02/03/2015

1. Basic information

Number and name of the activity	Activity 5.5. Policy oriented study on remote sensing agricultural drought monitoring methods
Activity leader *(name, organization, email)*	Prof. Dr. János Tamás, University of Debrecen, tamas@agr.unideb.hu
Duration of the activity	01/06/2013 – 31/01/2015
Participating partners *(name, organization, email)*	János Tamás, University of Debrecen, tamas@agr.unideb.hu Attila Nagy, University of Debrecen, attilanagy@agr.unideb.hu János Fehér, University of Debrecen, feher.medve@t-online.hu Stelian Nistor, University of Oradea, snistor@uoradea.ro Viliam Nagy, Institute of Hydrology of the Slovak Academy of Sciences, nagy@uh.savba.sk
Chairman of the CWP	Dr. József Gayer

2. Contribution to Challenges

Your activity belongs to:

- *Operational mode (next year drought, ongoing multiple-year drought)*
- *Strategic mode (future drought, prepared for global change)*

Please explain (max 500 characters).

The Activity 5.5 belongs to operational mode. The policy oriented study on remote sensing agricultural drought monitoring methods is a pro-active drought risk monitoring system. This system can indicate drought hazard based on remote sensing data and provide early warning of drought effect on agriculture by predicting of potential yield loss. This system facilitates farmers and stakeholders early responses on drought effects.

What is your activity addressing?

- *Which of the seven steps described in the Guidelines for Drought Management Plans (act. 2.1)*
- *monitoring, forecasting / prediction, impacts, vulnerability, measures, management, risk management*

The study addresses agricultural drought monitoring and yield loss forecasting including five remote sensing based drought risk (threshold) levels.

Shortly describe main challenges which you have addressed with your Activity on International, regional (especially CEE), national level? How has your Activity contributed to these challenges? (Max 1000 characters)

Among the different drought types the agricultural drought is the least quantified, thus the most uncertain drought type. Agricultural drought is influenced by several complex factors, whose measurements are complicated, time and resource intensive and their impact (such as yield loss) is indirectly measurable or only at a later date. Remote sensing of crop biomass is one of the most important solution for measuring agricultural droughts and its effects, although the cumulated knowledge on RS can slowly be implemented into practice. This activity supports filling the gap of knowledge in this field with the development of agricultural drought related decision parameters and its application in practice from raw spectral datasets. Signalling levels of this activity and free of charge available homogenous remote sensing data (MODIS NDVI spectral indices) and land use (CORINE database) datasets can be applied in national and CEE scale.

3. Contribution to Objectives (max 1000 characters)

Were the Activity objectives achieved (see Activity list)? Describe how you have achieved these in quantitative and qualitative terms. Are there any, which were not achieved?

The main aim of the activity was to establish decision support system for drought monitoring by concrete identification of remote sensing and GIS data tools for agricultural drought monitoring and yield loss forecast, which eventually provides information on implementation of drought risk levels.
The objectives were to

1. identify green and brown water resources on watersheds on the role of soil and crop water content status in water balance for the most important crops and fruit (wheat, corn and apple).
2. formulate concrete signalling and intervention levels of drought by which spatial and temporal extent of risk to the actual drought situation in the crops and apple can be quantified
3. define the integration of RS and GIS tools and intervention levels for drought monitoring system to facilitate decision makers.

The objectives were achieved, except for in the case of apple, where yield loss prediction was not possible due to the effect of other meteorological effect on apple yield.

4. Description of the implementation process and methodologies applied *(max 1000 characters)*

Describe and explain what actions have been taken to address the challenge(s) mentioned in point 2
What were the key implementation issues?

- *describe all phases of implementation*
- *actions taken, instruments used*
- *information and methodologies applied*
- *etc.*

Did you encounter problems during the implementation phase? If so, how were they overcome? What problems could not be solved?

The methods and databases having been explored include employment of remote sensing data on land use, as well as biomass production, soil characteristics for better integration and understanding of cropping patterns influenced by hydrology and soil types. Internationally available land use (CORINE database, topographic maps) remote sensing data, MODIS NDVI spectral indices, soil data (agro topographic map, soil water management properties, map of water management properties of soils), hydrology (soil water table), digital elevation models were processed and integrated to determine yield loss thresholds and soil water holding capacities. RS toolbox includes the integration of land use, soil physical, meteorological and satellite data into a model, which can be a feasible tool for plant specific drought risk evaluation. Remote sensing data were calibrated by yield, and validated with other drought index data from EDO.

5. Outputs *(max 3000 characters)*

What are the main outputs of your activity? Please shortly describe each of them (main purpose, etc.)

The case study has three important steps, milestones, which correspond and relate to each other in hierarchical way.

Output 1: Green and brown water resources on watersheds

Based on the amount of green and brown water, water balance analysis of a watershed concerning different land use, agricultural practice for each crop (wheat, corn and apple) from agricultural drought severity point of view are as follow: analysis of green water content at different soil terrain and climate (non irrigated circumstances and rain-fed) circumstances and analysis of brown water content at different soil terrain and climate (non irrigated circumstances and rain-fed) circumstances

Output 2: Signalling and intervention levels of drought based on remote sensing datasets.

A specific data integration process were managed to set with which other conventional drought indices can be specified and refined by actual yield loss data, based on the calibration of remote sensing based maps. Toolbox was elaborated for concrete identification of remote sensing and GIS data tools was also added for agricultural drought monitoring and yield loss forecast, which eventually provides information on physical implementation of drought risk levels. As a result, five drought risk levels were developed to identify the effect of drought on yields, such as: Watch, Early Warning, Warning, Alert and Catastrophe.

Output 3: Integration of RS and GIS tools and intervention levels into drought monitoring system

A user-friendly drought monitoring and yield loss mapping process script was generated in order to make it possible for yield forecasting of other users in ArcGIS environment. The remote sensing based agricultural drought monitoring and yield loss forecasting method can effectively indicate anomaly of droughts and yield losses and can identify the possible intervention areas. The methodology is also appropriate for early warning of droughts, since yield loss can be predicted 2 months before the irreversible yield loss and/or quality degradation realized. By plant specific calibrated yield loss maps the developed spatial decision supporting system gives

precise information for farmers on drought risk of the different region. Thus decision makers can easily use it to estimate yield loss in a certain field. Such models and scripts were generated, which can be used by other users for other drought risk affected areas. This digital IDMP geoprocessing framework process makes it possible to access and share the knowledge tool of drought monitoring and yield loss forecasting for users and stakeholders.

6. Added value *(max 1000 characters)*

What is the "added value »generated by your Activity? What new (science, practical experience, guidelines or others) was developed by IDMP CEE and how your work is related to earlier knowledge (research) and experiences in the past?

The added value is the agricultural drought monitoring and yield loss forecast method, with which the yield loss of maize and wheat can be predicted 4-6 weeks before harvest and drought effected sites can be delineated more accurately. The impact of drought on agriculture can be diagnosed far in advance of harvest, which is the most vital need for stakeholders concerning food security and trade. This information can facilitate drought intervention activities reduce impacts of drought on possible stock uncertainty and can facilitate decision makers in more accurate mitigation measures and preparedness plans for a specific region.
A new drought related soil moisture regime GIS database were also established in which the data based on water management parameters of high resolution soil data by using different GIS SQLs clearly showed that the impact of drought were more severe in extreme water management soils.

7. Lessons learnt and transferability *(max 2000 characters)*

This section considers how your experience can be used elsewhere.
What are the most important lessons from this Activity that might be useful for other countries and policy level in the preparation / implementation of Drought Management Plans?

Agricultural drought monitoring and yield loss forecast method is also extendable for other IDMP CEE countries, as it is based on utilization of NDVI, which is a normalized data and the calibration of it is also based on normalized yield data sources. NDVI data and yield loss data from the whole CEE countries can be easily compared. Since NDVI is strongly correlates to biomass, and biomass with yield; thus low NDVI means low biomass and low yield in CEE countries. Furthermore the magnitude of the potential yield losses is connected to the five drought risk levels, which are applicable to other IDMP CEE countries. In case of average weather circumstance the optimal amount of corn and wheat yields (t/ ha) have little difference in the CEE region.
The results are also appropriate for establishing of further complex studies on water use, water management and water scarcity:

- The extent of the drought can be transformed to exact amount of water, that is missing for an average yield (t/ha) from an area and should be utilized in a certain farm or a watershed. Both wheat and maize has it characteristic water demand unit for producing 1 ton of yield.
- Using the time series analysis of the results of this model those site that can also be identified, where irrigation is often required. Combining these results and soil maps and the drought related soil moisture regime map those sites can be identified, where drought has regular effect, and possesses good soil characteristics, with large available water content capacity.
- Yield loss has negative effect not only on farmers but also on the whole agricultural sector, which can be influence the economy of regions and definitely the prices of wheat and maize based food, including animal nutrients, thus livestock prices).
- Since stocks highly influence prices, mapping of yield losses of CEE region can support to create joint export market strategy of the region and can give information in future stock problems.

8. Proposals for follow-up *(max 2000 characters)*

In case resources become available in what aspects would you like to continue your activity? Some concrete proposals for follow-up projects?

Within Activity 5.5 a new policy oriented remote sensing agricultural monitoring method as well as risk levels and risk signalling system were elaborated. The elaborated new method and system were focused on some pilot areas within CEE region and for two major crops (wheat and maize) using internationally available data such as land use (CORINE database, topographic maps) remote sensing data, MODIS NDVI spectral indices, soil data (agro topographic map, soil water management properties, map of water management properties of soils), hydrology data (soil water table).

In case resources become available the following activities are recommended to be carried out:

- extension of the monitoring method and risk signalling system for *other crop types*, which are characteristic is the CEE region and have significant economic role.
- extension of the monitoring method and risk signalling system for the *entire CEE region*
- determination of that amount of water, which is missing for an average yield (t/ha) from an given agricultural area. (This result could assist setting up a better irrigation strategy.)
- Using the time series analysis of the results of the method, those site can also be identified, where irrigation is often required. Combining these results and soil maps and the drought related soil moisture regime map, those sites can be identified where drought has regular effect.
- Mapping of yield losses within CEE region in combination with economic losses. This can support to elaborate joint export market strategy of the region and can give information to reduce future stock problems.

9. Annexes

Milestone reports, tables, other data, etc.

Three milestone reports were delivered in the period of the Activity 5.5.