1935, 1945-1946,1947-1948, 1949-1950, 1952-1953, 1982-1983, 1985-1986, 1987-1988, 1989-1990, 1992-1993, 1999-2000, 2000-2001, 2001-2002, 2002-2003, 2006-2007 and 2008-2009), severely impacting agricultural production (Sandu et al, 2009).

In the 1901-2010, air temperature rose by 0.6°C. In the past 20 years, the warmest year was 2007 (11.5°C) and the coldest year was 1985 (8.4°C). Examining decades, the trends of the mean multi-annual air temperatures over the 1961-2010 period, show that in the 2001-2010 interval, the air temperature rose by 0,4...0,6°C in comparison with every decade. The increasing trend is illustrated in Fig. 2.2.2.

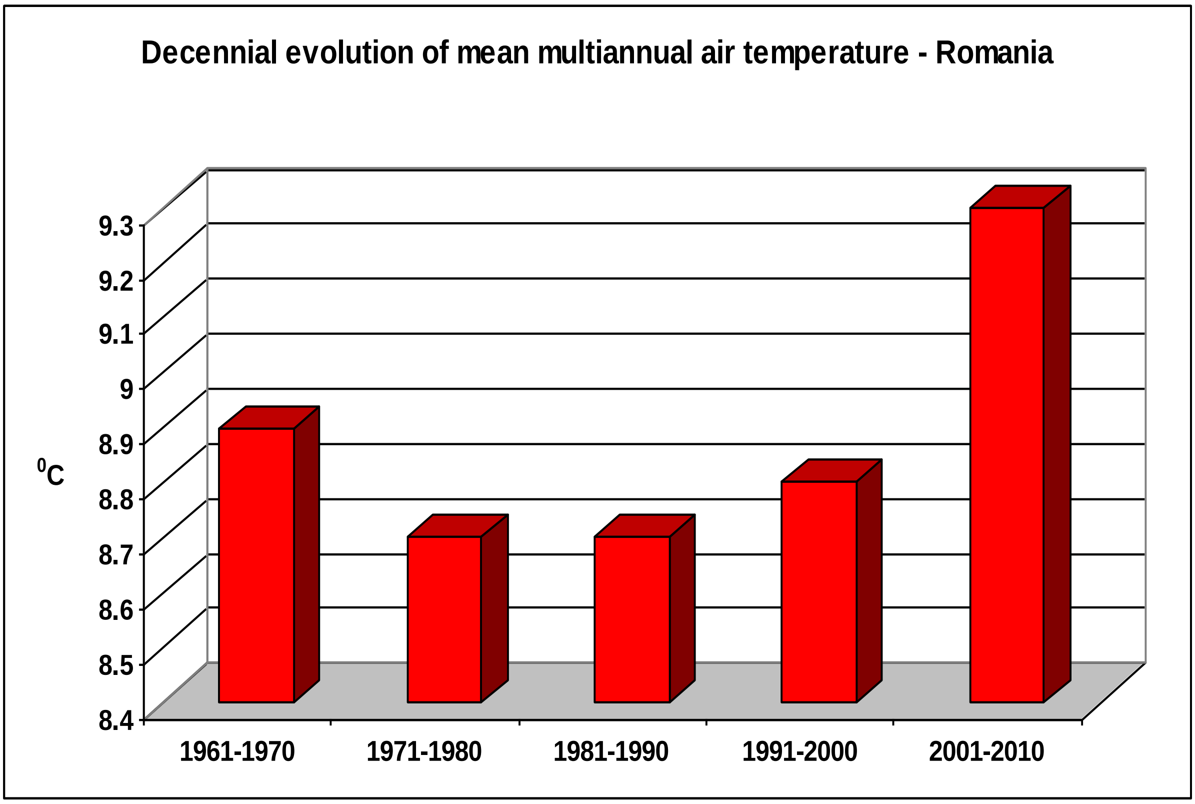

Fig. 2.2.2. Decennial evolution of mean multiannual air temperature – Romania

Tab. 2.2.1: Decennial evolution of the mean multi-annual air temperature recorded in Romania, over 1961-2010 period

Periods	Mean air temperature
1961-1971	8.9 / +0.4°C
1971-1980	8.7 / +0.6°C
1981-1990	8.7 / +0.6°C
1991-2000	8.8 / +0.5°C
2001-2010	9.3°C
2001-2010 / +0.4…+0.60C	

As indicated in Figure 2.2.3, the 1900-2008 period demonstrated a general decreasing trend in the annual precipitation amounts post 1961, and a parallel enhance of the precipitation deficit, especially in the south and south-east of the country.

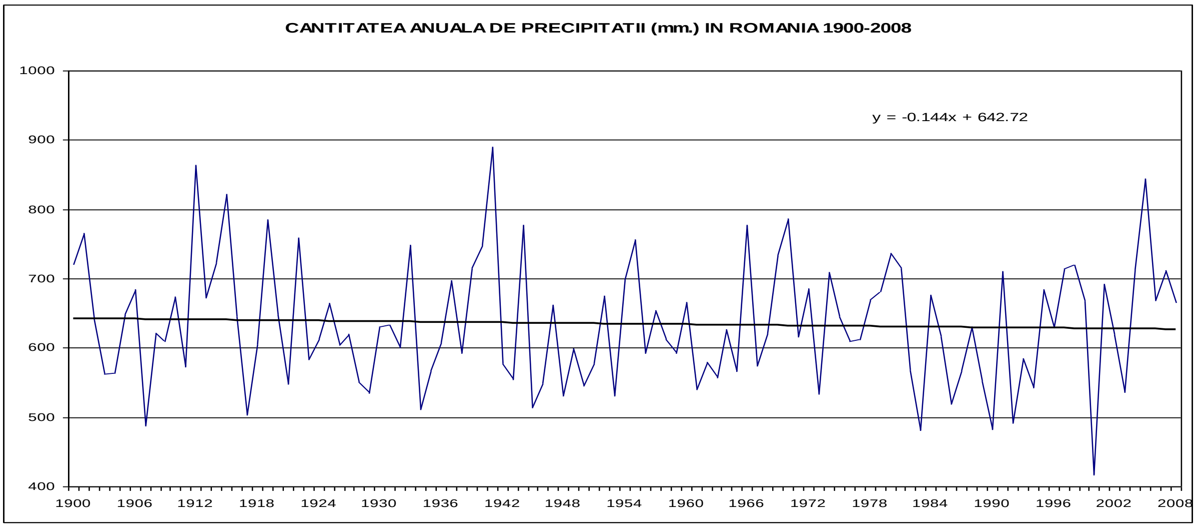

Fig. 2.2.3: Annual rainfall amounts trend in Romania, over 1901-2008 period

The development of these parameters presents an upward trend as regards to the thermic resources in comparison to the hydric ones. This expresses a natural thermic potential, richer than the hydric ones, implying that the water coming from precipitations is the limitative factor with negative effects upon field crops productivity.

During the period of 1961-2010, the most vulnerable agricultural areas with rainfall deficit are areas in the South, South-East and East of country, especially Dobrogea, Baragan, Moldova, South of Oltenia and South of Muntenia. In these areas, the annual precipitation for the 1961-2010 period is characterized by a high variability that impacted crop yields in the vegetation season (April – October).

BOX: CERES models

To evaluate the climate change impact upon maize and winter wheat, CERES models were run for current climate conditions (1961-1990) as well as for the 2020-2050 regional climate scenario-anticipated conditions, considering the direct effect of increased CO_2 concentrations (from 330 to 450 ppm) upon the photosynthesis processes. The results simulated under climate change conditions were compared to those obtained for the current climate. Thus, changes in yield levels and the length of vegetation period, as well as in cumulated precipitation and evapotranspiration during the vegetation season were quantified. The results help to identify agricultural measures and technological options that can improve effective use of water by crops. Two models CERES-Wheat and CERES-Maize simulate future climatic predictions at a very fine resolution (10 km) over 2020-2050. The models allow simulating crop management practices: application of irrigation, using different soil classes, and changes in sowing date.

Crop efficiency is strongly influenced by climate variability. Accurate diagnostics of the agro-meteorological conditions are crucial for understanding the risks caused by extreme weather events, for decision making, and for sustainable development measures. The Romanian agro-meteorological observation network provides weekly in-situ monitoring. Information is collected, processed and published in the Operational Bulletin that is disseminated to farmers for early-warning. During extremely dry years, this service enables monitoring of drought dynamics, and allows for assessment of the spatial extent as well as the intensity of the drought (Sandu et al, 2010).

Agriculture is strongly influenced by the availability of water. Climate change will modify rainfall, evaporation, runoff, and soil moisture storage. Both changes in total seasonal precipitation and changes in variability patterns are important. The occurrence of moisture stress during flowering, pollination, and grain-filling is harmful to most crops, particularly so to maize, soybeans, and wheat. Increased evaporation from the soil, and accelerated transpiration in the plants themselves, will cause moisture stress; as a result there will be a need to develop crop varieties with greater drought tolerance. The demand for irrigation water is projected to rise in a warmer climate (Mateescu et al, 2010).

2.2.2. Literature

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2.3. Bulgaria[7]

Bulgaria consists of a very diverse topography. Lowlands (0 to 200 m) cover 31.45% of the country, hills (200 to 600 m) 40.90%, highlands (600 to 1600 m) 25.13%, and mountains (over 1600m) 2.52%. The local and regional climate is heavily influenced by the latitude, altitude, topography, proximity of Black Sea and dominant atmospheric circulation. Bulgaria is located on the transition between two climatic zones – moderate continental and Mediterranean. Annual precipitation varies in these two zones. There are significant differences in the radiation balance in winter and summer, caused by the insulation at the country latitude. As a result, the thermal conditions are characterized by well-pronounced seasonality. The summer is warmer and the winter is relatively cold. The autumn is slightly warmer and drier than the spring. The seasonality is modified, to some extent, by the circulation conditions and the mountains' influence. The zonal extension of the Balkan Mountains and Rila-Rhodope mountain massif is a natural barrier for invasions of cold air masses towards the southern part of the country. These mountains are also obstacles for the warm air masses to overflow the mountains, and the foehn effect is observed over their northern slopes. The country is split into North and South Bulgaria by the Balkan Mountains, which have a strong effect on the temperature regime.

Annual precipitation in Bulgaria ranges from 550-600 mm in the lowest elevations in the country to 1000-1100 mm in the highest elevations (Fig. 2.3.1). The precipitation distribution in the country is mainly caused by the synoptic atmospheric conditions over Bulgaria, which are influenced considerably by topography. Insufficient precipitation is climatically common in some parts of Bulgaria. According to the Budyko drought coefficient, the country is characterized by insufficient moisture. This coefficient is calculated using data from the annual radiation balance and total annual precipitation (Budyko, 1989). The Budyko drought coefficient is between 1.5 and 1.8 for Bulgaria.

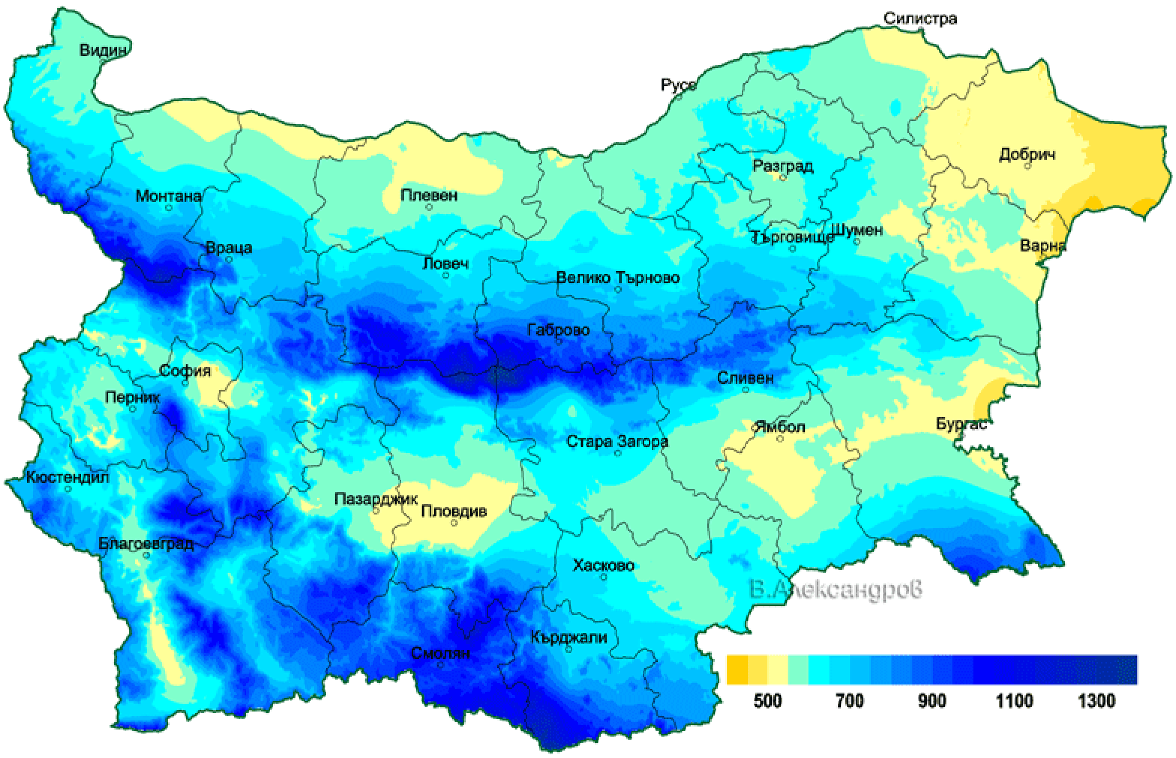


Fig. 2.3.1: Annual precipitation in Bulgaria, mm (Source: V. Alexandrov).

[7] Prof. Vesselin Alexandrov, Prof. Ivan Raev and Assoc. Prof. Galia Bardarska

2.3.1. Current climate trends and drought risks

A minimum value of annual average air temperature in the country occurred in the first decade during the last century. After that, average air temperature increased. In early 1940s, there was also a cold spell. A slight warming is observed from the middle of 1980s. The years 1994 and 2000 were among the warmest years on record in Bulgaria. Despite the slight increase in average air temperature during the last two decades (Fig. 2.3.2), there was no significant warming trend during the last century in Bulgaria. The linear trend for the 20th century varies within the interval from 0.2° to 0.5°C, which is lower than the predictions made by the IPCC (1998). This confirms that regional environments can deviate climatically from global trends. Although regional differences are relatively high, according to the IPCC (1998) most of Europe has experienced an average increases in air temperature of about 0.8°C in the 20th century. The increase has not been continuous throughout the century; at most stations, an increase to about 1940 was observed, followed by a levelling off or even a decrease until about 1970, and then a renewed warming to the present period. These features are most pronounced in middle to high latitudes. Some locations in southern Europe experience different trends, where some stations show a cooling trend. During the decade 1981-1990, warming over most of Europe has been exceptionally high, with increases in annual means of 0.25°-0.5°C with respect to the long-term average.

The average air temperature in the winter shows a positive trend – winters during the second half of the century are milder than before. There is a statistically significant trend in an air temperature increase during the winter season in the northern Danube stations during the two considered periods 1901-2000 and 1931-2000.

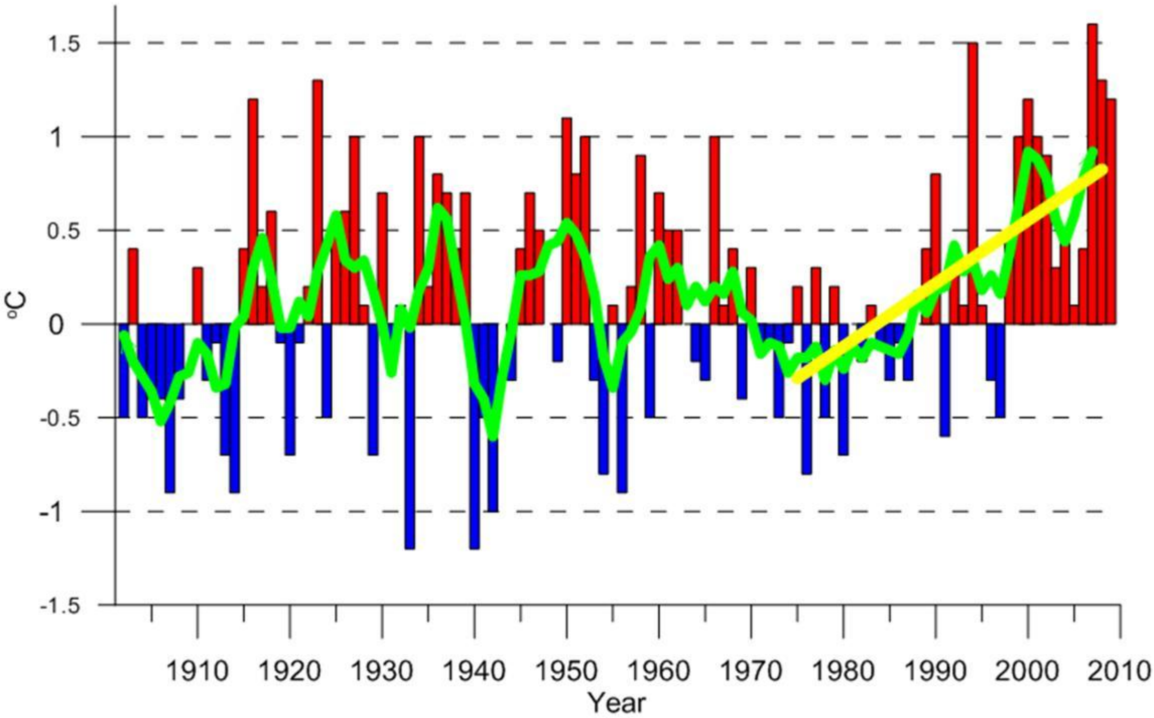


Fig. 2.3.2: Air temperature anomalies in Bulgaria compared with the basis period 1961-1990 (Source: Experts investigations).

Mean annual precipitation in Bulgaria varied considerably from year to year during the 20th century. In some years, very low annual precipitation caused droughts of different intensities. The country has experienced several drought episodes during the 20th century, most notably in the 1940s and 1980s (Fig. 2.3.3). The drought spells in the 1940s and 1980s were observed throughout the country. Drought in Bulgaria was most severe in 1945 and in 2000 where in the latter case, precipitation was

30% less than the current climatic values. In some weather stations, a significant wet spell occurred in the 1950s. This was followed by relatively high precipitation values in the 1960s and 1970s. Generally, the variations of annual precipitation in Bulgaria showed an overall decrease (Fig. 2.3.3).

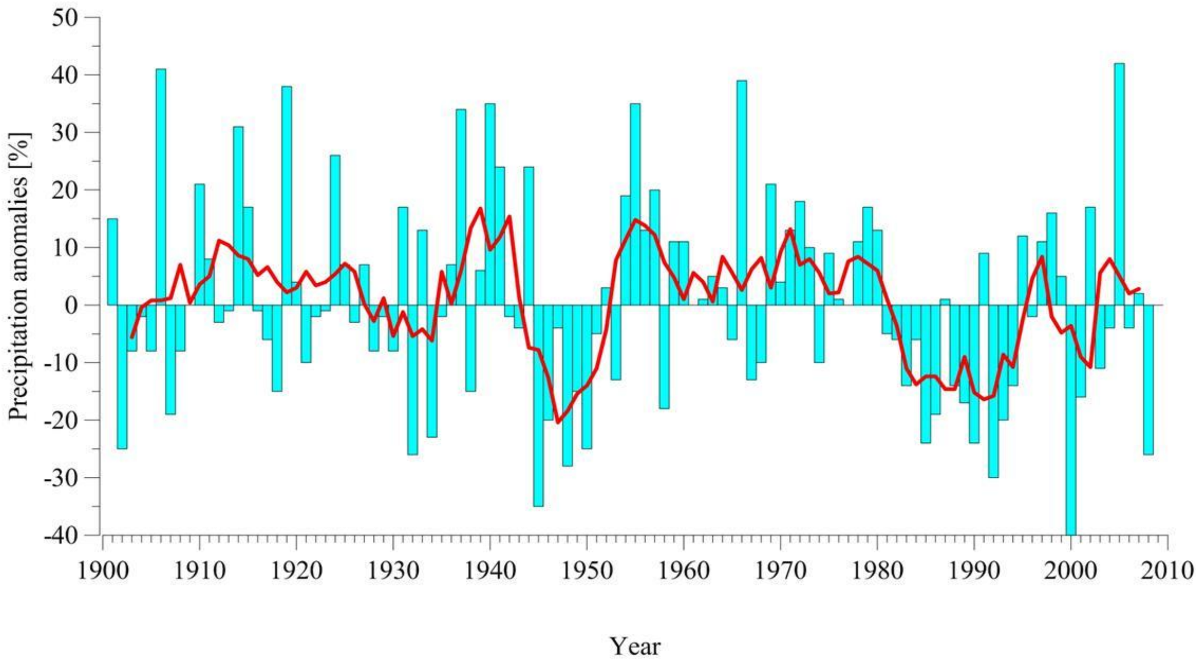


Fig. 2.3.3: Anomalies of the annual precipitation in Bulgaria compared with the period 1961-1990 (Source: Experts investigations).

In 2011, a period exceeding 60 days without rain was observed. This indicates an extremely hot year. Correspondingly, precipitation over Southern Bulgaria was considerably below the average at the end of the summer and in the beginning of the autumn 2011. This sustained dry period caused severe losses in the agricultural sector. It is expected, because of low soil moisture required for germination, that drought will negatively affect the growth and productivity of crops during the new agriculture season. The rivers' status was assessed to be in a crisis during this summer. The water levels of large rivers were reduced more than 75%. Parts of Southwest Bulgaria were endangered with water supply restrictions.

Drought is also related with fire activity in forest ecosystems which is one of the main threats for its composition, structure and functioning. The analysis on the fire situation in Bulgarian forests for the last 30 years show a sharp increase in the number of fires, and in the size of burned down areas after 1989. The peak years in relation to forest fires (1993, 2000 and 2007) were undoubtedly a result of drought. The burnt out areas with forest stands in Bulgaria for the period 1999-2008 is 124 451 ha.

In previous years, the frequency of extreme meteorological and climate phenomenon has increased. The annual amplitude between the maximal and minimal air temperatures decreases – the minimal temperature increases faster than the maximal. At the end of last century, the thickness of snow cover showed a tendency of decreasing. The upper border of the broad-leaved forests is moving to higher altitudes. Furthermore, there is tendency for increasing shortage of water in the soils due to increased water evaporation from the soil surface and through transpiration from the vegetation. The risk by air drought increased (Fig. 2.3.4).

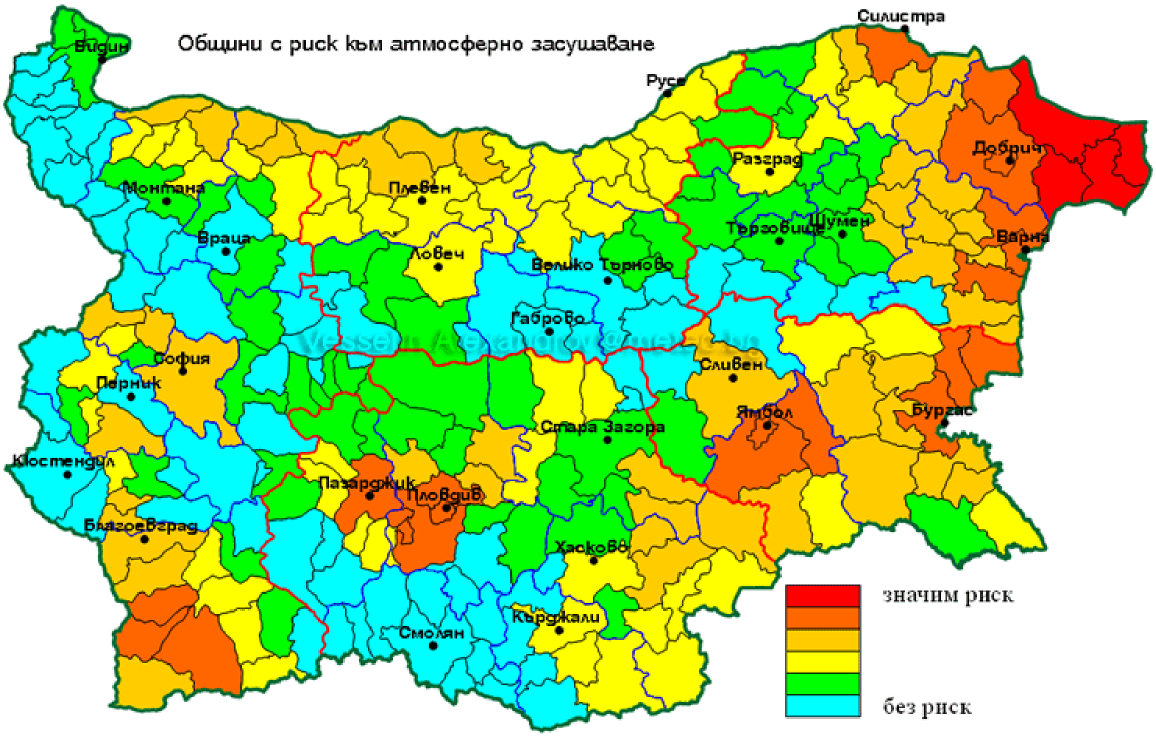


Fig. 2.3.4: Municipalities with risk by air drought

Without risk *- Snow;* ***Low*** *- Fires likely to be self extinguishing and new ignitions unlikely. Any existing fires limited to smouldering in deep, drier layers;* ***Moderate*** *- Creeping or gentle surface fires. Fires easily contained by ground crews with pumps and hand tools;* ***High*** *- Moderate to vigorous surface fire with intermittent crown involvement. Challenging for ground crews to handle, heavy equipment (bulldozers, tanker trucks, aircraft) often required to contain fire;* ***Very High*** *- High intensity fire with partial to full crown involvement. Head fire conditions beyond the ability of ground crews; air attack with retardant required to effectively attack fire's head; and* ***Extreme*** *- Fast spreading, high intensity crown fire. Very difficult to control. Suppression actions limited to flanks, with only indirect actions possible against the fire's head. Source: Vesselin Alexandrov.*

Three major periods during the 20th century are characterized by long and severe droughts, namely 1902-1913, 1942-1953 and 1982-1994. During the first period, the drought years were approximately 20% of the total number of years. On the other hand, they increased to 40% during the second period and to approximately 50% during the last period 1982-1994. Another characteristic of the last period is that years with above normal precipitation were not observed in South Bulgaria. Average precipitation in the Danube plain was about 560 mm and it was 540 mm in the Tracian lowland. Precipitation during the period May-September was 280 and 230 mm, respectively. The coefficient of variation (CV) in the two regions was about 0.25-0.35, which shows insignificant moisture resources or a dry climate.

The driest year during the study period of the 20th century (1901-1996) was 1945. Other particularly dry years were 1902, 1907, 1932, 1934, 1946, 1948, 1950, 1953, 1985, 1986, 1990, 1992 and 1993. It is important to remark that there are some differences in the classification of dry years, regarding the regions of North and South Bulgaria.

Particular years, months or subsequent months with insignificant precipitation, i.e. periods of atmospheric drought, are not uncommon; they can be considered a normal climate characteristic in Bulgaria. Climatically, about two subsequent dry months occur in the lower areas of the country. However, some years experience six or more subsequent dry months. Long dry periods during the cold-half of the year were observed in 1913, 1934 1967, 1976 and 1983. Similar periods during the summer occurred in 1928, 1945, 1965 and 1985.

2.3.2. Climatic Characteristics of Drought

Drought in Bulgaria is characterized by different features during the different seasons in the year. The spring drought is characterized by normal air temperatures, low air humidity and strong winds. These weather conditions affect the environment for crop sowing, germination and initial development. The delay of the crop germination affects the crop growth and development during the entire crop-growing season. The pest population under drought conditions increases considerably and damages the agricultural crops. The spring droughts are especially typical in Northwest Bulgaria (40% of the spring drought cases) and at the coastal region of the Black Sea.

The summer drought brings high air temperatures, low air humidity and intensive transpiration. The summer drought is a typical soil-atmospheric drought, especially when available soil moisture in the top 1 m decreases less than 70% of the available capacity. The agricultural crops fade and stop their growth. They are becoming yellow and dry when soil moisture decreases considerably. The agricultural crops are especially damaged when the summer drought is combined with dry winds. The intensive summer droughts are longest at the Black Seas coast and in the Thracian lowland.

The spring agricultural crops are harvested in the autumn. The autumn drought, however, affects the tillage, crop sowing, germination of the winter crops. This is why the winter crops are not well developed and can easily be damaged by frost. The autumn drought is typical for the Black Sea coast, Northeast Bulgaria and the Thracian lowland.

The long-term variations of the basic meteorological elements in Bulgaria have been studied for a long time. Special attention has been paid to precipitation sums and the average annual and seasonal air temperature. For that purpose, data from the weather stations with the longest time series in the country has been used. There are some weather stations in the country with available weather data for more than 100 years. The long-term variations of the non-growing (November-March) period, potential crop-growing (April-September) and actual growing seasons of winter crops (October-June) and spring crops (April-September) have been also studied. A special attention has been also paid to the dry periods without precipitation. There are several studies available that assess the long term variations of air temperature and precipitation relationships (Ganev and Krastanov (1949, 1951)). Another study carried out by Sabeva (1968) concentrated on the dry periods between 1896 and 1960. The study confirmed the relation between the number of the drought periods and the precipitation sums. Some of the more recent studies are concerned with the long-term variations of annual precipitation in different regions and also seasonal precipitation for the period May-September. There is a clear decreasing trend of precipitation at the end of the 20th century. The last 20 years were drier and warmer than normal for the period of the so called “current climate” (1961-1990) (Koleva et al., 1996). Annual precipitation was approximately 80-85% less than normal, and the winters were especially dry. Air temperature in January was higher than the current climatic value. July precipitation was close to normal, but air temperature was above the normal for the current climate. Similar drought conditions during the 20th century were also observed from 1945 to 1953 (Koleva, 1995). Fig. 2.3.5 presents the variability of annual precipitation in the mountain area of Bulgaria. A well expressed decrease in recent years is easily seen.

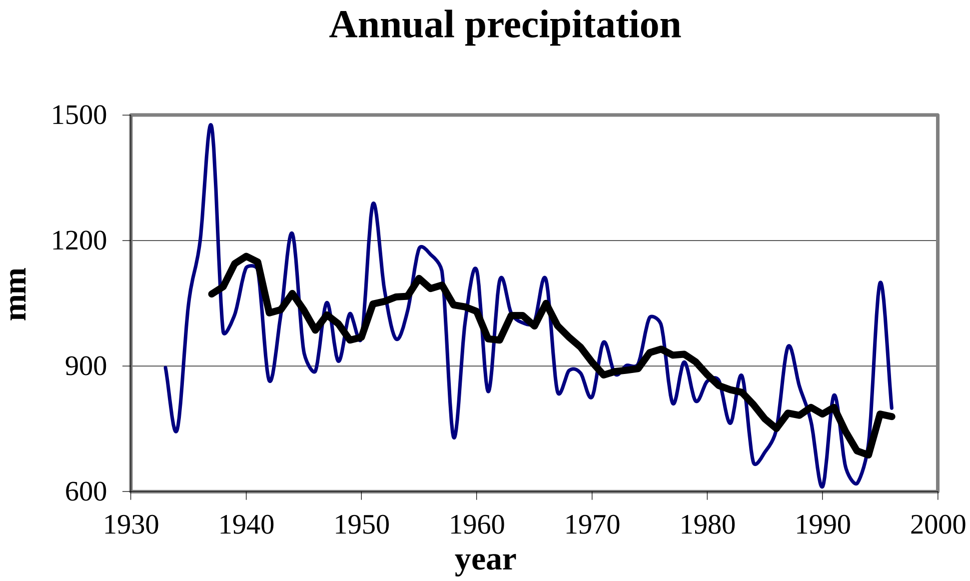
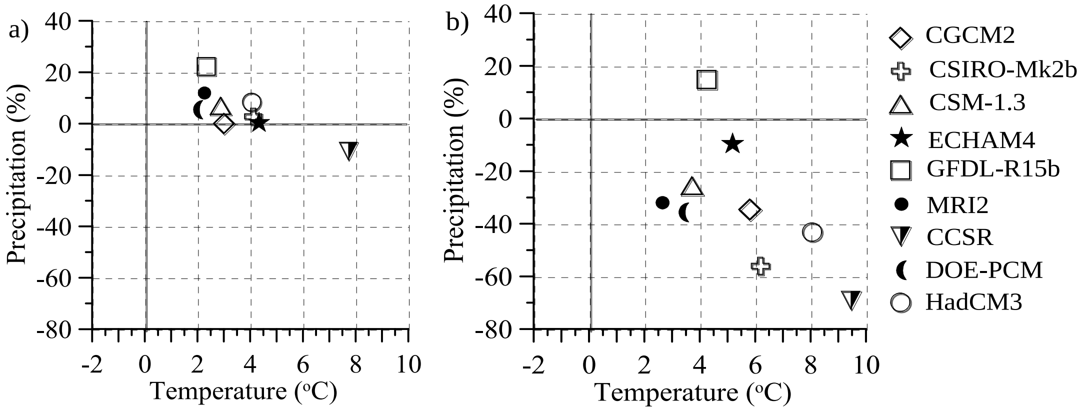


Fig. 2.3.5: Variation of annual precipitation (thin line) and its 10-years moving average (dark line) for mountain area

2.3.3. Climate change scenarios

Although several uncertainties in relation to future precipitation exist, most climate models, show slight increases in precipitation during the winter and precipitation reductions during the summer in the region of the Balkan Peninsula. The same GCMs shown in Fig. 2.3.6 indicate similar trends of mean air temperature and precipitation for Bulgaria at the end of the 21st century. The highest increase of air temperature in the country is simulated by CCSR model. Precipitation is expected to increase up to 20% during the winter season. However, it is projected to decrease significantly during the summer season. The only GCM (among the others provided by the Tyndall Centre) which simulates an increase in precipitation during the summer season is the US GFDL-R15b model.



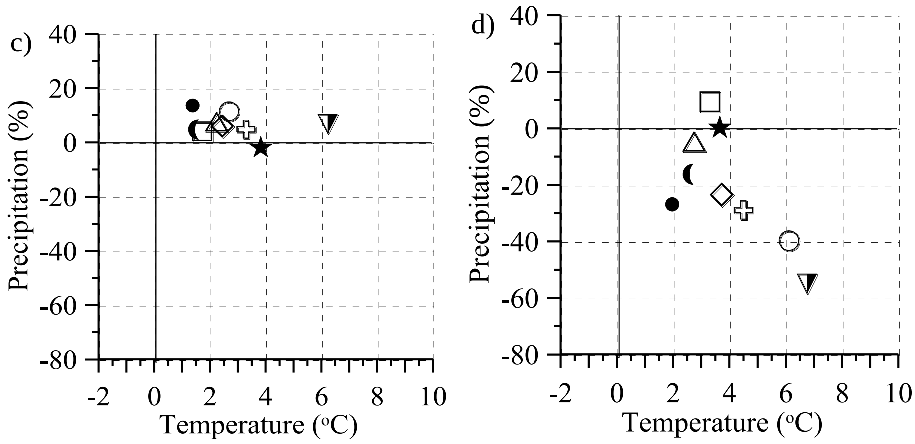


Fig.2.3.6: GCM climate change scenarios for air temperature and precipitation during winter (ŕ,c) and summer (b,d) in Bulgaria at the end of the 21st century, relative to 1961-1990 under two IPCC SRES emission scenarios (A2: a,b; B2: c,d)

The GCMs predicts that annual mean air temperatures in Bulgaria is to rise between 0.7° (HadCM2) and 1.8°C (GFDL-R15) in the 2020s. However, the HadCM2 model simulated a slight decrease in air temperature for November in the 2020s. A warmer climate is also predicted for the 2050s and 2080s, with an annual temperature increase ranging from 1.6°C (HadCM2) to 3.1°C (GFDL-R15) in the 2050s, and 2.9°C (HadCM2 and CGCM1 models) to 4.1°C (ECHAM4) in the 2080s. Warming is projected to be higher during the summer in the 2080s.

The CGCM1 model predicted an increase in annual precipitation in the 2020s and 2050s. The GFDL-R15 model projected a decrease in precipitation in May, June and July in the 2020s and 2050s. The ECHAM4, HadCM2, and CSIRO-Mk2b models simulated a decrease in monthly, seasonal and annual precipitation in the 2080s. The changes in monthly solar radiation are expected to vary between -10 and 10 % during the next century. An increase of solar radiation is expected during the cold half of the year, based on the ECHAM4 model runs.

HadCM3 climate change scenarios were also created for every used weather station from selected areas in Bulgaria. Fig. 2.3.7 shows the monthly climate values of air temperature and precipitation in Novachene (north Bulgaria) under the HaDCM3 climate change scenarios for the years 2020, 2050 and 2080. It could be seen that the newer HadCM3 model simulates higher increases for monthly air temperature in comparison to the previous HadCM2 ones. Even air temperatures in July and August in 2080 are projected to be near 8şC higher than air temperatures, relative to the period 1961-1990.Simulated HadCM3 precipitation has a similar direction for the 21st century as for the HadCM2 and ECHAM4 models – a decreasing one. Monthly precipitation in Novachene from May to September is projected to be about 50 % reduced in 2080. Only precipitation in February and March as well as December is expected to increase during the 21st century.

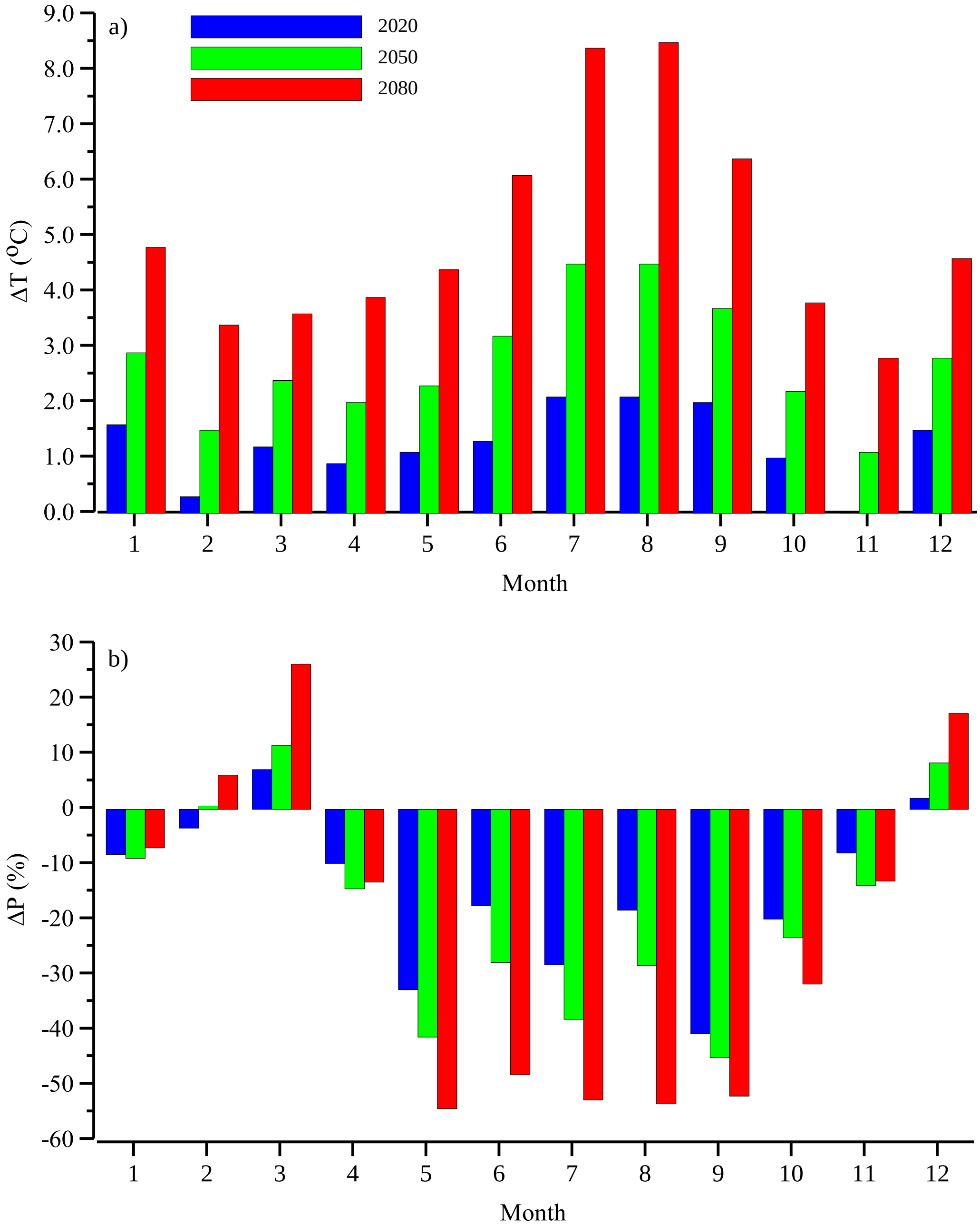


Fig.2.3.7: Monthly climate values of air temperature (a) and precipitation (b) in Novachene (north Bulgaria) under the HaDCM3 climate change scenarios for 2020, 2050 and 2080.

2.3.4. Literature

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2.4. Hungary[8]

Hungary is a flat country. Despite of this, a significant spatial variability has evolved between the meteorological and climatic environment of different regions. Around the Carpathian basin, one of the worlds most closed basins; the climate is determined by interaction from three sources: the oceanic, the Mediterranean and the continental. In Hungary, 72 % of the land is used for agricultural purposes, a figure significantly higher than the rest of Europe. Of this land, only 2 % can be irrigated, resulting in significant economic loss (30-60% yield loss), in the face of the frequent droughts. Damage from drought takes many forms, both direct and indirect. Identifying and monitoring the consequences of the aridification process is very important in preventing and mitigating drought damage. Regarding the relative frequency and strength of Hungarian droughts, Pálfai (2010), among others, assembled a 300 years long data series, using 30-year class width. The most remarkable droughts occurred between 1983 and 2009.

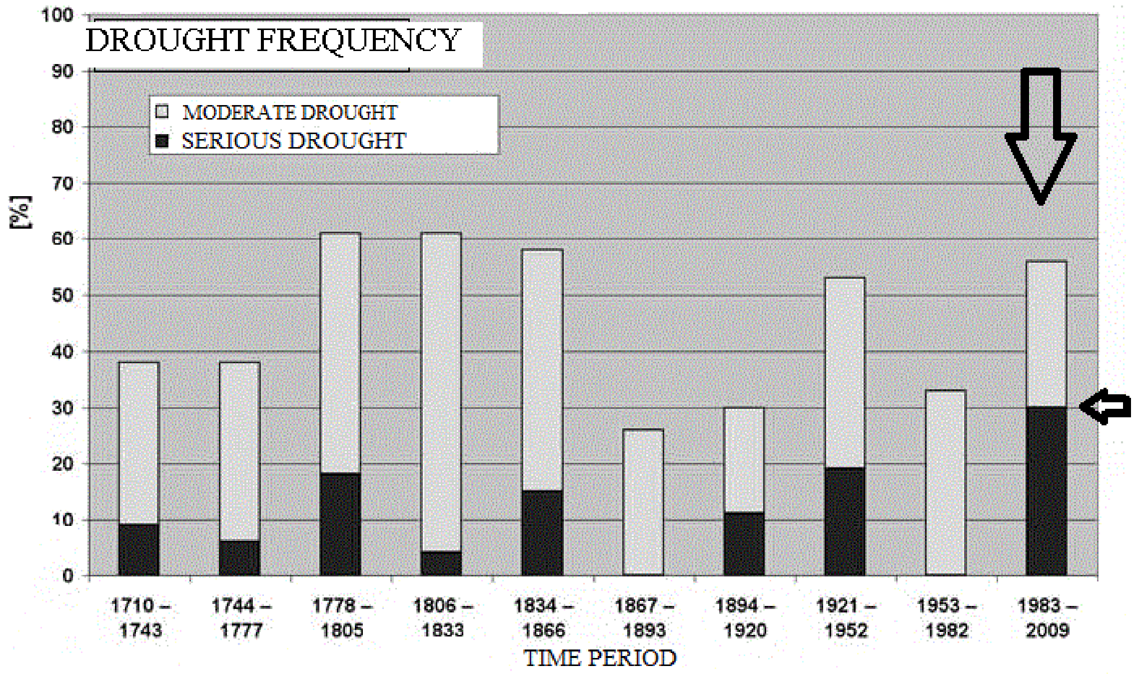

Fig. 2.4.1: Drought frequency in Hungary based on 300 years long period Source: Pálfay, (2010)

According to the Hungarian Meteorological Service's measurements (recorded from 1901), the value and intensity of precipitation are the most variable meteorological data. During the 107 years (1901-2008), the annual amount of precipitation has decreased by 7%. In the Fig 2.4.2, the anomaly of the Hungarian precipitation amount is presented based on the 1971-2000 time period.

[8] Prof. Janos Tamas, University of Debrecen, Hungary

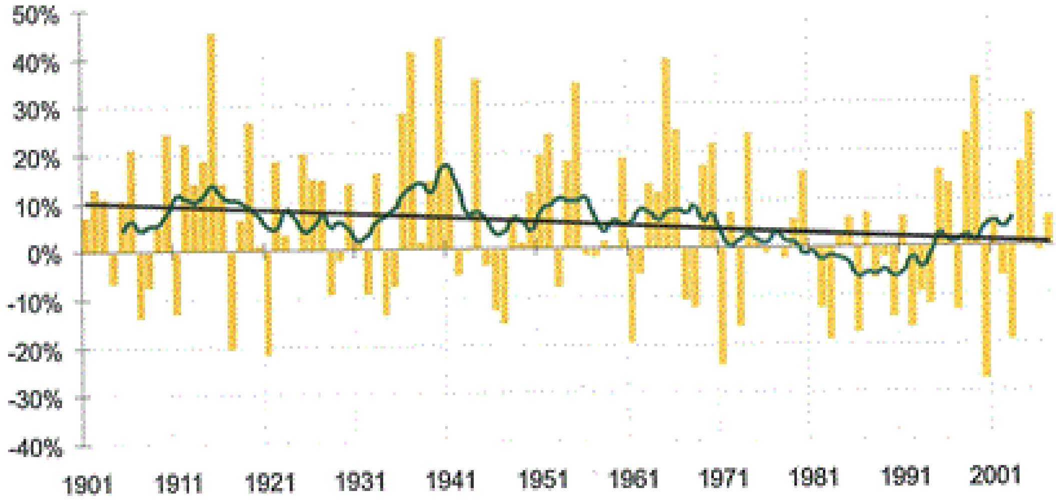

Fig. 2.4.2: The anomalies (%) of Hungarian averages of the annual amount of precipitation with 10-year moving average (green) and linear trend (yellow), 1901-2007. Source: Bihari and Szalai (2008)

Statistically, the biggest precipitation decrease occurs in the spring season. The spatial and/or time variability are scale-dependent, and increase with the detailed ground resolution. The total number of days when the intensity of precipitation is very low (<1mm/d) has increased in the last two decades, which resulted in that the length of the annual maximal dry period becomes longer. Moreover, the risk increases for heavy storm events and flash floods.

Also, the temperature shows unambiguous increase in Hungary, both annually and seasonally. The biggest seasonal increase can be seen in the summer season. While the increase of the annual average temperature was 0.86°C between 1901 and 2007, the warming of summers exceeded the 1°C as presented by the figure below.

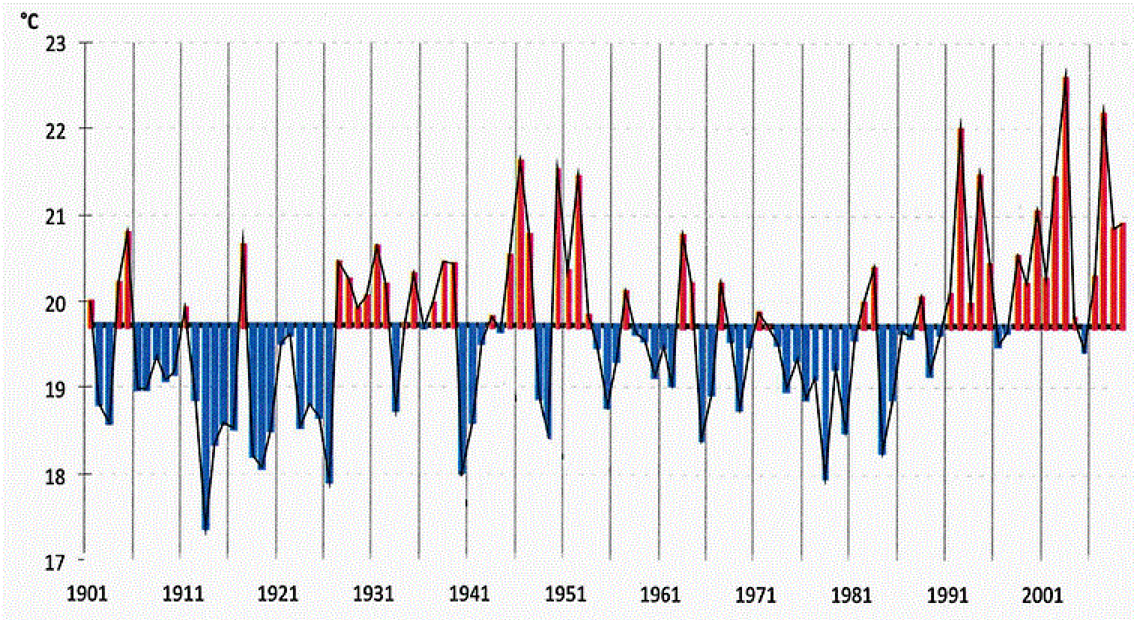

Fig. 2.4.3: Hungarian average of the summer temperature differences (1901-2009); Source: OMSZ, (2009)

The figure below shows the time series of the Palmer-index (PDSI). As shown in the graph, both the wettest and the driest months experience relative water scarcity (Debrecen city), which is indicated by the decrease of the value of their PDSI-index.

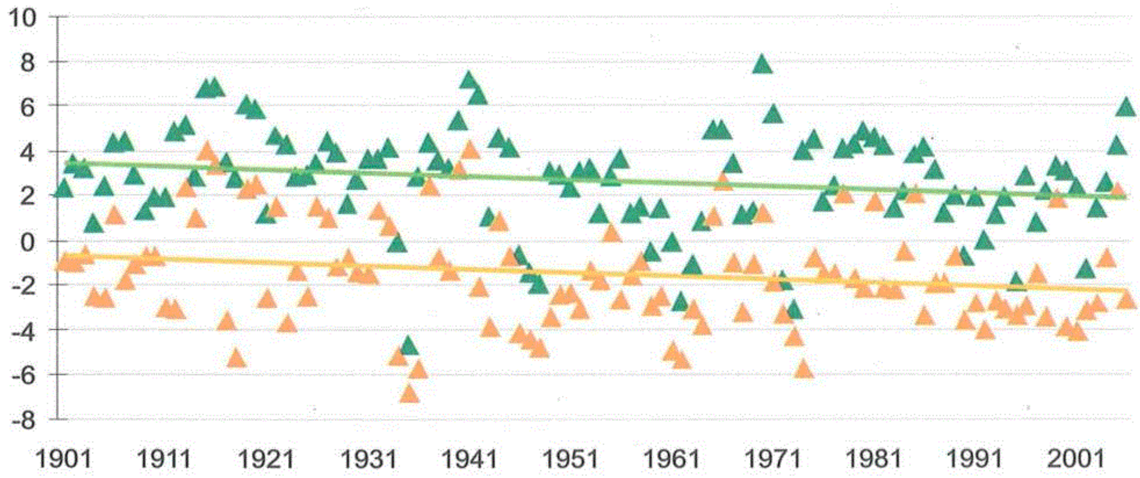

Fig. 2.4.4: Annual maximum and annual minimum values of the Palmer-index (PDSI) (1906-2001), Debrecen city, Hungary; Source: Bihari et al. (2008)

In Hungary, the drought risk is also significantly influenced by other environmental factors. Intensive ground water pumping in the central part of the country has resulted in a decrease of the average ground water level by 15-20 m in the past decade. Heavy clay, sandy soil and salt-effected (solonetz) soils which cover almost 50% of the total agricultural arable land also lead to the significant drought problems in Hungary.

The map of complex drought risk evaluation is presented in Fig. 2.4.5 permanent drought risk is observed in the Hungarian Great Plain, which is the largest agricultural area.

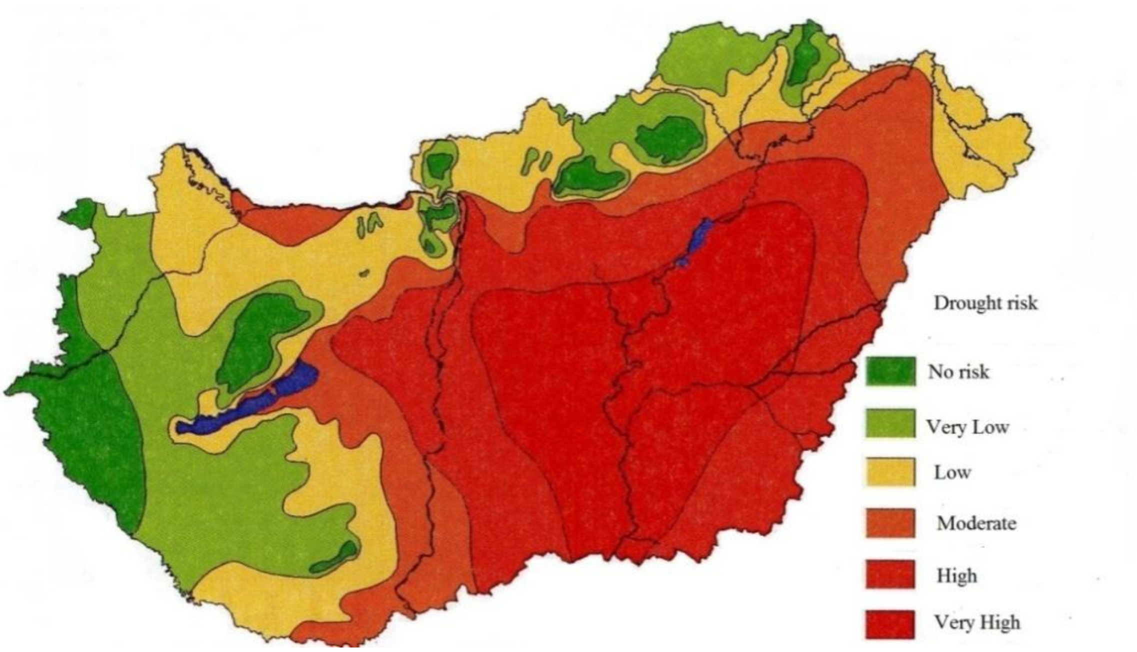

Fig. 2.4.5: Drought risk zones of Hungary based on Pálfai Drought Index

2.4.1. Literature

Bihari, Z., Lakatos, M., Szalai, S. (ed., 2008) Climatic change in Hungary(In Hungarian: Magyarország éghajlatáról) OMSZ - Hungarian Meteorology Service, Budapest, Hungary.

OMSZ (2009) Climate and drought in Hungary (In Hungarian: Magyarország éghajlata és az aszály). Hungarian Meteorology Service, Budapest, Hungary.

Pálfai, I. (2010) Climatic changes and agricultural water management (In Hungarian: Éghajlatváltozás és mezőgazdasági vízgazdálkodás) Hidrológiai Tájékoztató, Budapest, ISSN 0439-0954, pp.41-44.

2.5. Ukraine

2.5.1. Climate situation in Ukraine[9]

Ukraine's climate is influenced by its southern location and by the interaction of atmospheric circulation form three sources: the oceanic, the Mediterranean and the continental.

For a long time, the intrusion of hot masses from the Middle Asia was considered to be the main cause of droughts in Ukraine. However, this hypothesis has been proven wrong because the average atmospheric pressure near the land surface in Ukraine decreases during the summer months from north-west to south-east. As winds blow in the direction of higher to lower pressure, the transfer of hot mass from the Middle Asia to Ukraine is not significant (Buchinsky, 1970).

The main reason for drought formation in Ukraine has instead been traced to the intrusion of cold air from the north, north-west or west and formation of huge anti-cyclone behind the cold front. It furthermore involves some slow moving anti-cyclones. Together, they create favourable conditions for heating of the soil, and consequently air heating. Sub-sequent anti-cyclones create conditions where the drought starts threatening the vegetation. Although some days with cold weather can occur between them, this is not sufficient to saturate soil with moisture.

The dry cold air, coming from the Arctic does not contain enough moisture. Advancing into the south, the air is gradually heated up and becomes even drier. This atmospheric circulation determines the distribution of radiation balance over the territory of Ukraine. This is commensurable with the balances observed in tropical and equatorial latitudes and consists of 20-38 kcal/m^2 for a season. In June, for example, radiation balance is changing from 7.5 up to 9.0-kcal/m^2 for a month. The maximum radiation balance in the summer is observed in Sought Steppe, where it can reach 10.0 kcal/m^2 for a month.

The Khersonska and Crimea peninsula regions are facing the greatest drought risk. The droughts are commonly accompanied by hot winds when relative air moisture can decrease to 7-15%, while temperature can rise up to +40şC. The average number of days with hot winds is shown in Fig. 2.5.1. In these instances, dry winds, usually from the east, occur in Ukraine in July and August, (Buchinsky, 1970).

[9] P. Kovalenko, L. Filipenko, O. Zhovtonog (2008), Peculiarities of droughts mitigation and forming in Ukraine, Institute of Hydraulic Engineering and Land Reclamation of Ukrainian Academy of Agrarian Science

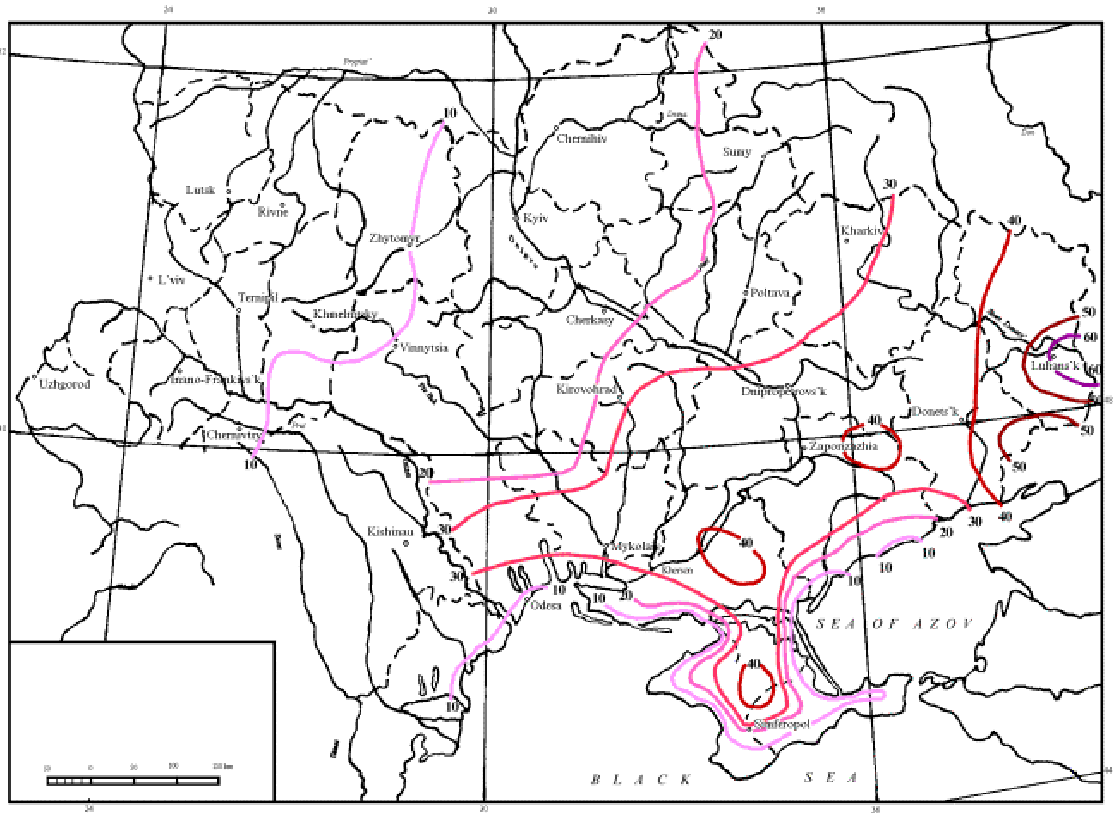

Fig.2.5.1: Average number of days with hot winds in Ukraine (Konstantinov et al., 1966)

2.5.2. Droughts in Ukraine[10]

The southern areas of Ukraine suffer from permanent moisture deficiency and severe droughts are common. The annual precipitation in these areas is often barely sufficient to sustaining agricultural production, thus, in drought years; water scarcity becomes an acute issue. Soil moisture deficit during the growing season for receiving optimum top moisture in the central and southern regions is 50-100 and 150-200 mm, respectively.

Droughts are inherent to the climate of Ukraine. However, they often bring damage to the areas of Steppe and Forest-Steppe. These areas are the zones with the most favourable soil-climatic conditions for agriculture development. The risk posed to the national economy caused by droughts is aggravated by the frequency of drought occurrence.

In the past three decades, droughts have increased, both in frequency and intensity. Moreover, there is a dangerous trend of droughts distribution over territory which earlier belonged to a zone of sufficient moisture. Drought-related crop losses are estimated to 50% of the yield. The contributing of climatic changes to fluctuations of crop productivity makes up: for winter crops 20-50 %, for summer 35-75%. In combination with anthropogenic factors, an increase in drought occurrence and intensity lead to land degradation and desertification. In addition, due to unfavourable economic situation, the irrigated area of Ukraine keeps being reduced.

By 2008, droughts have started to appear even in the zone of Polesye, as an obvious manifestation of climate change. Droughts even occurred in years with normal precipitation leading to crops shortages. Fig. 2.5.2 shows 0.5-1.5 t/ha crop reduction in drought 2003 compared to non-drought

[10] T. Adamenko and A. Prokopenko (2009), Monitoring Droughts and Impacts on Crop Yield in Ukraine from Weather and Satellite Data, Ukrainian Hydrometeorological Centre, Kyiv, Ukraine, in F. Kogan et al. (eds.), Use of Satellite and In-Situ Data to Improve Sustainability, Proceedings of NATO ARW “Science for Peace and Security Series C: Environmental Security”.

year of 2008. Fig. 2.5.3 shows that in dry years during 1990-2008, winter wheat yield reduced 2-3 times compared to non-dry years.

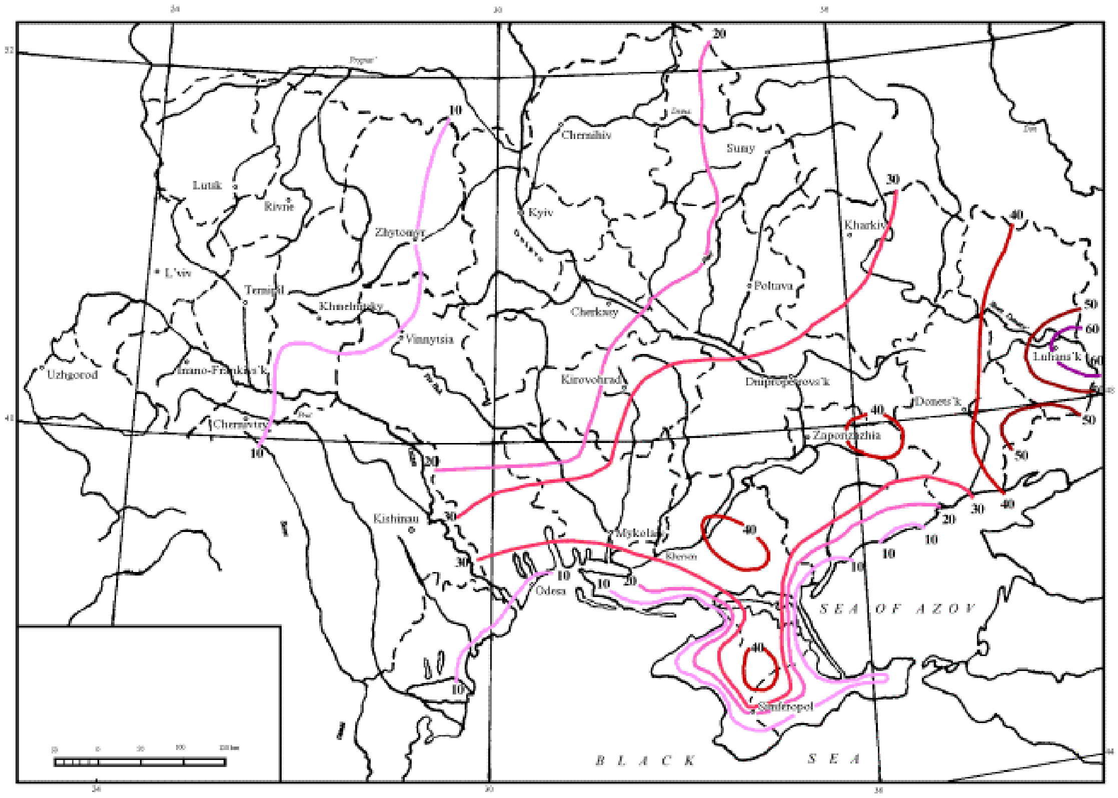

Fig. 2.5.2: Crop yields in dry (2003) and non-dry (2008) years in Ukraine

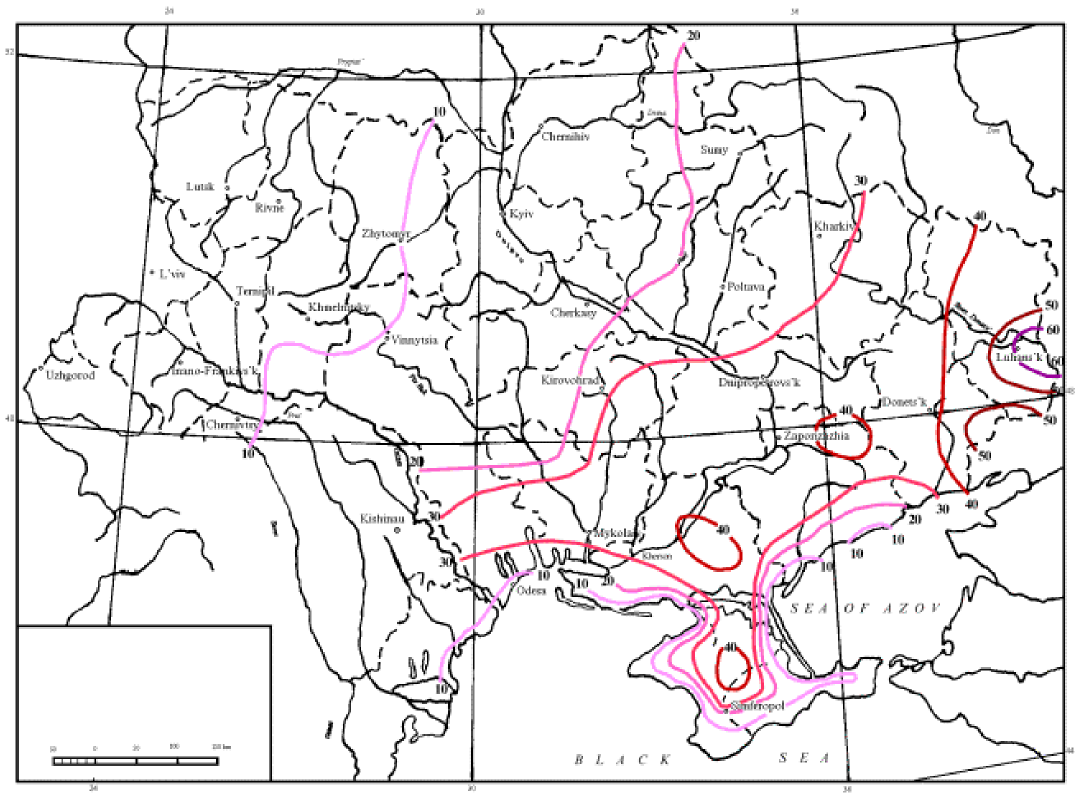

Fig. 2.5.3: Average Ukrainian winter wheat yield

Under conditions of insufficient natural moisture, only irrigation can prevent losses in agricultural production. Potential increases in yields at observation of optimal irrigation regime and other requirements of agro-techniques comprise 200-250%, and in separate dry years it could be higher.

2.5.3. Literature

Buchinsky I.E. (1970). The droughts, hot winds and dust storms in Ukraine and their control. Urozhay, Kyiv, 234 p.

Konstantinov A.R., Sakali L.I., Gojsa N.I., Olejnik R.N. (1966). Thermal and water conditions of Ukraine, Gidrometizdat, Leningrad, p. 591

2.6. Slovakia[11]

In the past, the issues of droughts, desertification and soil and land degradation are only gradually being brought to the attention of the public. This is due to the fact that in Slovakia, the occasions of droughts has not been a significant problem. The impact of drought in the agricultural sector was moderated by irrigations.

A significant increase of air temperature of 1.4°C in 1951-2009 and 1.7°C in 1881-2009 was recorded in Slovakia. The mean precipitation has remained relatively unchanged 1881-2009. Contrastingly, the mean relative air humidity decreased in 1901-2009 by about 6% in southern Slovakia and less in higher altitudes. Changes in solar radiation balance variables were insignificant in the period 1951-2009.

These developments have resulted in a serious increase of E_o (potential evapotranspiration sums calculated by the Budyko method) since 1951 (by about 17% in the South and by about 10% in the North). Generally, an increase in E_o results in a higher demands for soil moisture. Low precipitation in the years 1975-1993 resulted in a significant decrease of soil moisture and E sums as well. On the other hand, higher E_o sums in time of low precipitation resulted in significant runoff decrease in northern Slovakia.

In 1994-2010, Slovakia was subjected to both serious droughts (2000, 2002, 2003, 2006, 2007, 2008 and 2009), and severe flooding events (1997, 1998, 2002, 2006 and 2010). Models, accounting for trends until the year 2100, demonstrate that with an increase of average air temperature of 3°C, and small change in average relative air humidity and precipitation, both duration and severity of droughts will increase by about 18%. These changes will mainly occur in connection with anticyclone weather types. Furthermore, these cyclonic weather events will carry a 30 % higher precipitation than to similar events in the past (1901-1990).The autumn of 2011 was the second driest since 1881. Despite this, the drought caused relatively little economic damage as it commenced only by the end of the agricultural production season.

According to studies, global warming will impact individual regions of Slovakia differently, although the effects will generally be negative. Commonly in southern Slovakia, summers will be dryer and hotter with an increase in heavy rain and thunderstorms. The effects of these changes can be countered by shifting some of the agricultural production in these southern areas to northern regions where conditions may be more favourable. Global warming may impact annual precipitation, causing periods of excessive precipitation (floods) and periods of insufficient precipitation (water scarcity). Moreover, less snow will fall, affecting the water balance in the spring and early summer, causing a significantly reduced water level. General decrease of snow cover days is expected in higher mountain regions (above 900 m a.s.l.).

[11] Elaborated by Dr. Jana Poórová, RNDr. Pavol Faško, Dr. Olga Majerčáková, RNDr. Peter Škoda, Ms. Lívia Lešková – Slovak Hydrometeorological Institute Bratislava, Prof. Milan Lapin, Comenius University, Bratislava. Compilation and editing by Eng. Milan Matuška, GWP CEE Secretariat and Dr. Peter Rončák, GWP Slovakia

2.7. Poland[12]

Poland is situated in a transitory temperate climate zone. Droughts in Poland have a character of atmospheric anomaly, following the rainless period. A lack of precipitation over a large area that lasts for a longer period of time forms the first phase of drought: meteorological drought. Scarcity of water resources propagates through the subsurface part of the hydrological cycle, causing the second phase: soil drought. Finally, groundwater recharge reduction evolves into the third phase: hydrological drought. This phase cause decrease of groundwater heads, groundwater discharges, as well decline of stream flow (Dębski, 1970; Maidment, 1993).

It is commonly assumed that droughts in Poland appear every 4-5 years (Lorenc, 2006). Observation of droughts in Poland territory goes back to 14th century. In the 19th century, the numbers of droughts were estimated to 23 whereas for the 20th century, it has been estimated to 20. The detailed analysis of historical drought intensity in Poland was done within the framework of KLIMAT project. The measure of drought intensity was performed indirectly by assuming drought extension. Usually, the bigger spatial drought extension meant longer drought duration and intensity. Table 2.7.1 summarises frequency of droughts, assuming three levels of drought intensity: 1-local, 2-regional and 3-national drought extension since 1501.

Tab. 2.7.1: Occurrence and intensities of historical droughts from 1500-1900 on the territory of Poland

Period	Drought intensity class		
	I	II	III
1501 - 1550	2	6	5
1551 - 1600	3	10	7
1601 - 1650	1	10	2
1651 - 1700	0	9	10
1701 - 1750	4	12	3
1751 - 1800	0	4	2
1801 - 1850	16	6	8
1851 - 1900	0	7	5
Total	**26**	**64**	**43**

Within the period of 1951-2000 there were several droughts and dry periods, affecting a great part of Poland. The research (Farat et al., 1995; Dubicki at al., 2002) recognized atmospheric droughts in the following years: 1951, 1953, 1954, 1959, 1963, 1964, 1969, 1976, 1982, 1983, 1989, 1992 and 1994.

Regular measurements of meteorological and hydrological parameters allowed for more detailed analysis of spatial extent, intensity and duration of droughts. For the period of 1966-2005, based on long-term daily measurements, meteorological and hydrological drought phases were recognized and characterized. The most severe droughts were the ones in 2002-2003 and 2005-2006 (and quite recently a drought in 2011).

The Fig 2.7.1 presents temporal variation of monthly Standard Precipitation Index (SPI) values for March estimated from more than 100 precipitation stations within the period 1970-2005. The other months of extreme precipitation deficit were July 1994, October 2005, and September 1982 with around 60% of the stations of SPI below 1.5. The bigger the percentages of stations having negative SPI values, the greater drought intensities were noted.

[12] Dr. Tamara Tokarczyk and Dr. Wiwiana Szalińska, Institute of Meteorology and Water Management in Warsaw, Poland

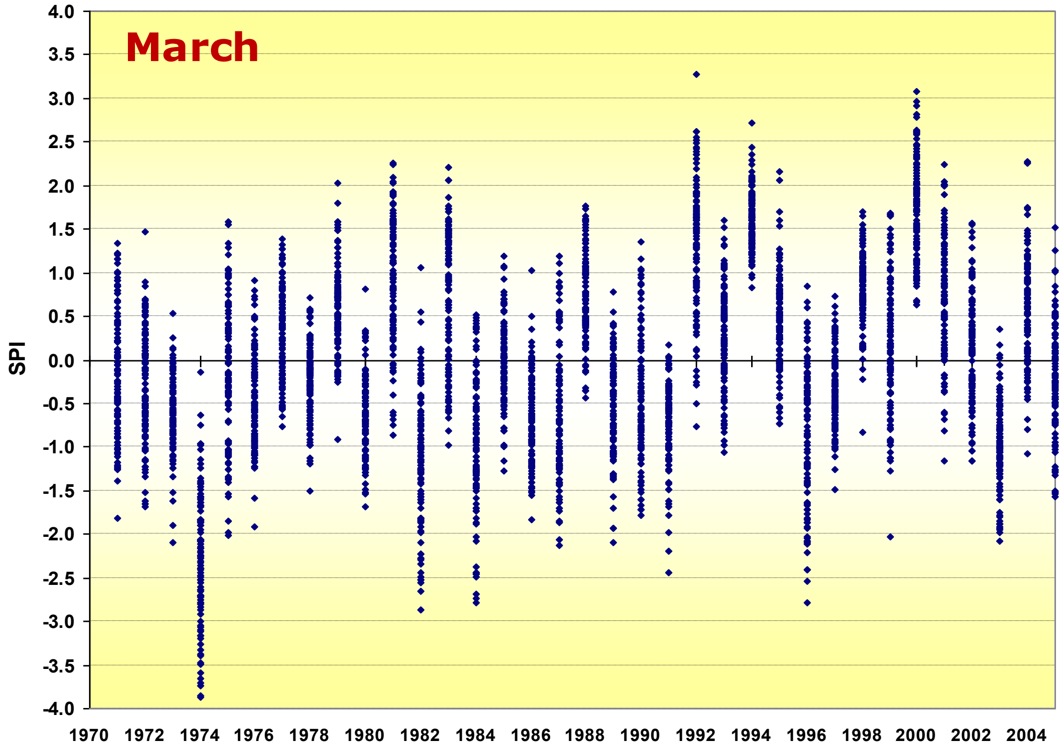

Fig. 2.7.1: Temporal variation of SPI values for the month of March observed on 107 precipitation stations within the period of 1970-2005 for the selected meteorological stations from the territory of Poland.

Spatial extent of extreme meteorological droughts within the period 1970-2005 is presented as spatial distribution obtained by interpolation of SPI values. Fig. 2.7.2 presents the situation for April 1974 which was one of the months with the most severe meteorological droughts.

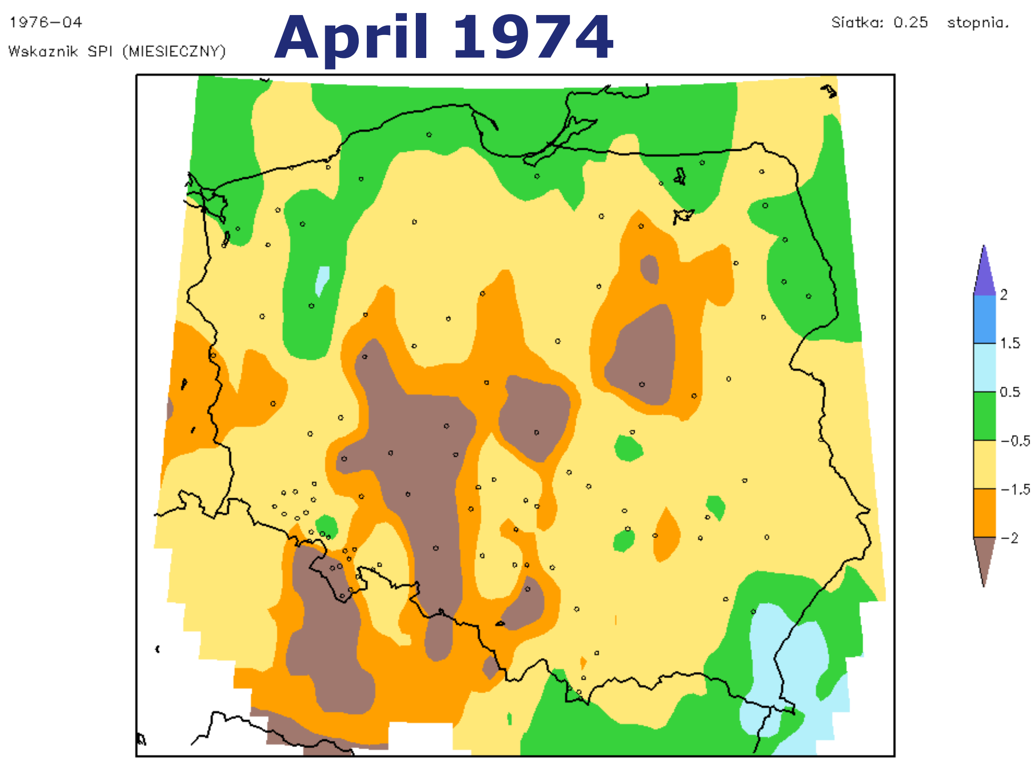

Fig. 2.7.2: Spatial distribution of drought intensity according to SPI values.

Hydrological drought is usually interpreted as low stream flows. In order to assess the intensity of hydrological drought, a value of maximal water deficit observed within the period of 1966-2005 was used as a reference to analyze the other drought events. The biggest values of water deficit were found for: 1969-1970, 1983-1984, 1990-1993 and 2003. There were also the ones of the longest durations from 114 days (in the Wieprz River) to 963 days (in the Przemsza River).

Fig. 2.7.3 presents the spatial distribution of water deficit and duration of hydrological droughts observed 1966-2005. The most intensive droughts were the one observed in 1992. For the area of lowlands and the northern part of Poland it was the most intensive drought in this period. The other intensive ones were in 1983 of the maximal water deficit in Nysa Klodzka catchments. Also intensive and regionally extensive drought was observed in 2003. Droughts in 1982, 1993 an 2000 were very intensive locally. Similarly, the duration of observed droughts was the biggest in 1992 and 1983.

Droughts with two phases of drought formation: meteorological drought evolving to hydrological one were recognized for the years: 1969, 1982-1983, 1989, 1992, 1993, 1994, 2000 and 2002.

Occurrence and intensity of droughts observed in Poland have severe economical, social and environmental impacts. Primary droughts in Poland constitute an important risk factor for agriculture. Difficulties in operational planning and undertaking proper actions for mitigating drought effects arise from the unpredictability and irregularity of drought occurrence.

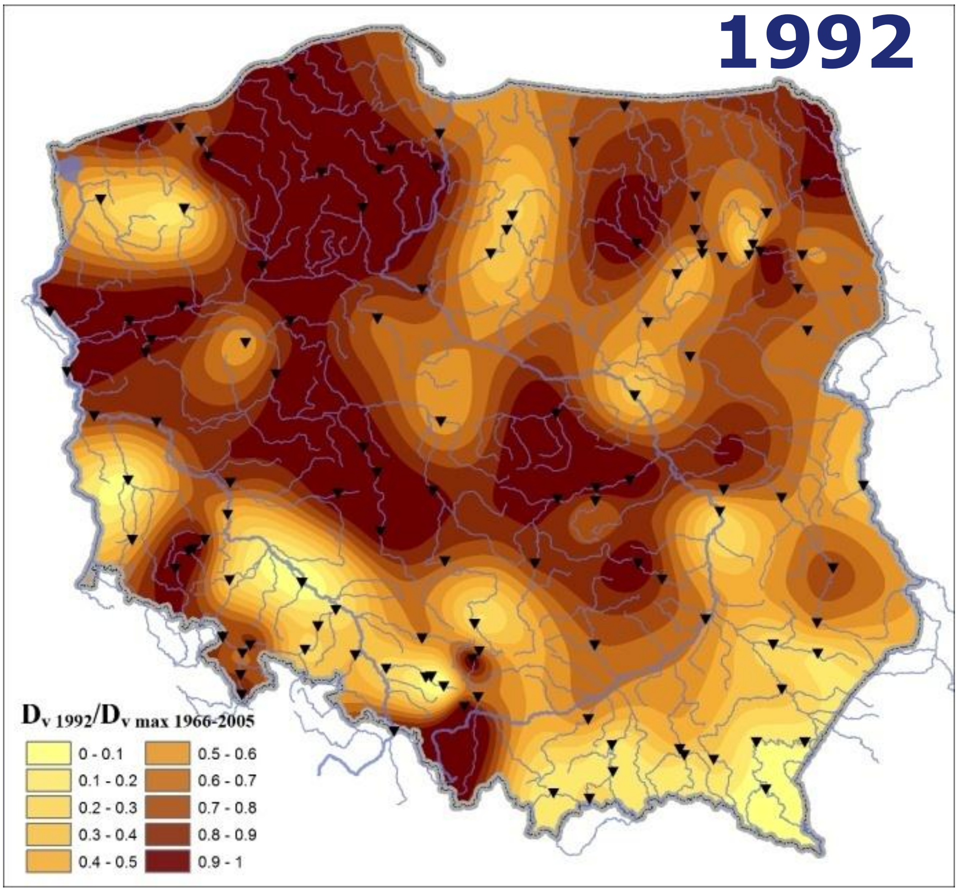

Fig. 2.7.3: Spatial distribution of water deficit in year 1992 when Poland experienced the most extensive hydrological drought over the years 1951-2005

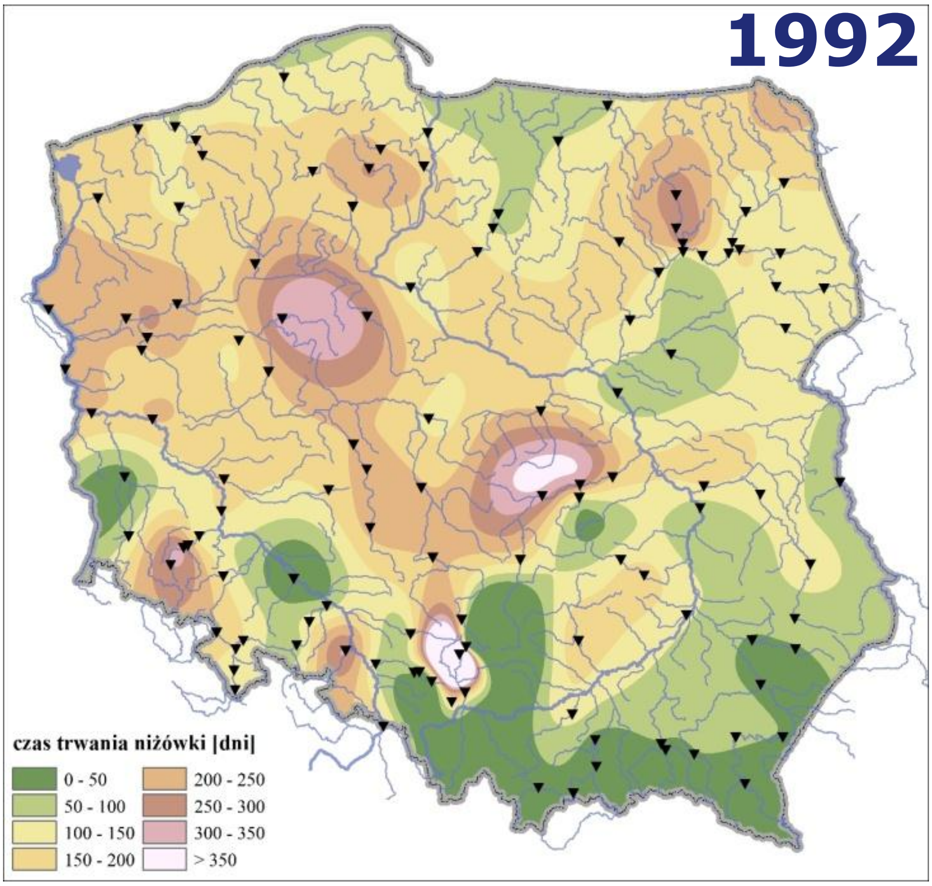

Fig. 2.7.4: Spatial distribution of duration (in days) of the hydrological drought in 1992 being the most extensive hydrological drought in the period 1951-2005

2.7.1. Literature

Dębski K. (1970). Hydrology, Dział Wydawnictw SGGW, Warszawa.

Dubicki A., Tokarczyk T., et al., (2002) Water resources in the upper and middle Odra river basin under drought conditions. Wyd. IMGW, Warszawa.

Farat R. i in., (1995). Susza na obszarze Polski w latach 1951-1990, Materiały Badawcze, Seria Gospodarka Wodna i Ochrona Wód, IMGW, Warszawa.

Maidment D. R. (1993). Handbook of hydrology, McGraw-Hill, Inc., New York.

2.8. Lithuania[13]

Drought as a hazardous extreme hydrometeorological phenomenon is indicated in Government Resolution No. 241 (2006) "Regarding Confirmation of Criteria of Extreme Events. The document distinguishes the types of droughts as drought during the period of active plant growth and very low river run-off.

The most intensive droughts affecting more the 50% of the country and lasting longer than one month occurred in 1963, 1964, 1967, 1969, 1970, 1971, 1975, 1976, 1979, 1982, 1983, 1992, 1994 (Galvonaitë, Valiukas, 2008). The largest deficiency of precipitation was detected during 1971, 1975, 1976, 1964, 1992 and 1994.

The past twenty years has been characterized by frequent droughts at a national as wall as at a regional scale. The meteorological drought is identified by the Hydrothermal Coefficient (HTC) (HTC<0.5, longer than one month), or number of days without precipitation, or with less than 0.5 mm/day precipitation rate (longer than one month) (Selianinov, 1966). New indices, such as Standardized precipitation index (SPI) and Effective Drought Index (EDI) were introduced for the analysis of regional droughts.

The large scale atmospheric circulation patterns which create favourable conditions for drought intensification and/or initiation are related either to the Scandinavian anticyclone genesis, or to the small gradient anticyclone field occupying continental Europe. Another patterns favouring drought development in Lithuania represent blocking flow and large scale wave patterns with upper ridge over eastern and north-eastern Europe. Various atmospheric circulation classification methods demonstrate similar results: cluster analysis reveals that the primary cause of drought is the Central European ridge and the secondary cause is the Scandinavian anticyclone genesis. Using the principal component analysis, the reverse outcomes are obtained (Fig 2.8.1).

From an agricultural point of view, the most fertile soils and the most intensively cultivated arable lands are located within the Middle Lithuanian Lowland and the South Eastern part of Coastal Lowland (see Fig. 2.8.2). The droughts are quite hazardous phenomena for farmers in this region. The intensity of droughts is the highest in the northern part of this region (in Latvia southern part) and along the border of Kaliningrad region.

[13] Assoc. Prof. Gintautas Stankunavicius

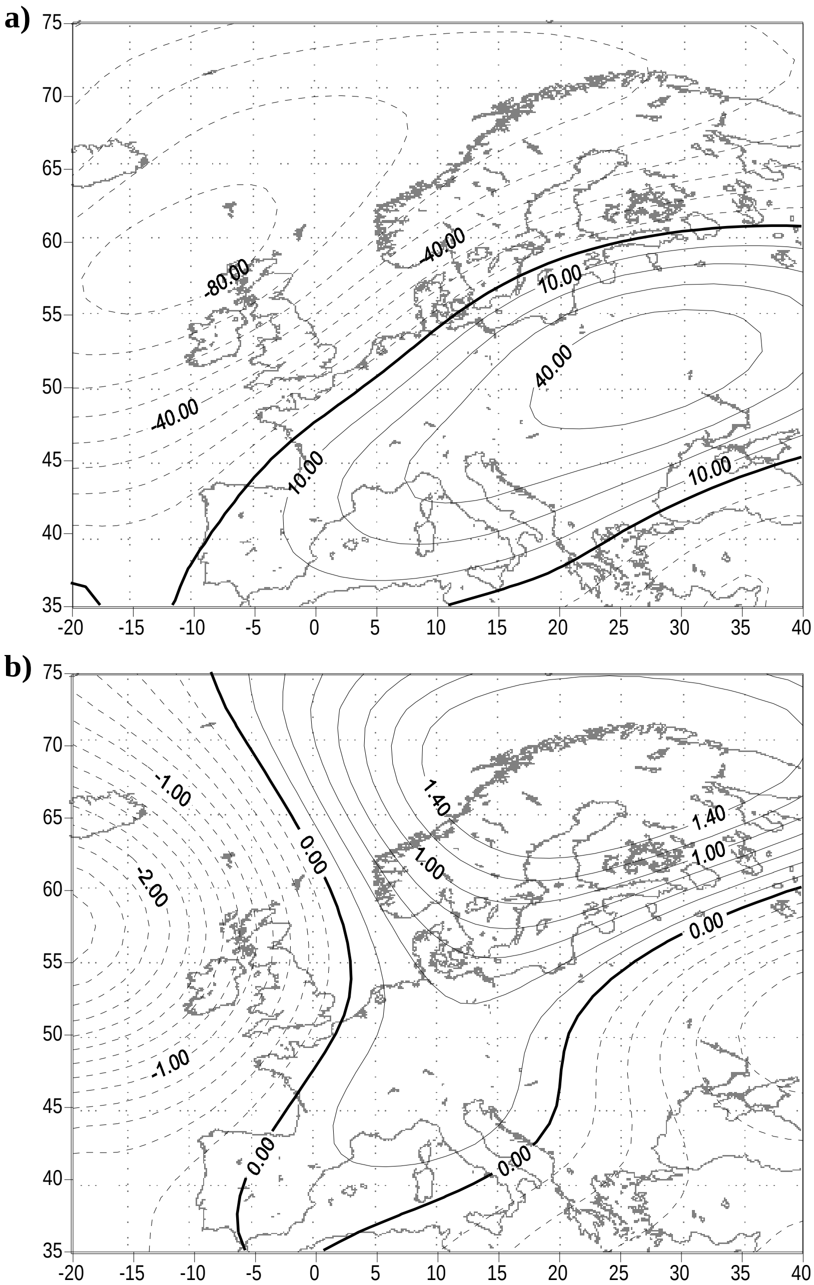

Fig. 2.8.1 Leading atmospheric circulation patterns favouring regional drought intensification and accounting more than 20% of drought days variance extracted according: (a) cluster analysis and (b) principal component analysis. Numbers on isolines indicate average values of geopotential height at 500 hPa level anomalies for particular cluster (a) and the factor loadings (b)

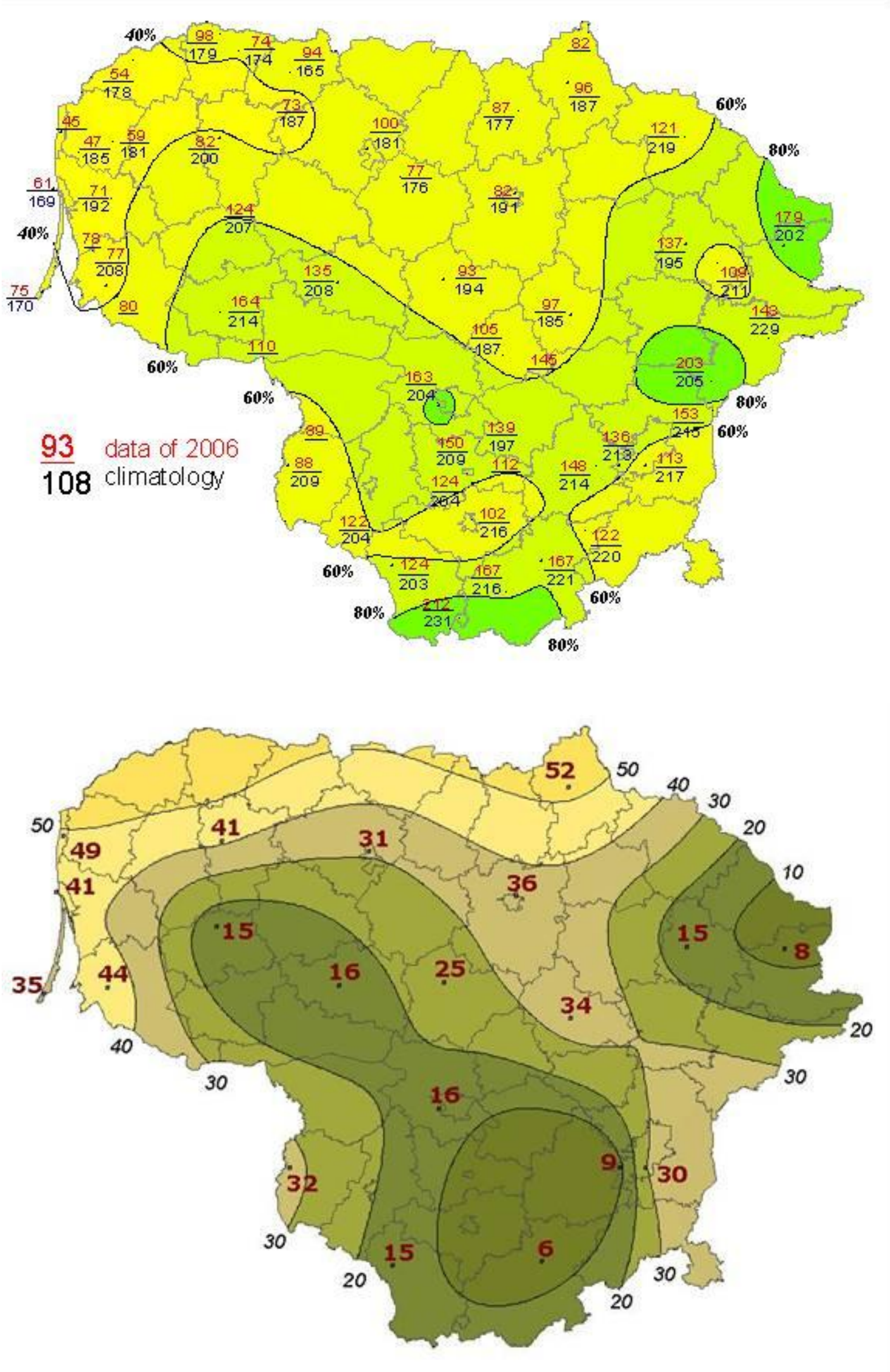

Fig. 2.8.2: (a) Precipitation amount for May-July, 2006. Percentage of climatology norm is indicating by isolines. Isolines are drawn by every 20%. Numbers near location of meteorological stations show: counter – seasonal rainfall in 2006, denominator – climatology. (b) devastating drought duration in July 2006 (in days).

Generally, however, droughts (sometimes dry spells are identified as droughts) in Lithuania are not considered to be a region-wide problem like in the Mediterranean region.

2.8.1. Literature

Galvonaitë A., Valiukas D. (2008). Pavojingř hidrometeorologiniř reiđkiniř átaka űkio đakoms. LHMT. Vilnius (in Lithuanian).

Selianinov, G. (1966). Agroclimatic Map of the World. Leningrad Publishing Centre (in Russian)

Section 3: Mapping current policies regarding drought monitoring and management

3.1. Slovenia[14]

Drought is a normal part of climate, although its spatial extent and severity varies in seasonal and annual time scales. A critical component of national strategy to reduce economic, social and environmental risks is a comprehensive drought monitoring system that can provide early warning of drought’s onset and end, and determine its severity. An important element is also to deliver that information to a climate and water sensitive sectors in a timely manner. With this information, the impacts of drought can be reduced or avoided in many cases. In recent years, some progress on the field of drought monitoring in Slovenia and also in South-Eastern Europe, has been made. Slovenia is also hosting Drought Management Centre for South-Eastern Europe.

The decision support systems for drought monitoring and water management were established at the Environmental Agency of the Republic of Slovenia (EARS). It has improved substantially over the last decade, mainly because of participation in different national and European projects. Agrometeorological Division develops products to provide advices to agricultural sector. The water balance model IRRFIB is functioning on a daily basis. Physical connections between soil, crop and weather parameters represent a basis for modelling the water balance. The model calculates reference daily water balance for different regions and represents important agricultural decision support tool in the frame of agrometeorological information system.

Quick and accurate transfer of information to end users has been enabled with recent development of the technical infrastructure. An open code solution, developed on the Linux platform, is based on the PostgreSQL database, where meteorological, soil, crop and agro technical data are stored. Daily meteorological data from regional meteorological stations are automatically delivered into the system, controlled and stored into the database every day at 7 UTC. Reference evapotranspiration (ET_o) is calculated by Penman-Monteith equation using air temperature, wind speed, air humidity and net radiation. Penman-Monteith’s was the most suitable method for evapotranspiration calculation in Slovenia (Kurnik & Kajfež-Bogataj 2004). Calculations for water demands are prepared for different crops and soil types during the vegetation season. Information about crop water demands are automatically transferred to the Agricultural Advisory Agencies. In addition, 10-days reports about soil water balance in Slovenia are available on the web site of Agrometeorological Department.

Box 3.1: EuroGEOSS project supports drought monitoring

In the framework of the EuroGEOSS project, interoperability arrangements were implemented between the European Drought Observatory (EDO) and Drought Management Centre for South-Eastern Europe (DMCSEE). Open source applications and OGC (Open Geospatial Consortium) standards are used. Static map presentation of drought indicators (SPI and WBA) were transformed into dynamic map presentations and included in EDO architecture with use of Mapserver and Web mapping standard (WMS). In addition, all Slovenian and national drought relevant datasets were included in EuroGOESS metadata catalogue. The framework of EuroGEOSS project is in fact improving drought data availability and the possibility for validation of drought indicators at various spatial scales.

[14] Prof. Lucka Kajfez Bogataj, Biotechnical Faculty, University of Ljubljana, Slovenia

3.1.1. Literature

Kurnik, B. & Kajfež-Bogataj, L. (2004) Primerjava različnih metod za izračun referenčne evapotranspiracije v Sloveniji. Fakulteta za matematiko in fiziko, Univerza v Ljubljani, Diplomskodelo, 66 p.

3.2. Romania[15]

3.2.1. Institutional arrangements regarding drought monitoring and risk management

Romania has ratified the Convention to Combat Desertification (UNCCD) by Law Nr. 111/1998. In 2008, Romania developed the National Strategy and Action Programme concerning desertification, land degradation and drought prevention, on short, medium and long term (NSAP). The Ministry of Agriculture and Rural Development (MARD) is in charge of the development of the National Action Program to Combat Desertification. An advisory body is the National Committee to Combat Drought, Land Degradation and Desertification, established in 2004. MARD is also responsible for reporting on UNCCD implementation. There is also the Ministry of Environment and Forests (MEF), and its research institutes, focused on meteorology, hydrology, and environmental protection.

The national strategy for mitigating desertification and drought effects includes the following measures:

- identification and zoning of desertification;
- measures to prevent land degradation;
- rehabilitation of severely degraded lands;
- prevention of soil and groundwater pollution;
- upgrade of the national irrigation system;
- development of educational activities to raise public awareness concerning planting of trees within the national wooding campaign;
- monitoring and forecasting of land changes;
- dissemination of information to the authorities and the public;
- developing the capacity to respond to information through effective emergency planning;
- operating an effective alert system to release a timely and effective warnings to the public;
- conducting studies on meteorological observations of risks and their impacts as a useful knowledge base for disaster risk managers;
- real-time monitoring allowing for timely information on immediately pre- and post-disaster conditions.

National Meteorological Administration

National Meteorological Administration (NMA) is the national meteorological authority, with a continuous service since 1884. NMA is involved in activities of the World Meteorological Monitoring. Currently NMA is subordinated to the Ministry of Environment and Forests (MEF). Its activities are funded from the state budget. Additional funding comes from providing specific services in meteorology.

The National Meteorological Observation Network within the NMA includes 7 Regional Meteorological Centres (RMC). Since 2005, the National Integrated Meteorological System (SIMIN) has become fully operational, including the National Weather Radar Network (5 C-band and 3 S-band Doppler radars covering the Romanian territory and up to 100-200 km in the neighbouring countries), Automated Surface Observation Stations, Upper Air Radiosonde Observations, Lightning Detection Network, Hydrological Buoy Sensors, new MSG-1 and MSG-2 receiving and processing systems, Central and Regional Forecast Centres, VSAT Communication Network. All data from measurements and observations are processed, validated, transmitted and stored through their

[15] Dr. Elena Mateescu, Executive Director of National Meteorological Administration and Dr. Liviu Nicolae Popescu, President of GWP Romania

integration in SIMIN. At the end of the year 2010, the entire meteorological network comprised a number of 159 operational weather stations, out of which 114 were automatic stations (MAWS).

The NMA is also a key institution in the National Committee for Emergency and Disasters (NCED). According to Regulation for management of emergency situations generated by floods, extreme weather events, accidental damages of hydro-technical constructions and accidental pollutions (Ministry of Administration and Interior, No. 455/30.05.2005), NMA is responsible for carrying out the weather forecasts and warnings as well as timely information to NCED and other decision points.

An important component of the NMA meteorological activities is gathering and transmission of observation data from the ground radars and upper-air stations network.

The training and capacity building program of the NMA staff is provided by the National School of Meteorology (http://www.snm.inmh.ro).

By its nature, meteorology imposes a close international collaboration and Romania is one of the founding members of the World Meteorological Organization (WMO). Besides the international data exchange, NMA participates in the WMO programmes, related both to scientific projects financed by the European Community (EC) or bilateral and multilateral collaboration. In 2010, Romania acceded to the Convention for the establishment of the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT).

The meteorological profile:

- Synoptic and climatological observations and measurements: 159 stations (fig. 3.2.1)
- Number of automatic weather stations (MAWS): 114
- Agrometeorological observations and measurements stations: 55
- Radar network: 8 radars (5 C-band and 3 S-band Doppler radars)
- Actinometric observations and measurements (solar radiation): 7 stations;
- Observations and measurements of sea parameters: 5 stations;
- Aerological observations and measurements: 2 stations;
- Nivological observations and measurements: 5 stations;
- Pluviometric observations and measurements: 67 stations.

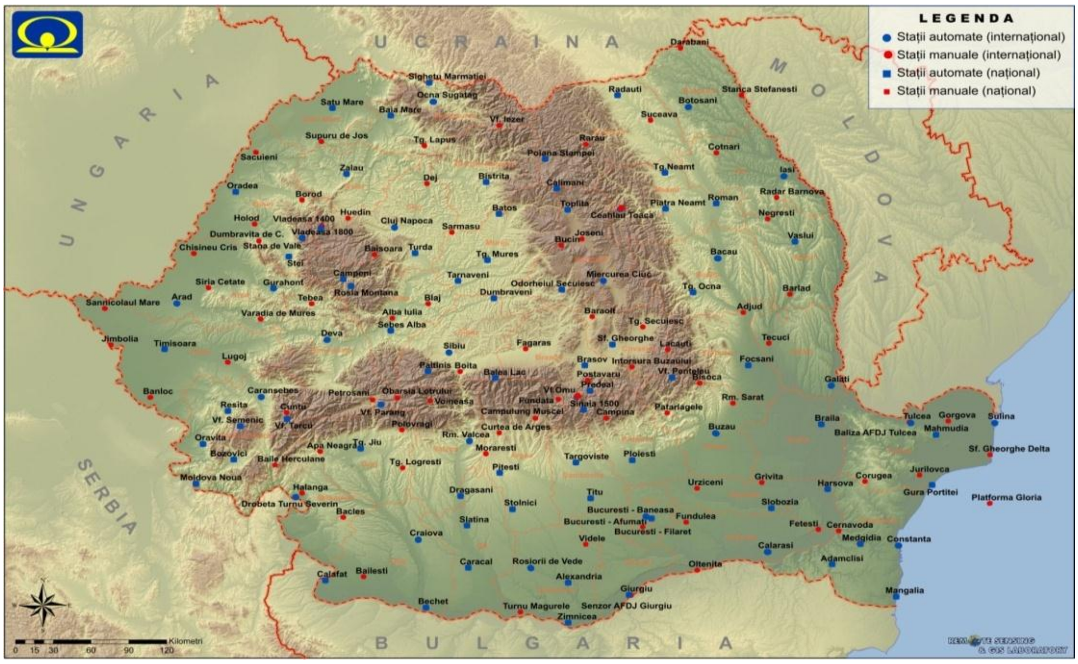

Fig.3.2.1. Romanian meteorological stations network

National Hydrological Administration

The “Romanian Waters” National Administration has the following main functions:

- management of water resources both for the surface, for the ground waters, and their protection against exhaustion and degradation,
- administration, operation and maintenance of the Water Management National Systems infrastructure;
- administration, operation and maintenance of minor water rivers, lakes and ponds, the sea wall and beaches, wetlands and other water protected areas;
- administration, operation and maintenance of the National Hydrological and hydro-geological system;
- administration, operation and maintenance of the National System of Water Resources Quality Monitoring and Supervision;
- allocating the rights for surface and groundwater resources use and granting water use permits;
- defence against floods;
- the authorization of activities that impact and/or use water resources; training and capacities improvement;
- development of water quantity and quality status yearbooks;
- river basin management planning.

Since 2011, a new hydrological forecast and warning system has been established under the DESWAT project (Destructive Water Abatement and Control of Water Disasters). The main objectives of DESWAT project are:

- Upgrade of the hydrological monitoring system that includes
  - 633 stations – with water level, air and water temperature, and precipitation sensors;
  - 247 supplemental rain gauge stations – with precipitation sensors;
  - about 70 stations – which also contain water quality sensors (dissolved oxygen, conductivity, pH, turbidity, etc);
  - data communication systems for the data provided by the hydrometric stations using mainly radio data transceiver modules and GSM modem communication.
- Develop hydrological data integration and processing software able to analyse data from various monitoring sensors, radars; :
- Integration of the two DESWAT and SIMIN projects within the Romanian National Integrated Meteorological System

The system will also include a flash-flood guidance (FFG) component, in which soil-moisture deficits are continuously estimated, using a hydrological model for each small basin (with a mean area of 30 – 50 km^2). The deficits are used together with up-to-date (1hr, 3hr and 6hr) precipitation totals, to estimate the amount of additional precipitation needed for streams to reach bank full conditions.

National Institute of Hydrology and Water Management

The National Institute of Hydrology and Water Management (NIHWM) was established in 2002 as a result of administrative structural reorganization of water management. NIHWM is in charge of

- Carrying out international programs and agreements (WMO, IHP UNESCO, UE, etc.)
- Exchange data, information and hydrological forecasts at an international level
- Constituting and updating the National Fund of Hydrological and Hydro-Geological Data

At the national, regional and local levels, Ministry of Environment and Forests provides guidelines for the management of emergencies, such as floods and drought. These include:

- Regulations for management of emergency meteorological and hydrological situations, accidents at the hydro-technical constructions and accidental pollutions; regulations regarding irrigation systems during the extended droughty periods;
- The river basins plans to restrict water use during critical periods, elaborated for each of 11 Water Basins Administrations (WBA).
- Regulations for exploitation of the dams and lakes at water deficit periods.

3.2.2. International arrangements regarding drought monitoring and risk management

Romania is involved in UNCCD process endorsed Annex V through Law 111/1998. At regional level, Romania is currently developing a Research Thematic Network (RTN) on deforestation in temperate zones affected by drought. Romania is also a member of Drought Centre for South East Europe (DMCSEE).

Romania participates in several international projects aiming to better understanding drought risks, and assessment of vulnerability regarding climate change. These include:

- FP6: Central and Eastern European Climate Change Impact and Vulnerability Assessment – CECILIA (2006-2009). The main objective is to deliver a climate change impacts and vulnerability assessment in targeted areas of Central and Eastern Europe. Emphasis is given to applications of regional climate modelling studies at a resolution of 10 km for local impact studies in key sectors of the region, respectively forestry, agriculture, hydrology and air quality.
- INTERREG IV-C Program, Type 1: Regional Initiative Project, Priority 2: Environment and risk prevention, Sub-theme: Water management. WATERCoRe Project – WATER scarcity and droughts - Co-ordinated activities in European Regions” (2010 – 2013). The program is aimed to improve regional development policies. WATER CoRe intends to provide an exchange platform for water scarcity and drought issues, on regional and local level for all European regions.
- PROJECT CE DGE no. 07.0316/2010/582303/SUB/D1, Mitigation Drought in Vulnerable Area of the Mures Basin / MIDMURES” (2011-2012) is a pilot project on development of prevention measures to halt desertification in Europe. The main goal of the MIDMURES project is to contribute to the improvement of agricultural water saving and drought forecasting in the Mures pilot area. A part of the project includes an agro-meteorological bulletin (Fig. 3.2.2).

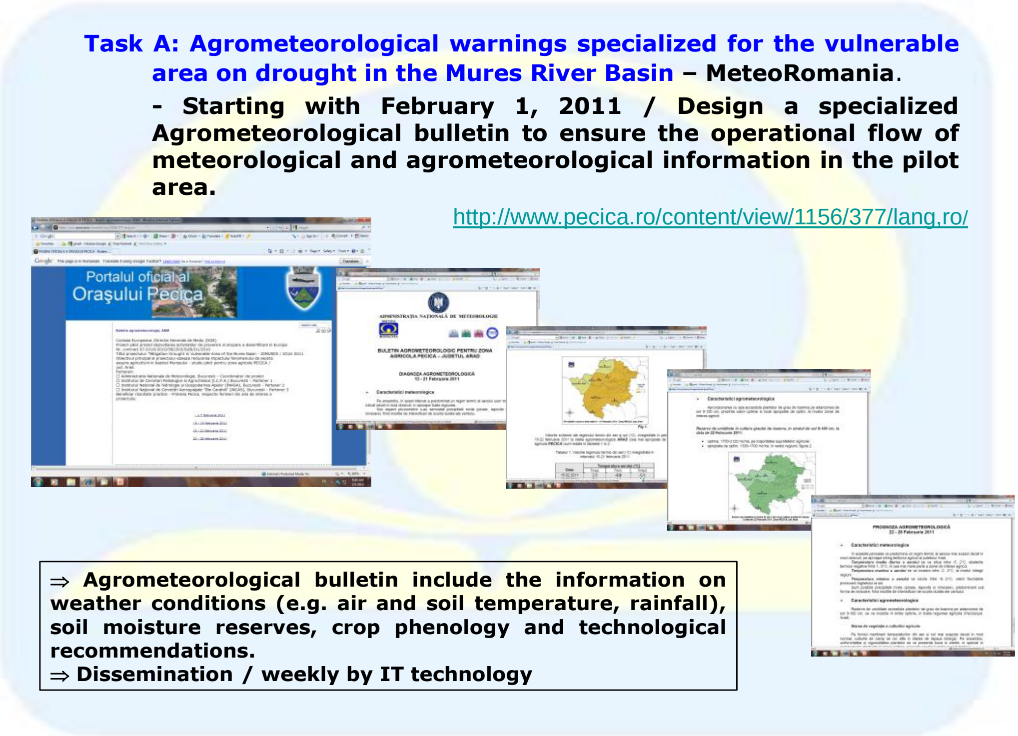

Fig.3.2.2. Mures River Basin agrometeorological bulletin

3.3. Bulgaria[16]

3.3.1 Institutions involved in drought monitoring

Bulgaria provides for more than 134 years information and assessment of weather and water resources and droughts.

Currently, there are 36 meteorological stations with GOS stations density 0.32/1000 km^2. Based on the data of the DMCSEE there are also:

- 47 automatic weather stations (AWS) with AWS density 0.42/1000 km^2. Less than half of the stations measure precipitation;
- 437 manned meteorological stations (measuring at least precipitation, with manned stations density 3.94/1000 km^2;
- 31 soil moisture measurement sites and 373 groundwater measurement sites;
- Data on soil type and soil water holding capacity are also available.

The real time meteorological/hydrological data processing, preparation of meteorological/ hydrological predictions and products as well as the development and set-up of relevant methodologies and software are the major tasks of the National Institute of Meteorology and Hydrology at Bulgarian Academy of Sciences (NIMH-BAS) (www.meteo.bg).

The NIMH-BAS is the main provider of scientific research and activities in the fields of meteorology, agrometeorology and hydrology.

Division of Climatology and Meteorological Network of the NIMH-BAS provides meteorological and climate data, information, analyses, consultations, expert assessments, scenarios and predictions for the needs of governmental organizations and institutions. It develops meteorological and climate expert assessments, consultations, scenarios and predictions for various sectors such as industry, environment, and agriculture.

Division of Meteorological Database and Information Service mainly establishes, manages, maintains and develops a meteorological database. It develops meteorological data for the Annual statistical book.

Division of Agro-meteorology provides agro-meteorological data, information, analyses, consultations, expert assessments, scenarios and predictions. It also provides methodical and technical support as well as optimization of the agro-meteorological network. A monthly bulletin is published.

The NIMH-BAS agrometeorological service (network) is faced to financial cuts from the state budget. Furthermore, some of the agrometeorological and phenological stations are closed down, because of the lack of funds.

Division of Hydrological Forecasting of NIMH is involved in hydrological data processing, hydrological forecast as well as the development of relevant methodologies and software.

A new Division of Water Management and Use has been established in 2010 as a result of re-organization of Bulgarian Academy of Sciences.

The Scientific Coordination Centre for Global Change of the Bulgarian Academy of Sciences (SCCGC-BAS) is a voluntary association of representatives from academia and research institutions. The SCCGC-BAS is a consultative/advisory body to the BAS.

[16] Prof. Vasselin Alexandrov, Prof. Ivan Raev and Assoc. Prof. Galia Bardarska

The Forest Research Institute at Bulgarian Academy of Sciences and Forestry University in Sofia have several forest ecological stations for monitoring the main drought parameters – temperature and precipitation. These stations are part of European network ENFORS.

3.3.2 Monitoring soil drought in Bulgaria

Fig. 3.3.1 presents a flowchart of the major steps related to monitoring soil drought in Bulgaria. It becomes an important source of information to be used in policy-making. It still requires some technical improvements, moreover a coordination of various organizations need to be considered.

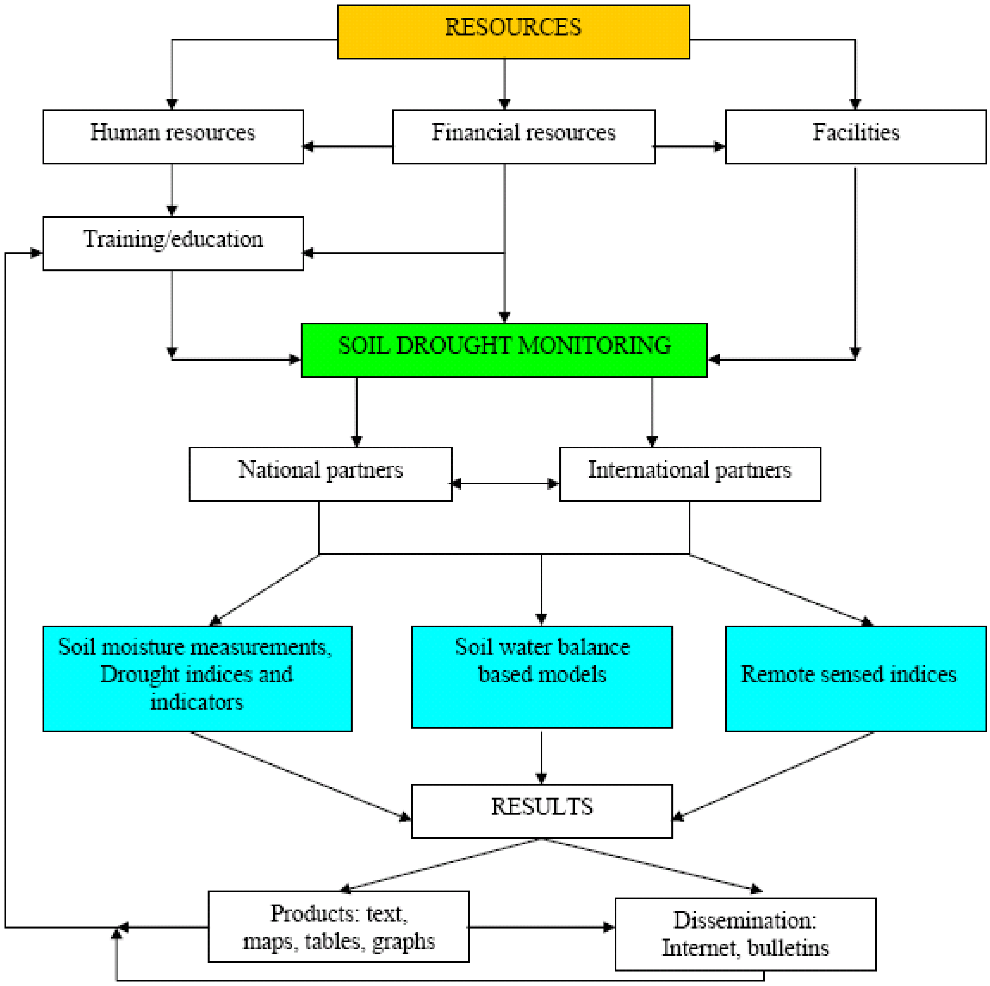

Fig. 3.3.1: Flowchart of the major steps related to monitoring soil drought.

In Bulgaria, the soil drought monitoring in the country is implemented by various research institutes such as:

- Institute of Meliorations and Mechanization – national centre in the field of irrigation;
- Soil Institute "Pushkarov" – with recent national projects, including investigations on soil degradation (e.g. erosion, acidity, salinity, etc.) and changes of the soil physical conditions under drought. Development of systems and levels of soil monitoring is also included in these projects. All this can be incorporated as elements of the foreseen monitoring of the system "soil-vegetation-atmosphere" in the context of the UNCCD;
- Agricultural Institute in General Toshevo, Agricultural University in Plovdiv, etc.

It is necessary to point out that the above mentioned organizations implement soil drought monitoring (including measurement of soil moisture) mainly in limited regions or locations. It is considered that the main national system for direct measurement of soil moisture is based in NIMH-BAS.

Bulgaria is the member of the Drought Management Centre for South-Eastern Europe (DMCSEE) located in Ljubljana, Slovenia. Moreover Bulgaria played an important role in the establishment of the Centre. At the request of the Ministry of Environment and Water of Bulgaria, in 2006, the UNCCD Secretariat in cooperation with WMO organized in Sofia, Bulgaria the workshop that initiated the establishment of this Centre in the context of the UNCCD.

In 2011, Bulgaria also organized the national seminar on Contemporary model for monitoring, assessment and drought impact in Bulgaria. More than 100 participants discussed of approaches to long-term planning of actions in drought conditions, as well as effective water use.

3.3.3 Mapping current policies regarding drought management

The Programme of measures to limit the negative consequences of droughts has been approved by the Council of Ministries in 2001. These measures are of legislative, administration and investment character, and they are primarily concerned with:

- water resources protection;
- overcoming of the drinking water shortages;
- sufficient water for irrigation;
- public information and awareness about water resources savings.

Drinking water supply is one of the main problems in the drought episodes. For example, in 2000 about 20% of total population suffered seasonal water shortages (Fig. 3.3.2). The principal measures to reduce drinking water shortages are focused on rehabilitation of old water supply system where high volume of water is lost by leakages, and construction of several dams (storage reservoirs) in drought regions.

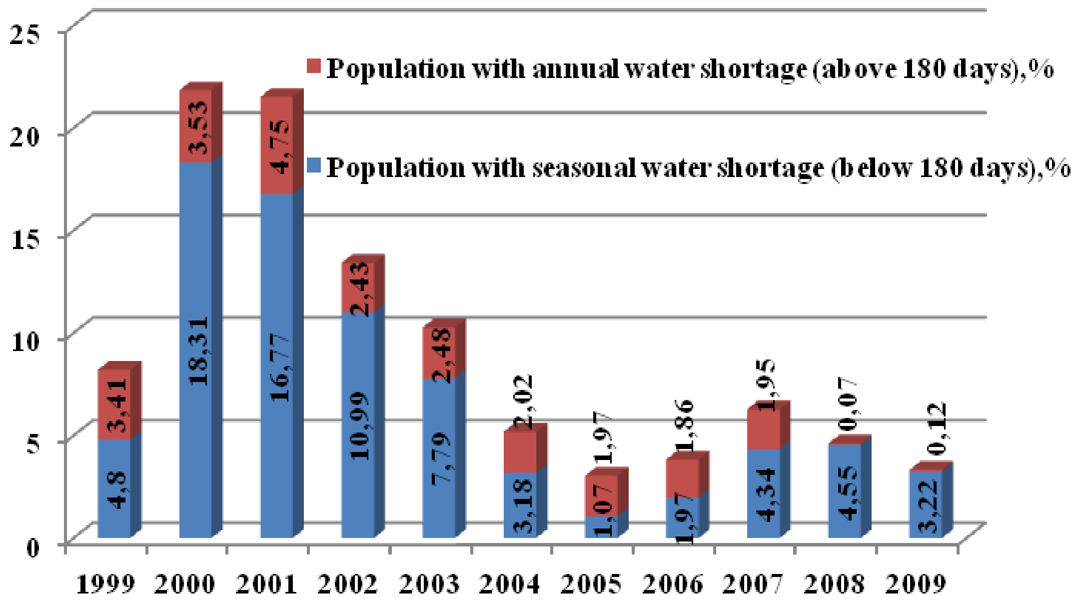

Fig. 3.3.2: Percentages of population which suffer by water shortages in Bulgaria in the period 1999-2009 (Source: National Statistical Institute).

Irrigation systems are faced to similar problems of insufficient maintenance. Although the agriculture sector contributes to the national GWP only by a small portion, much of Bulgarian population is involved in agriculture production.

The institutions responsible for implementation of the 2001 Programme are Ministry of Environment and Water, Ministry of Regional Development and Public Works, Ministry of Agriculture and Forestry (now Ministry of Agriculture and Food), Ministry of Health, municipalities, and private firms. So far, the implementation of the Programme has not been effective due to weak political, administrative and financial support.

3.4. Hungary[17]

3.4.1. National and international levels

The Ministry of Rural Development is the main responsible organization and competent authority in Hungary for drought management. Drought management has a significant role in water management planning especially in the Middle-Danube region. The Ministry of Rural Development is also supervising and coordinating all activities concerning the relation between water management and climate change on country level. The Ministry is also responsible for the elaboration of drought management policy for the regions taking into account climate change. The National Climate Change and Drought management policy directly influences the regional and local activities.

The National Meteorological Service

The OMSz - Hungarian Meteorological Service is an independent central institution under the supervision of the Minister for Environment and Water financed by the state budget. The Service funds are provided under the separate title in the budget of the Ministry of Rural Development Water. The Hungarian Meteorological Service, among others:

- Operates the official national basic system of observation, telecommunication and data processing in connection with the examination of the atmospheric environment including the observation of the atmospheric radio-activity;
- Maintains and operates the national atmospheric observation system established over the territory of the country including surface observations and upper atmosphere observations.;
- Meteorological remote sensing activity;
- Maintenance of measuring sites, instruments and equipment;
- Maintains and operates the national meteorological telecommunication system connected to the Global Telecommunication System of the WMO as well as to the joint telecommunication network of the International Civil Aviation Organization and the WMO;
- Operates the meteorological information systems ensuring the control, processing and archiving of data on the atmospheric environment;
- Ensures that information from the past and present state of the atmosphere are analysed including future development prediction Maintains the meteorological information system serving for the security of air transport.

The country profile from meteorological network point of view:

- Total country area: 93,029 km^2 (out of total area the water surface area is 0.74%)
- Population: (estimate) 10,000,000
- Population density: 108 /km^2
- Number of meteorological stations in WMO GOS catalogue: 34
- GOS stations density: 0.36 /1000 km^2
- Number of automatic weather stations (AWS): 91
- AWS density: 0.97 /1000 km^2
- Number of manned meteorological stations (measuring at least precipitation): 593
- Manned stations density: 6.37 /1000 km^2
- Number of soil moisture measurement sites: 3
- Number of groundwater measurement sites: 1609

[17] Dr. Janos Feher, GWP Hungary

Hungary also participates at the international work of DMCSEE.

3.4.2. Regional level

Environmental and Water Management Directorates (EWMDs)

The EWMD is a territorial – deconcentrated – state (budgetary) organization organized according to basin borders. Essentially, it has been working on the same field since 1953; it is the successor of the civil engineering and river engineering bureaus functioning since the last third of the 19th century. The EWMD operates and maintains water management facilities and basins. It is also responsible for development and implementation of national water management concept including regulatory functions. EWMDs main tasks involve:

- Registering, protecting and dividing the water resources of their territories;
- Treating, operating, maintaining and developing the state waters, basins and water utilities
- Operating, maintaining and developing the territorial hydrographical network,
- Providing on/with the state works the flood and inland inundation protection and the water quality prevention in case of damages to ships;
- Establishing, harmonizing, validating the coherence between the water management of the state, local council and other public and private sector (persons, farms, factories etc.) (water administration);
- Providing the first instance water administrative competence (certification, monitoring).

Environmental, Nature Protection and Water Inspectorates

The Inspectorates as ‘green authorities’ are state administrative organizations functioning under the supervision of the Minister of Environment and Water; they are separate legal entities, individually managing central budgetary organizations. The Inspectorates maintain the National Environmental Information System and cooperate with all monitoring and information systems. Their main tasks include competencies in environmental management ranging from regulatory, administrative, monitoring and decision making functions. However, they are not specifically focused on drought monitoring.

3.5. Ukraine[18]

3.5.1. Ukrainian institutions involved in drought monitoring

The Ukrainian Hydrometeorological Centre

THE UHMC produces hydrometeorological forecasts related to the hydrological regime of rivers and storage reservoirs, condition and productivity of crops. It also informs the population on weather conditions and produces warnings on adverse conditions and natural hazards, like floods and droughts. It also produces the bulletin for an agricultural year and other specialized meteorological, hydrological and agrometeorological forecasts. The UHMC works under the auspices of the Ukrainian Ministry of Emergencies. The UHMC is the main methodological organization of the hydrometeorological service on such issues as weather conditions forecasting, hydrometeorological maintenance and service, carrying out of agrometeorological works and supervision, processing and distribution of hydrometeorological information. The UHMC is a member of the World Meteorological Organization.

In case of threat and occurrence of dangerous and spontaneous meteorological phenomena and natural hazards like floods and droughts, the UHMC cooperates with regional Hydrometeorological Centres and other organizations of hydrometeorological service both of Ukraine and neighbouring countries with the aim to forecast and assess the impact and notify alert and warning.

The Department of Agrometeorology of UHMC

It comprises around 20 experts of agrometeorology to assess meteorological and climatic conditions of agriculture production in geographic space and time. The Department possesses the fullest information on condition of crops and current agrometeorological conditions of agricultural plants cultivation and has opportunity to adequately and objectively estimate the future harvest of basic crops. The department receives and processes information from 145 meteorological stations and carry out monitoring of main crops in a concrete region. It is also an advisory body to Ministry of Agrarian Policy and related agencies including farming organizations and individual farmers. The Department maintains a databank of scientific and operational agrometeorological data.

3.5.2. Drought monitoring in relation to crop yield forecast

Ukraine has a sufficient experience in the development of various components of drought monitoring including conducting surveys on agricultural crops. The automated program of “DROUGHT” has been developed on the basis on assessment of drought and hot winds, their influence on grain yield by the UHMC in cooperation with the Odessa State Environmental University OSENU (A. Polevoy). This program is compatible with automated working place of an agrometeorologist (ARM-Agro), i.e. with the operative agrometeorological information and allows each decade to assess the impact of drought on crop cereals (winter wheat, spring barley) as shown in Fig. 3.5.1.

[18] Mykola Kulbida, Director of the Ukrainian Hydrometeorological Centre and Tatyana Adamenko, Head of Agrometeorology Department, Ukrainian Hydrometeorological Centre in Kiev, Ukraine

Fig. 3.5.1: Estimated reduction in yield of spring barley (%) due to drought in regions of Ukraine. (Calculation June 30, 2009).

In addition the UHMC uses a well-known complex index of moistening and water-supply of plants – hydrothermal coefficient – HTC (the ratio of total precipitation to the sum of temperatures above 10°C), which is also calculated in the operational mode. Ukraine signed the UN Convention on Combating Desertification, but today very little attention is paid to the implementation of the Convention.

Agrometeorological monitoring is regularly carried out by 188 meteorological stations in Ukraine. In parallel with the meteorological observations at about 145 stations monitoring on growth, development, condition, humidity security of crops according to a single method simultaneously at all stations. Observations are carried out for the most common crops (winter, spring, legumes, oil seed and industrial crop) in the area of a meteorological station observation. Standard observation of weather elements is carried out every 3h. The regularity of crop observations is 2 days; the actual water-supply is defined once in 10 days.

The harvest assessment is carried out with a temporal resolution of a decade. Forecasting is carried out on several levels (weather station, district, region and country) using all the methods developed, tested and adapted to the territory of Ukraine.

On Fig 3.5.2, model estimates on crop yield are made for any period of vegetation. The results are available to a broad stakeholders ranging from ministries to farmers and insurance companies.

Fig. 3.5.2: Assessment of the impact of weather on winter wheat yield (in % of optimum conditions) in administrative regions on May 31, 2009

In the years of particularly unfavourable weather conditions the meteorological stations carry out ground-route survey of agricultural crops. All the agrometeorological information comes to the regional centres and from them it goes to the UHMT.

Processing of the agrometeorological observations is performed on an “Agrometeorologist Automated Working Place (AWP)”. An AWP is a specialized program for an operative display of operational meteorological and agrometeorological information, processing and systematization for development of the various operational and long term materials by the agrometeorologists.

Today the UHMC, having an adequate support and staffing, is actively pursuing work on adaptation of satellite data for assessing the status and productivity of crops in Ukraine. Development of monitoring system with regular data from satellite observations will significantly increase their effectiveness of drought management.

3.6. Slovakia[19]

3.6.1. Drought monitoring arrangements

In 2002, Slovakia joined the initiative of the United Nations Convention to Combat Desertification (UNCCD). National Secretariat of the Convention has been located at the Department of Foreign Affairs at the Ministry of Agriculture. The daily technical tasks with respect to implementation of the Convention are conducted by the Soil Science and Conservation Research Institute in Bratislava (SSCRI). The SSCRI is acting as National Focal Point (NFP). Also, the National Advisory Committee was established to provide political platform. Its activities are coordinated with National Secretariat and NFP. The Convention requires the signatory countries to adopt and implement the National Action Programs (NAP) which Slovakia elaborated in 2005 and it is focused on:

- measures to mitigate impacts of drought and soil degradation,
- monitoring and information system including early warning systems,
- starting and supporting of relevant research and development programmes,
- education support and raising public awareness,
- identification of the specification and mechanisms of Slovak aid to developing countries affected by the drought.

Unfortunately, this NAP has not been yet adopted by the Slovak Parliament because of financing the Programmes. Therefore, the NAP is substituted by the programmes focusing on the solution of specific priorities as follows:

1. Scientific programme relevant to the Convention, specifically for increase of the soil water holding capacity including related information system.
2. Use the available finances from the state budget for partial implementation of the measures in the practice especially from so called Agri-Environment budget for financial support of measures dedicated to agriculture and related environmental protection. This specific budget is envisaged to be available in years 2014-2020. For this time concrete steps are taken to implement the results of the scientific programme mentioned above.
3. Joint project of the Ministry of Environment and Ministry of Agriculture of the Slovak Republic on The National Capacity Self-Assessment related to NAP and to the two above mentioned priorities. The project has been elaborated with financial support of the UNDP in 2004, and coordinated by Slovak NFP.

In 2004, the Soil Conservation Service was established to supervise, in cooperation with other relevant state administration bodies, the following activities:

- survey and monitoring of agricultural soil
- keeping record and information databases on agricultural soil
- elaboration of proposal to mitigate soil damage
- analysis, assessment and quantification of the status and development of soil degradation
- development of proposals for procedures and projects aiming to protect and sustainable use of agriculture soil in specific localities.

[19] Elaborated by Dr. Jana Poórová, RNDr. Pavol Faško, Dr. Olga Majerčáková, RNDr. Peter Škoda, Ms. Lívia Lešková – Slovak Hydrometeorological Institute Bratislava, Prof. Milan Lapin, Comenius University, Bratislava. Compilation and editing by Eng. Milan Matuška, GWP CEE Secretariat and Dr. Peter Rončák, GWP Slovakia

Because of the serious impact of drought on water management, this issue has been included into the Slovak National River Basin Management Plan developed according to the EU Water Framework Directive. The Slovak Water Act (2004) stipulates measures regarding droughts in two paragraphs. In Paragraph 1, the Water Act orders the reduction of unfavourable effects of drought and in Paragraph 21, the minimum residual discharge is defined as follows: "State administration authority for permitting water abstraction is limited by the current discharge in the river, which should still enable general water use and ensure the basic functions of the river and the preservation of its water ecosystems". However, the Water Act does not take into consideration the drought consequences and does not prioritize the needs to increase drought resilience. Also, the Act does not address the issue of drought warnings.

The drought monitoring is performed by Slovak Hydrometeorological Institute in cooperation with relevant organizations and institutions dealing with monitoring of soil characteristics, forests, and crops yields.

3.6.2. Current policies regarding drought management

The National Strategy for Climate Change and legislation for Integrated Drought and Water Shortage Management is still in the process of development. Some steps have are already accomplished.

The problems of droughts and water shortages are addressed through the Drought and Water Shortage Working Group, which is coordinated by the Ministry of Environment. This Working Group comprises the representatives of Slovak Hydrometeorological Institute, the Slovak Water Management Enterprise, the Water Research Institute, and the Institute of Hydrology of the Slovak Academy of Sciences.

In 2009 "The Fifth National Communication of the Slovak republic on Climate Change" has been developed that addresses the future trends in water scarcity and extreme events of foods and recommends adaptation measures. The adaptation measures are also stipulated in the National River Basin Management Plan (2009) and these include, among others:

- Re-evaluate the estimation of design floods and reassess the safety of dams and water structures.
- Re-evaluate future water needs.
- Re-evaluate the safety of existing water withdrawals from reservoirs for water supply and energy production and low flow augmentation.
- Developing methodologies for drought assessment and to introduce new indicators into current practise.
- Investigate droughts and their impacts on the status of water bodies.
- Increase of climate change impact research.

One of the key tools to asses the available water resources in Slovakia is the annual Water Balance. Water Balance assesses all aspects of water management, including water quality and quantity. Additionally, it specifies which regions and periods of time water resources were not sufficient to meet society's demands. The aim of the Water Balance is to report on water resources availability. The water balance is assessed based on monitoring results from 137 hydrological stations.

3.6.3. Present status of drought monitoring

At present, no specific and systematic drought monitoring is established in Slovakia. In general, the drought is understood as a long period of extremely low moisture content in the environment, caused by long period of extremely small precipitations and consequently extremely low discharges in water streams and characteristics of the ground waters.

The Slovak Hydrometeorological Institute (SHMI) is the main institution to monitor meteorological and hydrological data. The network of meteorological and hydrological stations has a significant historical continuity. At present, atmospheric precipitation is monitored at more than 600 precipitation stations. In addition, other meteorological components 8such as evaporation from water surface) are measured and monitored at almost 100 meteorological stations.

There are approximately 420 hydrological stations in Slovakia which monitor the water levels on a daily basis. Approximately 280 stations are able to transfer online data to the central database. There are approximately 700 gauging stations to measure precipitations, 80 of them are able to transfer data to the central database. Based on such data, the index of previous precipitation for river basins and the significance of the discharges (N-annual rate and M-daily rate) on a daily basis is calculated by the hydro-meteorological service.

Several hydrological characteristics are calculated based upon the information received from the monitoring. These include daily water discharges, average minimum and absolute minimum water discharges, minimum annual and monthly water discharges. Based on these characteristics, the regional occurrence and significance of droughts were processed for the winter and summer seasons (see Fig. 3.6.1).

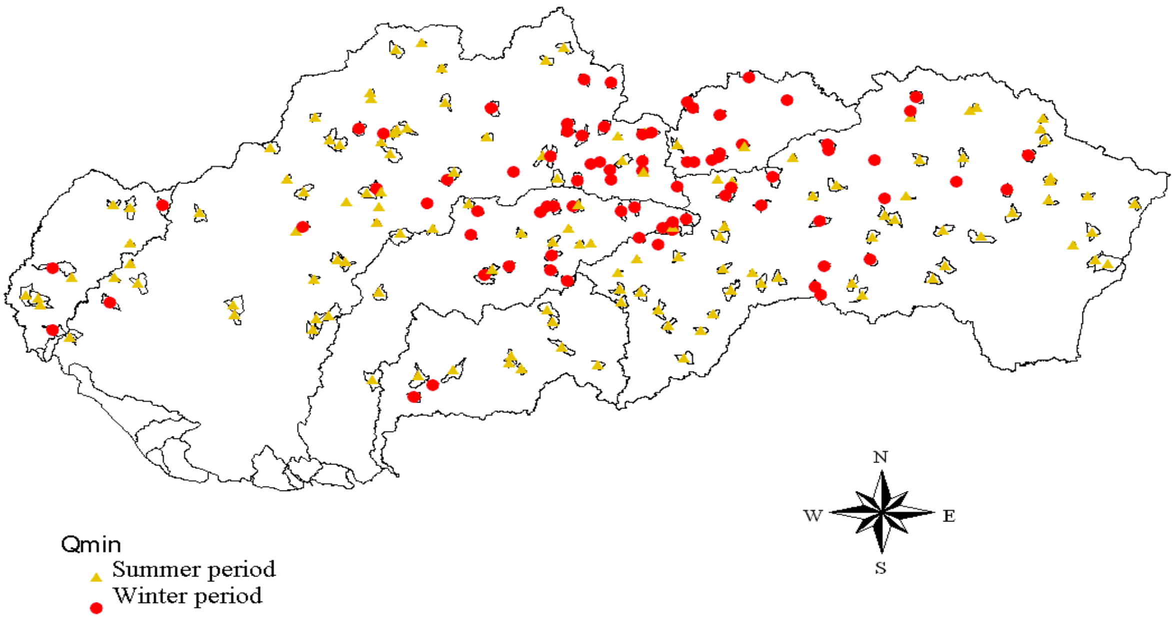

Fig. 3.6.1. Regional evaluation of the occurrence of droughts for the winter and summer seasons

In Slovakia, mostly southern regions belong to potentially endangered areas. Experience gained in the last quarter of 20th century indicate, that the risk of occurrence of precipitation deficit will be higher also in other regions of Slovakia. The occurrence of regional droughts has been recorded. Several published papers document precipitation deficit that was defined as follows:

1. precipitation deficit was lasting at least 15 days and precipitations were less than 1 mm,
2. precipitation deficit was lasting at least 20 days and precipitations were less than 2,5 mm,
3. precipitation deficit was lasting at least 30 days and precipitations were less than 5 mm.

3.6.4. Literature

Ministry of Environment (2009), The Fifth National Communication of the Slovak republic on Climate Change

3.7. Poland[20]

3.7.1. Mapping current policies regarding drought-related monitoring and management

The environmental administration is distributed between four levels: the State, voivodeships, counties and municipalities. **The Water Law** of 2001 (with amendments) is the most important legal act, providing basic regulations concerning requirements that the user of water should comply with. This act defines the so-called special use of water that requires the state permission. The Water Law also stipulates the following principles:

- protection of ground and surface water resources against pollution and over exploitation,
- protection against floods and droughts,
- exploitation of water for the sailing and energy purposes,
- providing people and water management facilities with proper quality water,
- meeting the needs of people concerning health, hygiene and recreation.

Protection against floods and drought risk is one of the main tasks of water management imposed by Water Law.

Small Water Retention Programme, especially important for drought management, have been started in the early 90s aiming at restoration of small water reservoirs and building new systems of water retention. In 2002, the Ministry of Environment, National Fund for Environmental Protection and Water Management and Agency for Modernization and Restructuring of Agriculture signed an agreement towards increasing small retention developments and spreading the ecological water retention measures.

The Agriculture Drought Monitoring System (ADMS) is operated by the Institute of Soil Science and Plant Cultivation - State Research Institute (IUNG-NRI) on behalf of the Ministry of Agriculture and Rural Development. The ADMS supports implementation of the insurance policy established by the Polish Government, according to the 2005 "Act on insurance subsidies concerning agricultural crops and farm animals”.

Box: System of drought monitoring in Kujawy and the upper Notec Valley
Another system of drought monitoring was developed and maintained by the Institute of Technology and Life Science in Bydgoszcz. This system is dedicated to meteorological and agriculture drought prediction and has been performed since 2008. Meteorological drought is evaluated using SPI (Standardized Precipitation Index) and agriculture drought using CDI (Crop Drought Index). Prediction of meteorological and agricultural drought is made in the 10-days periods, using forecast of precipitation obtained from WeatherOnline. This monitoring system is used in decision making and activity planning in agricultural production, water management in rural areas, irrigation and estimation of yield losses. [Łabedzki, Bak 2011].

ADMS aims to identify areas where there are crop losses caused by the drought conditions. In determining the areas affected by drought, besides the value of climatic water balance, the characteristics of the soil water retention are determined by soil category, and are identified based on soil and agricultural maps. In 2008, the ADMS used data from 55 synoptic stations and about 220

[20] Dr. Tamara Tokarczyk and Dr. Wiwiana Szalińska, Institute of Meteorology and Water Management in Wroclaw, Poland

rainwater stations (under the operation of the Institute of Meteorology and Water Management (IMWM).

The main administrative body dealing with water management is the Minister of the Environment, responsible for rational water policy in the country. The tasks of the Minister include among others also the development of a national program for the aquatic environment, draft River Basin Management Plans, and a plan for flood risk management and **drought risk management.** These tasks comprise also agreeing with the president of the National Water Management Authority the national strategy of water management and actions for **mitigating flood and drought impacts** as well as shaping the state's policy by proposing proper laws, creation of legal and economic instruments.

The President of the National Water Management Authority (NWMA) is a central government administration authority responsible for the management and use of waters. The President of the NWMA also governs Regional Water Management Boards (RZGW). The RZGWs are the regional non-affiliated governmental administration units that implement water management policy approved by the Minister of the Environment. The RZGWs also are responsible for water management investments of regional ad national significance.

The management system of water resources comprises both the central and local government administrative bodies. The planning, executive and investment tasks are subject to the local governments of all levels – of the voivodeship, county and commune. The overall scheme of institutional structure of water management in Poland is presented in Fig. 3.7.1.

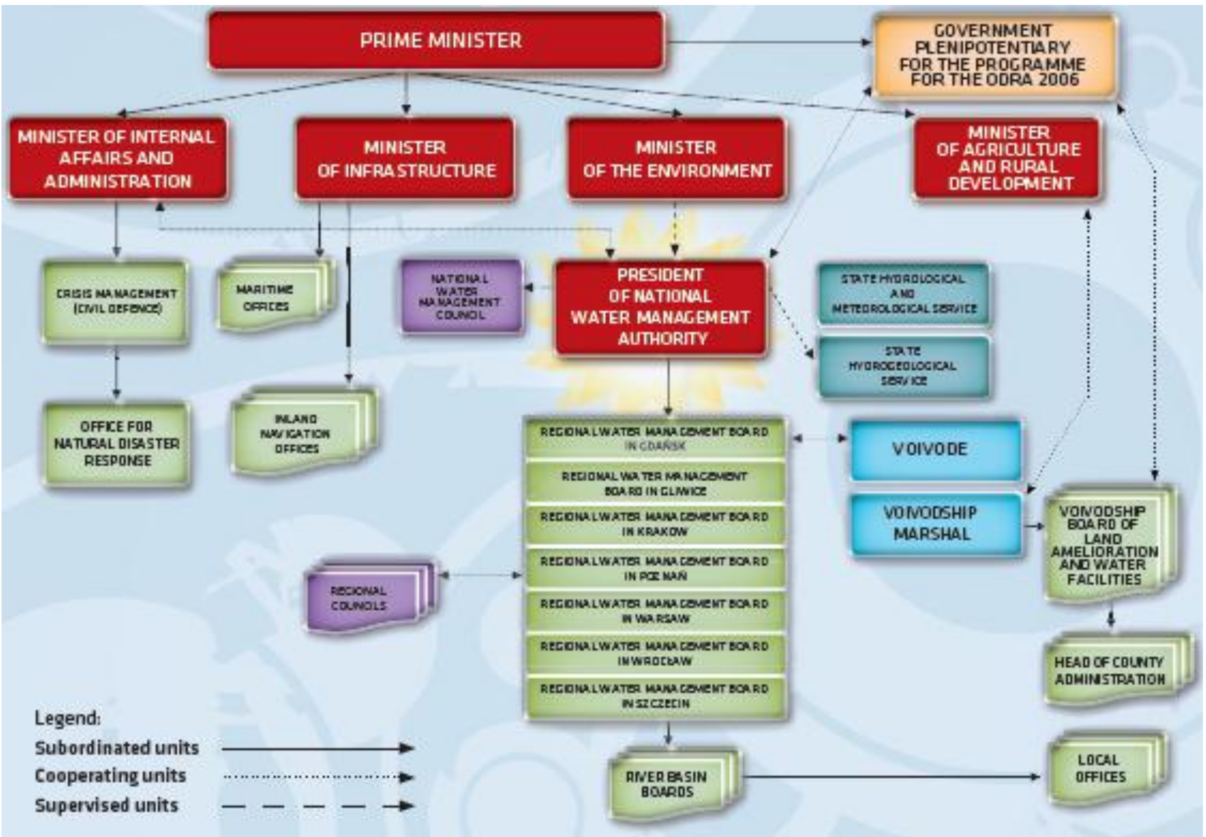

Fig. 3.7.1: Organizational structure of water management in Poland (source: National Water Management Authority)

The task of **drought monitoring** is within the State Hydrological and Meteorological Services. The Institute of Meteorology and Water Management - National Research Institute (IMWM NRI) is a research-development unit merging responsibility of State Hydrological and Meteorological Services and the Institute of Water Management. The Institute is supervised by the Minister for Environment.

Basic statutory tasks of the Institute include scientific and development activities as well as state services in the following domains: meteorology, hydrology, oceanology, water management and engineering and water resources quality. These tasks cover carrying out scientific-research, making regular measurements and observations with the use of basic systems and measurement networks (including drought monitoring), acquisition, archiving, processing and making available measurement and observational materials, for both national and international bodies, preparation and dissemination of forecasts and warnings for general public and national economy protection as well as for state defence against hydrological and meteorological hazards (floods and droughts).

The obligation to provide continuously the state authorities, general public and national economy with current information on the state of the atmosphere and hydrosphere, forecasts and warnings both in normal as well as in emergency situations, requires development of the tools addressing drought monitoring and forecasting.

3.7.2. Literature

Labedzki L., Bak B. (2002). Monitoring suszy za pomocą wskaźnika standaryzowanego opadu SPI, Woda-Srodowisko-Obszary wiejskie, t.2, z.2, s. 9-19, Wyd. IMUZ, Falenty.

3.8. Lithuania[21]

The river basin management plans, approved by Lithuanian government include information concerning potential drought impact on water bodies. The small river basins (catchment's area less than 50 square km) were not included to the list of the water bodies because they usually dry up during dry summers. The main institution involved in drought monitoring is the Lithuanian Hydro-Meteorological service supported by the academia (Vilnius University).

[21] Assoc. Prof. Gintautas Stankunavicius

Section 4: National and regional GWP CEE initiatives proposed for IDM Programme

4.1. Slovenia[22]

Many challenges face Slovenia in the process of implementing drought preparedness measures:

- Underdeveloped irrigation system (economic justification of reconstruction of the system should be prepared),
- Other public infrastructure on the rivers (e.g. river reservoirs) could be built for drought mitigation, where possible,
- Drought monitoring and early warning systems should be improved,
- Public risk funds or subsidies should be considered.

Project examples

Listed below are examples of national projects which could be implemented in order to improve drought monitoring in Slovenia:

- Improvement of the database with additional measurements of soil water holding capacities;
- Implementation of new drought indicators in operational drought monitoring (SPEI, PDSI,);
- Integration of various datasets, related to meteorological, hydrological and agricultural drought, into one central drought monitoring portal;
- Implementation of comprehensive drought indicator for Slovenia;
- Integration of drought indicators with drought impact data, with the aim of producing early warning systems for the most vulnerable sectors;
- Research on the level of vulnerability of the most drought affected regions in Slovenia (south-eastern Slovenia, Karst region, west Slovenia).

Listed below are examples of regional (South-Eastern Europe) projects which could be implemented in order to improve drought monitoring in the region:

- Expand the staff force of the DMCSEE consortium and explore possibilities for financing DMCSEE;
- Integrate the operational drought monitoring systems from SEE Europe into DMCSEE drought monitor;
- Research correlations between drought impact data and drought indicators;
- Validate existing drought indicators on regional level in terms of their capability to monitor agricultural and hydrological drought;
- Define correlations between circulation patterns and drought occurrence in SEE;
- Research the possibilities for seasonal drought forecasting on different time scales in SEE;
- Integrate seasonal drought forecasts into existing drought monitoring system
- Research the climate change impact on drought occurrence in SEE.

[22] Prof. Lucka Kajfez Bogataj, Biotechnical Faculty, University of Ljubljana, Slovenia

4.2. Romania[23]

Experts from Romania recommend two main institutional components of drought management programme, with complementary activities and links between them across levels:

- A regional Risk Monitoring Component, responsible for an extended and harmonized monitoring of climate and water supply dynamics, aiming to achieve an early observation of drought conditions. These observations are based on harmonization and/or elaboration of specific indicators for drought, water resources status and its impacts in the critical conditions.
- A Risk Assessment Component, assessing the risk, magnitude and impact, including environmental, economic and social impact of droughts. This will help to identify the priorities for the decision-making process. For accurate assessment, the role of the National Meteorological Services and Water Management Authorities is crucial.

To ensure efficient planning and implementation, communication between the above two components are principal. This could e.g. occur through periodical reports.

It is also recommended to carry a pilot study in one of the most vulnerable drought areas. In order to learn from previous drought events, it would be useful to implement a feedback process to assess the practices implemented in the past. Specifically, this feedback process should include:

- review of past drought episodes in the context of climatic trends that affect the duration and severity of droughts;
- development of support tools, useful across the implementation chain, from decision-makers to users;
- identification of the knowledge gaps and development and strengthening the national capacities to provide effective early warnings to drought.

A feedback process will achieve the following results:

- Harmonized data, and information of the drought damage potential and water scarcity, as influenced by climate change effects and regional conditions;
- Tools for assessment of climate change implications to soil water balance: the water use, the loss in agricultural crop production, and drought impacts on growth and development of the agricultural crops;
- Agreements on specific measures to prevent land degradation, as well as rehabilitation measures to be apply on lands already severely degraded;
- Development of public awareness campaigns and capacity building in the relevant institutions including mechanisms to facilitate exchange of information between scientific and technical institutions.
- Recommendations for an improved use of land systems in agricultural crop production under conditions of water scarcity.

[23] Dr. Elena Mateescu, Executive Director of National Meteorological Administration and Dr. Liviu Nicolae Popescu, President of GWP Romania

4.3. Bulgaria[24]

Experts from Bulgaria recommend improving drought monitoring, including testing new drought indices. There is a need to assess the frequency and severity of drought by the water balance model. Institutional measures at national level should include capacity building of decision makers. Also, the introduction of drought management at schools would bring a better understanding on potential measures to increase resilience to droughts.

It is also important to continue in cooperation with the DMCSEE by means of exchange of specialists and organizing joint workshops. A joint project on drought adaptation measures and mitigation of droughts at regional level (for example at transboundary basin) would increase knowledge transfer of good practices undertaken in different sectors.

One of the major problems in applying simulation climate scenarios from the global climate models is related with so-called “regionalization” or “scaling” toward higher space disjunctive ability.

[24] Prof. Vesselin Alexandrov, Prof. Ivan Raev and Assoc. Prof. Galia Bardarska

4.4. Hungary[25]

There is a need for better knowledge of the spatial distribution of future water use and demand. This knowledge, supported by the need for the development of common international indices to define droughts and water scarcity resulting in appropriate maps, will enable better planning and management of limited resources. Special attention should also be devoted to the equitable allocation of water resources in a transboundary context.

As the most vulnerable region is the Tisza River Basin that is recommended to be explored in terms of reducing waster scarcity. Although appropriate abstraction control, such as registering of water abstractions, drainage system changes, cessation of illegal abstractions, use of crops with a low water demand, and application of water-saving irrigation technologies are effective measures, it is not known to what extent these will be applied throughout the Tisza River Basin to address over-exploitation. The measures need to target specific local situations within the basin.

Guidelines should be developed for future wetland restoration and reconnection programmes throughout the Tisza River Basin. These guidelines should address both technical issues associated with sustainable management of wetland functions, and land ownership issues, as well as address public concerns associated with alternative approaches to flood mitigation, while raising awareness of the full range of benefits attributed to wetlands. Based on the ecosystem service approach, these should highlight the benefits of wetlands in the Tisza River. Experiences and lessons learned from projects should be widely shared to the wider stakeholder community.

Datasets produced by GIS-Remote sensing based Earth observing satellites should play a crucial role for providing an **early alarm system using spatial decision modelling. GIS mapped drought indices** have to be developed and should become common tools to measure the intensity and spatial extent of droughts. In the near future, it is recommended to introduce the GIS-WEB based drought monitoring using remote sensing data to the Tisza watershed.

Energy and water save irrigation and groundwater depletion are major issues and more information would be needed for both issues. Biomass production will increase (plus 1 million ha will be used for these purposes till 2020) on Tisza, but no information exists this how will effect drought risk. It is recommended that Advanced Land Use Change Modelling should be applied to find out sustainable water use scenarios for the problem of increased water demand due to increase biomass production in the region.

At the national level, there is a need to establish comparable national approaches for monitoring and recording groundwater abstractions. An overview of the methodologies used to establish national minimum ecological flows should also be prepared, to potentially lead to comparable limits and approaches to managing low-flow situations in a transboundary context.

[25] Compiled by Prof. Janos Tamas with contribution from Dr. Janos Feher

4.5. Ukraine[26]

Currently, strategies for the management of the Dnieper River basin are based on reservoirs empting before the spring floods come. This way, the reservoirs can be filled up again during the spring flood and subsequent empting them until the next spring floods come. The forecasts of the water inflow to the reservoirs are developed in the Soviet period, and need data on snow cover and soil moisture in Russian and Belarusian parts of Dnieper/Pripyat river watershed. Unfortunately, Ukrainian institutions currently do not receive all necessary information (snow accumulation and snow melt, runoff amounts form their Dnieper River watersheds, and river flow rates in these territories) to estimate when and how much water is coming to the Ukrainian portion of the Dnieper River and its tributaries. This jeopardizes a sound flood and drought management.

Adaptation of water resources sector to climate changes for strengthening transboundary coherence of river flow (including flood and drought), are proposed by Ukrainian experts. A proposal is to a project focused on strengthening of flow & water quality forecasting, emergency response and water management in transboundary Dnieper River basin taking into account climate change uncertainties. The main objective of the proposed project is to implement modern water resources management technologies in the Dnieper basin countries of Ukraine, Russian Federation and Belarus, such as:

- remote sensing hydrology,
- watershed modelling,
- flood and drought forecasting,
- regional meteorological modelling,
- analyses of climate change data,
- optimization of reservoir operation,
- prediction of the regional aspects of the global climate changes.

These tools should be utilised to strengthen transboundary coherence of river flow (including flood and drought) as well as forecasting and improving water management in the transboundary Dnieper River basin.

[26] Dr. Andriy Demydenko, Ukrainian Center for Environmental and Water Projects

4.6. Slovakia[27]

The Slovak National Strategy for Climate Change (2009) defines land use, agriculture (irrigation pattern), industrial production (particularly energy production), navigation and drinking water supply as the most important in terms of integrated drought management. The implementation of IWRM approaches is recognized as the efficient response to reduce the consequences of drought and water shortage. The IWRM approaches include technical solutions, in a combination with sound economic and legal instruments. Modelling of possible future scenarios as well as identification of areas vulnerable to drought risks will serve a basis for the drought management strategy. The models and research should identify new parameters of hydrological regimes and appropriate responses. It is proposed to define long-term and special technical measures as follows:

Long-term (preventive) Measures

- Design of special plans for land management during periods of extreme droughts;
- Planning and management of water resources in several annual cycles;
- Support of long-term hydrometeorological drought forecasting;
- Support of drought-related scientific research programmes;
- Educating general public about water conservation and rational use.

Special (technical) Measures

- Establishing rational hydro-ecological limit values of water discharges in rivers for the healthy functioning of the river basin in emergency situations;
- Establishing specific limits of surface and groundwater resources use, depending on the hydrological situation (analogy with levels of flood activity);
- On-line monitoring of surface and groundwater resources, introduction of the soil moisture monitoring as a primary indicator of the beginning of a drought and its relation to medium-term hydrometeorological forecasts;
- Regular monthly and annual hydrological and water management assessment.

One of the important technical measures is proposed as a pilot project regarding **the improvement of soil water holding capacity**[28].

The water holding capacity of soil is a very important agronomic characteristic to be considered in drought management. Soil water holding capacity is determined by several factors. Although some factors are beyond human control, others, such as soil organic matter content and soil texture can be managed. Moreover, measures implemented to improving the soil texture and variability of water balance in the entire watershed (landscape) can be beneficial, both in terms of preventing drought and improving food security. Development of the watershed which reduces surface water runoff and extends its duration, e.g. through a shortening of the periods when the earth surface has no vegetation cover is particularly important. Slovakia has well developed digital models and soil information system, thus the implementation of technical soil management measures will be in favour of both agriculture and water regime. These technical measures include:

[27] Elaborated by Dr. Jana Poórová, RNDr. Pavol Faško, Dr. Olga Majerčáková, RNDr. Peter Škoda, Ms. Lívia Lešková, Slovak Hydrometeorological Institute Bratislava and Prof. Milan Lapin, Comenius University, Bratislava. Compilation and editing by Eng. Milan Matuška, GWP CEE Secretariat and Dr. Peter Rončák, GWP Slovakia

[28] Prof. Pavol Bielek, Slovak Agricultural University in Nitra

- identification of compacted soils in the agricultural area (detailed soil information system has been already finalized and is available for each controlled land (field) in Slovakia, where about 800,000 hectares of soils are compacted, i.e. the soils of reduced water-holding capacity),
- selection of priority fields where water-holding capacity is reduced critically,
- financial support from Agri-Environmental Program for sub-soiling technology purchasing and subsidizing sub-soiling application
- implementation of sub-soiling technology in selected priority fields.

Implementation of the Program will increase the water retention of targeted territories and increase the yield of agricultural plants with about 20 to 40% without compromising the water demands. This pilot project is replicable in other countries.

It is also recommended to continue and upscale the research project is being conducted by the Technical University Zvolen that deals with **the assessment of drought stress in forest**. Because of the significant economic and environmental importance of forest in the CEE countries, this issue could also be included into GWP CEE regional IDMP. The objective of the project is to quantify the drought stress on damage to woody plants. It involves employment of drought indices (SPI) and the physiological response of the forest. The project comprises the following work packages:

- Work package 1:: Proposal of a drought index specifically adapted to woody plant species
- Work package 2: Evaluation of eco-physiological aspects of growth and health status of spruce and beech stands in connection to drought stress
- Work package 3: Integration of the evapo-transpiration model into the growth model SIBYLA and its extrapolation with the aid of GIS.

The proposed approach will consider both short-term (day-day) dynamics of climate factors, including short-term changes in water accessibility, the actual water demands of the relevant forest stand determined by its species composition as well as structure and current evaporation conditions. This comprehensive approach to drought evaluation can also be implemented on a greater scale.

Finally, the proposal for the IDMP program is **to enhance integrated monitoring system** that will link partial monitoring systems, particularly meteorological, agriculture, forest and hydrological monitoring systems. Specifically, the following steps are recommended at the national (Slovak) level:

Meteorological drought monitoring: This would be developed in line with the WMO programme and it would be implemented together with the Slovak Hydrometeorological Institute.

Hydrological drought monitoring: This will be shaped according to the progress achieved in the EU Water Scarcity and Drought Expert Network in which Slovak experts actively participate.

Agricultural drought monitoring: This is under the responsibility of the Ministry of the Agriculture and at this time there are no planning documents dealing with this issue.

Forest drought monitoring: The methods were produced by Forest Faculty of the Technical University Zvolen, and verified in practice by Forest Research Institute in Zvolen.

This program requires a thorough cooperation between several sectors and central governmental bodies.

4.6.1. Literature

The 5th National Communication of the Slovak Republic on Climate Change (2009): Slovak Ministry of the Environment and the SHMI, URL: http://unfccc.int/resource/docs/natc/svk_nc5.pdf

4.7. Poland[29]

The Institute of Meteorology and Water Management (IMWM) has been developing a concept to amplify the existing Hydrometeorological Monitoring and Warning System with drought protection and management procedures in order to issue and disseminate warnings and alerts on drought. The system of cooperation and communication between water management institutional structures dedicated to flood protection and management is illustrated on Fig. 4.7.1.

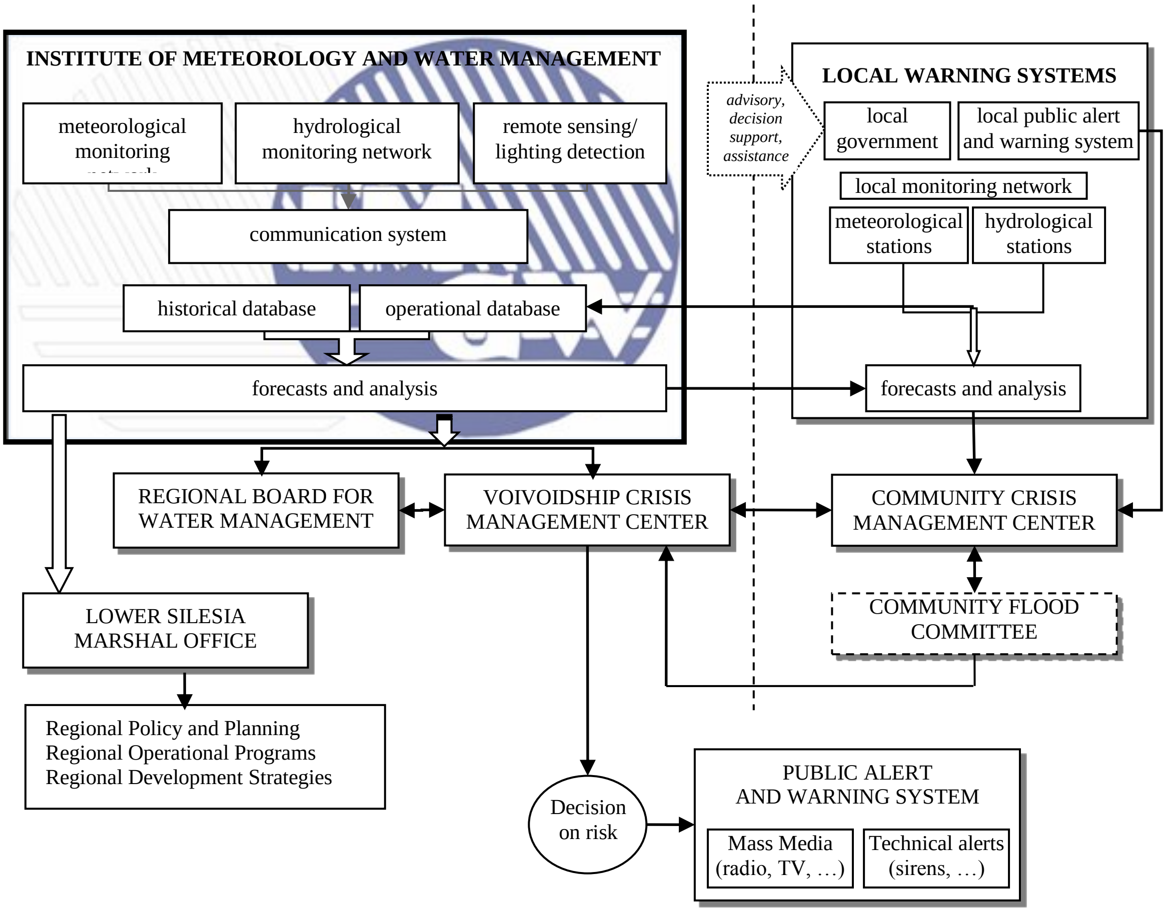

Fig. 4.7.1. Integrated Hydrometeorological Monitoring and Warning System

The recommendation is to develop and enhance the **drought monitoring and forecasting tools and risk assessment procedures** to support decision making. The proposed project is being developed within the framework of the study conducted by IMWM titled "Environmental, economic and social impacts of climate change". The scheme includes detection of meteorological and hydrological drought, analysis of drought intensity and duration, and drought hazard evaluation. The central assumptions are as follows:

- to apply methods that use standard meteorological and hydrological parameters measured within a hydrometeorological monitoring network operated by IMWM,

[29] Dr. Tamara Tokarczyk and Dr. Wiwiana Szalińska, Institute of Meteorology and Water Management in Wroclaw, Poland. Comments to the regional study on "Increasing Soil Water Holding Capacity: An Example of Best Practice" proposed by Country Water Partnership Slovakia, by Prof. Andrzej Kedziora, Institute for Agriculture and Forest Environment, Polish Academy of Sciences, Poznan - Country Water Partnership Poland.

- to enhance existing hardware and software infrastructure,
- to meet the expectations of the users of hydrological forecasting offices: the institutions responsible for water management, water users, crisis management centres and the society.

Operational application of drought management requires developing multipurpose software for drought hazard assessment which is able to run analysis and provide results in a real time. In order to facilitate the work of the hydrological forecast office, it is required to incorporate the drought indices estimations and analysis routines into the System of Hydrology (SH), operating within the framework of Monitoring, Forecasting and Warning System (SMOK). SH is a software platform aimed at data harmonization and data management, analysis and visualization, effective hydrological modelling, multi-task applications and product generation. The specific requirements for each analytical component of the developed software package for drought hazard assessment are determined by data availability, functional objectives and users' requirements.

The functionalities of the multi-data systems are as follows:

- detection of various stages of drought, including meteorological and hydrological drought identification,
- tracing of temporal variability of drought up to present time,
- mapping of drought spatial distribution,
- providing a standardized and dimensionless measure of drought intensity, and
- information on vulnerability to drought formation.

The following table summarizes the groups of meta-data products, targeted users and type of drought information to be available to target users.

Tab. 4.7.1: Groups of products and end-user specification of drought hazard assessment scheme

Group of products	Specification of relevance	Information on drought	End-user
Reports	Historical and statistical reports for meteorological and hydrological yearbooks, R&D	Multi-criteria historical droughts evaluations and analysis	Researchers, experienced and eligible customers
Maps & Graphs	Data and results visualization: multilayer GIS maps, temporal variability plots, web-site presentations	Values of drought indices plotted over the region at different administrative and physiographic resolution	Public and society
Warnings	Elaboration and distribution of forecasts, preparation of hydrological messages and issue of warnings	Drought hazard communications and warnings	Professional users, forecasters

Currently, several drought indices are applied in Poland. These include Effective Drought Index (EDI), Standardized Precipitation Index (SPI), Flow Duration Curve (FDC) and NIZOWKA (Dynamic shortage of water resources index). These drought indices are suited for different contexts. It is proposed to translate and interpret these indices for operational use (end users), so called a combined application scheme.

Figure 4.7.2 presents the combined scheme for operational drought hazard assessment with interactions with the existing infrastructure.

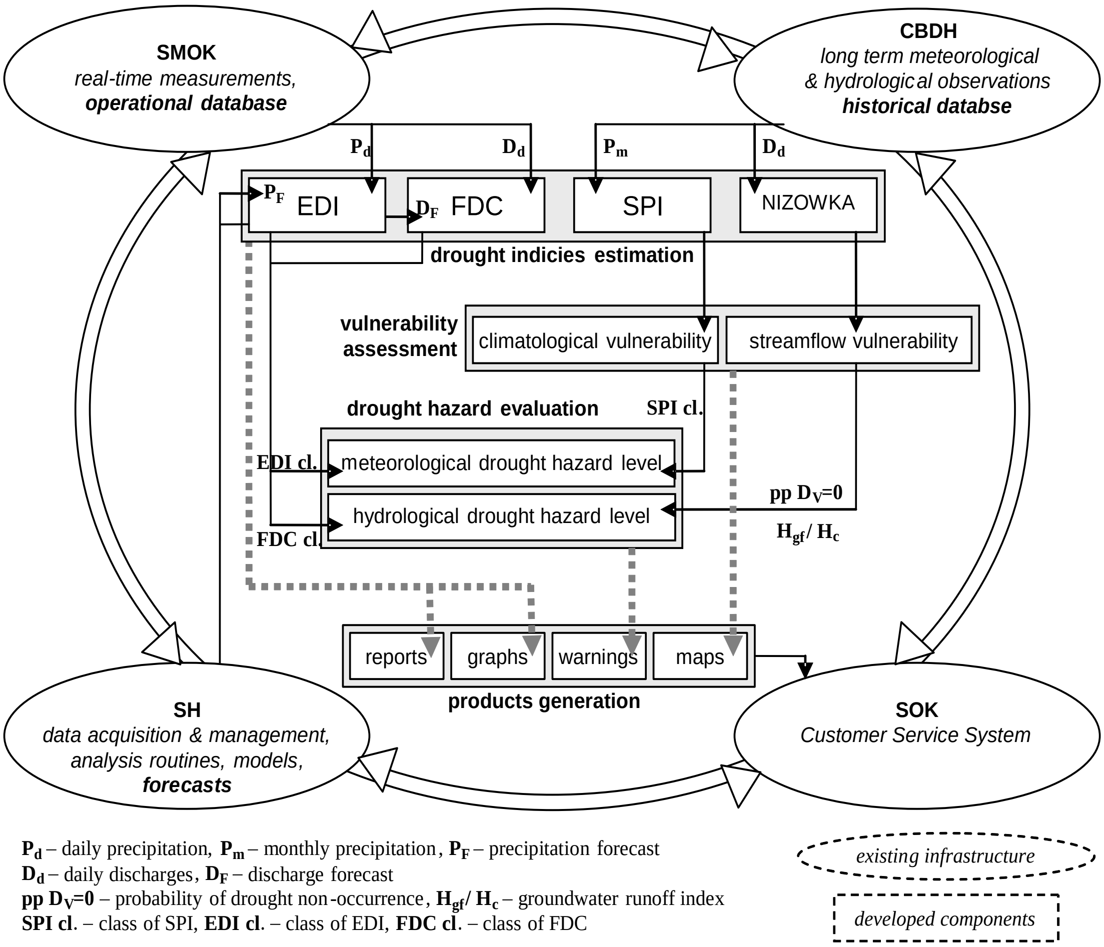

Fig. 4.7.2: Concept of operational drought hazard assessment scheme.

It is proposed to pilot the concept of operational drought hazard assessment scheme in the middle Odra basin case study.

The other proposal is to conduct a study on **the development of the indicator for soil moisture assessment based on rainfall data**. Appropriate soil management will aid the process of drought management. Through the development of an indicator for soil moisture, based on precipitation and runoff of water, it is possible, with the use of drought indices, to identify meteorological and hydrological drought phases. A combined analysis of recognized meteorological and hydrological drought events will be the basis to detect a number of days that rainfall influence soil moisture conditions and a number of days associated with depletion of water resources for particular river basin. The project would consist of the following steps:

- Selection and adoption of drought indices to evaluate meteorological and hydrological conditions with the required temporal resolution (days, decades, months);
- Combined analysis of meteorological and hydrological drought phases for historical low-flow events;
- Identification and parameterization of soil drought phases for recognized events;
- Classification of soil moisture conditions based on the preceding rainfall data and catchment's characteristics;
- Elaboration of indicator for actual soil moisture assessment based on preceding rainfall totals.

Section 5: Conclusions and Recommendations for the IDMP Initiative

It is acknowledged that drought is a complex phenomenon to identify and predict and it can have tremendous impacts on local and even national economies. The main guiding principles for drought risk reduction include political commitment; knowledge development; drought policies that focus not only reactive approaches but also on proactive approaches like adaptation strategies development; drought monitoring, risk assessment, identification of appropriate risk reduction measures; developing policy mechanisms to enforce drought reduction strategies; and long-term investments.

Although drought has scores of definitions, it originates from a deficiency of precipitation over an extended period of time, usually a season or more, but it is a normal, recurrent feature of climate. There are three basic types of droughts, namely: meteorological, agricultural and hydrological. Their impact on society results from the interplay between a natural event and the demand people place on water supply. Recent droughts and the resulting economic and environmental impacts, have underscored worldwide the vulnerability of societies to this natural hazard.

As shown in this report (***Section 2***), significant part of the CEE region is vulnerable to frequent occurrence of droughts that have adverse consequences on the people living in drought-prone areas through their impact on water scarcity, land degradation, agricultural production and ecosystems degradation. Climate variability is high in the region both temporally and spatially. In addition, climate change already amplifies the frequency and severity of droughts in the region.

The common feature across the CEE countries is that all of them are especially sensitive in respect to both the variability and change in precipitation. The most probable future climate development in CEE region is directed towards warm and slightly drier summers, warm winters with a rather unchanged average level of annual rainfall and an increased frequency of extreme weather events. If these changes persist, they will clearly result in the increase of drought hazards. Another common feature of CEE countries is that in all of them, the sector most vulnerable to drought losses is agriculture. However, in the severe drought situation shortages, water supply to population and industry may also be affected.

Concerning current policies regarding drought monitoring and management in the CEE region (***Section 3***), the situation differ considerably in individual countries. The effects of drought are due not only to the physical nature of the hazard, but also to society's ability to manage the associated risks. Drought monitoring, prediction and early warning are not adequate in some countries of the region and obviously they need to be improved. Although most CEE countries have well developed meteorological and hydrological monitoring, these systems are not translated into concerted efforts to support decision makers in other sectors of the national economy (such as agriculture). Some countries (with a strong tradition of agriculture production) also have developed a sound agro-meteorological monitoring and drought warning system. It should be confirmed that several countries undertake serious attempts to adopt a more comprehensive and integrated approach towards drought mitigation across various sectors.

Having in mind that drought episodes have local and regional character, there is not a suitable mechanism to share information and knowledge among countries and transboundary basins. This is in spite of the fact that several basins in the region are of a transboundary character, regional integration of drought monitoring and early warning is not at the level desired. Transnational integrated approach is needed for successful tracking of drought, comparing its impacts using common methodology and assessing vulnerability of various sectors to drought occurrence.

At present, all countries of the CEE region need to improve their both short-term and long-term responses across sectors to meteorological, agricultural and hydrological droughts. Improvements in national and regional frameworks for drought monitoring, early warning and response are needed.

It should be underlined that this Inception Report is based on information obtained directly from the GWP CEE Country Water Partnerships and it represents situations in the specific countries rather than in the entire region. Thus, the following five categories of national and regional GWP CEE initiatives are proposed for IDMP (***Section 4***):

- Drought preparedness measures (investment and non-investment measures, like for example drought insurance systems,
- Enhancement (and/or development) of drought monitoring and early warning systems;
- Development of capacity building programs for water managers and farmers;
- Integrated drought management including design of real-time operational systems of different complexity;
- Development case studies to document good practices in application of integrated drought management (including transboundary basins).

As indicated in the Section 4, of the IDMP initiative envisages the following outputs:

- Knowledge base: compilation of information and knowledge on recorded practices in drought planning and management;
- Guidance on technical and institutional aspects – tools and methodologies developed to support an increased drought risk responses;
- Advocacy and increased stakeholder buy-in for the integrated drought management approach through regional and country dialogues;
- Improved drought early warning services, including monitoring and prediction and application of drought prediction products, building upon existing regional initiatives.

It is recommended to establish a web-based ***Integrated Drought Management Platform*** for detection, monitoring, forecasting and information exchange that will include:

- commonly agreed products (e.g. objectively measurable drought indices covering as many contributing parameters as possible),
- joint comparison and analysis of information,
- mutual exchange of knowledge & methodologies
- downscaling products, and
- real-time monitoring and forecasting products and services (early warning, preparedness).

To organize these anticipated outputs, it is recommended:

- To collaborate closely with WMO on the drafting the workplan on Integrated Drought Management Program (2013-2015);
- To invite the DMCSEE and the European Drought Centre (research think tank of the EU) to conduct the proposed activities and seek synergies;
- To invite and inform national secretariats of UNCCD of all CEE countries to contribute to specific case studies dealing with degradation of land caused by desertification
- To seek an appropriate mechanism and cooperation with agriculture sector at national levels
- Having in mind a transboundary context of drought risk management it is recommended to invite the UNECE and its Task Force on Climate Change Adaptation to coordinate and share achievements in IDM program in CEE region and seek a potential of the program replication in

other signatory UNECE countries (specifically those in Central Asia, where GWP has also its partners).

GWP CEE Workplan 2012

This Inception Report indicates clearly that the CEE region has adequate human capacity specialized in drought management, to launch the IDM Programme. Final decisions concerning the scope and scale of the GWP CEE IDMP depend on the available funds and certainly will be further discussed by different gremia. Although the workplan 2012 is limited to GWP activities, it is envisaged that other strategic allies (WMO, DMCSSE and EDC) will be informed on anticipated program.

To start the GWP CEE part of the WMO/GWP IDMP, it is proposed to embark on two principal activities (August -December 2012):

1. Organization of the **Regional Workshop on Integrated Drought Management Platform** comprising regional drought experts in CEE CWPs together with representatives of WMO, DMCSEE, EC (DG Environment) UNECE, UNCCD regional focal points. The main objective of the workshop is to formulate and commit to the IDMP initiative. Decision makers of agriculture sector of selected countries should be also invited.

   The Water Research Institute in Prague, the Slovak Hydrometeorological Institute in Bratislava and the Warsaw University of Life Sciences in Poland are preliminarily proposed localities for the workshop. Depending on travel cost the decision will be made regarding the venue. The cost of the workshop should be bear by GWP CEE and WMO (estimate of max. 50 participants).

2. Implementation of the regional study on "**Increasing Soil Water Holding Capacity: An Example of Best Practice in Drought Mitigation**"**.** This study was proposed by CWP Slovakia and deals with measures to increase soil water holding capacity. The soil water holding capacity is a key attribute of soil quality. Water holding capacity is determined by several factors, some of which are beyond our control but some of which can be managed. Management practices designed to improve soil structure are the main way to improve water holding capacity and contribute to increase resilience to drought risks. The target group is agriculture sector. The estimated budget of the project is 15,000 EUR.

Proposal for GWP/WMO program on Integrated Drought Management Platform (2013-2015)

The main objective of the workshop organized in 2012 is to define and prioritize activities for a joint GWP/WMO program. The overall objective of the Program is to provide policy and management guidance, sharing best practices and knowledge for drought management.

It is a medium-term initiative (2013-2015) that will result in an establishment a Drought Help Desk. The basic principles are as follows:

- To shift the focus from reactive to proactive measures through mitigation, reduction of vulnerability and preparedness
- To integrate the vertical planning and decision making processes at regional, national and community levels into a multi-stakeholder approach involving key sectors (agriculture, energy)
- To promote the evolution of the drought knowledge base and to establish a mechanism for sharing knowledge
- To provide access to information and knowledge at all levels
- To build capacity of various groups of stakeholders.

The following list of potential activities and measures are proposed by GWP CEE. Depending on agreement with program partners (WMO and others) and financial feasibility, the priority areas and detailed workplan (2013-2015) will be agreed by the end of 2012.

The list of measures, activities, studies in the IDM Programme

- **Preventative measures** (the hydrological planning to be considered in RBM plans)
- **Operational measures** (provision of information, access to monitoring data, water control – use restriction in periods of extreme droughts)
- **Organizational measures** (institutions, capacity building, coordination mechanisms)
- **Follow-up measures** and restoration or exit drought measures.

Other important elements of the future IDMP program are:

- Development of tools for early alarm system using spatial decision modelling
- Assessment and guidance on new drought indices (PDSI, PMDI, etc.)
- Enhancement of institutional aspects of monitoring system (integration of hydrological, meteorological and agriculture monitoring)
- Optimization of functioning of water storage reservoirs
- Development of capacity building programs for water managers and farmers.

The significant amount of proposals came from GWP CEE experts that regard case studies and pilot studies to test best practices of various aspects of drought management. These include:

- Case studies of agro-meteorological observations of extreme events
- Case studies on drought management in transboundary basins (Tisza and Dnieper)
- Case studies on revitalisation of wetlands as part of climate change adaptation strategies

Auxiliary studies and projects of importance for drought management

- Special study on “Increasing soil water holding capacity as one of the basic drought management measures”, proposed by GWP Slovakia
- Special study on “Assessment of drought stress in forest stands from the viewpoint of water balance of trees and stands”, proposed by GWP Slovakia
- National study on “Identification of gaps in monitoring and drought management to be bridged”, proposed by GWP Slovakia
- Special study on “Elaboration of an indicator for soil moisture assessment based on rainfall data” proposed by GWP Poland.

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