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Review of Land Evaluation Methods for Quantifying Natural Constraints to Agriculture

The Institute for Environment and Sustainability
Joint Research Centre, Ispra (Italy).

Åse Eliasson

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Foreword

This report provides an overview of selected land evaluation methods for quantifying natural constraints to agriculture. It has been compiled for decision-makers with no specialised knowledge of land evaluations and the aim is to give an overview of methods and soil and climate criteria, which are applied for classifying areas less favourable for agriculture in Europe.

The report is part of the Joint Research Centre's technical support to DG Agriculture and Rural Development in their preparatory work to find a new definition for classifying the Other/Intermediate Less Favoured Areas to be implemented after 2010.

The report includes standardised descriptions of selected land evaluation methods that are internationally known and applied on the continental and regional level, namely: The Land Capability Classification, the Framework for Land Evaluation, the Agro-ecological Zoning Methodology, the Agricultural Problem Land Approach and the Expert System for Constraints to Agricultural Production in Europe. Criteria used in these methods and examples of applications and results are included, with preferences to applications on the European level. An overview of land evaluation methods and criteria, which are currently applied for indicating low land productivity, by the Member States for their classification of the Other Less Favoured Areas are included. Finally, a summary of the reviewed methods and criteria and a discussion of issues of importance in the ongoing work on identifying common biophysical criteria for the Other Less Favoured Areas are provided.

The report is aimed to be a base for DG Agriculture and Rural Development in their consultation with Member States and future networks of scientists involved in the progress of classifying the Other Less Favoured Areas from biophysical criteria, seen as natural handicaps to agriculture.

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The Section 1.3 on Less Favoured Areas has earlier been published in Eliasson et al., (2007) and has been prepared by Åse Eliasson with the support of Jean-Michel Terres and Catharina Bamps of the Rural, Water and Ecosystem Resources Unit, Institute of Environment and Sustainability, Joint Research Centre.

Contents

1. Introduction

1.1 Land Evaluation

Land evaluation is an important tool in the improved and sustainable management of land resources. Land evaluation can be formally defined as “the process of assessment of land performance when used for a specified purpose, involving the execution and interpretation of surveys and studies of land forms, soils, vegetation, climate and other aspects of land in order to identify and make a comparison of promising kinds of land use in terms applicable to the objectives of the evaluation” (FAO, 1976).

Conceptually, land evaluation requires matching of the biophysical conditions and management requirements of appropriate kinds of land use with land qualities, whilst taking local economic and social conditions into account. It includes analysis of data and information about the land on, for example, its soils, climate and vegetation conditions as well as economical and social factors.

Land evaluation has a wide range of purposes from land use planning to exploring the potential for specific land uses or the need for improved land management or land degradation control. It can provide practical answers to questions such as *"What other uses of land are physically possible and economically and socially relevant?", "What inputs are necessary to provide a desired level of production?"* and *"What are the current land uses and what are the consequences if current management practices remain the same?"* (Hubert, 2003).

Depending on the purpose, land evaluation can be carried out at different scales, e.g. local, national, regional (e.g. European) and global and with different levels of quantification, i.e. qualitative vs. quantitative. Studies at the national scale may be useful in setting national priorities for development, whereas studies at the local level are useful for selecting specific management options for implementation (Hubert, 2003).

There are various descriptions of land evaluations and different terminologies and concepts used, see list below. Many land evaluation tools originate from the Agricultural Land Capability Classification System (Klingebiel and Montgomery, 1961). The term “land capability” is mainly based on the assessment of soil and/or climate conditions to support common cultivated crops and pasture plants. In comparison, the term “land evaluation” often refers to the analysis of specific crops and its land management options and socio-economic content. A well known land evaluation system is the Framework for land evaluation developed by the Food and Agriculture Organization of the United Nations (FAO, 1976 and 2007). In this report the term land evaluation has been chosen as an overall term, but it also includes land quality, land capability and land suitability assessment methods. The term “land qualities” is more related to the work by DG Agriculture and Rural Development on developing common biophysical criteria, mainly soil and climate criteria for classifying areas with natural constraints to agriculture.

Concepts used in the field of land evaluation:

- **Land:** An area of the earth's surface. In the context of land evaluation, land includes all properties of the surface, soil and climate, together with any resident plant and animal communities (FAO, 1996).
- **Land mapping unit:** Is a mapped area of land with specified characteristics. Land mapping units are defined and mapped by surveys, e.g. soil survey, forest inventory. Their degree of homogeneity or of internal variation varies with the scale and intensity of the sampling scheme used. In some cases a single land mapping unit may include two or more distinct types of land, with different suitabilities, e.g. a river flood plain, mapped as a single unit but known to contain both well-drained alluvial areas and swampy depressions (modified from FAO, 1976)
- **Land quality**: A complex attribute of land which acts in a distinct way in its influence of land for a specific use. Examples are moisture availability, soil quality, erosion resistance, flooding hazards etc. (FAO, 1976).
- **Land evaluation:** the assessment of land performance when used for a specified purpose, involving the execution and interpretation of surveys and studies of land forms, soils, vegetation, climate and other aspects of land in order to identify and make a comparison of promising kinds of land use in terms applicable to the objectives of the evaluation (FAO, 1976).
- **Land capability/land suitability:** Capability is viewed by some as the inherent capacity of land to perform at a given level for a general use, and suitability as a statement of the adaptability of a given area for a specific kind of land use; others see capability as a classification of land primarily in relation to degradation hazards (FAO, 1976).

For further information on: the theories of land evaluation, see Rossiter (1996); the history of land evaluation, see van Diepen (1991); the use of economic valuation, see Rossiter (1995); and glossary of land evaluation terms, see FAO (2007). In addition, for an ongoing work on soil quality and sustainability evaluation to support soil related policies of the European Union, see (Tóth et al., 2007)

1.2 Natural Constraints to Agriculture

Natural constraints to agriculture concern the suitability of land to be used for rainfed agriculture and can be characterised by the following conditions (after Fischer, 2002):

Climatic conditions:

- The yield-quality reducing factors of pests, diseases and weeds.
- The climatic factors, operating directly or indirectly, that reduce yield and quality of crop mainly through their effects on yield components and yield formation.
- The variability and degree of water-stress during the growing period.
- The climatic factors which affect the efficiency of farming operations and costs of production.
- The risk of occurrence of late and early frost.

Soil and terrain conditions:

- Landform and other features effecting the use of the land, workability and accessibility.
- Internal soil requirements: e.g. soil temperature regime, soil moisture regime, soil fertility, effective soil depth for root development and other physical and chemical soil properties.
- External soil properties: e.g. soil slope and occurrence of soil flooding and soil erosion.

Please note that the above conditions have different influences depending on crop type and level of inputs and management.

1.3 Less Favoured Areas

Objectives of the scheme

Certain rural areas are classified as Less Favoured Areas (LFA) because conditions for farming are more difficult due to natural constraints, which increase production costs and reduce agricultural yields. The aid for the LFA in the EU dates back to 1975 and has since then undergone several reforms from being focused on addressing rural depopulation towards increased focus of maintaining certain agricultural land use and environmental protection. In addition, over time Member States have been offered increased flexibility of the implementation of the measure, i.e. Member States are responsible for changing the LFA classified, which has resulted in regional differences on how the measure is applied within the Member States.

The LFA measure is under the legislation of EC, Council Regulation (1999) No. 1257/1999 until the end of 2009, where the aims of the LFA measure are:

- to ensure continued agricultural land use
- to maintain the countryside
- to maintain and promote sustainable farming
- to ensure environmental requirements and safeguarding of farming in areas with environmental restrictions
- to contribute to viable rural communities in the LFA

A new LFA scheme is expected to enter into force in 2010 according to the new objectives set by Council Regulation (EC) No. 1698/2005, where the objective "to ensure environmental requirements and safeguarding of farming in areas with environmental restrictions" has been moved to other measures and the social objective "to contribute to viable rural communities in the LFA" has been removed.

Within the Rural Development Policy for 2007-2013 (EC, Council Regulation 2005), the LFA scheme is part of Axis 2 which aims at improving the environment and the countryside by supporting land management. The Rural Development and the LFA scheme are financially supported by the European Agricultural Guidance and Guarantee Fund.

Categories

There are four categories classified as LFA. Each category covers a specific cluster of natural handicaps in Europe in which the continuation of agricultural land use is threatened.

1. **Mountain areas (Article 18) –** are characterised as those areas handicapped by a short growing season because of a high altitude, or by steep slopes at a lower altitude, or by a combination of the two.
2. **Other LFA (Article 19) –** are those areas in danger of abandonment of agricultural land use and where the conservation of the countryside is necessary. They exhibit all of the following handicaps: land of poor productivity, production which results from low productivity of the natural environment, and a low or dwindling population predominantly dependent on agricultural activity.
3. **Areas affected by specific handicaps (Article 20) –** are areas where farming should be continued in order to conserve or improve the environment, maintain the countryside, and preserve the tourist potential of the areas, or in order to protect the coastline.
4. **Areas subjected to environmental restrictions (Article 16) –** are areas with restrictions on agricultural usage resulting from the implementation of limitations on agricultural land use imposed by the EC. (This article is no longer in force in the Rural Development Policy 1698/2005)

In 2004, the surface area classified as LFA in the EU 25 Member States accounted for 91 million hectares, which represents 54% of the utilised agricultural area of the EU. Of the total LFA classified, the category 2 (Other LFA) represented as much as 66%, see Figure 1.3.1 (IEEP, 2006a).

Category 3 (specific handicaps) cannot exceed 10% of the area of the Member State concerned. The spatial distributions of the municipalities/communes classified as LFA in Europe are shown in Figure 1.3.2.

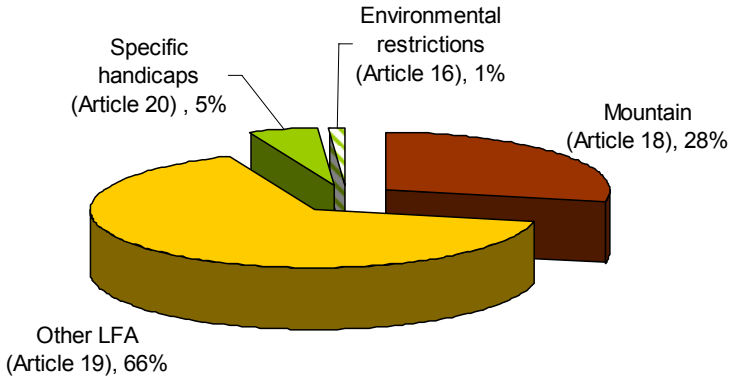

Figure 1.3.1. Representation of the different categories of the total area classified as LFA.

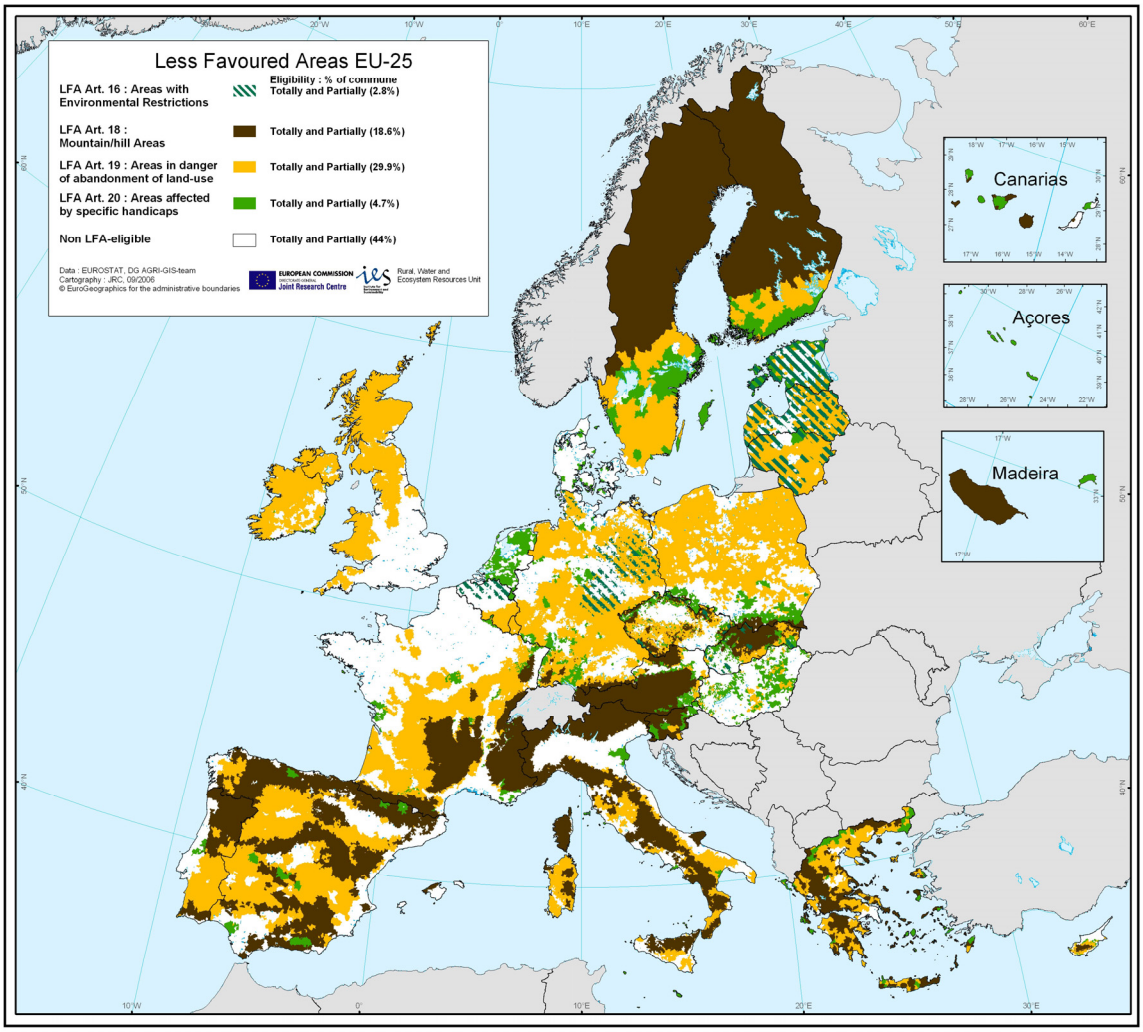

Figure 1.3.2. The map shows the distribution of communes in Europe, i.e. Local Administrative Unit 2 (Nuts 5) that have been classified under the current legislation as being eligible for LFA support for the 4 categories. Please note that the map shows the information aggregated at communal level: the communes for which the whole (total) or part of the communal territory (partially) is eligible for LFA support. The percentage of the total number of communes eligible by the different articles is shown in brackets in the legend.

Classification

For a farmer to be eligible for LFA payments there are two distinct levels of eligibility. Firstly, the farm has to be located in an area classified as an LFA. Eligible LFA are designated at the commune or lower level in the Member States (see Figure 1.3.2). Secondly, it is the conditional criteria which are defined at farm level, for which the farmer has to apply with a number of rules and criteria. The Joint Research Centre LFA project concerns the first level of eligibility, the areas classified as Other LFA (refer to areas shaded in yellow Figure 1.3.2).

The Other LFA is defined by Article 19 as areas which are in danger of abandonment of land use and where conservation of the countryside is necessary. Eligible areas for the Other LFA must be homogenous in natural production conditions and fulfil the characteristics of all the criteria below (current legislation):

- Land productivity: Criteria indicating poor land conditions and low productivity, difficult cultivation and limited potential which cannot be increased except at an expensive cost, and which is mainly suitable for extensive farming. (Example of indicators applied: yields in relation to national average yields; stocking rate; percentage of grazing land; diverse indices of land quality.)
- Economic performance of agriculture: Criteria indicating low level of agricultural production, acknowledged below average output per hectare. (Example of indicators applied: farm/labour income per working unit.)
- Population: Criteria indicating low or declining population predominantly dependent on agricultural activity, the accelerated decline of which would jeopardise the viability of the area concerned and its continued habitation. (Example of indicators applied: population density, agricultural population and depopulation rate.)

Member States use a wide range of different criteria for classifying the Other LFA. Examples of indicators that are applied in the Member States are shown in brackets under the respective characteristic. For the first condition on land productivity a wide range of different criteria and methods are used in the Member States. This is the category of criteria which relates to the Joint Research Centre's LFA project on identifying potential common biophysical criteria.

Eligibility at farm level

The second level of eligibility for LFA payments concerns the eligibility at farm level. The eligibility criteria are the same for all the four different categories of the LFA and are defined as (EC, Council Regulation 1999):

- Farm a minimum land area. The limit applied varies between Member States from 0.1124 ha in Malta to 10 ha in England, with the majority having a limit of 1-3 ha.
- Undertake to farm for at least 5 years.
- Apply Good Farming Practices, standards consistent with the protection of the environment/countryside to promote sustainable agriculture.

In addition to these mandatory eligibility criteria, most Member States apply a variety of additional criteria to define eligibility for the scheme at farm level. Examples of additional farm eligibility criteria concern the following:

- Type of land use: e.g. grasslands only eligible, grassland and/or crops for fodder only eligible, exclusion of certain crops (corn, flowers, permanent crops and tobacco) and exclusion of irrigated areas.
- Type of livestock: certain type of livestock required in some cases and minimum and maximum stocking density is required for the farm to be eligible.
- Criteria on farm properties: age of farmer, farm income, family income, residence of farmer.

Compensatory payments

In 2004 compensatory payments were granted to 1.8 million farmers (18% of total), where 40 million hectares[1] were used as a calculation base for the compensatory payments, which amounts to approximate 24% of the utilised agricultural areas of the EU 25[6]. The public expenditure amounted to 3 075 million Euros, including 1 561 million Euros from the European Agricultural Guidance and Guarantee Fund, which equates to an average co-financing rate from Member States of 51% (IEEP, 2006a)

In 2004, the weighted average payment per hectare for LFA was 75 Euro for the EU 25 Member States, but payments ranged from 15-25 Euro/hectare in Spain and Estonia to 180-250 Euro/hectare in Malta, Finland and Austria. Previously, the LFA payments were based on per head of livestock, but then changed under Agenda 2000 to area payments to break the link with production.

The payments are often differentiated in the Member States depending on various factors such as: type of land use, stocking rate, zones (on land quality, yields), farm size, full time or part time farmers.

Evaluations of the LFA scheme

In 2003 a review of the LFA scheme was carried out by the Court of Auditors (2003). The main points of criticisms were that:

- Member States use a wide range of indicators to determine whether areas are less favoured or not, which lead to differences in the eligibility of the beneficiaries.
- The surface areas classified as LFA were highly variable. The rate of surface areas classified as LFA of the utilised agricultural areas varies considerably in the Member States, from 1% in Denmark to 98% in Luxembourg.
- The category of Other LFA (Article 19) is considerably larger than the other categories, and for this category the regulation has not been so clearly defined.

[1] This figure relates only to areas which actually received compensatory allowances, excluding Cyprus, Italy and Lithuania.

In 2005 the Council defined the new Rural Development Policy for 2007-2013, by adopting Regulation 1698/2005. In this framework, the Council adopted a new definition of the LFA other than mountain areas which, according to Article 50.3 a), of Council Regulation 1698/2005,

"*must be affected by significant natural handicaps, notably a low soil productivity or poor climate conditions and where maintaining extensive farming activity is important for the management of the land".*

However, the Council could not reach an agreement on the criteria to be used for defining such "Other LFA". A Commission non-paper[2] containing common delimitation criteria was discussed by a Council working group and was rejected due to the absence of fully examining other options.

In 2006, a comprehensive evaluation of the LFA measure was carried out by the Institute for European Environmental Policy (IEEP, 2006b) for DG Agriculture and Rural development. The evaluation report concluded that:

- The principal goal of the LFA measure had been attained in the EU 15. The area of total land abandonment is small in comparison to other industrialised countries although it is difficult to determine this on the data available.
- The LFA measure is of importance for the contributions of the objective "maintaining the countryside", through the continued use of agricultural land and also to "maintain and promote sustainable farming systems". Continued agricultural management has made greater contribution to the countryside where it supports the maintenance of valued open landscapes, semi-natural habitats and biodiversity, it assists in the control of forest fires, or contributes to good soil and water management. Furthermore, features such as grazed semi-natural grasslands and hillside terraces stem from farming practices.
- The objective "to contribute to viable rural communities" in order to prevent rural depopulation through continued agricultural activity (which was removed in the Rural Development Plan 1698/2005) has ceased to be relevant for most part of the EU 15 as the share of employment directly dependent on agriculture has declined.
- The measure has been most effective on livestock farms, which have been the focus of payments in most Member States.
- The compensatory payments have been more effective in maintaining land use rather than securing the most appropriate form of management with both intensification and under-grazing in some areas. However, the pressure of over intensive management has been removed with the change to area payments instead of per head of livestock.

New definition of the Other LFA

The JRC is supporting DG Agriculture and Rural Development in the new definition of the Other LFA (Article 50.3 a), former Article 19) by providing technical support and consulting with experts through informal networks in the Member States.

[2] A non-paper is a non official document.

The motive for changing the current definition of the category Other LFA is to allow for objective criteria for a more transparent approach in Europe and to respond better to the Axis 2 objectives on Land Management and Environment of the Rural Development planning. The aim is to make compensatory payments for the additional cost of managing the land due to natural handicaps.

The reason for the future new definition to be based on natural conditions and not to include socio-economic indicators, e.g. on farm/labour income per working unit, is to better achieve the new policy objectives: Axis 2, where LFA is one of the measures. This is inline with the negotiations with the World Trade Organisation to allow support related to environmental constraints (green box).

It is envisaged that the criteria should be based on the definition in the Council Regulation 1698/2005 article 50. 3 a), which states that the Other LFA:

"*must be affected by significant natural handicaps, notably a low soil productivity or poor climate conditions and where maintaining extensive farming activity is important for the management of the land"*

For more background information of the LFA see; EC, Council Regulation (1999 and 2005); IEEP (2006a and 2006b), which provides an extensive evaluation of the LFA measure; and Eliasson et al. (2007) for the proceedings of an expert consultation in identifying common soil and climate criteria that can be used for the new definition of the Other LFA, including background information on the LFA.

1.4 Objectives of this Report

The objectives of this report are to:

i. Describe internationally known land evaluation methods applied on the continental and regional level.
ii. Give an overview of biophysical, soil and climate criteria applied internationally and in the Member States for the Other Less Favoured Areas.

The report is written for a non-specialised land evaluation user and is aimed to be a base for DG Agriculture and Rural Development in their consultation with Member States and future networks of scientists involved in the progress of classifying the Other LFA from biophysical criteria, seen as natural handicaps to agriculture.

The report provides the following information:

- An introduction to land evaluation, natural constraints to agriculture and Less Favoured Areas (Chapter 1).
- A review of selected internationally known land evaluation methods with focus of methods applied on the continental and regional scale. A standard template has been followed to report in a consistent way and to ease further analysis and comparisons on common soil and climate criteria and definitions (Chapter 2).
- A summary of land evaluation methods and criteria on low land productivity applied in the Member States for the classification of the Other Less Favoured Areas (Chapter 3).
- Summary of reviewed methods and criteria and discussion of issues of importance in relation to the new definition of the Less Favoured Areas (Chapter 4).
- List of references (Chapter 5).

The report builds on published and non-published information that has kindly been provided by the acknowledged scientists.

2. Land Evaluation Methods Applied Internationally

2.1 Introduction

There is a range of land evaluation assessment methods, which are applied internationally and a review of selected methods applied on the continental and regional scale is included in this report. Different methods have been constructed for different purposes and therefore the process and analysis are different. An overview of these selected land evaluation methods are given in Table 2.1.1 and an in-depth description of the respective method, example of application with preference to the European level and results are provided. The review does not cover land evaluation methods applied on the field scale level and for further information on national land evaluation methods see Heineke et al. (1998) and Jones et al. (2005).

A standard template has been followed to report in a consistent way of the selected land evaluation methods and to ease further analysis and comparisons on common soil and climate criteria and definitions. The content of the individual descriptions of the different methods depends on what has been available in documentation, contributions and what has been considered relevant in relation to the work on the new definition of the Other (Article 19) Less Favoured Areas (EC, 1999), i.e. to define common biophysical criteria, mainly soil and climate criteria for Europe.

Table 2.1.1. Selected land evaluation methods known internationally and applied on the continental and regional scale. Methods are presented in order of year of origin.

Land evaluation method	**Description**
Land Capability Classification (Klingebiel and Montgomery, 1961)	The first Land Capability Classification was developed in the USA by the Soil Conservation Service (now the Natural Resources Conservation Service) of the US Department of Agriculture (USDA) and the method mainly provides a broad interpretation of soil qualities. Land Capability Classification is a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without degrading the soil over a long period of time. The USDA Soil Conservation Service has used this method for over 40 years as a planning tool in laying out conservation measures and practices on farms to prevent land degradation. The method has been a base for many other systems and is applied widely.

Continuation of Table 2.1.1.

Land evaluation method	Description
Framework for Land Evaluation (FAO, 1976 and 2007)	The Framework for Land Evaluation was published by the FAO (Food and Agriculture Organization of the United Nations) in 1976 and was a way to standardize land evaluations, building on earlier concepts and methodologies to improve compatibility in-between different methods as well as to include socio-economic concepts. The Framework was revised in 2007 to serve as a discussion base for further developments. The framework provides a set of principles and concepts for application of land evaluations at the local, national and regional scale. More detailed guidelines are provided for applications within forestry, rainfed agriculture, irrigated agriculture, extensive grazing and land use planning. The framework has been extensively applied and been the base in the development of computerised evaluation tools and databases.
Agro-Ecological Zoning (FAO, 1978, 1996 and Fischer et al., 2002)	AEZ (Agro-ecological Zoning) Method uses a land resources inventory to assess all feasible agricultural land-use options for specific management conditions and levels of inputs, and to quantify the expected production of relevant cropping activities. The AEZ methodology is widely recognised and has been developed by the FAO in collaboration with IIASA (The International Institute for Applied System Analysis). The AEZ methodology provides a standardised framework for the characterisation of climate, soil and terrain conditions relevant for agricultural production.
Agricultural Problem Land Approach (FAO,1990 and Nachtergaele, 2006)	The Problem Land Approach is a straightforward and simple approach for identifying broad types of agricultural problem soils and limitations in climate. The approach identifies mainly soil types with common characteristics that dominate frequently agricultural land use. A simple classification system for Agricultural Problem Land has been developed and applied for Europe.
Expert System for Constraints to Agricultural Production in Europe (Le Bas et al., 2001 and 2002)	ESCAPE (Expert System for Constraints to Agricultural Production in Europe) is a model that has been developed by INRA (French National Institute for Agricultural Research) and applied Europe-wide in collaboration with the Joint Research Centre (Soil and MARS, Monitoring Agriculture with Remote Sensing). The model is based on simple soil and climate criteria, with a minimum set of parameters, which vary according to different crop groups namely: cereals, maize, root crops, oilseed crops, grasslands, olive trees and vineyards. Three sets of limitations are evaluated: soil, temperature and water constraints.

2.2 Land Capability Classification

What is the Land Capability Classification?

The first land capability classification was developed in the USA by the Soil Conservation Service (now the Natural Resources Conservation Service) of the US Department of Agriculture (USDA). The method has been a base for many other systems and has been applied widely. Its origin dates back to the 1930s and it was developed for one socio-economic condition: typical mixed family farms in the middle USA, where soil conservation and prevention of land degradation was the critical issue in the 1960s.

In this report the Land Capability Classification method refers to the method developed by the USDA (Klingebiel and Montgomery, 1961) although it should be recognised that the term "land capability" is used in a number of land classification systems. Land capability classification is a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without degrading the soil over a long period of time (FAO, 1976). A good description of the USDA Land Capability Classification system, which also been used for this review, can be found by Rossiter (1994).

When to use the Land Capability Classification?

Examples of applications of the USDA Land Capability Classification are for, identification of different groups of land suitable to different types of production and mapping of broad types of agricultural land suitability.

Criteria and method of the Land Capability Classification

The USDA Land Capability Classification method is based on the classification of a land unit into a) capability class, b) capability subclass and c) capability unit, which are described below.

The method is based on a number of assumptions such as:

- The capability classification is an interpretive classification based on the effects of combinations of climate and permanent soil characteristics on: limitations affecting land use, risk of soil damage if mismanaged, needs for soil management and risk of crop failure. This opposed to soil classification, which is based directly on the soil characteristics.
- The criteria on the presence of water on the surface or excess water in the soil, lack of water for adequate crop production, presence of stones, presence of soluble salts or exchangeable sodium, or both, or hazard of overflow are not considered as permanent limitations to use in the classification where the removal of these limitations is feasible.
- Within a class there might be different soils but with the same degree of limitations in soil use for agricultural purposes or hazards to the soil, when it is

used. If the land unit consists of more than one capability class the land unit is given the lowest class.

- There is no crop productivity rating, i.e. class IV (see below) can be more productive than class I, but also more fragile.
- Profitability is not determined.
- A single moderately high level of management is assumed.
- Factors such as distance to market, conditions of roads and location of fields are not included.

The USDA Land Capability Classification is based on eight capability classes, from I (best) to VIII (worst):

I. Soils have few limitations that restrict their use.
II. Soils have some limitations that reduce the choice of plants or require moderate conservation practices.
III. Soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.
IV. Soils have very severe limitations that reduce the choice of plants, require very careful management, or both.
V. Soils have little or no erosion hazards but have other limitations, impractical to remove, that limit their use largely to intensive pasture or grazing, forest, or wildlife food or cover.
VI. Soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or grazing, woodland, or wildlife.
VII. Soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, forest or wildlife.
VIII. Soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, or water supply, or to esthetical purposes.

Class I to IV are applicable for arable land and the classes V to VIII are not to be used for cropping, but may have use for pasture, grazing, forest, wildlife, recreation and esthetical purposes. The classes correspond to a ranking of major kinds of land uses from: very intense cultivation (I), intense cultivation (I-II), moderately intense cultivation (I-III), limited cultivation (I-IV), intense grazing (I-V), moderate grazing (I-VI), limited grazing (I-VII), forestry (I-VII), to wildlife (I-VIII).

The criteria on limitations to determine the various capability classes concern:

- climate (temperature and dryness)
- slope
- susceptibility for wind and water erosion
- flooding resulting in crop damage
- wetness
- soil depth (including limitation on fragipans and claypans)
- soil texture and structure (workability, soil-moisture holding capacity)
- low soil fertility
- soil salinity and alkalinity

- landform (e.g. badlands, rock outcrops, sandy beaches)

The capability subclasses indicate the major limitation by four classes:
(e) Erosion: is made up of soils where the susceptibility to erosion is the dominant problem or hazard in their use. Erosion susceptibility and past erosion damage are the major soil factors for placing soils in this subclass.

(w) Excess water: is made up of soils where excess water is the dominant hazard or limitation in their use. Poor soil drainage, wetness, high water table, and overflow are the criteria for determining which soils belong in this subclass.

(s) Soil limitations within the rooting zone: includes soils that have limitations such as shallowness of rooting zones, stones, low moisture-holding capacity, low fertility difficult to correct, and salinity or alkalinity.

(c) Climatic limitation: is made up of soils where the climate (temperature or lack of moisture) is the only major hazard or limitation in their use

The capability unit is a subdivision of the capability subclasses depending on the management practices. For example, class IIIs (Soils have severe limitations that reduce the choice of plants, require special conservation practices, or both; soil limitations within the rooting zone) could be due to excess gravel in the root zone or excess salts, i.e. the codes IIIs1 and IIIs2 could be assigned. The capability units are assigned for the individual applications, but they generally correspond to phases or soil groups in the national soil survey.

The classification is based on the written definition interpreted by a land surveyor, this opposed to a systematic classification scheme. However, although the method is subjective it can be very consistent when applied by an experienced land surveyor. The method can be made more objective by the construction of interpretive tables where different characteristics can be set for each class (Rossiter, 1994).

Applications of the Land Capability Classification

The USDA Soil Conservation Service has used this method for over 40 years as a planning tool in laying out conservation measures and practices on farms to prevent land degradation. Figure 2.2.1 shows the result by state of the application in the USA.

It has been adapted for many other conditions and extensively applied in Latin America, but always with a "typical" farmer in mind. One constraint is that it cannot deal at all with special crops, e.g. like cranberries.

Adaptations of the method to local conditions are often made in the various applications to better fit the individual needs. One example is the Land Capability Classification for Agriculture by MLURI (Macauley Land Use Research Institute) in Scotland, which is used for the classification of the Less Favoured Areas which is based on the USDA Land Capability Classification (MLURI, 1991).

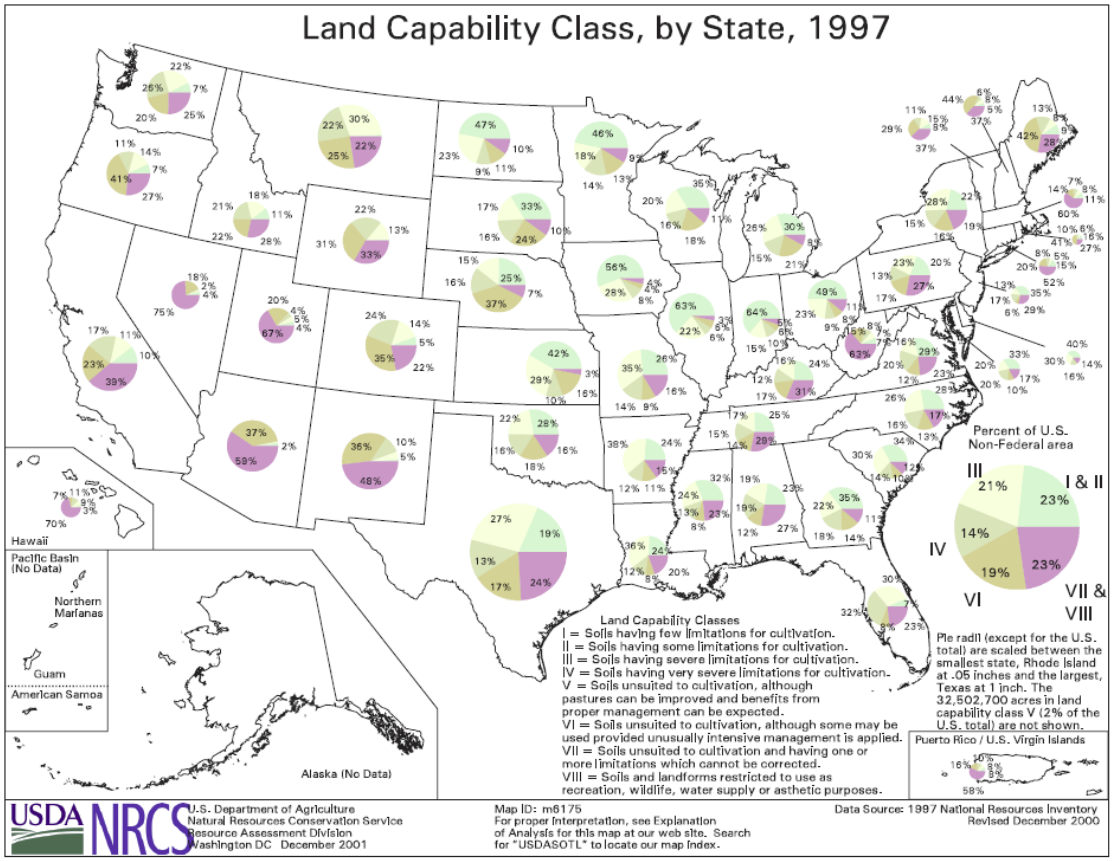

Figure 2.2.1. Land Capability Classification in the USA, showing percentage of capability class I-II, III, IV, VI, VII-VIII in the different states. The capability class V is not shown as it only amounts to 2% of the total land classified (USDA, 1997).

Links on the web

USDA Land Capability Classification
http://soils.usda.gov/technical/handbook/contents/part622p2.html#ex2

2.3 Framework for Land Evaluation

What is the Framework for Land Evaluation?

The Framework for Land Evaluation was published in 1976 by the FAO (Food and Agriculture Organization of the United Nations) and was a result of ways to standardise and improve the compatibility in-between land evaluations. The framework was a result of working groups mainly driven by European soil scientists working with development projects (Rossiter, 1994). The framework sets out a number of principles involved in land evaluations, some basic concepts, the structure of a suitability classification and the procedures necessary to carry out a land suitability evaluation. The framework is not a ready method and does not therefore identify thresholds for criteria etc. The principles and procedures can be applied in all parts of the world. The framework is built from earlier concept and methodologies, including the USDA Land Capability Classification (Klingebiel and Montgomery, 1961). What was new at this time, in 1976, was that it included socio-economic concepts. Following the published framework more detailed guidelines have been published with applications within forestry, rainfed agriculture, irrigated agriculture, extensive grazing and land use planning (FAO, 1983, 1984, 1985, 1991, 1993). The framework has been extensively applied and been the base in the development of computerised evaluation tools and databases (Hubert, 2003).

In 2007, a discussion paper on the Land Evaluation Framework was published to serve as a base for further developments on the evolvement of land evaluations to include additional concepts, definitions, principles and procedures in the Framework and to address them more systematically. The framework also needs to reflect current concerns regarding climate change, biodiversity and desertification. It recognises the multiple function of land and benefits, the importance of sustainability, the availability of new tools and the need for participatory approaches (FAO, 2007).

The framework can be described in three levels of details: a) framework, b) guidelines and c) examples of evaluations.

When to use the Framework for Land Evaluation?

The Framework for Land Evaluations can be used for a range of applications covering land evaluations on: different types of agriculture and livestock production, either together with forestry, recreation or tourism and nature conservation with different objectives. The framework has been extensively applied and been the base in the development of computerised evaluation tools and databases.

Criteria and methodology of the Framework for Land Evaluation

Some key points from the Framework of Land Evaluation are that:

- Evaluation is carried out separately for each specific land use and then compared.
- Land is ranked from very suitable to unsuitable land for a specific use, instead of ratings from excellent to poor.
- There are no bad land areas, only inappropriate land uses.
- Land should be evaluated in both physical and socio-economical terms:

The framework recognises four main types of suitability classification, depending on whether the evaluation is qualitative or quantitative, or if it refers to current or potential suitability.

An example of the land suitability classification scheme for rainfed agriculture is given in Table 2.3.1.

Table 2.3.1. Land suitability classification for rainfed agriculture (in Hubert, 2003 from FAO, 1976 and 1983).

<table>
<tr><td colspan="4">Order: Suitable</td></tr>
<tr><td colspan="3">S1 class</td><td>High</td><td>no or non-significant limitations</td></tr>
<tr><td>S2 class</td><td>S2e sub-class</td><td>S2e-1 unit
S2e-2
etc.</td><td>Moderate</td><td>moderately severe limitations which reduce productivity or benefits or increase required inputs</td></tr>
<tr><td colspan="3">S3 class</td><td>Marginal</td><td>overall severe limitations; given land use is only marginally justifiable</td></tr>
<tr><td colspan="4">Order: Not Suitable</td></tr>
<tr><td colspan="3">N1 class</td><td>Currently not suitable</td><td>limitations not currently overcome with existing knowledge within acceptable cost limits</td></tr>
<tr><td colspan="3">N2 class</td><td>Permanently not suitable</td><td>limitations so severe that they preclude all possibilities of the given use</td></tr>
</table>

The Subclass includes different kinds of limitations. Below are some of the most common limitations shown:

(c) Temperature regime
(m) Moisture availability
(w) Oxygen availability to roots (drainage)
(n) Nutrient availability
(r) Rooting conditions
(f) Flood Hazard
(z) Excess of salts
(x) Toxicities
(q) Potential for mechanisation
(e) Erosion hazard

Applications of the Framework of Land Evaluation

The framework has been extensively applied and is used in the FAO and UNDP (United Nations Development Program) project and by many agencies, with modifications made locally. In addition, automated approaches based on computer models providing quantitative assessments in comparison with earlier non-automated

qualitative approaches have been developed. Examples are the Agro-ecological Zoning methodology (Fischer et al., 2002) which is directly based on the Framework of land Evaluation and ALES (the Automated Land Evaluation System) developed at Cornell University (Rossiter, 2007). In Figure 2.3.1 is the Suitability index shown globally for rainfed wheat, as an example of an application based on the Framework for Land Evaluations. In addition, national to regional databases on soil and terrain, SOTER (FAO, 1995a) containing standardised information on e.g. landform, morphology, slope, parent material and soils which are useful in applications of land evaluations have been created by the partners: UNEP (United Nations Environment programme), ISRIC (International Soil Reference and Information Centre), IIASA (The International Institute for Applied System Analysis), European Soil Bureau and National Soil Institutes.

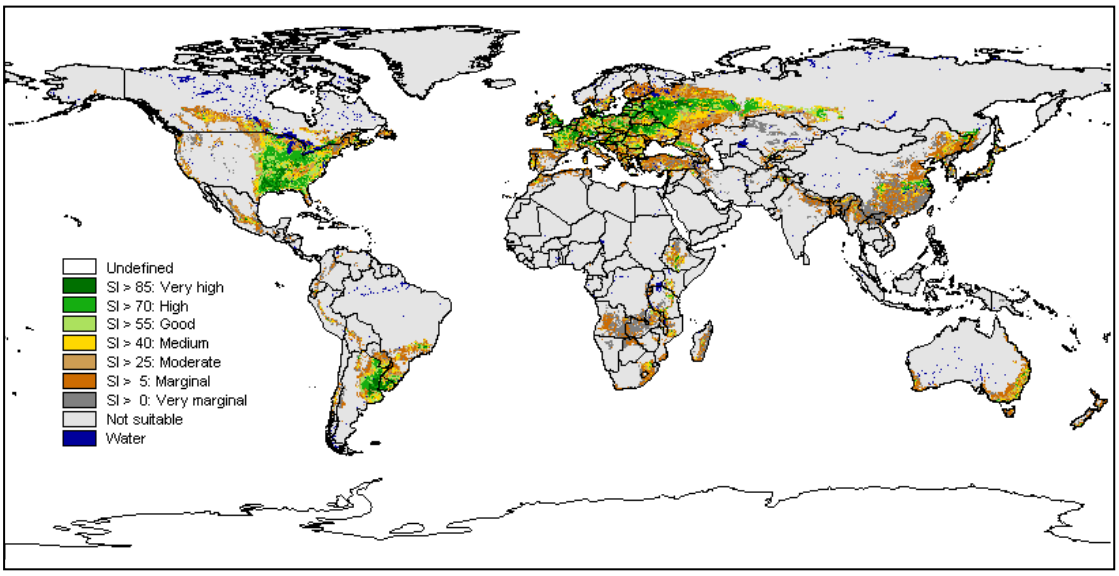

Figure 2.3.1. Suitability of rainfed wheat globally from the Agro-ecological Zoning methodology, which is based on the Framework for Land Evaluations (Fischer et al., 2002)

Links on the web

Report: Framework for Land Evaluation
http://www.fao.org/docrep/X5310E/X5310E00.htm

Report: Land evaluation, towards a revised framework
http://www.fao.org/nr/lman/docs/lman_070601_en.pdf

2. 4 Agro-ecological Zoning methodology

What is the Agro-ecological Zoning?

The Agro-ecological Zones (AEZ) methodology is based on a land resources inventory for assessing all feasible agricultural land-use options for specific management conditions and levels of inputs, and to quantify the expected production of relevant cropping activities. The AEZ methodology has been developed by FAO (Food and Agriculture Organization of the United Nations) in collaboration with IIASA (The International Institute for Applied System Analysis) and the methodology has been applied worldwide with the development of a worldwide spatial land resource database that enables evaluation of biophysical limitations and production potential of major food and fibre crops of various conditions (Fischer et al., 2002). The original Agro-ecological Zones project (FAO, 1978) was an early exercise in the application of land evaluations at a continental scale, which was followed by the publication of the "Agro-ecological Zoning guidelines" (FAO,1996) and "The Global Agro-ecological Assessment for Agriculture in the 21st Century: Methodology and Results" (Fischer et al., 2002).

Agro-ecological Zoning is defined as the division of an area of land into smaller units, which have similar characteristics related to land suitability, potential production and environmental impact (FAO, 1996).

The term AEZ methodology has become widely used over the last 20 years and it has been associated with different activities which are described below:

1. AEZ provides a standardised framework for characterising climate, soil and terrain conditions relevant to agricultural production. The concepts of length of growing period and of latitudinal thermal climates have been applied in mapping activities focusing on zoning at different scales, from sub-national to national.

2. AEZ applies matching procedures for prediction of crop yields under different levels of inputs and management conditions. The matching is based on identified crop specific limitations of prevailing climate, soil and terrain conditions. This provides maximum potential and agronomical attainable crop yield for a land mapping unit (processing unit usually grid cell).

3. AEZ provides a frame for various types of land resources assessments application. On the basis of the information acquired in the first two activities a number of applications are available, such as: quantification of land productivity. Extent of rainfed and irrigated cultivation potential, estimation of the lands population supporting capacity, and multi-criteria optimisation of land resources use.

When to use Agro-ecological Zoning?

AEZ can be used in various assessment applications, such as:

- land resource inventory
- inventory of land utilization types and production systems
- potential yield calculation

- land suitability and land productivity evaluation , including forestry and livestock productivity
- estimation of arable areas
- mapping agro-climatic zones, problem soil areas, agro-ecological zones, land suitability, quantitative estimates on potential crop areas, yields and production
- land degradation assessment, population supporting capacity assessment and land use optimisation modelling
- assessing and mapping flood and drought damages to crops
- assessment of impact of climate change
- monitoring land resources development

Criteria and Methodology of the Agro-ecological Zoning

The AEZ framework is described in five different elements, which are illustrated in a very simplified way in Figure 2.4.1. The elements include:

1. Land utilization types (LUTs): Selected agricultural production systems with defined input and management relationships, and crop-specific environmental requirements and adaptability characteristics.
2. Land resources database: Geo-referenced climate, soil, and terrain data, combined into a database. Pedotransfer rules are used for estimating some soil variables.
3. Crop yields and LUT requirements matching: Procedures for calculating potential yields and for matching crop/LUT environmental requirements with the respective environmental characteristics contained in the land resources database, by land unit and grid-cell.
4. Assessments of crop suitability and land productivity
5. Applications for agricultural development planning.

The methodology includes a crop catalogue database for all the Land utilization types (where 154 crops are distinguished and defined at three levels of input and management options, termed high, intermediate and low). The Crop catalogue holds for each crop and level of input a range of factors of crop characteristics, such as: length of crop growth cycle, specific crop water requirement coefficients, yield reduction factors relating to moisture stress and yield loss accordingly and crop requirements (e.g. thermal climate requirement, growing period requirements, and soil and terrain requirements).

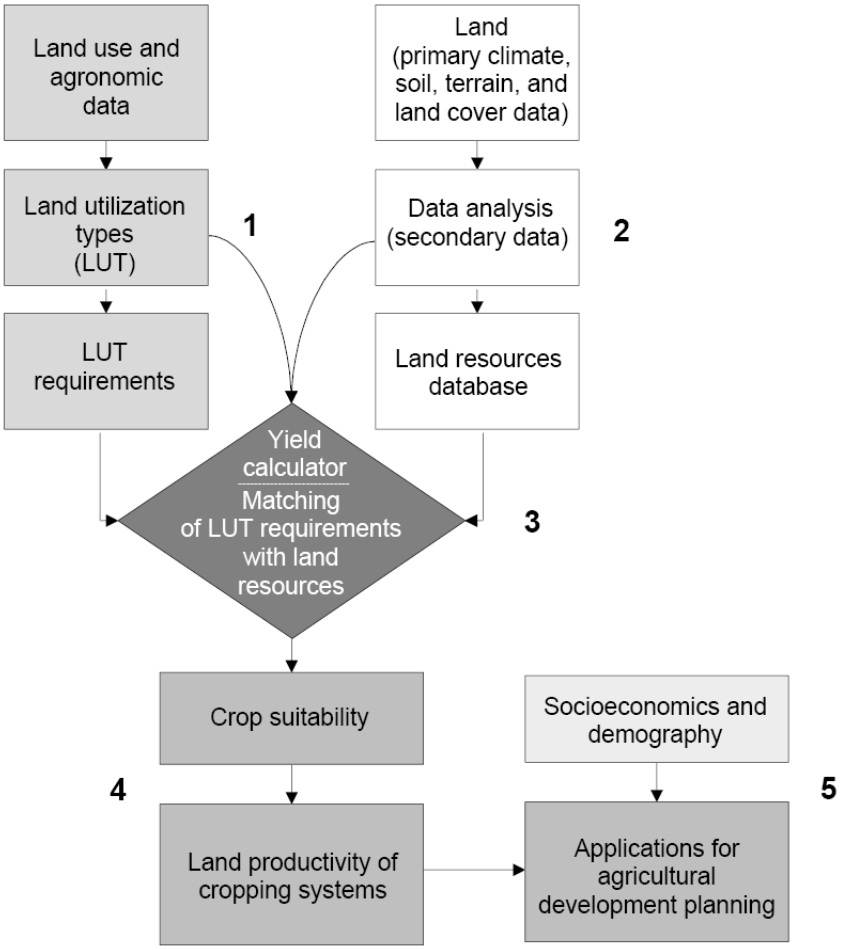

Figure 2.4.1. Conceptual framework of Agro-ecological Zoning methodology (Fischer et al., 2002)

The AEZ database includes spatial information of land (e.g. topography, soil, climate, land use) which are used in a Geographical Information System (GIS). The database is used as input to the AEZ models to analyse the various land use potentials. The AEZ models include models for calculating e.g. the length of the growing period, irrigation requirements, crop biomass, land suitability and land productivity.

The AEZ methodology is based on the criteria below which characterise constraints to agriculture (see Table 2.4.1 for on overview of classification of constraints):

- LGP (length of growing period with cold temperatures and moisture limitations): Too dry (including too wet).
- Temperature: Too cold.
- Terrain-slope constraints: Too steep.
- Soil depth constraints: Soils too shallow.
- Soil fertility constraints: Natural soil fertility too low.
- Soil drainage constraints: Natural soil drainage too low.
- Soil texture/stoniness constraints: Soils too stony and of coarse texture.
- Soil chemical constraints: Soils of too high salinity, alkalinity and toxicity.
- Presence of miscellaneous land units: Dunes, shifting sands, salt flats, rock debris, desert detritus, glaciers and snow caps.

Table 2.4.1. Criteria and classification of constraints used in AEZ for rainfed crops (compiled from Fischer et al., 2002).

Criteria	Severe constraint	Constraint	Slight constraint	No constraint
LGP (a)	<60 days in hyper arid and arid moisture regimes	120-190 days in dry semi-arid moisture regimes. 365 days in humid conditions (Wetness constraint)	Class not used for that constraint	Class not used for that constraint
LGPt (b)	<120 days	<180	Class not used for that constraint	Class not used for that constraint
Slope	>30%	16-30%	8-16%	<8%
Soil depth (c)	<50 cm	50 -100 cm	Class not used for that constraint	>100 cm
Soil fertility (c)	Soils with low natural fertility	Soils with medium natural fertility	Class not used for that constraint	Soils with high natural fertility
Soil drainage (c)	Poorly and imperfectly drained soils	Class not used for that constraint	Class not used for that constraint	Excessively and well drained soils
Soil texture (c)	Coarse texture or stones, boulders or rock outcrops in the surface layer or at the surface	Soils with heavy cracking clays	Class not used for that constraint	Soils with medium and fine texture
Soil chemistry (c)	Soils with severe salinity, alkalinity or gypsum limitations. Soils with saline and alkaline phase	Class not used for that constraint	Class not used for that constraint	All other soils
Miscellaneous land units	Dunes, shifting sands, salt flats, rock debris, desert detritus, glaciers and snow caps	Class not used for that constraint	Class not used for that constraint	Class not used for that constraint.

(a) LGP is based on a combination on thermal classes and length of growing period, based on temperature and water availability.

(b) LGPt is based on temperature criteria only.

(c) These criteria are based on pedotransfer rules from the FAO soil name.

The AEZ method also includes constraint set for irrigated agriculture and type of irrigation.

Agro-ecological Zoning Applications

The AEZ methodology has been applied globally (Fischer et al., 2002), regionally and nationally in many countries. The methodology has been applied to pan-European climate, soil and terrain databases where the result from the ongoing Global AEZ 2007 (FAO/IIASA, 2007) has been provided for the purpose of this report. The result is based on the methodology described above where the datasets below have been applied as follows:

Gridded climate parameters from East Anglia University (Climate Research Unit of the Tyndall centre) have been used:

- Average 1961-2000 monthly variables for a 10 x 10 minutes latitude/longitude grid (CRU CL2.0, New et al., 2000)
- Annual time series 1961-2000 for a 0.5° by 0.5° latitude/longitude for monthly climatic variables (CRU TS 2.1, Mitchell et al., 2003)

Soils and terrain slope data from the following sources have been used:

- The soil data are based on the European Soil Database (ESB, 2004).
- The terrain slope data has been derived from digital elevation data produced by the NASA Shuttle Radar Topographic Mission (SRTM). The SRTM data is available as 3 arc second Digital Elevation Models (CGIAR-CSI, 2006). Original SRTM tiles covering the European continent were used[3]. From this data slope gradients were calculated; resulting in distributions of eight slope classes for each 5' grid-cell: 0-0.5%, 0.5-2%, 2-5%, 5-8%, 8-16%, 16-30%, 30-45%, and >45%.

Figure 2.4.2 and 2.4.3 and Table 2.4.2 show the results of climate, terrain and soil constraints for each 5 min grid cell[4]. The results shown, reflect constraints for all land, i.e. irrespective of its current use. Obvious characteristics are areas with severe temperature constraints in northern Scandinavia and high mountain areas. Dryness constraints (slight to moderate moisture constraints) are prevailing in centre and southern Spain and southern Italy. Severe terrain and soil constraints are wide-spread and indicated by the red and brown colours.

[3] For areas beyond 70 degrees north, elevation data from GTOPO30 (EROS, 2002) was used.

[4] Where constraints coincide, for display purposes on the map, in the bar chart and occurrence table, preferences are given as follows: Severe constraints over moderate and slight constraints, and temperature constraints over moisture constraints, terrain slope constraints and soil related constraints.

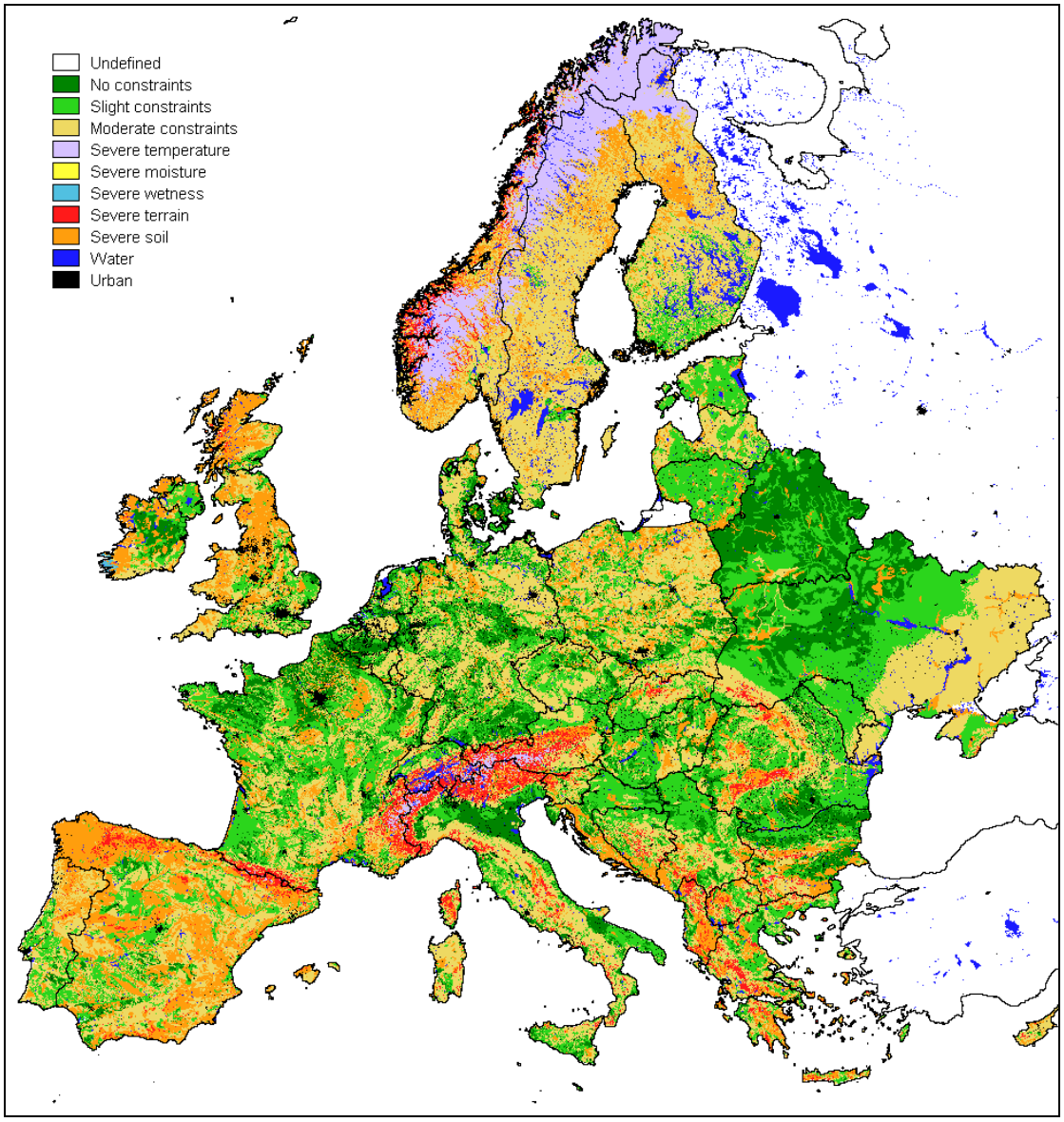

Figure 2.4.2. Map of climate, soil and terrain constraints for rainfed agriculture for all land derived with Global AEZ methodology applied to pan-European datasets (FAO/IIASA, 2007). The slight and moderate constraints include climate, soil and terrain constraints.

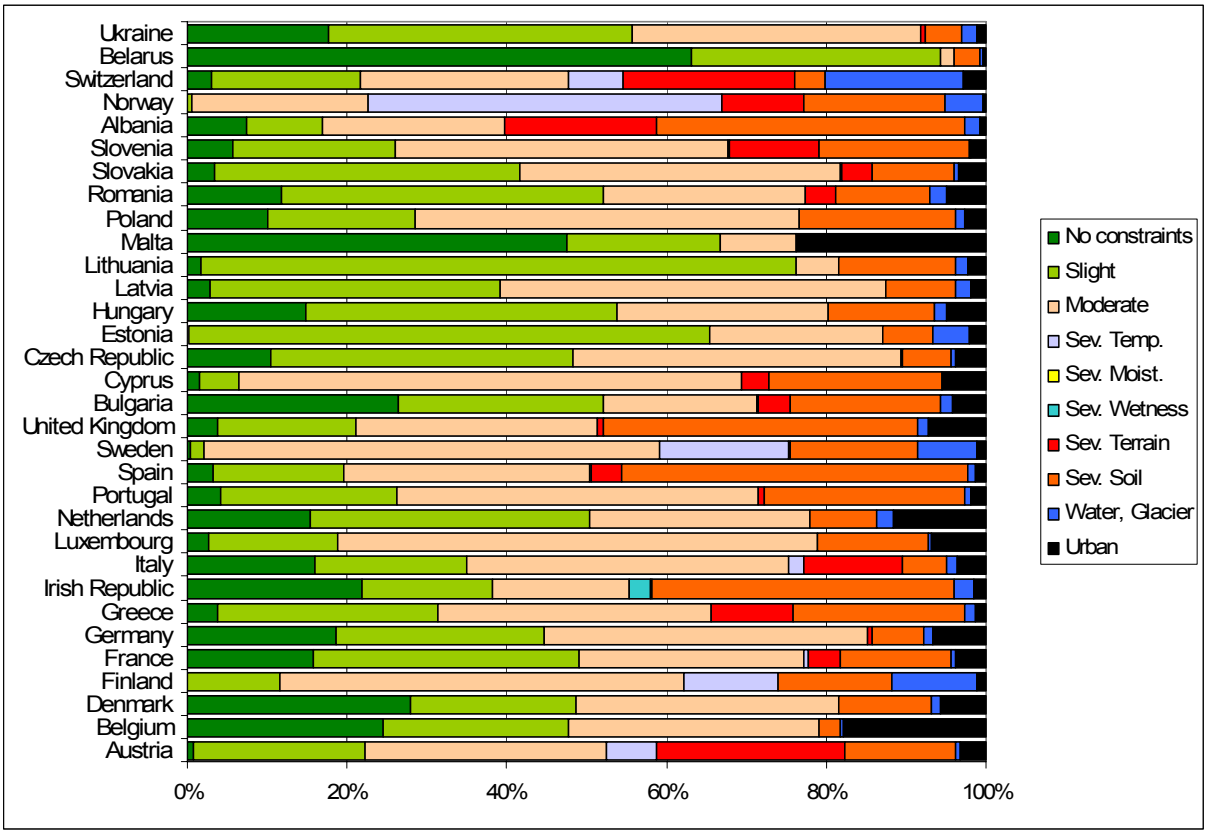

Figure 2.4.3. Biophysical constraints, shown as severe climate, soil and terrain constraints, moderate constraints and slight constraints for rainfed agriculture for all land in Europe by country (FAO/IIASA, 2007).

Table 2.4.2 shows the regional differences in Europe where the countries of Northern Europe have the larges areas of land constrained to agriculture.

Some characteristics that can be distinguished from Table 4:

- Severe temperature constraints: In Norway, Sweden, Finland, Switzerland, Austria and Italy.
- Severe wetness constraints: In Ireland.
- Severe terrain slope constraints: In Austria, Switzerland, Albania, Italy, Slovenia, Greece, France, Spain, Bulgaria, Slovakia, Romania, and Cyprus.
- Severe soil constraints: Widespread. Over 20% of the land classified in Spain, Albania, UK, Ireland, Portugal, Cyprus, and Greece.

Table 2.4.2. Percentage occurrence of climate, soil and terrain constraints for rainfed agriculture to all land by country in Europe (FAO/IIASA, 2007).

Country	No constraints	Slight constraints	Moderate constraints	Severe temperature constraints.	Severe moisture constraints.	Severe wetness constraints	Severe terrain slope constraints	Severe soil constraints	Water, Glacier	Urban
Austria	0.8	21.4	30.4	6.3	0.0	0.0	23.5	13.8	0.7	3.2
Belgium	24.6	23.2	31.4	0.0	0.0	0.0	0.0	2.6	0.3	17.9
Denmark	27.9	20.8	32.9	0.0	0.0	0.0	0.0	11.6	1.1	5.7
Finland	0.1	11.6	50.6	11.7	0.0	0.0	0.0	14.4	10.6	1.2
France	15.7	33.3	28.2	0.7	0.0	0.0	3.9	13.9	0.5	3.8
Germany	18.6	26.1	40.5	0.0	0.0	0.0	0.5	6.6	1.1	6.6
Greece	3.9	27.4	34.2	0.0	0.0	0.0	10.4	21.4	1.3	1.4
Irish Republic	21.9	16.2	17.2	0.0	0.0	2.6	0.3	37.8	2.6	1.4
Italy	16.1	19.0	40.3	1.9	0.0	0.0	12.3	5.6	1.3	3.6
Luxembourg	2.7	16.2	60.2	0.0	0.0	0.0	0.0	13.9	0.4	6.9
Netherlands	15.5	34.9	27.6	0.0	0.0	0.0	0.0	8.3	2.1	11.6
Portugal	4.1	22.1	45.2	0.0	0.0	0.0	0.7	25.1	0.8	1.9
Spain	3.2	16.5	30.7	0.1	0.0	0.0	3.9	43.4	0.9	1.3
Sweden	0.4	1.8	56.9	16.2	0.0	0.0	0.2	15.9	7.5	1.1
United Kingdom	3.9	17.3	30.1	0.0	0.0	0.0	0.8	39.3	1.3	7.3
Bulgaria	26.4	25.7	19.2	0.1	0.0	0.0	3.9	19.0	1.4	4.2
Cyprus	1.6	4.8	62.9	0.0	0.0	0.0	3.6	21.7	0.0	5.4
Czech Republic	10.4	37.8	41.2	0.0	0.0	0.0	0.2	6.0	0.5	3.9
Estonia	0.2	65.2	21.6	0.0	0.0	0.0	0.0	6.2	4.7	2.0
Hungary	14.8	39.0	26.4	0.0	0.0	0.0	0.0	13.4	1.4	5.0
Latvia	2.8	36.4	48.2	0.0	0.0	0.0	0.0	8.8	1.9	1.9
Lithuania	1.7	74.4	5.3	0.0	0.0	0.0	0.0	14.6	1.5	2.4
Malta	47.6	19.0	9.5	0.0	0.0	0.0	0.0	0.0	0.0	23.8
Poland	10.1	18.4	48.1	0.0	0.0	0.0	0.0	19.5	1.1	2.7
Romania	11.8	40.3	25.4	0.0	0.0	0.0	3.8	11.7	2.1	5.0
Slovakia	3.5	38.2	40.1	0.2	0.0	0.0	3.9	10.2	0.5	3.5
Slovenia	5.7	20.3	41.7	0.1	0.0	0.0	11.3	18.7	0.2	1.9
Albania	7.4	9.5	22.8	0.0	0.0	0.0	19.0	38.6	1.9	0.8
Norway	0.0	0.5	22.2	44.3	0.0	0.0	10.1	17.8	4.8	0.3
Switzerland	3.1	18.5	26.0	6.9	0.0	0.0	21.4	3.7	17.4	2.8
Belarus	63.1	31.3	1.7	0.0	0.0	0.0	0.0	3.1	0.4	0.4
Ukraine	17.8	37.9	36.3	0.0	0.0	0.0	0.4	4.6	1.9	1.1

Links to Agro-Ecological Zoning

Website: Agro-ecological Zoning information
http://www.fao.org/ag/agl/agll/prtaez.stm

Report: Global Agro-ecological Assessment for Agriculture in the 21st Century
http://www.iiasa.ac.at/Research/LUC/SAEZ/index.html

Report: Agro-ecological Zoning, Guidelines
http://www.fao.org/docrep/W2962E/W2962E00.htm

2.5 Agricultural Problem Land Approach

What is the Agricultural Problem Land Approach?

The Agricultural Problem Land Approach[5] is based on two approaches one on Problem soils and one on constraints due to climate. The Problem Land approach is a straightforward and simple method for identifying broad types of agricultural problem soils. The approach identifies mainly soil types with common characteristics that frequently dominate agricultural land use and has been developed by the Asian Network on Problem soils (FAO, 1990).

The agricultural problem soils considered in the Problem soil database hosted by FAO are:

- Acid soils (with and without aluminium toxicity, acid sulphate soils)
- Calcareous soils (typical soils of semi-arid and arid climates)
- Histosols (peat soils)
- Salt-affected soils (saline and sodic soils)
- Sandy soils (coarse texture soils)
- Steeplands (sloping land)
- Vertisols (heavy cracking clay soils)

However, it needs to be recognised that different types of agriculture (arable land, pasture, agro forestry) as well as different types of crops, demand different types of soils for an optimal production. Therefore one soil may be a problem soil for one type of land use, whereas it is not so for another type.

When to use the Agricultural Problem Land Approach?

The Problem Land Approach is suitable for, identification of different groups of problem land to agriculture and mapping of broad agricultural land suitability.

Criteria and method of the Agricultural Problem Land Approach

The Agricultural Problem Land Approach starts searching for a potential limitation to agricultural use from the top in Table 2.5.1, searching for land with the defined problem land key, i.e. starting from areas identified as cold, then going down the list. If none of the characteristics are found on the land unit analysed, the land is identified as very suitable for agriculture.

[5] The term Agricultural Problem Land Approach has been chosen here as proposed from Nachtergaele (2006). In the literature it is often referenced as the Agricultural Problem Soils Approach.

Table 2.5.1. Classification system for the Agricultural Problem Land Key (FAO, 1990, modified by Nachtergaele, 2006)

Problem land key (criteria) (a)	**Description**
Cold (b)	Land Areas with a Boreal or Arctic climate: few crops can be grown.
Dry	Other Land areas which have a Length of available growing period less than 120 days (GAEZ zone). Few crops can be grown without irrigation.
Steep	Other land areas with dominant slope > 16% (limit to be adapted to EU regulations may include roughness factor).
Shallow	Other land areas which have depth limitations within 50 cm of the surface caused by the presence of coherent and hard rock or hard-pans.
Poorly drained	Other land areas which are waterlogged and/or flood for a significant part of the year.
Coarse textured	Other land areas which have coarse textures with less than 18% clay and more than 65% sand, or have gravel, stones, boulders or rock outcrops in surface layers or at the surface.
Heavy cracking clay	Other land areas which have vertical cracks properties (high clay content and cracked when dry).
Severe fertility limitation	Other land areas which exhibit deficiencies in major, secondary and minor plant nutrients.
Saline/ Alkalinity limitation	Other Land areas comprised of soils with a high salt content or exchangeable sodium saturation within 100 cm of the surface.
Peat	Other land areas in which more than half of the upper 80 cm is composed of organic materials saturated with water for long periods of time or artificially drained.
No Constraints	Other land areas with none of the above constraints to sustained agricultural production.

(a) The key on Acid sulphate limitations was removed by Nachtergaele (2006) as these are of very limited extent in Europe, i.e. the Polder landscapes in the Netherlands.

(b) Cold areas are defined from thermal climate classification. Boreal (cold) defined as at least one month with monthly mean temperature, corrected to sea level, below 5˚C and more than one but less than four months above 10°C. Arctic (cold) all months with monthly mean temperature, corrected to sea level, below 10°C.

Application of the Agricultural Problem Land Approach

The classification system for Agricultural Problem Land have been applied for Europe (Nachtergaele, 2006) on the basis of the Digital soil map of the world, scale 1: 5 million (FAO, 1995b). The result of the assessment of the major soil characteristics based on the Digital soil map of the world (Scale 1:5 million) according to the classification scheme shown in Table 2.5.1 can be summarised as (Nachtergaele, 2006):

-
- Steep Slopes: In mainly Greece, Slovenia, Italy, Portugal, Austria and Spain corresponding with mountain ranges.
- Shallow soils, not on steep slopes: In the Netherlands and Estonia mainly.
- Wet, badly drained soils, not on steep and shallow soils: In nearly every European country, except the Mediterranean countries and in Sweden.
- Coarse textured, not on steep, shallow and wet soils: They are widespread in the European countries and in particularly in Poland, Sweden, Denmark, Finland and Latvia.
- Saline soils: Only in Hungary.
- Peat soils: Significant extents in Finland, Sweden, The Netherlands and the United Kingdom.

In Figure 2.5.1 are the land areas being too cold and too dry shown according to the Problem Land Approach (Table 2.5.1). The map is derived from the results from the Global AEZ (Fischer et al., 2002) described earlier.

Boreal climate (too cold) correspond to 65% and 88% of the total land areas in Sweden and Finland, respectively. These areas correspond to a maximum length of the growing period of 180 days. The too dry areas appear in very limited areas: Austria (7%), France (0.5%), Greece (1%), Italy (2.4%), Spain (3%). However, please note that the analysis is based on long-term average monthly climatic data, which does not consider variations from year to year or within the month.

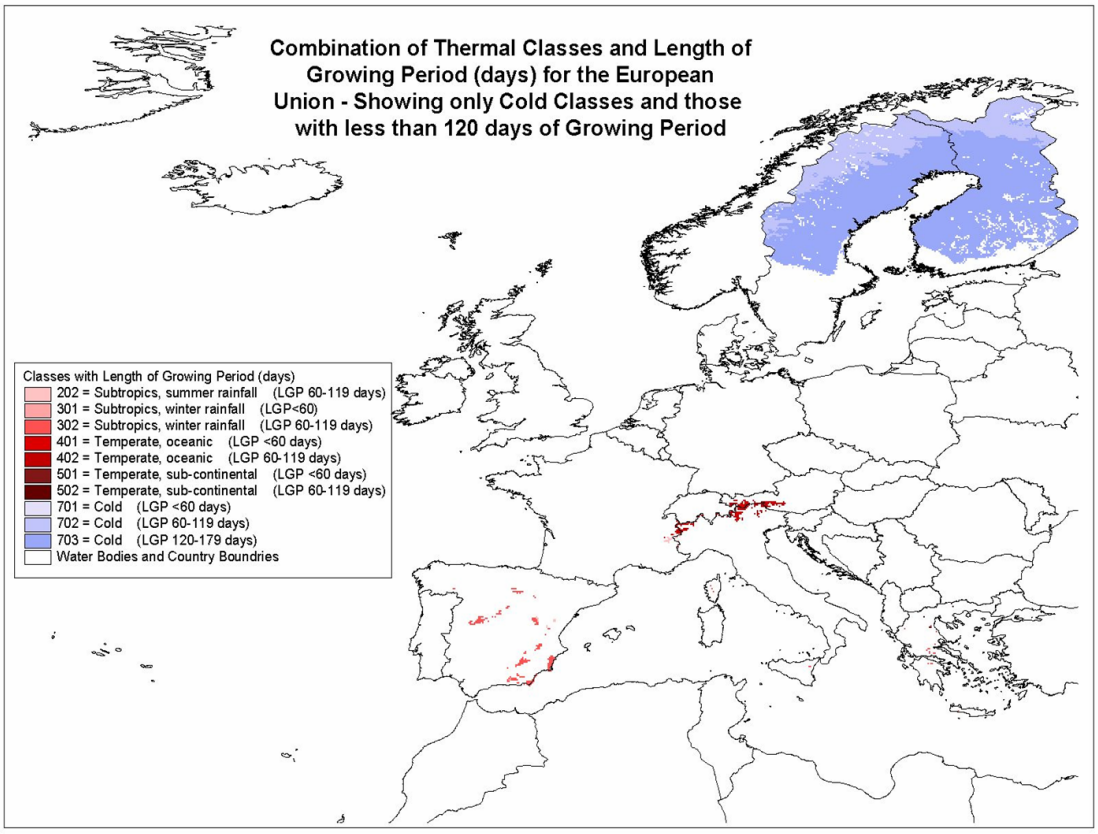

Figure 2.5.1. Map showing areas being too cold (in blue) and too dry (in red) according to the Problem Land Approach (in Nachtergaele, 2006, from Fischer et al., 2002).

Links on the web

Problem soils database
http://www.fao.org/ag/AGL/agll/prosoil/prosoil.asp

Problem soil website
http://www.fao.org/ag/AGL/agll/prosoil/index.htm

2.6 Expert System for Constraints to Agricultural Production in Europe

What is ESCAPE?

Expert System for Constraints to Agricultural Production in Europe (ESCAPE) is a land resources assessment model that has been developed by INRA (French National Institute for Agricultural Research) and applied with European datasets in collaboration with the Joint Research Centre (Soil and MARS, Monitoring Agriculture with Remote Sensing). The aim of the model is to evaluate soil and climate constraints to crop production in Europe by a relative simple approach using straightforward criteria and a minimum set of parameters. The model is based on a number of soil and climate criteria, which varying according to the main crops: cereals, maize, root crops, oilseed crops, grasslands, olive trees and vineyards. See Figure 2.6.1 for an overview of the ESCAPE methodology.

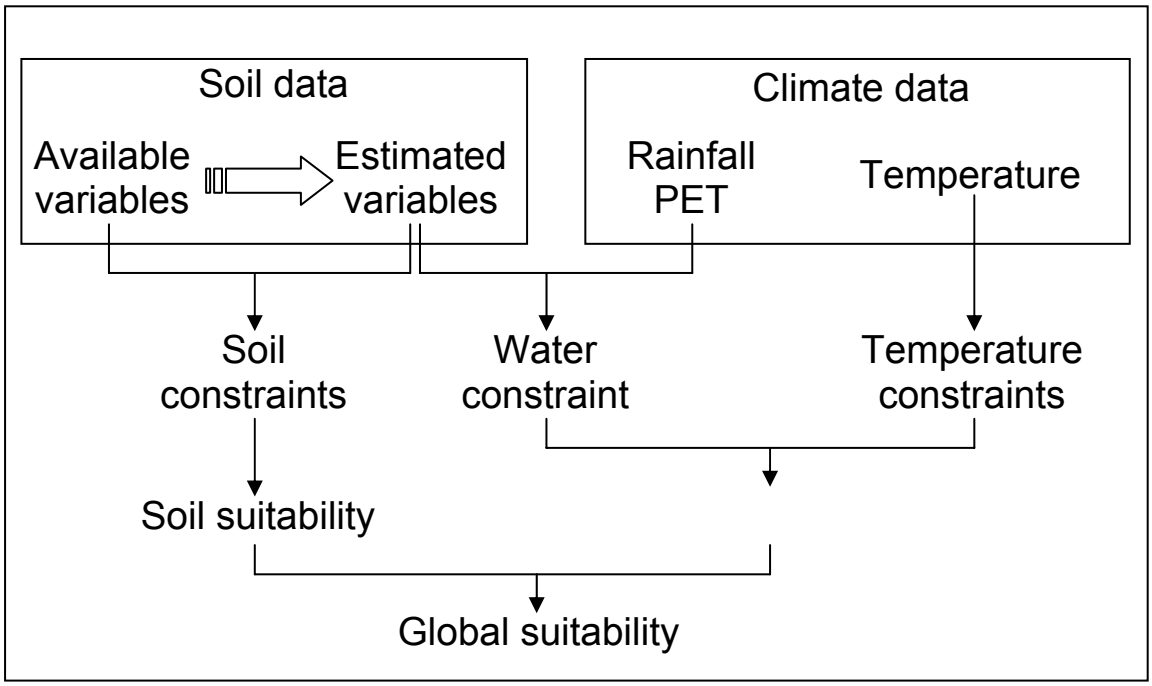

Figure 2.6.1. Overview of the ESCAPE methodology (Le Bas, 2006).

The methodology can be described in five elements:

1. Land evaluation units: are based on the combination of the climatic grid cells and the soil mapping units.
2. Land resource database: georeferenced soil and climate data. Pedotransfer rules are used for estimating some soil variables.
3. Climate, water and temperature constraints: a number of criteria used for defining the conditions of the soil, temperature and soil water moisture.
4. Assessment of soil and climate suitability: assessment of suitability for different crop groups for each land evaluation unit.
5. Global suitability: integrated crop suitability.

When to use Escape?

ESCAPE has been designed for applications on the European or regional level concerning: land suitability evaluation and assessing soil and climate constraints.

Criteria and methodology of the ESCAPE methodology

The model is based on three different types of limitations to agriculture: temperature, soil and water constraint:

Temperature constraints:

- Frost constraint
- Germination constraint
- Flowering constraint
- Ripening constraint
- Heat constraint

Soil constraints:

- Chemical soil fertility
- Oxygen availability to roots
- Rooting conditions
- Mechanisation conditions

Water constraints: based on a water balance

The constraints are applied to each land evaluation unit and for each crop group. Below is a description of the application of the different constraints and criteria considered.

The temperature constraints are related to the conditions for a certain crop development from germination to ripening in time. It is based on the calculation of the potential growing period for these crops. Three main stages are considered for spring annual crops: germination, flowering and ripening. The model determines the period during the year where these stages can occur considering a number of constraints. Then, two classes are considered, suitable or unsuitable, depending on whether the total crop development is possible or not in relation to the climatic cell. In Table 2.6.1 are the temperature criteria shown.

Table 2.6.1. Temperature constraints used in ESCAPE. Thresholds of constraints are set according to each crop type. Below are the thresholds shown for spring cereals (compiled from le Bas et al., 2001).

Criteria for estimating temperature constraints	**Suitable**	**Unsuitable**
Frost constraint	mean 10 day T >-5˚C	mean 10 day T <-5˚C
Germination constraint	mean 10 day T >5˚C	mean 10 day T <5˚C
Flowering constraint	T sum >1300 ˚C	T sum <1300 ˚C
Ripening constraint	T sum >1600 ˚C	T sum <1600 ˚C
Heat constraint (a)	mean 10 day T <25˚C	mean 10 day T >25˚C

(a) Not specific for crop group.

The soil constraints are evaluated for each soil typological unit concerning conditions for: mechanisation, rooting, oxygen availability to roots and chemical fertility (Table 2.6.2). Constraints are estimated in three classes: suitable, acceptable or unsuitable, by a combination of one or more soil criteria in hierarchical decision trees. For each soil criterion, thresholds have been adapted to the data available in the Soil Geographical data Base of Europe at scale 1:1 million (where soil data are only qualitative, thus the thresholds are corresponding to limits of classes as described in the data base (i.e. for slope, the limits of 8%, and 25% correspond to limits of slope classes in the data base). The thresholds are also depending on the values taken by the soil criteria situated above in the decision tree, and varying accordingly to the group of crops. For example, for cereals, the coarse textured soils are considered not suitable if the rooting depth is below 50 cm and acceptable if the rooting depth is above 50 cm. The weight of each soil constraint is dependent on the difficulties to overcome them through agronomic practices, e.g. drainage. The soil evaluation model is developed through the ALES expert system (Rossiter and Van Wambeke, 1997, and Rossiter, 2007).

The water constraint relates to the soil water balance, i.e. combination of climate and soil water properties where the soil can compensate for the climatic deficit by its water storage capacity. The soil water balance simulates two soil layers. Water constraints are determined only from the crop growing period defined from the temperature constraints. The water balance is calculated on a 10 day average using the available water capacity in the Soil Geographical Data Base of Europe and rainfall and potential evapotranspiration from climatic database (MARS, 2007). Periods of water stress are defined when the actual evapotranspiration / potential evapotranspiration is less than 0.3. Water constraints are only determined within the crop period calculated with temperature constraints. The crop period is reduced if there is water stress for more than 30 consecutive days and the final results for water suitability are acceptable or unsuitable if the crop cycle can be achieved or not during the resulting crop period.

The temperature, soil and water constraints are finally combined in a global decision tree where the most limiting constraint for the land unit determines the global evaluation (see Figure 2.6.1).

Table 2.6.2. Criteria and description of soil constraints used in ESCAPE. Thresholds of constraints are set according to each crop type. Below are thresholds shown for cereals (compiled from Le Bas et al., 2001)

Soil constraints in ESCAPE	**Criteria for estimating constraint**	**Suitable**	**Acceptable**	**Not suitable**
Chemical soil fertility	Soil Cation Exchange Capacity	>15 cmol(+)/kg	<15 cmol(+)/kg	Class not used for that constraint
Oxygen availability to roots	Water regime (a)	Not wet within 80 cm for over 3 months, nor wet within 40 cm for over 1 month	Wet within 80 cm for 3 to 6 months, but not wet within 40 cm for over 1 month	Wet within 80 cm for over 6 months, but not wet within 40 cm for over 11 months or Wet within 40 cm depth for over 11 months
Rooting conditions	Rooting depth (b)	>100 cm	30-100 cm	<30 cm
	Soil texture	Medium, medium fine, fine	Very fine, coarse texture if rooting depth > 50 cm	Coarse texture if rooting depth < 50 cm organic topsoil
	Salinity	Low: <4 mmhos/cm	Medium: 4-15 mmhos/cm	High: >15 mmhos/cm
	Alkalinity	Low <6%	Medium 6-15%	High >15%
Mechanisation conditions	Rooting depth (b)	>50 cm	30-50 cm	<30 cm
	Slope	<8%	8-25%	>25%
	Volume of stones (c)	<10%	10-20%	>20%
	Water regime (a)	Not wet within 80 cm for over 3 months, nor wet within 40 cm for over 1 month or Wet within 80 cm for 3 to 6 months, but not wet within 40 cm for over 1 month	Wet within 80 cm for over 6 months, but not wet within 40 cm for over 11 months	Wet within 40 cm depth for over 11 months

(a) as defined in the Soil Geographical Data Base of Europe at 1:1 000 000 scale at the STU level.

(b) Corresponds to the soil depth if there is no obstacle to roots. If there is an obstacle to roots it is the depth until this obstacle to roots.

(c) Presence of stones with a diameter >7.5 cm

ESCAPE applications

For the European application the datasets applied were:

- The Soil Geographical Data Base of Europe at scale 1:1 million (ESB, 2004).
- The MARS meteorological data, 1975-1999, 50 km x 50 km grid (MARS, 2007). Climatic data are analysed by 10 day periods

The results of the analysis show 3 types of suitability (suitable, unsuitable and acceptable) for spring cereals in Europe (Figure 2.6.2 and Table 2.6.3).

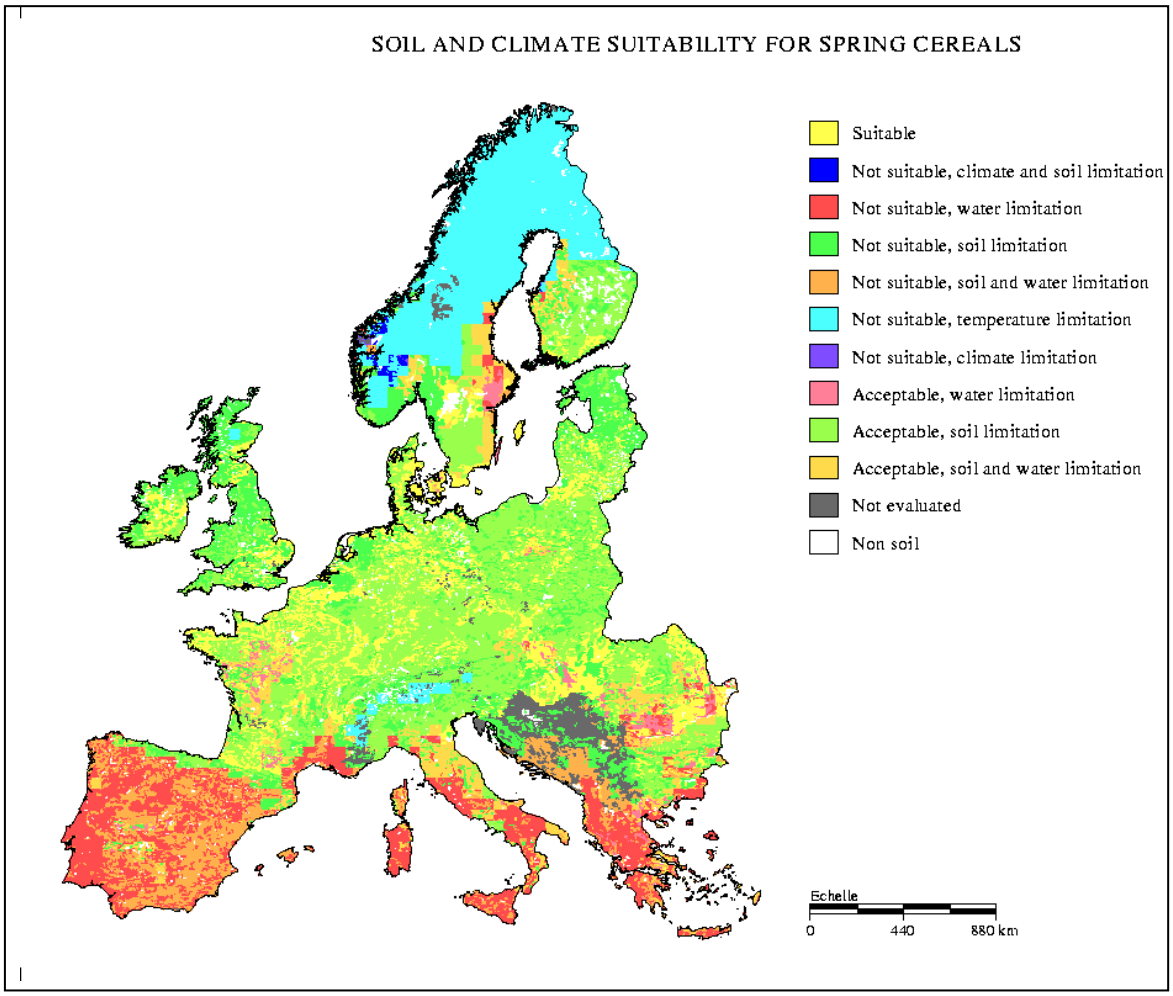

Figure 2.6.2. Dominant combined suitability class per land geographical unit for spring cereals in Europe (Le Bas et al., 2002)

Table 2.6.3. Combined land suitable assessment of all land with respect to temperature, water and soil constraints for spring cereals in Europe as shown in Figure 2.6.2 (compiled from Le Bas et al., 2002).

	Not suitable	**Acceptable**	**Suitable land**
Temperature constraints	13%	-	87%
Water constraints *(a)*	19%	7%	67%
Soil constraints (a)	32 %	47%	15%
Combined temperature soil and climate (a)	*47%*	*34%*	*12%*

(a) The percentages do not sum up to 100 as soil data are not available for 6% of the area.

The following conclusions can be drawn of the analysis:

- Unsuitable areas due to temperature constraints are mainly in Northern Europe or in Mountain areas and represent 13% of the total land area.
- Unsuitable areas due to water constraints are mainly in Southern Europe and represent 19% of the total land area.
- Unsuitable areas due to soil constraints are more scattered and amount to 32% of the total land area. Soil limitations are mainly due to limiting conditions for mechanisation.
- Combining all the constraints on the European level, 47% of the total land area is considered as not suitable for agriculture.

3. Land Evaluation Methods Applied by the Member States for the Less Favoured Areas

3.1 Introduction

In this section an overview of land evaluation methods and criteria used in the Member States for indicating poor land productivity for the current classification of the Other Less Favoured Areas are given, of which some are soil and climate criteria which could be used for the future new definition of the Other Less Favoured Areas (see page 8, New definition of the other LFA). The section does not provide a review of existing national land classification systems.

Land productivity in the current legislation of the Less Favoured Areas (EC, Council Regulation, 1999) No. 1257/1999 is described as criteria indicating poor land conditions and low productivity, difficult cultivation and limited potential which cannot be increased except at an expensive cost, and which is mainly suitable for extensive farming. See page 6 for further description of the other two criteria used in the current legislation on Economic performance of agriculture and Population.

3.2 Methods and Criteria Applied for the Less Favoured Areas

In the current classification of the Other Less Favoured Areas, some Member States use information from national land evaluation methods in order to indicate conditions on land productivity. Below is a list of identified national land evaluation methods used by the respective Member State for their classification of the Other Less Favoured Areas (IEEP, 2006a and 2006b):

- Agricultural comparison figure- Germany (LVZ) and Austria (BZ)
- Land quality index - Poland
- Soil climatic index - Austria
- Land suitability assessment - Hungary
- Various indexes of land/soil quality and/or soil fertility - Estonia, Spain, Cyprus, Latvia, Luxembourg, Hungary, Poland, Slovenia, Slovak republic, Finland and United Kingdom.

However, please note that that these are all different types of land evaluation methods, i.e. some only including climate or soil conditions and/or some include economic valuation of land which is an additional economic evaluation, i.e. not part of land evaluation.

Table 3.2.1 presents an overview of the criteria applied in the Member States for classifying the Other Less Favoured Areas according to the condition on Land productivity, i.e. poor land conditions. Only criteria which are of biophysical character, linked to land evaluation and extensive farming (land use and yield) are included. Socio-economic criteria on land productivity, e.g. economic productivity potential and farm income per working unit are not included. Some index systems are

a combination of land evaluation criteria and productivity criteria and have therefore been included.

Table 3.2.1. Criteria indicating poor land productivity (land quality and extensive farming) used by the Member States for the Other LFA (derived from IEEP, 2006a and b)[6]. The calculation unit normally refers to the municipality. Utilized Agricultural Area (UAA).

Member State *(i)*	**Criteria on land productivity *(ii)***	**Threshold for being Classified as Other LFA *(ii)***
Belgium	Area of permanent meadow and pasture/ UAA	>80%
	Area of an altitude above 400 m.a.s.l./ and area	>50%
	No. days without frost	<150 days
	Output per hectare from bovine/national average	<70%
	Cereal yields/national average	<80%
Czech Republic	Productivity Index-output per hectare: average productivity of agricultural land	<34 points (equals 80% of national average)
Germany	Productivity Index: Agricultural Comparison Index (LVZ)	<15-32.5 points *(iii)*
	Area of permanent grasslands/UAA *(iv)*	>80%
Estonia	Soil quality index: (inc. water regime, stoniness, relief, humus content)	<39.94 points
Ireland	Ploughed area	<7.8 %
	Livestock density	<1 LU/forage hectare
Greece	Yields/national average	<80%
	Area of rough grazing/UAA	>30%
Spain	Productivity Index: L. Turc (climatic index)	<30 points *(iii)*
	Irrigated area/arable land	<20% *(iii)*
	Fallow area/arable land	>20% *(iii)*
	Arable land/productive area	<50% *(iii)*
France	Output per hectare / national average	<80%
	Livestock density	<I LU/hectare *(v)*
Italy	Wheat yields/ national average	<66%
	Area of rough grazing/utilised forage area (hay yield , 20 q/hectare)	>50%
	Livestock density	<0.65 LU/hectare
Cyprus	Land suitability assessment: areas classified as “infertile land”	>50% of land classified as category 4 and 5
Latvia	Soil quality index	<38 points
Lithuania	Cereal yields/national average	<80%

[6] Some modifications have been for Finland, Hungary and UK, for which the writer has additional information from bilateral meetings between DG Agriculture and Rural Development and the concerned Member States .

Continuation of Table 3.2.1.

Member State *(i)*	**Criteria on land productivity *(ii)***	**Threshold for being Classified as Other LFA *(ii)***
Luxembourg	Area of forage/UAA	>90%
	Livestock density	< 0.95 or 1.19 LU/hectare *(vi)*
	Drainage conditions	Unfavourable drainage
	Relief conditions	Uneven character of area
Hungary	Productivity index (inc biophysical criteria)/national average	<80%
Austria	Productivity index: agricultural comparison index (BZ)	<30 -35 points *(vii)*
Poland	Land quality index: (inc soil, climate, relief and water conditions)	<52-72.5 pints *(iii)*
Portugal	Area affected by handicaps/UAA	>50%
	Livestock density	<0.2 LU/hectare
Slovenia	Land quality index: inc. relief (inclination, altitude and exposure), climatic conditions and soil properties.	Ratio of low agricultural potential.
Slovak Republic	Soil index: soil index of fertile soils as an indicator for yield.	<21.6 points
	Area of permanent grasslands and fodder crops/UAA	>50%
	Livestock density	< 1 LU/hectare
	Yield of grains/national average	<80%
Finland	Agricultural comparability index: Nikula index (soil quality and climatic conditions).	<440 points
	Area permanents grassland and pasture/UAA	>70%
Sweden	Index of yield/national average	<80%
	Area of fodder land/UAA	>70%
United Kingdom	Area of grassland/UAA	>70%
	Livestock density	I LU/hectare
	Land capability classification (Ireland and Scotland)	

i. *Malta, Denmark, and the Netherlands do not apply to the Other Less Favoured Areas.*
ii. *The application of one or more of the criteria for the respective Member State differs, i.e. sometimes it is enough that one criterion is fulfilled and in other cases all.*
iii. *Threshold variable within the country.*
iv. *Criteria not applied in all sub-regions in the country.*
v. *Only applied when forage area/ UAA is >50%.*
vi. *Depend of cost for supplementary feedings.*
vii. *Depend of share of grassland.*

The thresholds of the criteria are included for information, but it has to be kept in mind that the thresholds made for the same criteria used by several Member States are not comparable as the combined use of the criteria differs from Member State to Member State and also by sub-regions in the country.

4. Summary of Review and Discussion

This chapter summarises the reviewed land evaluation methods and brings up some issues of importance in relation to the preparatory work on a new definition of the Other Less Favoured Areas to be implemented after 2010. The report is aimed to be a base for DG Agriculture and Rural Development in their consultation with Member States and future networks of scientist, including the Joint Research Centre, involved in the progress of classifying the Other Less Favoured Areas from biophysical criteria, seen as natural handicaps to agriculture.

The aim of this report was to describe relevant land evaluation methods which are known and applied internationally and to give an overview of biophysical, mainly soil and climate criteria applied in the reviewed land evaluation methods and in the Member States for their classification of the Other Less Favoured Areas.

The report has reviewed five different land evaluation methods, namely the:

- Land Capability Classification (Klingebiel and Montgomery, 1961)
- Framework for Land Evaluation (FAO, 1976 and 2007)
- Agro-ecological Zoning Methodology (FAO, 1978 and 1996 and Fischer et al., 2002)
- Agricultural Problem Land Approach (FAO, 1990 and Nactergaele, 2006)
- Expert System for Constraints to Agricultural Production in Europe (Le bas et al., 2001 and 2002)

The land evaluation methods have been described in a standardised framework with list of soil and climate criteria and examples of results of applications with preferences to applications on the European level.

A comparison of the results of the applications on the European level from the reviewed methods is difficult as they are based on different methodologies, definitions, thresholds and data. However, the following natural constraints to agriculture can be summarised from the applications of land evaluations on the European level from the Agro-ecological Zoning Methodology (page 26), Agricultural Problem Land Approach (page 31) and Expert System for Constraints to Agricultural Production in Europe (page 37):

- Temperature constraints: In Norway, Sweden, Finland, Switzerland, Austria and Italy.
- Moisture constraints: Mediterranean countries.
- Slope constraints: In Austria, Switzerland, Albania, Italy, Slovenia, Greece, France, Spain, Portugal, Bulgaria, Slovakia, Romania, and Cyprus.
- Soil constraints: Widespread.

Making a comparison of the reviewed land evaluation methods, the following soil and climate criteria are commonly applied on a European level for identifying natural constraints to agriculture:

1) Temperature
2) Heat stress
3) Water balance
4) Slope
5) Rooting depths
6) Drainage
7) Texture
8) Fertility limitations
9) Saline/sodic/toxic limitations

Observations of the methodologies applied by the Member States for the classification of the Other Less Favoured Areas on indicating poor land productivity shows that these criteria are also found in the methods applied by e.g. Austria, Cyprus, Estonia, Finland, Germany, Hungary, Latvia, Poland, Slovenia and the UK (IEEP, 2006 and Eliasson et al., 2007).

Looking on the criteria applied by the Member States for indicating land productivity (Table 3.2.1, page 40) under the current legislation there is a wide range of different criteria. In comparison, the criteria indicating low levels of agricultural productivity and population are more similar for the Member States (IEEP, 2006b). The reason for this is that statistics and information on these criteria are more widely used and there is a common frame on how these criteria are defined and collected.

For the new definition of the Less Favoured Areas (see page 8, New definition of the Other LFA) soil and climate criteria are sought for indicating natural constraints to agriculture. Looking on the current criteria applied by the Member States for indicating poor land productivity some apply soil and climate criteria, which could be used for the future new definition of the Other Less Favoured Areas.

When it comes to biophysical criteria, there are several ways of classifying climate, soil and terrain information and every country has developed their individual land evaluation systems for specific purposes and needs. The fact that there is a wide range of different criteria used by the Member States for indicating low land productivity can partly be seen as a result of that. The biophysical criteria used for classifying the Other Less favoured Areas are often clear and well defined, but in some cases they do not relate closely to the condition on productivity of agricultural land (IEEP, 2006b). Criteria that are easily compared across the Member States are criteria such as, average yield per hectare, livestock density and percentage of land of permanent pasture of Utilized Agricultural Area.

Below are some issues listed in relation to the future work of DG Agriculture and Rural Development in their consultation with Member States and future networks of scientists involved in the progress of classifying the Other Less Favoured Areas from biophysical criteria, seen as natural handicaps to agriculture:

i. The list of common criteria identified above from the land evaluation methods applied internationally can be recognised as important soil and climate criteria for an assessment of natural constraints to a general agricultural use on the

European level. However, some criteria might not be relevant in some countries and regions, as seen in the results on page 26-27 (Agro-ecological Zoning Methodology) and 31(Agricultural Problem Land Approach) and page 37 (Expert System for Constraints to Agricultural Production in Europe).

ii. The list of applied criteria and land evaluation methods for classifying the less Favoured Areas on page 40-41 shows that there is a wide range of criteria and different types of land evaluation methods used for the characterisation of low land productivity in the Member States. Some Member States do use soil and climate criteria, which can be used in the new definition of the Less Favoured Areas.

iii. Differences in the application of the criteria on the European and Member State level concern: the level of detailed classification, accuracy and the use of harmonised or heterogeneous datasets. Using pan-European data gives a gross classification of zones using course scale (small scale) maps, but it provides more harmonised information, i.e. the agricultural attributes (soil, climate and terrain) are built on the same classification system although the accuracy and scale of the data behind is largely variable. National and local data provides a more detailed classification using finer scale maps (large scale) and classification systems that are more specific for the agricultural systems in the Member States. For further information on Soil data in Europe a good inventory by country has been done by Bullock et al., (2005).

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Abstract
This report provides an overview of selected land evaluation methods for quantifying natural constraints to agriculture. It has been compiled for decision-makers with no specialised knowledge of land evaluations and the aim is to give an overview of methods and soil and climate criteria, which are applied for classifying areas less favourable for agriculture in Europe. The report is part of the Joint Research Centre's technical support to DG Agriculture and Rural Development in their preparatory work to find a new definition for classifying the EU Other/intermediate Less Favoured Areas to be implemented after 2010. The report includes standardised descriptions of selected land evaluation methods known internationally, namely: The Land Capability Classification, The Framework for Land Evaluation, the Agro-ecological Zoning Methodology, the Agricultural Problem Land Approach and the Expert System for Constraints to Agricultural Production in Europe. Criteria used in these methods and examples of applications and results are included, with preferences to applications on the European level. An overview of land evaluation methods and criteria, which are currently applied for indicating low land productivity by the Member States for their classification of the Other Less Favoured Areas are included. Finally, a summary of the reviewed methods and criteria and a discussion of issues of importance in the ongoing work on identifying common biophysical criteria for the Other Less Favoured Areas are provided. The report is aimed to be a base for DG Agriculture and Rural Development in their consultation with Member States and future networks of scientists involved in the progress of classifying the Other Less Favoured Areas from biophysical criteria, seen as natural handicaps to agriculture.

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