ENHANCING FOOD SECURITY THROUGH THE AFRICULTURES PROJECT: DESIGN OF CROP, WATER AND DROUGHT SERVICES

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ABSTRACT

Smallholder farmers produce about 70% of Africa's food supply. These farmers are vulnerable to a number of risks, mainly climate related, which have a tremendous impact on food security and thus poverty. Information about crop yields, vegetation conditions and weather, among others, are essential to policy makers to enhance food security. Earth observation data, analytics and modeling from various sources, at a variety of spatial and temporal scales could be used to support policy and decision making in the field of food security. This paper describes crops, water and drought services that are being developed in the AfriCultuReS project. Preliminary results are presented, which reflect the uneven distribution of precipitation, water bodies, and vegetation conditions throughout Africa.

Index Terms **–** Food security, early warning system, Earth Observation, crop modeling, drought, weather, water monitoring.

1. INTRODUCTION

Information of crop monitoring, vegetation condition and environmental status at any given time is essential for early warning systems for food security, as it provides valuable information for decision-makers. Towards this direction, the EC funded H2020 project "AfriCultuReS: Enhancing Food Security in African Agricultural Systems with the Support of Remote Sensing" uses EO based data to develop an integrated agricultural monitoring and early warning system for Africa that will support decision making in the field of food security.

Following the concept of co-design, the development of AfriCultuReS services has focused on the satisfaction of the users' requirements, which were closely tied to the description of agroecosystems and socioeconomic aspects that reflect the current situation in African agricultural production, as well as to the priority agricultural risks in the African countries. The services will be first demonstrated and validated in pilot countries and specific test sites (see section 2.1), to be further upscaled into the whole African continent.

Crop services are provided by several crop monitoring and early warning initiatives and programs such as FEWS NET, FAO GIEWS, GEOGLAM, where global bulletins/reports are published with crop yield and production information and food security alerts. For the latter, information on crop stress and plant growth is

required, distinction should be made between agricultural and non-agricultural vegetation, and yield should be forecast for specific crops.

In most cases the analysis of NDVI timeseries is used to describe crop condition and derive growth stages. In particular low and medium resolution NDVI anomaly and Vegetation Condition Index (VCI) are commonly used. Various field-level crop growth models are used providing information on crop yield and biomass production.

Food production is argued to affect water resources in three ways; a) through withdrawal of water for irrigation, b) through land cover changes and c) through alterations in water division due to changes in land use management [1]. Considering livestock management, apart from direct water consumption for drinking purposes, water is indirectly connected to the animal products in form of pasture, fodder and grains that are eaten by the animals. Therefore, this feature is considered to multiply the overall water consumption and in fact, constitutes the majority of water used for animal products [2].

Droughts are the world's costliest natural disaster. In sub-Saharan Africa, they account for less than 20% of natural disasters and over 80% of the affected population [3]. Droughts are naturally occurring climate phenomenon, resulting in prolonged shortages of surface and ground water. Human activity can also exacerbate droughts. Due to its severe socioeconomic implications, numerous specialized indices have been proposed to quantify drought [4].

The aim of this work is to present the technical design of spatial products for crop, water and drought parameters, using various EO, meteorological and climatological data.

2. DEVELOPMENT OF SERVICES

2.1. Study areas

The focus of AfriCultuReS project is on the whole African continent, covering various agroclimatic zones: North-Africa, Sahel, Gulf of Guinea, Great horn of Africa, Western Cape, Equatorial and Central Africa, and South-Africa. Eight pilot African countries are selected to reflect the diversity of climate, ecosystem and farming conditions in Africa: Tunisia, Niger, Ghana, Ethiopia, Kenya, Rwanda, Mozambique, and South-Africa.

2.2. Crop services

AfriCultuReS' crop services include crop mask and calendar, crop phenology and condition, crop yield and early warning. The definition of some of these services are detailed below.

Crop phenological profiles, assessed through historical NDVI projection over a specific site were used after interpolation and spline smoothing. Then, the phenological function is analyzed to retrieve the phenological metrics for each pixel. Vegetation development is well described by the following phenological stages: 1) Start Of Season (SOS), or onset of photosynthetic activity, 2) End Of Season (EOS), or the very end of the senescence period, 3) the maturity peak located the NDVI maximum value and 4) the dormancy period, characterized by no photosynthetic activity and related to soil preparation or soil restoration practices. For all phenological stages key transition dates and NDVI metrics will be retrieved, as illustrated in Figure 1.

Crop condition assessment service at coarse resolution is provided by the Vegetation Condition Index (VCI) product from the Copernicus Global Land Service (https://land.copernicus.eu/global/). VCI compares the current NDVI to the range of values observed in the same period in previous years. Maps with a spatial resolution of 1km will be produced every 10 days for Africa. Three VCI classes proposed by Qian, et al. [5] will be used (0.7-1: normal vegetation condition, 0.5-0.7: moderate vegetation condition, 0.3-0.5: poor vegetation growth, <0.3 extremely poor growth condition).

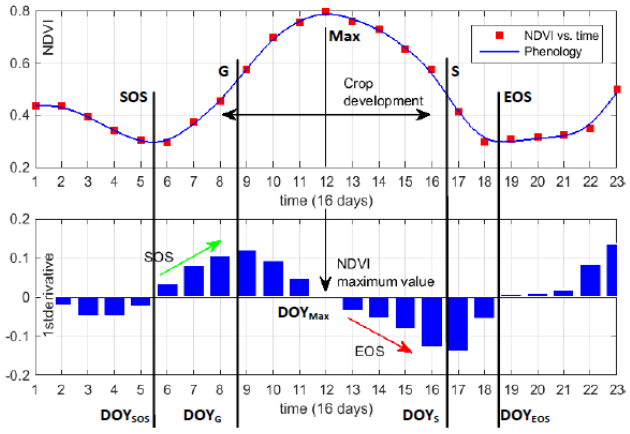

Figure 1. Key parameters of phenological development.

2.3. Water services

Water related services cover the monitoring and assessment of water qualitative and quantitative characteristics and mapping of surface inland water bodies (WB). The WB mapping at coarse (>1km) and medium (100m – 1km) resolution will be provided using Copernicus Land Services data. For the equivalent WB mapping at high resolution, timeseries of Sentinel-1 data along with fuzzy logic techniques will be used every 10 days, in order to automatically detect the areas covered by water during the year, while providing the maximum and minimum extent of the water surface and its seasonal dynamics.

2.4. Drought services

Drought monitoring services are currently based on the analysis of several meteorological drought indices, depending on several meteorological parameters (e.g. precipitation or temperature) and other geospatial data (e.g. soil moisture).

Amongst the indicators, the Standard Precipitation Index [6], the Palmer Drought Severity Index (PDSI) [7] and the Standardized Precipitation-Evapotranspiration Index (SPEI) [8] are the current reference at European scale to identify and monitor meteorological droughts. In addition, indicators based on the soil water content, such as the Soil Moisture Anomaly (SMA) which is included as a product of the Copernicus European Drought Observatory amongst other national climate services, characterize the plant water stress and the intensity and duration of an agricultural drought event.

The AfriCultuReS Climdex Service, will integrate the previously defined indicators, amongst others, in the R-based framework Climate4R [9] to estimate the indices for the different pilot sites at different time-horizons (e.g. seasonal forecast, climate-change projections) and spatial resolutions from the products included in the Copernicus data server. As a result, different products, depending on the user's needs and the time-horizons, will be produced.

3. RESULTS AND DISCUSSION

The map of VCI on 21/11/2018 is displayed in Figure 2. Areas in red are those described as extremely poor vegetation condition, while those in orange and yellow are poor and moderate, respectively. The areas with poor and extremely poor conditions are concentrated on southern Africa, the Sahel belt, and some regions of east Africa. This may be due to the delayed onset of the rain season, also reported in the GEOGLAM's crop monitor early warning bulletin for southern and east Africa.

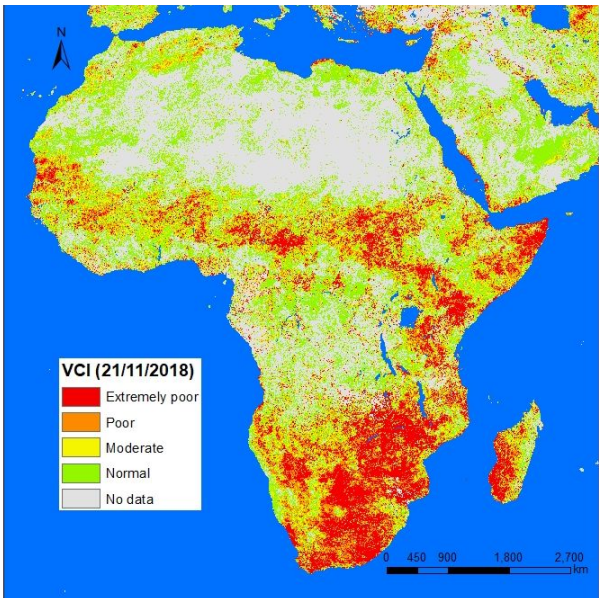

Figure 2. VCI map at coarse resolution over Africa.

A preview of the WB mapping service at medium resolution (300 m) on 11/12/2018 is demonstrated in Figure 3. Permanent WBs (e.g. sea, lakes, etc.) are represented with dark blue color, whereas detected non-permanent water bodies are marked with light blue color. Areas with no water are represented with brown color and grey color represents areas with no data availability.

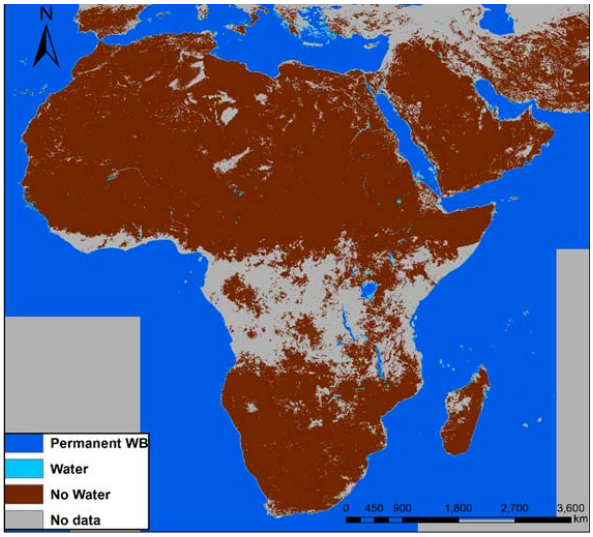

Figure 3. WB map at coarse resolution over Africa.

Within the framework of AfriCultuReS, several of the meteorological and agricultural drought indices will be

estimated to construct an operational drought service using the available EO data and the products of numerical model data available from within the AfriCultuReS atmospheric services, ranging from meteorological forecasts (Figure 4) to seasonal forecasts and near- and long-term climate projections.

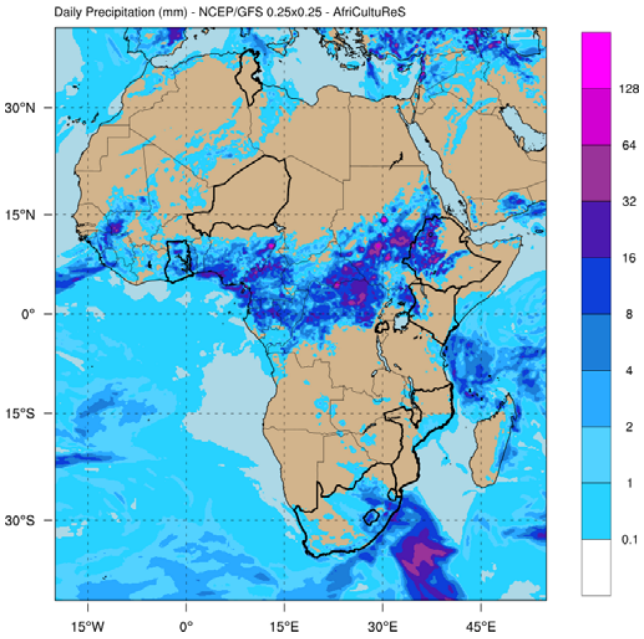

Figure 4. Daily precipitation (mm) Africultures meteorological product based on the NCEP/GFS model (0.25ox0.25o) for Africa. AfriCultuReS pilot counties are shown with bold borderlines.

4. DISCUSSION AND CONCLUSION

The above-mentioned services, together with other services that will be developed within the AfriCultuReS project, are expected to boost the provision of information on threats to food security in Africa. For instance, crop products will feed early warning systems for crop yield failure. Water services will help identify the water availability as well as water use and misuse. Drought prediction will help plan ahead and mitigate its impacts. In view of the validation phase and the appreciation by the users, services are expected to improve and make further steps towards being provided in an operational basis.

5. ACKNOWLEDGEMENTS

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