D1.2.1 - Data set from Task 1.2 (object geometry, landscape structures)

INRGREF

Land use

Land use has been monitored over agricultural plots (2016, 2017, 2018) and the corresponding clusters of crop sequences were classified into five types (biennial, forage crop, wheat, spice/legume and miscellaneous) in Lebna watershed. The objective is to examine the extent to which the spatiotemporal distribution of crops at the landscape scale relates to collective crop rotations. A spatial statistical test was developed to perform the evaluation. Results suggested that there are collective crop rotations that apply to groups of adjacent fields on different farms. During 2019 - 2021 cropping seasons, the collected data allowed the production of land use maps in the Lebna study area. The collected data set consisted on: 1) crop sequence type on 9200 agricultural plots over 2016, 2017, 2018 cropping seasons to characterize their spatial arrangements and the importance of collective crop rotations, and 2) annual land-use time series over six cropping seasons (2016, 2017, 2018, 2019, 2020, 2021). The ongoing work will deepen our description of the structure of the cultivated landscape and the physical constraints to its evolution. We will focus on the role of structural elements of the landscape (road, tracks, wadi, natural vegetation, etc.) and their characteristics in the spatial arrangement of the observed crop sequence clusters.

Publication : Biarnès A., Bailly J.S., Mekki I., Ferchichi I. 2021. Land use mosaics in Mediterranean rainfed agricultural areas as an indicator of collective crop successions: Insights from a land use time series study conducted in Cap Bon, Tunisia. Agricultural Systems, 194, 103281.

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Crop Biomass

A wide range of data was collected over the Lebna catchment during the agricultural seasons from 2019 to 2021. Thus, field campaigns have been conducted over different plots of the catchment to monitor vegetation growth.
The monitored crops were cereals (wheat, oat and barley), legume (faba beans) and cereal-legume mixed crops (vetch-triticale mixture and vetch-triticale-faba bean mixture).
In each field campaign, hemispherical images were acquired using a Nikon D3200 camera with a fisheye lens. Those images were used to determine the biophysical parameters of the vegetation cover (LAI, Fcover and FAPAR) after being processed with the software CAN-EYE. Meantime, vegetation heights and above ground biomass were acquired over the same fields. The fresh biomass collected was then weighed and dried to obtain the dry biomass. Also, a measurement campaign on 24 plots of the Lebna catchment was carried out

during the agricultural season 2020/2021 for the purpose of spatializing the biomass.
Furthermore, temporal series of Sentinel-2 images were collected and processed to determine vegetation indices (NDVI, NDWI, NDRE…).
In an advanced stage after piling up the dataset, correlations between ground measurements and remote sensing data were established and they served to estimate biomass and water productivity of the three types of crop.

Table 1: Dataset of 2019/2020

season 2019/2020	LAI+ vegetation height	Biomass+ phenological stage	Sentinel Images
27/11/2019			X
07/12/2019			X
15/01/2020	2 (Mixt)+1(Faba bean) +1(Wheat)	2 (Mixt)+1(Faba bean) +1(Wheat)	
22/01/2020		1 (barley)+1(faba bean)	
05/02/2020	2 (Mixt)+1(Faba bean) +1(Wheat)	2 (Mixt)+1(Faba bean) +1(Wheat)+1(barley)	
10/02/2020			X
13/02/2020	2 (Mixt)+1(Faba bean) +1(Wheat)+1(barley)	2 (Mixt)+1(Faba bean) +1(Wheat)+1(barley)	
25/02/2020			X
28/02/2020	1 (barley)+1(faba bean)		
01/03/2020			X
03/03/2020	1(wheat)+2(mixt)	1 (wheat)+2(mixt)	
10/03/2020	1(barley)+1(mixt)+1(faba bean)	1(barley)+1(mixt) +1(faba bean)+1(wheat)	
05/05/2020			X
25/05/2020			X

Table 2: Dataset of 2020/2021

season 2020/2021	LAI+ vegetation height	Biomass+ phenological stage	Sentinel images
16/12/2020			X
20/01/2021			X
30/01/2021			X
27/01/2021	2 (wheat)+2(mixt)	2 (wheat)+2(mixt)	
04/02/2021	2 (wheat)+2(mixt)	2 (wheat)+2(mixt)	X
11/02/2021	2 (wheat)+2(mixt)	2 (wheat)+2(mixt)	
19/02/2021	2 (wheat)+2(mixt)	2 (wheat)+2(mixt)	
25/02/2021	2 (wheat)+2(mixt)	2 (wheat)+2(mixt)	
04/03/2021	2 (wheat)+2(mixt)	2 (wheat)+2(mixt)	
11/03/2021	2 (wheat)+2(mixt)	2 (wheat)+2(mixt)	
24/03/2021	2 (wheat)+2(mixt)	2 (wheat)+2(mixt)	
26/03/2021			X
31/03/2021	2 (wheat)+2(mixt)	2 (wheat)+2(mixt)	
08/04/2021	2 (wheat)+2(mixt)	2 (wheat)+2(mixt)	
14/04/2021	2 (wheat)+2(mixt)	2 (wheat)+2(mixt)	
20/04/2021			X
25/04/2021			X
27/04/2021	2 (wheat)+2(mixt)	2 (wheat)+2(mixt)	

05/05/2021	2 (wheat)+1(mixt)	2 (wheat)+1(mixt)	
10/05/2021			X
30/05/2021			X
04/06/2021			

Publications :

Boukari M., Zitouna-Chebbi R., Mekki I., Abdelghaffar A., Benyoussef S., Jacob F. (2021) Evaluation of biomass production and water productivity of cereal-legume mixture cropping in Lebna catchment, Cap-Bon, Tunisia. In Atlas Georesources International Congress (AGIC2021).
Alaya I., Mekki I., Boukari M., Benyoussef S., Jacob F., Zitouna Chebbi R. (2021) Evaluation of WAPOR for the estimation of the annual rainfed crops biomass, Tunisia. In the 3rd Euro-Mediterranean Conference for Environmental Integration (EMCEI-2021).
Ben Abdelghaffar A., I. Mekki, R. Zitouna Chebbi , M. Boukari , F. Jacob , S. Benyoussef. (2021). Evaluation of the efficiency of mixed cropping systems: case of the associated cereal-legume agricultural system in the Lebna-Cap Bon. In the 3rd Euro-Mediterranean Conference for Environmental Integration (EMCEI-2021).
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CESBIO

Landcover data - Ground observations

In order to be able to train and validate classification algorithm, ground data represent a key information that is rarely available on a routine basis, especially in southern countries. The collect of such data as begun in the Tensift area since 2016, i.e. before ALTOS, but this is a long-term initiative to which this project contributes. The data is collected every year at two periods in order to observe both winter and summer crops: trees (olive, citrus, apricot, pomegranate, ...), cereals (wheat, barley), watermelon, melon, tomato, fava bean, peas.

The survey is achieved based on visual observation of around 200 plots for each season, which are stored in the form of polygons (shapefile format). The survey is not based on a fixed set of plots, they change with each field trip. plots change each year. So far, about 2500 plots have been observed between 2016 and 2021, presented in the following table.

Year	Nb of plots observed
2016	349
2017	254
2018	401
2019	671
2020	500
2021	295

Landcover maps

As mentioned in D1.2.2, a time series of land cover maps at 30 m resolution has been produced between 1984 and 2018 for the Tensift area, for 29 years among

the 35 year period (i.e. when landsat data was available. This data still requires some cleaning but already constitutes a very significant contributions to land cover changes in this area.

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LISAH

Small reservoir geometries – hydrological connectivities

Methodological innovation for the caracterisation of small reservoir geometries was brought through a work on derivatives of Sentinel images data series. State-of-the-art algorithms proved to be efficient on larger water bodies and are known to be limited for smaller water bodies such as the upstream small reservoirs of the Lebna catchment in Tunisie, due to spectral mixing within water pixels. For this subtask the material produced consists in R scripts that allow to map reservoir on a pixel basis. These scripts developed during a Msc internship aim to process raster time series of a water occurrence index derived from full-year Sentinel-1 and Sentinel-2 data series. These scripts require pre-processed Sentinel tiles into annual and mmonthly water occurrence indices ranging from 0 (no water at all during the considered period of time) to 1 (water detected during the considered period of time). They allow to characterize the ability to map small water bodies according to various characteristics : reservoir surface, shape index and robustness to morphomathematics erosion transformation.

Reference :

Kanmegne J., *Etablissement de typologies de retenues par traitement de séries temporelles d'images Sentinel*, MsC thesis, ESGT, FR, 2021

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N.B : a sub-part of the deliverable concerning hydrological connectivities was planned as a contribution to this item. Due to human resources issues (the person who was hired for this work left the team) it could not be produced in due time. Another person was just hired – this subpart of the deliverable will thus be produced at the end of the project. Contact person : jerome.molenat@inrae.fr

IRTA

Mapping irrigation systems

Maps of irrigation systems are of critical value for a better understanding of the human impact on the water cycle, while they also present a very useful tool at the administrative level to monitor changes and optimize irrigation practices. In this study, we proposed a novel approach for classifying different irrigation systems (flood, sprinkler and drip irrigation) at field level by using remotely sensed data at subfield scale as inputs of different supervised machine learning (ML) models for time-series classification. The ML tested were Time Series Random Forest, Rocket and ResNET. The ML models were trained using ground-truth data from more than 300 fields collected during a field campaign in 2020

across an intensely cultivated region in Lleida, Catalunya, Spain. Time-series of two hydrological variables retrieved from satellite data, actual evapotranspiration (ETa) and soil moisture (SM) were used as inputs of the ML models. ETa was run on a daily basis at 20-m resolution and using the Two-Source energy balance modelling approach with Copernicus-based inputs during years 2018-2020. On the other hand, SM was obtained from the disaggregation of low-resolution original data employing the DisPATCH algorithm. But for this study, SM was retrieved at 20 m resolution using as input Land Surface Temperature obtained by sharpening Sentinel-2 with Sentinel-3 images. Results showed the best results when used for classification, especially when combined together, retrieving a final accuracy of 90.1 ± 2.7%. All the three ML models employed for the classification showed that they were able to distinguish different irrigation systems, regardless of the different crops present in each field. For all the different tests, the best performances were reached by ResNET, the only deep neural network model among the three tested. The resulting method enables the creation of maps of irrigation systems at field level and for large areas, delivering detailed information on the status and evolution of irrigation practices.

Figure. Maps of irrigation Systems obtained from a) SIGPAC (farmer's declaration), and ResNET Machine learning model for b) 2018, c) 2019 and d) 2020.

Publication:

G. Paolini, M. J. Escorihuela, O. Merlin, M. P. Sans and J. Bellvert, "Classification of Different Irrigation Systems at Field Scale Using Time-Series of Remote Sensing Data," in *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, vol. 15, pp. 10055-10072, 2022, doi: 10.1109/JSTARS.2022.3222884.

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INAT-LISAH

Pesticides treatments surveys

Two surveys were performed to interview farmers of the Lebna watershed. First survey in June 2019 asked for winter 2018 treatments and summer 2019, second survey in August 2020 asked for winter 2019 treatments and summer 2019 treatments. Database coded Information consists of 516 situations of 132 cultivated plots representing a total of 200ha. For each situation (plot and seasons) the specified parameters are detailed:

- farmers level of education (4) and age (4), irrigated or pluvial, the area of the plot, the cultivation (between 29), treated (161) or non-treated (355)
- principle of treatment (herbicide (101), fungicide(73), insecticide(50), and the active ingredients involved (32).

The database is associated with the list of commercial products, ingredients and doses authorized for agricultural use in Tunisia in 2018. Objectives of data recollection were shared by the Eranet-Med Project CHAAMS that mainly focuses on herbicides and particularly on glyphosate water contamination. Scientific explanation of the database is not achieved and should benefit from new inputs in order to describe global phytosanitary pressure on the watershed. Conclusive elements would come from association of the present dataset to : 1-observatory OMERE pesticide surveys 2-to land cover maps built in the mark of the project.

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UNICA

Hydrological connectivities

Innovative methodologies have been developed to characterize the surface/subsurface hydraulic connectives in a typical semi-arid echosystem. The applied methodology consist on a multiscale approach for the investigation of storage water effect in the dynamics of soil moisture. The case study is the Orroli, for wich the spectrum of root-zone soil moisture content in a Mediterranean ecosystem is examined using 14-years of half-hourly measurements. A distinguishing hydro-climatic feature in this ecosystems is that sources (mainly rainfall) and sinks (mainly evapotranspiration) of soil moisture are roughly out of phase with each other. For over 4 decades of time scales and 7 decades of energy, the canonical shape of the measured soil moisture spectrum is shown to be approximately Lorentzian determined by the soil moisture variance and its memory but with two exceptions: the occurrences of a peak at diurnal-to-daily time scales and a weaker peak at near annual time scales. Model calculations and spectral analysis demonstrate that diurnal and seasonal variations in hydroclimate forcing responsible for variability in evapotranspiration had minor impact on the normalized shape of the soil moisture spectrum. However, their impact was captured by adjustments in the temporal variance. These findings indicate that precipitation and not evapotranspiration variability dominates the multi-scaling properties of soil moisture variability consistent with prior climate model simulations. The soil moisture memory inferred by the annual peak of soil moisture (340 d) is consistent with climate model simulations, while the memory evaluated from the loss function of a linearized mass balance approach leads to a smaller value (50 d), highlighting the effect of weak non-stationarity on soil moisture variability. The connection between the soil moisture state and atmospheric processes at different scales has made the investigation of θ variability a necessity for quantifying and modelling climatic, hydrological and ecological processes.

Publication: Roberto Corona, Gabriel Katul, Nicola Montaldo: “disa*The root-zone soil moisture spectrum in a mediterranean ecosystem”*, Journal of Hydrology, Volume 609, 2022, 127757, ISSN 0022-1694, https://doi.org/10.1016/j.jhydrol.2022.127757.

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