Integrated Drought Management Programme

ACTIVITY 5.4. DROUGHT RISK MANAGEMENT SCHEME: A DECISION SUPPORT SYSTEM

MILESTONE NO. 1.2.

IDENTIFICATION OF THE NATIONAL MEASURES FOR DROUGHT VULNERABILITY ASSESSMENT

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Name of the milestone:	Identification of the national measures for drought vulnerability assessment
WP:	
Activity:	5.4. Drought Risk Management Scheme: a decision support system
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1. Introduction

The report contains an inventory of drought measures (indicators) that are applied to evaluate drought impacts and vulnerability to drought in countries involved in the Project Activity 5.4. The inventory covers the methodology to characterize drought impacts and vulnerability assessment along with the revision of the most vulnerable national sectors to drought and the stakeholders identification.

Understanding drought's evolution, complexity, and drought impacts including vulnerability to drought, permits implement effective mitigation and preparedness measures to reduce drought impacts. To this end, comprehensive and well-coordinated drought management at international, regional, and national levels are needed to build drought resilient societies and economies.

Vulnerability assessment is also crucial aspect for developing national drought management plans (DMP) arising from EU Water Framework Directive. Drought risk management is the subject of many formal documents (among others acts of law too) released in the recent time. The main documents are summarized below.

Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (so-called Water Framework Directive). The purpose of the directive is to establish a framework for the protection of all waters, including inland surface waters, transitional waters, coastal waters and groundwater. The directive isn't directed to the drought but some aspects of it are taken into account. The environmental objectives determined in the Water Framework Directive are the core of the EU legislation providing for a long-term sustainable water management based on a high level of protection of the aquatic environment. They should be achieved for all so-called water bodies in the form of good ecological status. Drought episodes can greatly affect the availability of water resources and impact the status of water bodies and associated ecosystems, which needs to be avoided by all means. The frameworks for the protection of water bodies:

- prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems,
- promotes sustainable water use based on a long-term protection of available water resources,
- aims at enhanced protection and improvement of the aquatic environment, inter alia, through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances,
- ensures the progressive reduction of pollution of groundwater and prevents its further pollution,
- contributes to mitigating the effects of floods and droughts and thereby contributes to:
- the provision of the sufficient supply of good quality surface water and groundwater as needed for sustainable, balanced and equitable water use,
- a significant reduction in pollution of groundwater,
- the protection of territorial and marine waters,
- achieving the objectives of relevant international agreements.

Communication from the Commission of the European Communities to the European Parliament and the Council addressing the challenge of water scarcity and droughts in the European Union. The communication is the main document concerning drought in the European Union at the moment. It distinguishes two basic terms connected to the lack of water:

- drought – means a temporary decrease in water availability due for instance to rainfall deficiency (natural phenomenon),
- water scarcity – means that water demand exceeds the water resources exploitable under sustainable conditions (anthropogenic causes).

But both water scarcity and droughts are treated not just a matter for water managers but rather as situations with direct impact on citizens and economic sectors which use and depend on water (such as agriculture, tourism, industry, energy and transport). The communication presents 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. According to the communication the following challenges need to be addressed:

- Progressing towards full implementation of the Water Framework Directive.
- Ineffective water pricing policies which generally do not reflect the level of susceptibility of water resources at local level.
- Land-use planning (in order to change policy-making patterns and to move forward effective land-use planning at the appropriate levels).
- Huge potential for water saving across Europe – policy making should be based on a clear water hierarchy (water uses should also be prioritised); it is clear that public water supply should always be the overriding priority to ensure access to adequate water provision.
- Further integration of water-related concerns into water-related sectoral policies (in order to move towards a water-saving culture).
- Policy action on water scarcity and droughts (needs to be based on high-quality knowledge and information on the extent of the challenge and projected trends).

The proposed policy orientations for future action are the following:

- putting the right price tag on water.
- allocating water and water-related funding more efficiently:
- improving land-use planning,
- financing water efficiency,
- Improving drought risk management:
- developing drought risk management plans,
- developing an observatory and an early warning system on droughts,
- further optimising the use of the EU Solidarity Fund and European Mechanism for Civil Protection
- Considering additional water supply infrastructures.
- Fostering water efficient technologies and practices.
- Fostering the emergence of a water-saving culture in Europe.
- Improve knowledge and data collection:
- a water scarcity and drought information system throughout Europe,
- research and technological development opportunities.

A Blueprint to Safeguard Europe's Water Resources

The European Commission declares that water is essential for human life, nature and the economy – so proposes the Blueprint to Safeguard Europe’s Water Resources, which aims to tackle the obstacles which hamper action to safeguard Europe's water resources and is based on an extensive evaluation of the existing policy. Its long-term purpose is to ensure the sustainability of all activities that impact on water, thereby securing the availability of good-quality water for sustainable and equitable water use. This goal is already enshrined in the WFD in various ways. The Blueprint will help to achieve the goal by identifying obstacles and ways to overcome them.

The Blueprint recognises that the aquatic environments differ greatly across the EU and therefore does not propose any one size fits all solution, in line with the principle of subsidiarity. It emphasises key themes which include: improving land use, addressing water pollution, increasing water efficiency and resilience, and improving governance by those involved in managing water resources. The specific Blueprint objectives are:

- efficiency incentive water pricing,
- metering take up,
- water use reduction in agriculture,
- reduction of illegal abstraction/impoundments,
- awareness of water consumption (e.g. embedded in globally traded goods),
- maximisation of the use of Natural Water Retention Measures (Green Infrastructure),
- efficient water appliances in buildings,
- reduction of leakages,
- maximisation of water reuse,
- improvement of governance,
- implementation of water accounts,
- implementation of ecological flow,
- application of target setting,
- reduction of flood risk,
- reduction of drought risk,
- better calculation of costs and benefits,
- better knowledge base,
- support to developing countries,
- tackling pollution,
- cross-cutting.

To achieve above mentioned objectives the following actions are proposed:

- develop CIS Guidance on Natural Water Retention Measures (Green Infrastructure),
- green CAP pillar I to support Natural Water Retention Measures (through ecological focus areas),
- use Structural & Cohesion Funds & EIB loans to support Natural Water Retention Measures,
- develop CIS Guidance on ecological flow (and water accounts),
- apply GMES services to detect illegal abstraction.

EC Guidelines: Drought Management Plan Report Including Agricultural, Drought Indicators and Climate Change Aspects, Technical Report

This report presents general guidelines to develop a Drought Management Plan, which while not an obligation to Member States, can be a powerful tool to alleviate drought impacts. The application of a DMP must in any case comply with WFD environmental objectives. The report summarizes the main items needed to develop a Drought Management Plan (DMP):

- Indicators and thresholds establishing onset, ending, and severity levels of the exceptional circumstances (prolonged drought).
- Measures to be taken in each drought phase in order to prevent deterioration of water status and to mitigate negative drought effects.
- Organizational framework to deal with drought and subsequent revision and updating of the existing drought management plan
- A DMP should also include a section dedicated to so-called prolonged drought.

The report reflects the change of drought management – from crisis management to drought planning (based on developing comprehensive, long-term drought preparedness policies and plans of actions that may significantly reduce the risks and vulnerabilities to extreme weather events). According to the report a DMP should provide a dynamic framework for an ongoing set of actions to prepare for, and effectively respond to drought, including: periodic reviews of the achievements and priorities; readjustment of goals, means and resources; as well as strengthening institutional arrangements, planning, and policy-making mechanisms for drought mitigation. DMP should be prepared in advance before it is needed, based on relevant country specific legislation and after careful studies is carried out concerning the characterization of the drought in the basin, its effect and the mitigation measures.

DMP is closely linked with Water Framework Directive (WFD) criteria and objectives. The purpose of the WFD is to enhance the protection of water bodies and the status of aquatic ecosystems by promoting sustainable water use. The WFD places the integrity of freshwater ecosystems at the core of water management. Measures to prevent and alleviate drought consequences and water scarcity are thereby entirely appropriate within its context. The scale for applying the DMP within the WFD framework should be the river basin or a sub-basin that makes a management system. The main objective of DMP is to minimize the adverse impacts on the economy, social life and environment when drought appears. It also aims at extending WFD criteria and objectives to realize drought management. This general objective of DMP can be developed through a series of specific objectives that might include:

- Guarantee water availability in sufficient quantities to meet essential human needs to ensure population's health and life.
- Avoid or minimize negative drought impacts on the status of water bodies, especially on ecological flows and quantitative status for groundwater and in particular, in case of prolonged drought.
- Minimize negative effects on economic activities, according to the priority given to established uses in the River Basin Management Plans, in the linked plans and strategies (e.g. land use planning).

DMP should reflect multilevel approach. At national level, focus should be put in policy, legal and institutional aspects, as well as in funding aspects to mitigate extreme drought effects. National level measures should determine drought on-set conditions through a network of global indices and indicators at the national or regional level global basin indices/indicators network, which for instance can activate drought decrees for emergency measures with legal constraints or specific budget application. DMPs at river basin level are contingency management plans supplementary to River Basin Management Plans – they are mainly targeted to identify and schedule on-set activation tactical measures to delay and mitigate the impacts of drought. Moreover River Basin Management Plans have to include a summary of the programmes of measures in order to achieve the environmental objectives and may be supplemented by the production of more detailed programmes and management plans (e.g. DMPs) for issues dealing with particular aspects of water management. At local level, tactical and response measures to meet and guarantee essential public water supply as well as awareness measures are the main issues.

In order to achieve the specific DMP objectives, three basic elements should support a DMP:

- a drought early warning system,
- drought indicators correlation with thresholds for different stages of drought as it intensifies and recedes,
- measures to achieve specific objectives in each drought phase.

In the development of the DMP, it is necessary to ensure transparency and public participation. A possible content for the documents integrating the DMP may include:

- General basin characterisation under drought conditions.
- The river basin's experience on historical droughts.
- Characterization of droughts within the basin.
- Drought warning system implementation.
- Program of measures for preventing and mitigating droughts linked to indicators systems.
- Organizational structure of the DMP (identification of competent entity, committee or working group to identify drought impacts and propose management measures).
- Update and follow-up of the DMP.
- Public supply specific plans.
- Prolonged drought management.

The associated part of DMP should always be programme of measures concerning mitigation measures classified as:

- preventative or strategic measures,
- operational (tactical) measures,
- organizational measures,
- follow-up measures,
- restoration or exit drought measures.

Identification and structure of program of measures should correspond to indicators status, including:

- normal status,
- pre-alert status,
- alert status,
- emergency or extreme status.

A critical component within drought management is the continuous observation and evaluation of the development of a drought event.

WMO Guidelines: Guidelines for National Drought Management Policies and Preparedness Plans

The intent of the policy development and planning process described in this report is to provide a set of generic steps or guidelines that nations can use to develop the overarching principles of a national drought policy aimed at risk reduction and the development of drought mitigation and preparedness plans at the state level that provide the framework for the implementation of the principles of the national drought policy. Following these guidelines, a nation can significantly change the way they prepare for and respond to drought by placing greater emphasis on proactively addressing the risks associated with drought through the adoption of appropriate mitigation actions. The risk assessment methodology embedded in this process is designed to guide governments through the process of evaluating and prioritizing impacts and identifying mitigation actions and tools that can be used to reduce the impacts of future drought episodes. Both the policy development process and the planning process must be viewed as ongoing, continuously evaluating the nation's changing exposure and vulnerabilities and how governments and stakeholders can work in partnership to lessen risk.

The report defines four principal elements of a Drought Risk Reduction Policy Framework:

- risk and early warning, including vulnerability analysis, impact assessment, and communication;
- mitigation and preparedness, including the application of effective and affordable practices;
- awareness and education, including a well-informed public and a participatory process;
- policy governance, including political commitment and responsibilities.

Another important component of this framework is the inclusion of policy options for emergency response and relief. The national drought management policy is treated as a process according to 10 steps for policy and preparedness planning. The process is intended to be generic, i.e., applying this methodology in each country setting would require adapting it to the current institutional capacity, political infrastructure, and technical capacity that already exists.

There are the following steps:

Step 1: Appoint a national drought management policy commission

Step 2: State or define the goals and objectives of a risk-based national drought management policy

Step 3: Seek stakeholder participation; define and resolve conflicts between key water use sectors

Step 4: Inventory data and financial resources available and identify groups at risk

Step 5: Prepare/write the key tenets of a national drought management policy and preparedness plans, which would include the following elements:

- monitoring, early warning and prediction,
- risk and impact assessment,
- mitigation and response.

Step 6: Identify research needs and fill institutional gaps

Step 7: Integrate science and policy aspects of drought management

Step 8: Publicize the national drought management policy and preparedness plans and build public awareness

Step 9: Develop educational programs for all age and stakeholder groups

Step 10: Evaluate and revise national drought management policy and supporting preparedness plans

2. Identification of national sectors vulnerable to drought

Lithuania

Municipal water supply to the settlements in the Lithuanian is completely based on the groundwater use; the risk of water shortage due droughts only occurs in rural areas where the shallow groundwater is used. Droughts may also affect the quality of shallow ground water.

Droughts cause the reduction of some small rivers runoff with lowering of water levels and deterioration of water quality as well as recreational potential.

The reduction of soil water content, lower ground water levels could lead to degradation of ground water quality. There is likely deterioration of biodiversity characteristics including a possible reduction of the habitat of indigenous species due to drying out of habitat areas.

The water scarcity for the industry in total is unlikely to occur because of good availability of groundwater in Lithuania. It is likely a negative impact of droughts on the objects of recreation due to reduction of water levels. The increased contamination of surface waters may occur due to decreased runoff during drought. The reduction of runoff in summer has insignificant impact on the industry development but may negatively influence to the water quality in receiving water bodies considering water scarcity for dilution of wastewaters deteriorating their quality. Certain risk exists due droughts for hydropower facilities.

Loss of productivity and quality of timber (lack of moisture may provoke drying and reduction of forest cover). Droughts significantly increase probability of forest and peat bog fires. The number of forest fires and the area affected by fires is highly correlated with the intensity of droughts. In last decades the most intensive droughts were in 1992, 1999, 2002 and 2006, consequently the largest number of forest fires was in the same years (figure 1).

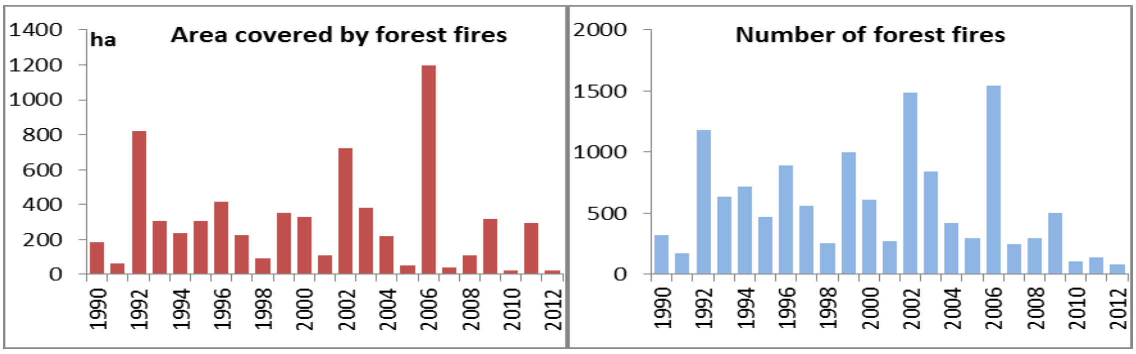
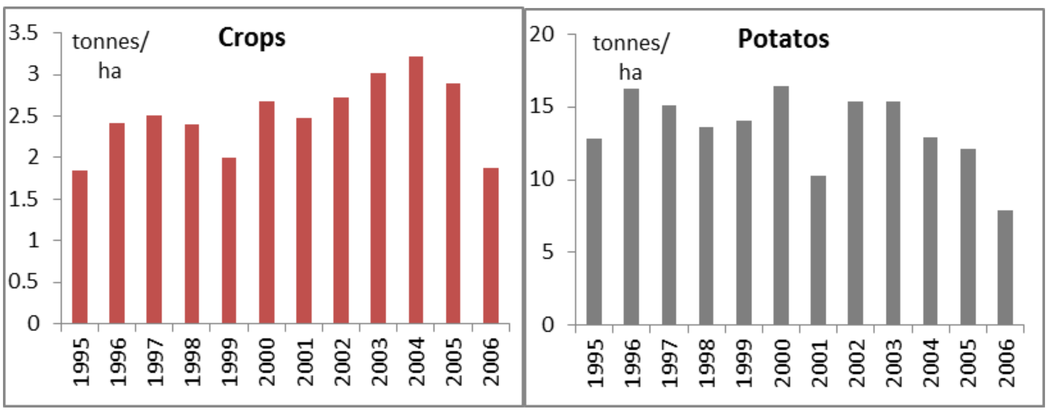


Figure 1: The dynamics number of forest fires and the area of forests affected by fires in 1990-2012.



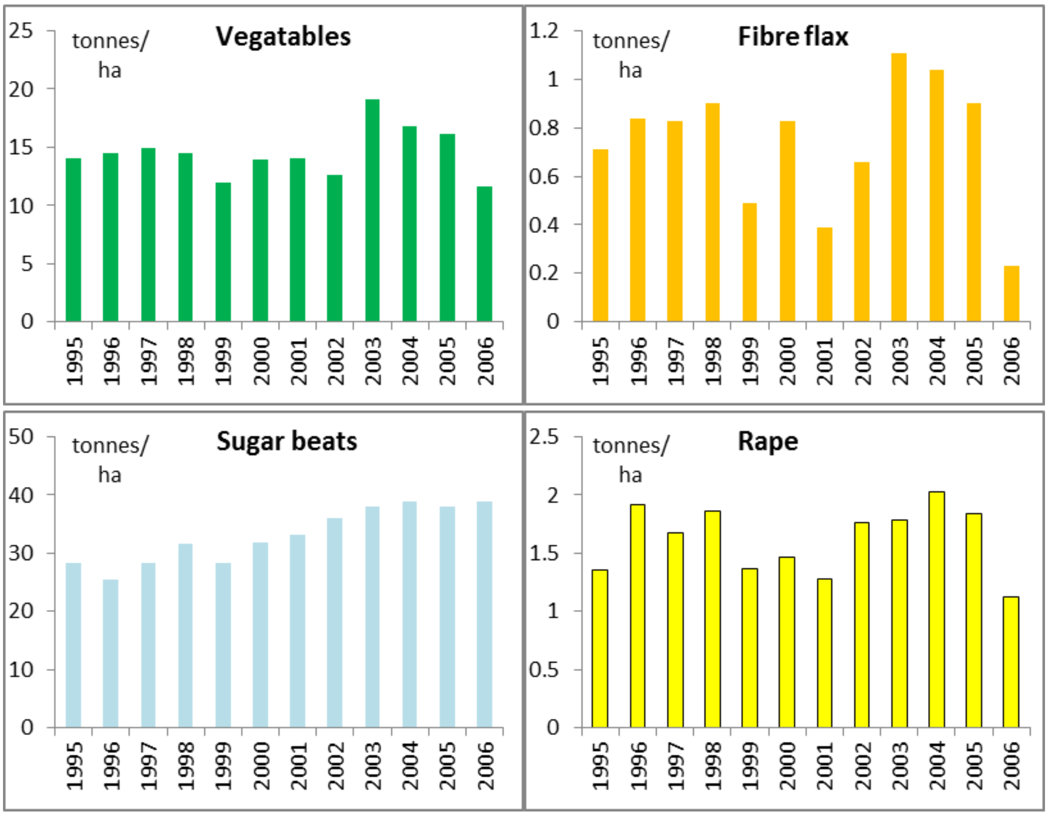


Figure 2. The dynamics of productivity of agricultural plants in 1995-2006 (data: Šapolaitė and Skulskis 2008).

The fall in crop productivity is the main impact of droughts in Lithuania. In 1995, 1999 and 2006 due to droughts the productivity of crops was less than 2 tonnes/ha (figure 2). In 2002 the long drought had the largest impact on productivity of forage plants (Šapolaitė and Skulskis 2008), but effect on other agricultural plants was merely noticeable. The costs of drought impacts due to last intensive drought in 2006 were 200 million €.

Poland

There are some economic sectors vulnerable to drought. Their vulnerability to drought is dependent on many aspects like location or intensity (both drought and water use). The volume of water used by main water users is presented in table 1, 2 and 3.

SPECIFICATION	2000	2005	2010	2011	2012
	hm^3				
T O T A L	11048,5	10940,3	10866,4	11152,2	10830,3
Surface waters	9150,6	9205,7	9172,6	9461,6	9142,9
Groundwater	1747,3	1640,4	1625,2	1628,5	1629,8
Water from mine and building constructions drainage (used for production)	150,6	94,2	68,6	62,1	57,7
Production purposes[a]	7637,9	7734,1	7650,7	8008,1	7697,1
Surface waters	7221,5	7420,9	7382,3	7740,0	7439,1
Groundwater	265,8	219,0	199,8	206,0	200,3
Water from mine and building constructions drainage (used for production)	150,6	94,2	68,6	62,1	57,7
Irrigation in agriculture and forestry and filling and completing fishponds	1060,6	1101,0	1153,3	1111,2	1102,4
Surface waters	1060,6	1101,0	1153,3	1111,2	1102,4
Exploitation of water supply network	2350,1	2105,2	2062,4	2033,0	2030,8
Surface waters	868,5	683,8	637,0	610,5	601,4
Groundwater	1481,5	1421,4	1425,4	1422,5	1429,5

[a] Excluding agriculture, forestry, hunting and fishing
– from own intakes.

Table 1: Water withdrawal for needs of the national economy and population by sources of withdrawal (Central Statistical Office 2015)

HYDROGRAPHIC REGIONS	Total		For purposes of						
			production [a] (from own intakes)			irrigation in agriculture and forestry [b]	exploitation of water sypply network [c]		
			total	waters			total	water	
				surface water	groundwater			surface water	groundwater
	in hm^3	per km^2 in dam^3	in cubic hectometres						
T O T A L	10830,3	34,6	7697,1	7439,1	200,3	1102,4	2030,8	601,4	1429,5
WISŁA BASIN	6095,7	36,4	4358,1	4212,0	104,8	584,3	1153,2	490,1	663,1
Wisła from the source up to the Dunajec estuary	807,9	63,4	395,1	342,6	15,9	95,2	317,6	249,7	67,8
Dunajec basin	54,1	10,7	15,4	13,4	2,0	0,7	37,9	26,1	11,9
Wisła from the Dunajec estuary up to the Wisłoka estuary	1261,0	183,2	1168,7	1163,9	2,6	57,7	34,6	1,0	33,6
Wisłoka basin	24,4	5,9	3,8	2,7	1,0	1,2	19,4	12,0	7,4
Wisła from the Wisłoka estuary up to the San estuary	34,6	13,0	6,8	5,4	0,9	17,7	10,1	-	10,1
San basin	232,3	15,4	135,1	131,0	4,1	33,5	63,7	30,2	33,5
Wisła from the San estuary up to the Wieprz estuary	164,5	24,1	102,8	94,8	8,0	30,5	31,2	0,2	31,0
Wieprz basin	150,0	14,4	10,0	1,1	7,8	90,7	49,3	0,9	48,5
Wisła from the Wieprz estuary up to the Pilica estuary	1662,2	386,6	1621,0	1618,4	2,6	16,6	24,6	0,2	24,5
Pilica basin	99,2	11,5	7,2	0,6	6,5	35,7	56,3	8,4	47,9
Wisła from the Pilica estuary up to the Narew estuary	361,9	82,3	216,0	207,9	7,5	21,5	124,4	94,6	29,8
Narew from the source up to the Biebrza estuary	53,0	8,3	3,7	–	3,7	21,0	28,3	8,5	19,8
Biebrza basin	19,3	2,8	2,9	–	2,9	2,4	14,0	–	14,0
Narew from the Biebrza estuary up to the Bug estuary	625,3	43,2	558,4	552,5	5,9	32,6	34,4	0,0	34,4

HYDROGRAPHIC REGIONS	Total		For purposes of						
			production [a] (from own intakes)			irrigation in agriculture and forestry [b]	exploitation of water sypply network [c]		
			total	waters			total	water	
				surface water	groundwater			surface water	groundwater
	in hm^3	per km^2 in dam^3	in cubic hectometres						
Bug basin	90,1	4,9	9,5	0,1	9,1	33,2	47,4	0,3	47,1
Narew from the Bug estuary up to the Wisła estuary	74,1	11,0	3,9	0,1	3,8	3,4	66,7	33,6	33,2
Wisła from the Narew estuary up to and including the Bzura estuary	113,1	14,2	7,3	0,7	6,6	51,0	54,8	0,1	54,7
Wisła from the Bzura estuary up to the Drwęca estuary	87,6	12,9	39,3	35,7	3,6	10,8	37,6	5,4	32,2
Drwęca basin	38,7	6,7	3,7	1,0	2,6	15,0	20,1	0,7	19,4
Wisła from the Drwęca estuary up to and including the Brda estuary	71,1	10,7	12,3	7,5	4,9	8,0	50,8	18,4	32,4
Wisła from the Brda estuary up to the Baltic Sea	71,4	11,3	35,4	32,4	3,0	5,9	30,1	0,0	30,1
ODRA BASIN	4389,3	40,8	3217,1	3123,3	77,6	479,0	693,2	104,2	589,0
Odra from the border of the country up to the Nysa Kłodzka estuary	166,8	19,6	71,1	43,1	16,0	24,5	71,2	0,8	70,4
Nysa Kłodzka basin	30,0	7,1	2,3	1,0	1,1	10,0	17,7	6,5	11,2
Odra from the Nysa Kłodzka estuary up to the Bóbr estuary	459,5	20,3	71,8	58,1	13,2	211,1	176,5	40,4	136,1
Bóbr basin	77,6	12,6	4,4	0,4	1,6	30,3	42,9	13,0	29,9
Odra from the Bóbr estuary up to the Warta estuary	52,4	15,6	25,2	25,0	0,2	15,9	11,3	1,4	9,8
Warta from the source up to the Prosna estuary	1677,1	100,0	1510,7	1489,6	20,4	45,8	120,6	0,4	120,3
Prosna basin	33,6	7,6	1,8	0,5	1,3	5,0	26,8	0,2	26,7
Warta from the Prosna estuary up to the	170,2	12,0	13,2	4,0	9,0	44,2	112,8	19,2	93,5

HYDROGRAPHIC REGIONS	Total		For purposes of						
			production [a] (from own intakes)			irrigation in agriculture and forestry [b]	exploitation of water sypply network [c]		
			total	waters			total	water	
				surface water	groundwater			surface water	groundwater
	in hm^3	per km^2 in dam^3	in cubic hectometres						
Noteć estuary									
Noteć basin	154,7	8,8	36,0	27,9	7,9	64,5	54,2	0,8	53,5
Warta from the Noteć estuary up to the Odra	23,6	10,5	7,4	5,3	2,1	5,7	10,5	–	10,5
Odra from the Warta estuary up to the Szczecin Bay	1543,8	206,5	1473,2	1468,5	4,7	22,0	48,6	21,4	27,2
BASINS OF COASTAL RIVERS	335,9	9,7	120,4	103,8	16,4	39,1	176,4	4,8	171,6
Szczecin Bay catchment basin (excluding Odra basin)	4,2	3,4	0,1	0,0	0,1	–	4,1	–	4,1
basin of rivers in Western Pomerania up to the Wisła estuary	190,6	10,6	57,7	46,7	10,9	15,7	117,2	4,7	112,5
Wisła Bay catchment basin (excluding Wisła basin)	93,6	13,1	54,6	52,5	2,1	11,6	27,4	–	27,4
Pregoła basin	47,4	5,8	8,0	4,5	3,4	11,8	27,7	0,1	27,6
OTHER BASINS	9,5	3,2	1,4	–	1,4	0,0	8,0	2,3	5,7
Niemen basin	6,8	3,2	1,4	–	1,4	0,0	5,4	–	5,4
Dniestr basin	1,4	2,9	0,0	–	0,0	–	1,3	1,3	0,0
Dunaj basin	0,5	1,7	0,0	–	0,0	–	0,5	0,3	0,2
Łaba basin	0,8	23,6	–	–	–	–	0,8	0,7	0,1

[a] Excluding agriculture, forestry, hunting and fishing. [b] And filling and completing fishponds. [c] Water withdrawal by intakes, before entering the water supply network.

Table 2: Water withdrawal for needs of the national economy and population by sources of withdrawal and hydrographic regions in 2012 (Central Statistical Office 2015)

SPECIFICATION	2000	2005	2010	2011	2012
AGRICULTURAL LAND AND FOREST LAND					
Irrigated area in thous. ha	99,1	77,9	68,9	66,5	66,8
Irrigated objects	821	706	597	686	675
with area in ha:					
20-25	113	115	92	122	124
26-50	244	221	191	249	239
51-100	216	177	149	161	156
101-200	128	105	82	89	87
201-500	91	67	63	48	52
501-750	13	7	7	5	5
751-1000	8	6	5	5	5
1001 ha and more	8	8	8	7	7
Water withdrawal in hm^3	112,6	94,9	76,8	84,5	81,7
of which wastewater	2,2	2,1	1,7	1,5	1,6
FISHPONDS					
Filled area in thous. ha	44,8	47,7	49,8	48,7	49,6
Filled objects	688	743	791	794	793
with area in ha:					
10-25	253	273	304	315	304
26-50	183	194	203	205	206
51-75	78	88	96	92	95
76-100	53	65	62	61	61
101-150	67	67	66	65	68
151-200	21	24	23	22	25
201-500	25	25	30	27	27
501 ha and more	8	7	7	7	7
Water withdrawal in hm^3	950,3	1008,1	1078,2	1028,1	1022,3

Table 3: Irrigation in agriculture and forestry and completion of fishponds by size of objects (Central Statistical Office 2015)

The main users of water are the following:

- Drinking water supply.
- Agriculture.
- Forestry.
- Industry.
- Hydropower.
- Fisheries.
- Tourism and recreation.
- Inland navigation.

There are no detailed analyses concerning drought vulnerability for the whole Poland taking into account particular water user sectors. But on the basis of past accidents you can conclude that agriculture and forestry are the sectors with the largest risk to the drought. Problems with drinking water supply seldom occur (mainly in southern part of the country) because of primary groundwater intakes. The lack of water for industry, hydropower and fisheries is usually only during prolonged drought or in some areas with aggregated water needs. The drought influence on inland navigation, tourism and recreation can be completely negligible.

Romania

The sector most vulnerable to drought losses is agriculture. But, in the severe drought situation shortages, water supply to population and industry (including the energy sector) may also be affected. Each time when the drought occurs, many of the same issues are raised in Romania.

The present-day and foreseeable climatic data highlight the increase in frequency and intensity of the drought phenomenon, its potential effects on the most vulnerable sectors (agriculture, waters and forests, biodiversity, energy, transport etc.)., requiring specific adaptation measures to the limiting environmental conditions.

Hazards associated to the climate change are greater for:

(1) human health (a higher frequency and longer duration of the heat waves have an impact of the health of the elderly, negatively impacting the health services, which are overstressed even in normal weather situations);

(2) food safety (troubles in agriculture, caused by drought and by a non-sustainable approach as regards the land cultivation at subsistence level);

(3) biodiversity (forest fires, discontinuation of the ecosystems' dynamics because of high temperatures and the modification of precipitation distribution patterns);

(4) energetic safety (drought influences both over the hydroelectric power plants and the nuclear power plant from Cernavoda, as their regular activity relies on the befitted level of the Danube River. This is all the more relevant whereby at country level almost 36% out of the electricity produced comes from hydro sources and 19% from nuclear sources).

One of the most visible effects of this situation is noticeable in agriculture, where the vegetal yield varied largely from year to year, in the context of variable climatic conditions. The 2001-2012 interval was particularly droughty; the drought negatively impacted the agricultural productivity; the mean yield by ha, decreased by more than 50% on the land surfaces where irrigation systems are absent. According to Ministry's of Agriculture and Rural Development data, the excessively droughty agricultural years 2011-2012 strongly impacted about 5.9 million hectares, the level of losses varying over different area and culture. Nevertheless, the most affected cultures include corn, wheat, barley, two-row barley, sunflower, and rape and soya.

Culture	Average yield 2009-2010-2011 (Thousand tonnes)	2012 (Thousand tonnes)	Yield decline
Corn	9,577	5,158	- 46.1 %
Wheat	6,048	4,941	- 18.3 %
Barley/Two-row-barley	1,273	972	- 23.6 %
Potato	3,788	2,430	- 35.8 %
Sunflower	1,383	1,165	- 15.7 %
Rape	750	148	- 80.2 %
Soya	125	70	- 44.0 %

Table 4: The losses in agriculture caused by drought

Given the effects of climate change in Romania reflected by temperature and precipitation regime shift, increasing number of droughts events being more and more apparent after 1981, the pedological extreme and severe drought that is manifested especially in the south, south-east and east part of Romania as well as the climate change projections in Romania for the 21st century, that will result in a high variability of agricultural production, with negative consequences on food supply and on national economy, the following measures to adapt to the effects of changes climate in the agricultural sector are required:

- ✓ supporting agricultural research and experimental production for the modification the structure of crops and selecting varieties with resistance to drought;
- ✓ improving the availability and applicability of modeling and adaptation options for the use of farmers (providing data and results on the response of water resources to climate change scenarios, promote the use of GIS technology, etc..)
- ✓ further elaborating of the Good Practice Guides for agriculture, especially for non-irrigated agriculture;
- ✓ develop and implement local action plans (at the communa level) for climate change adaptation;
- ✓ institutional capacity building in relevant domains regarding drought and water scarcity, as well as mechanisms to facilitate the exchange of information between institutions.
- ✓ conduct educational activities for public awareness on the effects of drought, desertification and water shortages, particularly in rural areas;

At the farm level are very important some elements of adaptation to climate change. Possible solutions to medium term should include:

- ✓ adaptation of the periods for conducting agricultural activities;
- ✓ selection of the crops and varieties better adapted to changes in the growing season and water available, as well as with greater resistance to new climatic conditions and moisture;
- ✓ crop adaptation based on use of existing genetic diversity and of the new opportunities offered by biotechnology;
- ✓ introducing of animals heat-resistant species and adapting of the animal nutritional regime to the demands caused by climate extremes.
- ✓ efficient use of water by: reducing water losses, improvement of the irrigation techniques, water recycling and storage;
- ✓ better management of soils by increasing water retention to maintain soil moisture;

At the national level, especially in south, south-east and east of Romania where drought will reach the highest intensity values (extreme/Co-300 m3/ha and severe/600-900 m3/ha) and taking into account the increase of intensity and frequency of droughty years, it is necessary to provide investments in irrigation infrastructure and improvement of the water resources management.

Strategy of the Ministry of Agriculture and Rural Development in irrigation sector has the following main objectives:

(1) Rehabilitation of irrigation infrastructure belonging to the public domain of the State on the area of approx. 823 thousands hectares, economically viable

(2) Changing power solution for 3 irrigation systems with the surface of approx. 56 thousands ha, which are currently fuelling from Siret and Prut powered from magistral channel Siret – Bărăgan

(3) Fitting of the area of approximately 425 thousands ha, to be arranged with irrigation works in areas adjacent of the magistral channel Siret – Bărăgan, powered from the magistral channel Siret - Bărăgan.

3. Inventory of methodology to characterize drought impact and vulnerability assessment

Lithuania

The drought identification and major losses in Lithuania are related to agricultural droughts. Consequentially, there are a lot of works on the assessment of water shortage impacts on health and yield of crops (Šabajevienė et al 2008), fruit trees (Sakalauskaitė et al 2007), vegetables (Žebrauskienė et al 2003; Sakalauskienė et al 2008; Rasiukevičiūtė et al 2011), trees (Vitas 2002; Ozolincius et al 2009).

The only nationwide methodology of drought vulnerability assessment is used by German insurance company VEREINIGTE HAGEL. The vulnerability is estimated for different crops and the calculations are based on climate, soil, and topography data. Unfortunately, the actual formulas and calculation procedures are not publicly available.

Poland

Vulnerability shows the degree of susceptibility of society to a hazard, which could vary either as a result of variable exposure to the hazard, or because of coping abilities, which include protection and mitigation. The purpose of assessing vulnerability is to identify appropriate actions that can be taken to reduce vulnerability before the potential for damage is realized (Wilhelmi, Wilhite, 2002).

Vulnerability of agricultural to drought is generally referred to as the degree to which agricultural systems (crops) are likely to experience harm due to drought stress. When drought occurs, vulnerability of crops depends on several parameters, the most important ones being the ability of the particular type of crops to adapt to drought stress and the environment of its growth (soil, climate, available soil water). Because of the complexity of the issue of vulnerability, assessments are commonly subjective and vary between regions and hazards. Downing and Bakker (2000) state that vulnerability is a relative measure and the analyst must define its critical levels. Factors influencing drought vulnerability are numerous, and their inclusion may depend on data availability. The identification of key vulnerability factors are usually based on their significance for agricultural sector. Analysis of drought literature suggests that climate, soils, land use, cultivated crops, access to irrigation are the most significant factors of agricultural drought vulnerability that should be taken into account.

For the purpose of the present study, at the present stage of analysis, an assumption is formed that two factors are taken for the assessment of agriculture vulnerability to drought:

- an agroclimatological factor of vulnerability (hazard factor) defined by synthesizing climate, crop and soil data in the form of water deficit in the growing period for a particular crop on a particular soil
- a soil factor defined by the area of very light and light soils in a region as a share in total arable soil area.

The assessment of agricultural drought vulnerability is made for late potato, sugar beet, cereals (winter wheat, spring barley), maize and winter rape in five regions of Poland. The country was divided into the regions on the basis of diversity of climate and agro-climatic conditions:

A – north-eastern covering the voivodships: podlaskie, warmińsko-mazurskie;

B –north-western covering the voivodships: pomorskie, zachodnio-pomorskie;

C – central-western covering the voivodships: lubuskie, wielkopolskie, kujawsko-pomorskie, łódzkie;

D – central-eastern covering the voivodships: mazowieckie, świętokrzyskie, lubelskie;

E – south-western covering the voivodships: dolnośląskie, opolskie, śląskie;

F – south-eastern covering the voivodships: małopolskie, podkarpackie.

Crop water deficits

In the study the assessment of vulnerability is made with reference to different crops and to the probability of water deficit of crops. It is assumed that the probability characterizes the agrometeorological conditions of crop production. Water deficit at the probability of exceedence 0.2 is assumed as a hazard index. Such deficit can occur once in five years.

Water deficits of a particular crop were taken from the „Atlas of water deficit of cultivated plants and grasslands in Poland" (Ostrowski *et al.* 2008). Water deficits were defined as a difference between non-easily available soil water and actual soil water, taking into account precipitation and potential evapotranspiration. They were calculated for soils recommended for growing a given crop, using the model CROPBALANCE (Łabędzki 2006; Łabędzki *et al*. 2008) with the application of water balance method for the soil root zone:

$$N = (1 - p)TASW - (ASW + P - ET)$$

where:

N – water deficit for a particular crop on a particular soil (mm),

TASW - total available soil water in the root zone (mm),

p – soil water depletion fraction, fraction of *TASW* that a crop can extract from the root zone without suffering water stress (dimensionless), according to Allen *et al.* (1998),

ASW - available soil water in the root zone (mm),

P - precipitation (mm),

ET_p – potential evapotranspiration of a crop, actual evapotranspiration under full water supply (mm).

According to this procedure, water deficits were calculated with a time step of a 10-day period for 35-year time series. The growing season sum of water deficits at a given probability was estimated using the gamma probability distribution. An example of the spatial distribution of water deficit of late potato and sugar beet at the probability 0.2 on light soil is shown in figure 2.

Connecting the maps of water deficits with the map of the actual distribution of soil cover in Poland, the maps of the spatial distribution of water deficits on real soil in each point of the country were created (example in figure 3).

Then, taking into account the area of crop cultivation in voivodships from the official statistical data for 2011 (Użytkowanie… 2012), the soil area-weighted mean water deficit of crops in every voivodship and region was estimated.

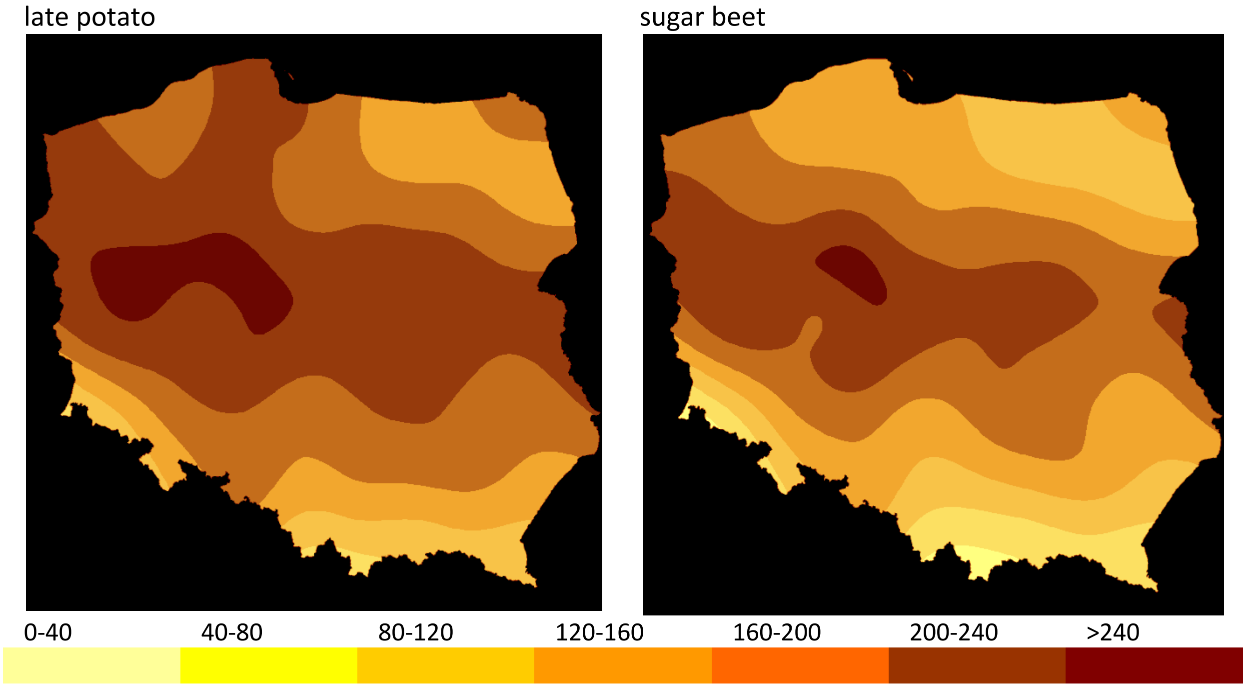


Figure 2: Water deficits (mm) in the growing season at the probability 0.2 on light soil Source: Ostrowski et al. (2008)

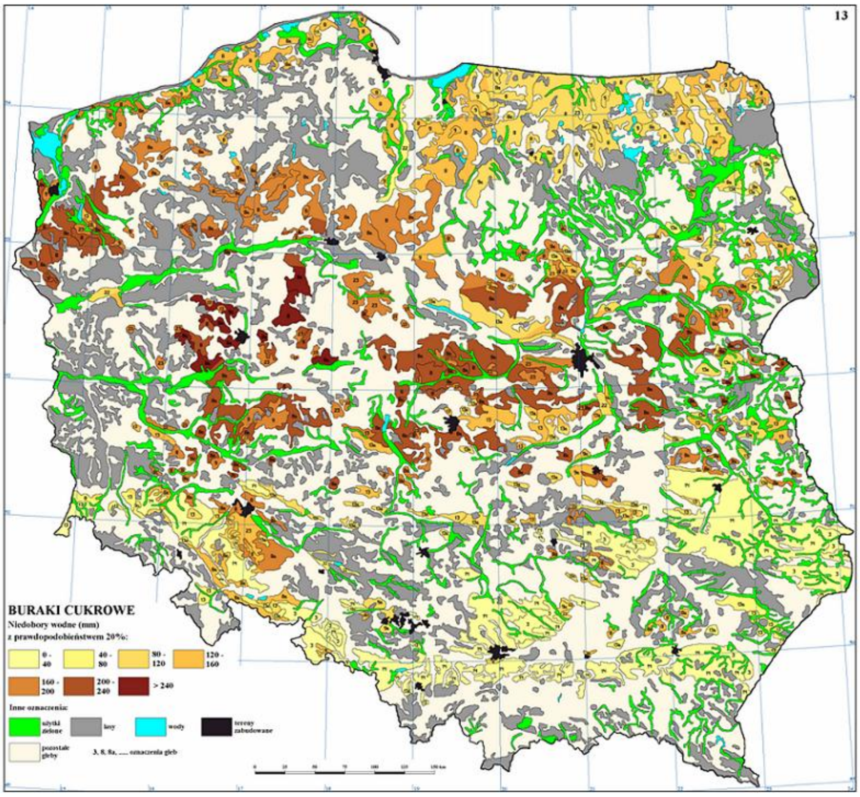


Figure 3: Water deficits in the growing season of sugar beet at the probability 0.2 Source: Ostrowski et al. (2008)

Soils

The geographic pattern of soil water-holding capacity is important for studying water stress for plants. Plant-available water-holding capacity of soil is estimated as the difference in water content between field capacity and permanent wilting point. Field capacity is the amount of water retained by a wetted soil after it has been freely drained by gravity for some period of time. The water-holding capacity of the soil is mostly dependent on soil porosity, which, in turn, depends on soil texture and structure. In Poland, soils vary from clay soils, with generally fine texture and high water-holding capacity, to sandy soils with coarse texture and low water-holding capacity. Sandy soils are most common. The soil root zone water-holding capacity, as a significant agricultural drought vulnerability factor, was used in this study to group soils with similar abilities to buffer crops during periods of water deficits.

Spatial differentiation of soil cover in Poland according to a susceptibility of different categories of soil to the drought comprises the categories: a very light soil (with very low soil water-holding capacity, very susceptible to drought), light soil (with low soil water-holding capacity, susceptible to drought), medium-heavy soil (with medium soil water-holding capacity, medium susceptible to drought), heavy soil (with high soil water-holding capacity, less susceptible to drought). Evaluation of the share of very light and light soils in the voivodships and the regions was made on the basis of the map showing the spatial distribution of the four soil categories, developed by the Institute of Soil Science and Plant Cultivation (figure 4).

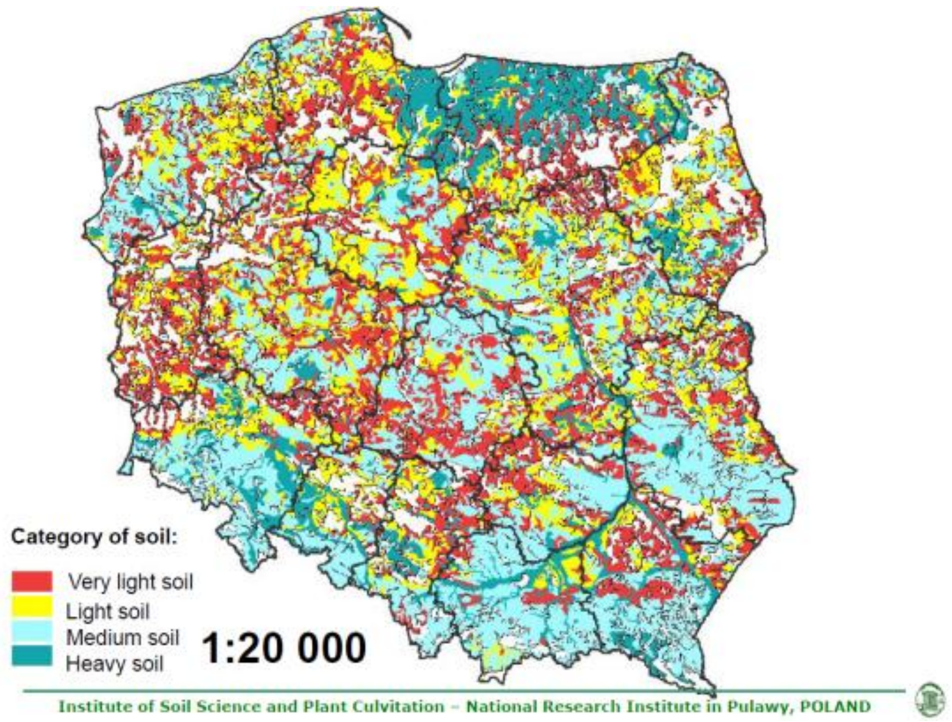


Figure 4: Spatial distribution of the four soil categories in Poland. Source: Kozyra et al. (2009)

Vulnerability assessment

The following numerical weighting scheme was used to assess drought vulnerability. Each class of two vulnerability factors has been assigned a rank between 1 and 6, with 1 being considered least significant in regard to drought vulnerability and 6 being considered most significant (table 5). Besides each factor was assigned a relative weight based on an informed assumption on relative contribution of each factor to overall agricultural drought vulnerability. It is recommended that the sum of weights is equal 1. It was hypothesized that a hazard factor (water deficit at a given probability) is important two times more than a soil factor (area of very light and light soils). The assumption was based on the rather obvious fact that smaller area of light soils with low water capacity and smaller water deficits lessen vulnerability to agricultural drought in a region.

The final result of the combination of *n* factors is a numeric value, which is calculated using the general equation:

$$V = \sum_{i=1}^{n} w_i r_{ij}$$

V – vulnerability

n – number of factors

w_i – weight of factor i

r_{ij} – rank j of factor i

i – the number of a factor

j – the number of a factor class

	Agricultural drought vulnerability factor i			Rank r_{ij}
	i	1	2	
Agricultural vulnerability factor class j	j	***N* (mm)**	***S* (%)**	
	1	0-40	0-10	1
	2	41-80	11-20	2
	3	81-120	21-40	3
	4	121-160	41-60	4
	5	161-200	61-80	5
	6	> 200	81-100	6
Weight w_i		0.667	0.333	

N – drought hazard: water deficit (mm), sum in the growing period
S – share (%) of very light and light soils in arable soil area

Source: own study

Table 5: Weighting scheme for assessing agricultural drought vulnerability

Similar approach was presented by Wilhelmi and Wilhite (2002) for Nebrasca in USA and Slejko *et al*. (2011) for Slovenia in the framework of Drought Management Centre for Southeastern Europe.

According to this formula and the data from Table 1, the maximum value of vulnerability index is 6 and the minimum is 1. A high numeric value is assumed to be indicative of a geographic area that is likely to be more vulnerable to agricultural drought. Vulnerability was classified into four classes, identifying geographic areas with: no vulnerability, low, moderate, high and very high vulnerability (table 2). The derived classes were based on the numerical weights, informed judgment and the analysis of the combined input variables.

Agricultural drought vulnerability	
V value	assessment
1.0-2.0	no
2.1-3.0	low
3.1-4.0	moderate
4.1-5.0	high
5.1-6.0	very high

Source: own study

Table 6: Agricultural drought vulnerability classification

Finally the number value of vulnerability *V* was calculated using data from table 5 and Eq. 1, taking into account the weighted water deficit and the area of very light and light soils in each region as a ratio to the total arable soil area (in %). On the base of the assumed classification (table 6) the verbal assessment was assigned.
The results are presented in table 7 and the maps of vulnerability assessment in the regions in figure 5.

Region	Late potato	Sugar beet	Cereals	Maize	Winter rape
north-eastern	+	-	-	+	-
north-western	++	+	+	++	+
central-western	++++	+++	++	++++	++
central-eastern	+++	++	++	++	-
south-western	++	+	+	-	+
south-eastern	+	-	-	-	-

- - no vulnerability
- + low vulnerability
- ++ moderate vulnerability
- +++ high vulnerability
- ++++ very high vulnerability

late potato sugar beet

Table 7: Assessment of vulnerability of different crops to drought

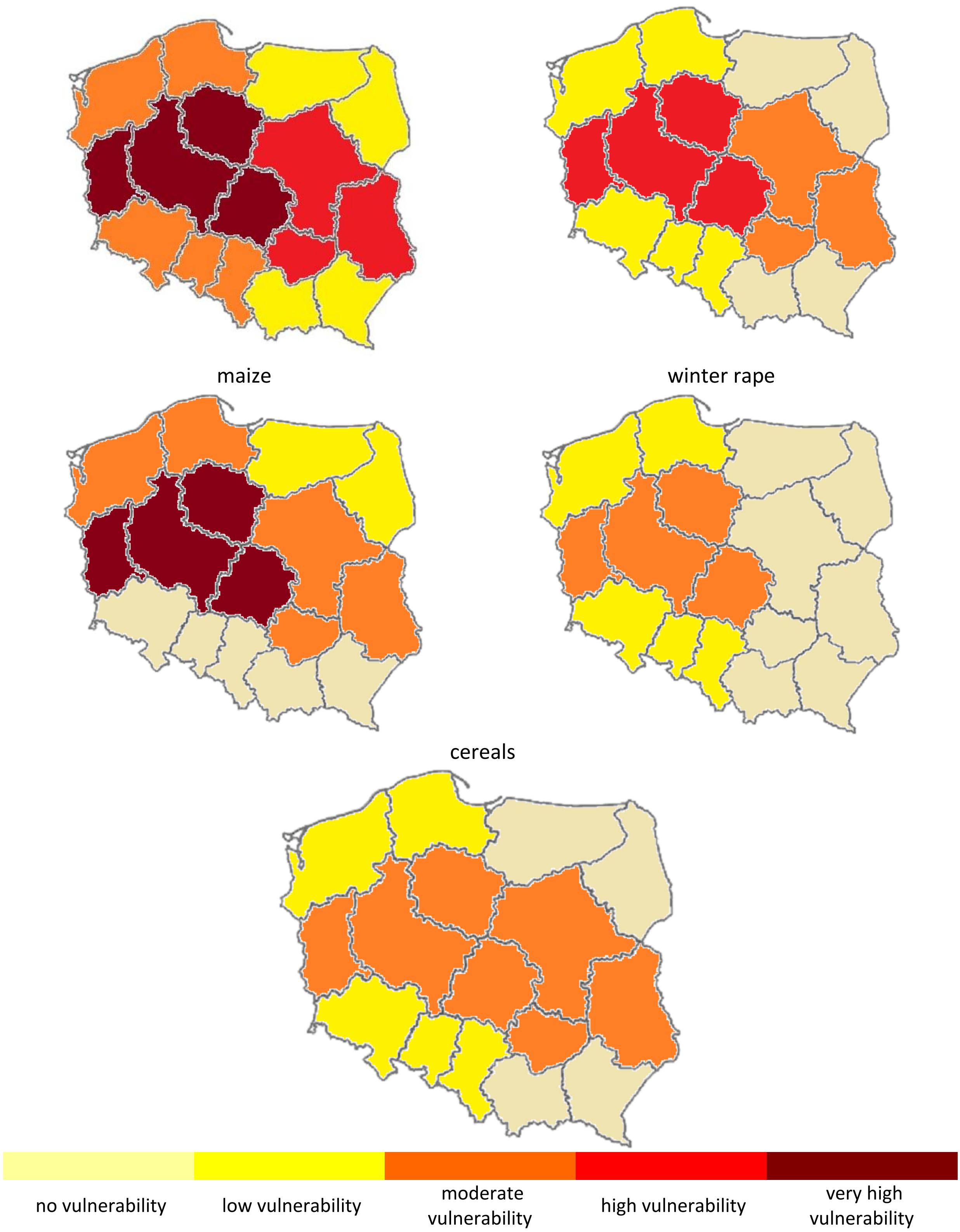


Figure 5: Maps of agriculture vulnerability of different crops to drought in Poland

Romania

The climate in Romania is expected to undergo significant changes over the coming decades. In near future term (2011-2040), the most pressing consequences are those related to thermal changes (e.g. hotter summers with more frequent and persistent heat waves) over entire country (more pronounced over Southern and Eastern regions) and to reduction in mean precipitation in Southern and Southern-East part of Romania. Estimates based on analysed projections suggest that on the longer terms (2041-2070 and 2071-2100) the temperature increase will continue to grow and the reduction in mean precipitation will extend over majority areas of the country, especially in warm season. The rainfall reduction seems to be more pronounced in the Southern and Eastern regions of Romania. In this context, territory highly exposed to the pedological drought hazard, tending to become arid and even desert comprises large surfaces in Dobrudja, southern and eastern Wallachia, southern Oltenia and southern Moldavia. These areas may be framed in the category of the areas the most vulnerable to excessive and prolonged pedological drought. The vulnerability degree of the cultivated species to the materialization of the thermal and hydric stress respectively is established on the grounds of the specific reference limits / hazard levels and classes, so as to assess the agroclimatic favourability degree of the agricultural surfaces for agricultural sorts and species with a different resilience to the occurrence of those hazards. Thus, the analysis of the agroclimatic phenomena implying thermal and hydric stress involves identifying the critical parameters and thresholds over specific calendar intervals, corresponding to the undergoing of the growth and development processes in plants, as well as over the whole vegetation period, so that the favourability degree for agriculture from the agrometeorological standpoint is also established.

The National Strategy for Climate Change (NSCC) in Romania, which has an important adaptation section (approved in July 2013 by the GO 529/2013), refers to the effects of climate change on water safety, agriculture, energy, transport, industry, insurance, biodiversity, health, tourism, forestry, infrastructure, and recreational activities. The drought is analyzed as one of the major climatic risks with high negative impact on all economic sectors mentioned as the most vulnerable (13 sectors) in our country. The NSCC builds technical knowledge upon the background of the Guide on Adaptation to Climate Change issued in 2008. The strategy adds extra guidance on the approaches and institutional cooperation needed to cope with climate change in Romania in an integrative and multi-sectoral providing more information on implementation/application aspects of adaptation relative to the Guide.

Sectors analysed in recent studies to be directly affected by projected changes in temperature and precipitations over Romania are presented below.

- Agriculture

  In near future (2011-2040), under climate change conditions, stronger and more spatially extended droughts will likely affect Romanian territory in the growing season, with significant impact on agriculture activities.

  Vulnerabilities in adaptation of agriculture activities in Romania to effects of climate change:
  - demographical problems (decline of local population, ageing of local population) ;
  - economic problems (lack of infrastructure for irrigation; low productivity for small farmers);
  - social problems (propriety fragmentation, youth migration from rural areas).
- Tourism

  A recent study shows using statistical modelling that extreme temperatures negatively influence the number of foreign tourists at the Black Sea coast; increasing mean monthly temperature favours the larger presence of foreign tourists (Surugiu et. al, 2012).

  Tourism in mountain stations is differently affected by monthly mean temperature compared with the stations near the Black Sea coast – increasing temperatures have a negative impact on the occupancy rate in the mountain area (Surugiu et. al, 2012). Precipitation and snow change in the mountain areas are also important factors influencing future winter activities in touristic sites. The potential for artificial snow production will be diminishes in these areas.

The above mentioned study also found the vulnerabilities in adaptation of touristic activities in Romania to adverse effects of climate change:

- demographical problems (decline of local population, ageing of local population, a large proportion of local population working in tourism sector);
- economic problems (fluctuations in local economic activity; strong dependence of local economy on tourism; low productivity of non-touristic activities);
- social problems (a high percentage of local population is dependent on touristic activities which is strongly seasonal; a high rate of jobless people from the local population).

- Health

  A pressing problem today and in the near future is the impact of heat waves in urban areas. Under climate change conditions, many part of the Romanian territory will be affected by frequent and persistent heat waves, but urban areas are more likely to feel negative effects than others (Bojariu et al, 2013). Heat waves effects are more severe in high populated urban areas. Young people and older one are most vulnerable but people affected by certain diseases are also highly vulnerable.

Much more vulnerability assessments have to be coupled with the information about physical basis of climate change to obtain updated and improved knowledge for adaptation in all sectors identified in the strategy for climate change in Romania.

In addition, the Strategy adds extra guidance on the approaches and institutional cooperation needed to cope with climate change in Romania in an integrative and multi-sectoral manner. On national level, the Strategy recommends the following actions: (1) periodically updating climate change projections; (2) supporting climate research and building a national data base on climate change; (3) assessing costs related to climate change for prioritary sectors; (4) elaboration of the National Agenda on Climate Change and implementing it in relevant policies; (5) monitoring and analysis of adaptation to climate change; (6) raising climate-related awareness of general public. As for the sectoral recommendations, a sound base for assessing costs related to climate change for different sectors is the evaluation of the state of the art in the knowledge of adaptation to climate change in Romania. Defining specific objectives on different time horizons and the tools to monitor the way to reach these are also important for sectoral approach of adaptation. However, more efforts have to be dedicated to improve and update the inventory of recommendation and adaptation measures for all sectors identified in the strategy for climate change in Romania. Also, mitigation and adaptation measures have to be coherently integrated.

For this Report was selected three important sector-related findings regarding vulnerabilities and measures of adaptation to climate change which are illustrated in tables 4 and 6.

Table 4. Sectoral-related vulnerabilities to projected change in temperature and precipitation

Sector	Vulnerability		
	demography	economy	society
Agriculture	decline of local population; ageing of local population	lack of infrastructure for irrigation; low productivity for small farmers	propriety fragmentation; youth migration from rural areas
Health	ageing of local population; concentration of population in urban areas	land use changes	increasing rate of diseases prone to thermal impact among people

Tourism	decline of local population; ageing of local population	fluctuations in local economic activity; strong dependence of local economy on tourism; low productivity of non-touristic activities	a large proportion of local population working in tourism sector which has a strong seasonality; a high rate of jobless people from the local population

Table 5. Sectoral-related adaptation measures to projected change in temperature and precipitation

Sector	Adaptation measures
Agriculture	elaboration of drought risk maps based on climate change related hazards under present and future conditions; elaboration of associated management plans for climate adaptation based on studies of regional and local changes in behavior of genotypes; implementation of planned actions and monitoring (including disaster management community) according to the National Strategy for Climate Change in Romania
Health	elaboration of risk maps for heat wave in urban areas under present and climate change conditions; elaboration of associated management plans for climate adaptation to heat waves on central and local levels of administrations; implementation of planned actions with disaster management community and monitoring according to the National Strategy for Climate Change in Romania
Tourism	elaboration of risk maps based on climate change related hazards under present and future conditions; elaboration of associated management plans for climate adaptation based on winter and summer tourism activities (e.g. in mountain locations, alternative activities to traditional winter sports could taken into account; at seaside locations, touristic season could be extended beyond the traditional interval from May to September); implementation of planned actions and monitoring according to the National Strategy for Climate Change in Romania

4. Stakeholders on national, regional and local levels and their needs for information on drought risk

Lithuania

The main stakeholders in Lithuania are the governmental institutions responsible for drought management (table 1) and representatives of sectors vulnerable to droughts.

The largest drought related losses are in the agricultural sector. Due to this, the main stakeholders are the farmers and insurance companies. Both need information on extent, propagation and intensity of agricultural droughts.

The forest and peat bog fires are common during droughts. The Directorate General of State Forests and Fire and Rescue Department needs information on soil water content in peat bogs, the forest fire risk class in forests and forecast of meteorological conditions

The hydrological droughts may affect the hydropower companies and water truism. These sectors need well-timed forecast of hydrological conditions.

In Lithuania the municipal water use is affected only in rural areas where the shallow ground water is used. The municipal administrations need the forecasts of drought conditions to secure the water supply from alternative sources.

Institution	Responsibility
Ministry of Agriculture	Organize and coordinate the measures for livestock, agriculture, and food sources protection. Establish special protective measures for managing of disaster consequences. These measures are mandatory for all land managers, owners and users. Give recommendations to farmers about protection of livestock, plants and forage. Make proposals for organization of compensation for the loss.
Ministry of Environment	Provides meteorological and hydrological information and forecasts to institutions involved in the management of emergency.
Ministry of Health	Coordinates the individual and public health care.
Ministry of Economy	Coordinates the state monetary reserve and plans the usage of material resources.
Ministry of interior	Coordinates firefighting, people and property rescue, and other rescue operations.
State food and veterinary service	Organize drinking water, food and forage laboratory tests and risk assessment.
Administration of municipalities	Ensure the implementation of State Emergency Operations Center instructions and measures imposed by the municipal emergency plan. Warn and inform the public, state and local authorities and institutions about the state of emergency, possible

Institution	Responsibility
	consequences and measures to eliminate and prevent the spread of emergency situation. Integrate all measures of civil protection located in the municipality to organize the aid for the victims, if necessary, organize evacuation of population.

Table 8: Institutions and their responsibilities for drought in Lithuania

Poland

The stakeholders to drought risk information correspond to all sectors of water use. But the drought risk information level is the most important matter in this case. The bigger scale of information (regional and national level especially) is intended mainly to only planning purposes – to set strategic or planning documents, required by the law and making basic possibility to take more specific actions. Information like described is needed mainly by public administration – both authorities and professional departments responsible for specific economic sector (like water management, agriculture, forestry, industry, fisheries, hydropower etc). It can be important for representatives of sectors agglomerated in national or regional companies to make better possibility to policy or investment force/realisation too (for example insurance companies

In the case of particular water users (like farmer, water plant, industry plant, hydropower station tec.) drought risk assessment for local scale is the most important information. Drought risk should be analyzed for areas as small as possible, sometimes for single locations too. Most often user should participate to the assessment because in many cases it should be prepared for its needs strictly. So it's important all data concerning drought should be collected both by public institutions (responsible for monitoring or management for example) but by users too.

Stakeholder	Drought risk information		
	National level	Regional level	Local level
Public administration	ministry (mainly of environment and agriculture) water management authorities (KZGW) for strategic and planning purposes (policy establishment) - identification of regions and sectors vulnerable to drought and water scarcity	regional administration (voivodship, marshall) water management authorities (RZGW) - river basin district for planning purposes - identification of regions and sectors vulnerable to drought and water scarcity in the context of potential water lack mitigation (in the result of responsible programmes of measures and water management rules implementation)	local administration (communities) water management authorities (RZGW) – basin for planning purposes - identification of places and users vulnerable to drought and water scarcity in the context of potential water lack mitigation (in the result of responsible programmes of measures and water management rules implementation)
Drinking water supply	*possible initiating of large investments (important in national scale) if needed*	*possible initiating of large investments (important in regional scale) if needed*	water plants users of private wells for drought mitigation purposes - determination of drought occurrence and intensity possibility regarding particular locations and users so that be able to temper drought effects
Agriculture	*possible initiating of programmes of drought mitigation in agriculture (important in national scale)*	*possible initiating of programmes of drought mitigation in agriculture (important in regional scale)*	farmers for drought mitigation purposes - determination of drought occurrence and intensity possibility regarding particular locations so that be able to temper drought effects (crop decreases)
Forestry	*possible initiating of programmes of drought mitigation in forestry (important in national scale)*	*possible initiating of programmes of drought mitigation in forestry (important in regional scale)*	foresters for drought mitigation purposes - determination of drought occurrence and intensity possibility regarding particular locations so that be able to temper drought effects (forestry production decrease, forestry fires)
Industry	-	-	industry plants for drought mitigation purposes - determination of drought occurrence and intensity possibility regarding particular locations and users so that be able to temper drought effects (production decrease)

Stakeholder	Drought risk information		
	National level	Regional level	Local level
Hydropower	*possible initiating of large investments (important in national scale) if needed*	*possible initiating of large investments (important in regional scale) if needed*	power plants so-called small hydropower stations for drought mitigation purposes - determination of drought occurrence and intensity possibility regarding particular locations and users so that be able to temper drought effects (energy production decrease)
Fisheries	-	*possible initiating of large investments (important in regional scale) if needed*	fish ponds for drought mitigation purposes - determination of drought occurrence and intensity possibility regarding particular locations and users so that be able to temper drought effects (fish production decrease)
Inland navigation	*possible initiating of large investments (important in national scale) if needed*	*possible initiating of large investments (important in regional scale) if needed*	goods navigation (very rarely in Poland) public transport navigation (very rarely in Poland, in some cities only, not primary) users of tourist water routes (small ships, yachts, canoeing) for drought mitigation purposes - determination of drought occurrence and intensity possibility regarding particular locations so that be able to temper drought effects (impossibility of navigation realisation)
Insurance	insurance companies for general drought insurance policy establishment - identification of regions and sectors vulnerable to drought and water scarcity	-	-
Society	*information role and public participation*	*information role and public participation*	*information role and public participation*

The grey background indicates no contribution to drought risk assessment.

Table 9: The example drought risk information needs of stakeholders regarding to different information levels

Romania

In Romania, the main stakeholders involved in actions concerning drought monitoring and management (table 8) are central and regional authorities from all economic sectors affected by this type of hazard (such as: water resources, agriculture, environment, forestry, biodiversity, energy, transport, etc).

National Meteorological Administration is responsible for ensuring the weather forecast's unitary character in Romania, being the only operator at national and regional level. Therefore, within the daily teleconferences carried out at pre-established hours, the short-range and medium-range forecasts are harmonized by Regional Weather Forecast Service (RWFS) forecasters under the National Weather Forecast Centre (NWFC) meteorologist's guidance. Besides current forecasts, NMA works out reports, notices, and warnings regarding severe weather phenomena, at national level through NWFC and at regional level through RWFSs. The information is operatively disseminated to SIMIN users, briefing-terminals being located in important decision points (such as the Inspectorate for Emergency Situations, Ministry of Environment and Climate Change, Ministry of Agriculture and Rural Development, and other ministries, etc.), while the products are adjusted to the main users' specific requests. Also, the Agro-meteorological Service is a basic component of the operational activity and investigates the impact of climate variability and change on crops (including phenology and yield), and on the main components of soil water balance. The monitoring is done daily for agro-meteorological parameters and the changes in the soil moisture content at the plant level, identifies periods and agricultural areas seriously affected by extreme events including droughts, elaborates weekly bulletins, and carries out long-term agro-meteorological forecasts upon soil moisture reserves. Modeling and GIS techniques are used to monitor the spatial extent of extreme weather phenomena and to assess the most vulnerable areas to drought.

Early warning drought and risk management systems are obvious and efficient contributors that can facilitate adaptation to climate variability and changes, **IF:**

- the existing network of meteorological and agrometeorological are developed in order to ensure reliable ongoing data at national/ regional/local level;
- a historical climate data archive can be provided, especially an archive on climate impacts in vulnerable sectors on water scarcity and droughts;
- climate data analysis are developed in order to determine the patterns of inter-annual and intra-seasonal variabillity and extremes;
- the gaps in the development of regional climate scenarios and enhance capacity/experience in the use of different models are improved;
- information on the characteristics of system vulnerability and adaptation effectiveness such as resilience, critical thresholds and coping mechanisms are extended to identify opportunities for adaptation measures to drought, and the potential of particular practices.

Good practices may greatly help to decrease vulnerability of agriculture with respect to drought and water scarcity. To assess the drought risk management system will be useful to implement a feedback process in the drought cycle in order to learn from past practices in the mitigation or prevention, preparedness, response and recovery strategies. This process is based on:

- assess past and current droughts in the context of trends and extreme events that affect the duration and severity of droughts;
- identify potential threats and establish the degree of vulnerability sectors to droughts and how these vulnerabilities vary by region within a country;
- identify the gaps and take appropriate steps to develop and strengthen the national capabilities to provide effective drought early warnings.

In order to reduce the vulnerability of Romania to drought it is necessary to involve the whole society to fulfil the insurance efforts of the resilience necessary for the application of the adaptation measures provided in this document.

In this respect we propose:

NEEDS	ACTIONS
1. Agro climatic observation, monitoring and forecasting	Extension and modernization of the existing network of agrometeorological stations and the development of the equipment to ensure reliable ongoing data at national/ regional/local level Improvement of the collection, management, and use of observational data and other relevant information on the current and historical climate and its impact for agriculture; Development of the climate prediction products (seasonal forecasts/three months); The design of climate information and predictions into early warning and disaster prevention system (based on various climate forecasts indices – heat index, drought indices, climatological indices etc).
2. Create systematic archives of information - extreme maximum air temperature, heat waves, droughty years , etc) and available research studies	1. A comprehensive inventory of available studies, adaptation measures and policies related to the impacts of drought on agriculture and water management 2. Review of known impact projections and regional effects with focus on adaptation measures to drought in all economic sectors, particularly in agriculture and water management domain.
3. Enhancement of cooperation, transfer of technology, know-how and practices	1. The exchange of knowledge and experience, and the actual transfer of good practices to local and regional authorities, including a database of relevant case studies with a particular emphasis to the impact on different sectors; 2. Regional training of stakeholders for adopting the best available practices for drought and climate change adaptation based on available information and studies.
4. Climate modeling and scenarios	1. Identify gaps in the development of regional climate scenarios and enhance capacity/experience in the use of different models – training activities, education and training fellowships, participation in scientific assessment under IPCC and research under WMO, EU/FP programmes, INTERREG, SEE, COST Actions, etc; 2. Improve the availability and applicability of CC modeling for use by decision makers and farmers (provide data and outputs of the response of water resources to possible climate change scenarios, promote the use of GIS technology, etc)
5. New research projects/programmes	1. New research projects focusing on different themes: - Knowledge for Climate: information focused on the impact of climate change on crop and forest yield, pests and diseases, and the development of a database on droughts and risk mapping at regional level; - Decision support systems: supporting policy development, project development and transfer of information in the science-policy interface; 2. Integrated research program on drought, including cross-sectoral synthesis in order to develop knowledge's regarding the effects of climate change on regional development in the short, medium and long term (within/among sectors, spatial/temporal scales, technology, socio-economic conditions, etc);

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