Global Water Partnership
Central and Eastern Europe

Integrated Drought Management Programme

Activity 5.4. Drought Risk Management Scheme: a decision support system

Milestone no. 3.1.

DROUGHT RISK MANAGEMENT SCHEME FOR ODRA RIVER

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Global Water Partnership Central and Eastern Europe (GWP CEE), Regional Secretariat
Slovak Hydrometeorological Institute, Jeseniova 17, 833 15 Bratislava, Slovakia
Phone: +421 2 5941 5224, Fax: +421 2 5941 5273, e-mail: gwpcee@shmu.sk

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Activity leader:	Tamara TOKARCZYK (PL) Tamara.Tokarczyk@imgw.pl
Participating partners:	Tamara Tokarczyk [a)] Wiwiana Szalińska [a)] Marta Bedryj [a)] Małgorzata Kępińska – Kasprzak [a)] Leszek Łabędzki [b)] [a)] Institute of Meteorology and Water Management, National Research Institute, Wroclaw Branch(IMGW-PIB), [b)] Institute of Technology and Life Sciences (ITP)
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Introduction

The presented report contributes to Output 3 of the Activity 5.4. The goal of this output is to develop a common framework for drought risk management that will constitute a systematic approach for different national, regional and sectoral contexts. The report provides the context for the framework development that demonstrate the operational risk assessment in the region of Middle and Upper Odra River basin. ***The report summarized the objectives for the drought risk management at regional level for the operational applications, revise the current status in the Odra River basin and formulates the recommendation to build integrated drought risk management scheme.***

In Poland the most important act of low regulating water related aspects is **Water Act of Law.** The Polish Water Act of Law gives main regulations concerning water management. According to it drought protection is one of the main objectives of water management, among others connected to dealing with problems with water quantity (like assuring people with enough water quality and quantity, the water resources protection before overexploitation, assuring agriculture and industry with enough water, taking care about water needs of tourism, sport and hydroenergy).
The drought protection should performed according to drought management plans for river basin districts and sub-basin districts. First of all they should cover:

- ✓ the analysis of possibility to increase water resources,
- ✓ the proposals of new/modified water devices,
- ✓ the proposals of necessary changes of water use and retention.

Moreover drought management plans should also provide program of measures. Drought management plan is the part of water management planning that aims at:

- ✓ achieving or maintaining at least good water status,
- ✓ improvement of water resources status,
- ✓ improvement of water use possibilities,
- ✓ decrease of negative for water substances, leading to it,
- ✓ improvement of flood protection.

Water Act of Law imposed on the President of the National Water Management Authority to develop a plan of flood control and mitigate the effects of drought for the areas of the river basins. The latter became obligatory for the basins with recognized water deficit hazards. Planning for drought mitigation was new to the Polish system of water management planning. The water management planning consists of the general planning documents along with the detailed documents prepared for particular basins. This implies establishing the detailed rules of water use or the restriction of water abstraction. Still there is no accepted methodology for preparation of the document for drought management planning in Poland. Two (of seven) regional water management authorities, both located in Odra river basin (in Wroclaw and Szczecin), have just drawn up the projects of drought management plans (DMP) summarizing all needed information to create the proper act of law (Regional Board of Water Management in Szczecin 2012, Pectore-eco for Regional Board of Water Management in Wroclaw 2012).

1. Objectives for drought risk management

The essential aim of drought risk management is to establish and develop measures to reduce the socioeconomic and environmental impact of drought effects. Drought risk reduction is obtainable by building comprehensive and multi-sectoral framework including the following elements (Fig.1) [UNISDR, 2009]:

1. **Policy and governance** as an essential element for drought risk management and political commitment.
2. **Drought risk identification**, **impact assessment, and early warning**, which includes hazard monitoring and analysis, vulnerability and capability analysis, assessments of possible impacts, and the development of early warning and communication systems.
3. **Drought awareness and knowledge management** to create the basis for a culture of drought risk reduction and resilient communities.
4. **Reducing underlying factors of drought risk** such as changing social, economic and environmental conditions, land use, weather, water, climate variability and climate change.
5. **Strengthening preparedness** for drought to move from policies to practices in order to reduce the potential negative effects of drought.

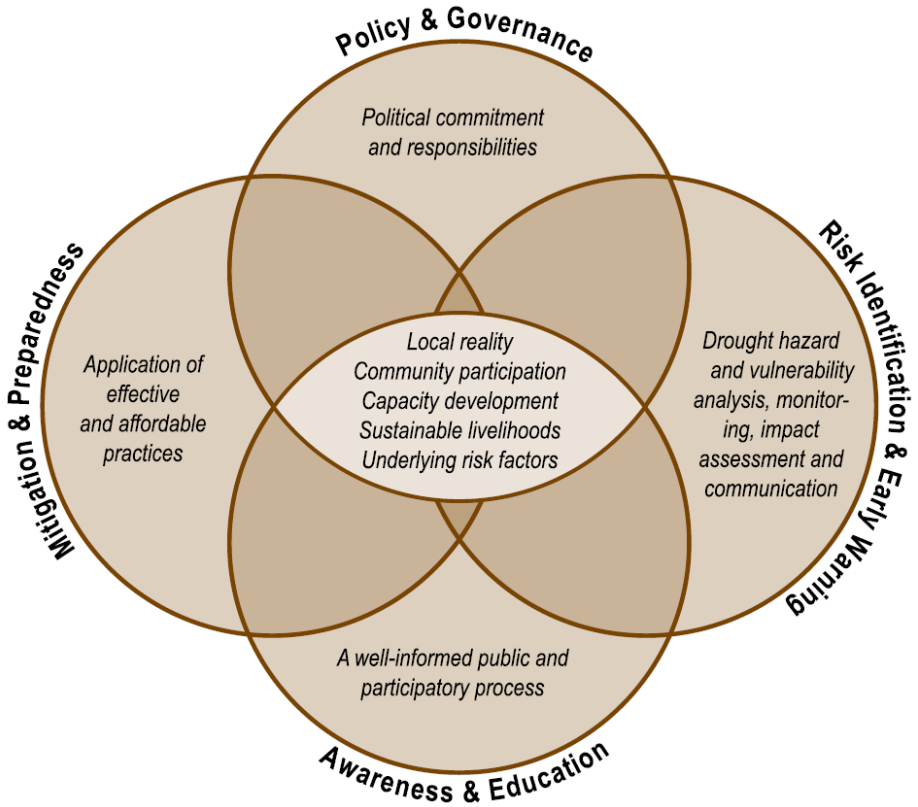


Fig. Main elements for Drought Risk Management Framework (based on UNISDR and National Drought Mitigation Center, University of Nebraska-Linkoln).

A starting point for drought risk management is gaining knowledge about hazard occurrence, the potential effects of the drought hazard, and the related vulnerabilities of potential impacts [UNISDR, 2009]. Understanding the drought hazard and the corresponding impacts and underlying

vulnerabilities, and communicating these risks in an effective manner, forms the basis for developing operational drought risk management scheme in the Odra river basin. The scheme is aiming at identification, assessment and drought risks monitoring along with drought risk prediction and early warning in the Odra River basin.

Guiding principles for drought risk identification, impact assessment, and early warning activities should be guided by the following principles [UNISDR, 2009]:

(1) Drought risk is the combination of the natural hazard and the human, social, economic and environmental vulnerability of a community or country, and managing risk requires understanding these two components and related factors in space and time.
(2) Increasing individual, community, institutional and national capacities is essential to reducing vulnerability to drought impact.
(3) Impact assessment plays an important role in drought risk management, in particular, identifying most vulnerable groups and sectors during drought.
(4) Drought monitoring and early warning systems play an important role in risk identification, assessment and management.

The main items that are needed to develop a drought management scheme for operational applications includes:

Monitoring network

Decision makers need timely and accurate information about the development of drought conditions to anticipate the onset of drought. Drought monitoring must be a continuous process to anticipate in a timely manner the hazard of drought episode. Monitoring network is therefore a measuring system, built up on available data and representing a simple concept. The main components of drought monitoring network should facilitate monitoring in real time: climatological variables, hydrological variable, soil moisture monitoring along with the groundwater monitoring. In many countries it is very common that these parameters are obtained by different services and by different operator. It is required to integrate data from different source an provide tools to obtain drought related products. Building effective drought related products requires long-term observations from one hand and real-time observation on the other. Recent developments have improved satellite's drought monitoring capabilities providing timely, spatially continuous information at high resolution.

Drought indicators and triggers

Determining the beginning, ending and affected area can be achieved by establishing adapted indicators and thresholds. Drought indicators are variables that describe the magnitude, duration, severity and spatial extend of drought. Drought triggers are threshold values of an indicator that distinguish a drought level and determine the beginning of the management actions. In operational context in order to determine the onset of a drought event it is crucial to specify the degree of departure from the average of the climatic variable under consideration over some time period. This is done by comparing the current situation to the long-term average.

While establishing DMP it is recommended that river basin authorities establish an appropriate indicator system that allows identifying the different extreme phenomenon phases, predicts possible impacts, and establishes associated measures to apply. To obtain an indicators system and

determine representative indicators, it is necessary to select, aggregate and weight basic indicators based on the associated resources and demands. Finally, the calibration of indicators through historical series, allows adjusting the thresholds to each indicator, and obtaining an aggregated group of indicators, suitable for and representative of the basin. Selection of the group of indicators should take into account whether the information readily available and is likely to remain available over time, what is the calculation costs and time to obtain results, and if the information is meaningful for the given area and period.

Drought prediction and early warnings

The first purpose of a drought early warning system is to determine the probability of a drought event and monitor its spatial extend, duration, severity and impacts. Requirements for drought prediction range from a few weeks to several months. This can be achieved by establishing a system of indicators that are easy to obtain and representative of the spatial and temporal situation of drought, allows drought on-set identification, control and assess their severity. Indicator system should incorporate climate, soil and water supply factors such as precipitation, temperature, soil moisture, snowpack, groundwater levels and streamflow. A selection of indicators is also dependent on the sector that early warning system is dedicated to. Indicators could be normalized in an appropriate threshold, e.g. from 0 to 1, to allow easy comparisons among different kind of indicators and the classification among severity drought categories.

It is also essential to support the development and improvement of relevant databases and the exchange and dissemination of drought products at international, regional, national, and local levels.

Drought hazard assessment

The frequency of occurrence of drought at various levels of intensity and duration defines the drought hazard and drought-prone regions. The return period of a drought is related to the severity of the impacts. Drought intensity, duration and spatial extend are the main characteristics that differs one drought from another. Therefore it is critical to better understand the temporal and spatial variation of this hazard. It is also essential to identify trends in temperature and precipitation amounts, changes in the seasonal distribution and intensity of precipitation events, and other changes in climate that might be helpful in understanding how the hazard may change in duration, frequency and extent in the future.

Impact assessment

The impacts of drought are diverse and depend on the underlying vulnerabilities. Drought impact assessments begin by identifying direct consequences of drought, such as reduced crop yields, livestock losses and reservoir depletion. Drought impacts can be therefore classified as economic (industry, power production, agricultural, transport), environmental (mortality of fish species, impacts on river banks and biodiversity and flora, loss of biodiversity in terrestrial areas depending on the aquatic system, impacts on wetlands - Natura 2000 sites, Forest fires risk, ecological status) or social (drinking water supply, tourism). The impacts of drought depend on their duration, intensity and location. Impacts should be examined for their occurrence in past or recent droughts, but consideration should also be given to the future impacts.

The impact assessments are a good starting point to determine underlying vulnerabilities to target response measures during drought. Vulnerability is determined by a combination of information on sectors, populations, or activities that are vulnerable to drought.

Risk assessment

Drought risk is the combination of the natural hazard and the human, social, economic and environmental vulnerability of a given area. A methodology of "drought risk assessment" aims to determine the nature and extent of drought risk by analyzing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend. Drought risk assessments (and associated risk mapping) include: a review of the technical characteristics of drought such as their location, intensity, frequency and probability, the analysis of exposure and vulnerability including the physical, social, health, economic and environmental dimensions; and the evaluation of the effectiveness of prevailing and alternative coping capacities in respect to likely risk scenarios.

Service delivery and organizational framework to deal with drought events.

A service delivery includes a set of principles, standards, policies and constraints used to guide the design, development, deployment and operation of services delivered to a specific user community in a specific context. Different users and drought context requires different content and presentation of information on drought. Preparing this information involve collaboration among relevant scientific groups, policymakers and stakeholders. This includes the adoption of drought hazard and vulnerability indicators and standards, modification of risk assessment methodologies to using metrics and maps most relevant to needs of decision makers, stakeholders and clients. In addition institutions producing and providing information on drought need to cooperate locally, regionally, nationally and internationally with the institutions eligible for drought management. This aim to assess and monitor regional and transboundary hazards and vulnerabilities and exchange relevant information to mitigate drought effects.

Organizational framework requires clear division of competence and tasks between responsible institutions: for data collecting/data analysis and drought forecasting, generation of alerts and warnings, for planning, developing drought mitigation measures and for crisis management and operational actions coordinators.

2. Current status of drought risk management in Odra River

2.1. Study area

The Odra River with a total length of 854 km is one of the two main rivers of Poland (Fig. 1). The Odra river basin is 124 049 km², of which 107 169 km² are in Poland (86,4%), 7 278 km² in the Czech Republic (5,9%), and 9 602 km² within the boundaries of Germany (7,7%)2. The source of the river is in the Czech Republic in the Odrzanskie Mountains (Oderské vrchy) at the altitude of 634 m above

sea level. 21.4% of the Odra's water river basin lies 300 above sea level, 54% - between 100-300 m above sea level, 24% - below 100m. The highest point is Śnieżka (Sněžka/ Schneekoppe) in the Giant Mountains (Karkonosze/ Krkonoše/ Riesengebirge) – 1602 m above sea level. For the first 47 km, the Odra has a character of a mountain stream. The drop of the river from Ostrava (Ostrawa/ Ostrau) to the mouth of the Warta is about 27 cm/km, however below Schwedt it is below 5 cm/km. The relief is seep and the underlying clay shale is rather impermeable. The extensive drainage is aggravated by urbanization, large scale deforestation and drainage of agricultural lands in hilly area. Theses, combined with high annual rainfall (up to 1 400 mm) mainly concentrated in summer results in rapid runoff that amounts to 18.5 billion m3. The Odra flows into the Szczecin (Stettin) Lagoon.

The Odra is navigable from Kedzierzyn-Kozle (Kandrzin-Cosel) (including the Gliwice Canal that starts in the city) down the course of the river. Below Brzeg Dolny up to the mouth of the Warta water levels periodically preclude freight shipping navigation. Through a system of canals, the Odra has a navigable connection with Szprewa and Hawela. All reservoirs on the Odra are practically impenetrable for bi-habitat fish.

The Odra and most of its tributaries are very important ecological passageways of relatively low level of natural environment changes (in relation to the most of the EU rivers). There are seven national parks within the area of the Odra catchment. In the territory of Poland they are: Karkonosze (Karkonoski/Krkonoše/Riesengebirge), Table Mountains (Góry Stołowe/Stolové hory/ Heuscheuergebirge), Wielkopolska (Wielkopolski Park Narodowy), Drawno (Drawieński Park Narodowy), Ujscie Warty (Park Narodowy Ujście Warty) and Wolin (Woliński Park Narodowy); in the territory of Germany it is the Unteres Odertal (Dolina Dolnej Odry). Moreover, within the Odra river basin there are also landscape parks, nature preserves along with other forms of sanctuaries. Many areas, especially in river valleys, are being intended for protection within a framework of the NATURA 2000.

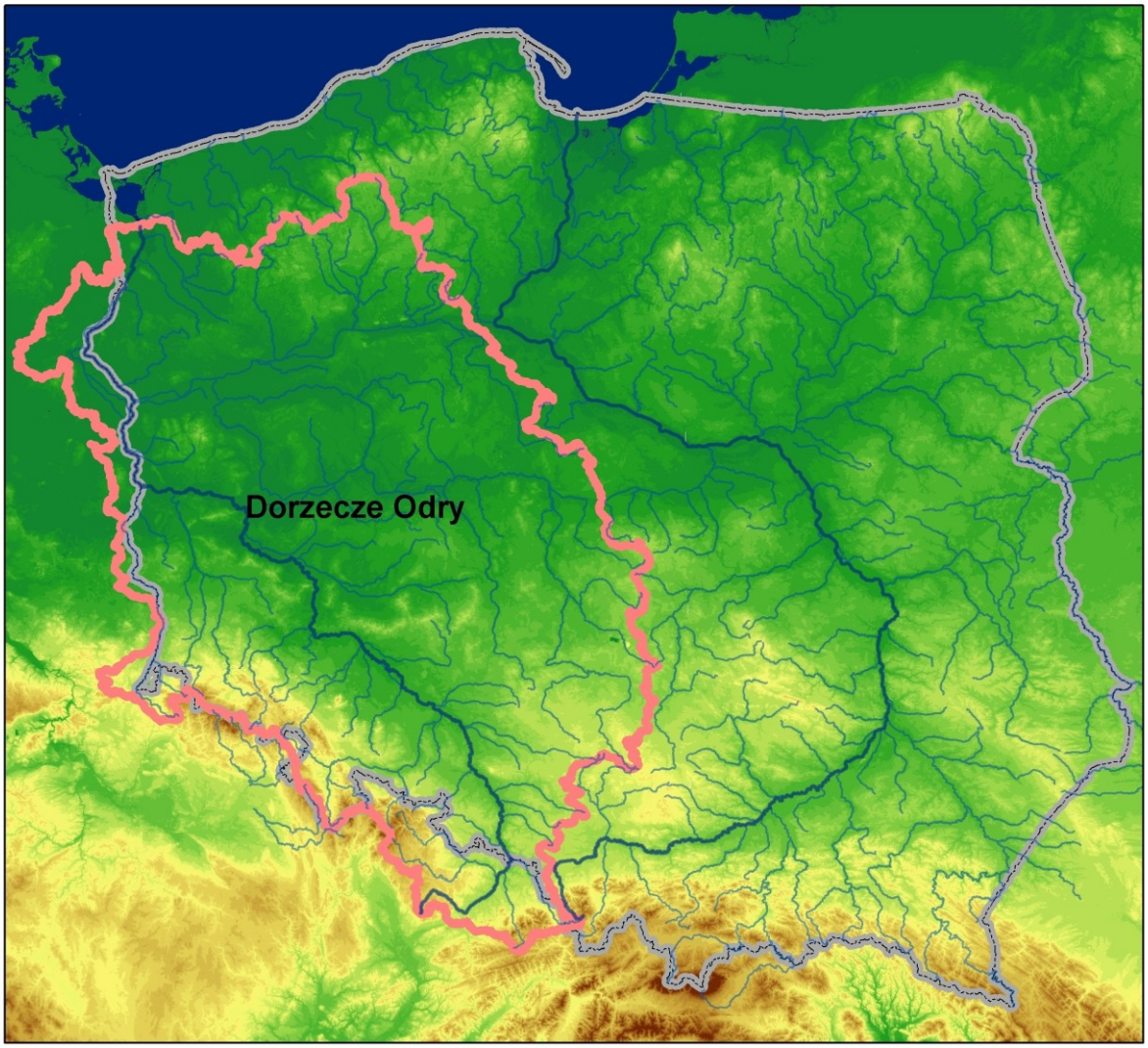


Fig. 1. The area of Odra River basin

2.2. Organizational framework for water management in Poland

Water management in Poland is one of the sectors of the national economy which is strongly connected with other fields of economic activities. The aim of water management as understand in economic and scientific activity is the rational development and use of surface water and groundwater resources, with consideration given to their quantity and quality consideration given to their quantity and quality. The main tasks of water management in Poland are deemed to include:

- improvement of the cleanliness of surface waters and groundwater
- ensuring the appropriate quantity and quality of water for the population, industry and agriculture,
- protection against floods and drought,
- protection of waters against pollution and their incorrect or excessive use,
- maintenance and improvement of the status of aquatic and water - dependent ecosystems,

- creation of the conditions for the use of water resources for energy, transport and fishing purposes,
- meeting needs related to tourism, sports and recreation.

Responsibilities of National Water Management Authority are specified in the Water Law Act and include: Law Act and include:

- elaboration of the river basin water management plans whose implementation is supported by the program of measures supported by the program of measures ,
- elaboration of the flood protection and drought prevention plans,
- elaboration and maintenance of water information system,
- supervision the national hydrological meteorological and hydrogeological services,
- supervision the national hydrological meteorological and hydrogeological services,
- programming, planning and supervision of the implementation of tasks related to the conservation of water, water works and water management investments.

The National Water Management Authority is a central administrative body responsible for water management, including water conservation and water use. The President of the National Water Management Authority is supervised by the minister responsible for the water management (Minister of Environment). National Water Management Authority is supported by 7 regional authorities (RZGW) operating within the hydrographical boundaries.

Water management in Poland is realized through in hydrographical boundaries, but at the same time a lot of other tasks connected with the realization of water management are also carried out within administration boundaries (Fig. 2).

> ***hydrografic boundaries*** - authorities responsible for planning and control tasks,

> ***administration boundaries*** - authorities responsible for realization, implementation measures.

KZGW Krajowy Zarząd Gospodarki Wodnej

Levels of planning and analysis in water management

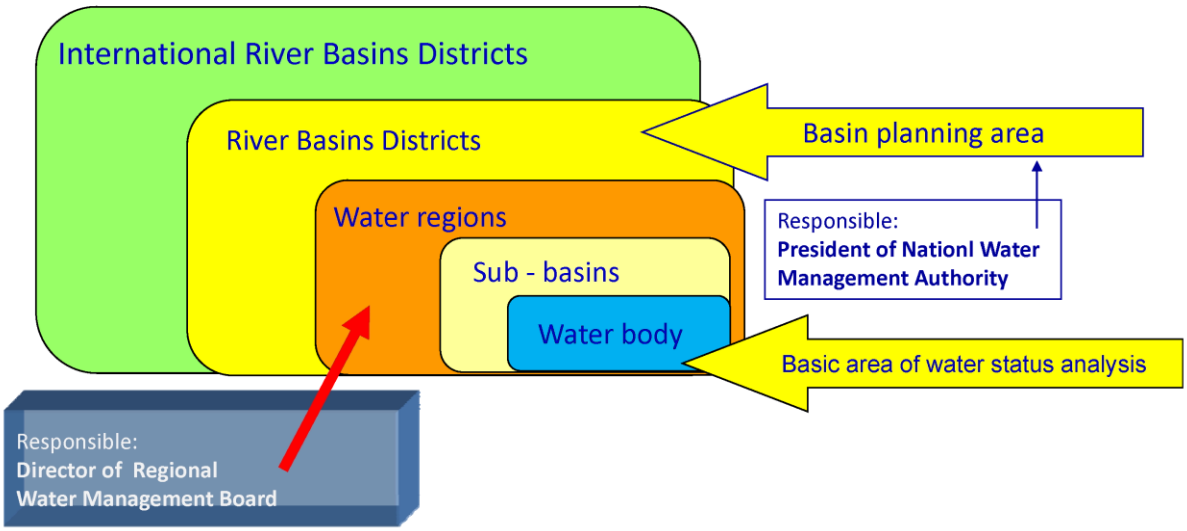


Fig. 2. Levels of planning and analysis in water management

2.3. Management of water resources to mitigate drought impacts

In the current legal system of drought protection is appointed as one of the main tasks of water management. Polish Water Act of Law provides the following measures for drought mitigation:

- ✓ preserving and creation of any water retention systems - natural and artificial,
- ✓ reasonable control of the water flows,
- ✓ building effective monitoring, forecasting and warning system against extreme hydrometeorological events

Water management is performed for system of hydrographic basins and water regions. The recognized tools for protection against drought include:

1) planning tools (analysis , plans, programs):
   a) recognizing the needs, current state and development of retention,
   b) flood protection and drought management plans for the river basins,
   c) water management plans for the river basin,
   d) water use policy in the region,
2) water use regulations ,
3) instructions for water management on hydrotechnical structures ,
4) monitoring, prediction and early warning against drought.

In Poland except from national flood protection plan and drought mitigation plan, there are no other legal instruments dedicated purely for drought management. Within the framework of this plan it is possible to prevent / mitigate / capacity building in the case of drought.

Drought protection impose by Water Act of Law defines two drought management rules:

1) Director of the Regional Water Management Board is responsible for coordination the activities related to the protection against drought in the region, including data collection, processing and providing information for the spatial planning and crisis management centers;

2) In the event of natural disaster, the Director of the Regional Water Management Board is entitled to introduce temporal restrictions on the use of water - particularly for the collection of water or discharging sewage into water or soil and impose changes in water reservoirs management.

2.4. Drought risk management plans

Water management, including building DMP, in the river basin is coordinated by the President of the National Water Management and is delegated to Directors of the Regional Water Management Boards. The first development of the preliminary DMP for Odra basin was prepared by Regional Board of Water Management in Szczecin 2012 and later by Pectore-eco for Regional Board of Water Management in Wroclaw 2012. Both DMP were prepared in similar way, using the same set of indexes. The applied drought indices embodied meteorological, agricultural drought assessment, drought in ecosystem, hydrological drought and groundwater drought.

Meteorological drought was estimated with the use of:

- ✓ Standardized Precipitation Index
- ✓ value of precipitation deficiency,
- ✓ no days without precipitation.

Agricultural drought was estimated with the use of:

- ✓ climatic water balance in a given period.

Drought estimation in ecosystems was estimated with the use of:

- ✓ estimation on the basis of natural habitat type in the context of drought vulnerability.It was assumed that drought estimation should refer to plant types. Some habitats were identified to be good indexes for drought impact assessment (mainly peatlands) and the results were extrapolated to other habitats.

Hydrological drought:

low flow estimation (duration and water deficit).

Groundwater drought

the low groundwater levels estimation using the water table (duration and intensity)

The average water table was treated as the threshold to identify drought periods. The index of groundwater drought was determined as:

$$k_n = 1 - \left(\frac{G}{SNG_W}\right)$$

k_n – the index of groundwater drought

G – the present water table

SNG_W – the average low water table for the period of years (average minimum annual water tables for the period of years).

The estimation of drought was done according to the following classification:

$k_n > 0,1$	No groundwater drought
$0,1 \geq k_n > -0,1$	The threat of groundwater drought occurence
$-0,1 \geq k_n > -0,3$	Shallow groundwater drought
$-0,3 \geq k_n$	Deep groundwater drought

the percentage of water levels below SNG

These indices were used for drought risk assessment to define three levels of warnings: pre-alert (I), alert (II) and emergency (III) drought status.

For hydrological drought the corresponding thresholds for the defined levels are the following:

$$Qnn_w + 0,05 \cdot Qnn_w < prealert \leq Qnn_w + 0,1 \cdot Qnn_w$$

$$Qnn_w \leq alert \leq Qnn_w + 0,05 \cdot Qnn_w$$

$$alert < Qnn_w$$

For groundwater drought the thresholds are derived from analysis of duration of low water tables below SNG and confronted to the possibility of groundwater recovery.

The economic drought was estimated for surface water and groundwater separately using multicriteria maps showing the drought risk for selected regions.

The basis of above mentioned maps were for surface water:

- ✓ the estimation of duration and intensity of hydrological drought,
- ✓ the intensity of surface water intakes,
- ✓ the area of aquatic ecosystems,
- ✓ the estimation of agricultural drought propagation possibility in the context of soil types.

In the result three classes of drought risk (in aspect of surface water) were determined:

I	The regions with requirements of strong drought mitigation actions.	Intensive hydrological drought, Very intensive exploitation of surface water, Large area of aquatic ecosystems and/or soil types supporting agricultural drought propagation
II	The regions with requirements of basic drought mitigation actions or preventive measures.	Hydrological drought can restrict water use in a moderate way, soil types supporting agricultural drought propagation
III	The regions without requirements of drought mitigation actions.	Moderate hydrological drought, low water use, small area of aquatic ecosystems and/or soil types without supporting of agricultural drought propagation

The similar approach was used for groundwater, The basis of multicriteria maps were:

- the occurrence of groundwater drought periods,
- the distribution of geographical zones,
- water reserves volume confronted to actual groundwater intakes volume,
- water reserves volume confronted to groundwater intakes volume determined in water licenses,
- actual groundwater intakes volume,
- the influence of mines.

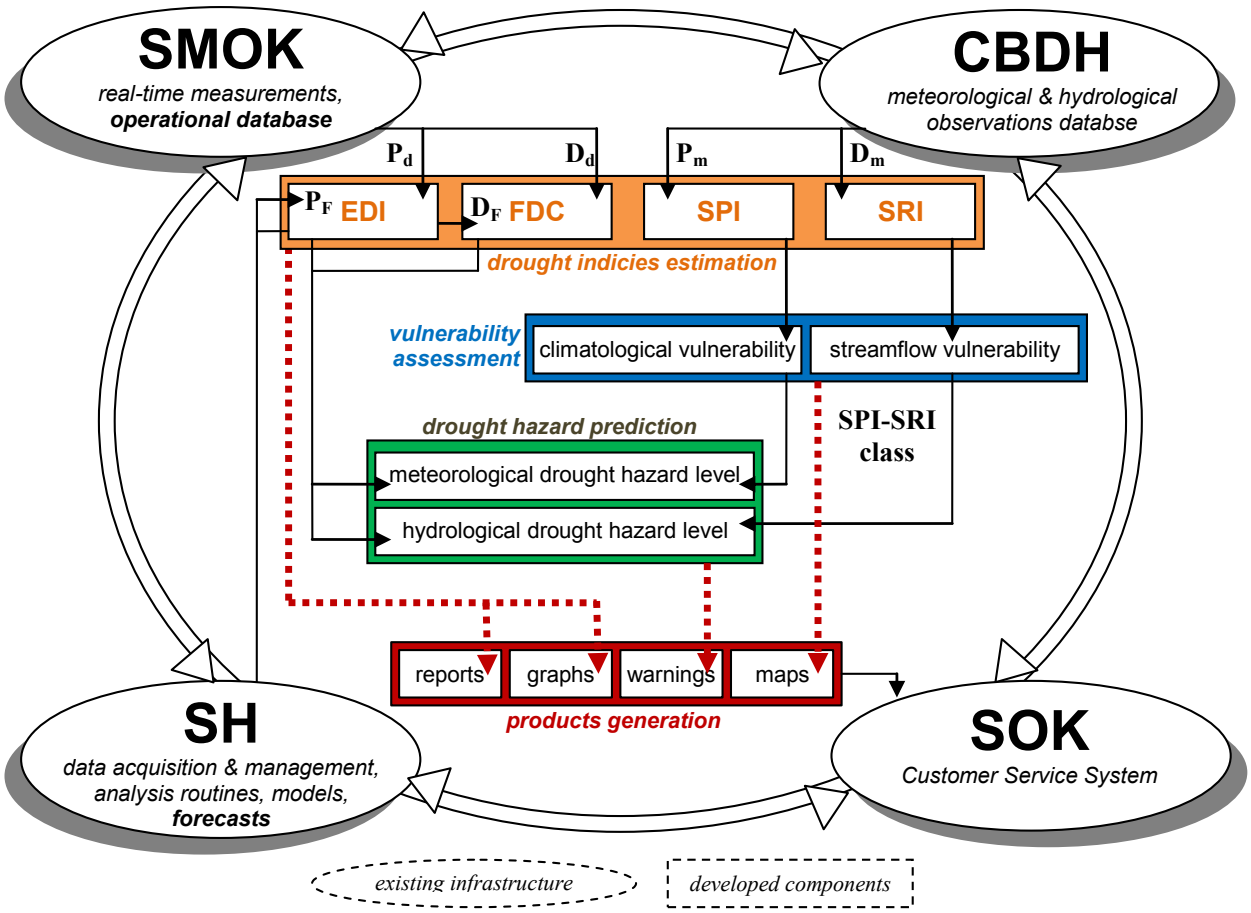
In the result three classes of drought risk (in aspect of groundwater) were determined:

I	The regions with requirements of strong drought mitigation actions.	Intensive groundwater drought with risk of restriction of water use occurrence
II	The regions with requirements of basic drought mitigation actions or preventive measures.	groundwater drought with moderate risk of restriction of water use occurrence
III	The regions without requirements of drought mitigation actions.	Other regions

2.5. Drought monitoring and prediction

The responsibility for forecasting and monitoring drought phenomena is on the state hydrological and meteorological service and on the state hydrogeological services, namely the Institute of Meteorology and Water Management and Geological Institute respectively. As part of the statutory tasks they provide warnings against drought hazard.

The Institute of Meteorology and Water Management, National Research Institute has developed and implemented a set of tools for the operational meteorological and drought hazard assessment. The developed tools cover drought indices estimation, susceptibility to drought assessment and drought hazard prediction. They are streamlined into an operational system to support the operational work of meteorological and hydrological forecast offices (Fig. 3). In 2011 the system was lunched to run operationally for the selected catchments of the Odra River and the Wisla River basins. The crucial resulting products are presented on the website operated by IMWM-NRI: POSUCH@ (Operational System for Providing Drought Prediction and Characteristics) (http://posucha.imgw.pl/). The prediction of meteorological and hydrological drought hazard is performed as short term for 3-days and long-term for 3 months [Tokarczyk & Szalinska, 2013 *a* and *b*].



P_d – daily precipitation, **P_m** – monthly precipitation, **P_F** – precipitation forecast
D_d – daily discharges, **D_m** – monthly precipitation, **D_F** – discharge forecast

Fig.3 Hydrometorological drought hazard assessment system operated by Institute of Meteorology and Water Management (source: Tokarczyk, Szalinska, 2013).

In terms of monitoring of hydrogeological resources, The Geological Institute, National Research Institute is preparing long-term forecasts for three months. These forecasts analyze historical low flow periods and observed droughts, the current state of groundwater and surface waters, current meteorological conditions as well as the data from the period prior to the forecast and the forecast of the hydrometeorological conditions. The prediction includes as well information on the potential impact of predicted groundwater levels on the water collation.

There is also a nationwide monitoring system for agricultural drought performed by the Institute of Technology and Life Sciences (ITP). The system provides information on the areas where due to the type of soil and the observed meteorological indicators, there is a hazard of drought occurrence. Determination of areas at risk of drought is associated with insurance system - payments of compensation for losses caused by drought.

3. Recommendation on development of drought risk management in the Odra River

3.1. The need to improve drought governance

Planning for drought prevention and mitigation solutions introduced in the world (USA , UK) include the preparation of such plans by the institution that is responsible for water management at the national, regional, as well as catchments levels. These plans include the definition of multi-level institutional structure, along with the competence sharing and building management tools that allows to mitigate drought impacts. At the national level this requires preparing two basic documents: 1) long-term forecast of drought risk for the next hydrological year, 2) plan for drought mitigation actions embodying. The latter should include the following elements:

- the group of participants responsible for drought protection strategy, the competence of the group, institutional dependencies and relationship with water management bodies.
- analysis of the drought prevention and mitigation including: analysis of drought hazard, analysis of the retention capacity (natural and artificial), together with the assessment of its potential to mitigate drought impacts, plans to increase retention rate, analysis of the existing and planned water use scheme, development of a package management tools (permissions , restrictions, etc.) that aimed at mitigating a drought effects
- drought immediate response actions to mitigate direct drought effects including collaboration with regional water authorities and crisis management centers.

The same plans should be performed at the regional level however with the higher level of detail.

According to this, the improvement on drought governance in Poland and in Odra river basin in particular should be defined within the existing institutional structure of water management. Within the existing authorities, including state services, it is recommended to organize drought management groups for planning and managing drought risk. This groups should be organized at different administrative levels: national, regional and local [Godyn, 2009].

At the national level the drought management group should be organize within the framework of National Water Management Body and should be responsible for:

- developing long-term forecasts of drought hazard, developing drought management plans in the country, including the water basin districts, supervising and coordinating the work at the regional level in the implementation of the tasks related to drought risk reduction.
- cooperation with hydrometeorological and hydrogeological services responsible for drought forecasting.

At the regional level the drought management groups should be responsible for the preparation of regional plans, supervising collaboration for drought reduction at the level of the individual water regions. The actual competence of Directors of Regional Water Management Boars on introducing restriction in water intakes during the state of natural disaster could be broaden by a spatial regulations concerning the state when severe drought is predicted. This should concern changes in water management on reservoir or temporal changes permits for water intakes)

At the local level of given water body drought management group should be responsible for drought vulnerability reduction, for preparing local action plans and measures to mitigate the drought impacts and for having control over the water supply companies and other users of water resources.

Such drought management groups could work on the periodical basis. In Poland, serious droughts recur every 4-12 years and usually do not affect the whole country. Therefore this groups should
Drought management group should organize regular meetings most likely at the beginning of the hydrological year (November, December). At national level it is necessarily to summarize the previous year, to identify the state of water resources and formulate the plans for the coming year that would be adopted for developing water management strategies for water regions at the regional level.
At the local level drought management groups should develop the operational actions plans in case of drought event, cooperate in monitoring the state of resources and participate in educational campaigns and awareness rising, prepare the local society for the situation of water resources shortage and introducing local measures for reducing drought risk. This should be done with close collaboration with local stakeholders and enterprises responsible for water supply.

3.2. The need to improve drought risk identification

The drought risk management system refers to the drought monitoring and forecasting methods, drought assessment and risk analysis procedures as well as drought management recommendations to support decision making. This includes the development of decision-support models for the dissemination of drought-related information to end users and appropriate methods for encouraging feedback on climate and drought assessment products, and on other forms of early warning information.
Augmenting forecast and early warning information with decision support capabilities to provide information on options for reducing vulnerability to drought enhances local coping capacities and provides an important mechanism for reducing drought risk.
The need to improve drought monitoring system for the Odra River basin with the goal of improving preparedness and reducing drought impacts have to concern the following aspects:

- ***Monitoring and prediction tools:***

Due to the complex nature of drought as well as its large spatial and temporal extent, the drought risk management system should be developed on the multisectorial and national/regional level. So far all the existing drought monitoring and forecasting systems are operated independently. Therefore there is a great need to introduce the linkages between existing systems in order to provide a coherent long-term outlook on the state of surface water and groundwater resources, the status of water in reservoirs and on this basis formulate drought mitigation actions and strategies.
The drought early warning system includes preparation and dissemination of forecasts and warnings on weather and water related hazardous situations for national and regional scale. Such system build on national, regional and local levels should combine the tools for: operational detection and prediction of various stages of drought, including meteorological, agriculture and hydrological drought identification, tracing of temporal variability of drought up to daily time step, mapping of drought spatial distribution, providing forecasts of drought hazard formation for different time

horizons, and projecting seasonal and regional susceptibility to drought. The developed tools for operational drought early warning and long term prediction should be aimed at reducing forecast uncertainty. Drought early warning system should profit from the recent developments of the meteorological and hydrological networks including automatic sensors to monitor weather, satellite images and products, radars, agro meteorological observations and measurements, etc.

- ***Mapping and assessing the impact of droughts:***

There is a vital need to organize and manage the drought vulnerability assessment by developing the tools for mapping and assessing the impact of drought. The improvement strategy should concern:
- organized collection of drought related data and information concerning drought formation, exposure to drought and impacts of droughts;
- developing a set of drought indices for various applications that can be calculated in a timely manner based on the information that is readily available;
- develop a set of thresholds values for the defined set of indicator that distinguish a drought level and determine the beginning of the management actions;
- building a concept for drought hazard, susceptibility to drought and vulnerability maps generation with the use of GIS techniques;
- identifying drought management approach (immediate response or decrease vulnerability) to recover or mitigate recognized direct and indirect impacts of drought within economic, environmental and social contexts.

References

UNISDR, 2009. Drought Risk Reduction Framework and Practices: Contributing to the Implementation of the Hyogo Framework for Action. United Nations secretariat of the International Strategy for Disaster Reduction (UNISDR), Geneva, Switzerland, 213 pp.

Tokarczyk T., Szalińska W., 2013 a. The operational drought hazard assessment scheme – performance and preliminary results. Archives of Environmental Protection, vo. 39, no 3, pp.61-77.

Tokarczyk T., Szalińska W., 2013 b. Combined analysis of precipitation and water deficit for drought hazard assessment. Hydrological Sciences Journal, DOI: 10.1080/02626667.2013.862335.

Godyń, Izabela, 2009, Instrumenty planistyczne i zarządzania dla potrzeb łagodzenia zjawiska suszy, Czasopismo Techniczne z. 1 – Środowisko z. 1-Ś

Drought management plan report including agricultural, drought indicators and climate change aspects, Technical Report 2008-023, Office for Official Publications of the European Communities

Wilhite D.,2005, Drought and Water Crises: Science, Technology, and Management Issues, CRC Press, Boca Raton, Florida 2005