HELLENIC MINISTRY OF RURAL DEVELOPMENT AND FOODS

ADMINISTRATIVE SECTOR FOR COMMUNITY RESOURCES AND INFRASTRUCTURE

Applying Common Criteria to Identify Agricultural Areas with Natural Constraints

GREECE

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Contents

Application of Biophysical Criteria

INTRODUCTION

This report presents the results of the delimitation of areas with natural constraints (ANC) based on Article 32 of Reg. (EU) 1305/2013. It is well known that the concept of less-favored areas was introduced by Directive 75/268 / EEC "to ensure the continuation of agricultural activity and thereby to maintain a minimum population density or the maintenance of the countryside in certain less-favored areas"; and with the ultimate aim of 'favoring agricultural activities and improving the income of farmers in these areas'. The mountainous and “disadvantaged” areas were first established for Greece by Directive 81/645 / EEC. Mountain areas are defined as 3,399 Local administrative Units - LAU (LAU2, formerly NUTS level 5). At this stage, soil and climatic data, as well as agriculture land data, to be provided by the RDP Special Management Service for 2014-2020, were used to identify areas subject to physical constraints by applying the relevant instructions issued by the European Union. Spatial soil data were obtained from the Soil Map of Greece (Scale 1: 30.000) provided by OPEKEPE (https://iris.gov.gr/SoilServices/) Meteorological data were provided from the Hellenic National Meteorological Service (HNMS) for the period 1971-2000. For the implementation and spatial analysis of the criteria it was considered that a LAU2 can be classified as subject to physical constraints since 60% of the Utilized Agricultural Areas (UAA) is covered by one or more criteria. The results show that 2.308 LAU2 are primarily subject to physical constraints. The total area occupied by these LAU2 amounts to 4,766,954.0 ha and includes 2,523,055.6 ha of UAA.

Data

Data used for the mapping of the biophysical criteria are described in this section, which is organized by group of criteria: climate, soil and terrain.

Data for Climate Criteria

The required climate data came from Hellenic National Meteorological Service (HNMS), which is the National Service responsible to cover all the meteorological and climatological of the country (http://www.hnms.gr/hnms/english/index_html).

A total of 140 meteorological stations distributed all over the country were used (Figure 1). The density of meteorological stations is 1 station per 950 km^2 and it can be considered adequate according to the international standards. However, Greece is characterized by a vast spatial variability of meteorological conditions in contrast to the relatively small size of the country (e.g. the annual precipitation depth ranges from well above 2000 mm/yr at the higher elevation at the northwest to well below 500 mm/yr at the southeast of the country [Soulis et al. 2016]), which can be attributed to its steep relief including a massive sierra with a north-south direction dividing the mainland of the country, as well as its very long shoreline (Figure 1). Accordingly, possible limitations could be the variability of meteorological stations density across the country and the underrepresentation of higher elevations most meteorological stations are located at lower altitudes (Figure 1).

According to the Commission's guidelines the recommended WMO reference climatic period should be used. The current climate reference period in use by WMO consists of 30 years from 1 January 1961 to 31 December 1990. However, it is also suggested that it is possible to adapt the reference period to following a 'rolling' set of 30 year, updated every 10 years (period starting on 1 January of a year ending with the digit 1, e.g. 1971, 1981) depending on best available datasets, with the duration of the 'rolling' period being 30 years.

Based on the above and considering the best available meteorological datasets, in this application the reference climatic period consists of 30 years from 1 January 1971 to 31 December 2000.

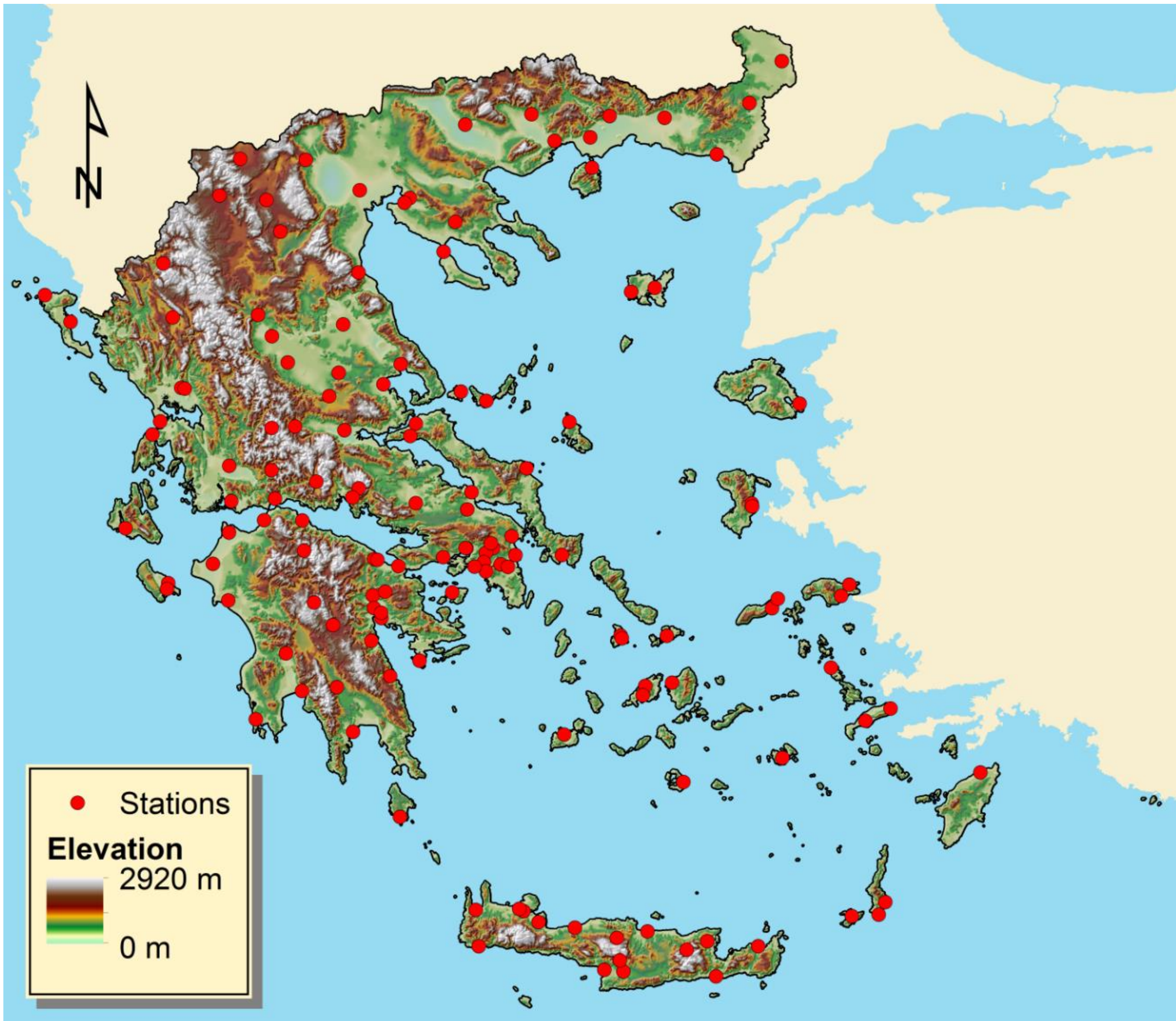

Figure 1. Meteorological stations positions and relief map.

The data used were daily time-series of:

- Precipitation (mm)
- Minimum, Maximum, and Mean Temperature (^{o}C)
- Mean Relative Humidity (%)
- Wind Speed at 2 m height (m/sec)
- Sunshine hours (h)

The available time series were assessed for integrity and consistency and existing gaps were filled using data from neighboring stations considering the distances as well as the temperature and precipitation lapse rates.

Especially for the case of sunshine hours data, which are used for the estimation of solar radiation, the available data come only from 42 meteorological stations while there were several gaps in the data series. Therefore, in the cases of missing sunshine hours data, the estimation of solar radiation was made using the equation proposed by Valiantzas (2013):

$$R_s \approx k_{Rs} \cdot R_A (T_{\max} - T_{dew})^{0.5} \quad 1$$

where R_s is the solar radiation, R_A is s the extraterrestrial radiation, T_{max} is the maximum temperature, T_{dew} is the dew point temperature and k_{Rs} is an empirical radiation adjustment coefficient which generally varies from 0.12 to 0.25 and with a conventionally adopted value of 0.17.

This equation is based on a similar equation proposed by Hargreaves and Samani (1982):

$$R_s \approx k_{Rs} \cdot R_A (T_{\max} - T_{\min})^{0.5} \quad 2$$

where T_{min} is the minimum temperature.

Both equations were calibrated and evaluated by comparing the ET_o values calculated using solar radiation values estimated by sunshine hours data with values calculated based on equations (1) and (2) for all the data points that sunshine hours data were available (376,000 data points). As it can be observed in Figure 2 both equations performed very well but equation (1) performed slightly better (R^2 = 0.974) than equation (2) (R^2 = 0.957). The calibrated k_{Rs} parameter values were 0.168 for equation (1) and 0.195 for equation (2). Therefore, equation (1) was used to estimate solar radiation in the cases of missing sunshine hours data.

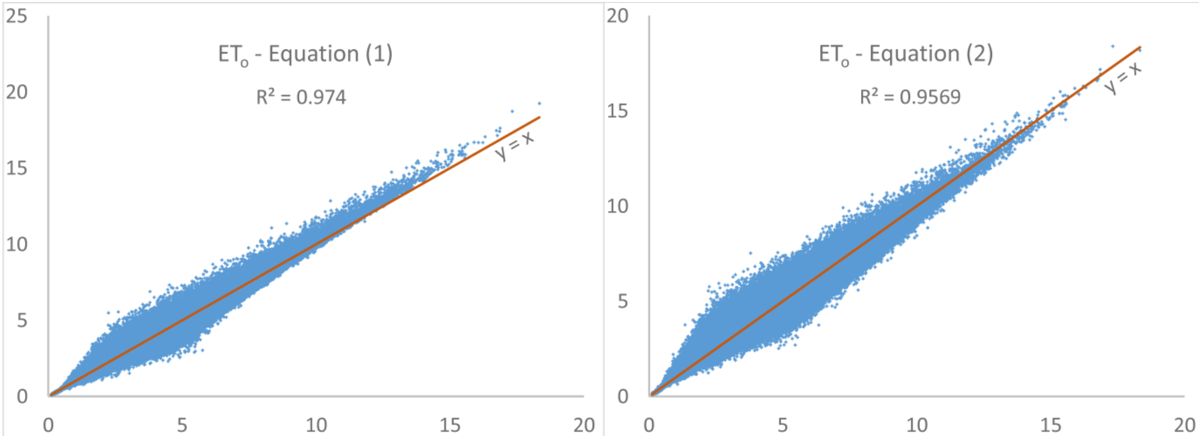

Figure 2. Comparison of ET$_o$ values calculated using solar radiation values estimated by sunshine hours data with values calculated based on equations (1) and (2) for all the data points that sunshine hours data were available.

Data for Soil and Terrain Criteria

Spatial soil data were obtained from the Soil Map of Greece (Scale 1: 30000) provided by O.P.E.K.E.P.E. (Payment and Control Agency for Guidance and Guarantee Community Aid, Ministry of Agricultural Development and Food). Soil Map of Greece consists of 9751 polygons and more than 10000 Soil profile points (Figure 3). It covers 3850231 ha of agricultural areas and it has been published in 2015. The features that were recognized were: Slope, Soil acidity (pH values), Sodicity (ESP), Salinity (Soil Electrical Conductivity), Soil Depth, Soil Texture and Stoniness and Soil Drainage.

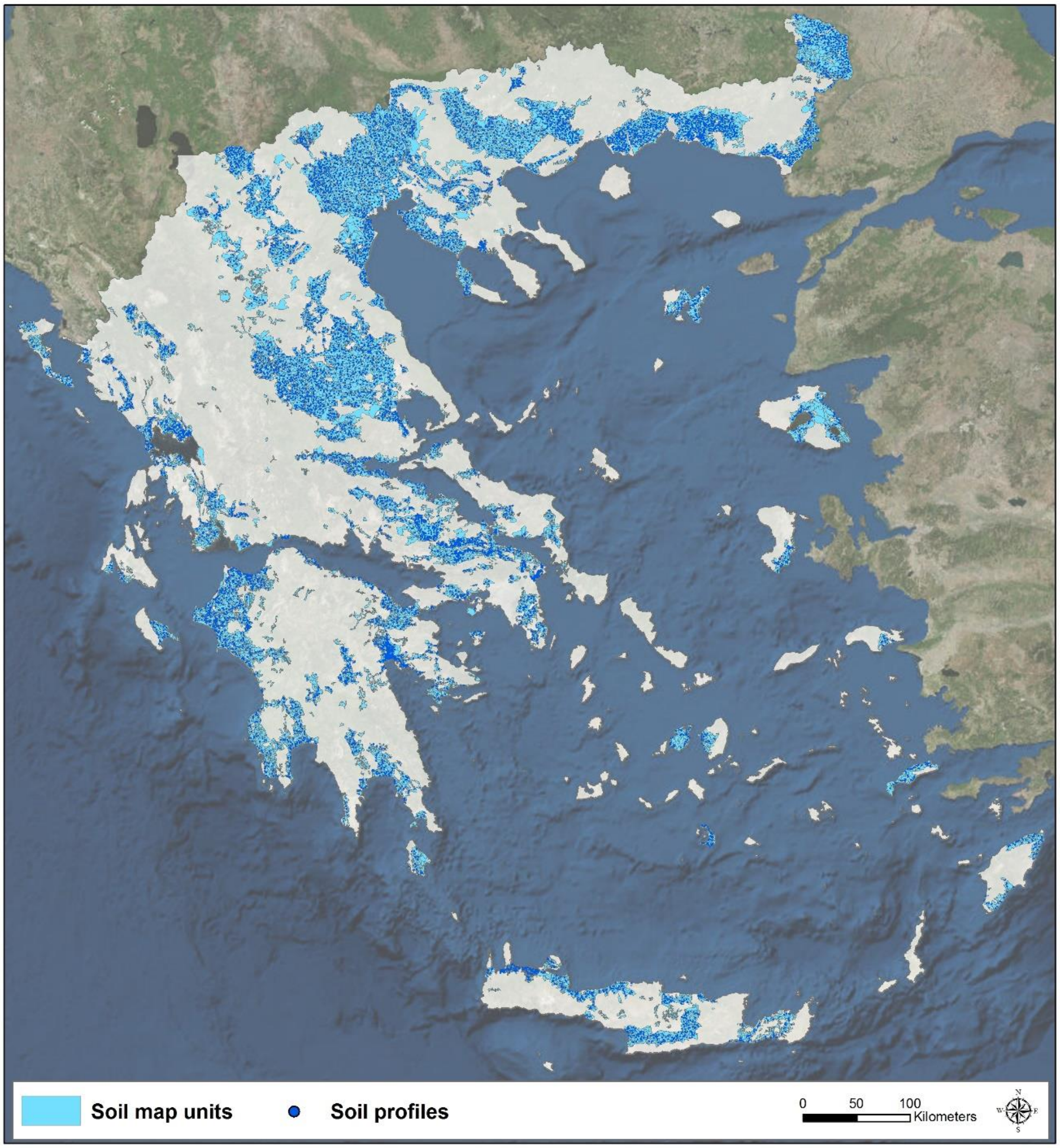

Figure 3. Soil map of Greece

Digital Elevation Model

For preparation of maps, digital elevation model of Greece is used, provided by Shuttle Radar Topography Mission (SRTM) (http://srtm.csi.cgiar.org., Jarvis et al., 2008). For data accuracy purposes digital elevation model data are connected with data on prevailing slope in each municipality.

To prepare the necessary mapping material, slope angle information is obtained from the digital elevation model, gathering information about the relief of the area (in this case - the area of the whole country).

The basis for calculating a slope angle a digital elevation model is used, which offers starting data in raster format. A preparation of a digital elevation model and thematic rasters, as well as geospatial data analysis and mapping visualization is available due to ArcGIS Spatial Analyst and 3D Analyst extensions.

A slope angle was calculated for this new-made data layer using 3D Analyst extension Slope from the elevation model, making raster data with slope angle values.

Administrative boundaries used

Administrative boundaries used (shapefile format) are the Local Administrative Units (LAU level 2 formerly NUTS5, municipalities level) and were provided by the RDP Special Management Service for 2014-2020. Municipalities have resulted from merging several former municipalities and communities (themselves the subject of a previous reform with the 1997 Kapodistrias plan). They are further subdivided into municipal units and finally into communities (Figure 4).

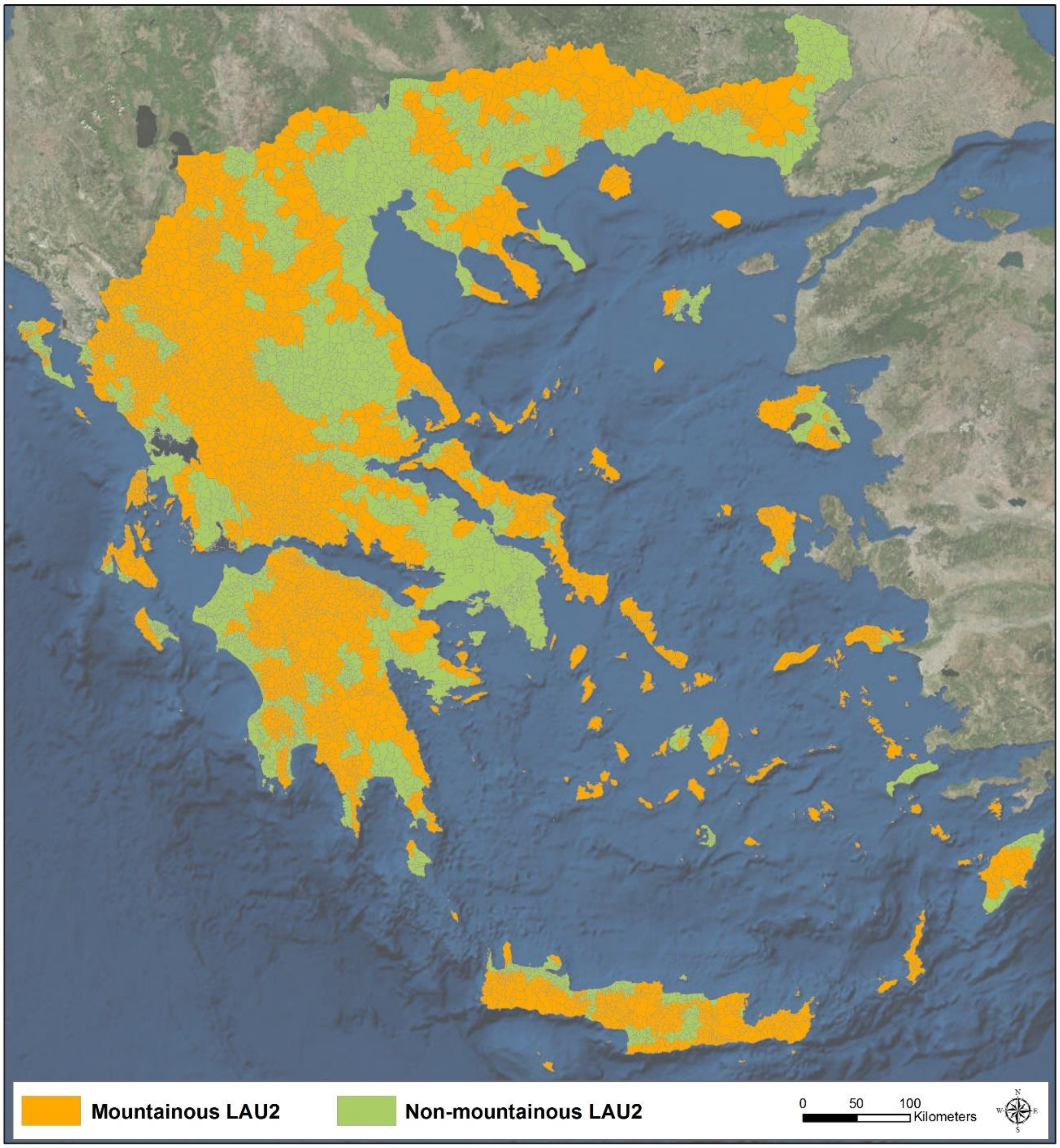

Figure 4. Mountainous and non-mountainous areas.

Agricultural land data used

The spatial data of the agricultural land used are determined by the polygons of the eligible blocks, as they emerged in the creation of the "Single Farm Requests Identification System". They are vector files, with scale 1: 10,000. The production of polygons involves the digitization of eligible wider areas with a defined maximum area of 1the blocks as well as the ineligible areas within these blocks (Figure 5). The polygons produced are characterized by corresponding unique codes, with land use codes, while their total and eligible area is recorded in the database. Blocks receive a Cover ID based on which they are characterized as eligible or not (Table 1).

Table 1. Land use codes for eligible blocks

CODE	**USE**
10	Forestry
11	Mixed forest
20	Urban
21	Urban Mixed
30	Pasture
31	Pasture Mixed
40	Arable
41	Arable Mixed
50	Permanent crop
51	Permanent Mixed
60	Olives
61	Olives Mixed
70	Vineyards
71	Vineyards Mixed
90	Other
91	Roads- Waters
92	Abandoned

Land use codes 10, 20, 90, 91, 92 which correspond to forest, urban, other use, roads - water and abandoned areas, are identified as ineligible blocks. For the needs of this project, only the eligible blocks were considered. The final utilized agricultural area was derived from the spatial distribution of the eligible ones per municipal district. For each handicap criterion, the analysis concerned the Utilized Agricultural Area by LAU2.

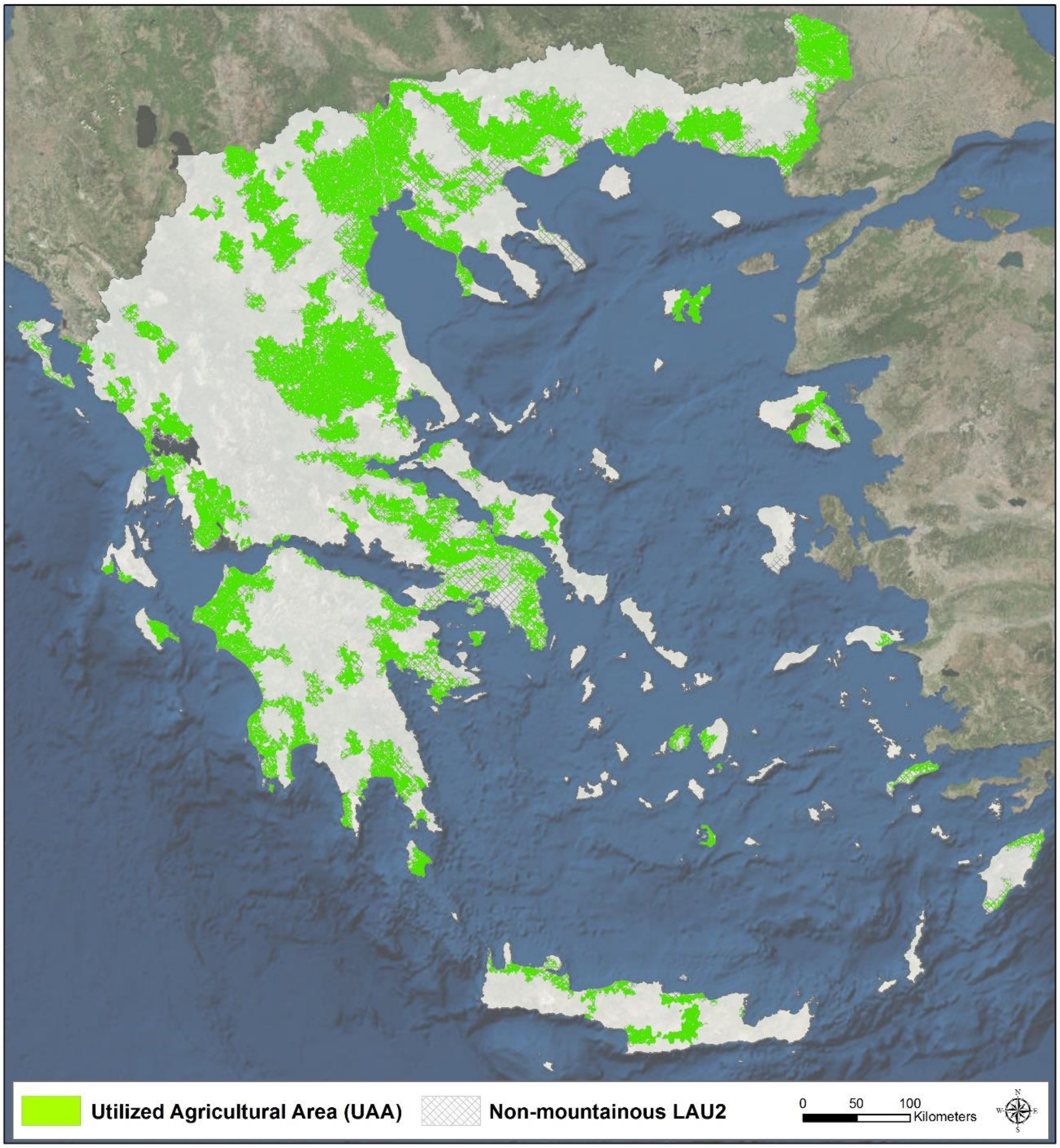

Figure 5. Utilized Agricultural Area in non-mountainous areas.

CRITERIA CALCULATION METHODS AND RESULTS

Climate Criteria calculation: Dryness

Precipitation

According to the Commission's guidelines, the calculation should be carried out with the annual totals of precipitation (P, mm) and of potential evapotranspiration (PET, mm) and the calculation should be made for each year of the available data time series.

Accordingly, the annual totals of precipitation for each year of the 30 years reference period and for each of the 140 meteorological stations were calculated. Then, the annual precipitation data for each year were interpolated to produce the spatial distribution of the annual precipitation depth. As it is suggested to the Commission's guidelines the spatial interpolation was carried out with the co-kriging interpolation method in order to take advantage of the covariance between annual precipitation depth and elevation. Especially for the case of Greece, which is characterized by vast spatial variability of precipitation depths mainly due to its steep relief this technic may help to overcome the limitations posed by the meteorological stations density and the underrepresentation of higher elevations as most meteorological stations are located at lower altitudes (Figure 1).

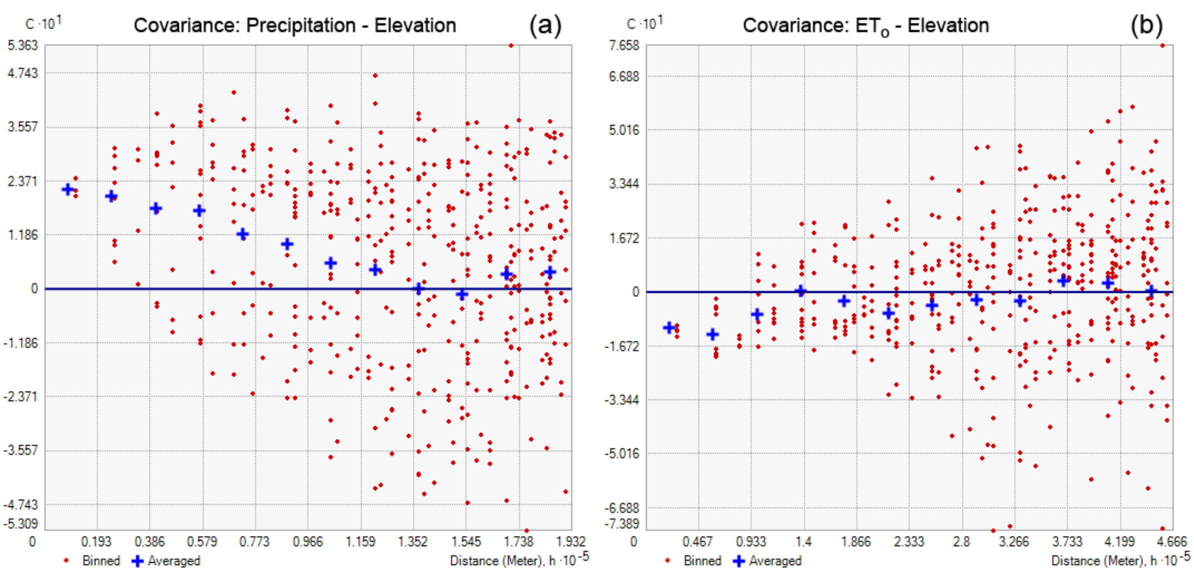

Figure 6. Cross- covariance between (a) Precipitation and Elevation and (b) ETo and Elevation

Considering the number and distribution of the meteorological stations, the steep relief of the studied area on one hand and the computational limitations on the other hand a grid resolution of 1000 m was chosen. Furthermore, regarding the spatial resolution of the interpolation, a coarse Digital Elevation Model (DEM) having a spatial resolution of 200 m was used as secondary information.

At a first step of the analysis, the correlation between the precipitation depth and elevation was examined in order to examine if the use of the co-kriging method is justified. In Figure 6a the covariance between Precipitation and Elevation is plotted. In this figure a clear positive covariance can be observed.

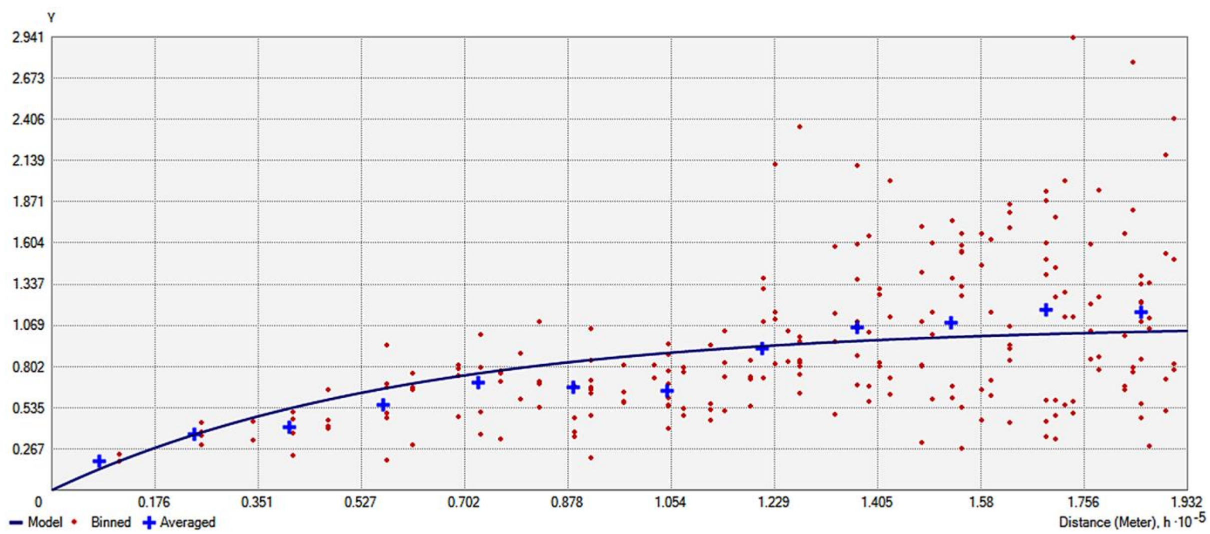

Figure 7. Semivariogram and fitted exponential model.

At a second step the most suitable co-kriging method was selected and the Semivariogram / Covariance Modeling parameters were evaluated. The best results were obtained using simple co-kriging method. Furthermore, the exponential Semivariogram model fitted adequately in the studied dataset as it can be seen in Figure 7. Finally, it was found that considering anisotropy improved the interpolation performance because it allowed taking into account the effect of the massive sierra with a north-south direction dividing the mainland of the country (Figure 1). It should be noted that the interpolation parameters evaluation was made using as a paradigm the 30 years average annual precipitation depths.

Following, using the selected interpolation parameters a series of 30 layers representing the spatial distribution of the annual precipitation depth for each year was created. The obtained results can be seen in Figure 8.

Finally, to test the accuracy of the interpolated surfaces cross-validation of all the obtained results was made. The obtained statistical measures were the following

- Mean Error: -52 and -64 mm
- Root Mean Square Error: 158 to 184
- Root Mean Square Standardized Error: 0.82 to 1.07

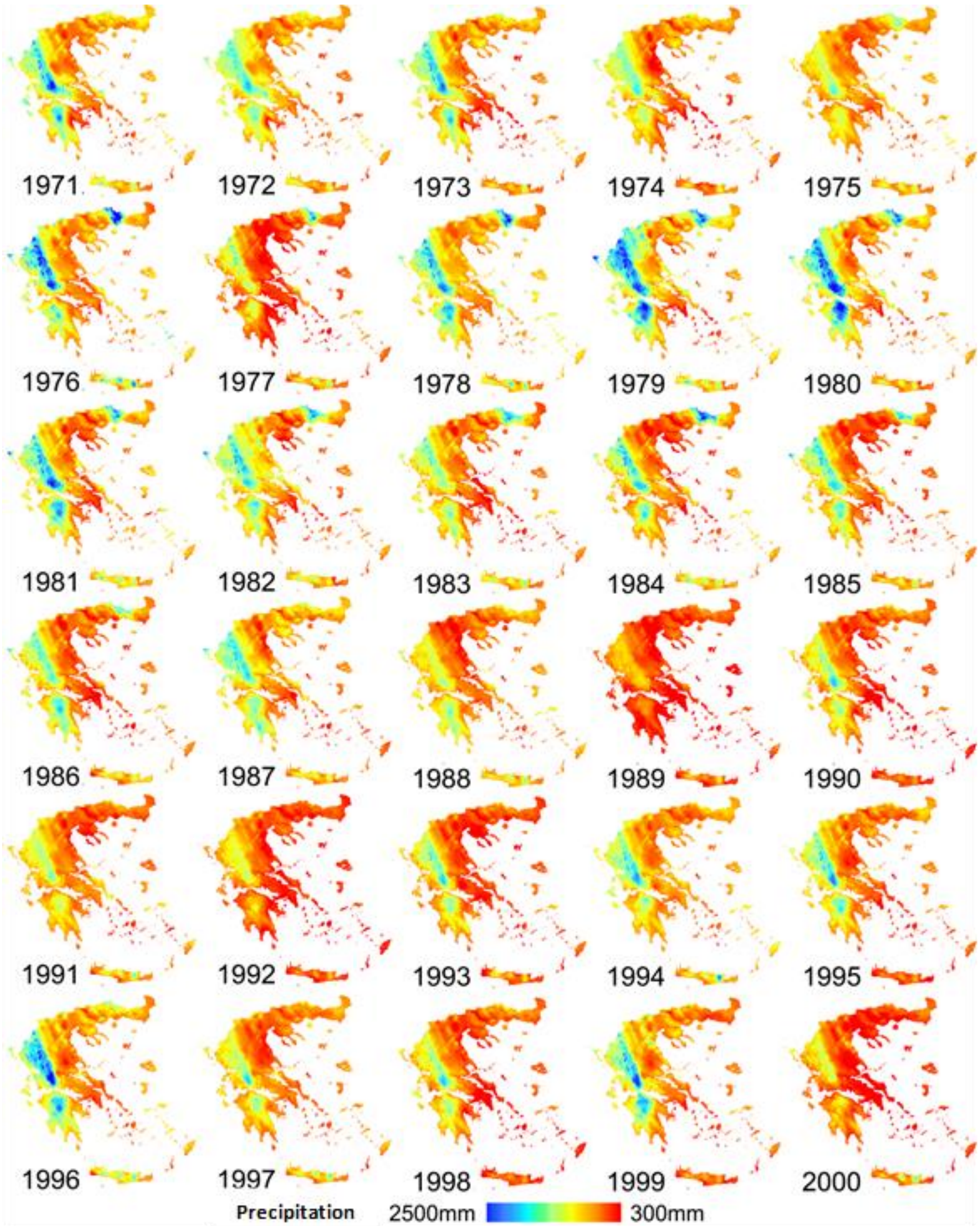

Figure 8. Spatial distribution of the annual precipitation depth.

Potential Evapotranspiration

According to the Commission's guidelines, the calculation Potential Evapotranspiration (PET) was also carried out with the annual totals for each year of the available data time series.

Therefore, the daily grass reference evapotranspiration rates (ET_o, mm/day, potential evapotranspiration rates in relation to a living grass reference crop) were calculated using the FAO Penman-Monteith formula (Allen et al., 1998) for each day of the 30 years reference period and for each of the 140 meteorological stations. Then, the annual totals of ET_o for each year of the 30 years reference period and for each of the 140 meteorological stations were calculated and the annual ET_o data for each year were interpolated to produce the spatial distribution of the annual ET_o depth.

Initially it was investigated if the co-kriging interpolation method may provide improved prediction by taking advantage of the elevation data. However, as it can be seen in Figure 6b the covariance between ET_o and elevation is weak. As it is also reported by Shi et al. (2014) and Soulis (2015) the relationship between ET_o and elevation is complicated and it is very difficult to develop an algorithm for estimating spatially distributed ET_o over mountainous regions. In contrast, it would be possible to consider the clearer relationships between meteorological parameters and topography (e.g. temperature - elevation, aspect - solar radiation) in order to improve the estimation of ET_o spatial distribution (e.g. Soulis and Dercas, 2007; 2010; Soulis et al., 2016). However, the calculation of ET_o using the FAO Penman-Monteith formula should be done in a daily time step. Accordingly, using this approach (i.e. first to estimate the spatial distribution of the meteorological parameters and then to compute ET_o in spatially distributed form) would require the interpolation of the corresponding meteorological parameters for each day of the 30 years reference period requiring the calculation of 30 years x 365 days x 5 parameters = 54750 layers. Accordingly, the use of co-kriging was neglected in the case of ET_o. Nevertheless, it should be noted that any resulting inaccuracies are mainly expected in mountainous areas with very high elevations.

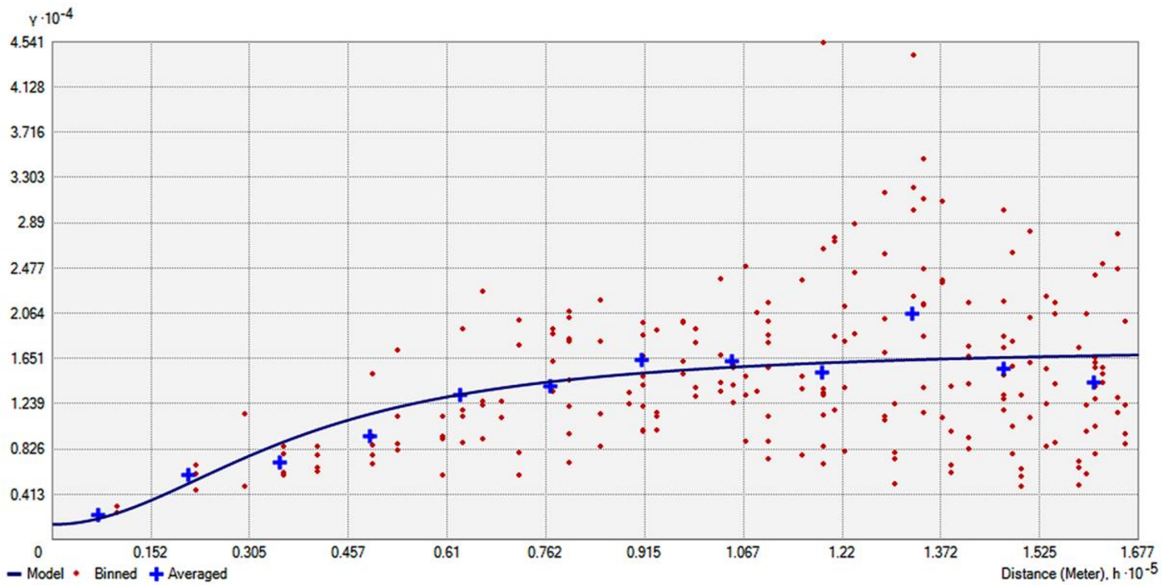

Figure 9. Semivariogram and fitted rational quadratic model.

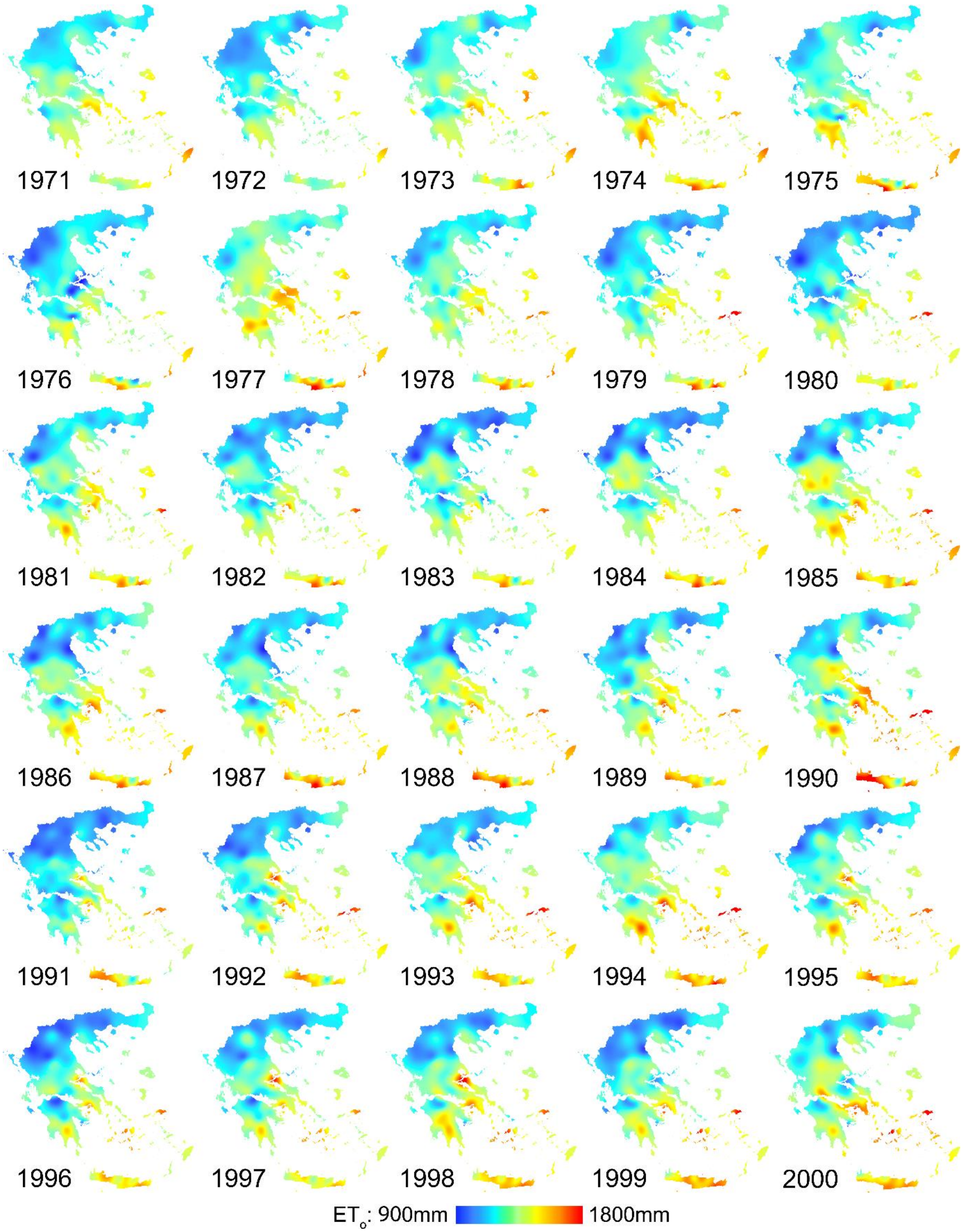

Figure 10. Spatial distribution of the annual ET_o depth.

Similarly, to the precipitation, a grid resolution of 1000 m was also chosen for the case of ET_o. However, in the case of ET_o the best results were obtained using the ordinary kriging method. Furthermore, the rational quadratic semivariogram model fitted adequately in the studied dataset as it can be seen in Figure 9. Finally, it was found that in this case considering anisotropy did not improve the interpolation performance. It should be noted once again that the interpolation parameters evaluation was made using as a paradigm the 30 years average annual ET_o.

Following, using the selected interpolation parameters a series of 30 layers representing the spatial distribution of the annual ET_o depth for each year was created. The obtained results can be seen in Figure 10.

Finally, to test the accuracy of the interpolated surfaces cross-validation of all the obtained results was made. The obtained statistical measures were the following

- Mean Error: -4 to -7.7 mm
- Root Mean Square Error: 72 to 124
- Root Mean Square Standardized Error: 0.84 to 1.52

Dryness

Using the interpolated precipitation (P) and PET surfaces, the Aridity Index (AI) surfaces corresponding to each year of the 30 years reference period were calculated as follows:

$$AI = P/PET \tag{1}$$

The obtained Aridity Index surfaces can be seen in Figure 11.

Next, the number of years during which the dryness threshold is fulfilled (AI values ≤ 0.5) is computed. The output is a raster with the number of years during which the threshold is fulfilled (Figure 12).

Finally, the areas subject to dryness were obtained by assigning 1 to values of the previous output raster with number of dry years > 20%, and by assigning 0 to values ≤ 20%. The cells with a value of 1 are those areas subject to constraints due to dryness (Figure 13). As it can be observed, the areas subject to dryness are mainly located at the South East part of the country and at lower elevations.

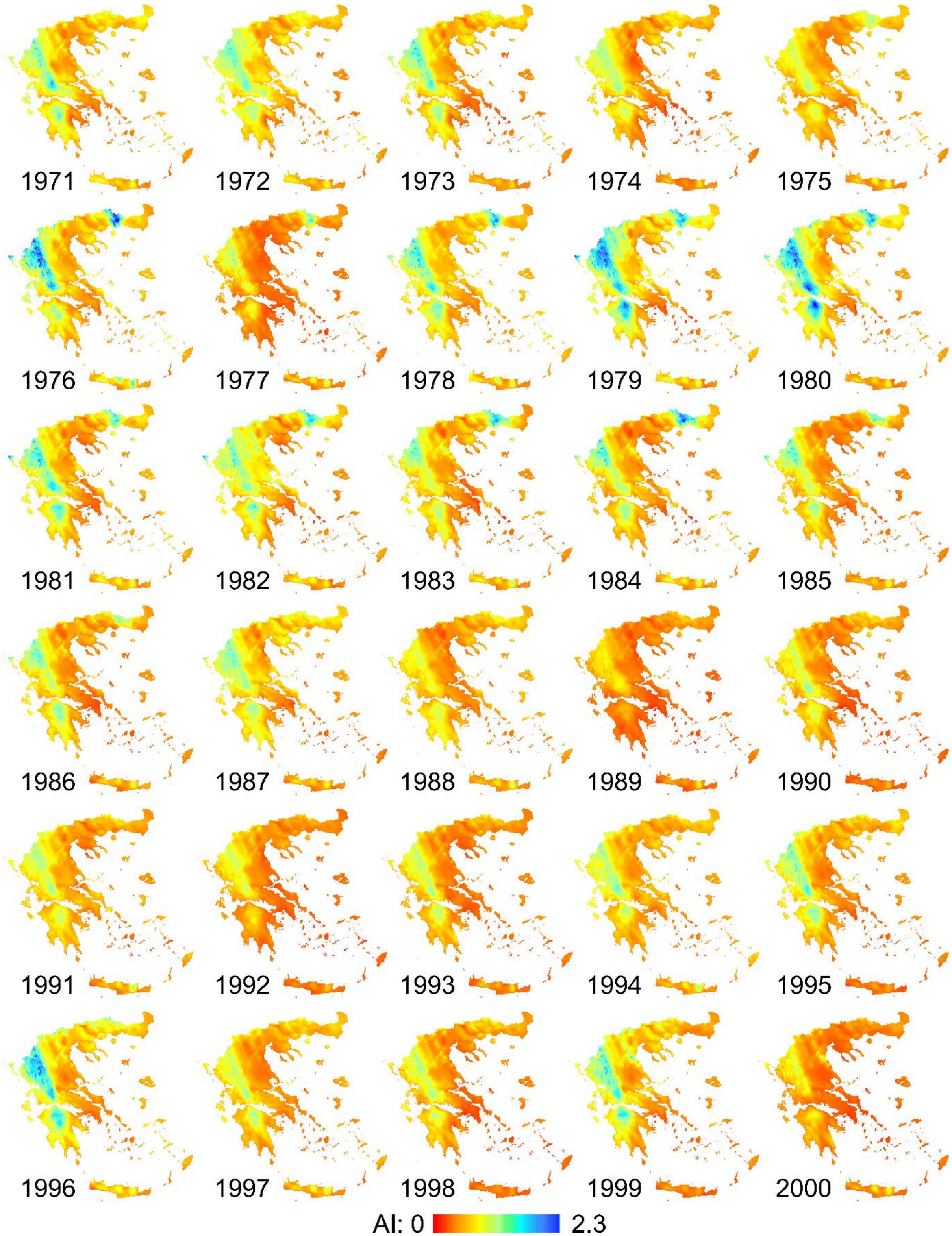

Figure 11. Spatial distribution of Aridity Index.

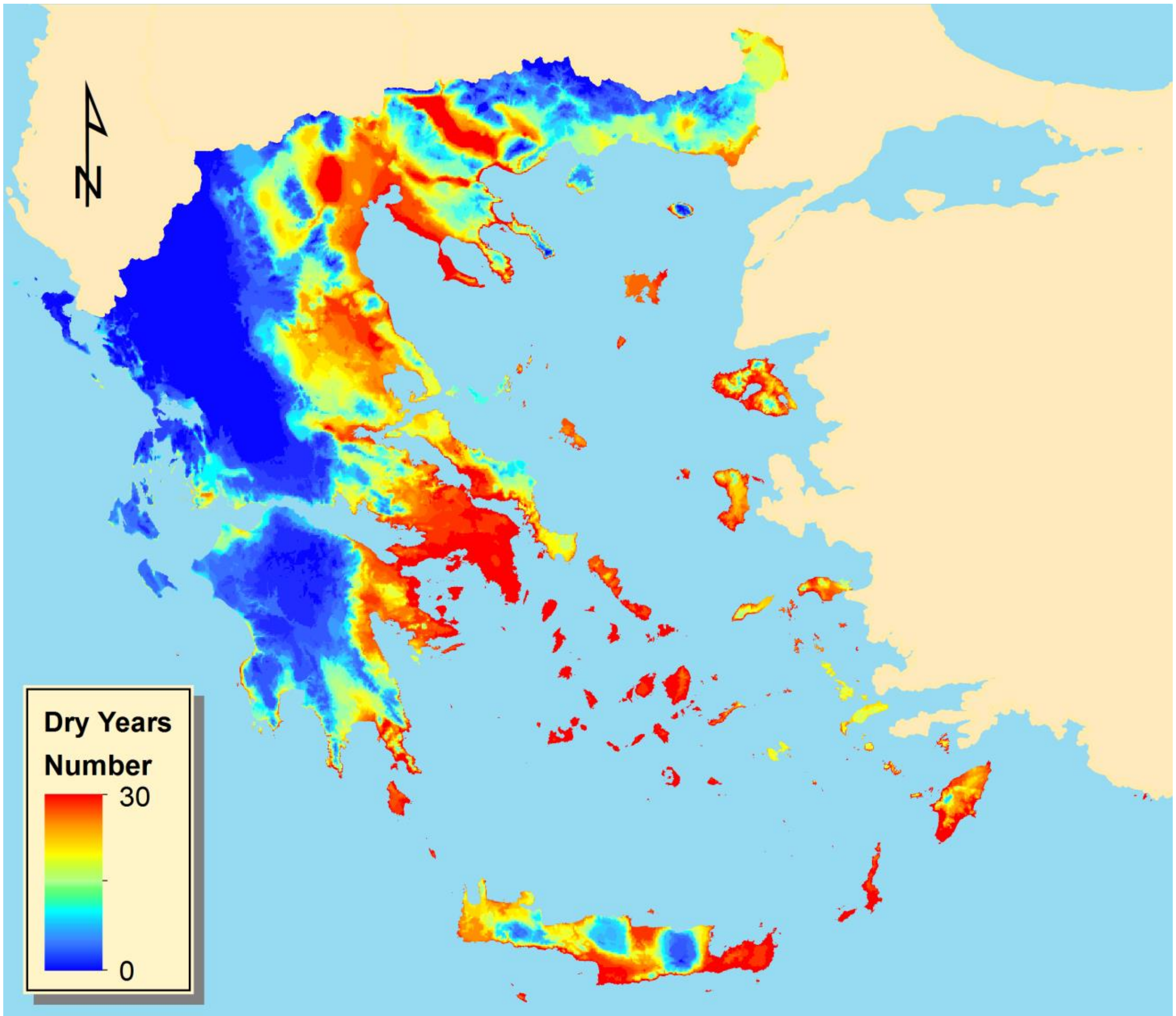

Figure 12. Number of years during which the dryness threshold is fulfilled.

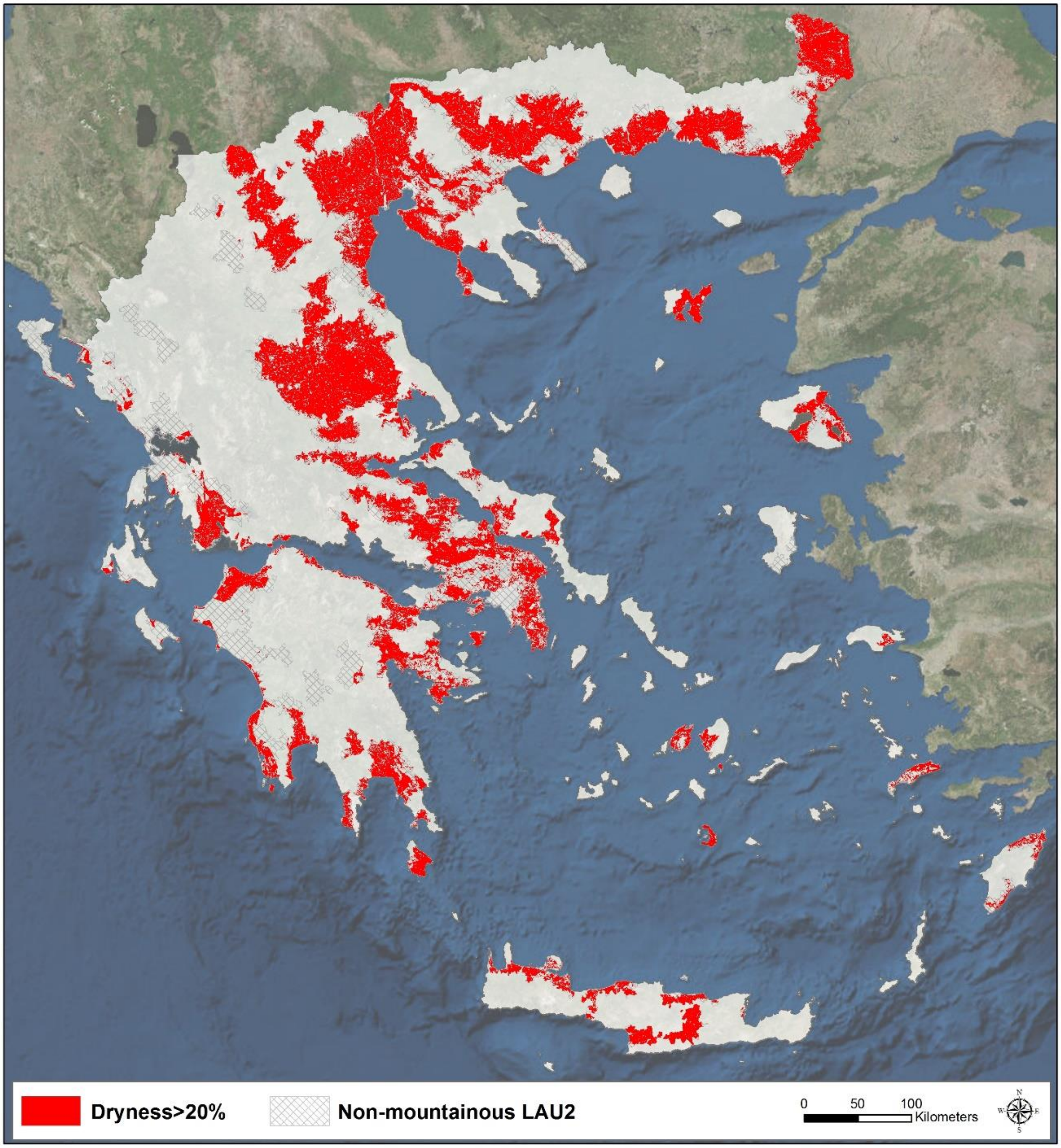

Figure 13. Areas subject to dryness.

Soil/Terrain data description and Criteria calculation

Criterion: Limited Soil Drainage

Definition

Poor drainage reduces the space available for the gaseous phase activities, in particular gaseous oxygen, in the rooting zone. It increases the incidence and severity of soil-borne pathogens and can make it impossible to till the soil. An additional major effect of water-saturated soil on agriculture is that it can make the land inaccessible.

Soil drainage provided by the Soil Map of Greece

Definition of drainage classes

Class A – Soils very well drained. They are characterized by the absence of iron and manganese mottles throughout the depth of the ground. The brownish colors prevail, the soil usually has a high hydraulic conductivity and the water is filtered into its deepest layers. The soil remains wet only during the wet period of the year (wet months).

Class B-Soils well drained. They are characterized by the presence of iron and manganese mottles or gray mottles at depths between 100 and 150 cm from the soil surface. The brown colors prevail throughout the depth of the ground. During the growing season, these soils are not sufficiently wet for a long period of time to adversely affect their growth.

Class C- Soils well drained. They are characterized by the presence of iron and manganese mottles or gray mottles at depths between 50 and 100 cm from the soil surface. On some soils of this class there may be mottles at a depth of less than 50 cm but less than 2%. The underground aquifer in the wet months rises and is likely to adversely affect perennial crops. These soils require drainage for sensitive crops.

Class D – Soils inadequately drained. They are characterized by the presence of iron and manganese mottles or some reduction sites at a depth of between 30 and 50 cm from the soil surface. The percentage of eruptions in this layer is less than 20%. These soils are characterized by high humidity for a long period of the year near the surface, with the result that crops are adversely affected in the spring. Multi-year crops require drainage.

Class E – Soils poorly drained. They are characterized by the presence of iron and manganese mottles at depths less than 30 cm from the soil surface while the presence of iron and manganese mottles or reducing sites includes 20-50% at depths between 30 and 50 cm from the soil surface. These soils have a high level of underground aquifers during the wet months of the year. In order to cultivate perennial plants or early spring crops, drainage is required.

Class F, G – Soils very poorly drained. Terrains with a permanent groundwater level at a depth usually greater than 75 cm from the soil surface. If the reduction conditions prevail more than 50% at a depth of 75-150 cm, the soil is characterized by F drainage. If reducing conditions are less than 75 cm deep, the soil is characterized by G drainage. If there is a seasonal variation in the aquifer, the drainage class may be characterized in combination with one of the aforementioned classes (eg E / F, E / G etc.). These soils are wet to the surface during the longest period of the year, so as to prevent the normal growth of most crops. Drainage is absolutely necessary.

Threshold

The thresholds identify land areas that are waterlogged for significant periods during the normal growing season and that thus affect normal farming operations, crop yields or livestock husbandry management.

Soil is said to have limited drainage if it is classified as being:

- wet within 80cm (from the surface) for over 6 months, or wet within 40cm for over 11 months; or
- poorly drained (soils are commonly wet for considerable periods - ground water table commonly within 40cm from the surface, or classified as very poorly drained (wet at shallow depths for long periods - ground water table is commonly within 15cm from the surface; or
- soil with *gleyic colour pattern* within 40cm from the surface;

Assessment

Soil drainage characteristics can often be inferred from their name in the soil type classification system. Moreover, certain soil properties are also directly related to poor drainage. These are the more common approaches for assessing excess soil moisture related to drainage. Soil morphology is commonly used to assess drainage status. Soils have observable morphological features which provide information on their general hydrodynamic behavior. However, the use of hydromorphic features can be misleading, as colour and mottling are not always indicative of the water status of the soil, and it is not always possible to establish clear quantitative limits (which are based on expert judgement, the influence of the local and meteorological conditions at the moment of observation, etc.).

Most map classification systems and soil maps include criteria related to water regimes such as average, maximum or minimum values for (i) depth to saturated layers, (ii) length of time of saturation and / or (iii) depth or occurrence of oxydo-reduction mottles.

For example, the World Reference Base for Soil Resources - WRB (FAO-IUSS-ISRIC, 2006) - defines soil properties that are directly related to poor drainage, namely *gleyic* and *stagnic* features. These features define soil reference groups, such as Gleysols and Stagnosols. Other reference groups which are associated with poor internal drainage are, for example, (i) Solonchaks in low-lying areas with a shallow saline water table, (ii) Solonetz soils in flat lands with impeded vertical and lateral drainage, and (iii) Histosols with a shallow water table. However, there is not always a direct relationship between a taxonomic class (e.g. Gleysols) and actual drainage conditions. The WRB therefore gives only a broad indication of the soil characteristics, and the soil units identified by reference groups for the limited drainage often need to be confirmed by soil profile measurement datasets (Erdogan and Toth, 2014).

In other soil databases, the annual average soil water regime is an estimate of the soil moisture conditions throughout the year. It is based on time series of matrix suction profiles, or groundwater table depths, or soil morphological attributes, or a combination of these characteristics. The annual soil water regime is expressed in terms of the duration of the state of soil wetness during the year. A soil is wet when it is saturated and has a matrix suction of less than 10 cm, or a matrix potential over -1 kPa. Time is counted in cumulative days and not as successive days of wet conditions. “Wet” means waterlogged.

Soil data and criteria mapping relationships

In order to create the criterion “Limited Soil Drainage” of Greece (Figure 14), the polygon vector file of the soil mapping units for the drainage was used and in particular the classes F and G that correspond to poorly drained and very poorly drained soils (which are the closest classes comparing to the threshold defined in the Guidelines) . Drainage classes F and G selected and intersected with UAA polygons of non-mountainous areas (LAU2 polygons). The above spatial analysis was developed using ESRI ArcGIS Desktop software v.10.4 and in particular Data Management and Analysis tools.

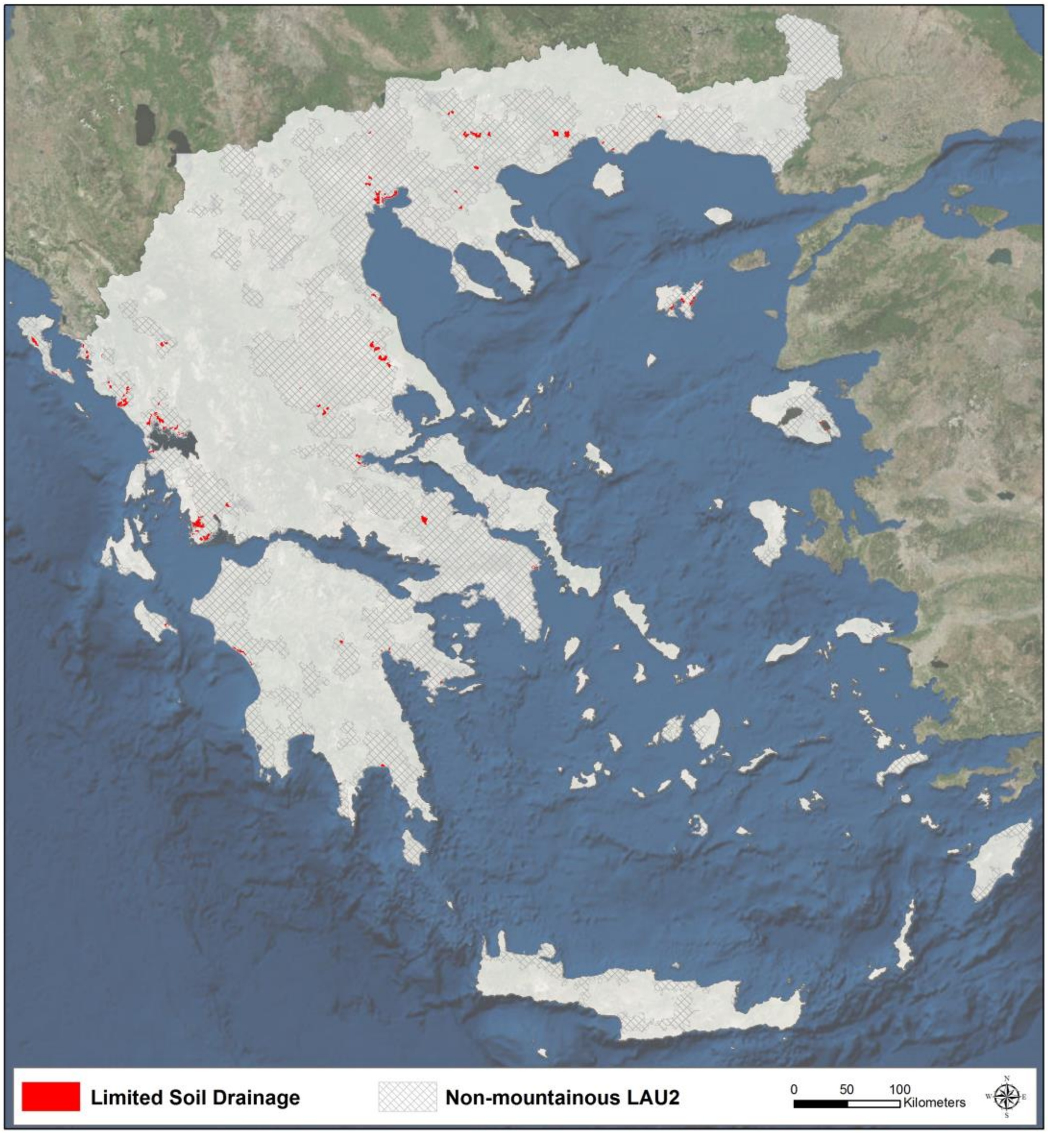

Figure 14. Criterion Limited Soil Drainage of Greece.

Criterion: Shallow Rooting Depth

Definition

Rooting depth is the maximum depth from the soil surface to where most of the plant roots can extend. It is defined as the effective soil depth above any barrier to root extension.

Soil depth provided by the Soil Map of Greece

Soil depth as it is presented in the Soil Map of Greece, is divided into 6 classes as follows:

Depth (cm)	0-15	15-30	30-60	60-100	100-150	>150
Cartographic symbol	1	2	3	4	5	6

Threshold

A soil is said to have limited physical rooting depth when the effective soil depth above any barrier to root extension is less than 30 cm.

Assessment

During routine field surveys, rooting depth is typically assessed using an auger. The observed depths are then interpolated with reference to the landscape structure to produce rooting depth estimates of land areas or mapped units.

If the soil classification system has classes with boundary values different from the 30cm threshold, then it may be necessary to perform a reclassification and applied a correction factor established with independent analytical dataset representative for the given area (soil profile data); similarly, as described earlier.

Soil data and criteria mapping relationships

Criterion of “Shallow Rooting Depth” was created by using the soil depth variable from the vector polygon file of the soil mapping units and in particular symbols 1 and 2 that correspond to soil depth 0-15 and 15-30 cm (Figure 15). Soil depth values 0-15 and 15-30cm were selected and intersected with UAA polygons of non- mountainous areas (LAU2 polygons). The above spatial analysis was developed using ESRI ArcGIS Desktop software v.10.4 and in particular Data Management and Analysis tools.

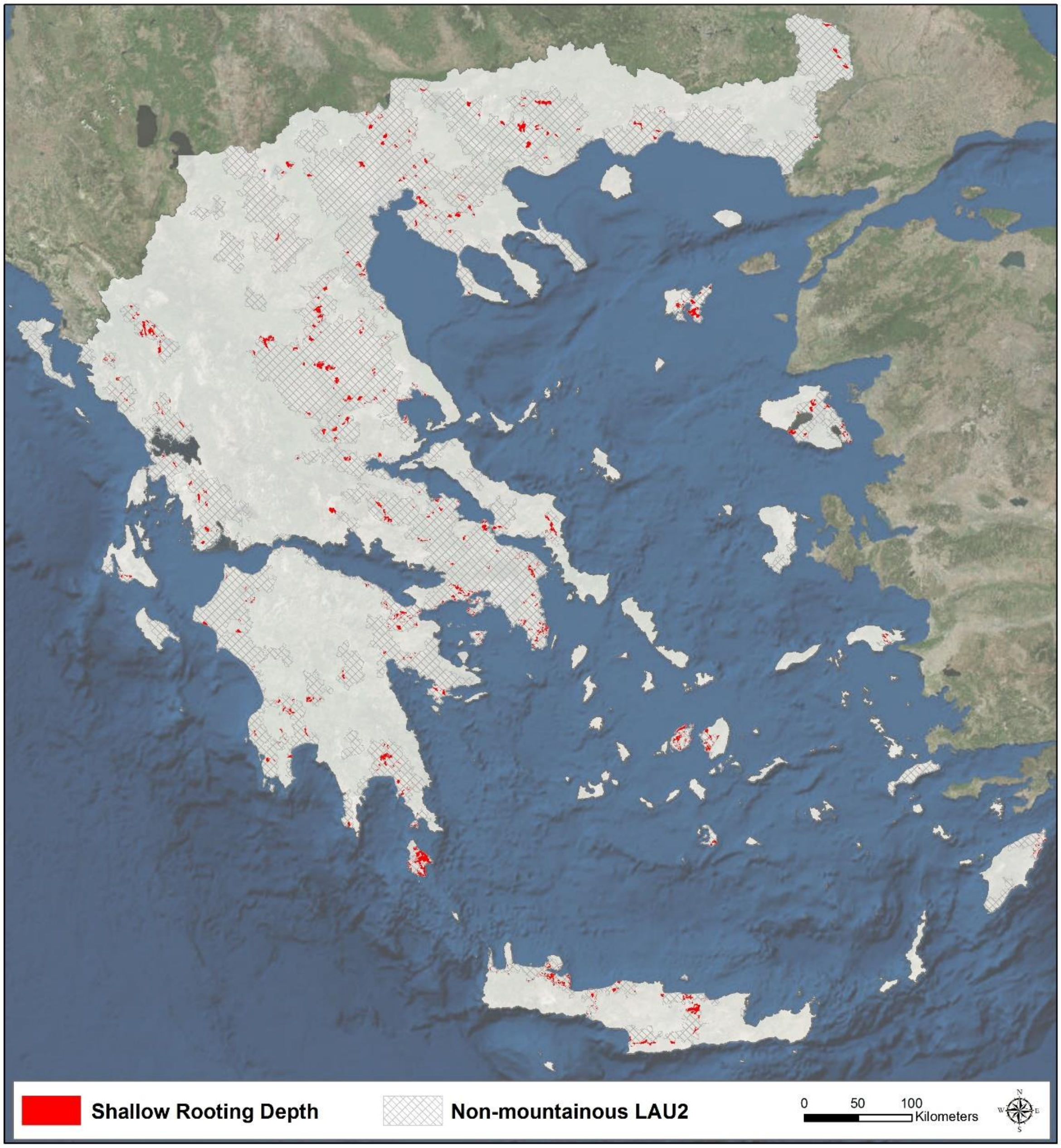

Figure 15. Criterion of Shallow Rooting Depth of Greece.

Poor Chemical Properties

Criterion: Soil Salinity

Definition

Salinity is the presence of soluble salt in the land surface, in soil or rocks, or dissolved in water. It can be a natural process that has been accelerated by human intervention that disturbs natural ecosystems. Soil salinity refers to the total amount of soluble salt in the soil.

Soil Salinity provided by the Soil Map of Greece

According to the soil map of Greece, soil electrical conductivity is divided in 4 classes, presented below:

E. Conductivity (ds/m)	0-4	4-8	8-15	>15
Cartographic Symbol	1	2	3	4

Threshold

Salinity tolerance is influenced by plant physiology, soil and environmental factors and their interactions. Although crop response to soil salinity is crop specific, levels above 4 dS/m in topsoil severely affect many plants.

Assessment

Soil salinity is determined by measuring the electrical conductivity of a solution extracted from a water-saturated soil paste. Soil names in the WRB that can be used for indicating severe salinity constraints of natural saline soils are Solonchaks and *salic* and *petrosalic* soils.

Soil data and criteria mapping relationships

Criterion of "Soil Salinity" was produced by using the respective values of the vector polygon file of the soil mapping units and particularly symbols 2, 3 and 4 that correspond to Electrical Conductivity values greater than 4 ds/m (Figure 16). The selected polygons with the desirable electrical conductivity values were intersected with UAA polygons of non- mountainous areas (LAU2 polygons). The above spatial analysis was developed using ESRI ArcGIS Desktop software v.10.4 and in particular Data Management and Analysis tools.

Figure 16. Criterion Soil Salinity of Greece.

Criterion: Soil Sodicity

Definition

Sodicity refers to the presence of a high proportion of adsorbed sodium in the clay fraction of soils. Sodic soils are normally characterised by a dense, strongly structured, clay illuviation horizon that has a high proportion of adsorbed sodium ions. In the context of areas with natural constraints for agriculture in Europe, soil sodicity is a characteristic of land for which the proportion of adsorbed sodium in the soil clay fraction is too high for plants to perform or survive.

Soil Sodicity provided by the Soil Map of Greece

Soil Sodicity values resulted from the Soil Map of Greece are presented in the following table:

ESP	<6	6.1-15	>15
Cartographic symbol	1	2	3

Threshold

The effect of Exchangeable Sodium Percentage (ESP) on the yield, chemical composition, protein and oil content and uptake of nutrients is severe when soil sodicity is at ESP ≥ 6 in the topsoil.

Assessment

Sodicity is determined by measuring the exchangeable sodium proportion of the cation exchange capacity, or by comparing the soluble Calcium and Magnesium in a soil solution (SAR – Sodium Adsorption Ratio).

According to the WRB classification, soils that have a high content of exchangeable Na are Solonetz, *natric* soils, or *sodic* soils, which can be used for indicating a severe sodicity constraint.

Soil data and criteria mapping relationships

In order to create the criterion "Soil sodicity" of Greece (Figure 17), the polygon vector file of the soil mapping units for the ESP values was used and particularly symbols 2 and 3. Symbols 2 and 3 correspond to ESP values above 6 in the topsoil. The selected polygons with desirable ESP values were intersected with UAA polygons of non-mountainous areas (LAU2 polygons). The above spatial analysis was developed using ESRI ArcGIS Desktop software v.10.4 and in particular Data Management and Analysis tools.

Figure 17. Criterion Soil Sodicity of Greece.

Criterion: Soil acidity

Definition

Soil acidity is indicated by soil pH and is measured in pH units. The soil pH is defined as the negative decimal logarithmic value of the hydrogen ion activity (expressed in mol dm-3) in aqueous solutions. As the amount of hydrogen ions in the soil increases the soil pH decreases thus becoming more acidic. A neutral condition corresponds to pH = 7, above this value soils are considered to be alkaline.

Soil acidity provided by the Soil Map of Greece

Soil acidity is divided into 6 categories as described in the following table:

pH	<4.5	4.5-5.5	5.6-6.9	7.0-7.9	8.0-8.5	>8.5
Cartographic symbol	1	2	3	4	5	6

Threshold

Severely acidic conditions occur when pH values are less than or equal to 5.0, impeding normal crop growth.

Assessment

Although the international standard (ISO 10390) permits the use of either water, or 0.01 mol dm-3 $CaCl_2$ or 1 mol dm-3 KCl solutions for the measurement of pH. The computation of the pH criterion shall be made on pH values measured in 1:5 soil: water suspension (referred to as pH 1:5 H_2O). The harmonization of the measurement method is important because there can be a difference of 1 or more pH units between measurements made using water or $CaCl_2$ solutions.

Soil data and criteria mapping relationships

“Soil acidity” criterion was produced by using pH values, derived from the vector point file (with a point density every 1000 meters) of soil profile analytic data (Figure 18). pH values (measured in 1:5 soil: water) from topsoil profile points were selected and interpolated using Inverse Distance Weighting (IDW) method. Cross Validation (using jackknife method –leave-one-out approach) was performed and Root Mean Square value equals to 0,588. IDW surface was then converted to raster and reclassified. pH values less than or equal to 5.0 were selected and intersected with UAA polygons of non- mountainous areas (LAU2 polygons). The above spatial analysis was developed using ESRI ArcGIS Desktop software v.10.4 and in particular use of Geostatistical Analyst, 3D Analyst and Analysis tools.

Figure 18. Criterion Soil Acidity of Greece.

Criterion: Unfavourable Soil Texture and Stoniness

Definition

The texture of a soil refers to the relative proportions of different-sized soil particles in the bulk soil. It is more correctly called particle-size distribution. Conventionally, it is divided into two parts: coarse fragments, which are larger than 2 mm in diameter, and fine soil, which is smaller than 2 mm in diameter.

Unfavourable Soil Texture and Stoniness provided by the Soil Map of Greece

Soil texture provided from the Soil Map of Greece is described as follows:

	Very coarse	Coarse	Medium coarse	Medium fine	fine
0-25 cm	1	2	3	4	5

Relation of constituents of fine earth by size, defining textural classes

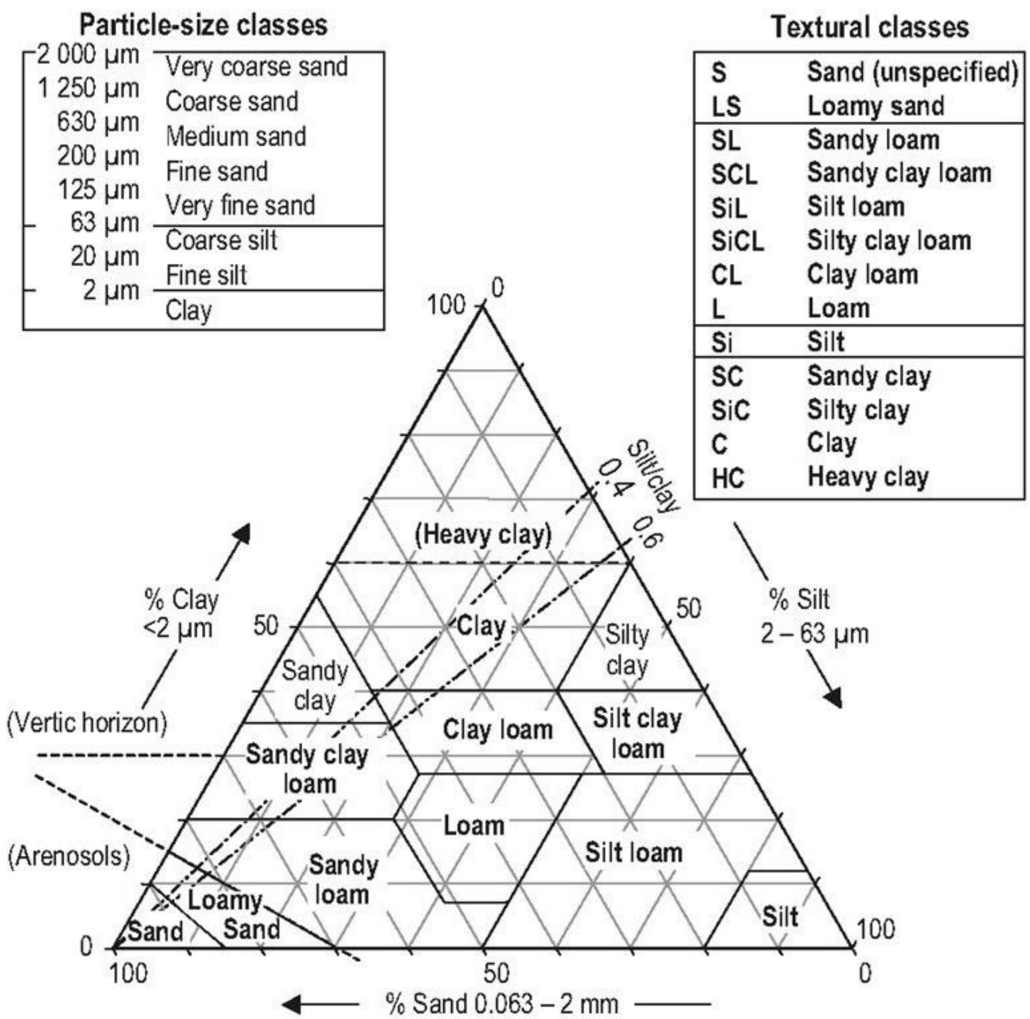

Figure 19. Texture classes defined according to the FAO texture triangle (FAO, 2006)

Soil stoniness is divided into four classes according to the percentage of the composition as follows:

Stoniness (%)	0	<20	20-60	>60
Cartographic Symbol	0	1	2	3

Threshold

Soil texture or stoniness is said to be a limiting constraint if any of the following conditions are met:

- coarse fragments (> 2 mm) of any kind make up more than 15% volume in the topsoil, including any proportion of rock outcrops, boulders, or
- texture class in half or more (cumulatively) of the soil within 100 cm of the surface is sand or loamy sand [defined as silt% + (2x clay%) <=30%];
- the topsoil texture class is heavy clay (60% clay); or
- the topsoil contains 30% or more clay and there is a soil layer with *vertic* properties within 100 cm of the soil surface.

Assessment

Coarse fragments (> 2 mm) are described by their abundance (volume %), size, shape, state of weathering, and nature.

Fine earth (< 2 mm) is defined by the relative proportion (by weight) of sand, silt and clay as determined in the laboratory; the upper limits used here correspond to the FAO norms (FAO, 2006) and are 2 000, 63 and 2 micrometres, respectively. National systems may use different limits, but it is necessary to harmonise data using either transfer functions or soil profile datasets with measurements of particle size.

Vertic properties, as defined by the WRB (FAO-IUSS-ISRIC, 2006), have either:

- More than 30% clay throughout a thickness of at least 15 cm, and one or both of the following characteristics:
  - slickensides or wedge-shaped aggregates;

- cracks ≥ 1-cm wide that open and close periodically;

or

- a coefficient of linear expansion (COLE) of 0.06 or more, averaged over a depth of 100 cm from the soil surface.

Not all soil classification are using the same textural class system and therefore it is proposed to use the most appropriate class, taking care not to pass the threshold indicated in the regulation (conservative approach) or to perform a reclassification, if possible.

If this is applied, it is recommended to verify the accuracy of the reclassification by cross-analyzing the derived information with an independent analytical dataset representative for the given area (soil profile data, laboratory measurements) containing the parameter to be mapped. Possibly, this should be done using quantitative statistical analysis; this quantitative analysis can then be the basis to establish a correction factor for the calculation of the share of the SMU fulfilling the threshold.

Soil data and criteria mapping relationships

In order to create “Unfavourable Soil Texture” criterion the polygon vector file of the soil mapping units for topsoil texture was used and in particular the symbol 5 that correspond to sandy clay (SC), silty clay (SiC) and clay (C) soils (Figure 20). In order to exclude the undesirable categories, SiC and SC, the final selection was based on the simultaneously existence SMUs with value 5 and analytical soil profile data (point shapefile) with clay% values greater than 60 %.

The above spatial analysis was developed using ESRI ArcGIS Desktop software v.10.4 and in particular Data Management and Analysis tools.

Criterion of “Stoniness” was produced by using the respective values of gravel (%) of vector polygon file of the soil mapping units and particularly symbols 2 and 3 that correspond to gravel values more than 15% (Figure 21).

The above spatial analysis was developed using ESRI ArcGIS Desktop software v.10.4 and in particular Data Management and Analysis tools.

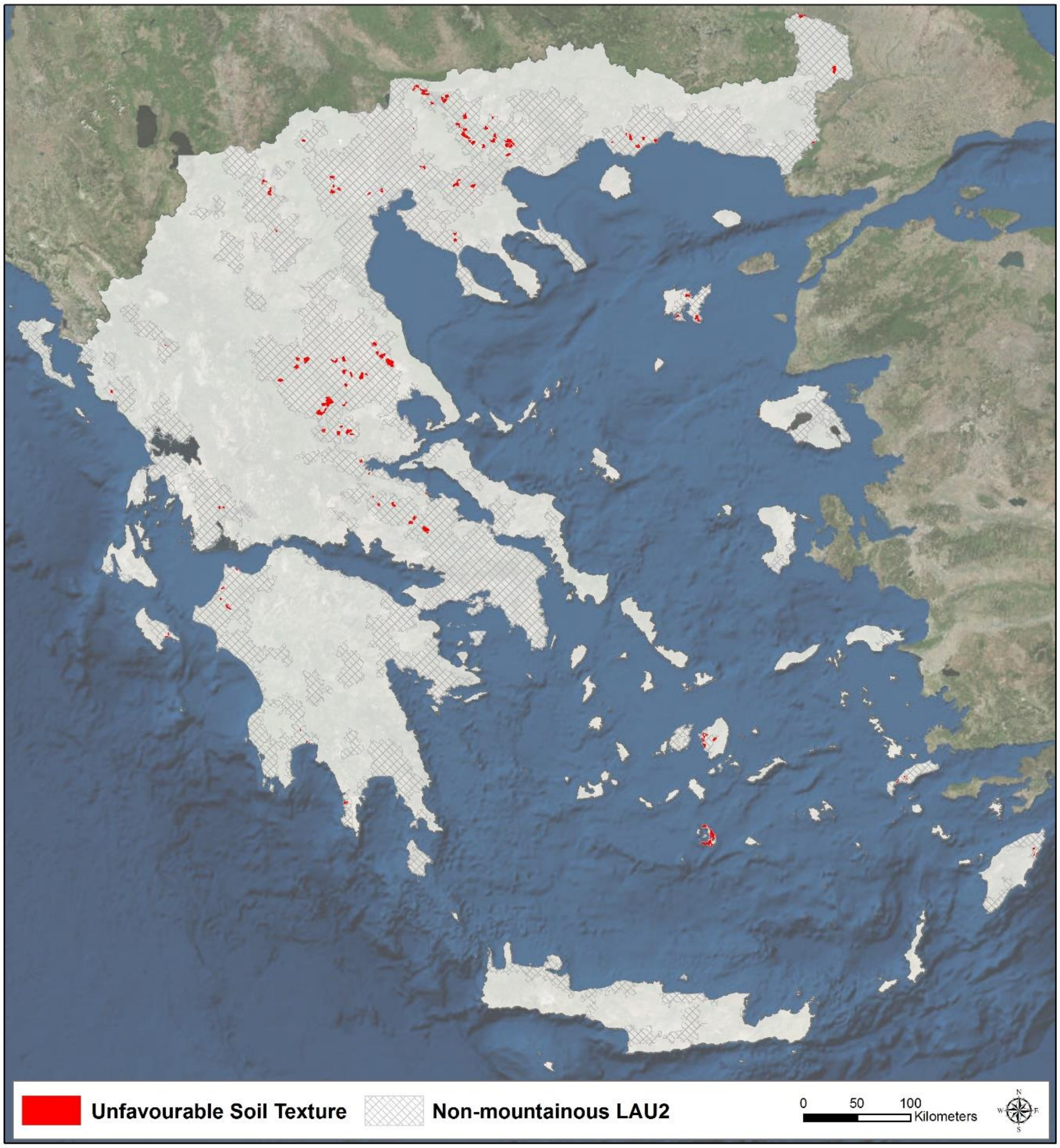

Figure 20. Unfavourable Soil Texture of Greece.

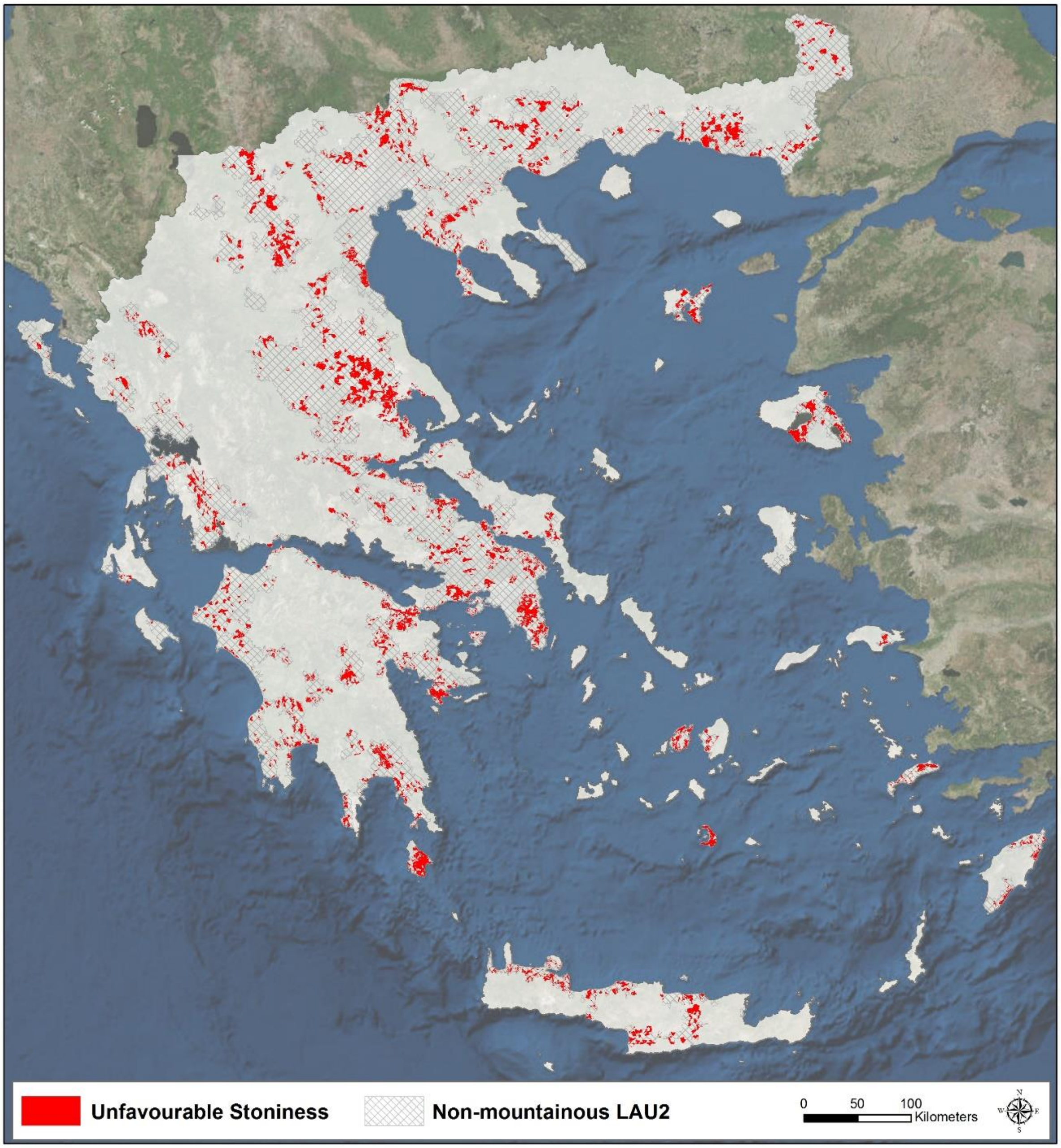

Figure 21. Unfavourable Stoniness of Greece.

Criterion: Slope

Definition

The slope is the angle between the soil surface and the horizontal. It can be expressed in degrees or as a percentage (45 degrees = 100%). Steep-slope farming requires specific / adapted equipment.

Threshold

Slopes greater than 15% pose severe problems for mechanised cultivation.

Assessment

The slope can be calculated from the DEM.

Soil data and criteria mapping relationships

Criterion of “Slope” was produced by using digital elevation model (DEM) with a spatial resolution of 30 m. Slope percent values were calculated using 3D Analyst extension. Slope from the elevation model, making raster data with slope values (Figure 22). Reclassify procedure was applying and slope values greater than 15% were selected. Selected slope value cells converted to feature class and then intersected with UAA polygons of non- mountainous areas (LAU2 polygons). The above spatial analysis was developed using ESRI ArcGIS Desktop software v.10.4 and in particular 3D Analyst, Conversion, Data Management and Analysis tools.

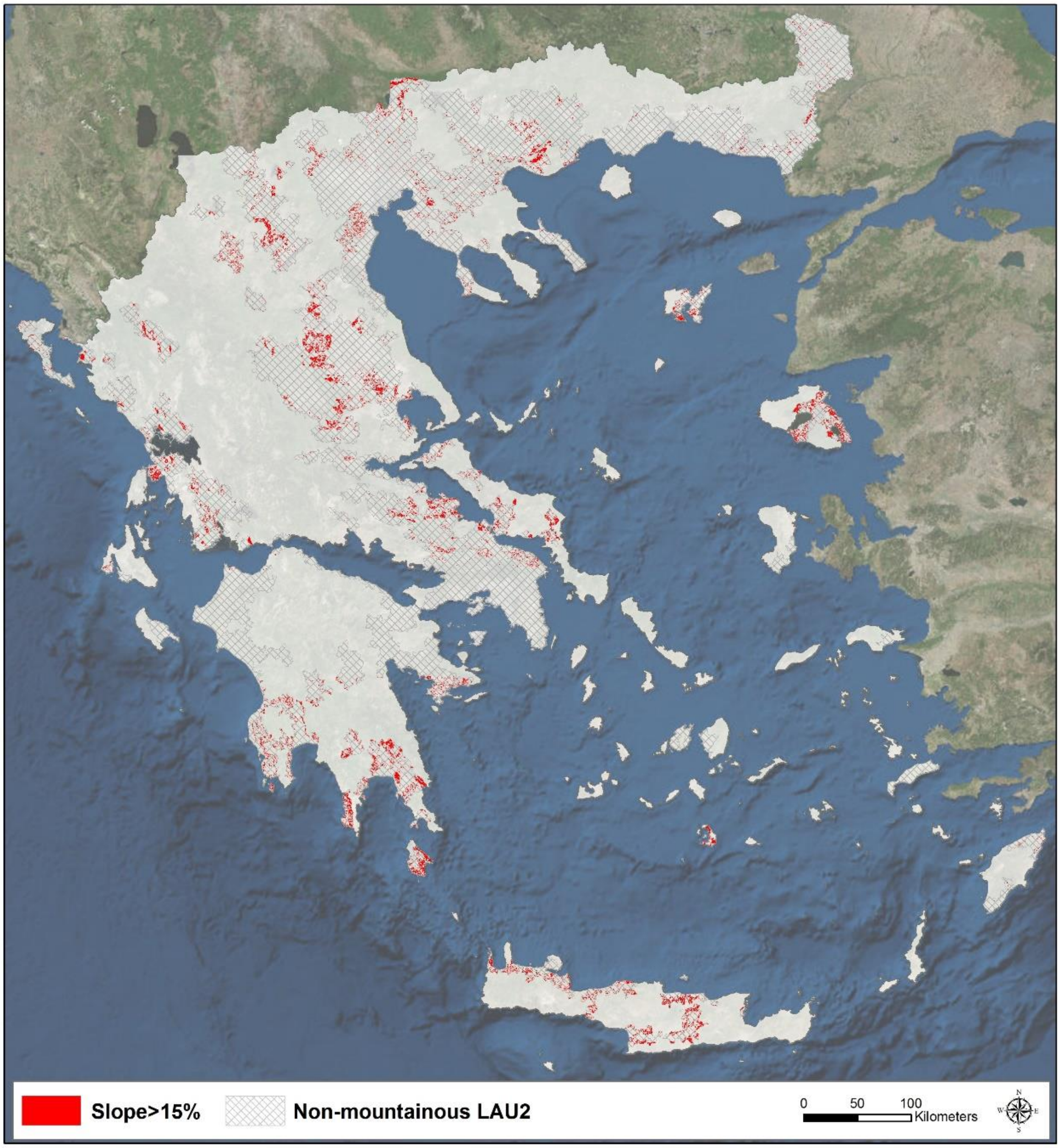

Figure 22. Criterion of Slope (Greece).

Spatial Impact Assessment of Biophysical Criteria

The table 2 below illustrates the spatial impacts of applying each criterion as well as all the criteria as a whole. The analysis shows that the main limiting factors are Dryness, Unfavourable Texture and Stoniness.

Table 2. Spatial impact assessment

Criterion	UAA Constrained (ha)	% of total UAA area (UAA of non-mountainous LAU2)	Intersected No of non-mountainous LAU2
Limited Soil Drainage	6,749.08	0.19	246
Unfavourable Soil Texture	63,417.54	1.8	264
Stoniness	705,183.46	20.01	1691
Shallow Rooting Depth	150,592.41	4.27	715
Soil Salinity	113,089.51	3.21	419
Soil Sodicity	12,478.66	0.35	77
Soil Acidity	379.80	0.01	73
Dryness	3,037,793.84	86.20	2301
Slope	285,129.19	8.09	1740
All criteria without the application of the 60% limit	2,620,946.2	95.2	2680
	UAA Constrained (ha)	**% of total UAA area (UAA of non-mountainous LAU2)**	**No of non-mountainous LAU2**
All criteria after the application of the 60% limit	2,299,494.96	83.6	2308

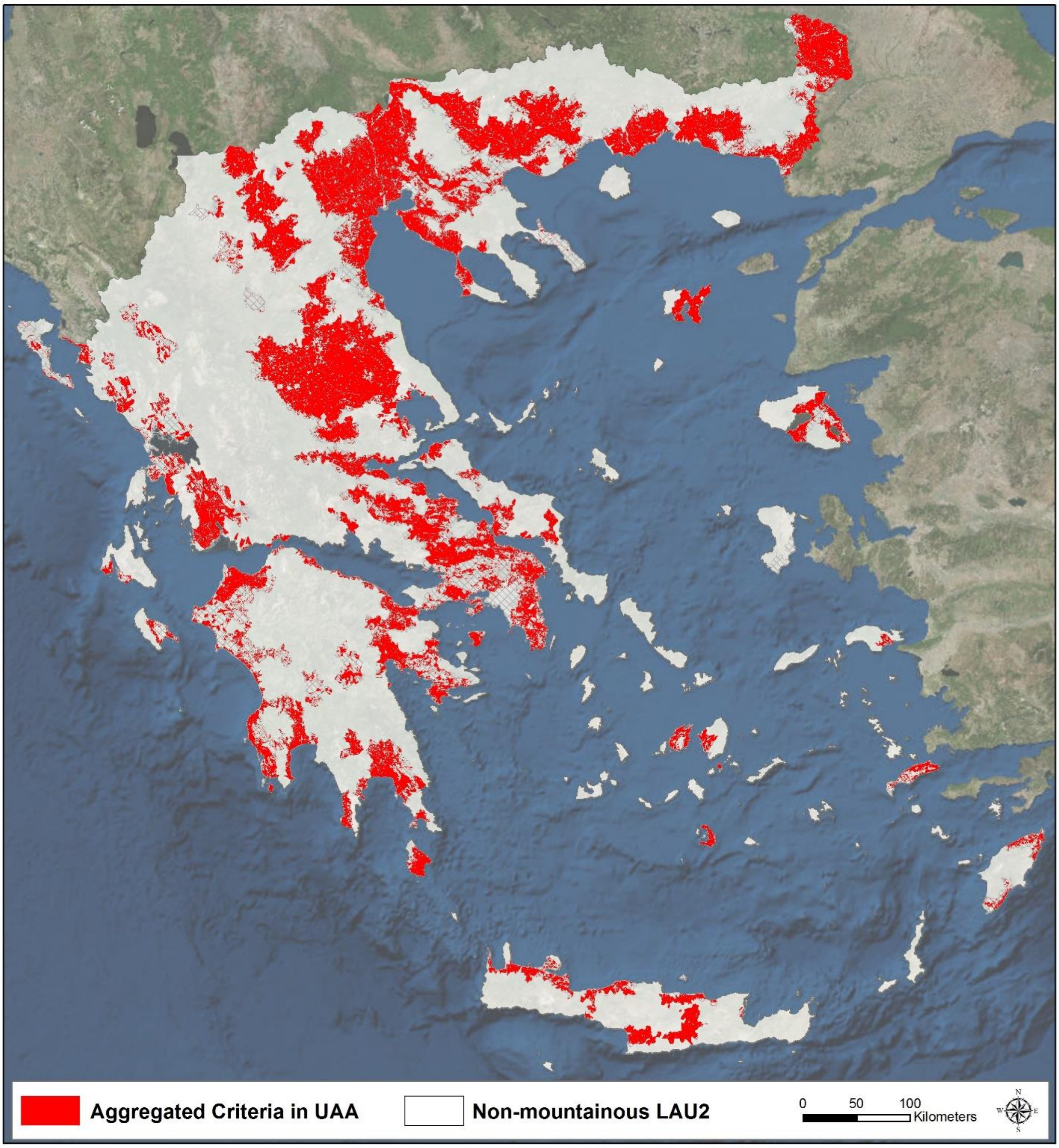

Figure 23. Aggregated criteria in UAA.

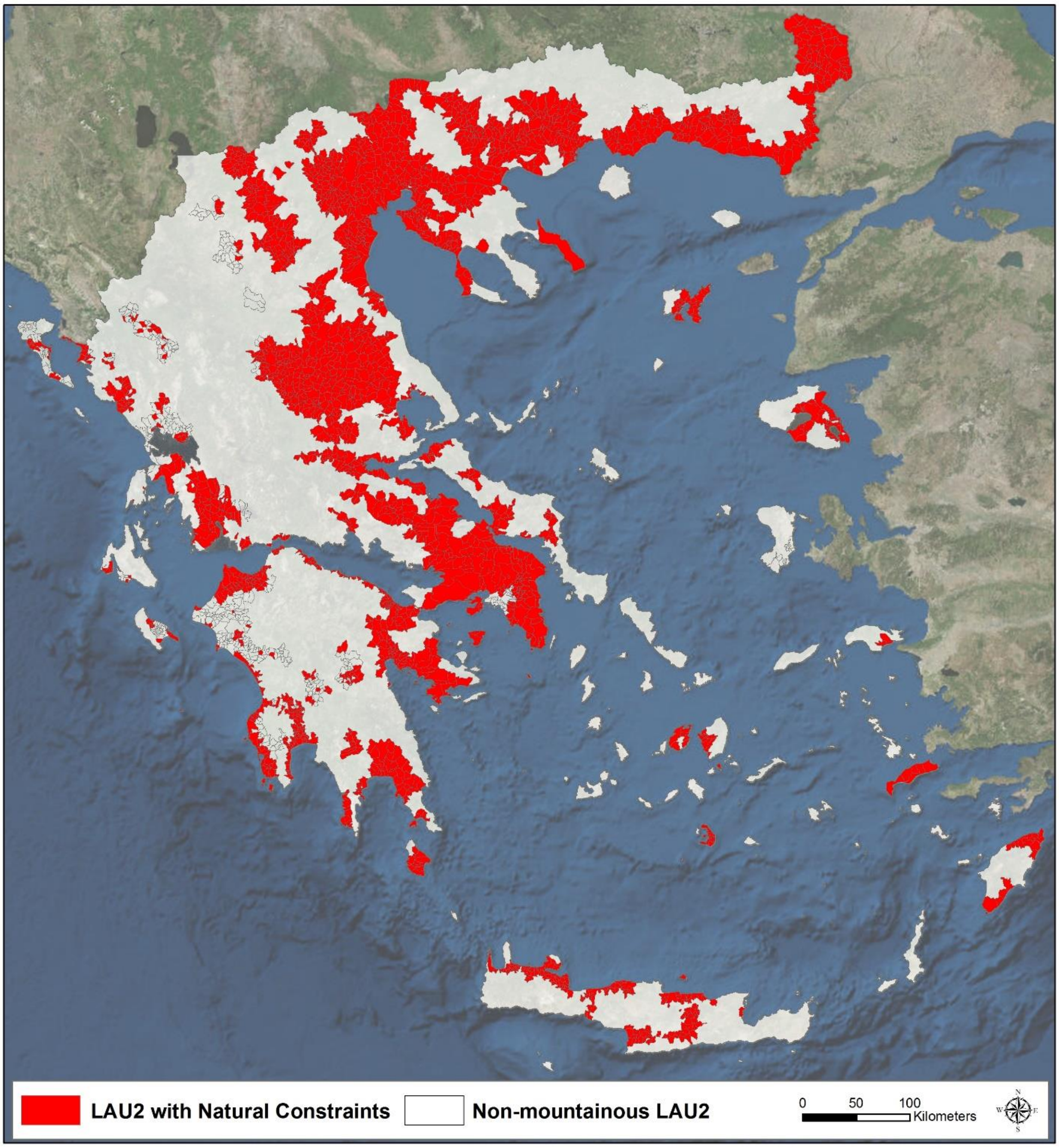

Figure 24. Non mountainous LAU2 for which constrained UAA ≥ 60% of total UAA.

Spatial impact in relation to the current delimitation is summarized in the following tables

Table 1. Previous (LFA) delimitation [EC 1698(2005)]

	Art. 50 (2) Mountain	Art. 50(3)a Significant natural handicap	Art. 50(3)b Specific handicap	No Natural Handicap
Agricultural area (ha)	2,177,222.99	1,269,341.37	248,815.88	1,231,430.47

Table 2. Calculated delimitation with bio-physical criteria (Areas with Natural Constraints) before Fine-tuning

EC 1698(2005) EU 1305(2013)	Art. 50(3)a Significant natural handicap Agricultural area (ha)	No handicap Agricultural area (ha)	Total Agricultural area (ha)
Art 32.1(b) Areas facing significant natural constraints	1,170,177.64	1,129,317.32	2,299,494.96
No constraints	99,163.72	102,113.15	201,276.88
Total	1,269,341.37	1,231,430.47	2,500,771.84

Finetuning and Specific Constraints

INTRODUCTION

Article 32(3) of the Rural Development Regulation for the period 2014-2020 stipulates the following: *When delimiting the areas concerned by this paragraph, Member States shall carry out a fine-tuning exercise, based on objective criteria, with the purpose of excluding areas in which significant natural constraints, referred to in the first subparagraph have been documented but have been overcome by investments or by, economic activity, or by evidence of normal land productivity, or in which production methods or farming systems have offset the income loss or added costs referred to in Article 31(1)*

This report presents the results of the “fine tuning” procedure followed to identify and exclude areas with significant natural and specific constraints (ANC) based on Article 32 of Reg. (EU) 1305/2013, that have been overcome by investments, or by economic activity, or by evidence of normal land productivity, or in which production methods or farming systems have offset the income loss or added costs referred to in Article 31(1)

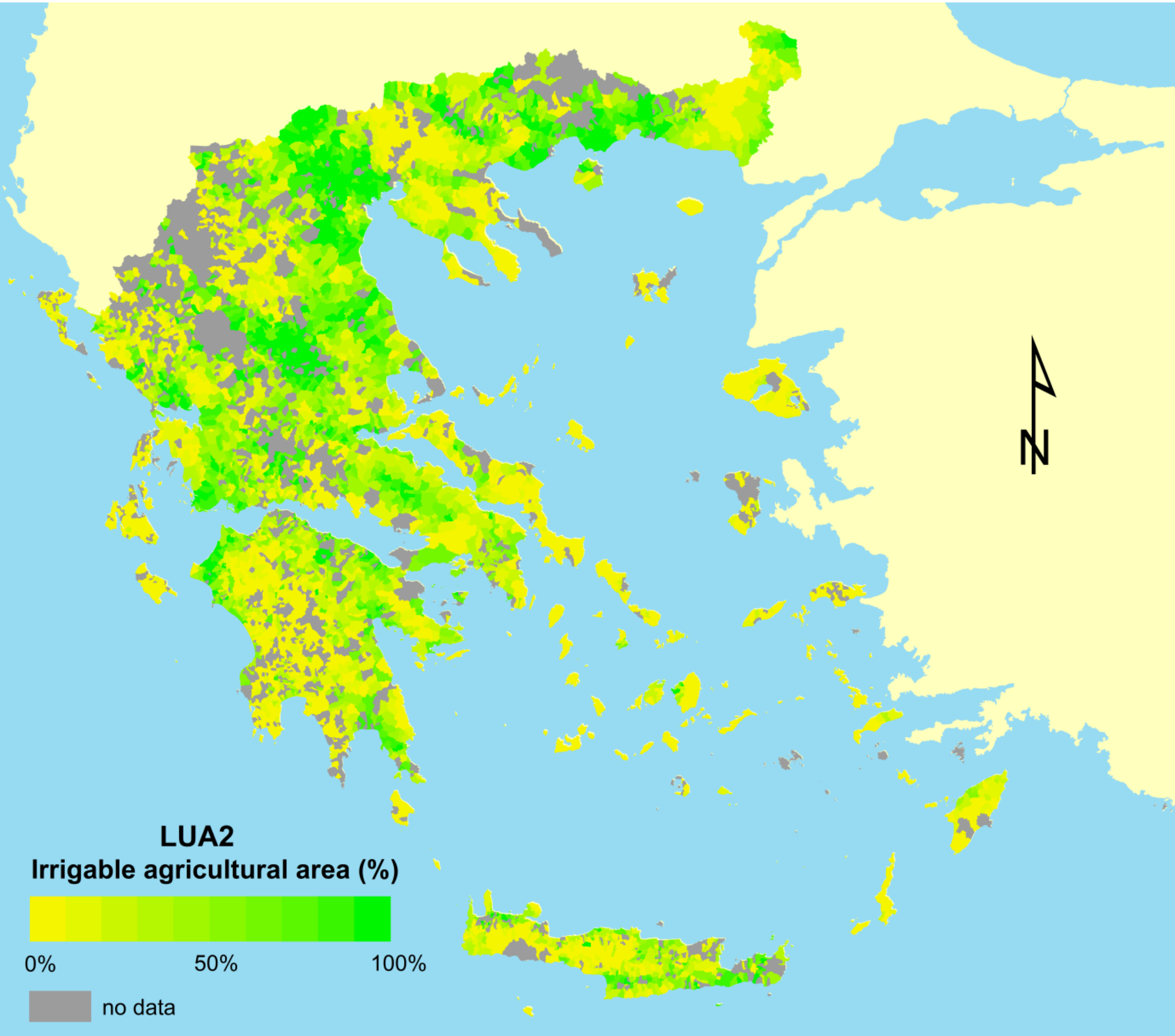

Figure 1. Percentage of irrigable agricultural area for all LUA2 according to ELSTAT Census of Agricultural and Livestock Holdings (2009).

The mountainous and "disadvantaged" areas were first established for Greece by Directive 81/645 / EEC. Mountain areas are defined as 3,399 Local administrative Units - LAU (LAU2, formerly NUTS level 5). At a second stage, soil and climatic data, as well as agriculture land data, were used to identify areas subject to physical constraints by applying the relevant instructions issued by the European Union (Kalivas et al., 2017). At this stage, irrigated areas data and economic data provided by the Hellenic Statistical Authority (ELSTAT, 2009) and by Payment and Control Agency for Guidance and Guarantee Community Aid, Ministry of Agricultural Development and Food (OPEKEPE, 2016) were used to identify and exclude areas with significant natural and specific constraints (ANC) that have been overcome.

Figure 2. Irrigated and non-irrigated parcels for the year 2016 according to OPEKEPE data.

DATA

Overcoming Natural Constraints - Dryness

According to the results of the delimitation of areas with natural constraints (ANC) based on Article 32 of Reg. (EU) 1305/2013 (Kalivas et al., 2017), the major constrain for the case of Greece is

“Dryness”, affecting 86.2% of total utilized agricultural area (UAA) of non-mountainous local administrative units (LAU2), followed by “Unfavorable Soil Texture” (20.09%), Stoniness (20.01%), and “Slope” (8.09%). Accordingly, the major investments made over the years to overcome natural constraints concern to Irrigation.

Reliable data on irrigable areas and irrigated areas were available at LAU2 level. The main data source was the data provided by the Hellenic Statistical Authority (ELSTAT, 2009) on the number of farms and the total area that is irrigable and that is irrigated for different crops for each LAU2 according to the latest (2009) Census of Agricultural and Livestock Holdings (Figure 1). Supplementary spatial data representing the parcels with irrigation information for the year 2016 (Figure 2) were provided by the Payment and Control Agency for Guidance and Guarantee Community Aid, Ministry of Agricultural Development and Food (OPEKEPE, 2016), while maps illustrating the major collective irrigation networks were obtained by the Master Plans on Water Resource Management for the 14 water districts of Greece (Ministry of Environment and Energy, 2015). Finally, additional information on the surface drainage networks constructed in parallel with the major collective irrigation networks were obtained by the National Data Bank of Hydrological & Meteorological Information (NDBHMI, 2017).

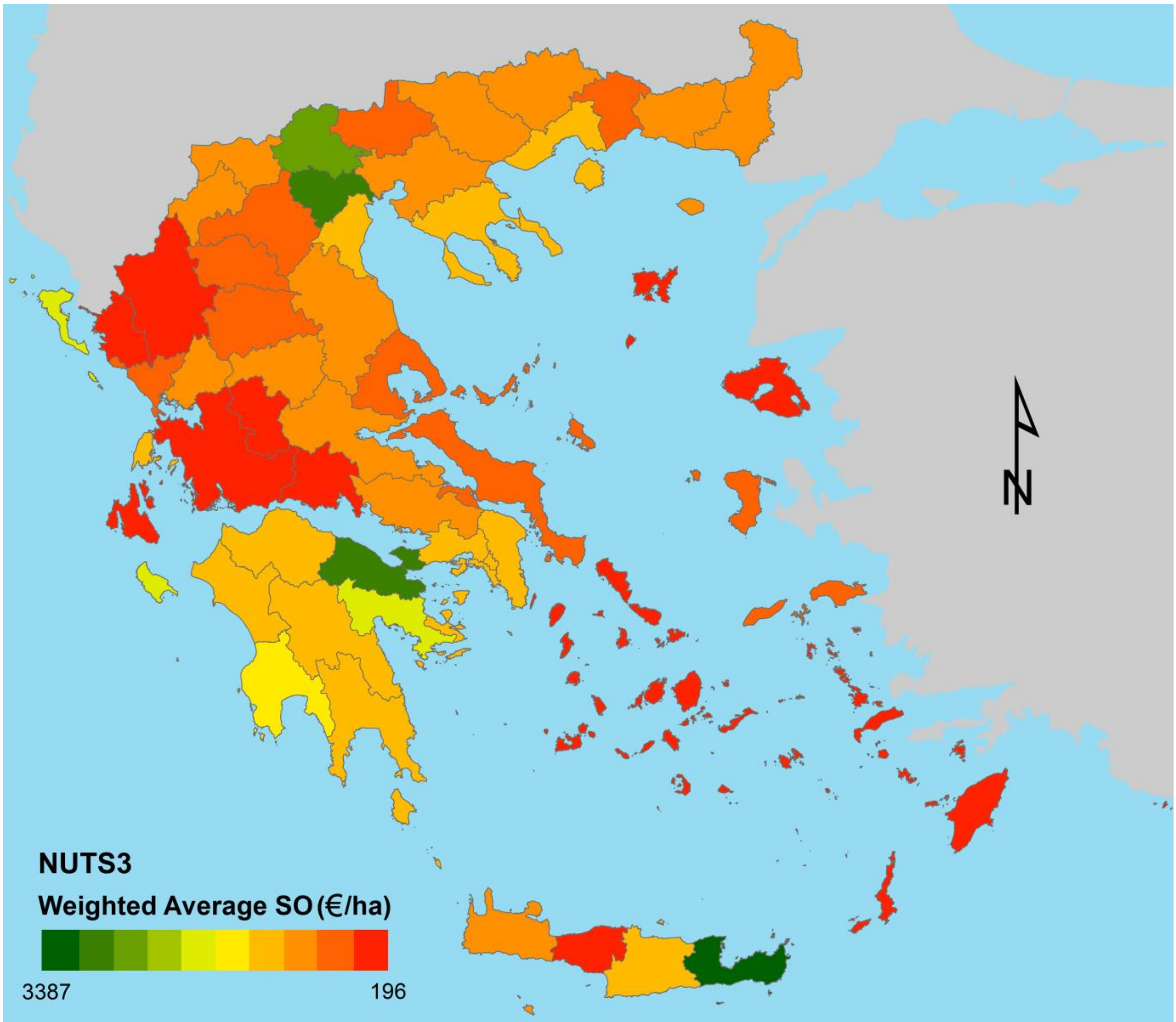

Figure 3. Spatially weighted average Standard Output for crop production at NUTS3 level.

Economic Fine-Tuning

The exclusion of areas which have overcome natural constraints by economic activity was based on Standard Outputs (SO) data at a prefecture (NUTS 3) level (FADN, 2010), which is the most disaggregated level available for standard output reports (Figures 3 and 4).

The Standard Output (SO) of an agricultural product (crop or livestock), is the average monetary value of the agricultural output at farm-gate price, in euro per hectare or per head of livestock. There is a regional SO coefficient for each product, as an average value over a reference period (5 years). The sum of all SO per hectare of crop and per head of livestock in a farm is a measure of its overall economic size, expressed in euro.

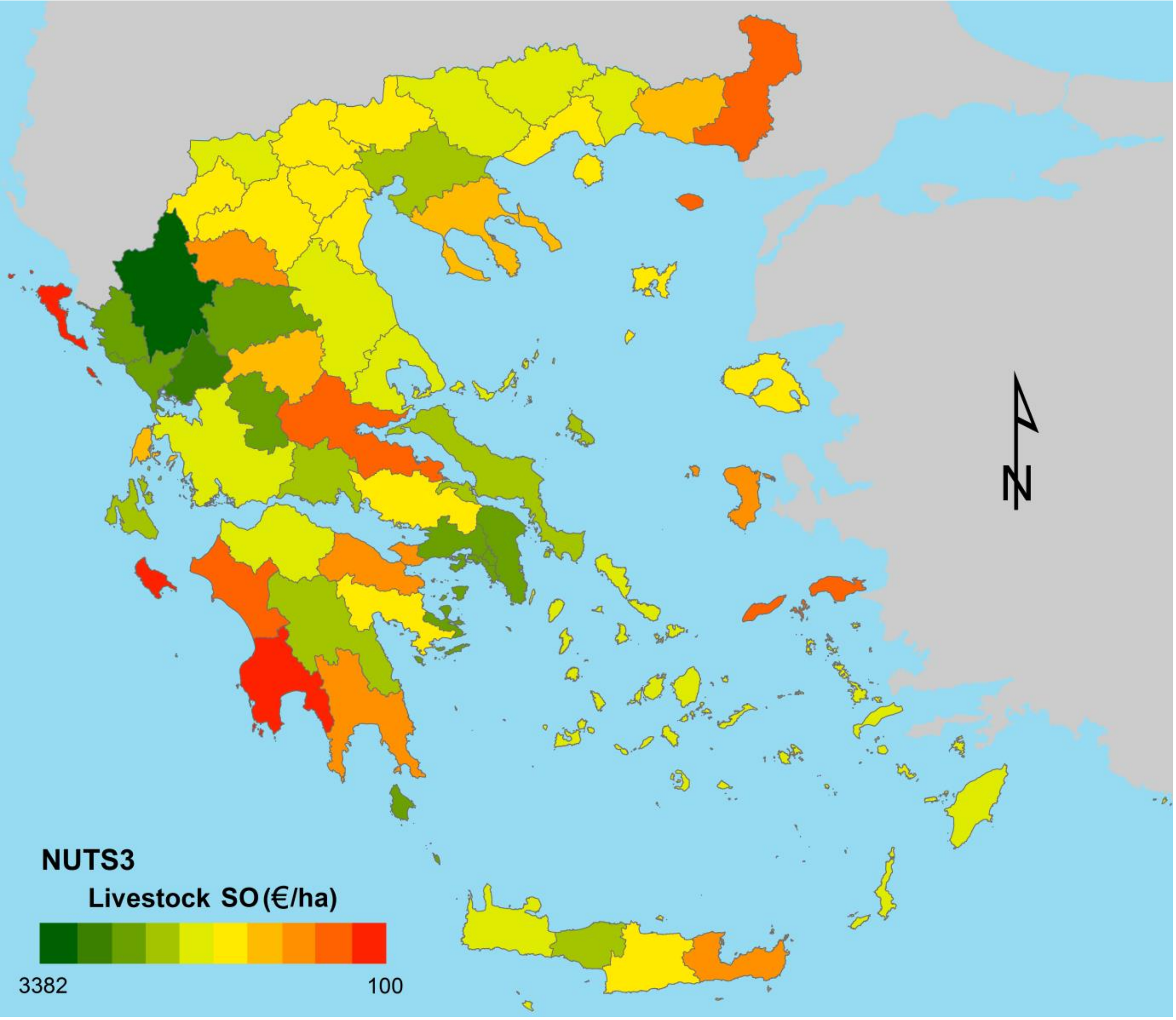

Figure 4. Standard Output for livestock production referred to the UAA at NUTS3 level.

FINE TUNING METHODS AND RESULTS

Overcoming Natural Constraints - Dryness

The primary reliable data on irrigable areas were available at LAU2 level. Accordingly, fine-tuning was done on the administrative map resulted by the delimitation of the areas subject to physical constraints (Figure 5) described in the first report (Kalivas et al., 2017).

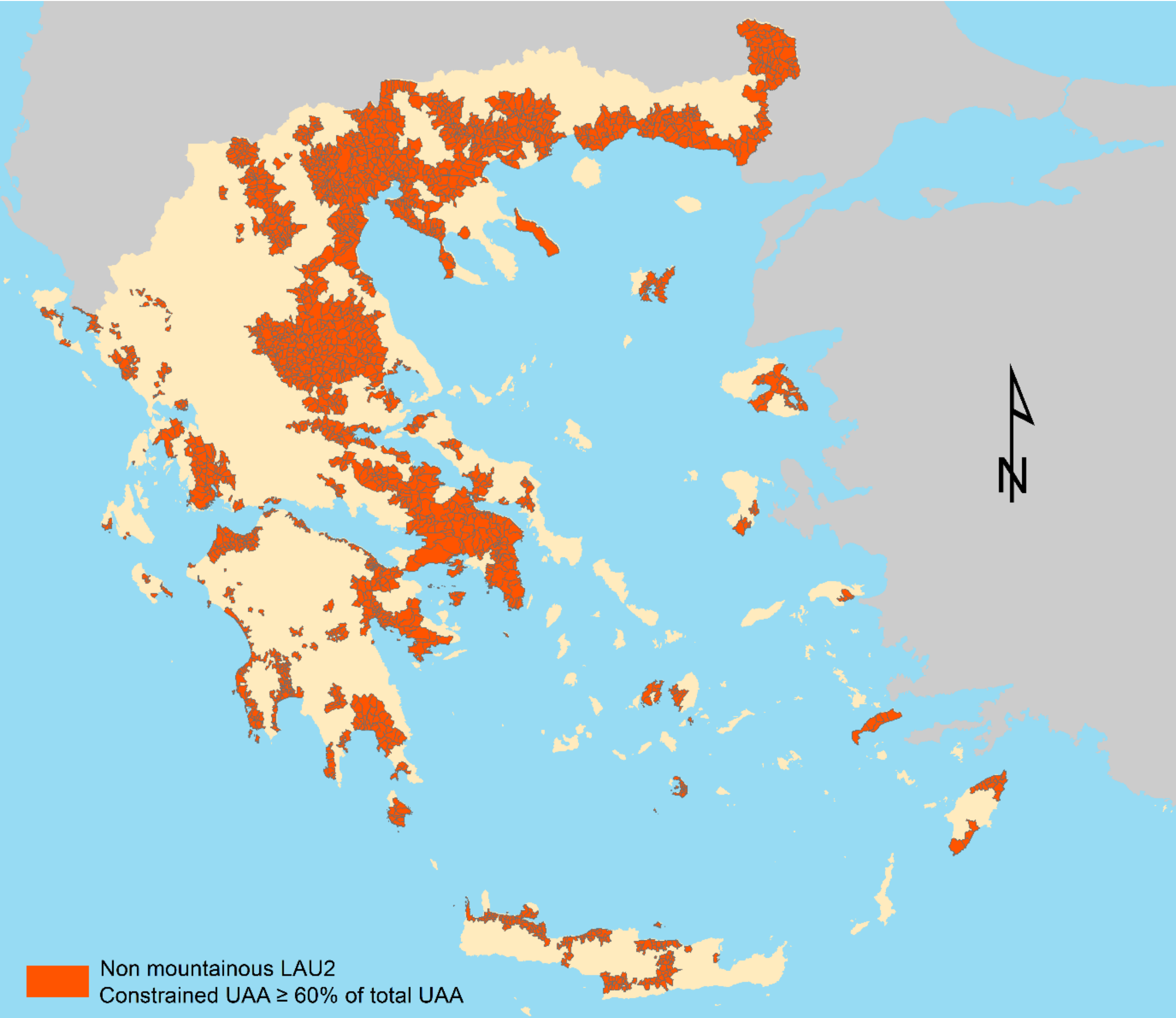

Figure 5. Non mountainous LAU2 for which constrained UAA ≥ 60% of total UAA.

For each LAU2 the percentage of irrigable utilized agricultural area was calculated using both the data provided by the Hellenic Statistical Authority (ELSTAT, 2009) and those provided by the Paying Agency (OPEKEPE, 2016). Only those LAU2 where calculated percentage from both sources was at least 50% were identified as irrigable (Figure 6).

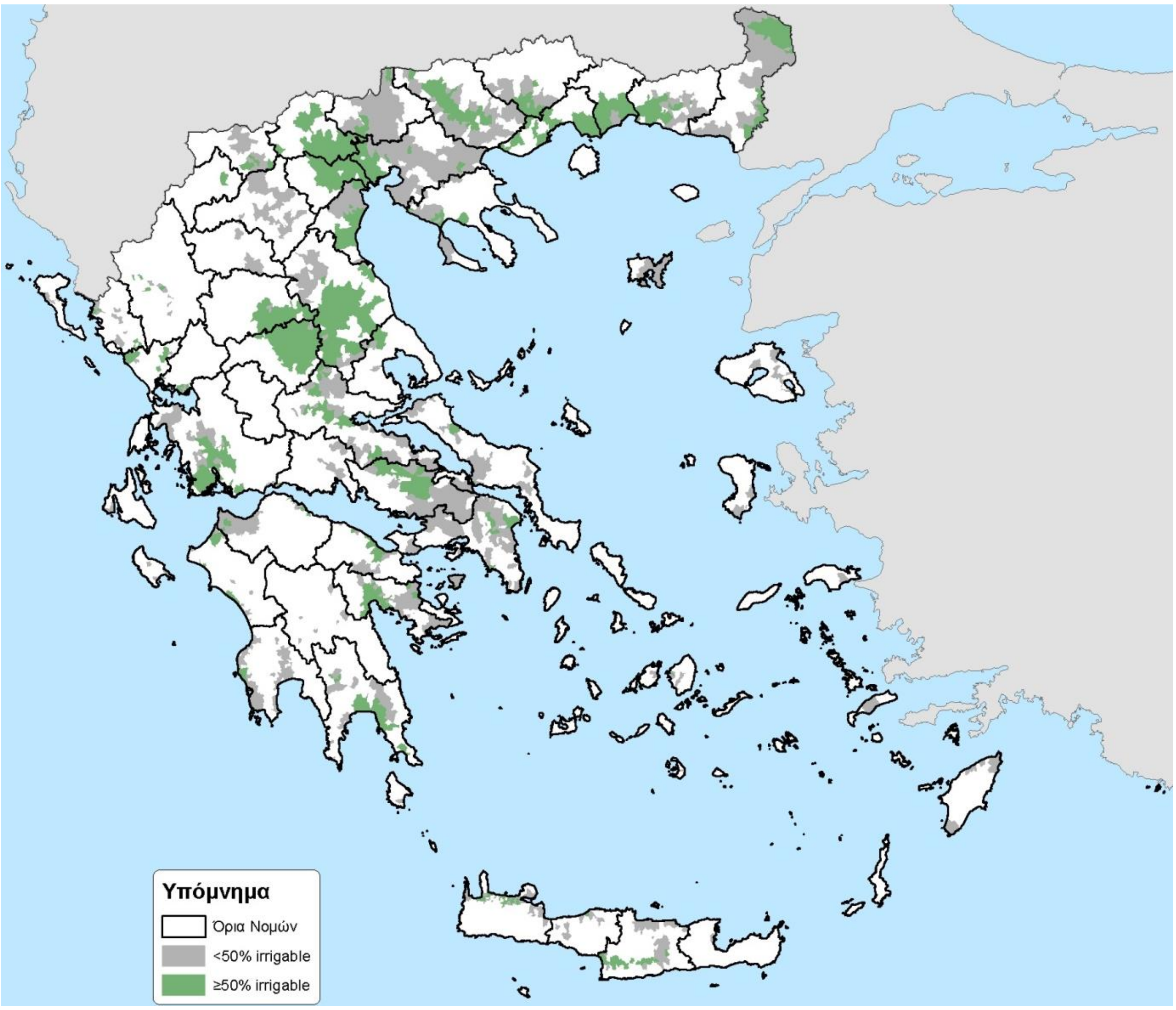

Figure 6. Non mountainous LAU2 with natural constrains for which at least 50% of the total UAA is irrigable according to ELSTAT.

The final results were manually validated using maps illustrating the major collective irrigation networks that were obtained by the Master Plans on Water Resource Management for the 14 water districts of Greece (Ministry of Environment and Energy, 2015).

As a final step, the non-mountainous LAU2 with natural constrains for which at least 50% of the total UAA is irrigable, which have natural constrains other than dryness covering at least 60% of the Utilized Agricultural Area (UAA) were identified (Figure 8). For this purpose, the delimitation of the areas subject to physical constraints described in the first report (Kalivas et al., 2017) considering only the soil/terrain criteria (neglecting the criterion of "dryness"). In this procedure, the areas covered by drainage networks were considered in the delimitation of the areas constrained by limited soil drainage (Figure 9) even if the corresponding areas cover only 2.28% of the UAA. Furthermore, the criteria for the delimitation of the areas constrained by unfavorable soil texture were modified because in the case that irrigation water is readily available the effect of coarse soil texture on crop production can be also handled. The resulted LUA2 are illustrated in Figure 10.

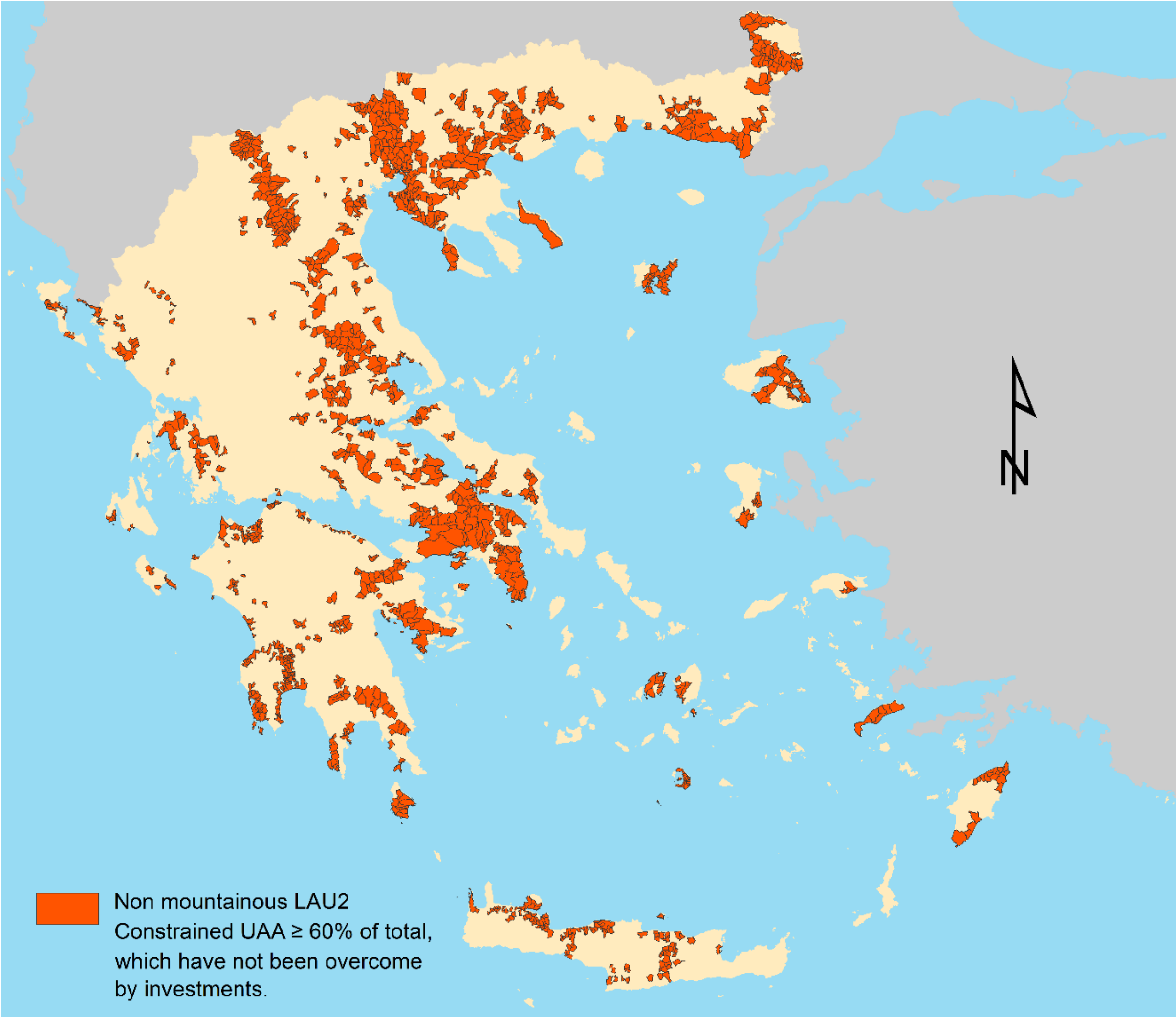

Figure 8. Non mountainous LAU2 with natural constrains covering at least 60% of the Utilized Agricultural Area, which have not been overcome by investments.

Figure 9. Areas covered by surface drainage networks and areas constrained by limited soil drainage.

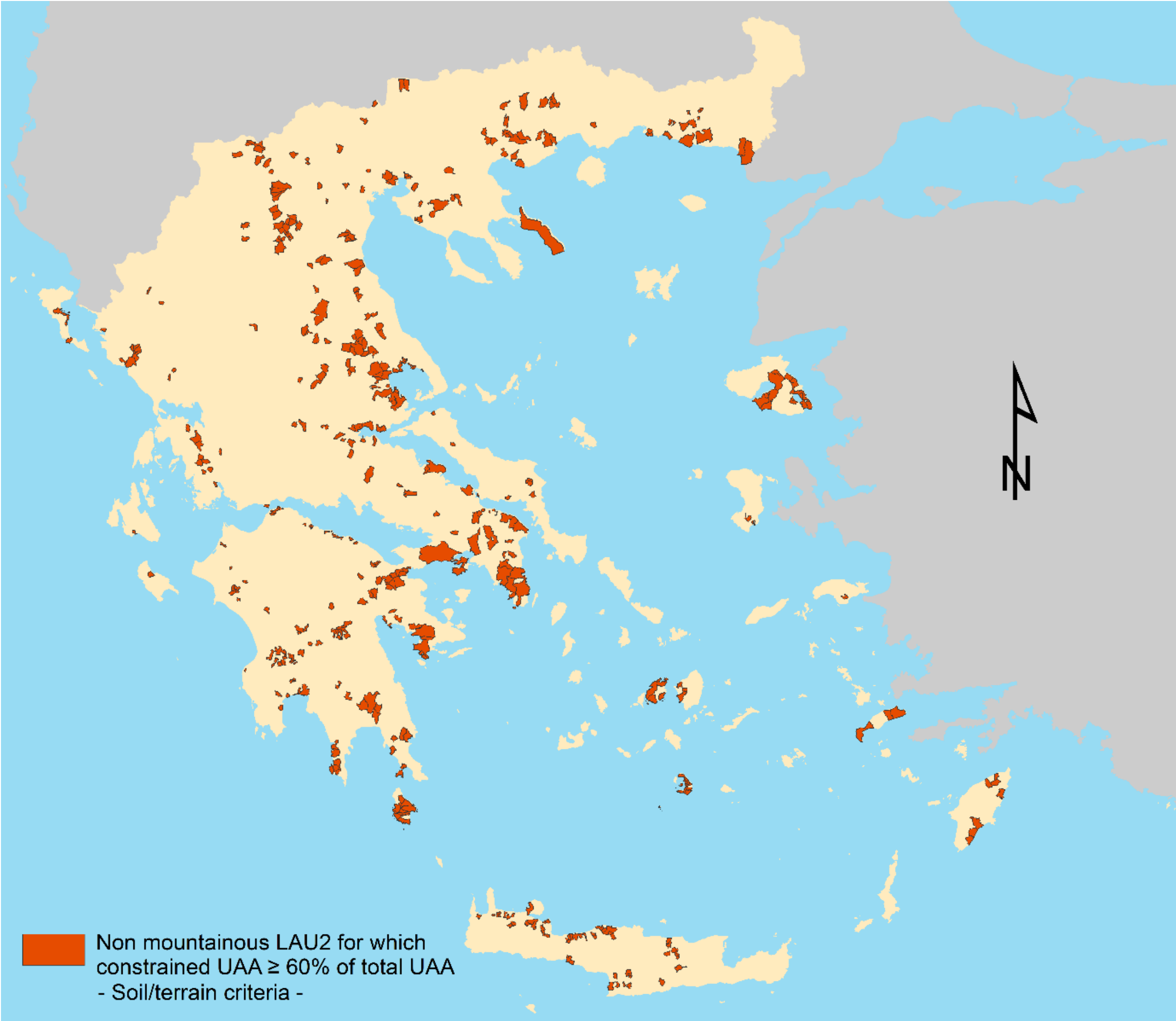

Figure 10. Non mountainous LAU2 with natural constrains, considering only soil and terrain criteria, covering at least 60% of the Utilized Agricultural Area.

The result of the investments fine tuning is displayed in the following table.

UAA affected by Dryness	UAA excluded due to irrigation investment	UAA where dryness constraints have not been overcome by investments	UAA under natural constraints other than dryness	Total UAA under natural constraints after investments fine tuning
(1)	(2)	(3 = 1 - 2)	(4)	(5 = 3 + 4)
1.891.012,24	864.182,55	1.026.829,69	408.482,72	1.435.312,41

Economic Fine-Tuning

At a first step, using the Standard Output (SO) of each crop and the cultivated area corresponding to each crop for each NUTS3, the spatially weighted average SO for crop production at NUTS3 level was estimated (Figure 3). In this way, it was made possible to compare the SO of NUTS3 with different crop patterns and different UAA.

Following, using the SO and the number of heads for each type of livestock and for each NUTS3 the total livestock output for each NUTS3 was estimated. The total livestock output was then divided by the total UAA for each NUTS3 to estimate the SO for livestock production referred to the UAA at

NUTS3 level (Figure 4). Accordingly, the estimated composite SO values for crop production and livestock were comparable to each other and it was possible to estimate a combined SO value for both crop and livestock production at NUTS3 level. The combined SO was estimated by adding the corresponding SO values for crop production and for livestock production for each NUTS3 (Figure 11).

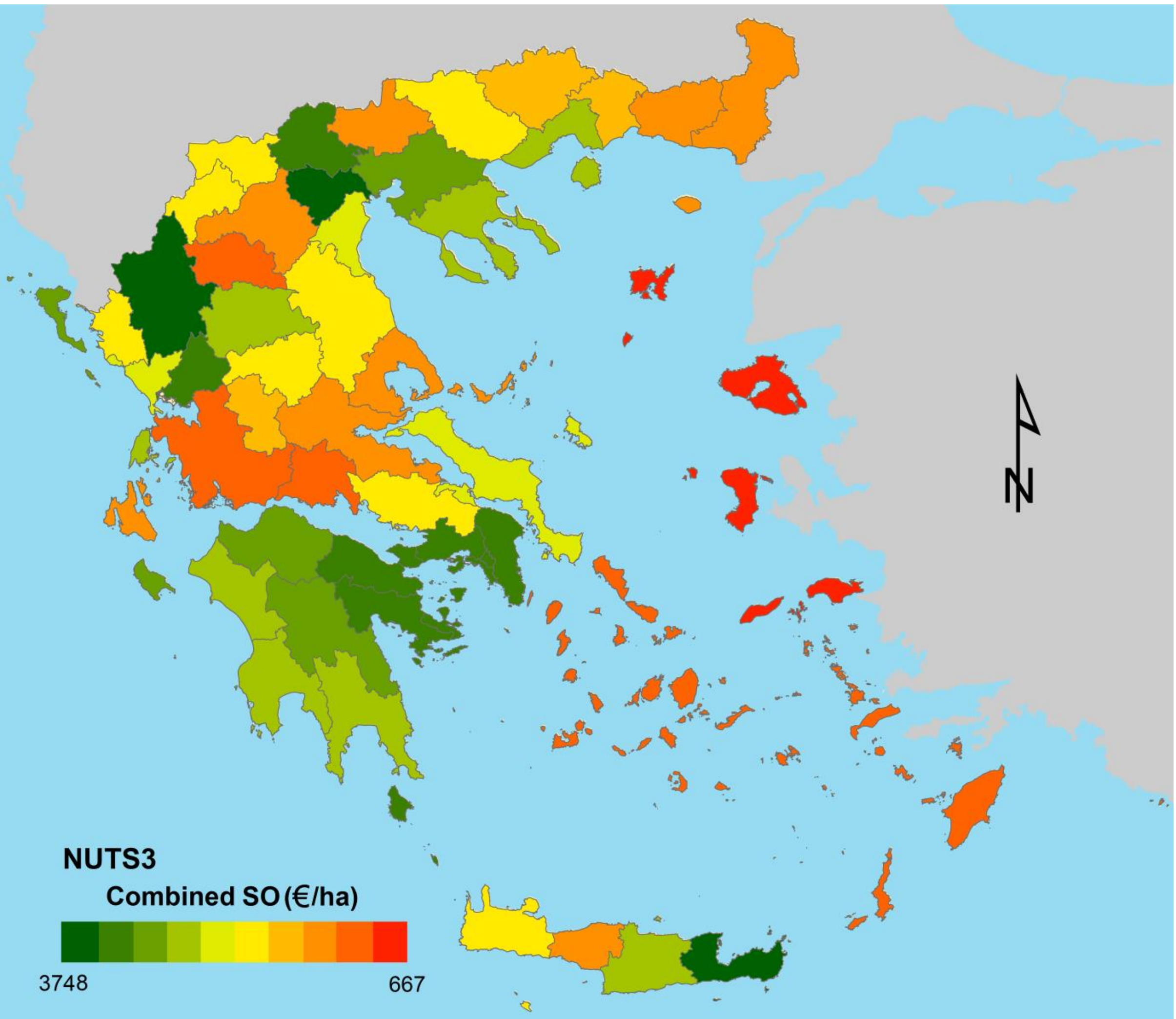

Figure 11. Combined Standard Output value for both crop and livestock production at NUTS3 level.

Finally, the average combined SO (1736.5 €/ha) as well as the 80% of the average combined SO (1389.2 €/ha) for Greece were calculated. The NUTS3 were then classified at three categories according to their combined SO value (Figure 12).

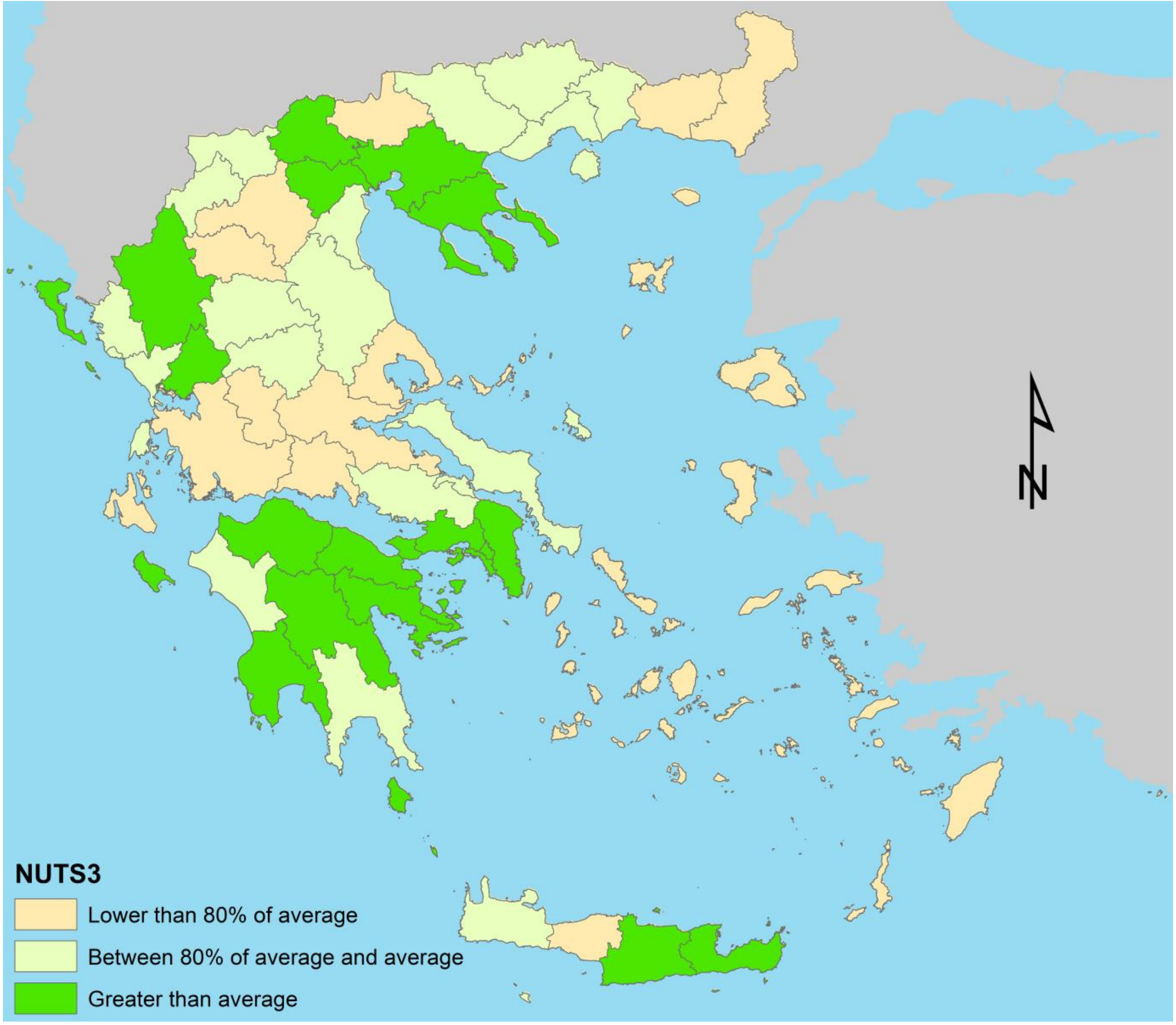

Figure 12. NUTS3 classified at three categories according to their combined SO value.

The result of the economic fine tuning, in case the threshold for adequate economic performance is set at the level of the national average, is displayed in the following table.

Total UAA under natural constraints after investments fine tuning	UAA excluded due to good economic performance	Total UAA under natural constraints
(1)	(2)	(3 = 1 – 2)
1.435.312,41	330.737,10	1.104.575,31

ANC after Fine-Tuning

The LAU2 characterised as ANC, after investments and economic finetuning, in case the threshold for adequate economic performance is set at the level of the national average, are presented in Figure 13.

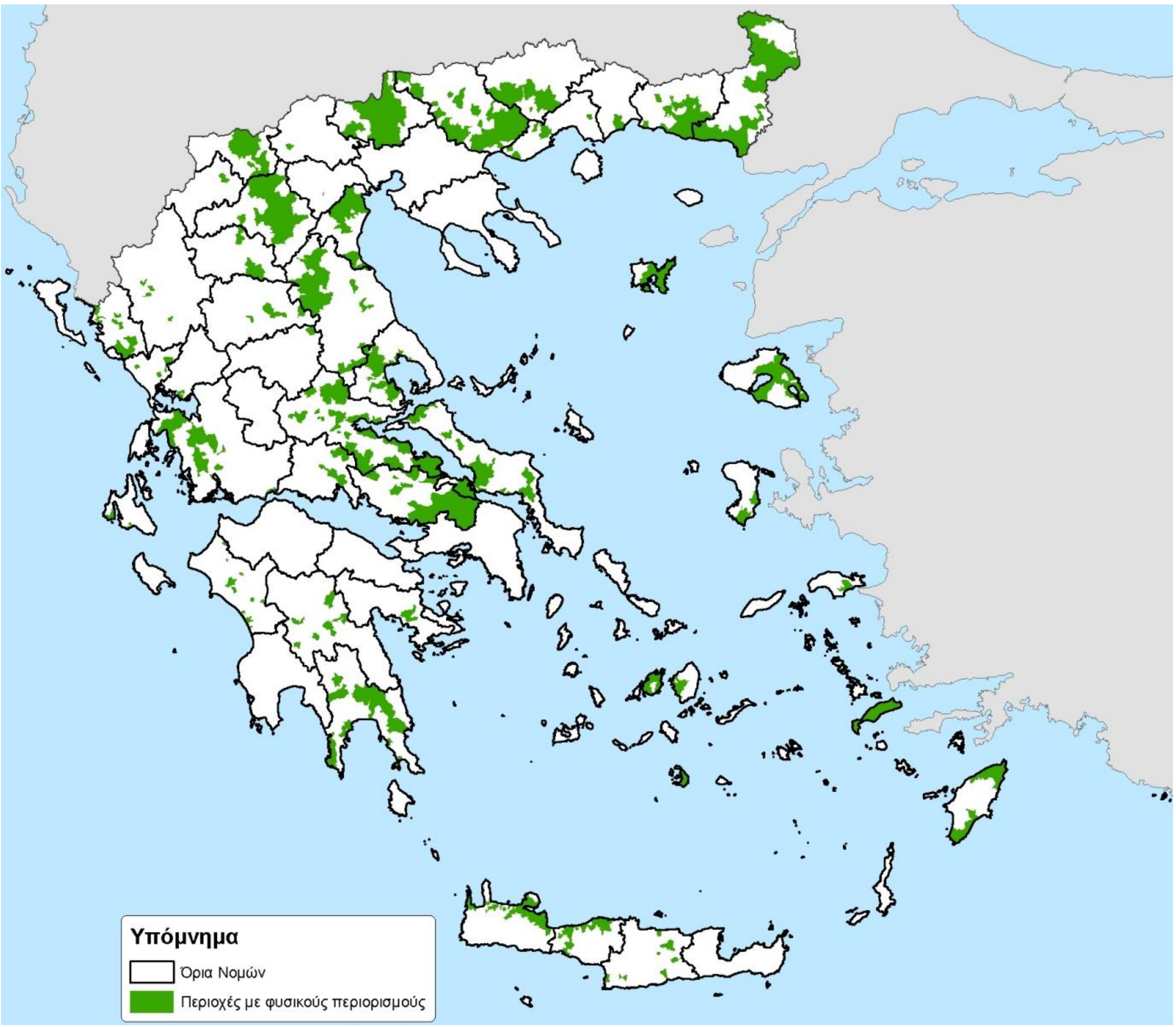

Figure 13. Non mountainous LAU2 for which constrained UAA ≥ 60% of total UAA after fine tuning.

Specific Constraints

Most of Greece’s borderline is shared with non EU countries, namely Turkey, FYROM and Albania. Maintenance of the countryside is of paramaount importance along the land borders of the country and especially in the region of Thrace, both for social and national security reasons.

In these areas, agriculture is the main source of income and, therefore, supporting agricultural activity may countribute substantially to sustaining a critical population of inhabitants. In this context, LAU2 in the region of Thrace and along a zone of 20km from the northern land borders of the country that are not subject to mountain or other natural constraints are designated as areas with specific constraints.

Another important characteristic of Greece is that it has a large number of islands, with estimates ranging from somewhere around 1,200 to 6,000 depending on the minimum size to take into account (Figure 1). The number of inhabited islands is as high as 227.

The largest Greek island by area is Crete, located at the southern edge of the Aegean Sea. The second largest island is Euboea or Evia, which is separated from the mainland by the 60m-wide Euripus Strait, and is administered as part of the Central Greece region. Euboea is connected by road to the mainland with two bridges.

The Greek islands, except Crete and Euboea are mostly isolated from the mainland and face significant problems in the transportation of goods by sea especially during winter when the seas are heavy and the available connections less frequent. Furthermore, there are increased costs for energy and water supply as well as for most other goods and services.

Additionally, maintaining agricultural activity, in combination with fisheries, in the small islands is absolutely necessary to preserve the tourist potential of the area and to protect the coastline.

Accordingly, LAU2, located in the small islands, that are not subject to mountain or other natural constraints are designated as areas with specific constraints

The final map of LAU2 characterized mountain or ANC or Areas with Specific Constraints is presented in Figure 14.

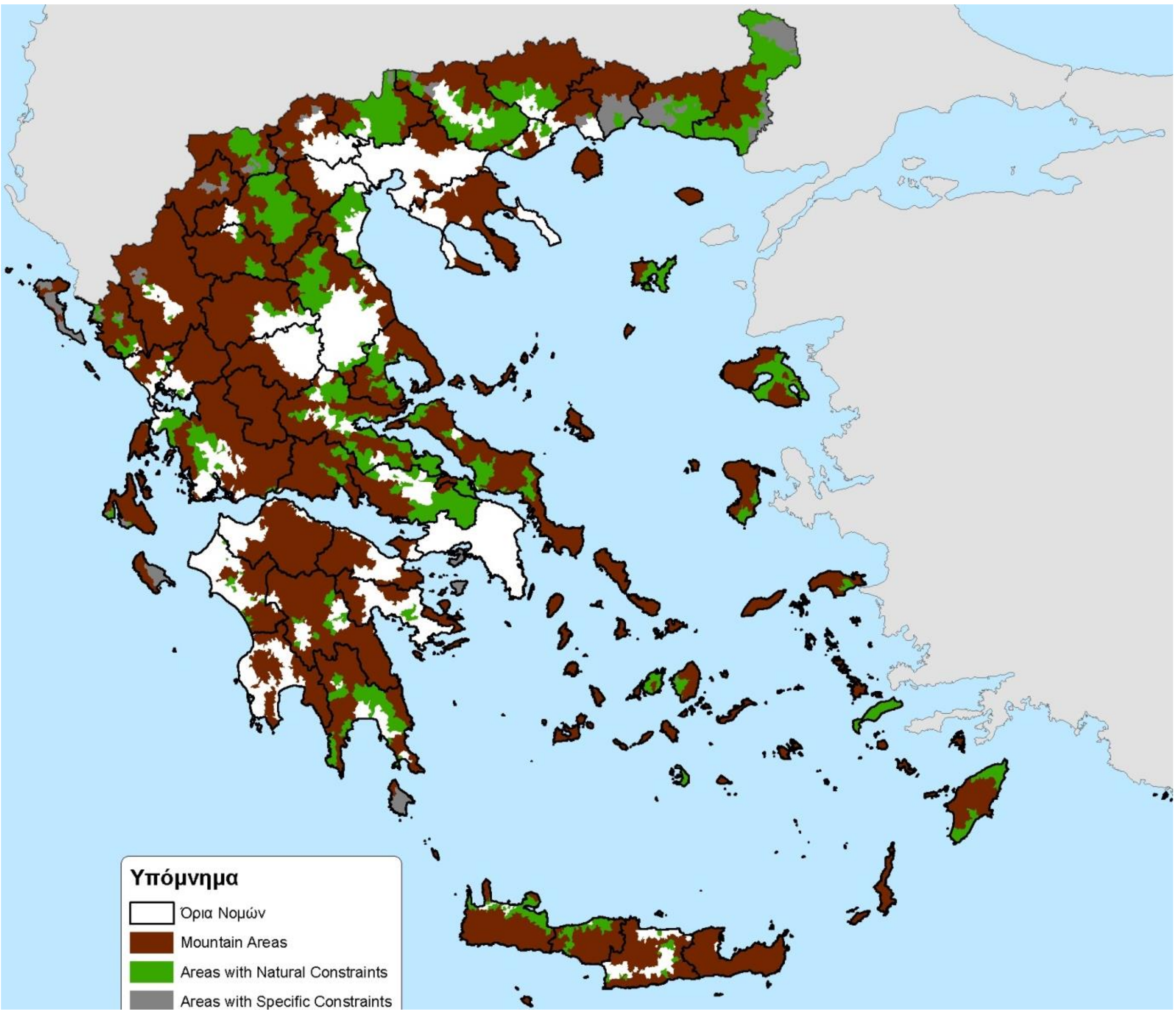

Figure 14. LAU2 characterized Mountain, ANC or Areas with Specific Constraints

Spatial Impact

The spatial impact of the delimitation is presented in the following table.

	Article 32(1).a Mountain areas	Article 32(1).b Areas with natural constraints	Article 32(1).c Areas with specific constraints	No constraints
UAA (ha)	2.177.222,99	1.104.575,31	203.934,92	1.441.077,41
% Total UAA	44,19%	22,42%	4,14%	29,25%
% Country	16,49%	8,37%	1,54%	10,92%

Level of Support

INTRODUCTION

This report follows the identification of areas with significant natural and specific constraints (ANC) based on Article 32 of Reg. (EU) 1305/2013 and aims at estimating the appropriate level of compensation. According to the Article 31 of Reg. (EU) 1305/2013:

1. Payments to farmers in mountain areas and other areas facing natural or other specific constraints shall be granted annually per hectare of agricultural area in order to compensate farmers for all or part of the additional costs and income foregone related to the constraints for agricultural production in the area concerned.
2. Additional costs and income foregone shall be calculated in comparison to areas which are not affected by natural or other specific constraints, taking into account payments pursuant to Chapter 3 of Title III of Regulation (EU) No 1307/2013.
3. When calculating additional costs and income foregone, Member States may, where duly justified, differentiate the level of payment taking into account: a) the severity of the identified permanent constraint affecting farming activities; b) the farming system.
4. Payments shall be fixed between the minimum and maximum amount laid down in Annex II (between 25 €/ha and 250 €/ha). These payments may be increased in duly substantiated cases taking into account specific circumstances to be justified in the rural development programmes.

The methodology used to estimate the appropriate level of compensation according to the Article 31 of Reg. (EU) 1305/2013, considering also the limitations posed due to the availability of required data is described in the following section.

DATA METHODS AND RESULTS

According to the Article 31 of Reg. (EU) 1305/2013, payments to farmers in areas facing natural or other specific constraints shall be granted annually per hectare of agricultural area in order to compensate farmers for all or part of the additional costs and income foregone related to the constraints for agricultural production in the area concerned. The additional costs and income foregone shall be calculated in comparison to areas which are not affected by natural or other specific constraints. In order to follow the above requirements, specific data on the Farm Net Income (FNI) for the LAU2 with natural or specific constrains and for the non-constrained LAU2. However, the available data up to now concern the previous delimitation of Less Favored Areas (LFA) and as it is logical there aren’t available any relative data for the new delimitation.

Using data coming from the Farm Accountancy Data Network (FADN) database (FADN, 2017), concerning the precious delimitation of LFA for the three-year period 2010 – 2012 a comparison of the total output per hectare, the inputs per hectare (intermediate consumption, depreciation, total external factors), and the FNI per hectare between typical farms located in the less-favored mountain areas, less-favored not mountain areas (LFA), and not in less-favored mountain areas (non-LFA) is presented in Table 2..

The Farm Net Income (FNI) is calculated as the Total output (TO) minus the Intermediate Consumption (IC), the Depreciation (D), and the Total external factors (TEF).

$$FNI = TO - IC - D - TEF \quad (1)$$

Table 2. Comparison of the total output per hectare, the inputs per hectare, and the net income in the less-favored mountain areas, less-favored not mountain areas (LFA), and not in less-favored mountain areas (non-LFA).

	Total output (€/ha)	Intermediate consumption (€/ha)	Depreciation (€/ha)	Total external factors (€/ha)	Farm Net Income (€/ha)
in less-favored mountain areas	2404	1107	343	208	746
in less-favored not mountain areas	2280	1199	352	233	496
not in less-favored areas	3230	1498	482	418	832

As it can be seen in Table 2 there is an important difference between the TO of the mountain areas, the LFA, and the non LFA areas. As it can be also seen in Table 3 the ratio total inputs / total output ranges between 1.28 and 1.44 and it is relatively stable.

Table 3. Total output per hectare, total inputs per hectare, and total output / total Input ratio in the less-favored mountain areas, less-favored not mountain areas (LFA), and not in less-favored mountain areas (non-LFA).

	Total output (€/ha)	Total Inputs (€/ha)	Total Output / Total Input
in less-favored mountain areas	2404	1658	1.45
in less-favored not mountain areas	2280	1784	1.28
not in less-favored areas	3230	2398	1.35

Using also data coming from the Farm Accountancy Data Network (FADN) database (FADN, 2017), the average Total Output / Total Input rates for the entire country were calculated for the last five available years (2011-2015). The ten years average rate was 1.25.

The calculated Combined Standard Output values for both crop and livestock production at NUTS3 level are presented in Table 4.

Table 4. Combined Standard Output values for both crop and livestock production at NUTS3 level.

NUTS3 Code	Name	Combined SO (€/ha)
EL411	LESVOU	668.0
EL412	SAMOU	807.8
EL413	CHIOU	872.5
EL231	ETOLOAKARNANIAS	957.6
EL422	KIKLADON	974.9
EL245	FOKIDOS	1006.7
EL421	DODEKANISOU	1013.2
EL131	GREVENON	1087.0
EL244	FTHIOTIDOS	1189.4
EL133	KOZANIS	1199.6
EL123	KILKIS	1202.5
EL111	EVROU	1211.5
EL223	KEFALLINIAS	1221.6
EL433	RETHIMNIS	1224.8
EL113	RODOPIS	1271.6
EL143	MAGNISIAS	1288.3
EL243	EVRITANIAS	1318.7
EL114	DRAMAS	1391.9
EL112	XANTHIS	1413.4
EL434	CHANION	1464.5
EL212	THESPROTIAS	1475.2
EL241	VIOTIAS	1484.4
EL141	KARDITSIS	1499.5
EL134	FLORINIS	1505.5
EL132	KASTORIAS	1508.2
EL126	SERRON	1528.0
EL142	LARISIS	1528.2
EL242	EVVIAS	1567.9
EL214	PREVEZIS	1600.3
EL125	PIERIAS	1617.9
EL254	LAKONIAS	1687.7
EL233	ILIAS	1691.5
EL115	KAVALAS	1693.0
EL224	Lefkados	1694.0
EL144	TRIKALON	1714.8
EL255	MESSINIAS	1751.3
EL127	CHALKIDIKIS	1756.5
EL127	DIIKISI AGIOU OROUS	1756.5
EL431	IRAKLIOU	1761.9
EL232	ACHEAS	1860.6
EL252	ARKADIAS	1877.4

EL122	THESSALONIKIS	1878.9
EL222	KERKIRAS	2029.8
EL221	ZAKINTHOU	2163.1
EL300	ANATOLIKIS ATTIKIS	2426.3
EL300	ATHINON	2426.3
EL300	DITIKIS ATTIKIS	2426.3
EL300	PIREOS	2426.3
EL251	ARGOLIDOS	2538.2
EL211	ARTIS	2910.0
EL124	PELLIS	2923.8
EL253	KORINTHIAS	3080.5
EL121	IMATHIAS	3437.6
EL213	IOANNINON	3745.1
EL432	LASITHIOU	3747.7
	Average Value	**1736.5**

Based on the above, in this report it is proposed that the difference between the average combined SO value of the LAU2 facing natural or other specific constraints (1330.9 €/ha) after fine tuning and the economic fine-tuning criterion (the average combined SO = 1736.5 €/ha) could be used to define the compensation level. However, this value should be adjusted considering the Total Output / Total Input rate in order to consider the total inputs and to estimate an indicative FNI value. The obtained results are presented in Table 5.

Table 5. Compensation level calculation using the Total output / Total input rates for two periods.

Period	Total output / Total input	Average SO (€/ha)	Average SO of NUTS3 below Average SO (€/ha)	Net Average SO (€/ha)	Net Average of NUTS3 below Average SO (€/ha)	Compensation Level (€/ha)
2011-2015	1.25	1736	1331	347	266	**81**

This preliminary estimation of the average compensation level lays between the minimum and maximum amount laid down in Annex II (25 €/ha and 250 €/ha).

Finally, it should be noted that this preliminary compensation level can be used until specific data on the Farm Net Income (FNI) for the LAU2 with natural or specific constrains and for the non-constrained LAU2 based on the current delimitation will be made available.

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