MedAgriFoodResilience

"Socio-environmental shocks assessment and resilience empowerment in Mediterranean agri-food heritage systems: Italy, Morocco, Algeria FAO GIAHS sites"

Complete GIS database and related user's manual

Deliverable 2.1

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1. The GIS database and the user's manual

Results of T2.1 and T2.2 allowed to obtain an extensive amount of spatial data on different issues, including landscape and land uses, soil, geology, hydrology, climate, and crop systems. The database is available on the official project website (www.medagrifood.eu).

The following table summarizes the main characteristics of the different GIS layers that have been produced, including the type (R = raster, V = vector), the Coordinate Reference System (EPSG), and the main data included into the attribute table.

The land use dynamics have been classified according to the VASA (Historical and Environmental Approach) approach, which is based on the analyses of land use maps of at least two different years to measure landscape changes and trends in cultural landscapes, to assess landscape changes, the overall level of integrity and the main vulnerabilities. The analysis of the land use changes between the different time intervals allows to produce a new layers with new polygons, each of them including the information about the land use in the two different considered periods. On the basis of this information, each polygon has then been classified according the previous and current land use, according to a classification based on standard dynamics:

- Unchanged. The main type of land use remains the same during the time interval, or when there is a change between similar land uses.
- Urban sprawl. Replacement of natural or agricultural land uses with urban areas, infrastructures, or buildings.
- Intensification. The transformation from low-consumption land uses (in terms of biomass removal, mechanization, fertilizer, and crop protection products) to land uses characterized by high specialization and by a high need of energy supplies, i.e. the replacement of the traditional cultivations with modern and intensive monocultures.
- Extensification. The opposite of the previous dynamic, which is rarely linked to a return to traditional land uses, but more often is due to the abandonment of the traditional system now replaced by uncultivated land.
- Forestation. Process in which trees or shrubs occupy lands once used for agricultural activities.
- Deforestation. Removal of woodlands or shrublands for obtaining land for pastures or crops.

Area	Map	Name of the layer	Type	Data source	EPSG	Description of the data included into the attribute table
Olive orchards of Assisi-Spoleto (Italy)	GIAHS site border map	BORDERS	V	GIAHS application documentation	3004	The boundaries of the GIAHS site.
	Land use map at 1954	LU_1954	V	Own realization. Manual photointerpretation of 1954 black and white aerophotos.	3004	Each polygon contains the information about the land use type, land use macrocategory, and the surface in hectares.
	Land use map at 2011	LU_2011	V	Own realization. Manual photointerpretation of 2011 color high-resolution orthophotos.	3004	Each polygon contains the information about the land use type, land use macrocategory, and the surface in hectares.
	Land use map at 2022	LU_2022	V	Own realization. Manual photointerpretation of 2021 color high-resolution orthophotos, updated to 2022 through field surveys.	3004	Each polygon contains the information about the land use type, land use macrocategory, and the surface in hectares.
	Land use changes map 1954-2011	DYNAMICS_1954-2011	V	Own realization. Intersect between the land use maps of 1954 and 2011.	3004	Each polygon contains the information about the land use of 1954, of the land use of 2011, of the surface in hectares, and of the classification of the land use dynamics.
	Land use changes map 2011-2022	DYNAMICS_2011-2022	V	Own realization. Intersect between the land use maps of 2011 and 2022.	3004	Each polygon contains the information about the land use of 2011, of the land use of 2022, of the surface in hectares, and of the classification of the land use dynamics.
	Land use changes map 1954-2022	DYNAMICS_1954-2022	V	Own realization. Intersect between the land use maps of 1954 and 2022.	3004	Each polygon contains the information about the land use of 1954, of the land use of 2022, of the surface in hectares, and of the classification of the land use dynamics.

	Slope map	slope_deg	R	Own realization. Elaborated from a 10 meters resolution Digital Terrain Model (DTM)	3004	Map of the slopes classified in degrees.
	Altitude map	altitude_class	R	Own realization. Elaborated from a 10 meters resolution Digital Terrain Model (DTM)	3004	Map of the altitude classified in classes of 50 meters
	Geological map	GEOLOGIC	V	Elaborated from the Geological map of Umbria 1:10.000	3004	Each polygon contains the information about the geological type. The description for each type can be found in the related Excel file (GEOLOGIC_description).
	Pedological map	PEDOLOGY	V	Elaborated from the Soil Map of Italy 1:1.000.000	3004	Each polygon contains the information about the soil region and the soil type.
	Hydrographic map	HYDROGRAPHY	V	Elaborated from the shapefile of rivers of Umbria	3004	Each line contains the information about the river type, the risk class and the name of each river.
	Hydrogeological map	HYDROGEO	V	Elaborated from the Hydrogeological map of Umbria 1:100.000	3004	Each polygon contains the information about the hydrogeologic complexe typologies and their permeability classes (indicated by numbers, from 1 to 6, where 1 is impermeable and 6 is high permeable).
	Phytoclimatic map	PHYTOCLIMATIC	V	Elaborated from the Phytoclimatic map of Umbria 1:200.000	3004	Each polygon contains the information about the bioclimatic categories.
	Climatic and rainfall spatial data	CLIMATE	V	Own realization. Elaborated from climatic and rainfall data of the closer meteorological stations.	3004	Punctual shapefile, with points corresponding to the closer meteorological stations. Data included in the attribute table for each meteorological stations: average yearly temperature in Celsius degrees, average lower temperature in Celsius degrees, average higher temperature in Celsius degrees, average yearly rains in millimeters.

	Local crop system database	CROP_SYSTEM	v	Own realization. Elaborated from the agricultural census periodically made by the Italian National Institute of Statistics (ISTAT).	3004	Each polygon corresponds to a municipality and contains the information about the number of farms, the area of olive groves in hectares and the Utilized Agricultural Area (UAA) in hectares. These information are reported for four different years: 1982, 1990, 2000, 2010.
Argan tree agro-forest-pastoral system of Ait Souab-Ait Mansour area (Morocco)	GIAHS site border map	BORDERS	V	GIAHS application documentation (ANDZOA)	4326	The boundaries of the GIAHS site.
	Elevation map	Elevation_class	R	Own realization. Elaborated from a 30 meters resolution Digital Elevation Model (DEM). https://earthexplorer.usgs.gov/	4326	Classified map of elevation
	Slope map	slope_deg	R	GIS analysis of DEM	4326	Classified slopes map in degrees.
	NDVI 2022 Map	NDVI_2022	V	USGS Sentinel 2-A	4326	The map shows the high and low values of NDVI for the year.
	NDVI 2015 Map	NDVI2015	R	USGS Sentinel 2-A	4326	The map shows the high and low values of NDVI for the year.
	NDVI 2010 Map	NDVI 2010	R	Landsat 7 Image	4326	The map shows the high and low values of NDVI for the year.
	NDVI 1994 Map	NDVI_1994	R	Landsat_5 image	4326	The map shows the high and low values of NDVI for the year.
	Land use map at 2022	LU_2022	R	USGS Sentinel 2-A	4326	Each polygon contains the information about the land use type.

	Land use map at 1994	LU_1994	R	USGS Landsat 5	4326	Each polygon contains the information about the land use type.
	Geological map	GEOLOGIC	v	Elaborated from the Geological map of Ouarzazate 1:500.000	4326	Each polygon contains the information about the geological type.
	Average Annual Rainfall Map	Climate	R	Elaborated from climatic and rainfall data of the closer meteorological stations.	4326	Data included in the attribute table for each meteorological stations: average yearly rainfall.

3. Definition of a set of indicators for the biophysical assessment of the territory

The use of indicators allows to synthetically describe the structure of the landscape of a certain territory, and the main transformations that have interested the structure of the landscape mosaic. Following it is possible to find a list of proposed indicators for the biophysical assessment of the territory of agricultural heritage systems:

Name	Symbol	Formula	Description
Number of land uses	NLU		Total number of land uses.
Number of patches	NP		Total number of patches.
Patch Density	PD	$PD = \frac{NP}{S} * 100$ *NP* = number of patches; *S* = total surface in hectares.	The number of patches for 100 hectares.
Mean Patch Size	MPS	$MPS = \frac{a_i}{n_i}$ a_i = area of the *i* land use class in hectares; n_i = number of the *i* land use patches.	Average area of a patch of a particular class.
Mean Size of Agricultural Patches	MPS_A	$MPS_A = \frac{a_a}{n_a}$ a_a = area of the patches used for agricultural activities in hectares; n_a = number of the patches used for agricultural activities.	The average size of patches used for agricultural activities, in hectares
Edge Density	ED	$ED = \frac{E}{A} * 10000$ *E* = sum of the lengths of the edge of the patches in meters; *A* = total patch area in square meters.	ED evaluates the level of fragmentation of a certain landscape. The higher the value of the index, the higher the fragmentation and the complexity of the landscape, while in the case of lower values, the landscape basically consists of a few, big regular patches
Shannon Dominance Index	D_1	$D_1 = \ln(n) + \sum\left(\frac{n_1}{N}\right) * \ln\left(\frac{n_1}{N}\right)$	Derived from the Shannon Dominance Index (Shannon & Weaver 1962). As D_1 increases, there is an increase in the dominance of some landscape patches over others, corresponding to the decrease in the complexity of the landscape mosaic and to its simplification, as the

		n = number of land use classes; n_1 = surface of each land use type in hectares; N = total area of the study area in hectares.	landscape is dominated by a smaller number of types of land use and by bigger patches.
Hill's Diversity Index	H_1	$$N_1 = e^{-\sum\left(\frac{n_1}{N}\right)*\ln\left(\frac{n_1}{N}\right)}$$ n_1 = surface of each land use type in hectares; N = total area of the study area in hectares.	Expresses the effective number of land uses that contribute to the diversity of a given landscape
Sharpe Index	C	$$C = \left(\frac{pk_2 - pk_1}{t_2 - t_1}\right) / S$$ pk_1 = surface in hectares of pk land use at year t_1; pk_2 = surface in hectares of pk land use at year t_2 ($t_2 > t_1$); $t_2 - t_1$ = time interval in years; S = total surface of the study area in km^2.	To be applied to the single land uses, comparing their extension in the same study area at different years. It allows to highlight the most relevance land use changes occurred in a given period in the same study area. The Sharpe Index is applied to individual land uses, and can have a positive or negative value. If the value is positive, it means that the land use recorded an increase of its surface in the study area in the reference period, while if the value takes a negative sign, the land use has undergone a reduction of its surface. The extensions of the different land uses in terms of hectares are not highlighted, but those that are the land uses most responsible for the changes that have characterized a certain time interval. By comparing the values of the Sharpe Index on a bar chart, it is therefore possible to immediately understand what the main changes in a given landscape have been in a certain period of time, as the length of the bar of the chart correspond to the intensity, of the landscape transformations: the length the bar is, more relevant is the land use change.
Historical Index	HI	$$HI = Hpv * \frac{Hgd}{Pgd}$$ Hpv = historical persistence of the land use, whose value is in the range 0-1, given by the ratio between the number in years in which that land use is present in the study area and the total number of years of the time	To be applied to the single land uses, comparing their extension in the same study area at different years. It has been developed with the purpose of assessing the value of a cultural landscape analysing the changes, in time and space, of any single land use, creating a hierarchy in which the land uses with a higher HI are the ones that suffered a higher decrease and the ones at risk of disappearing from the local landscape. The index attributes a higher value to those elements with a long historical persistence, but a present

		interval considered; if the persistence of that land use is continuous for the entire reference time or if the analysis takes into account only two dates, the ratio will be equal to 1. *Hgd* = surface in hectares occupied by the *gd* land use in the past. *Pgd* = surface in hectares occupied by the *gd* land use at the most recent year.	geographical distribution smaller than that in the past. The most interesting application of the HI is not just the creation of a land use hierarchy, but the possibility to transfer the values of HI for each land uses on the maps, becoming a real planning indicator. The HI values can be applied to maps in two different ways. The first one is for creating the Historical Index General Map, where at each patch of the current land use map is applied the corresponding value calculated for that land use. The map is then produced creating a scale of colours in order to highlight the location of the patches with the higher values of HI, and therefore, with the highest risk of disappearing. The second map that can be produced is the Historical Index Topographic Map, where the values of the HI are applied only to the patches that preserve the same exact land use of the past, therefore it is produced starting from the map of the dynamics. Differently from the classification of the unchanged dynamic, where the classification is made by macro-categories, in this map the patches have to maintain exactly the same land use of the past, therefore it is similar to a persistence map. The main limitation of the HI is that if a land use is already disappeared from the study area it is not possible to calculate the value of its HI.
Normalized Difference Vegetation Index	NDVI	$$NDVI = \frac{(NIR - red)}{(NIR + red)}$$ NIR – light reflected in the near-infrared spectrum. red – light reflected in the red range of the spectrum (visible).	NDVI defines values from -1.0 to 1.0. Negative values are mainly formed from clouds, water and snow, and values close to zero are primarily formed from rocks and bare soil. Very small values (0.1 or less) of the NDVI function correspond to empty areas of rocks, sand or snow. Moderate values (from 0.2 to 0.3) represent shrubs and meadows, while large values (from 0.6 to 0.8) indicate temperate and tropical forests.