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COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

Towards a better targeting of the aid to farmers in areas with natural handicaps

TECHNICAL ANNEX

Technical details for possible common criteria

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Technical Annex

Technical details for possible common criteria

1. INTRODUCTION

Soil, climate and terrain are the major determinants of the suitability of land for agricultural use. Every crop type has a set of requirements with regards to soil and climate. To yield a harvest, a crop needs sufficient physical stability, sufficient but not too much heat and photo-synthetically active radiation, oxygen, water and nutrients, in the absence of toxic substances or damaging impacts from storms or pests.

To keep the delimitation of areas affected by natural handicaps to agriculture simple, robust and transparent, a restricted selection of elementary soil, climate and terrain characteristics is made. These are judged to be most pertinent for distinguishing land according to its suitability for generic agricultural activity. The interaction of the selected land characteristics on the growth of crops is accounted for by one additional characteristic, the soil moisture balance.

There is a range of land quality assessment methods developed on the International and European level. Different methods have been constructed for different purposes and therefore the process and analysis are different.

A number of approaches were studied; a consensus was reached amongst experts and the JRC based on a set of requirements and recommendations that the UN Food and Agriculture Organisation (FAO) method the 'Problem Land Approach' was the best starting point. It is a straightforward and simple approach for identifying broad types of agricultural problem soils and limitations in climate. The approach identifies soil types with common characteristics that frequently dominate agricultural land. Therefore a simple classification system for identifying areas suffering from natural handicaps has been developed, by the JRC in conjunction with experts, for the Europe Union.

The reasons for choosing a modified "Problem Land approach" rather than a more elaborated Land Quality approach can be explained by the objectives pursued i.e. to identify areas with constraints to agriculture and not to identify all necessary conditions to reach optimal production for each kind of crop. Each criterion is distinct from the others in terms of impact and threshold. However all the individual criteria indicate at the specific threshold mentioned the point at which agricultural production is severely handicapped. This means that it is possible to compare the handicap of one criterion against another unrelated criterion.Hence the delimitation of areas is transparent and comparable across the whole of the Community regardless of which criterion is used in differing locations.

2. LEVEL OF DELIMITATION

The amount and density of data and the semantic detail available from point observations determine the spatial and semantic resolution of the results that can be obtained when mapping the area according to the criteria. The level of semantic resolution of the resulting mapping has a large effect on the area of land classified, due to the differing data sets and the

percentage of area that would need to be constrained for the whole area to then be classified as handicapped.

To accurately asses the areas constrained by natural handicaps it is important to map at an adequate administrative level, with the spatial and semantic resolution capturing the characteristics of the agricultural land in the area at the territorial level LAU2 or as close as possible to LAU2. Currently most delimited areas are based on the LAU2 level. This level is the most appropriate for mapping an area and the continuation of this administrative level will allow for a certain degree of continuity.

An area is considered affected by significant natural handicaps if a large part of the utilised agricultural area (UAA) in the area, at least 66%, meets at least one of the criteria listed in the table at the threshold value indicated.

The thresholds should be considered as a minimum level of handicap to be met for classifying an area as constrained, Member States would have the possibility to be more restrictive with the threshold level if this is justified by national circumstances.

The indicators used for fine tuning should be valid for the life time of a programme.

Member States should explain the methodology and parameters used in the general mapping and the fine tuning process.

The criteria indicated in the table below and the associated critical limits or threshold values can be used for European conditions to discriminate land presenting severe limitations for agricultural production on the basis that soil and climate data of sufficient spatial and semantic detail are available.

3. COMMON BIOPHYSICAL CRITERIA

The table below lists the common soil, climate and terrain criteria for classifying land according to its suitability for generic agricultural activity, as well as the threshold values indicating agricultural areas with severe natural handicap to agriculture.

CRITERION	DEFINITION	THRESHOLD
CLIMATE		
Low Temperature	Length of Growing Period (number of days) defined by number of days with daily average temperature > 5°C (LGP_{t5}) OR	≤ 180 days OR
	Thermal-time sum (degree-days) for Growing Period defined by accumulated daily average temperature > 5°C.	≤ 1500 degree-days
Heat Stress	Number and length of continuous periods (number of days) within the growing period for which daily maximum temperature (Tmax) exceeds the threshold.	One or more periods of at least 10 consecutive days with daily Tmax > 35°C
SOIL		
Drainage	Areas which are water logged for significant duration of the year (lack of gaseous oxygen in soil for root growth or land not accessible for tillage).	Poorly drained soil
Texture and Stoniness	Relative abundance of clay, silt, sand, organic matter (weight %) and coarse material (volumetric %) fractions in top soil material.	> 15% of topsoil volume is coarse material OR
		Unsorted, coarse or medium sand, loamy coarse sand OR
		Heavy clay (>60% clay) OR
		Organic OR
		Vertisol, clay, silty clay or sandy clay with vertic properties OR
		Rock outcrop, boulder within 15 cm of the surface
Rooting depth	Depth (cm) from soil surface to coherent hard rock or hard pan.	< 30 cm
Chemical properties	Presence of salts, exchangeable sodium and gypsum (toxicity) in the topsoil.	Salinity: > 4 deci-Siemens per meter (dS/m) OR
		Sodicity: > 6 Exchangeable Sodium

		Percentage (ESP) OR
		Gypsum: > 15%
SOIL AND CLIMATE		
Soil Moisture Balance	Number of days within growing period as defined by temperature > 5°C (LGP_{t5}), for which the amount of precipitation and water available in the soil profile exceeds half of potential evapotranspiration.	≤ 90 days
TERRAIN		
Slope	Change of elevation with respect to planimetric distance (%).	> 15%

The section below provides a more detailed definition and justification for each criterion, as well as the indications for its application within the simulation exercise.

4. DETAILS FOR EACH CRITERION

Criterion 1: Low Temperature

Definition

Low temperature is defined as the condition in which crop performance or survival is compromised by temperatures during the growing period which are insufficient for optimal growth and development of plants.

In the context of areas affected by natural handicaps for agriculture in Europe, low temperature is considered a characteristic of land for which thermal-time accumulation during the growing period is insufficient for plants to complete the production cycle.

Agricultural Impact

Low temperatures limit crop growth and development through the impact on important physiological processes such as photosynthesis and leaf appearance. Land in which thermal-time accumulation systematically is not sufficient for crops to complete the production cycle is unfavourable for agriculture.

Negligible growth occurs for most agricultural crops at temperatures below 5^{o}C. When crops are grown under lower than adequate temperatures, yields can be reduced by various mechanisms including: limited light interception (e.g. due to slow leaf area expansion), inefficient conversion of intercepted light into biomass (i.e. reduced photosynthesis rates), or direct damage to plant tissues caused by early or late frosts

Threshold

Temperature thresholds and thermal requirements for plant development vary among crop species and cultivars. For European conditions, thermal-time sum (TS) requirements can be used as a reference to delimit thresholds for the development of agricultural crops.

Severely limiting low temperature is said to occur if TS_5 is lower than or equal 1500^{o}Cd or if LGP_{t5} is lower than or equal than 180 days.

Assessment

To assess low temperature as a land characteristic, the concepts of thermal-time sums (TS_b, degree days, ^{o}Cd) or length of temperature growing period (LGP_t, days) can be used.

a) The length of the temperature growing period (LGP_{t5}), i.e. the number of days with daily average temperatures (T_{avg}) above 5^{o}C is calculated for each year. The LGP_{t5} characterizes the days in which temperatures are conducive to crop growth.

b) Thermal-time sums above a base temperature (T_b) of 5^{o}C, are calculated for each year by accumulating the difference between daily T_{avg} and T_b.

Calculated values of LGP_{t5} or TS_b are compared with reference thresholds for severe limiting conditions. Finally, the number of years with limiting conditions is counted. If limiting conditions occur in more than 20% of the years of the whole time series, the land is classified as constrained.

A time series of daily meteorological data preferably over 30 (or more) recent years is required to assess the probability of exceedance.

Criterion 2: Heat Stress

Definition

Heat stress is defined as the condition in which crop performance or survival is compromised by periods of exposure to high temperatures.

In the context of areas affected by natural handicaps for agriculture in Europe, heat stress is a characteristic of land which is subjected to one or more periods of continuous days within the growing period, for which maximum daily temperature (Tmax) exceeds 35oC.

Agricultural Impact

Episodes of high temperature, particularly during critical plant development stages drastically reduce yields of field crops. The thermal-sensitive period usually spans from one to two weeks around flowering.

Exposure to short episodes of high temperature during this thermal-sensitive period reduces the set of fruits and grains and limits grain filling. Possible impacts include a reduction in the number of flowers, number of pollens, pollen tube growth, pollen release, pollen viability and flower fertility.

Threshold

Thresholds for heat stress have been identified for common crops. These thresholds are different among crops and also vary within species. Yield loss is usually severe above 35oC, while the magnitude of damage increases with the period of exposure, increasing at higher temperatures until complete damage is observed at above 40-45oC, near lethal temperatures.

Severely limiting heat stress is said to occur when "one or more periods of at least 10 consecutive days with daily maximum temperatures above 35^{o}C" are observed.

Assessment

To assess heat stress, maximum temperature as a land characteristic (T_{max}, ^{o}C) can be used. The consecutive days with daily maximum temperature above 35 degrees should be accounted for in each year. Finally, the number of years with limiting condition (one or more periods of at least 10 consecutive days with daily maximum temperatures above 35^{o}C) is counted. If limiting conditions occur in more than 20% of the years of the whole time series, the land is classified as constrained.

A time series of daily meteorological data preferably over 30 (or more) recent years is required to assess the probability of exceedance.

Criterion 3: Drainage

Definition

Soil drainage refers to the maintenance of the gaseous phase in soil pores by removal (or non-addition) of water. A soil has internal drainage, i.e. the facility for removing excess water by gravity, and external drainage, i.e. the amount of water removed (or not added) by its position in the landscape with respect to contributing overland areas (runoff) or groundwater.

Agricultural Impact

Poor drainage reduces the space for the gaseous phase, in particular gaseous oxygen, in the rooting zone. It increases the incidence and severity of soil-borne pathogens and makes tillage impossible.

Threshold

The thresholds identify land areas that are waterlogged for significant periods during the normal growing season and thus affect normal farming operations or crop yields. It identifies soils on which farming operations for adapted crops are possible, but with severe yield reductions due to late planting or poor tillage, crop damage by transient anoxic conditions or plant pathogens resulting from poor drainage.

Soil drainage is said to be **severely** limiting if with regard to drainage the soil is classified as poorly or very poorly drained.

Assessment

Different methods for the assessment of this criterion are possible. Most map classification systems and soil maps worldwide include water-regime related criteria.

It is recommended that Member States identify the most suitable drainage/wetness representation in the national dataset that corresponds to the drainage criteria.

Fine tuning the area delimitation based on the 'Drainage' criterion

In many areas of Europe with natural drainage problems, soils have been artificially drained. If these drainage systems are permanent and functioning, the drained soil units should be evaluated as if they were better drained than without the installed drainage systems.

Member States should remove from the areas designated, on the basis of this criterion, those areas where restricted agricultural production in relation to the natural handicap is not observed because ***artificial drainage*** systems improved the water regime.

Criterion 4: 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 the particle-size distribution. Conventionally it is divided into two parts: coarse fragments > 2 mm effective diameter, and the fine soil.

Agricultural Impact

Soil texture is directly related to water-holding capacity and nutrient supply. Texture affects workability (ease of tillage), water infiltration, runoff, and water movement within the soil (both down and up).

Silt and very fine sand fraction is associated with a high susceptibility to accelerated water and wind erosion. Soils with high proportions of these fractions require intensive soil conservation practices.

Soils with a texture of coarse fragments directly reduce the volume of soil exploitable by roots, thus reducing water-holding capacity and nutrient supply. Sufficiently large coarse fragments prevent tillage, and even smaller coarse fragments wear tillage implements.

An important aspect of “texture” is the physical reaction of the soil to wetting and drying. Vertic properties severely limit tillage options, the soil changes from hard and dry to plastic and sticky over a narrow range of water contents, leaving only a small window for conventional tillage. Shrinking and swelling during the growing season can also damage plant roots.

Threshold

Soil texture is said to be severely limiting if any of the following condition are present:

(i) more than 15 % volume of coarse fragments (> 2 mm) of any kind in topsoil or

(ii) average texture class of rooting zone is

(a) unsorted, coarse or medium sand, loamy coarse sand or

(b) heavy clay (> 60% clay) or

(iii) organic soil as defined with organic matter (>30%) of more than 40 cm either extending down from the surface or taken cumulatively within the upper 80 cm of the soil or

(iv) texture class of clay, silty clay, or sandy clay with vertic properties or;

(v) any proportion of rock outcrops, boulders (largest dimension above or equal to 60 cm) within 15 cm of the 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 and are 2000, 63 and 2 micrometers. National systems may use different limits but it is possible to harmonise data using transfer functions.

It is recommended that Member States identify the most suitable texture representation and information on vertic features and organic soils in the national dataset that correspond to the texture criteria.

Fine tuning the area delimitation based on the 'Soil Texture and Stoniness' criterion

Member States should remove from the areas designated on the basis of this criterion, those areas where, on average, significant additional costs and income foregone for agricultural production in relation to the natural handicap are not observed.

The types of production indicators that seems appropriate for ensuring that those areas that are initially identified as suffering from a natural handicap are in reality constrained by that handicap are;

- average yields for arable crops representing the predominant crop in the area or
- livestock density or tree density in case of permanent crops or
- result indicator (standard gross margin) for a production type

– The average yield is close to the physical productivity of an area and is not influenced by market trends, it is considered the most adapted criterion for arable areas, but could also be used for permanent crops.

– The average stocking density is adapted to areas where livestock breeding is the main activity or

– where orchards or groves of trees is the main agricultural system

– The standard gross margin (SGM) can be considered as an indicator of the average profitability potential of agriculture in an area. The regional average SGM per hectare in comparison to a national average could therefore be used to exclude from LFA those areas where for example soils are poor but agriculture is sufficiently profitable compared to a national average, even when the yield per hectare is low (e.g. vineyards).

Member States should fix a ceiling expressed by a percentage of the national average of the yield or density or SGM for the indicators. Member States can exclude mountain areas from the national average, since these could significantly lower the average. Member States could also, if more applicable, use a regional average as a reference.

Member States can choose alternative or additional national or regionally specific indicators to use for the fine-tuning, while ensuring that the general principle of the Regulation and Strategic objectives of the intervention mechanism are complied with.

Criterion 5: 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 by the effective soil depth above any barrier to root extension, excluding impediments to root extension as such compact (massive) structure.

Agricultural Impact

Roots grow into the soil to provide a physical anchor for the plant, and to extract soil-bound water and nutrients. For annual grain crops and grasses, the anchoring function does not require great depth; .the first 10 cm or so provide enough stability. However, water is rapidly exhausted from shallow depths by the growing plant.

Rooting depth is generally constrained by coherent hard rock or hardpans (dense soil layers).

Physical limitations to rooting depth are also impediments to normal tillage, such that if plant roots cannot grow easily, it is unlikely that the plough can cut easily into the soil.

Threshold

Severe physical rooting depth: < 30 cm

Assessment

During routine field survey, rooting depth is typically assessed by augering. The observed depths are then interpolated with reference to the landscape structure to produce rooting depth estimates for land areas or map units.

Fine tuning the area delimitation based on the 'Rooting depth' criterion

See the previous section 'Fine tuning the area delimitation based on the 'Soil Texture and Stoniness' criterion, for fine tuning of the area delimited based on the criterion Rooting depth.

Criterion 6.1: Chemical Properties – 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 but has been accelerated by human intervention disturbing natural ecosystems. Soil salinity refers to the total amount of soluble salt in soil.

Agricultural Impact

With regard to agriculture, the consequences of soil salinity include:

a) Significant losses of productivity. With increasing soil salinity, plants always find it more difficult to extract water from the soils. Most normal crop and pasture plants are not highly salt-tolerant and will eventually die out under saline conditions;

b) Damaged soil structure and increasing content of toxic substances that may be limiting to plant growth; and

c) More serious soil erosion, both by wind and by water, due to worsening soil structure and reducing vegetation cover.

Threshold

Salinity tolerance is influenced by plant physiology, soil, and environmental factors and their interrelationships.

Levels over 4 dS/m (deci Siemens per meter) **severely** affect many plants.

Dry land salinity occurs where there is removal or loss of native vegetation, and its replacement with crops and pastures that have shallower roots. This results in more water reaching the groundwater system. The groundwater rises to near the surface in low-lying areas. It carries dissolved salts from the soil and bedrock material through which it travels. As saline groundwater comes close to the soil surface (within 2m), salt enters the plant root zone. Even where the groundwater does not bring much salt with it, the water logging of the plant root zone alone, can damage or kill vegetation

Assessment

Soil salinity is determined by measuring the electrical conductivity of a solution extracted from a water-saturated soil paste. However, soil classifications systems usually allow estimating salinity from the soil name.

Fine tuning the area delimitation based on the 'Salinity' criterion

See the previous section *'Fine tuning the area delimitation based on the 'Soil Texture and Stoniness'* criterion, for fine tuning of the area delimited based on the criterion Soil Salinity.

Criterion 6.2: Chemical Properties - Sodicity

Definition

Sodicity refers to the presence of a high proportion of adsorbed sodium in the clay fraction of soils. In the context of naturally handicapped areas 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.

Agricultural Impact Soil sodicity has two main effects on soils and indirectly on its agricultural capacity to produce. Note that the effects of sodicity are often indirect as they affect vital soil properties rather than crop growth itself.

Soils become prone to water logging due to the capping effect. They are also more prone to erosion and particularly erosion through water runoff.

Sodic soil runoff has a detrimental effect on water ways and reservoirs due to the mobilisation of nutrients with the soil. This has the unintended consequences of producing additional cost for cleaning the water and also an increased risk in producing algal blooms in water bodies which are a significant environmental problem.

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**

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). However, soil classifications systems usually allow estimating sodicity from the soil name.

Fine tuning the area delimitation based on the 'Sodicity' criterion

See the previous section *'Fine tuning the area delimitation based on the 'Soil Texture and Stoniness'* criterion, for fine tuning of the area delimited based on the criterion Sodicity.

Criterion 6.3: Chemical Properties - Soil Gypsum Content

Definition

Gysiferous soils are soils that contain sufficient quantities of gypsum (calcium sulphate dehydrate) to interfere with plant growth.

Agricultural Impact Many factors affect plant growth in gypsiferous soils, including gypsum content within the root zone, depth to a gypsic layer, depth to impermeable layers, crop tolerance level and gypsum solubility. Furthermore physical properties are often unfavourable, causing low water availability, slaking of loamy top soils, piping and collapse of irrigation canals. In soils with gypsum, almost all crops show deficiency of most plant nutrients, in particular phosphorus and micronutrients.

Threshold

Gypsiferous soils present a **severe** limitation to crop production once the gypsum percentage exceeds 15%.

Assessment

Gypsum is determined by the differential water loss method which estimates the gypsum percentage from the loss of water in the soil sample between 70 and 90°C. It can also be estimated with gravimetric determinations of precipitated $BaSO_4$. However, soil classifications systems usually allow estimating the presence of Gypsum from the soil name.

Fine tuning the area delimitation based on the 'Soil Gypsum Content' criterion

See the previous section *'Fine tuning the area delimitation based on the 'Soil Texture and Stoniness'* criterion, for fine tuning of the area delimited based on the criterion Soil Gypsum Content.

Criterion 7: Soil Moisture Balance

Definition

Deficit in the soil moisture balance is defined as the condition in which crop performance or survival is compromised by limited water availability during the growing period, which is insufficient for optimal growth and development of crops.

In the context of areas affected by natural handicaps for agriculture in the European Union, a deficit soil moisture balance is a characteristic of land for which the "number of days, within growing period as defined by temperature, for which the amount of precipitation and moisture available in the soil profile is not sufficient as compared to the reference evapotranspiration, for plants to complete the production cycle".

Agricultural Impact The soil moisture balance is a critical parameter for assessing the potential for crop production. Agricultural production is seriously impaired if soil water is limiting during the growing season causing adverse affects on plant growth and crop yields

Threshold

Short growing period provides unfavourable conditions for agriculture. On the basis of minimum crop cycle duration, the following critical limit has been established:

Severe Threshold: $\leq$ 90 days

Assessment

To calculate the soil moisture balance, the information on the number of days when average temperature (T_{avg}) > 5^{o}C and Actual evapotranspiration (AET) / Potential evapotranspiration (PET) > 0.5, is extracted for each observation year.. According to the threshold value for the severe constraint, years with <= 90 non-dry days are classified as constrained. A probabilistic approach is applied to take account of the variability between years. If the handicap occurs in more than 20 % of the years, the land is classified as constrained.

Fine tuning the area delimitation based on the 'Soil Moisture Balance' criterion

It is assumed that in areas with irrigation, water resources and irrigation infrastructure in place, **no** water stress occurs and that the number of days available for crop growth is generously sufficient. Irrigated areas are considered as favourable areas for agricultural production

Member States should remove from the areas designated on the basis of this criterion, those areas where restricted agricultural production in relation to the natural handicap is not observed because a high proportion, >50% of the UAA, is irrigated.

Criterion 8: Slope

Definition

Slope is the angle the soil surface makes with the horizontal. It can be expressed in degrees or as a percentage (45 degrees = 100 percent).

Agricultural Impact Slope as such has little or no direct influence on the yield of crops. However the steeper the slope the more difficult it becomes to manage the land and to grow crops. In particular mechanisation is hampered while access to land and all agricultural operations become more time consuming. Steeper slopes are also associated with shallower soils in general and with a higher risk for soil degradation (erosion) and land slides.

Threshold

Slopes above 15% pose **severe** problems for mechanized cultivation, specific equipment is required.

Assessment

From neighbouring altitude data, slope can be determined by algorithms. The resulting 'local' slopes must be averaged over a larger area to be applicable as an indicator of land suitability. When using a digital elevation model, the maximum rate of change between each cell and its neighbours is calculated, for example the steepest downhill decent for the cell.