Integrated Drought Management in Central and Eastern Europe

ACTIVITY LIST

1. BASIC INFORMATION

Number of Activity:	**5.5**
Title of the activity:	**Policy oriented study on remote sensing agricultural drought monitoring methods**
Duration of the activity:	*20 months (June 2013 – January 2015)*
Activity leader:	*Prof. Dr. János Tamás*
Chairman of the CWP:	*Dr. József Gayer*
Description of the activity:	

The identified problem area: Out of the three drought types, namely meteorological, hydrological and agricultural, the latter is the least quantified, thus the most uncertain drought type. The indexes of meteorological and hydrological drought parameters (temperature, precipitation, humidity etc) are based on well-measured and evaluated parameters and widely tested statistical methods (simple and complex index base). However, the agricultural drought is influenced by several complex factors, whose measurements are complicated, time and resource intensive and their impact (such as soil drought) is indirectly measurable or only at a later date (yield loss). In crop growing practice, for the time being it is not possible to measure exactly (except in laboratory conditions) the relationships among water stress symptoms (stoma resistance, temperature shock, pigment degradation, CH –demolish), available soil water content (hydraulic conductivity, field capacity, pF value) and forthcoming yield loss, as well as crop quality degradation. For farming practices and policy-makers the intervention time and the knowledge of spatial extend of the problem is critical for prevention or at least the reduction of the damage.

In the case of most watercourses, network of runoff measuring instrument has already been operated so hydrologic drought is forecastable. While on watershed areas just a few data available in the case of soil and plant moisture content. This resulted that these data are not suitable for reliable evaluation for agricultural droughts at watershed or regional level. Continuous measurements for getting information on actual soil water stock are only carried out by 2-5 % of farmers, while the crop water content is only measured before harvesting and in the case of grains. Empirical predictions of droughts are generally used in agriculture, but they based on precipitation. Decision makers have to take into account that agricultural sector utilize the 40-60 % of total water resource. The data on water utilization in agriculture is rather uncertain in Central Europe, thus the recognition and the evaluation of the agricultural droughts are difficult. Further more, during the hydrological cycle the amount of transpirated water will not fall back to soil surface in the place of origin, thus a spatial reallocation of water source has also negative effect on the estimation of the waterbalance on a site. There are important water reserve facilities since concerning different agricultural practice and landuse systems there are 2-6 times differences in specific water utilization between Central and Eastern Europe regions. As the uncertainty estimation could be reduced in agricultural water management, as well as the efficiency of water utilization could also be raised, the efficiency of the whole watershed management can significantly grow. Investment costs of drought risk reduction have to be paid in poor countries by profitable agriculture. In order to the farmers realize the efficiency of the expenditure for drought risk reduction investments and to invest in food industry and in rural development, it is necessary to calculate not only the cost but the virtual benefit of them which can occur in a case of a severe drought event. The direct economic and political benefit has to take into consideration as well, which benefit is coming from the increase of food safety and security resulted by a more reliable drought monitoring and forecasting system. These results support growing economic stability and thus decreases political risks in the drought affected regions. Nowadays in water management, remote sensing is one of most important solution for measuring agricultural droughts and its effects. Presently there is minimal technological barrier of the wide range technical application of remote sensing (RS), though the cumulated knowledge on RS can slowly be implemented into practice. Thus due to the lack of knowledge or some kind of misunderstanding, decision makers talks about this technology as research task, but it is a practice oriented development. This project is planned to support filling the gap of knowledge in this field, in order to develop agricultural drought related decision parameters and application in practice from raw spectral datasets. There is a possible way to continuously gather spectral physical data on plant water content, though the direct interpretation of these data is not feasible for farmers. Using field reference data (data of green and brown water content) as a calibration for remote sensing data, real plant water demand quickly and effectively can be mapped in spatial and in time on the surface.

The available remote sensing spectral based agricultural drought indexing can effectively indicate spectral anomalies, namely the possible intervention areas. However, on one hand, farmers have no experience with practical application of this spectral anomaly information, and the other hand they do not know how to correlate with different species, and growing vegetation phases.

This planned case study will focus on identification of agricultural drought characteristics and elaborate a monitoring method (with application of remote sensing data), which could result in appropriate early warning of droughts before irreversible yield loss and/or quality degradation occur. The spatial decision supporting system to be developed will help the farmers in reducing drought risk of the different region by plant specific calibrated drought indexes. This methodology will be extendable for other Central European countries when country specific data are available and entered into the system.

Determination of yield loss is a possible solution in the detection and identification of the extent of agricultural drought. Based on multi/hyper-spectral remote sensing data and spectral based technologies and drought indices, the main objective of this case study is to formulate concrete practical agricultural drought monitoring method and intervention levels with calibrating for the important crops and fruits (wheat, corn and apple) which are representative in the study area.

The case study will utilize the available database prepared for the Tisza River Basin. The land use in this basin is primarily agricultural type with dominant plough-land, which is characteristic to the so called corn-wheat belt of the Central and Eastern European countries and the region suffers from regular continental droughts. The selection of the three mentioned crops from crop water requirement point of view is justified that the wheat has evolved as a C3 plant because it naturally occurs in temperate regions of the Central and Eastern Europe, where the temperature is mild and as C3 plants are less energy efficient at high temperatures. Corn as a C4 plant is more energy efficient and more drought tolerant at high temperature. At the same time, it is more effected when drought develops by the end of summer than the wheat which is already harvested in August. Mechanism of apple drought tolerance is also typical from special crop water evapotranspiration point of view (root zone, phytotechnology, year impact etc).

The methods and databases to be explored include employment of remote sensing data on land use, biomass production, soil characteristics for better integration and understanding of spectral cropping patterns influenced by surface elevation, hydrology and soil types. Internationally available land use (CORINE database, topographic maps) remote sensing data, spectral indices, soil data (agrotopographic map, soil water management properties, map of water management properties of soils), hydrology (soil water table), digital elevation models will facilitate the establishment of the agricultural drought monitoring and intervention levels by the integration of production zones, water-saving soil cultivation concerning different soil types, soil water holding capacities and crop production and spectral characteristics of crops and fruits. In USA at Centre of Drought Monitoring (http://droughtmonitor.unl.edu/monitor.html) a similar work has already been started where spectral indices were elaborated only for different risk levels because of the lack of plant specific values. To make decision intervention, it would be necessary to have information about cumulative effects of these risks on watershed level. So available data on the field of agricultural drought has informative nature and not contains yield loss parameters.

Based on the above mentioned reasons in this policy oriented study we develop methods by which:

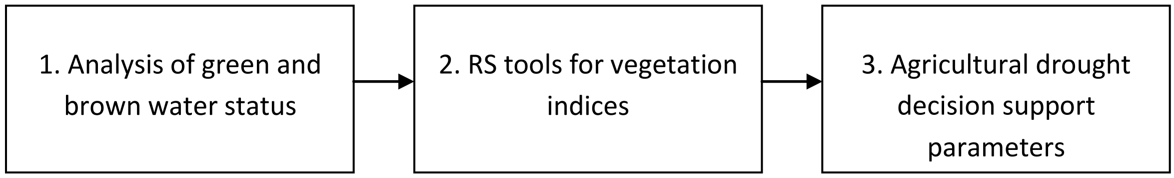
- 1. We analyse the soil and crop water content status within different agricultural water management practices at rain fed and irrigated systems for the most important crops and fruit (wheat, corn and apple). (*Agricultural drought means critical decrease in watercontent of plants, therefore the identification of this critical waterloss is essential. Certainly the amount of critical waterloss is plant and soil dependent. Therefore we chose to analyse the three different plant species.)*

- 2. We can specify a remote sensing toolbox to formulate concrete signalling and and intervention levels of drought by which spatial and temporal extent of risk to the actual drought situation in the crops can be quantified

- 3. We define the integration of RS and GIS tools and intervention levels for drought monitoring system to facilitate decision makers.

We are going to elaborate three outputs for the above objectives. The abovementioned three outputs follow a logical process flow. In the 1. part of the study the agricultural practice oriented scenario analysis for green and brown water resources will be carried out on watersheds, in order to gather information on water utilization of a site in case of different landuse, crop rotation and agricultural practice. These data are necessary for the calibration and validation of remote sensing data, which validation and calibration will be made in the 2. part of the study. These data will be used in part 3. in order to develop drought indicators and integrate them to drought monitoring system.

Logical process:



2. CONTRIBUTING ORGANIZATIONS / EXPERTS

Country	Organization	Contact
Hungary	University of Debrecen (UoDE) GWP Hungary (GWP-HU)	*Prof. Dr. János Tamás* *Dr. József Gayer* *Dr. János Fehér*
Slovakia	Institute of Hydrology of the Slovak Academy of Sciences (IH SAS)	*Dr. William Nagy*
Romania	University of Oradea (UoO)	*Dr. Stelian Nistor*

COMMENTS:

Key qualifications of partners:

Hungary (University of Debrecen and GWP HU):
- Applied hydrological remote sensing and GIS;
- Spatial Decision Supporting Systems

Romania (University of Oradea):
- Geography and Integrated watershed management

Slovakia (Institute of Hydrology of the Slovak Academy of Sciences):
- Agricultural water management, Soil hydrology

3. PLAN for IMPLEMENTATION of the activity

Name of the output 1	**Green and brown water resources on watersheds**
Type of the output (analysis, report, guideline, workshop, brochure, etc.):	An analysis report on the role of soil and crop water content status in waterbalance within different agricultural, landuse and water management practices at rain fed and irrigated systems for the most important crops and fruit (wheat, corn and apple)
Form (website, CD, printed, database, audio-visual, computer software, etc.):	*On the website of University of Debrecen, Water and Environmental management Institute (http://gisserver1.date.hu)* *CD on demand*
Purpose of the output:	*The purpose is to give information that how agricultural practice, crop rotation, landuse affect the brown and green waterstatus which can be the basis of converting remote sensing data to water management data system. Agricultural drought means critical decrease in watercontent of plants, therefore the identification of this critical waterloss is essential. Certainly the amount of critical waterloss is plant and soil dependent. Therefore we chose to analyze three different plantspecies (wheat corn and apple)*
Structure and description (contents, requirements for use, chapters, etc.)	*Based on the amount of green and brown water waterbalance analysis of a watershed concerning different landuse, agricultural practice for each crop (wheat, corn and apple) from agricultural drought severity point of view:* • *Analysis of greenwater content at different soil terrain and climate (non irrigated circumstances and rain-fed)circumstances* • *Analysis of brownwater content at different soil terrain and climate (non irrigated circumstances and rain-fed)circumstances*

Name of the output 2	**Signalling and and intervention levels of drought based on remote sensing datasets**
Type of the output (analysis, report, guideline, workshop, brochure, etc.):	Toolbox with the concrete identification of remote sensing and GIS data tools for agricultural drought monitoring and forecast.
Form (website, CD, printed, database, audio-visual, computer software, etc.):	*On the website of University of Debrecen, Water and Environmental management Institute (http://gisserver1.date.hu)* *CD on demand*
Purpose of the output:	*to facilitate farmers and decision makers:* • *to identify droughts and the characteristics of drought sensitive areas in an early stage,* • *to predict area-specific yield forecasts,* • *to calculate possible yield loss and* • *to determine the degree of intervention to reduce the harmful effects of drought*
Structure and description (contents, requirements for use, chapters, etc.)	• *Dissemination of the vegetation indexing methods and their purposes for selected crops* • *Elaboration of multi- and hyper-spectral remote sensing vegetation-drought indexing methods and databases, applicable for determination of yield loss of different crops* • *Collecting presently available indexing methods of agricultural drought in different phenophases for selected crops* • *Identification of drought signalling and intervention levels with the integration of vegetation indexing and the results of output 1. (soil and crop water content status in within different agricultural, landuse and water management practices) to predict possible yield loss as* • *Mapping of drought sensitive areas based on soil and climate data*

Name of the output 3	**Integration of RS and GIS tools and intervention levels into drought monitoring system**
Type of the output (analysis, report, guideline, workshop, brochure, etc.):	*Guidelines for national governments and local stakeholders to integrate the drought monitoring and intervention levels into national flood and drought protection plans, in application of signalling and intervention levels for farmers.*
Form (website, CD, printed, database, audio-visual, computer software, etc.):	*On the website of University of Debrecen, Water and Environmental management Institute (http://gisserver1.date.hu)* *CD on demand*
Purpose of the output:	*To get stakeholders acquainted with the agricultural drought monitoring and forecasting methods*
Structure and description (contents, requirements for use, chapters, etc.)	• *Description of what remote sensing data from what agricultural drought data can be calculated with which effectiveness (comparing costs and benefits)* • *Effect of agricultural droughts on yield loss and their economic boundaries* • *Role of agricultural drought indexing in forecasting and monitoring, comparing errors and uncertainties.* • *Integration possibilities of agricultural drought indexing, signalling and intervention levels to drought management plans - evaluation of decision risks.*

Steps for implementation of the activity	Till when?	Who is responsible?
Finalize **OUTPUT 1*:*** An analysis report on the role of soil and crop water content status in waterbalance within different agricultural, landuse and water management practices at rain fed and irrigated systems for the most important crops and fruit (wheat, corn and apple)	June 2013-Dec 2013	UoDE with contribution from partners
1.1 Analysis of greenwater content at different soil terrain and climate (non irrigated circumstances and rain-fed)circumstances	June 2013- Dec 2013	UoDE, IH SAS
1.2. Analysis of brownwater content at different soil terrain and climate (non irrigated circumstances and rain-fed)circumstances	June 2013-Dec 2013	UoDE, IH SAS
Finalize **OUTPUT 2:** Toolbox with the concrete identification of remote sensing and GIS data tools for agricultural drought monitoring and forecast	Sept 2013 – Jun 2014	UoDE with contribution from partners
2.1. Dissemination of the vegetation indexing methods and their purposes for the selected cops and fruit	Sept 2013-Febr 2014	UoDE
2.2. Elaboration of multi- and hyper-spectral remote sensing vegetation-drought indexing methods and databases for soil plant water status, applicable for determination of yield loss of different crops	Nov 2013-March 2014	UoDE
2.3. Collecting presently available indexing methods of agricultural drought in different phenophases of the selected crops and fruit	Nov 2013-March 2014	UoDE, IH SAS
2.4. Identification of drought monitoring and intervention levels based on vegetation indexing and possible yield loss as well as on soil and climatic conditions	Jan 2014- May 2014	UoDE, IH SAS, GWP-HU

2.5. Mapping of drought sensitive areas based on soil and climate data	Feb. 2014- June 2014	UoDE, IH SAS, UoO
Finalize **OUTPUT 3:** Report on integration of RS and GIS tools and intervention levels into drought monitoring system	May 2014 – Jan 2015	UoDE with contribution from partners
3.1. Description what agricultural drought data can effectively be calculated with the use of remote sensing data (comparing costs and benefits)	May 2014 –Sept 2014	UoDE,
3.2. Effect of agricultural droughts on yield loss and their economic effects	June 2014- Oct 2014	UoDE, IH SAS, GWP-HU, UoO
3.3. Role of agricultural drought indexing in forecasting and monitoring, comparing errors and uncertainties.	Sept 2014- Dec 2014	UoDE,
3.4. Integration possibilities of agricultural drought indexing, monitoring and intervention levels to drought management plans - evaluation of decision risks	Aug 2014-Jan 2015	UoDE, IH SAS, GWP-HU, UoO