Integrated Drought Management Programme

Global Water Partnership Central and Eastern Europe

Agricultural drought monitoring and yield loss prediction method

BRIEFING NOTE

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Briefing note on achievements of the Integrated Drought Management Programme in Central and Eastern Europe (IDMP CEE) Demonstration project

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This report presents the results from the Demonstration Project Drought Risk Management Scheme: a decision support system, which was part of the wider Integrated Drought Management Programme in Central and East Europe (IDMP CEE). Based on the results of the demonstration project and the expertise of the people involved, recommendations for the development of a decision support system were made.

Problem Description

Among the meteorological, agricultural and hydrological drought the agricultural drought is the least studied, and thus the least understood drought type. Agricultural drought is influenced by several complex factors, which are complicated to measure. To measure them requires vast amounts of time and resources, and furthermore, impacts such as e.g. yield loss is measurable only at a later stage. **Remote sensing (RS) of crop biomass is one of the most important solution for measuring agricultural droughts and its effects**, however, there were a number of technological barriers (for example one hyperspectral image can be 40-100 GB which took IT infrastructures several years ago hours to calculate it) to apply it. Nevertheless, **by using yield data or other meteorological reference data for calibration of remotely sensed spectral data, real plant water demand can be spatially and temporally mapped**.

Geographical Scope

The area studied is the lowland part of the Tisza River Basin, which is located in Central Europe (Hungary 29.4%, Slovakia 9.8%, Ukraine 8.1 %, Romania 46.2% and Serbia 6.5%) within the Carpathian Basin. In terms of hydrology, the Carpathian Basin is one of the most geographically isolated basins on Earth, and the investigated lowland has semi-arid to arid character. In this region, there is intensive agricultural activity where arable land constitutes for about 72%. The occurrence of floods and droughts often occur in the same year, or even in the same vegetation period.Main result of the project is the development of a 'Framework for Drought Risk Management', outlining the interrelationships and functional linkages between different elements for supporting decision-making in drought oriented systems. The framework is based on institutional, methodological, public, and operational components component of the framework in detail.

Aim

The main aim of the project was to establish a decision support system for drought monitoring, by identification of remote sensing and Geographic Information System (GIS) data tools for the development of an Agricultural Drought Monitoring and Yield Loss Forecasting Method. This method could eventually be useful for providing information regarding the risks of droughts.

Main objectives:

- to formulate concrete signalling and intervention levels of drought by which the extent of actual drought risk situation and potential yield loss of the two major crops (maize and wheat) can be quantified;
- to define RS and GIS based model for drought risk and yield loss forecasting mapping to facilitate decision-making.

Outcome

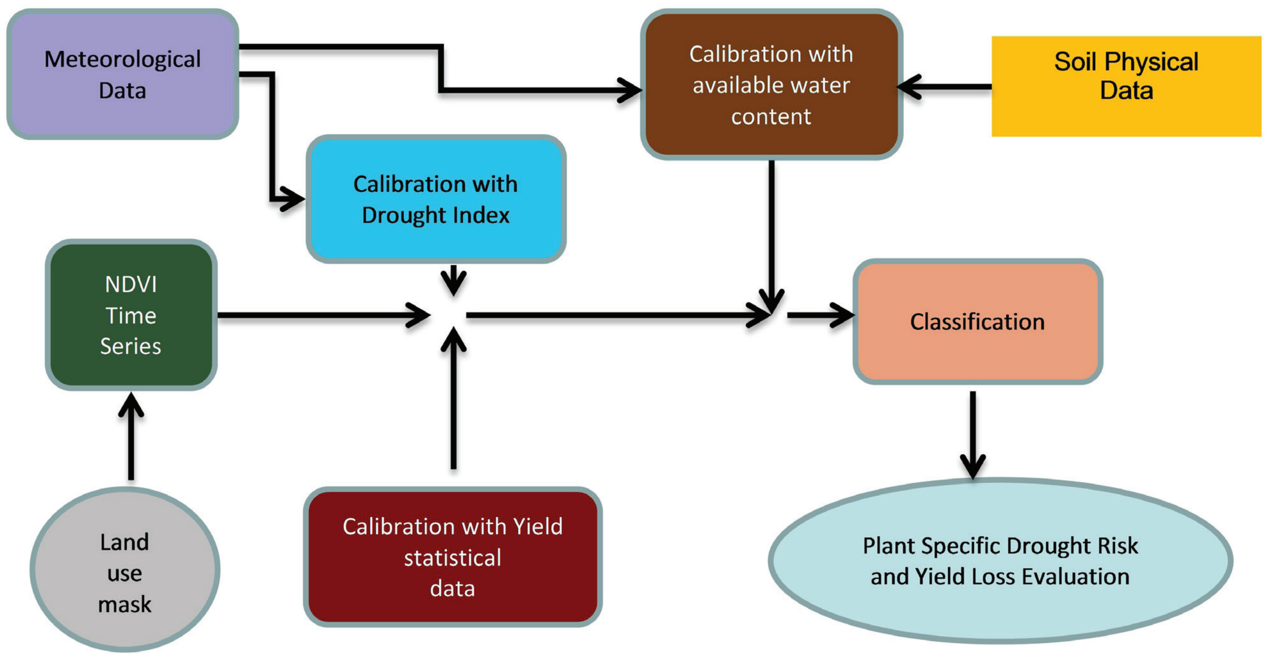
Project had three important steps, which correspond and relate to each other in a hierarchical way.

The first step gave information on how agricultural practices, crop rotation, and land use affect the brown and green water status. This information can be used as the basis of converting remote sensing data to a water management data system. Based on this information, the water resources and the supply of watersheds or regions can be calculated based on water management parameters of high resolution soil data, by using different GIS Structured Query Languages (SQL).

In the second step, MODIS NDVI **remote sensing data**, which maps the vegetation density on the Earth surface, **and GIS transformation and calibration tools were identified**. Combined with these, an Agricultural Drought Monitoring and Yield Loss Forecasting Method can be established. These tools are synthetised into one data integration and calibration process toolbox (see below), which also includes data on land use, physical soil properties, and meteorological and satellite data, which combined can be a feasible tool for evaluating drought risks for specific plants.

The toolbox is operationalised through three stages (Figure 1):
- data acquisition and processing;
- identification and calibration of biomass data and drought risk levels;
- drought risk evaluation and mapping.

Figure 1. Main steps of data integration and calibration process for Agricultural Drought Monitoring and Yield Loss Forecasting Method



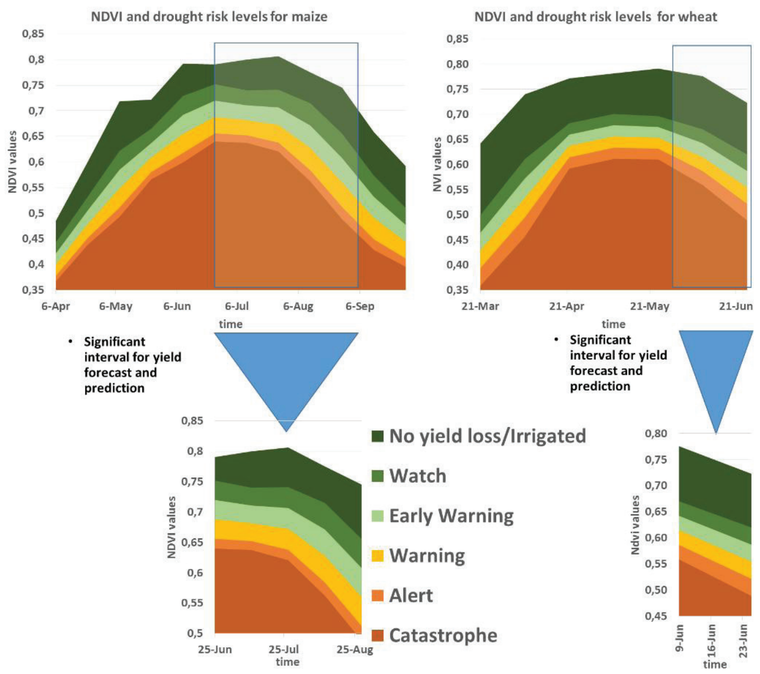


Figure 2. Drought risk and signalling NDVI levels for maize and wheat

As a result, five drought risk levels and their thresholds were developed to identify the effect of drought on yield: Watch, Early Warning, Warning, Alert and Catastrophe (Figure 2).

In the third and final step of the project, an **Agricultural Drought Monitoring and Yield Loss Forecasting Method was generated in ArcGIS, based on the five drought risk levels identified above**. This forecasting method can indicate an anomaly in droughts and yield losses, and identify the possible intervention areas. The method can also serve to provide an early warning for droughts, since yield loss can be predicted 2 months before the irreversible yield loss, and/or when quality degradation occurs. Through plant specific calibrated yield loss maps, the forecasting method gives precise information for decision makers on drought risk in the different regions. It can also be used to estimate yield loss in certain fields.

Other users for other drought risk affected areas can use the models and scripts that were generated during this project. Also, if integrating this model into drought monitoring systems, it would give other users and stakeholders access to yield loss forecasts.

Main strengths

The main strengths of Agricultural Drought Monitoring and Yield Loss Forecasting Method are:

- yield loss maps provide a systematic and spatially coherent picture of the vegetation water stress at a high spatial resolution (250 m) for the entire CEE region;
- there is a low disturbance of cloud cover due to the 1 day revisit time and 16 day smoothing of the MODIS NDVI images;
- yield loss can be calculated 1.5-2 months before harvesting.

Drought and water stress are not the only factors that can cause a decrease of yield. The weakness of this method, is that it cannot account for the difference between changes caused by drought or other factors for the NDVI. A change in land cover, or pests and diseases can also be responsible for a variation of the yield loss. Therefore, this method must be complemented with other data, giving information on e.g. the deficit of rainfall /soil moisture in order to determine if the variation in the vegetation response (signal) is linked with a drought event or not.

Conclusions

With the assistance of an Agricultural Drought Monitoring and Yield Loss Forecasting Method, the yield loss of maize and wheat can be predicted 4-6 weeks before harvest and, sites affected by droughts can be delineated more accurately. The impact of droughts on agriculture can be diagnosed far in advance of the time of harvest, which is critical for stakeholders in terms of food security and trade. The information gained through this monitoring can facilitate drought intervention activities, reduce impacts of drought on possible stock uncertainty, and can support decision makers in more accurate planning for mitigation measures for a specific region.

The data gained from an Agricultural Drought Monitoring and Yield Loss Forecasting Method provides critical information regarding droughts and crop growth. This is a valid complement to data outlining weather parameters, which also influence crop growth. Agricultural drought monitoring, and its consequent identification of intervention levels is thus a convenient tool to capture our understanding of yield loss and weather. Together with GIS, it provides a framework to process diverse data, which is geographically linked. Currently, monitoring, signalling and intervention levels for agricultural droughts can provide information on regional crop distribution and yield loss. This can be coupled to crop simulation models in a number of ways. These include: (a) direct use of MODIS NDVI as a forcing variable, (b) re-initialising or re-calibrating MODIS NDVI by yield data; and (c) using yield calibrated NDVI to estimate thresholds for drought (yield loss) categories, and using MODIS NDVI and thresholds in mapping of yield loss forecast.

In the case of agricultural drought monitoring, the signalling and intervention levels for yield loss forecasting, as well as the knowledge of the user of the model are the most critical aspects. **It is critical to build a stronger knowledge base for understanding the Agricultural Drought Monitoring and Yield Loss Forecasting Method**.

There are a number of ways to achieve this:

- Primarily, the Agricultural Drought Monitoring and Yield Loss Forecasting Method must make its information more accessible and user-friendly. The results must be delivered to decision-makers in a clear, consistent way, so that they can act on this information. Although this may seem evident in theory, it sometimes fails in practice.
- The information regarding agricultural drought monitoring, signalling, and intervention levels is more likely to be used if the information is calibrated.

*This demonstration project is part of the **Integrated Drought Management Programme in Central and Eastern Europe** which supports the governments of Bulgaria, the Czech Republic, Hungary, Lithuania, Moldova, Poland, Romania, Slovakia, Slovenia and Ukraine in the development of drought management policies and plans. It also builds capacity of stakeholders at different levels for proactive integrated drought management approach and tests innovative approaches for future drought management plans.*

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