SEVENTH FRAMEWORK PROGRAMME

Crop Monitoring as an
E-agricultural tool in
Developing Countries

E-AGRI
E-Agriculture

DESCRIPTION OF DATABASE OF BIO-PHYSICAL VARIABLES

Reference: *E-AGRI D41.2*

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Version: 1.0
Date: 28/01/2014

DOCUMENT CONTROL

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Issuing authority :

Change record

Release	Date	Pages	Description	Editor(s)/Reviewer(s)
1.0	28/01/2014		This document refers to the deliverable D41.2 database on bio-physical variables.xlsx.	Qinghan Dong, Herman Eerens

1. Reference file

D41.2 Database of bio-physical variables.xlsx

The database of biophysical variables refers to the database containing the five bio-physical variables generated for the 38 provinces of Morocco.

2. Production of variables:

The variables non-smoothed NDVI, smoothed NDVI, non-smoothed fAPAR, smoothed fAPAR, smoothed DMP are labelled respectively I, k, a, b, p. These variables are generated for the implementation of the Work package 4 for predicting the crop yield using remote sensing indicators.

__NDVI__: Normalized Difference Vegetation Index is the most elementary vegetation indices used for assesse the vegetation conditions. It is calculated from the visible and near-infrared light reflected by vegetation.

$$\mathbf{NDVI} = \frac{\mathbf{(NIR - Red)}}{\mathbf{(NIR + Red)}}$$

Healthy vegetation absorbs most of the visible light that hits it, and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light. NDVI is one of layers produced by SPOT-VEGETATION sensor.

__Smoothed NDVI__: to remove the remaining cloud contamination and other missing values, the smoothing procedure using a modified SWETS algorithm was conducted. The method inspects each pixel's time profile, detects all the cloudy observations and interpolates more appropriate values.

fAPAR: an unit-less biophysical parameter, is the fraction of the photosynthetic active radiation (400-700 nm) absorbed by the green vegetation. It is directly related to and serves as an input to the calculation of Dry Matter Productivity of vegetation, one of the main bio-physical variables of this work-package. It is calculated as the difference between the PAR absorbed by the top of the vegetation canopy (1-ρ1) minus the PAR absorbed by the soil (1-ρ2). ρ1 is estimated using the RED surface reflectance. ρ2 is calculated from the single scattering term that is reflected by the soil and that passes through the canopy without further scattering. In this equation, the soil reflectance is assumed constant per soil type and a look-up table is used together with a soil map to derive this reflectance. To estimate the transmission of the soil reflectance through the vegetation canopy an exponential function of the LAI is assumed, which also depends on the solar zenith angle θs. The use of the effective LAI (LE) ensures consistency between fAPAR and LAI.

$$f_{APAR} = (1-\rho_1) - (1-\rho_2) * e^{-G(\theta)\beta L_E / \cos\theta_s}$$

with

G(θ) the global light extinction coefficient = 0.5

β the coefficient for canopy multiple scattering = 0.9

The smoothing procedure was carried out using the same algorithm.

DMP: nickname for "Dry Matter Productivity", represents the daily growth of standing biomass. It is equivalent to the Net Primary Productivity, well known in climatological studies, but DMP is customized for agronomic applications and it is expressed in kilograms of dry matter per hectare and per day. Both variables refer to a rate process, i.e. the amount of vegetable matter produced per unit time.

Traditionally, estimation of DMP is based on the Light Use Efficiency (LUE) concept where biomass accumulation is considered as an ongoing process correlated with the amount of radiation absorbed or intercepted by green foliage (APAR). Plant production is approximately related to APAR multiplied by a conversion efficiency constant ϵ, and integrated over the season ($DMP=\int\epsilon*APAR$). The 'energy conversion factor' ϵ, expresses the efficiency with which the vegetation performs photosynthesis and APAR is the Photo-synthetically Active Radiation absorbed by the plant cover. A drawback of this method is that the LUE concept is based on the assumption that insolation and conversion efficiency from light to dry matter are constant in time and space, which is not always the case. In addition, stress factors such as water limitation and diseases are not taken into account. The LUE approach thus provides an estimate of potential production rather than the actual production. On the other hand, the method is computationally fast, and only depends on meteo and remote sensing data.

The approach led to the equation proposed by Monteith by expressing DMP in terms of external influences (incoming solar radiation) and conversion efficiencies, which account for the conversion of radiation during photosynthesis and for the losses of autotrophic respiration.

$$DMP = R \cdot 0.48 \cdot fAPAR \cdot \varepsilon(T_{12,} T_{24})$$

With

- R, the incoming shortwave solar radiation which on the average comprises 48% of PAR (Photo-synthetically Active Radiation)
- *f*APAR, the PAR-fraction absorbed by the green vegetation
- ε, the efficiency-term $\varepsilon=\varepsilon_1.\varepsilon_2$
- $\varepsilon_{1,}$ photosynthetic efficiency
- $\varepsilon_{2,}$ respiration.

The definition of these efficiency terms can be very complex. Here it is simply approximated as a function of the daily temperature. Whereas ε_1 depends on T_{12} (day), ε_2 depends on T_{24} (day+night), which is generally lower. These temperatures are computed as follows: $T_{12}=0.75*(T_{min}+T_{max})$ and $T_{24}=0.50*(T_{min}+T_{max})$. **The meteo data including incoming solar radiation and air temperature** come from the JRC MARSOP project, spatially gridded (at 0.25° resolution) and georeferenced.

The DMP-computation is achieved with the following steps:

- **MET2IMG**: The three requested variables of the meteo-database (temperatures T_{min}/T_{max} and solar radiation R) are converted to image form.
- **PRODmax**: This tool applies the above Monteith-equation on the meteo-images, but assuming fAPAR=1 for all meteo-cells. This results in an image $DMP_{max,1}$. The subscript 1 indicates the image still contains daily values.
- **COMPOSIT**: All $DMP_{max,1}$ scenes of a certain dekad are composited using a mean filter to a dekadal image $DMP_{max,10}$.
- **VISMOOTH**: The time series of dekadal fAPAR data is smoothed with the modified Swets-method prior to DMP calculation. The result is a time series of $fAPAR_{10}$ images. The smoothing at the level of fAPAR is justified, since this variable only changes gradually over time.
- **PROD**: the final result is computed via the multiplication: $DMP_{10} = fAPAR_{10} * DMP_{max,10}$.
  - $fAPAR_{10}$ is derived from remote sensing.
  - $DMP_{max,10}$: dekadal DMP, holding for fAPAR=1. The program internally resamples this Very Low Resolution image to the resolution of $fAPAR_{10}$ by means of bilinear interpolation.

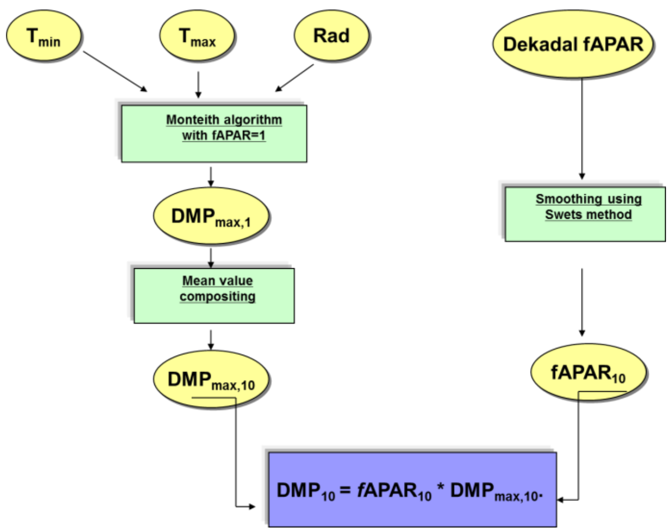

Figure 1: The work flow to compute the variable DMP

3. Annotations and specifications:

Table 1: Annotation of the variables (DT=Datatype: 1=unsigned byte with V=0→255, 2=signed short integer with V=-32768→+32767).

v	CONTENTS	DT	SCALING	FLAGS
i	NDVI non-smoothed	1	NDVI [-] = -0.08 + 0.004•V (V=0-250)	251=error/missing, 252=cloud, 253=snow/ice, 254=water, 255=other exception
k	NDVI smoothed			
a	fAPAR non-smoothed	1	fAPAR [%] = 0.5•V (V=0-200)	
b	fAPAR smoothed			
p	DMP noon-smoothed	2	DMP [kgDM/ha/day] = 0.01•V (V=0-32767)	-1=error/missing, -2=cloud, -3=snow, -4=water, -5=other exception
y	DMP smoothed			

Table 2: The considered Moroccan provinces and their Region_ID numbers.

ID	NAME	ID	NAME	ID	NAME	ID	NAME
1	AGADIR	11	EL JADID	21	KHENIFRA	31	SETTAT
2	TAROUDAN	12	EL KELAA	22	KHOURIBG	32	TANGIER
3	AL HOCEI	13	ERRACHID	23	LARACHE	33	TAOUNATE
4	AZILAL	14	ESSAOUIR	24	MARRAKEC	34	TATA
5	BEN SLIM	15	FES	25	MEKNES	35	TAZA
6	BENI MEL	16	FIGUIG	26	NADOR	36	TETOUAN
7	BOULEMAN	17	GUELMIM	27	OUARZAZA	37	TIZNIT
8	CASABLAN	18	FRANE	28	OUJDA	38	LAAYOUNE
9	CHEFCHAO	19	KENITRA	29	RABAT		
10	EL HAJEB	20	KHEMISSE	30	SAFI		